8.3 Onsite Power System

8.3.1 Alternating Current Power Systems

8.3.1.1 Description

The main generator provides power through the station switchyard to the transmission system via an isolated phase bus (IPB) system and three single-phase main step-up transformers (MSU). Incoming power to the onsite AC power system is from the station switchyard during all modes of plant operation, through the emergency and normal auxiliary transformers to the Class 1E and non-Class 1E distribution systems respectively.

The main generator is connected to the switchyard via two circuit breakers in the switchyard. Either breaker enables the generator to provide power to the transmission system. During main generator startup and synchronization with the grid, a generator automatic synchronizer is used in combination with an independent synchrocheck permissive relay, which provides a closing signal to the main generator breaker.

Prior to main generator synchronization with the transmission system, the plant loads are fed by the transmission system through the switchyard. The main generator circuit breakers in the switchyard are open at this time. The switchyard and offsite power supply arrangement allows station loads to remain powered from the same source during all plant operating modes and eliminates the need for bus transfers during plant startup or shutdown.

Main generator protection is provided by a primary and backup protection scheme. Protective device actuation trips the main generator output breakers in the switchyard, trips the generator excitation and initiates a turbine trip. Main generator protection includes stator overcurrent, ground fault and reverse power.

The MSU protection detects faults and initiates protection actions to minimize any potential damage to an MSU, while minimizing impact to the electrical distribution system. Protective devices installed for the protection of the MSU include transformer bank differential current, ground fault overcurrent, phase overcurrent and sudden pressure relays. Activation of an MSU protection device results in a turbine generator trip and a separation of the main generator from the grid by tripping the main generator breakers in the switchyard. The onsite electrical distribution continues to be powered from offsite through the switchyard with no power interruption to the onsite power distribution system. No offsite power source transfer is required during this transient.

If the offsite transmission system has a fault that results in a loss of power from the transmission system, the main generator continues to provide power to the plant loads from the switchyard via the normal and emergency auxiliary transformers. The main generator is designed to accept a load rejection without a turbine trip and continue to supply plant loads without interruption.

The onsite AC power supply system supplies all electrical loads of the plant and is subdivided into the Class 1E emergency power supply system (EPSS) and the non-Class 1E normal power supply system (NPSS). The EPSS supplies electrical power to safety-related loads and a limited number of non-safety-related loads. The NPSS supplies electrical power to the remaining plant non-safety-related loads.

The onsite distribution system, including the main generator, transformers, buses, bus feeder breakers, and their connections are shown on Figure 8.3-2—Emergency Power Supply System Single Line Drawing and Figure 8.3-3—Normal Power Supply System Single Line Drawing. Legend and symbols for the electrical single line diagrams are shown on Figure 8.3-1—Electrical Single Line Drawing Legend. The nominal ratings of the AC power system main components are listed in Table 8.3-1—Onsite AC Power System Component Data Nominal Values. Nominal bus voltages used in the onsite AC distribution system are 13.8 kV, 6.9 kV, 480 Vac, 208 Vac and 120 Vac.

8.3.1.1.1 Emergency Power Supply System

The purpose of the EPSS is to distribute power to 6.9 kV and 480 Vac safety-related loads and a limited number of non-safety-related plant loads. The EPSS electrical distribution system is a four division electrical power supply. Each division includes 6.9 kV switchgear, 480 Vac load centers (LC), and 480 Vac motor control centers (MCC) as shown on Figure 8.3-2.

Each division of EPSS distribution equipment is located in the respective Seismic Category I Safeguards Building (SB), Essential Service Water Pump Building (ESWPB) or Diesel Generator Building, which provides physical separation from the redundant equipment. The EPSS Class 1E switchgear buses, LCs, MCCs, distribution transformers and other Class 1E components meet the Seismic Category I requirements of RG 1.29. This physical design also facilitates access control to Class 1E power equipment areas.

Power to the EPSS is received from offsite power via two separate and independent circuits from the station switchyard through two emergency auxiliary transformers (EAT), 30BDT01 and 30BDT02. The EATs are three-phase, three-winding, core-type oil-immersed power transformers with two identically rated 6.9 kV secondary windings. The 30BDT01 normally powers distribution buses 31BDA and 33BDA, while 30BDT02 normally powers 32BDA and 34BDA.

The station remains connected to the offsite power sources without transferring buses or power sources during startup, full power operation or shutdown. Each offsite preferred power source is normally in service through its respective EAT. When connected to offsite power, the voltage level at 6.9 kV buses 31BDA, 32BDA, 33BDA and 34BDA is maintained by two EAT on-load tap changers at the nominal 100 percent voltage. The bus voltage is maintained at the nominal 100 percent following a ± ten percent deviation in the switchyard voltage combined with bus voltage changes as a result of changes in bus loading. The EPSS connection with offsite power utilizes no intervening non-Class 1E buses and does not share a common winding from the preferred power EATs with the non-Class 1E switchgear. This minimizes the probability that transients of non-safety-related loads will adversely affect the Class 1E equipment and eliminates additional failure points between the offsite source and the Class 1E equipment.

The EAT protection detects faults and initiates protection actions to minimize any potential damage to an EAT, while minimizing impact to the electrical distribution system by isolating the affected transformer in the event of a transformer fault. Protection devices installed for EAT protection include transformer differential, ground fault overcurrent, phase overcurrent and sudden pressure relays. An EAT related fault initiates an automatic fast transfer of the offsite power source, maintaining offsite power to all four divisions by switching the affected bus power supply to the unaffected EAT. The combined four EPSS divisions load under postulated conditions are within the ratings of each of the EATs. The fast transfer minimizes voltage decay and frequency difference to limit motor torque during the transfer, thus minimizing equipment degradation.

The EPSS distribution switchgear and nominal bus voltages are shown in Table 8.3-2—Emergency Power Supply System Switchgear, Load Center and Motor Control Center Numbering and Nominal Voltage.

EPSS divisions are functionally independent and physically separated from the others during normal bus alignments. An alternate feed is provided between EPSS divisions 1 and 2 (first divisional pair) to provide the normal and standby source of power to required safety-related systems, safety-related support systems, or components that do not have the required redundancy when certain electrical components, including the division 1 emergency diesel generator (EDG), are out of service. A similar alternate feed provides standby power to EPSS division 2, from division 1 when certain electrical components, including the division 2 EDG are out of service. Similar alternate feeds are used between divisions 3 and 4 (second divisional pair).

The divisional pair functional independence and physical separation are in accordance with IEEE Std 603-1998 (Reference 1) for safety-related system independence. This is accomplished by the separation of safety-related components between divisional pairs. A single failure or internal hazard, or both, in one divisional pair can only affect that one divisional pair. Therefore, during design basis accidents coincident with a single failure to any electrical component in a divisional pair, the second divisional pair supports safety-related function completion in accordance with single failure criteria IEEE Std 379-2000 (Reference 2), as endorsed by RG 1.53.

EPSS switchgear, load centers, MCCs, transformers, feeder breakers and load breakers are sized to provide sufficient power to start and operate connected loads, including loads fed through the alternate feeds.

The alternate feeds are capable of alignment as follows:

- Switchgear 31BDB can receive power from EDG supported 32BDA.
- Switchgear 32BDB can receive power from EDG supported 31BDA.
- Switchgear 33BDB can receive power from EDG supported 34BDA.
- Switchgear 34BDB can receive power from EDG supported 33BDA.

Each EPSS division has an EDG as its standby power source that will automatically start and supply the respective division if offsite power is de-energized to the division as described in Section 8.3.1.1.3. The EDGs connect to their respective divisional bus and have no automatic connection to any other division. The sequencing of large loads during LOCA-only conditions is accomplished in the same manner as the EDG load sequencing described in Section 7.3.1.2.12. Loads used in LOCA mitigation are sequenced onto the EPSS buses when supplied by offsite power to reduce the electrical transient on the electrical distribution system.

Two station blackout diesel generators (SBODG) are provided as an alternate AC source (AAC) to provide power to 6.9 kV switchgear 31BDC, 32BDB, 33BDB and 34BDC in the event of a loss of offsite power (LOOP) and simultaneous failure of all EDGs. The SBODGs automatically start on loss of voltage as sensed in the NPSS and are automatically connected to the NPSS. The EPSS switchgear are manually connected to the NPSS to receive power from the SBODGs. The NPSS and EPSS switchgear are separated by a non-Class 1E breaker on the NPSS switchgear and a Class 1E breaker on the EPSS switchgear. Section 8.4 describes the AAC source and station blackout (SBO) mitigation in detail.

Each EPSS division contains a low voltage regulating transformer that powers MCCs BNB02 and BNB03. The low voltage regulating transformer maintains the voltage at or above a minimum level to meet electrical requirements of MCC loads (primarily motor-operated valves) during EPSS system voltage transients, including EDG load sequencing. The low voltage regulating transformer also provides a regulated power source that is used for the Class 1E uninterruptible power supply (EUPS) system inverter static switch bypass source. The low voltage regulating transformers are load tested to their rated power output while verifying the nominal output voltage listed in Table 8.3-1.

MCCs can contain single-phase and three-phase dry type distribution transformers that provide power to panelboards as necessary for low voltage loads.

The EPSS provides power to certain non-safety-related equipment connected to the EPSS buses. Isolation of non-safety-related components to prevent Class 1E system degradation is in accordance with IEEE Std 308-2001 (Reference 3) and described in Section 8.3.1.1.9.

Refer to Section 14.2 for the initial plant startup test program. The initial test program verifies:

- Independence between redundant Class 1E sources and their load groups.
- Proper installation of components.
- Connections are correct and the circuits are continuous.
- Redundant components can be tested independently of each other.
- EPSS loads can operate on the preferred power supply.

EDG preoperational testing is described in Section 8.3.1.1.5.

The EPSS voltage, frequency, and waveform variations, including the effects of harmonic distortion, do not degrade safety-related component performance below an acceptable level as specified in Reference 3. This is accomplished by designing to minimize the harmonics that large non-linear loads, such as battery chargers, inject into the EPSS buses.

The EPSS controls and indications are described in Section 8.3.1.1.4.

8.3.1.1.2 Normal Power Supply System

The NPSS receives offsite power from the station switchyard and distributes it at the required voltage to the non-safety-related loads. The NPSS is separate and independent of the EPSS distribution system, as shown in Figure 8.3-3.

Offsite power is provided to the NPSS via two normal auxiliary transformers (NAT) BBT01 and BBT02, each powered from the switchyard via a separate overhead line. The NATs are three-phase, three-winding, oil-immersed power transformers with two identically rated 13.8 kV secondary windings. Each transformer is provided with two on-load tap changers to maintain the NPSS distribution system voltages during normal grid voltage fluctuations. The normal NPSS alignment has each NAT powering two of the four NPSS trains. In the event of a NAT failure, the affected trains are fast-transferred to the other functioning NAT with minimum voltage decay and frequency difference to limit motor torque during the transfer. The NPSS major distribution switchgear and nominal bus voltages are shown in Table 8.3-3—Normal Power Supply System Switchgear and Load Center Numbering and Nominal Voltage.

The NPSS is configured in four trains, supplying the Turbine Island (TI) plant loads, reactor coolant pump (RCP) buses in the Safeguards Buildings, auxiliary loads in the Radioactive Waste Processing Building (RWB), Nuclear Auxiliary Building (NAB) and Cooling Tower Structure area. The NATs are normally aligned to the NPSS buses so that in the event of a NAT failure, the affected buses are fast-transferred to the other NAT. The arrangement and sizing of the NATs permits all four NPSS trains to be powered from each NAT, allowing one NAT to be taken out of service.

Class 1E 13.8 kV switchgear 31BDE, 32BDE, 33BDE, and 34BDE provide power to the four RCPs. Each switchgear is located in its respective Safeguards Building in the Nuclear Island (NI). The RCP supply buses are supplied from non-Class 1E bus 31BBC, 32BBC, 33BBC and 34BBC respectively. Each RCP is powered from a different train.

The 13.8 kV switchgear 31BDE, 32BDE, 33BDE, and 34BDE incoming feeder breakers and the RCP circuit breakers are Class 1E components due to the safety-related RCP trip function. Each RCP circuit breaker trip is initiated from the protection system (PS) of the same division. The RCP circuit breaker and the bus supply breaker trips are generated from different PS divisions to satisfy RCP trip function single failure criteria.

Two SBODGs provide power to NPSS switchgear 31BBH and 32BBH as shown on Figure 8.3-3 during a LOOP event. SBODG start logic and operation is described in Section 8.4. In addition to providing an AAC source for SBO mitigation, the SBODGs supply NPSS buses to provide power to important non-safety-related loads, including the non-Class 1E uninterruptible power supply system (NUPS) and 12 hour uninterruptible power supply system (12UPS) battery chargers.

Certain NPSS MCCs in the Safeguards Buildings have the capability to be supplied from an alternate train to maintain power to important non-safety-related loads, including plant lighting, during maintenance activities. The NPSS control power is described in Section 8.3.1.1.4.

8.3.1.1.3 Electric Circuit Protection and Coordination

Electric circuit protection device setpoints are selected and coordinated so that the protective device nearest the fault will operate to isolate a fault. Consequently, electrical faults are localized to the smallest possible area without causing interruption or damage to other areas of the system. Protective devices are selected and sized, and setpoints are determined to maximize personnel safety and equipment operability, serviceability and protection. Coordination studies are conducted in accordance with IEEE Std 242-2001 (Reference 4) to verify the protection feature coordination capability to limit the loss of equipment due to postulated fault conditions.

The inter-divisional alternate feeds have a protection and coordination scheme to provide protection so that a fault on one division does not degrade the other division below an acceptable level. The alternate feed circuit protection scheme uses circuit breakers so that a malfunction of the components performing the alternate feed function or a malfunction of the components being alternately fed does not result in unacceptable influences in the division that supplies the power.

The numbers in parenthesis for the types of protective devices described for medium voltage (MV) and low voltage switchgear buses, MCCs, motors and transformers refer to the IEEE relay device number.

Bus Protection - 13.8 kV and 6.9 kV

These protective devices and actions are provided for station 13.8 kV and 6.9 kV switchgear:

Incoming source breakers have instantaneous overcurrent (50), inverse time overcurrent (51), and ground fault protection (51G) that trip and lockout the affected bus source breakers.

Undervoltage and Degraded Voltage Protection

The EPSS bus undervoltage and degraded voltage monitoring and protection schemes are designed in accordance with IEEE Std 741-1997 (Reference 5) and BTP 8-6 (Reference 6). The undervoltage and degraded voltage actions are independent of the redundant buses.

The EPSS undervoltage scheme is used to detect a loss of voltage or degraded voltage on the individual Class 1E 6.9 kV buses 31BDA, 32BDA, 33BDA and 34BDA. At each bus, all three phases are monitored to develop respective voltage signals that are sent to the I&C PS. The PS uses a two-out-of-three logic (which prevents a fault in a single sensing circuit from initiating the system or preventing its operation) to initiate protection features. Specific undervoltage and degraded voltage protection attributes are as follows:

- Once the loss of voltage setpoint is reached and a time delay is satisfied, the PS initiates a signal to separate the respective division switchgear from the preferred power supply and initiates an EDG start signal and subsequent connection to the respective switchgear. The undervoltage setpoint and time delay setting in the initiation signal permits ride-through of momentary voltage transients to prevent unnecessary separation of the offsite power supply and EDG starts.

- Once the degraded voltage setpoint is reached, two time delays are started in the PS. The first time delay is sufficient to allow bus voltage to recover from the largest motor starting inrush current and to allow a fault to clear. If the degraded voltage condition exists at the end of the first time delay, an alarm will alert the operator to the condition so that corrective action can be taken. The second time delay is sufficient to allow bus voltage to be restored by the EAT on-load tap changer. If a safety injection (SI) signal is received following the first time delay, the PS initiates a signal to separate the Class 1E switchgear from the preferred power source and start the respective division EDG. If the degraded voltage condition still exists at the completion of the second time delay, the PS separates the switchgear from the preferred power source and the respective division EDG is started and connected to the switchgear regardless of SI signal condition. Load shedding is described in Section 8.3.1.1.5. Sequencing of loads onto the EPSS following a loss of voltage is shown in Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads, Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads, Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads, and Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads for each EPSS division.

- An alarm is initiated for a degraded voltage condition related to bus high voltage.
- The EPSS undervoltage and degraded voltage protection is periodically tested to verify operation per the surveillance requirements detailed in Chapter 16. PS testing capability is described in Section 7.3.2.3.6.

The NPSS undervoltage scheme is used to detect a loss of voltage on the individual non-Class 1E 13.8 kV buses 31BBA, 32BBA, 33BBA, and 34BBA. At each bus, all three phases are monitored to develop respective voltage signals. Voltage on NAT secondary windings is also monitored to verify there is an adequate transfer source available. Two-out-of-three logic (which prevents a single phase fault from initiating the system or preventing its operation) is used to initiate protection features as follows:

- Once the loss of voltage setpoint is reached and a time delay is satisfied, the respective bus load feeder breakers are tripped. The NAT secondary winding voltage monitoring verifies there is voltage on the NAT secondary and initiates a transfer of the bus to the alternate source. The undervoltage setpoint and time delay setting permits ride-through of momentary voltage transients to prevent unnecessary bus transfers.
- An alarm is initiated for a degraded voltage condition related to high voltages.

Load Center Protection – 480 Vac

Incoming source breakers have inverse time overcurrent (51) and ground fault protection (51G) that trip and lockout the affected source breaker.

Each motor feeder breaker in the 480 Vac load center is equipped with a trip unit that has long time (51), instantaneous (50), ground fault (51G) detection and tripping features.

Circuit breakers feeding MCCs and other non-motor loads have as a minimum long time, short time and ground fault tripping features.

Each load center has an undervoltage relay which will initiate an alarm in the MCR upon loss of bus voltage.

Motor Control Center Protection – 480 Vac

The MCC feeders to low voltage motors have either motor circuit protectors or molded case circuit breakers.

MCC feeders to non-motor loads have thermal magnetic molded case circuit breakers with instantaneous trip elements to protect for overload and short circuit conditions.

Motor Protection – Medium Voltage

The MV motors are protected by a circuit breaker which is equipped with a motor protection relay that provides protection against phase, ground faults and other abnormal operating conditions, such as load imbalance and locked rotor currents. Examples of conditions for which the protective relays may provide protection are as follows. The conditions are not all inclusive.

- Instantaneous phase overcurrent (50).
- Time overcurrent or locked rotor protection (51).
- Thermal overload (49).
- Ground overcurrent (50G or 51N).
- Phase current unbalance (46).
- Current Differential (87).

Specific motor protection selection is based upon individual motor functional requirements.

Unless otherwise indicated, MV motors which operate continuously during normal plant operation are designed for Class B temperature rises and provided with Class F insulation systems.

Transformer Protection

Dry-type transformers have protective devices installed on both the primary and secondary sides. Protective devices may include transformer differential (87T), transformer ground fault (51G), instantaneous overcurrent (50) and inverse time overcurrent (51).

8.3.1.1.4 Onsite AC Power System Controls and Instrumentation

The onsite AC power system is provided with comprehensive monitoring and control features to maintain maximum reliability and availability of the safety-related components. Location of indicators and control features are in accordance with Reference 3. The EPSS switchgear, load center voltage and incoming line current are displayed in the MCR, the remote shutdown station (RSS) and locally. Bus voltage is indicated in the MCR and RSS for MCCs that are supplied by voltage regulating transformers or inverters. Circuit breaker status for safety-related components is indicated in the MCR, RSS and locally as required by the system.

These controls and indications are provided in the MCR and RSS:

- EDG output breaker – manual control from the MCR and RSS. Both of these locations are capable of manually synchronizing the EDG to the offsite power. Circuit breaker position is indicated in the MCR, RSS and locally at the switchgear. Output breaker automatic control is described in Section 8.3.1.1.5. Output breakers are interlocked to prevent inadvertent paralleling of two or more EDGs.

- Offsite power 31BDA, 32BDA, 33BDA and 34BDA supply circuit breakers – manual control from the MCR and the RSS. Circuit breaker position is indicated in the MCR, RSS and locally at the switchgear. A synchronizing circuit is used with the offsite circuit breakers to allow restoring offsite power to the EPSS when the EDG is supplying the EPSS buses. The manual synchronization is performed in the MCR. Automatic transfer of offsite power is as described in Section 8.3.1.1.1.

- Distribution transformer feeder circuit breaker – manual control from the MCR and the RSS. Circuit breaker position is indicated in the MCR, RSS and locally at the switchgear.

- SBODG output breaker – manual control from the MCR and RSS. Circuit breaker position is indicated in the MCR, RSS, local diesel control panel and locally at the switchgear.

- Individual system loads – the individual loads are controlled by the requirements of the supplied systems. Automatic or manual operation of the individual loads is governed by the requirements associated with the particular system.

- Medium voltage motors rated at 500 horsepower or greater are furnished with embedded temperature detectors.

Status of the electrical distribution system is displayed in the MCR, including alternate feed lineup.

EPSS switchgear and load center DC control power is supplied by the EUPS of the same division. The RCP circuit breaker and respective switchgear feeder breaker are also supplied from the EUPS. The RCP circuit breaker control power is supplied by the EUPS division located in the same Safeguards Building as the circuit breaker. NPSS BDE switchgear feeder breaker control power is from an adjacent division EUPS to satisfy RCP trip function single failure criteria. Indication and control of the RCP breakers and BDE switchgear feeder breakers is provided in the MCR and RSS. The NUPS provides the control power for the NPSS switchgear and load centers in the TI with the exception of 31BBH, 32BBH, 31BFX and 32BFX which are supplied by

12UPS. The 250 Vdc control power is used for circuit breaker close and trip devices and spring charging motors.

The DC control power that is used to open and close contactors on the MCCs is generated by 480 Vac to 24 Vdc power supplies that are in each MCC vertical section. Each power supply provides the control power for the motor starters in the associated vertical section. The 24 Vdc power supply provides control power to ride through voltage transients caused by faults and motor starts.

8.3.1.1.5 Standby AC Emergency Diesel Generators

Four safety-related EDGs provide standby AC power to the station safety-related and select non-safety-related loads in the event of offsite power loss or degradation. Each EDG is assigned to its respective EPSS division.

The four EDGs are located in two Emergency Power Generating Buildings (EPGB). Each EPGB is separated into two sections, one for each EDG. Divisions 1 and 2 are located in the same EPGB and divisions 3 and 4 are located in the other EPGB. The two EPGBs are located on opposite sides of the Safeguard Buildings, providing physical separation and protection against external hazards. Each EPGB is a Seismic Category I structure, built to provide physical protection for the EDGs. Within each structure, the two EDGs and their support systems are physically separated by a reinforced concrete wall to protect against internal hazards.

Diesel Engines and Subsystems

Each EDG is provided with support subsystems for reliable starting, loading and operation to satisfy safety-related functions during design basis accidents. Safety-related portions of each subsystem are designed and constructed in accordance with Quality Group C and Seismic Category I. Quality Group classifications are described in Section 3.2.2. Additionally, safety-related portions of each subsystem are also designed and tested to ASME Code Section III requirements. EDG support subsystems include:

- The diesel generator starting air system provides fast start capability for the diesel engine as described in Section 9.5.6.
- The diesel generator cooling water system dissipates heat from the crankcase, cylinder heads, turbochargers, governor oil, generator bearings, combustion charge air and lubricating oil as described in Section 9.5.5.
- The diesel generator air intake and exhaust system is described in Section 9.5.8.
- The diesel generator fuel oil storage and transfer system is described in Section 9.5.4.

- The diesel generator lubricating oil system stores and supplies clean lubricating oil to the engine bearings, crankshaft, turbocharger and other moving parts of the engine as described in Section 9.5.7.
- Ambient temperature conditions are maintained in each EDG building by the EPGB ventilation system. Each division has its own independent heating, ventilation and air conditioning (HVAC) system and is not connected to other divisions. The HVAC system provides a suitable environment for EDG operation as described in Section 9.4.9.

Generator

Each of the four EDGs is a Class 1E, Seismic Category I, AC synchronous, brushless three-phase generator that is a self-ventilated, air cooled, totally enclosed unit designed to provide a nominal output voltage and frequency of 6.9 kV and 60 Hz. Each EDG also includes (phase and neutral) instrument transformers, protective relaying, excitation system with digital voltage regulator, controls and instrumentation for operation. The generator is designed to the standards of NEMA MG 1-2006 (Reference 7).

The generator ratings are consistent with the load requirements identified in Table 8.3-4, Table 8.3-5, Table 8.3-6 and Table 8.3-7. The voltage regulator and excitation system provide response and operating characteristics to meet RG 1.9 for load step changes and full load operation. The generator output voltage setpoint automatically returns to rated voltage when the EDG is shutdown or upon switchover to emergency mode.

Protection – Emergency Diesel Generator

The diesel engine protection functions shut down the diesel engine and trip the diesel generator breaker when actuated. The active trips in emergency mode are determined by regulatory guidance in addition to those required by the manufacturer, such as low lube oil pressure and high cooling water temperature. The EDG starts in emergency mode if voltage is lost to the assigned EPSS bus or on a PS SI signal. All manufacturer-specified emergency mode trip functions that are active during emergency mode will have a coincident logic so that a minimum two-out-of-three trip signals are required to initiate a shutdown. A time-delayed essential service water low pressure signal which uses three sensors for two-out-of-three logic is active during all EDG operating modes. The low essential service water pressure trip is bypassed during start-up for approximately 120 seconds. Other protection functions are only active during periodic tests.

Engine Protection Features Active during all modes:

- Electrical overspeed.

- Engine mechanical overspeed.
- Low lube oil pressure.
- High jacket water temperature.
- Low essential service water pressure (time delayed).

Engine Protection Features Active during Test mode:

- Low expansion tank water level.
- Crankcase pressure.
- High lubrication oil temperature.
- Low lubrication oil level.
- Low fuel oil pressure.
- Governor failure.

Generator Protection Features Active during all modes:

- Generator differential current.

Generator Protection Features Active during Test mode:

- Time over current.
- High bearing temperature.
- High winding temperature.
- Rotating diode failure.
- Excitation fault (over and under excitation).
- Reverse power during parallel (with the grid) operation.
- Generator field ground.

Each protection device listed initiates an annunciator in the MCR, RSS and locally. Alarms and instrumentation are installed in the MCR and locally so that EDG monitoring, trending, and inservice testing programs can be accomplished. The alarm system is equipped with a first-out feature that indicates which EDG trip was actuated first, along with indication of other trips that are received. Alarms are indicated locally on an alarm display on the EDG local panel. Table 8.3-8—Emergency Diesel Generator Indications and Alarms, provides a list of local and remote alarms and indications for the EDGs.

The EDG bypass or deliberately induced inoperable conditions are automatically alarmed in the MCR. The bypass and inoperable status indicators provide operators with accurate information about the status of each EDG. Disabling or bypass indicators are separated from non-disabling indicators in accordance with BTP 8-7 (Reference 28), which allows operators to clearly determine the ability of the respective EDG to respond to emergency demand.

Performance – Emergency Diesel Generators

During normal plant operation, the EDGs remain in standby mode with the engines pre-lubricated and cooling water pre-heated for the EDG to be ready to start and accept load. The I&C PS EDG start signal is based on EPSS bus voltage, as described in Section 8.3.1.1.3, or an SI signal.

The EDGs are designed to start and accelerate to rated speed, then start and carry the loads listed on Table 8.3-4, Table 8.3-5, Table 8.3-6 and Table 8.3-7 in the sequence indicated. The EDG capacity can supply the power requirement of the safety-related and non-safety-related loads assigned to the respective EDG bus, and loads on the division that could be aligned to the EDG via the EPSS alternate feeds. Motor minimum torque values are not less than the criteria specified in Reference 7. The pump torque requirements through the acceleration period are less than the motor starting torque provided while the motor is at minimum specified voltage.

If a LOOP occurs during EDG testing, the EPSS bus is separated from the offsite power supply. The other redundant divisional EPSS switchgear separate from the EATs due to their individual bus monitoring circuits and undervoltage protection. The remaining EDGs start and supply power to the respective EPSS divisions.

Once an EDG start signal is initiated, the EDG automatically starts and accelerates to rated speed, adjusts for proper speed and voltage, and is in a ready-to-load condition. The start-up time of an unloaded diesel unit, from the emergency start signal to nominal speed, rated generator frequency and voltage, is less than or equal to 15 seconds. When the EDG output breaker permissive conditions of EDG speed, voltage and respective BDA switchgear normal and alternate source breaker position being open are met, the EDG output breaker is closed. Closure of the EDG output circuit breaker and load sequencing is performed by the PS. The PS controls EDG load sequencing by controlling the placement of loads onto the respective EPSS buses at programmed time intervals. Load shedding is accomplished by individually tripping large horsepower motors that were operating prior to the undervoltage condition. Motors that were shed are then restarted in the appropriate sequence or available for manual start as directed by operating procedures. The PS operation to control EDG load sequencing is described in Section 7.3.1.2.12. The functional logic used to generate an EDG actuation order is shown in Figure 7.3-23.

The voltage regulator control circuit regulates the exciter current to maintain the generator voltage greater than 75 percent of the nominal 6.9 kV during the load sequence. The governor limits the speed deviation during transient operation so that frequency does not drop to less than 95 percent of nominal as loads are applied. Voltage and frequency are restored to within ten percent and two percent of nominal, respectively within 60 percent of each load sequence step in accordance with RG 1.9.

Synchronization circuitry and indicators allow synchronization of the EDG to the offsite source following restoration of offsite power. The synchronization capability allows for shifting loads back to the preferred power source and restoring the EPSS supply to the EAT. The EDGs are then shut down and returned to a standby condition.

When paralleling the EDG with the offsite power source during surveillance testing or other conditions, a digital synchronization system and synchronization check relay is used to prevent damage to the generator from inadvertent paralleling out of phase. The system has an automatic mode and a manual mode. During automatic mode, the EDG synchronization to the grid is achieved without any additional operator manipulations. In both manual and automatic modes, a synchronization check relay allows the EDG output breaker or preferred power supply source breaker to close only after the operator has established proper paralleling conditions. Controls and indications exist in the MCR and RSS to start and stop the EDG, and establish parallel conditions by adjusting EDG speed and output voltage. If operating in parallel with the offsite power supply, an SI signal will cause the EDG output breaker to open, disconnecting the EDG from the EPSS. The EDG will remain at rated speed and voltage.

Testing – Emergency Diesel Generators

Periodic testing of each EDG is performed independently of the other EDG units. During periodic testing (except testing that demonstrates diesel generator system response under simulated design basis events (DBE)), the complete generator protection is available to prevent equipment damage to the engine or generator if a component malfunction occurs.

Preoperational site acceptance testing is conducted to demonstrate the ability of the EDG to perform its intended function. Testing is consistent with the test described in RG 1.9, Table 1 for the preoperational test program and conducted in accordance with IEEE Std 387-1995 (Reference 8) for site acceptance testing. Testing includes a minimum of 25 valid start and load tests without failure on each EDG to demonstrate reliability. Diesel generator designs not previously used as stand-by power sources for nuclear power generating stations will be qualified and type-tested in accordance with the guidance of Reference 8.

The load acceptance test demonstrates the ability of the load sequencer to properly sequence loads listed in Table 8.3-4, Table 8.3-5, Table 8.3-6 and Table 8.3-7 onto the EDGs within the specified time, while the EDG maintains and restores voltage and frequency within specifications.

Load tests are performed to verify an EDG output of 9500 kW or greater while maintaining steady-state frequency at 60 Hz ± 2 percent and steady-state output voltage between 6555 VAC and 7260 VAC. The EDG continuous rating is sufficient to supply the safety-related and non-safety-related loads assigned to each EDG per Table 8.3-4, Table 8.3-5, Table 8.3-6 and Table 8.3-7 for the respective EDG when derated for ambient air temperatures and essential service water temperatures. Additionally, periodic load tests are performed at a load of 105-110 percent to demonstrate capability to operate at the short term rating of 110 percent for a period of two hours.

Emergency Diesel Generator Reliability Program

EDG minimum reliability targets are described in Section 8.4.2.6.1. A COL applicant that references the U.S. EPR design certification will monitor and maintain EDG reliability during plant operations to verify the selected reliability level target is being achieved as intended by RG 1.155. Surveillance testing of the EDGs is in accordance with the availability testing described in RG 1.9, and is detailed in Chapter 16.

The EDGs are procured from a diesel generator manufacturer which meets the requirements of RG 1.9 and considers the recommendations of NUREG/CR-0660 (Reference 9). Specific included design recommendations of Reference 9 are:

- The starting air system air dryer minimizes moisture, as described in Section 9.5.6.2.2.
- The lube oil preheat system performs a non-safety-related function to continuously maintain the lube oil at a set temperature using a preheating unit when the diesel generator is in standby. A motor-driven pump circulates the lube oil through the engine and the standby heater unit to maintain the engine in a prelubricated condition to reduce wear during engine starts.
- The EPGB ventilation system includes particulate air filters in addition to maintaining the building at a positive pressure which limits dust and other contaminates entering the building.
- Combustion air and ventilation system intakes are a minimum of 20 ft above adjacent ground elevation. Diesel engine exhaust gases are released from the exhaust stack on the building roof on the opposite side of the building from the ventilation and combustion air intakes that are located on the building side.

- Fuel oil storage tanks and day tanks permit the removal of moisture and provide gravity flow from the day tank to the engine driven fuel oil pump, as described in Section 9.5.4.

- Local instrument panels in the diesel rooms at the engine are isolated from engine vibration.

Additional EDG reliability improvement recommendations related to limiting extended no-load operations, training of personnel responsible for maintenance and availability, post-maintenance test and inspection considerations prior to return to service and the maintenance program considerations associated with repetitive component failures, will be incorporated by the COL applicant.

8.3.1.1.6 Station Blackout Diesel Generators

Two station blackout diesel generators (SBODG) are provided for station blackout (SBO) conditions and are described in Section 8.4.

8.3.1.1.7 Electrical Equipment Layout

The electrical distribution system components distribute power to safety-related and non-safety-related loads in the Reactor Building (RB), Safeguards Buildings (SB), EPGBs, Essential Service Water Pump Buildings (ESWPB), Turbine Island (TI), Fuel Building (FB), Nuclear Auxiliary Building (NAB), Access Building (ACB), Circulating Water Pump Building (CWPB) and Radioactive Waste Processing Building (RWB).

The MSU and the auxiliary transformers are installed outdoors in the transformer yard near the Turbine Building.

EPSS 6.9 kV switchgear, 480 Vac load centers, MCCs and distribution transformers, are located in Seismic Category I Buildings electrical switchgear rooms. The electrical equipment is located in the SB, ESWPB or EPGB associated with its division.

The majority of NPSS 13.8 kV switchgear, 480 Vac load centers, MCCs and distribution transformers are located in the TI switchgear building. The NPSS 13.8 kV switchgear; 31BDE, 32BDE, 33BDE, and 34BDE, that provide power to the RCPs are located in their respective SB as well as the 480 Vac load center and MCCs that support non-safety-related equipment in the NI.

The onsite AC distribution switchgear, load center and MCC locations are provided in Table 8.3-2 and Table 8.3-3 for the EPSS and NPSS components respectively. General arrangement drawings showing locations of Class 1E equipment are located in Section 3.8.4.

8.3.1.1.8 Raceway and Cable Routing

Station routing of Class 1E and non-Class 1E raceways, cable trays and cables has been designed to meet independence, separation criteria, routing, fire protection and identification requirements of IEEE Std 384-1992 (Reference 10) as endorsed by RG 1.75.

Load Group Segregation

There are four safety-related load groups consisting of transformers, switchgear, load centers, MCCs and EDGs. Each group is separated to the extent practical by placing the AC power distribution equipment in the divisional SB, ESWPB and EPGB.

Cable Derating

Power cable insulation is rated for a continuous temperature of 194°F. Cable base ampacity is selected from the applicable tables of IEEE Std 835-1994(R2006) (Reference 11). Cables are derated in accordance with Reference 11 to account for ambient temperature. Further derating is applied where necessary for installation methods including routing through fire barriers.

Cable Tray Fill

Cables 4/0 American Wire Gauge (AWG) or greater or rated over 2001 volts are installed in a single layer where the diameter sum does not exceed the cable tray width.

The cross-sectional area sum of cables smaller than 4/0 AWG does not exceed the maximum allowable cable fill area as indicated in NFPA 70 (Reference 12).

Cable trays that contain 4/0 AWG or larger cables with cables smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables smaller than 4/0 AWG shall not exceed the maximum allowable fill area per Reference 12, and the 4/0 AWG and larger cables shall be installed in a single layer with no other cables placed on them.

Raceway and Cable Routing

Cable trays are arranged physically from top to bottom in accordance with the function and voltage class of the cables:

- 13.8 kV power cables.
- 6.9 kV power cables.
- Low voltage AC and DC power cables (480 Vac, 120 Vac, 250 Vdc, and 24 Vdc).
- Control cables (120 Vac, 250 Vdc, and 24 Vdc).

- Cables for low level analog and digital signals.

Power cables are installed in duct banks or raceways designed to provide a high level of protection against industrial hazards, long-term degradation, and other potential risks such as fire, missiles, pipe failure, water spray, or earthquakes.

Manholes for duct bank access have recesses for temporary sump pumps for water draining. Manholes located below the ground water line have a permanent sump pump design. Such areas are sloped so as to provide water drainage. Examples of cables that use underground duct banks include cables for the ESWPB, SBODG cables, offsite power cables from the EATs to the SB, and cables to the EPGB. Outdoor terminations are located in a NEMA 4X or better enclosure. Capability is provided to perform periodic test to detect insulation degradation in underground cables whether in a duct bank, directly buried or in a conduit, as described in NRC Generic Letter 2007-01 (Reference 13). One or more of the following testing methods can be used: partial discharge testing, time domain reflectometry, dissipation factor testing or very low frequency AC testing. A COL applicant that references the U.S. EPR design certification will describe inspection, testing and monitoring programs to detect the degradation of inaccessible or underground power cables that support EDGs, offsite power, ESW and other systems that are within the scope of 10 CFR 50.65.

Cable splices are not allowed in raceways or cable trays.

Distribution system switchgear are arranged to permit short cable connections between the switchgear and the loads in the lower part of the building via the cable floors, vertical cable risers and cable trays in the system rooms. The cables to the RB are routed via cable floors, the annulus, electrical containment penetrations, and cable trays in the RB system rooms.

The MV cables routed between divisions that provide the alternate feeds are routed in embedded conduit or concrete cable vault.

Cables originating in one division and routed to equipment in different divisions, or passing through a different division of the Safeguards Building are routed in the annulus. The annulus is divided into two zones for cable routing purposes. The lower zone is for cables that go to containment loads through electrical penetration assemblies. Cables to containment loads are routed to the connection boxes on both sides of the containment penetration. The upper zone is for routing non-Class 1E cables circumferentially to other buildings such as adjacent Safeguard Buildings, Fuel Building and Nuclear Auxiliary Building. Where cables transition from the Safeguards Building, Fuel Building or Nuclear Auxiliary Building to the annulus, the cables are routed from the cable rooms via air tight, fire rated barrier penetrations. Cables are routed horizontally in circumferential direction with the trays stacked vertically in the annulus.

The EDGs are located in the EPGBs on either side of the SBs, while the SBODGs are located in the TI Switchgear Building. The power cables from these sources are routed separately from each other and the preferred power source from the station switchyard (in underground duct banks) to avoid common cause failure between the various sources. The EPGBs and the TI Switchgear Building are connected with the SBs via underground duct banks.

The routing of power circuits from the EATs to the input terminals of the Class 1E buses, along with instrumentation and control circuits to the transformers, minimize to the extent practicable the likelihood of simultaneous failure of both offsite power circuits under operating and postulated accident conditions.

Cable trays and raceways containing Class 1E cables are supported by Seismic Category I supports. Cable trays and raceways containing non-Class 1E cables in Seismic Category I structures are supported by Seismic Category II supports.

8.3.1.1.9 Independence of Redundant Systems

EPSS Switchgear, Load Centers and Motor Control Centers

Redundant Class 1E switchgear, load centers and MCCs are located in their respective division SB, ESWPB or EPGB. High energy lines are not routed through the dedicated electrical rooms which contain the EPSS switchgear, load centers or MCCs. The Seismic Category I structures provide physical protection and separation between redundant Class 1E equipment. Therefore, the capability to perform safety-related functions is maintained following the physical effects of an internal hazard (for example, a fire). Furthermore, the occurrence of an internal hazard will not result in a common mode failure of the redundant equipment except during alternate feed. Maintaining safety-related function when an alternate feed is installed is described in Section 8.3.1.2.4.

Standby Power Sources

EDG independence and redundancy is described in Section 8.3.1.1.5.

Batteries, Battery Chargers, and Inverters

Section 8.3.2.1.5 describes EUPS battery, battery charger and inverter independence and redundancy.

Cabling Independence and Separation

Cabling separation is in accordance with Reference 10 as supplemented by RG 1.75. The cabling associated with redundant safety-related circuits is arranged so that a single failure cannot cause malfunctions in multiple divisions that prevent completion of safety-related functions. Separation distances described in this section are for circuits in raceways between redundant Class 1E divisions and between Class 1E and non-Class 1E circuits. Raceway configurations related to open-to-open, enclosed-to-enclosed, and enclosed-to-open are in accordance with Reference 10.

The MCR and RSS are controlled as non-hazard areas per the guidance in Reference 10. Separation distances for circuits in raceways between redundant Class 1E divisions and between Class 1E and non-Class 1E circuits in these areas is one inch horizontally and three inches vertically for open-to-open configurations. The vertical separation may be reduced to one inch if the enclosed raceway is below an open raceway. Where circuits are routed in an enclosed-to-enclosed configuration, the minimum separation is one inch horizontally and vertically. Where these separation distances cannot be maintained, barriers are provided between circuits requiring separation.

Cable floors are located beneath the switchgear and I&C rooms in each division of the Safeguard Buildings and beneath the MCR in Safeguards Buildings 2 and 3. The cable floors are controlled as limited hazard areas. The primary difference between a limited hazard area and a non-hazard area is that power circuits and equipment are restricted in the non-hazard area. Where these separation distances cannot be maintained, barriers are provided between circuits requiring separation.

- Cables larger than 2/0 AWG in open-to-open and enclosed-to-open configurations are separated by three feet horizontally and five feet vertically.
- Cables less than or equal to 2/0 AWG in open-to-open and enclosed-to-open configurations are separated by six inches horizontally and 12 inches vertically.
- Minimum separation may be reduced to one inch horizontally and three inches vertically if the circuits in the open configuration in an enclosed-to-open configuration are limited to control and instrumentation cables.
- Raceways containing only control and instrumentation cables in open-to-open and enclosed-to-open configurations are separated by one inch horizontally and three inches vertically.
- The vertical separation may be reduced to one inch if the enclosed raceway is below and open raceway.
- All enclosed-to-enclosed raceway configurations are separated by one inch horizontally and vertically.

Class 1E cables that are routed in areas containing pipe failure, missile or fire hazards are assigned to the same division as the piping or missile hazard. If the piping failure or effect of the missile source requires protective action, or the hazard is not qualified for DBEs, Class 1E cables and raceways are not located in the hazard area, except for those cables that terminate at devices or loads within the area. Protection of the Class

1E cables routed in hazard areas is provided by separation distance consistent with limited hazard areas or barriers.

Main control switchboards containing redundant Class 1E circuits maintain a minimum separation of one inch horizontally and six inches vertically between redundant circuits and between Class 1E circuits and non-Class 1E circuits. The control switchboards are made of flame-retardant material. Where separation distances are not maintained, barriers are installed between circuits requiring separation.

Circuits that do not meet the minimum separation distances and where barrier installation is not practical, may have lesser separation distances established by analysis of the cable installation. This analysis is based on tests performed to determine the flame retardant characteristics of the proposed cable installation, considering features such as insulation and jacket materials, raceway fill, raceway types, and arrangements in accordance with Reference 10.

Non-Class 1E circuits are electrically isolated from Class 1E circuits and associated circuits by the use of isolation devices, shielding, and wiring techniques or separation distance in accordance with Reference 10. The isolation and separation of the non-Class 1E components from the Class 1E system prevents degradation of the Class 1E system to an unacceptable level in accordance with Reference 3. Circuit breakers or fuses that are automatically opened by fault current meet the guidelines provided in RG 1.75. Periodic testing of circuit breakers (visual inspection of fuses and fuse holders) used as isolation devices are performed during every refueling to demonstrate that the overall coordination scheme under multiple faults of non-safety-related loads remains within the limits specified in the design criteria. Non-Class 1E circuits that are not analyzed and do not meet the minimum separation distances or have barriers providing separation between Class 1E circuits are treated as Class 1E.

Fiber optic cable routed throughout the plant may be placed in the same raceway as low-level analog and communication cables. Fiber optic cable routing is limited to non-hazard and limited hazard areas to the extent practical. Class 1E fiber optic cable routed through a hazard area, has physical protection provided. Class 1E fiber optic cable passing through another division is in a fire-protected enclosure to prevent a fire in one division from damaging fiber optic cable of another division. Damage to fiber optic cable does not result in spurious equipment actuation, but the loss of the component function.

A qualified cable routing program is used to plan cable routing throughout the plant. Field installation information, including as-installed cable lengths and proper routing verification is entered into the cable routing program. Proper cable installation is demonstrated using reports generated by the cable routing program to show that physical separation, physical protection, identification, separation of non-Class 1E and

Class 1E cables, separation of redundant Class 1E cables, and terminations meet acceptance criteria.

8.3.1.1.10 Containment Electrical Penetrations

Redundant Class 1E containment electrical penetration assemblies are physically separated to maintain Class 1E circuits and equipment independence so that safety-related functions required during and following DBEs can be accomplished. The redundant containment penetration assemblies are located in four quadrants of the Reactor Building. The minimum separation between redundant electrical penetration assemblies containing Class 1E or associated cables and non-Class 1E cables is provided in accordance with Reference 10, as endorsed by RG 1.75. Containment electrical penetration assemblies that contain Class 1E circuits contain only Class 1E circuits.

Redundant, series connected, overcurrent interrupting devices are provided for electrical circuits going through containment electrical penetration assemblies where the maximum available fault current is greater than the continuous rating of the penetration assembly. Class 1E protection devices are used for Class 1E circuits that meet this criterion. Overcurrent protection devices are designed, selected and coordinated in accordance with Reference 23. Containment electrical penetration assembly fault current clearing time curves for the current interrupting device are coordinated with the thermal capability curve of the containment electrical penetration assembly. The protective devices are located in separate panels or separated by barriers and are independent so that failure of one will not adversely affect the other. The penetrations will withstand the full range of fault current (minimum to maximum) available at the penetration. Protection devices are capable of being tested, calibrated and inspected.

Circuit breakers used as containment penetration conductor overcurrent protection devices are periodically tested by performing the following periodic testing requirements:

- At least once per 24 months each circuit breaker is verified by performing a calibration of the associated protective relays.
- At least once per 24 months (so that all RCP circuit breakers are demonstrated operational at least once every 72 months) select and functionally test a representative sample of at least 10 percent of circuit breakers of each type. Circuit breakers selected for functional testing are selected on a rotating basis. The functional test consists of injecting a current input at the specified setpoint to each selected circuit breaker and verifying that each circuit breaker functions as designed. For each circuit breaker found inoperable during the functional tests, additional representative samples of at least 10 percent of all the circuit breakers of the inoperable type are also functionally tested until no more failures are found or all circuit breakers of that type have been functionally tested.

The MV cables are routed through penetration assemblies separate from low voltage power and low voltage control cables.

Containment electrical penetration assemblies are Class 1E devices that are classified Seismic Category I in accordance with RG 1.29 to withstand a design basis seismic event without the loss of safety function. Additionally, the penetration assemblies are qualified for a harsh environment, as indicated in Section 3.11.2.1.

8.3.1.1.11 Criteria for Class 1E Motors

Class 1E motor nominal voltages are 6.6 kV for medium voltage motors and 460 Vac for low voltage motors. The nominal bus voltage that provides power to these motors is 6.9 kV for Class 1E distribution system medium voltage switchgear and 480 Vac for low voltage load centers and MCCs. The minimum voltage criteria for Class 1E motors to start and accelerate the connected load for medium voltage motors is 75 percent, low voltage motors is 70 percent, and motor-operated valve actuators is 80 percent. The motor terminal voltage supplied by the EPSS remains above the motor minimum starting voltage criteria during worst case bus loading conditions, which is when the EDG is supplying their respective switchgear while the medium and low voltage motors are being sequenced onto the buses. The Class 1E minimum voltage criteria is met during these loading conditions by maintaining EDG output voltage within the minimum voltage limits provided in RG 1.9 during the loading sequence. MCCs BNB02 and BNB03 receive power from their respective division low voltage regulating transformer 31BNT01, 32BNT01, 33BNT01, or 34BNT01. The transformer voltage recovery characteristics provide the nominal bus voltage during distribution system transients that supports the Class 1E motor minimum voltage criteria.

Load flow and voltage regulation studies will be verified by measurement to demonstrate distribution system capability to provide minimum starting voltage to the Class 1E motors during static and dynamic conditions, as described in Section 8.3.1.3.1.

8.3.1.1.12 Overload Protection for Motor-Operated Safety-Related Valves

Safety-related motor-operated valve overload protective devices are normally bypassed so the motor-operated valves are available to perform their safety-related function as provided in RG 1.106.

Abnormal conditions that would result in the overload tripping are annunciated in the MCR.

The overload protection is temporarily returned to service when the valve motors are undergoing periodic surveillance or maintenance testing.

8.3.1.1.13 Physical Identification of Safety-Related Equipment

Cable trays, conduits, and wireways containing Class 1E cables are color coded for ease of identification. These raceways are marked at each end, at all entrances and exits to rooms, and at intervals not to exceed 15 ft. Cables installed in these raceways are marked to identify their respective division at intervals of approximately five feet. Each cable is marked at each end with its unique identification number. Color codes for specific division is presented in Table 8.3-10—Cable Color Codes.

Class 1E power system components (e.g., switchgear, LCs, MCCs, and distribution panels) are identified by a unique, colored (refer to Table 8.3-10) nameplate that identifies the specific equipment and its division.

8.3.1.1.14 Electrical Heat Tracing

Electrical heat-tracing systems are installed as necessary to provide electrical heating where needed to maintain temperatures above ambient for either freeze protection or system operation. Power for heat-tracing is supplied from the onsite distribution system buses. Where safety-related process and effluent radiological monitoring and sampling systems require heat-trace to perform its function, the heat-tracing is powered from Class 1E distribution system buses and assigned to the appropriate EPSS or EUPS division.

8.3.1.2 Analysis

The EPSS, including the standby power sources, are designed to meet:

- GDC 2, GDC 4, GDC 5, GDC 17, GDC 18, and GDC 50 of 10 CFR 50, Appendix A.
- Applicable sections of 10 CFR 50.34(f).
- Three Mile Island (TMI) action plan requirements of NUREG-0737 (Reference 14).

Conformance with recommendations of RGs as well as IEEE Standards adopted by the RGs is described in this section.

8.3.1.2.1 Compliance with GDC 2

The onsite AC distribution system Class 1E components are located in Seismic Category I structures capable to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without losing their capability to perform safety-related functions. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in Chapter 2. The U.S. EPR design criteria for wind, tornado, flood, and earthquakes are described in Section 3.3, Section 3.4, and Section 3.7, respectively.

8.3.1.2.2 Compliance with GDC 4

Class 1E onsite AC distribution system components are located in Seismic Category I structures, in rooms constructed in such a manner that any internal hazard only affects the respective division. There are no high energy lines routed through the dedicated electrical rooms containing EPSS equipment such as switchgear, LCs, MCCs and distribution transformers. These rooms are also provided conditioned air that maintains ambient environmental conditions within equipment qualifications during normal operations and DBEs. Details of the design and construction of safety-related structures are included in Chapter 3.

The environmental qualification program for electrical equipment provides reasonable assurance that equipment remains operable during and following exposure to harsh environmental conditions as a result of a design basis event. An evaluation of equipment locations will be performed to determine if any electrical equipment will have to be qualified for submerged operation. Environmental qualification is described in Section 3.11. Safety-related electrical equipment located in an environmental harsh or radiation harsh environment that require qualification are listed in Section 3.11, Table 3.11-1—List of Environmentally Qualified Electrical/I&C Equipment.

8.3.1.2.3 Compliance with GDC 5

GDC 5 is satisfied with the U.S. EPR designed as a single-unit station.

8.3.1.2.4 Compliance with GDC 17

Compliance with GDC 17 is accomplished through the design of the onsite power AC distribution system capacity, capability, independence, redundancy, and meeting the application of the single failure criteria.

Offsite power compliance with GDC 17 is described in Section 8.2.2.4.

The four EPSS divisions, including the EDGs, have the independence, redundancy, and testability to perform their safety-related functions in the presence of a single failure.

The EPSS has been designed to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated from the plant, transmission network, or onsite electric power supplies. Meeting GDC 17 is further accomplished through incorporating the following guidance and standards in the onsite AC system design.

Conformance with RG 1.6

The EPSS is designed in accordance with RG 1.6 to provide independence between the redundant standby power sources that supply the safety-related loads.

The EPSS has four divisions, normally powered from the preferred power source, each with an independent and redundant EDG assigned to their respective switchgear 31BDA, 32BDA, 33BDA, and 34BDA. The EPSS divisions combine to make two divisional pairs. Division 1 and 2 constitute the first divisional pair while divisions 3 and 4 constitute the second divisional pair. The EPSS safety-related loads are separated between the divisional pairs and a loss of one divisional pair will not prevent the minimum safety-related functions from being performed.

The four EPSS divisions are normally functionally independent and physically separated from each other. During periods a standby power source is out of service, or other similar maintenance activities, alternate feeds are provided between division 1 and division 2 or between divisions 3 and division 4 as appropriate for the out-of-service EDG. The alternate feed configuration, consistent with separating the safety-related loads between divisional pairs, maintains the plant capability to complete safety-related functions coincident with a single failure.

Alternate feeds have these features to provide independence between divisions:

- When required for maintenance or other operating conditions, the alternate feeds are manually implemented and have no automatic connections between divisions.
- The alternate feed incorporates an engineering design feature that prevents having two different divisional power sources supplying power to the same bus simultaneously. This prevents paralleling two EDGs.
- Alternate feed protection and coordination prevents a fault on one division from degrading the other division below an acceptable level.

Conformance with RG 1.9

The EDG mechanical and electrical design properties for starting and loading, including following light load or no load operation, have been incorporated so that they will start, accelerate to rated speed and properly sequence design loads while maintaining nominal frequency and voltage within limits specified in RG 1.9.

The EDGs continuous load rating has been established utilizing the guidance in RG 1.9; specifically it is greater than the sum of the conservatively estimated connected loads that the EDG will power at any one time. In developing EDG load rating, performance characteristics for motors were calculated based on 90 percent efficiency, and power factors of 85 percent or less. At least ten percent margin exists in each EDG to account for future load growth.

An EDG emergency start signal overrides the engine and generator protection trips that are only effective during non-emergency conditions. The emergency start signal also overrides manual shutdown initiated at the controlling station. When operating in emergency mode, bypassed conditions that would have resulted in an EDG trip are annunciated in the MCR and locally to alert the operators of the abnormal condition.

Each EDG is equipped with controls and indications to startup, shutdown and parallel the generator with the preferred power source from the MCR and RSS. Safety-related EDG components, controls, indications and control panels are classified as Seismic Category I in accordance with RG 1.29. Control power for each EDG is from the EUPS system of the same division. The EDG auxiliary support components, including the starting air system compressors, Emergency Power Generating Building Ventilation system and fuel oil transfer pumps are powered from Class 1E buses from the same EPSS division the EDG serves.

EDG design, performance and testing, including preoperational testing, is described in Section 8.3.1.1.5.

Conformance with RG 1.32

The onsite AC power system has been designed in accordance with Reference 3, as endorsed by RG 1.32 to provide Class 1E power at the required quality which enables the safety-related systems to meet their functional requirements. The EPSS is the Class 1E onsite AC distribution system and the design and preoperational testing is described in Section 8.3.1.1.1.

Conformance with RG 1.53

The EPSS has been designed so that safety-related systems have the necessary electrical power to perform their safety-related function in the presence of a single detectable failure, all failures caused by the single failure, and all failures caused by a DBE per the guidance of Reference 2 as endorsed by RG 1.53. Compliance with the single failure criterion is further described in Section 8.3.1.1.1. The onsite AC distribution system capability to maintain safety-related function in the presence of a single failure is demonstrated in Table 8.3-9—Onsite AC Power System Failure Modes and Effects Analysis.

Alternate feeds as described in Section 8.3.1.1.1 provide the normal and standby source of power to required safety-related systems, safety-related support systems, or components that do not have four 100 percent redundant trains when certain electrical components, including EDGs, are out of service so that their safety-related function during DBEs coincident with a single failure are maintained. Independence and redundancy are maintained in these systems by using these features:

- Alternate feeds are limited to the redundant electrical divisional pairs of 1 and 2, or 3 and 4 which keep the load groups of division 1 and 2 physically separate and electrically independent from the load groups of division 3 and 4.
- At least one redundant train is supplied from division 1 or 2 and the other is supplied from division 3 or 4.

Conformance with RG 1.75

Each EPSS division is located in an independent Seismic Category I SB, ESWPB and EPGB. This arrangement provides physical separation through the use of Seismic Category I structures for the majority of the electrical equipment and circuits. Cable routing, derating, raceway fill, separation, identification of redundant Class 1E circuits and isolation of non-Class 1E circuits from Class 1E circuits is in accordance with Reference 10, as supplemented by RG 1.75.

Cable routing including cable derating and cable tray fill criteria is described in Section 8.3.1.1.8.

Cable independence and separation is described in Section 8.3.1.1.9.

Conformance with RG 1.153

The electrical distribution system design is in accordance with Reference 1, so that safety-related functions are supported by providing independence and separation as described in Section 8.3.1.1.1. Section 7.1 describes the use of Reference 1 instead of IEEE Std 603-1991 (Reference 40) as endorsed by RG 1.153.

Conformance with RG 1.155

SBO conformance with RG 1.155 is described in Section 8.4.

Conformance with RG 1.204

Station grounding and lightning protection is designed in accordance with IEEE Std 665-1995 (Reference 15), IEEE Std 666-1991(R1996) (Reference 16), IEEE Std 1050-1996 (Reference 17), and IEEE Std C62.23-1995 (Reference 18) as endorsed by RG 1.204 and as described in Section 8.3.1.3.5 and Section 8.3.1.3.8.

NUREG/CR-0660

Recommendations of Reference 9 have been incorporated in the EDG design as described in Section 8.3.1.1.5.

SECY-91-078

In accordance with SECY-91-078 (Reference 19), offsite preferred power is directly supplied to the EPSS; there are no intervening non-Class 1E buses. EPSS switchgear buses do not share windings from the preferred power EATs with the non-Class 1E switchgear.

The normal power supply system non-Class 1E buses receive offsite power from the station switchyard via the NATs. The offsite source to the switchgear is arranged such that there is a backup supply to each primary NPSS bus. The high speed offsite source transfer of the NPSS 13.8 kV bus is initiated from a NAT fault.

8.3.1.2.5 Compliance with GDC 18

The EPSS has been designed to permit periodic inspection and testing of important areas and features such as wiring, insulation, connections and switchboards to assess the operability and functionality of the systems and the condition of their components. The four division concept permits the testing of one division without affecting safety-related functions by having two remaining divisions available to support required emergency core cooling system (ECCS) injection while assuming a single failure of the third division.

Additionally, periodic testing of the EDGs is available to verify their capability to start and accept load.

Plant surveillance test procedures are developed to test portions of the logic circuitry, including any parallel logic, interlocks, bypasses and inhibit circuits as indicated in NRC Generic Letter 1996-01 (Reference 20), so that safety-related functions are verified to function as designed when actuated. Surveillance testing of the Class 1E distribution system components is detailed in Chapter 16.

Conformance with RG 1.47

EPSS components that provide power to the PS, the systems actuated or controlled by the PS and auxiliary or supporting safety-related systems have bypassed or inoperable status indicators in accordance with RG 1.47. The bypassed or deliberately induced inoperable component is automatically annunciated in the MCR to indicate the system or component condition. Bypassed or inoperable status indicators are displayed as indicated in Section 7.5.2.

Conformance with RG 1.118

Capability for periodic surveillance testing and calibration of EPSS equipment is provided while retaining the capability of the safety-related systems to accomplish their safety-related functions in accordance with IEEE Std 338-1987 (Reference 21) and the additional guidance provided in RG 1.118. The capability for testing and calibration of safety-related system equipment is provided during power operation and duplicates, as close as practical, the performance of the safety-related functions. Where testing and calibration during power operation would adversely affect the EPSS ability to perform its safety-related function, exceptions to the testing and calibration are in accordance with Reference 1, Section 5.7, as documented in Chapter 16.

8.3.1.2.6 Compliance with GDC 33, GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44

Compliance with the design requirements of GDC 33, GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44, are satisfied as they relate to the operation of the onsite AC power system through compliance with GDC 17 as described in Section 8.3.1.2.4.

8.3.1.2.7 Compliance with GDC 50

Containment electrical penetration assemblies are Class 1E devices and are designed, constructed and qualified in accordance with IEEE Std 317-1983(R2003) (Reference 22). Penetration assembly protection from fault currents inside containment is in accordance with the guidance in IEEE Std 741-1986 (Reference 23), as endorsed by RG 1.63.

Dual primary overcurrent interrupting devices are provided for electrical circuits going through electrical penetration assemblies where the maximum available fault current exceeds the continuous rating of the penetration assembly.

Containment electrical penetration assembly protection is described in Section 8.3.1.1.10.

8.3.1.2.8 Compliance with 10 CFR 50.63

U.S. EPR compliance with 10 CFR 50.63 is described in Section 8.4.

8.3.1.2.9 Compliance with 10 CFR 50.65(a)(4)

The description of the program for implementation of 10 CFR 50.65 is described in Section 17.6.

8.3.1.2.10 Compliance with 10 CFR 50.34 Pertaining to Three Mile Island Action Plan Requirements

Bypassed or deliberately induced inoperability of safety-related systems is automatically annunciated in the MCR to indicate the bypassed system or component. This feature is in accordance with RG 1.47 and satisfies the recommendation of TMI item I.D.3 for safety-related system status monitoring.

The EDGs provide standby power to a number of pressurizer heaters in each EPSS division. The heaters are capable of establishing and maintaining natural circulation at hot standby conditions during a LOOP. The pressurizer heaters are capable of being powered from offsite power or the EDG, and have the redundancy as described in TMI action item II.E.3.1.

Pressurizer safety and relief valves are described in Section 5.4.13. The process instrumentation for reactor coolant system pressure boundary over pressure protection is described in Section 5.2.2.8, Section 7.3.1.2.13 and Section 7.5.2.1.1.

The pressurizer level instrumentation is described in Section 7.5.2.1.1.

8.3.1.2.11 Branch Technical Positions

BTP 8-1 Requirements On Motor-Operated Valves in the ECCS Accumulator Lines

Safety injection system accumulator motor-operated isolation valves have the indications, alarm features, and control features described in BTP 8-1 (Reference 24) and are described in Section 7.6.1.2.4 and Section 7.5.2.2.5.

BTP 8-2 Use of Diesel-Generator Sets for Peaking

In accordance with BTP 8-2 (Reference 25), EDGs are not used for peaking service. They provide standby power in the event of a loss of the offsite preferred power source(s). They are periodically connected to the offsite power source, one at a time, for surveillance testing in accordance with station technical specification surveillance requirements and post maintenance testing.

BTP 8-4 Application of the Single Failure Criterion to Manually Controlled Electrically Operated Valves

A systematic evaluation of the U.S. EPR safe shutdown systems was performed to consider the potential inadvertent movement of manually controlled, electrically operated valves that could result in the loss of system safety-related function. The evaluation considered motor-operated valves, solenoid-operated valves and those valves operated indirectly by an electrical device for failures in both the “fail to function” and “undesirable function” condition.

Evaluation of the safe shutdown systems indicate that sufficient system redundancy is available to provide 100 percent cooling capacity with one system train disabled as a result of a misaligned electrically operated valve, with the exception of the safety injection system accumulator tanks discharge motor-operated isolation valve.

The evaluation indicated that closure of the safety injection system accumulator tanks discharge motor-operated isolation valve as a result of an electrical failure could disable the accumulator safety-related function. To prevent inadvertent movement of this valve from isolating the accumulator when the accumulator is required to be operable, power is removed from the valve motor by opening its MCC circuit breaker. This action is performed under administrative controls, and periodically verified in accordance with plant technical specification surveillance requirements as indicated in Chapter 16, Specification 3.5.1.

Power is restored to the valve during applicable plant conditions by closing the MCC circuit breaker. Capability to restore power is in accordance with BTP 8-4 (Reference 26), as operation of the valve is not required in the safety system operational sequence, and does not need to be rapidly restored during plant shutdown.

A redundant accumulator isolation valve position indication in the MCR is provided for verification of valve position.

BTP 8-5 Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems

Additional guidance from BTP 8-5 (Reference 27) has been incorporated into the design of the bypassed and inoperable status indicators. Bypassed or inoperable status indicators are displayed as indicated in Section 7.5.2.

BTP 8-6 Adequacy of Station Electric Distribution System Voltages

Safety-related equipment is protected from degraded voltage conditions on Class 1E buses by a degraded voltage monitoring scheme. The degraded voltage setpoint and time delays are developed in accordance with BTP 8-6 (Reference 6) as described in Section 8.3.1.1.3.

Electrical analysis results will be verified by bus voltage measurements taken during tests conducted as described in Reference 6 Section B.4.

BTP 8-7 Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status

The bypassed and inoperable status indications design for the EDGs conforms to the recommendations of Reference 28; the design is described in Section 8.3.1.1.5.

8.3.1.3 Electrical Power System Calculations and Distribution System Studies for AC Systems

The electrical transient analyzer program (ETAP), nuclear version 5.5.6N, is utilized to analyze the AC distribution system for load flow and voltage regulation, short-circuit studies and motor starting studies. ETAP has been qualified to 10 CFR 50 Appendix B, and also complies with 10 CFR 21, ASME NQA-1 (Reference 29) and ISO 9001 (Reference 30).

8.3.1.3.1 Load Flow/Voltage Regulation Studies and Under/Overvoltage Protection

A detailed analysis has been performed that demonstrates adequate voltage regulation is maintained at safety-related equipment terminals during worst case system configuration and load profile for expected power source voltage levels. Equipment that is considered for load flow and voltage regulation analysis includes safety-related and non-safety-related motors, switchgear, loads centers, MCCs and distribution transformers.

Analysis demonstrates system capability to provide minimum required voltage to safety-related equipment terminals. The analysis is verified with voltage measurements in the as-built electrical distribution system as described in Reference 6, Section B.4. EDG loading requirements and acceptance criteria are described in Section 8.3.1.1.5. Minimum voltage requirements for safety-related equipment and demonstration of electrical distribution system capability are described in Section 8.3.1.1.11. Class 1E inverter testing that demonstrates adequate inverter sizing is described in Section 8.3.2.4.3.

8.3.1.3.2 Short-Circuit Studies

A detailed analysis has been performed to evaluate worst case bolted three phase short-circuit fault currents in the onsite AC distribution system. The analyses are performed to evaluate acceptable ratings for equipment such as circuit breakers and switchgear bus work.

For each study case, short-circuit current results are compared to and must be less than the acceptance criteria (including at least five percent margin), which are the applicable circuit breaker interrupting and close and latch ratings and maximum bus bracing current capabilities. Table 8.3-1 provides nominal equipment ratings.

Containment electrical penetration assembly overload and short circuit current capability and associated over-current protection is described in Section 8.3.1.1.10.

8.3.1.3.3 Equipment Sizing Studies

Equipment sizing was initially performed using a spreadsheet load list and was subsequently verified using the ETAP load flow/voltage regulation and short circuit analysis results. Worst case loading was determined, and then equipment was selected that enveloped the load requirements. Major AC distribution equipment ratings are listed in Table 8.3-1.

The acceptance criteria for the major electrical system components are that the equipment ratings (for example continuous and short circuit current, voltage, volt-amp), are not exceeded when load flow/voltage drop, short circuit, and motor starting analyses are performed for normal and off-normal plant alignments and conditions, including DBA. In general, electrical system equipment sizing includes an approximate ten percent margin. Main transformers are sized to transfer main generator rated real and reactive power to the switchyard.

8.3.1.3.4 Equipment Protection and Coordination Studies

Electrical distribution system protection and coordination studies are performed in accordance with Reference 4 to develop a selectively coordinated system. The distribution system circuit breakers and fuses are selected to carry design loads and to interrupt overloads and the maximum fault current available at their point of application. Using this selection process, only the protective device nearest the fault will operate to isolate the fault or faulted equipment. This results in the fault being localized to the smallest possible area without causing interruption or damage to other portions of the systems. To the extent practical, upstream devices are sized and setpoints are determined so as to sense the fault but not operate before the downstream device. Then, if the downstream device fails to operate, the upstream device will operate to clear the fault.

Protective devices used for large motors and transformers are described in Section 8.3.1.1.3. EDG protection is described in Section 8.3.1.1.5. Main generator protection is described in Section 8.3.1.1. Equipment degraded voltage and undervoltage protection is described in Section 8.3.1.1.3.

8.3.1.3.5 Insulation Coordination (Surge and Lightning Protection)

U.S. EPR surge and lightning protection is provided for protection of plant personnel and equipment from the effects of transient over-voltages that can occur in electrical systems due to electrical faults or lightning strikes. The surge and lightning protection is designed in accordance with Reference 15, Reference 16, and Reference 18, which are endorsed by RG 1.204.

Lightning protection is provided for, as a minimum, the MSU, EATs, NATs, and structures containing safety-related equipment. The surge arresters are connected as close as possible to the terminals of the equipment to be protected and have a path to the ground grid as short and direct as practicable. The ground conductor from the surge arrester to the ground grid is one continuous run without splices. Each surge arrester has its own ground conductor for bonding to the ground grid. Surge arresters for lightning and surge protection are shown on Figure 8.3-2 and Figure 8.3-3.

The lightning protection system will be inspected following installation and after alterations or repairs made to a protected structure, as well as following lightning transients to the system. Additionally, the lightning protection system is inspected annually and an in-depth inspection is conducted every four years.

Insulation coordination is performed in accordance with the procedures described IEEE Std 1313.1-1996(R2002) (Reference 33) and IEEE Std 1313.2-1999(R2005) (Reference 34). Surge arrester selection is determined so that protection of major equipment, such as MSU, EATs and NATs is provided while giving maximum protection to the insulation of other equipment. The insulation coordination is determined from the known characteristics of voltage surges and the characteristics of the specific surge arresters used. From these characteristics, the proper insulation level of distribution system components and arrangement of protection components are selected to provide an insulation structure that will withstand voltage stresses to which the system and equipment could be subjected.

Insulation coordination is defined as the selection of insulation strength consistent with expected overvoltages to obtain an acceptable risk of failure. The degree of coordination is measured by the protective ratio, which is the ratio of the insulation withstand level to the voltage at the protected equipment. Three protective ratios are analyzed, comparing protective levels with corresponding insulation withstands.

$$PR_{L1} = \frac{CWW}{FOW}$$

$$PR_{L2} = \frac{BIL}{LPL}$$

$$PR_{S} = \frac{BSL}{SPL}$$

Where:

PR_{L1}	Lightning impulse protective ratio
PR_{L2}	Lightning impulse protective ratio
PR_S	Switching impulse protective ratio
CWW	Chopped wave withstand
FOW	Front-of-wave protection level
BIL	Basic lightning impulse insulation level
LPL	Lightning impulse protective level
BSL	Basic switching impulse insulation level
SPL	Switching impulse protective level

Acceptable coordination is achieved if PR_{L1} and PR_{L2} are equal to or greater than 1.2, and PR_S is equal to or greater than 1.15. An analysis is performed to verify acceptable insulation coordination on surge arresters installed on the as-built MSUs, EATs, and NATs.

8.3.1.3.6 Power Quality Limits

Electrical distribution systems have been designed to provide power to the connected loads such that the effects of total harmonic distortion (THD) in the Class 1E power systems do not degrade safety-related system performance. Equipment that is susceptible to degradation due to THD includes motors, transformers and switchgear due to a combination of copper and stray flux loses, and iron losses which can increase component heating, thereby shortening the life of some insulating components and reducing the steady-state current carrying capacity. Equipment connected to the distribution system that can contribute to THD includes battery chargers and inverters, which have been designed and selected to minimize the harmonics they inject into the distribution system buses. THD is maintained within the acceptance criteria of IEEE 519-1992 (Reference 35).

Medium voltage motor protection is described in Section 8.3.1.1.3. EDG protection is described in Section 8.3.1.1.5. Main generator protection is described in Section 8.3.1.1. Protective device application is consistent with the power quality required for the device to operate. An analysis will be performed to verify the THD present on the Class 1E buses is less than or equal to 5 percent.

8.3.1.3.7 Monitoring and Testing

The MCR and RSS monitoring of distribution system components as described in Section 8.3.1.1.4 is provided by the safety information and control system (SICS) and the process information and control system (PICS). SICS provides safety-related control and monitoring capability in the event that the PICS is not available. PICS is a non-safety-related human machine interface that provides monitoring and control of plant systems during plant operations, including accident conditions. The functional capabilities of SICS and PICS are described in Section 7.1.1.3. Where monitoring of component critical characteristics such as inverter output frequency and voltage is not provided in the MCR or RSS, alarms alert operators of out-of-tolerance equipment characteristics.

When maintenance testing of the EPSS switchgear and load center components does not interfere with plant operation, circuit breakers can be racked out to a test position. The racked out position allows testing the operational performance of the circuit breaker. MCC motor starter or circuit breaker testing can be performed to verify the operation and reliability of the equipment.

Protective relays and their input devices, such as potential transformers and current transformers, are tested during installation and periodically thereafter. Protective relay testing is accomplished by:

- Simulating relay inputs to confirm trip settings and repeatability, and determine actual performance characteristics.

- Inspection of cabling and wiring.

Distribution system testing capability is described in Section 8.3.1.2.5. Where system testing could cause perturbations to the electrical distribution systems and thereby challenge continued steady-state operation of safety-related systems, testing is normally permitted only during plant shutdown. Testing that is performed during plant shutdown conditions are LOOP testing, combined LOOP and LOCA testing, EDG test mode override where the EDG is initially operating in parallel with offsite power and a simulated SI signal is initiated, and EDG synchronizing test where the EDG is synchronized with offsite power while the unit is initially connected to the EPSS buses. Exceptions to performing these tests during power operation are in accordance with technical specifications.

Integrated testing of the Class 1E distribution system components, including the required plant conditions during testing is included in the surveillances provided in Chapter 16. Load sequencing is tested during the LOOP, LOCA, and LOOP/LOCA testing. Testing of inverters and uninterruptible power supply components, such as batteries and chargers, is described in Section 8.3.2.3.6.

8.3.1.3.8 Grounding

Station grounding is provided for personnel and equipment protection from the effects of transient over-voltages that can occur in electrical systems due to electrical faults or lightning strikes. Station grounding is designed in accordance with Reference 15, Reference 16 and Reference 17, as endorsed by RG 1.204. The primary function of the grounding system is to limit the step and touch potentials for plant personnel to safe levels at any location on the plant site. A typical station ground grid is shown for a U.S. EPR site on Figure 8.3-4—[[Typical Station Grounding Grid]].

The station ground grid, including conductor sizing, spacing in the matrix pattern and ground rod use, is designed based on site specific parameters, including local soil resistance properties and site layout as described in IEEE Std 80-2000 (Reference 36).

Plant structures, fences, tanks, switchgear, load centers, MCCs, motors, switch mats and cable trays are bonded to the station ground grid with two ground conductors and each conductor is bonded to the station ground grid in at least two places.

Electrical grounds for the ground bus of all switchgear assemblies, MCCs and load centers are bonded to the station ground grid in at least two places.

Each building is equipped with its own grounding system, which is connected to the station ground grid. Individual building steel support columns and re-bar mesh are bonded to the station ground grid.

The main generator, EDG and SBODG neutrals are high resistance grounded using a distribution transformer method. The station auxiliary transformers high voltage winding neutral point is directly grounded to the station ground grid. The neutral for the low voltage windings are grounded using a neutral grounding resistor.

The MV transformer secondary winding neutrals are connected to the ground system through a resistance. This grounding method provides proper detection and isolation of phase-to-ground faults.

Low voltage distribution transformer secondary windings are solidly grounded.

The isolated phase bus (IPB) is electrically continuous with three phase enclosures bonded together at the generator end and at the transformer end. The IPB is grounded at a single point at the MSU end, which limits circulating currents. The bus enclosures are electrically insulated from the support structures and adjoining equipment. IPB supports located inside the turbine building are connected to the building ground grid. Outdoor supports are grounded by connecting the base of each support to the ground grid with two grounding conductors bonded to the ground grid in two locations.

Plant instrumentation is grounded through a separate radial grounding system consisting of isolated instrumentation ground buses and insulated cables. I&C systems are grounded in accordance with Reference 17.

The DC system is operated as an ungrounded system. Ground detection is described in Section 8.3.2.3.7.

8.3.2 DC Power Systems

8.3.2.1 Description

The DC power system includes a Class 1E UPS (EUPS) system, a non-Class 1E 12-hour UPS (12UPS) system and a non-Class 1E UPS (NUPS) system. In general, the EUPS system provides uninterruptible DC control power for safety-related switchgear and load centers, I&C systems and uninterruptible AC motive power for safety-related motor-operated valves. The 12UPS system provides uninterruptible DC control power and AC motive power for similar non-safety-related equipment during normal operation and for selected equipment for at least 12 hours. The NUPS provides uninterruptible DC control power and AC motive power for various non-safety-related balance of plant equipment.

8.3.2.1.1 Class 1E Uninterruptible Power Supply System

8.3.2.1.1.1 General

The EUPS components are located in Seismic Category I Buildings in areas absent of high energy lines. Separation between redundant EUPS divisions is provided by the

Seismic Category I buildings. EUPS components are located so that there is physical separation between Class 1E equipment and non-Class 1E equipment. The separation also prevents an internal hazard from resulting in a redundant system common mode failure. EUPS Class 1E batteries, battery chargers, inverters, MCCs and the other components meet the RG 1.29 Seismic Category I guidelines.

Each EUPS division contains a Class 1E 250 Vdc two hour rated battery, two 100 percent capacity battery chargers, an inverter with a static bypass switch, distribution equipment and multiple AC/DC and DC/DC converters to supply 480 Vac, 250 Vdc, 120 Vac and 24 Vdc to the respective EUPS loads. The nominal ratings of each major system component are listed in Table 8.3-11—Onsite DC Power System Component Data Nominal Values. The EUPS system is illustrated on Figure 8.3-5—Class 1E Uninterruptible Power Supply System Single Line Drawing.

During conditions an alternate feed is in service as described in Section 8.3.1.1.1, the connected EUPS battery charger is aligned to the respective division BMB load center which provides an EDG backed power source to the battery charger. Proper alignment of the battery charger during implementation of an alternate feed and separation of safety-related components between divisional pairs provides EUPS independence and physical separation in accordance with Reference 1 for safety system independence.

The DC switchboard supplies switchgear and load center control power for the respective division Class 1E EPSS equipment.

The protection and coordination of EUPS components are described in Section 8.3.1.3.4.

The EUPS also provides power to select non-safety-related loads such as the radiation monitoring system (which provides some Type E post-accident monitoring variables), applicable communications systems as described in Section 9.5.2, and the special emergency lighting system. Separation is provided between these non-Class 1E circuits and Class 1E circuits in accordance with Reference 10 as described in Section 8.3.1.1.9.

The EUPS supplies assigned loads during normal and off-normal operation, including when onsite AC power is not available and during the starting phase of the EDGs when the battery charger AC input power is lost. During loss of power to the battery charger, the EUPS loads are powered from the battery via the DC distribution switchboard or inverters until the battery charger has been re-powered from the EDGs. Both battery chargers in division 1 and 4 are capable of being supplied by the SBODG. The battery charger supplied from 32BMB and 33BMB in division 2 and 3 respectively are also capable of being powered from the SBODGs.

The EUPS system components have local battery charger and inverter indications to permit system monitoring. DC switchboard and 480 Vac MCC voltage, battery charger output current and battery charge or discharge rate are indicated in the MCR and RSS. A DC switchboard undervoltage alarm indicates the battery is being discharged and a DC system ground alarm is provided in the MCR.

8.3.2.1.1.2 250 Vdc Batteries

The EUPS battery cells are the vented (flooded) lead-acid type. The battery is immediately available during normal operation and following the loss of power from the AC power system. Each battery is able to provide power for starting and operating DBE loads for a minimum of two hours when the AC supply to the battery charger is lost.

The battery voltage profile during the first two hours of discharge provides satisfactory operation of safety-related electrical loads during postulated DBE conditions.

Each EUPS divisional battery is located in a ventilated battery room that is separated from other EUPS equipment. The electrical division of the safeguard building ventilation system (SBVS) prevents accumulation of hydrogen and maintains design battery temperature. Hydrogen buildup is limited to one percent of the total volume of the battery area in accordance with RG 1.128. The battery ventilation supplied by the electrical division of SBVS is described in Section 9.4.6.

The EUPS battery installation design is in accordance with IEEE Std 484-2002 (Reference 37) as augmented by RG 1.128. The EUPS batteries are qualified in accordance with IEEE Std 535-1986 (Reference 38) as endorsed by RG 1.158.

The DC portion of the EUPS system is operated as an ungrounded system.

8.3.2.1.1.3 250 Vdc Battery Chargers

Each EUPS division contains two 100 percent capacity battery chargers that are powered from their respective division EDG-backed Class 1E load centers and MCCs. Each battery charger provides power for steady-state operation of connected loads during normal or post-accident operation while either maintaining the respective battery fully charged or recharging the battery to the fully charged state. The capacity of each battery charger is based on the largest combined demands of the various continuous steady-state loads plus charging capacity to restore the battery after the bounding DBE discharge to a state the battery can perform its design basis function for subsequent postulated operational and design basis functions. Battery chargers for each division are independent of battery chargers in other redundant divisions.

The battery chargers are normally operated in float charge mode to maintain their battery fully charged. Battery charger operational mode can be selected between float charge and equalize charge. The output of the charger is adjustable in each mode of operation. The battery chargers are designed to prevent the AC power supply from becoming a load on the battery. Transients from the AC system are prevented from unacceptably affecting the DC system and vice versa. A current limiting device automatically responds to limit charger output current to prevent charger damage in an overload condition. Battery charger output is filtered to reduce output ripple current over the entire load range of the charger.

These battery charger parameters are alarmed in the MCR to alert operators of an abnormal condition:

- Battery charger output breaker open.
- Battery charger DC output failure as determined by low charger output current.
- Battery charger AC power failure.
- Battery charger low DC voltage.

Each charger is capable of being isolated from the AC and DC systems by means of a disconnecting device to place the battery charger in standby condition or to isolate it for maintenance. During normal operation, one battery charger is in service with the other charger in standby. In the event of a charger failure, the other charger is placed in service manually at the local charger cabinet. The battery chargers incorporate an interlock in their output breakers to prevent having two different divisional power sources supplying power to the same bus simultaneously.

AC distribution system faults or battery charger internal faults are prevented from affecting the inverter powered loads. The battery charger high voltage shutdown relay removes the battery charger from service before the inverter output is affected. Following trip of battery charger output, the inverter continues to supply the MCC loads, including the power source to the I&C cabinets.

8.3.2.1.1.4 480 Vac Inverters

Four Class 1E inverters provide power at a nominal 480 Vac, three-phase, 60 Hz to the four independent divisions respective 480 Vac vital AC distribution MCCs (31BRA, 32BRA, 33BRA and 34BRA). Each inverter is normally powered from its respective DC distribution bus (31BUC, 32BUC, 33BUC, and 34BUC). The inverter limits the output voltage waveform THD to below Reference 35 maximum recommended limits.

Each inverter includes a static bypass switch to transfer power from the inverter to the EDG-backed bypass source. The static bypass switch automatically transfers to the bypass source on inverter failure, inverter overload, inverter output undervoltage or overvoltage, or manually. The transfer is a make-before-break transfer to the respective division voltage regulated MCC 31BNB02, 32BNB02, 33BNB02 and

34BNB02, which occurs with minimal change in voltage, frequency or phase displacement. Transfer to the bypass source is only possible when the bypass source is available. During inverter maintenance and tests, the vital AC distribution MCC supply is provided directly from the bypass source.

8.3.2.1.1.5 24 Vdc Converters

Each EUPS division supplies the respective division Class 1E I&C equipment with 24 Vdc via both 480 Vac to 24 Vdc converters and 250 Vdc to 24 Vdc converters. Typical converter cubical connection to the I&C system is shown in Figure 8.3-5. The converter cubicles are operated in parallel to provide two power supply feeds to each specific I&C cabinet group. Both the AC/DC and DC/DC converters are sized to supply the entire I&C cabinet group so that on failure of one converter cubicle the other converter cubicle can supply the power demand of the entire I&C cabinet group.

The 480 Vac to 24 Vdc converter cubicles contain several converter modules in parallel, supplied from the inverter fed MCC to provide an uninterruptible normal supply. The 250 Vdc to 24 Vdc converter cubicles also contain several converter modules in parallel, supplied from the battery switchboard to provide a dual power supply to the I&C systems. The output of each converter module has a fuse or circuit breaker installed for individual component protection. Electrical isolation between the converter cubicles is provided by blocking diodes.

Normally the AC/DC and DC/DC converter module sets are located in separate converter cubicles. For I&C cabinet groups with low power requirements the AC/DC and DC/DC converter module sets are located in the same cabinet. The AC/DC and DC/DC converter module sets can also be installed directly inside the I&C cabinet they supply. The converter cubicles are located near the I&C cabinet group they supply in the respective SB and EPGB.

8.3.2.1.1.6 Uninterruptible Motor Control Centers

MCCs 31BRA, 32BRA, 33BRA and 34BRA distribute the respective inverter output to the safety-related loads, including the AC/DC converter feeds and select non-safety-related loads as shown in Table 8.3-13—Division 1 Class 1E Uninterruptible Power Supply Nominal Loads, Table 8.3-14—Division 2 Class 1E Uninterruptible Power Supply Nominal Loads, Table 8.3-15—Division 3 Class 1E Uninterruptible Power Supply Nominal Loads, and Table 8.3-16—Division 4 Class 1E Uninterruptible Power Supply Nominal Loads respectively.

8.3.2.1.1.7 Panelboards

Panelboards 31BGA01, 32BGA01, 33BGA01 and 34BGA01 provide a 120 Vac uninterruptible single phase power supply and overcurrent protection for safety-related loads. Panelboards 31BLB01, 32BLB01, 33BLB01, and 34BLB01 provide a 120

Vac uninterruptible single phase power supply and overcurrent protection for the selected 120 Vac non-safety-related EUPS loads. The panelboards are supplied with uninterruptible power from the respective division BRA MCC. Isolation of the non-safety-related loads from the EUPS is described in Section 8.3.1.1.9.

8.3.2.1.2 12 Hour Uninterruptible Power Supply

The 12UPS is a non-Class 1E system that supplies uninterruptible AC and DC power to non-safety-related loads in the SBs. In addition to these loads, the 12UPS supplies SBODG auxiliary loads and control power for circuit breakers used to align the SBODGs to the NPSS and EPSS.

The 12UPS system, as shown in Figure 8.3-6—12-Hour Uninterruptible Power Supply System Single Line Drawing, is comprised of two separate trains supported by separate DC battery systems. Each train consists of a 250 Vdc non-Class 1E battery, a 100 percent capacity battery charger, a static bypass switch inverter, a 250 Vdc distribution switchboard, 480 Vac MCCs, AC/DC and DC/DC converters. A single standby charger is available to be placed in service manually should the normal charger in either train fail or require maintenance that necessitates removal from service. The 12UPS system batteries, battery chargers, inverters, MCCs (31BRC and 32BRC), and DC switchboards (31BUD and 32BUD) are located in separate dedicated electrical rooms in the Switchgear Building. MCCs (31BRB, 32BRB, 33BRB and 34BRB) and DC switchboards (31BUE, 32BUE, 33BUE and 34BUE) are located in the respective division SB.

Each 12UPS battery has adequate capacity for starting and operating connected loads for a minimum of two hours during a LOOP. Following the initial two hours, certain loads must be manually disconnected so the system has adequate capacity to complete its 12-hour beyond design basis, severe accident mission if required. During the entire 12-hour discharge time, assuming the loads are properly shed, the battery voltage does not drop below the minimum values required for the severe accident loads.

Each 12UPS battery charger supplies the normally operating assigned loads while maintaining the battery fully charged or recharging the battery following battery discharge. The standby battery charger has the same capacity as the normal battery chargers. The time to recharge the battery from a discharged state to approximately 95 percent capacity during operating conditions is 24 hours.

The inverters are equipped with a static bypass switch to provide power from the bypass source in case of inverter failure, high or low input voltage or output voltage.

The 12UPS provides power to non-safety-related I&C cabinets located in the SBs from 480 Vac MCCs and 250 Vdc switchboards through AC/DC and DC/DC converters, respectively. The converter cubicles are designed and operated similar to the EUPS converters described in Section 8.3.2.1.1.5.

NPSS trains 1 and 2 provide the normal power to the 12UPS battery chargers from load centers 31BFX and 32BFX, respectively. If voltage is lost on NPSS 6.9 kV switchgear 31BBH or 32BBH, the SBODGs automatically start and re-power their associated 31BBH and 32BBH. These switchgear supply the load centers (31BFX and 32BFX), therefore the SBODGs provide a standby source of power to the battery chargers.

The 12UPS components are equipped with local and remote indications and alarms that provide operators with accurate system status. The following 12UPS indications are provided in the MCR:

- The inverter supplied MCC bus voltage.
- The inverter common trouble alarm.
- The DC system ground alarm.
- The DC distribution bus voltage.
- The charger common trouble alarm.

The 12UPS system does not perform any safety-related functions. The 12UPS provides electrical power for beyond DBEs (e.g., severe accident and SBO). The severe accident loads are powered from MCCs 31BRB, 32BRB, 33BRB and 34BRB. The following are the severe accident loads.

- The AC/DC and DC/DC converters for control and monitoring systems.
- Dedicated valves for primary depressurization for each primary depressurization system line.
- Outer containment isolation valves (aligned to 12UPS during severe accident).
- Illumination of monitoring displays in the MCR.

The 12UPS is separated from the EPSS by two normally open and manually operated circuit breakers.

8.3.2.1.3 Non-Class 1E Uninterruptible Power Supply

The NUPS provides uninterruptible AC and DC power to non-safety-related loads that are needed to remain operational for investment protection such as turbine-generator protection and lube oil pumps.

The NUPS system, as shown in Figure 8.3-7—Non-Class 1E Uninterruptible Power Supply System Single Line Drawing, is comprised of two separate trains supported by separate battery systems. Each train consists of a 250 Vdc non-Class 1E battery, a 100 percent capacity battery charger, the 250 Vdc distribution switchgear, AC/DC converters, DC/DC converters, 480 Vac MCCs, and a static bypass switch inverter. A single standby charger is available to be placed in service manually should either in service charger fail or require maintenance that necessitates removal from service. The NUPS components are located in separate dedicated electrical rooms in the Switchgear Building.

Each NUPS battery has sufficient capacity for starting and operating required loads for a minimum of two hours, should the battery charger lose AC input power. During the discharge time, the voltage of the battery does not drop below the minimum values required for the loads.

Each NUPS battery charger powers the normally operating assigned loads while maintaining the battery fully charged or recharging the battery following battery discharge. The standby battery charger has the same capacity as the normal battery chargers. The inverters are equipped with a static bypass switch to provide power from the bypass source in case of inverter failure.

NPSS trains 1 and 2 provide the normal power to the NUPS battery chargers from load centers 31BFX and 32BFX, respectively. If voltage is lost on NPSS 6.9 kV switchgear 31BBH or 32BBH, the SBODGs automatically start and re-power their associated 31BBH and 32BBH switchgear. These switchgear supply the load centers (31BFX and 32BFX), therefore the SBODGs provide a standby source of power to the battery chargers.

The NUPS components are equipped with indications and alarms that provide operators with system status. The following NUPS indications are provided in the MCR:

- The inverter common trouble alarm.
- The NUPS system ground alarm.
- The charger common trouble alarm.

The NUPS distributes power from each 250 Vdc switchboard 31BUM and 32BUM to the control rod drive control system for motive power to the control rod drive mechanism (CRDM) operating coils. Power to the CRDM coils is supplied through two in-series reactor trip breakers located in separate cabinets within CRDM distribution panels 32BUB and 33BUB in SBs 2 and 3, respectively. The reactor trip breakers and the distribution panels are Class 1E devices to satisfy the safety-related function of tripping open to insert the reactor control rods when the PS de-energizes the reactor trip breaker undervoltage coil as described in Section 7.2. Trip breaker position is indicated in the MCR and RSS. The diverse I&C system described in

Section 7.8.1.1.3 actuates the reactor trip breakers shunt trip coil with a trip signal to mitigate “anticipated transient without scram” conditions.

8.3.2.1.4 Physical Identification of Class 1E Equipment

The physical identification of Class 1E equipment is described in Section 8.3.1.1.13.

8.3.2.1.5 Independence of Redundant Systems

The four divisions of EUPS system including inverters, batteries, battery chargers, MCCs, distribution panels, and converters are redundant and physically separated from each other. The EUPS equipment for each division is located in the Safeguard Building and Emergency Power Generating Building associated with that division.

The EUPS supplies uninterruptible power to the instrumentation and control devices for safety-related loads from the respective division. This independence between the redundant EUPS divisions includes control power for EUPS switchgear and load centers, EDG control power, and power for the converter cubicles that is supplied to I&C systems in the related division.

The independence of redundant systems is further described in Section 8.3.1.1.9.

8.3.2.2 Analysis

The EUPS is designed to meet the acceptance criteria established in GDC 2, GDC 4, GDC 5, GDC 17, GDC 18, and GDC 50 of 10 CFR 50 Appendix A. Additionally, conformance with recommendations of RGs as well as IEEE Standards adopted by the RGs is described in this section.

8.3.2.2.1 Compliance with GDC 2

The EUPS components are located in Seismic Category I structures to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without losing their capability to perform required safety-related functions. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in Chapter 2. The U.S. EPR design criteria for wind, tornado, flood, and earthquakes are described in Section 3.3, Section 3.4, and Section 3.7, respectively.

8.3.2.2.2 Compliance with GDC 4

EUPS system components are located in Seismic Category I structures, in rooms constructed in such a manner that any internal hazard only affects the respective division. Details of the design and construction of safety-related structures are included in Chapter 3.

There are no high-energy lines routed through the dedicated electrical rooms containing batteries, battery chargers, inverters, MCCs, panelboards or switchboards. These rooms are also provided with conditioned air that maintains ambient environmental conditions within equipment qualifications during normal operations, DBEs and SBO. Details of the design and construction of safety-related structures are included in Chapter 3.

8.3.2.2.3 Compliance with GDC 5

GDC 5 is satisfied with the U.S. EPR designed as a single-unit station.

8.3.2.2.4 Compliance with GDC 17

Compliance with GDC 17 is accomplished through the design of the onsite power DC distribution system capacity, capability, independence, redundancy, and single failure criteria.

There are four independent and redundant EUPS systems. Each EUPS system battery and battery charger provides power to the DC switchboard which provides power to the 250 Vdc loads and inverter of each division. The inverter powers the 480 Vac loads that require uninterruptible power and AC/DC converters that are operated in parallel to supply DC power to redundant safety-related loads. These components have the required independence, redundancy, and testability to perform their safety-related functions in the presence of a single failure.

Conformance with RG 1.6

The EUPS meets the requirements of RG 1.6 by providing Class 1E DC and uninterruptible AC power to redundant safety-related load groups.

During normal EPSS bus alignments, four redundant divisions are physically separated and electrically independent preventing failure in one division from having a detrimental affect on another division that would prevent performance of a safety function. Each EUPS division contains a battery and battery charger. There are no automatic or manual connections between EUPS divisions.

Conformance with RG 1.32

The EUPS batteries, battery chargers, inverters and distribution equipment are designed to provide sufficient power at the quality necessary for the safety systems to meet their functional requirements as described by Reference 3, as endorsed by RG 1.32.

Conformance with RG 1.75

Each EUPS division is located in separate Seismic Category I Safeguards Buildings and Emergency Power Generating Buildings. This arrangement provides physical separation through the use of safety class structures for the majority of the electrical equipment and circuits. Cable routing, derating, raceway fill, separation, and identification of redundant Class 1E circuits and isolation of non-Class 1E circuits from Class 1E circuits is in accordance with Reference 10, as supplemented by RG 1.75.

Cable routing, including cable derating and cable tray fill criteria, is described in Section 8.3.1.1.8.

Cable independence and separation is described in Section 8.3.1.1.9.

Conformance with RG 1.128

Initial design and installation of EUPS batteries meet the criteria of Reference 37, as supplemented by RG 1.128, for proper design and installation for large lead-acid storage batteries.

Conformance with RG 1.129

Maintenance and testing of EUPS batteries is in accordance with IEEE Std 450-2002 (Reference 39), as supplemented by RG 1.129. Battery surveillance testing is described in the technical specifications detailed in Chapter 16.

Conformance with RG 1.153

The electrical power functions of the power, instrumentation, and control portions of safety systems are designed in accordance with Reference 1, which meets or exceeds the requirements of Reference 40, as endorsed by RG 1.153.

Conformance with RG 1.53

The EUPS has been designed such that safety-related systems will perform their safety-related function in the presence of a single detectable failure, all failures caused by the single failure, and all failures caused by a DBE per the guidance of Reference 2 as accepted by RG 1.53. Onsite DC distribution system capability to maintain safety function in the presence of a single failure is demonstrated in Table 8.3-12—Class 1E Uninterruptible Power Supply System Failure Modes and Effects Analysis.

8.3.2.2.5 Compliance with GDC 18

The EUPS has been designed to permit periodic inspection and testing of important areas and features to assess the operability and functionality of the systems and the condition of their components.

Battery and battery charger capacities are periodically tested in accordance with technical specifications detailed in Chapter 16.

Conformance with RG 1.47

Bypassed, or deliberately induced inoperability of the EUPS batteries, battery chargers, and UPS inverters are automatically annunciated in the MCR to indicate the bypassed system or component in accordance with RG 1.47. The additional guidance provided in Reference 27 is used in the design of the bypass and inoperable status indicators for the engineered safety feature systems. Bypassed or inoperable status indicators are displayed as indicated in Section 7.5.2.

8.3.2.2.6 Compliance with GDC 33, GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44

Compliance with the design requirements of GDC 33, GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44, are satisfied as they relate to the operation of the onsite DC power system through compliance with GDC 17 as described in Section 8.3.2.2.4.

8.3.2.2.7 Compliance with GDC 50

Compliance with GDC 50 for containment electrical penetration assembly design, qualification and protection is described in Section 8.3.1.2.7.

8.3.2.2.8 Compliance with 10 CFR 50.63

Section 8.4 describes U.S. EPR compliance with 10 CFR 50.63.

Conformance with RG 1.155

During the onset of SBO, the EUPS and 12UPS maintain control power to I&C systems and distribution system equipment that is used for SBO mitigation. The EUPS also provides power to the main steam relief isolation valves, main steam relief control valves, and containment isolation valves that are operated during an SBO event. The 12UPS provides power to the RCP standstill seal system and seal leakoff line isolation once the RCPs have coasted to a stop to reduce reactor coolant system inventory loss. Additionally, the 12UPS provides control power for SBODG starting and alignment to EPSS buses to establish power to those systems necessary for safe shutdown. EUPS battery chargers are loaded onto the SBODGs when EPSS buses are re-energized. Therefore, the EUPS system maintains power to the EUPS loads throughout the SBO event.

SBO conformance with RG 1.155 is described in Section 8.4.

8.3.2.2.9 Compliance with 10 CFR 50.55a(h)

The four EUPS divisions are designed in accordance with Reference 1.

8.3.2.2.10 Compliance with 10 CFR 50.65(a)(4)

The description of the program for implementation of 10 CFR 50.65 is described in Section 17.6.

8.3.2.3 Electrical Power System Calculations and Distribution System Studies for DC Systems

The ETAP, nuclear version 5.5.6N, is utilized to analyze the EUPS system for load flow and voltage regulation and short-circuit studies. ETAP has been qualified to 10 CFR 50 Appendix B, and also complies with 10 CFR 21, Reference 29 and Reference 30.

8.3.2.3.1 Load Flow and Under/Overvoltage Studies

The purpose of the load flow simulation is to find the worst case voltage level at the DC switchboards 31BUC, 32BUC, 33BUC and 34BUC. It is assumed that there is a loss of power to the bus feeding the battery chargers so only the battery is powering the loads. The loads are simulated as a static total load at the worst case loading, which is the first minute of the battery duty cycle. The ETAP DC load flow calculation demonstrates bus voltage values with these system loads and sources. Based on the obtained bus voltage results, branch flows can then be calculated. A load flow analysis will be performed that verifies the EUPS DC operating voltage remains within the terminal voltage range of the supplied safety-related equipment during the battery duty cycle.

Allowable voltage ranges for equipment connected to the DC systems are provided in Table 8.3-11. The testing that demonstrates compliance with applicable design guidance and regulations, including acceptance criteria for battery and battery charger sizing, is described in Section 8.3.2.4.

8.3.2.3.2 Short-Circuit Studies

The ETAP DC short-circuit module calculates the total fault current, current contributions from different sources, and the rise time constant of the total fault current in accordance with IEEE Std 946-2004 (Reference 41). The fault under consideration is a short circuit between the positive and the negative terminals at the fault location. The contributing sources to the short-circuit current are the battery charger and battery since there are no DC motors connected to the DC switchboards. The analyses are performed to evaluate acceptable equipment ratings for equipment such as circuit breakers, fuses and bus work.

For each study case, short-circuit current results are compared to and must be less than the acceptance criteria, which are the applicable circuit breaker interrupting and maximum bus bracing current capabilities. Table 8.3-11 provides nominal equipment ratings.

8.3.2.3.3 Equipment Sizing Studies

Equipment sizing for the EUPS MCCs and switchboard buses is developed by performing the load flow, voltage regulation, and short circuit analyses based on electrical distribution system load requirements. Worst-case loading is determined, and then equipment is selected that will envelop the load requirements that have been analyzed.

Battery sizing methodology is performed in accordance with IEEE Std 485-1997 (Reference 42). The battery sizing takes into account the worst-case battery load conditions to develop the duty cycle and it includes specific load characteristics such as in-rush current. Battery cell discharge performance characteristic curves are used to calculate the cell capacity necessary for satisfactory battery performance based on the worst-case duty cycle. Duty cycle development and load characteristics are shown in Table 8.3-13, Table 8.3-14, Table 8.3-15, and Table 8.3-16. Other considerations included in the cell size are a ten percent design margin, a minimum battery temperature of 65°F, and 25 percent margin as an aging factor.

EUPS battery charger sizing is performed in accordance with Reference 41. The time considered to recharge the battery from a fully discharged state, based on the worst-case duty cycle, to approximately 95 percent capacity during operating conditions, is 24 hours.

Inverter sizing is performed by considering worst case load profiles as shown in Table 8.3-13, Table 8.3-14, Table 8.3-15, and Table 8.3-16. Conservative equipment power factors and additional margin is also applied to the inverter size.

DC system equipment ratings are listed in Table 8.3-11.

The acceptance criteria for the DC system equipment (such as batteries, battery chargers, inverters and DC switchgear bus and breakers, DC power panels and low-voltage power cables) are that the equipment ratings are sufficient to start and operate required loads during normal and off-normal plant conditions including DBA. The batteries, battery chargers and inverters are tested as described in Section 8.3.2.4 to demonstrate adequate sizing.

8.3.2.3.4 Equipment Protection and Coordination Studies

Electrical equipment protection and coordination is described in Section 8.3.1.3.4; studies similar to those described for the AC power systems are also performed for the DC systems.

8.3.2.3.5 Power Quality Limits

Equipment that is considered for the effects of poor power quality, including THD and THD limits, are described in Section 8.3.1.3.6.

Ripple voltage is an important consideration that affects the design life of batteries. Battery chargers contain output filters to maintain ripple voltage within the battery manufacturer's maximum acceptable limits.

The EUPS inverters contain an input filter that reduces ripple voltage at the inverter DC input terminals to prevent ripple voltage from adversely affecting inverter operation and to minimize inverter switching transients.

The primary loads on the DC system that are susceptible to poor quality DC voltage, including ripple voltage, are the digital I&C systems fed from the 24 Vdc converter output. To limit the potential for poor quality DC voltage, the output of the AC/DC and DC/DC converters is filtered to reduce ripple voltage. Additionally, each I&C cabinet further filters the 24 Vdc input to within the specific application input tolerance. Digital systems that are powered from low voltage AC power also have internal input voltage filters to reduce harmonics.

8.3.2.3.6 Monitoring and Testing

Periodic DC system component maintenance is performed in accordance with the component manufacturer's recommendations and industry standards, such as Reference 39 for battery maintenance and testing. Battery charger maintenance and testing, including verifying charger capacity, can be performed during power operation through use of the standby battery charger.

Where system testing could cause perturbations to the electrical distribution systems and thereby challenge continued steady-state operation of safety-related systems, testing is normally permitted during plant shutdown. Testing performed during plant shutdown conditions includes battery performance or modified performance discharge tests. Exceptions to performing these tests during power operation are in accordance with technical specifications. Inverter maintenance requiring removing the inverter from service is normally performed during plant shutdown conditions as well. Surveillance testing of the EUPS components, including required plant operating condition, is detailed in Chapter 16.

Individual system monitoring capability is addressed in Section 8.3.2.1.

8.3.2.3.7 Grounding

The DC portion of the EUPS is operated as an ungrounded system. This alignment provides increased system reliability and continuity of service, since a single ground will not adversely affect system operation. Each division is provided with a ground detector to identify and aid in the isolation of grounds. The ground detector provides annunciation in the MCR, constant ground monitoring of ground resistance magnitude (negative-to-ground and positive-to-ground), and recording. The ground detector has the sensitivity to detect high resistance grounds. Should there be a ground on the DC system, continued operation of the DC portion of the system is not affected. The plant will have procedures to troubleshoot and clear ground faults on the DC system.

The uninterruptible 480 Vac portion of the EUPS system grounding is as described in Section 8.3.1.3.8.

8.3.2.4 Inspection and Testing

Acceptance and periodic testing of EUPS system components is conducted to provide a record of acceptable operation of the system. Periodic testing of station batteries is performed per Reference 39, as augmented by RG 1.129. Surveillance testing of the EUPS system is conducted as detailed in the technical specifications given in Chapter 16.

8.3.2.4.1 EUPS Battery Acceptance Testing

Battery acceptance testing is conducted in accordance with Reference 39 as supplemented by RG 1.129 to demonstrate the EUPS battery capability to supply required loads for two hours while maintaining minimum voltage per Table 8.3-11. The acceptance test, temperature corrected discharge rate envelops the battery duty cycle provided in Table 8.3-13, Table 8.3-14, Table 8.3-15, and Table 8.3-16. The test is performed by maintaining the temperature corrected discharge rate equal to the manufacturer's two hour rating for the battery until battery terminal voltage decreases to 210 Vdc. Battery capacity is then determined and verified to meet the duty cycle requirements.

8.3.2.4.2 EUPS Battery Charger Capacity Testing

The EUPS battery chargers are load tested to their maximum continuous output current. This current is sufficient for maintaining power to the loads listed in Table 8.3-13, Table 8.3-14, Table 8.3-15, and Table 8.3-16 for the minimum two hours.

8.3.2.4.3 EUPS Inverter Capacity Testing

The EUPS system inverters are tested by applying their rated load while verifying the inverter maintains the nominal voltage and frequency output listed in Table 8.3-11. The inverter output is sufficient for maintaining power to the loads listed in Table 8.3-13, Table 8.3-14, Table 8.3-15, or Table 8.3-16 for the respective inverter.

Inverters are load tested while the input DC voltage is at or less than 210 Vdc to represent the discharge condition of the battery as the inverter power source.

8.3.2.4.4 12UPS Battery Acceptance Testing

Battery acceptance testing is conducted in accordance with Reference 39 to demonstrate the non-Class 1E, 12UPS battery capability to supply the load demand as described in Section 8.3.2.1.2 for 12 hours while maintaining minimum voltage per Table 8.3-11. The test is performed by maintaining the temperature-corrected discharge rate equal to the manufacturer 12 hour rating for the battery until battery terminal voltage decreases to 210 Vdc. Battery capacity is then determined and verified to meet the duty cycle requirements.

8.3.2.4.5 Battery Charger Capacity Testing of the 12UPS

The 12UPS battery chargers are load tested to their maximum continuous output current. The current is sufficient for maintaining power to the loads described in Section 8.3.2.1.2, while maintaining the respective 12UPS battery charged.

8.3.2.4.6 12UPS Inverter Capacity Testing

The 12UPS inverters are tested by applying their rated load while verifying the inverter maintains the nominal voltage and frequency output listed in Table 8.3-11. The inverter output is sufficient for maintaining power to the 12UPS loads as described in Section 8.3.2.1.2. Inverters are load tested while the input DC voltage is at or less than 210 Vdc to represent the discharge condition of the battery as the inverter power source.

8.3.2.4.7 NUPS Battery Acceptance Testing

Battery acceptance testing is conducted in accordance with Reference 39 to demonstrate the NUPS batteries have the capability to supply the analyzed load demand for two hours while maintaining minimum voltage. Analysis will be performed to determine battery duty cycle. Battery capacity is verified acceptable by performing a battery acceptance test to the manufacturer's two hour rating, which envelops the analyzed duty cycle. The acceptance test is performed by maintaining the temperature corrected discharge rate equal to the manufacturer's two hour rate until the battery terminal voltage reaches 210 Vdc. The battery capacity is then determined and verified greater than the analyzed duty cycle.

8.3.2.4.8 NUPS Charger Capacity Testing

Analyses are performed to determine NUPS system load. The NUPS battery chargers are load tested to the analyzed load demand to supply the analyzed loads while maintaining the battery charged.

8.3.2.4.9 NUPS Inverter Capacity Testing

Analyses are performed to determine NUPS inverter loads. The NUPS inverters are load tested to the analyzed load demand while verifying the nominal output voltage. Inverters are load tested while the input DC voltage is at or less than 210 Vdc to represent the discharge condition of the battery as the inverter power source.

8.3.3 References

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Table 8.3-1—Onsite AC Power System Component Data Nominal Values
Sheet 1 of 2

Component		Nominal Ratings
1.	MSUs (30BAT01, 30BAT02, 30BAT03, 30BAT04)	26 kV-(site-specific), single phase, 60 Hz 2100MVA (700MVA each phase) Cooling Class ODAF Temperature Rise 65°C
2.	EATs (30BDT01, 30BDT02)	(site-specific)-6.9 kV-6.9 kV, three phase, 60 Hz Rated Power 25/33.3/41.5 MVA Cooling Class ONAN/ONAF/ONAF Temperature Rise 65°C
3.	NATs (30BBT01, 30BBT02)	(site-specific)-13.8 kV-13.8 kV, three phase, 60 Hz Rated Power 140/186.2/232.4 MVA Cooling Class ONAN/ONAF/ONAF Temperature Rise 65°C
4.	NPSS 13.8 kV Switchgear	Rated Maximum Voltage, 15 kV Maximum Continuous Current, 3000 A Maximum Bus Bracing Current, 164 kA rms
	NPSS 13.8 kV Feeder Breaker	Rate Maximum Voltage, 15 kV Maximum Continuous Current, 3000 A Maximum Rated Interrupting Current, 63 kA Maximum Rated Closing and Latching Current 164 kA (peak value)
5.	EPSS and NPSS 6.9 kV Switchgear	Rated Maximum Voltage, 8.25 kV Maximum Continuous Current, 2000 A Maximum Bus Bracing Current, 104 kA rms
	EPSS and NPSS 6.9 kV Feeder Breaker	Rated Maximum Voltage, 8.25 kV Maximum Continuous Current, 2000 A Maximum Rated Interrupting Current 40 kA rms Maximum Rated Closing and Latching Current 104 kA (peak value)
6.	EPSS and NPSS 480 Vac Load Centers	Rated Maximum Voltage, 508 V Maximum Continuous Current, 4000 A Maximum Bus Bracing Current, 100 kA rms
	EPSS and NPSS 480 Vac Feeder Breaker	Rated Maximum Voltage, 508 V Maximum Continuous Current, 4000 A Maximum Rated Interrupting Current 100 kA rms

Table 8.3-1—Onsite AC Power System Component Data Nominal Values
Sheet 2 of 2

Component		Nominal Ratings
7.	EPSS 480 Vac MCCs	Rated Maximum Voltage, 508 V Maximum Continuous Current, 1600 A Maximum Bus Bracing Current, 100 kA rms
	NPSS 480 Vac MCCs	Rated Maximum Voltage, 508 V Maximum Continuous Current, 3200 A Maximum Bus Bracing Current, 100 kA rms
	EPSS 480 Vac MCC Feeder Breaker	Rated Maximum Voltage, 508 V Maximum Continuous Current, 1600 A Maximum Bus Bracing Current, 100 kA rms
	NPSS 480 Vac MCC Feeder Breaker	Rated Maximum Voltage, 508 V Maximum Continuous Current, 3200 A Maximum Bus Bracing Current, 100 kA rms
8.	EPSS Distribution Transformers:	Dry type 60 Hz, three phase, air cooled
	31BMT01, 32BMT01, 33BMT01, 34BMT01, 31BMT02, 34BMT02	6.9 kV to 480 Vac 2500 kVA
	32BMT02, 33BMT02, 31BMT03, 32BMT03, 33BMT03, 34BMT03, 31BMT04, 32BMT04, 33BMT04, 34BMT04	6.9 kV to 480 Vac 1500 kVA
	31BNT01, 32BNT01, 33BNT01, 34BNT01	480 Vac to 480 Vac 500 kVA Rated Input Voltage 460 Vac Rated Output Voltage 480 Vac

Table 8.3-2—Emergency Power Supply System Switchgear, Load Center and Motor Control Center Numbering and Nominal Voltage

Nominal Voltage Level	Division	Switchgear/Load Center/MCC
6.9 kV Switchgear	1	31BDA (1) , 31BDB (1), 31BDC (1), 31BDD (3)
6.9 kV Switchgear	2	32BDA (1), 32BDB (1), 32BDD (3)
6.9 kV Switchgear	3	33BDA (1), 33BDB (1), 33BDD (3)
6.9 kV Switchgear	4	34BDA (1), 34BDB (1), 34BDC (1), 34BDD (3)
480V Load Center	1	31BMB (1), 31BMC (1), 31BMD (3)
480V Load Center	2	32BMB (1), 32BMD (3)
480V Load Center	3	33BMB (1), 33BMD (3)
480V Load Center	4	34BMB (1), 34BMC (1), 34BMD (3)
480V MCC	1	31BNA01 (2), 31BNB01 (1), 31BNB02 (1), 31BNB03 (1), 31BNC01 (1), 31BND01 (3), 31BRA (4)
480V MCC	2	32BNA01 (2), 32BNA02 (1) 32BNB01 (1), 32BNB02 (1), 32BNB03 (1), 32BND01 (3), 32BRA (4)
480V MCC	3	33BNA01 (2), 33BNA02 (1) 33BNB01 (1), 33BNB02 (1), 33BNB03 (1), 33BND01 (3), 33BRA (4)
480V MCC	4	34BNA01 (2), 34BNB01 (1), 34BNB02 (1), 34BNB03 (1), 34BNC01 (1), 34BND01 (3), 34BRA (4)

Notes:

1. Equipment located in the respective division Safeguards Buildings.
2. Equipment located in the respective division Emergency Power Generating Buildings.
3. Equipment located in the respective division Essential Service Water Pump Building.
4. MCC supplied by EUPS system located in the respective division Safeguards Building.

Table 8.3-3—Normal Power Supply System Switchgear and Load Center Numbering and Nominal Voltage

Nominal Voltage Level	Train	Bus/Load Center
13.8 kV Switchgear	1	31BBA (4) 31BBC (1), 31BDE (1), 31BBD (5)
13.8 kV Switchgear	2	32BBA (4) 32BBC (1), 32BDE (1), 32BBD (5)
13.8 kV Switchgear	3	33BBA (4) 33BBC (1), 33BDE (1), 33BBD (5)
13.8 kV Switchgear	4	34BBA (4) 34BBC (1), 34BDE (1), 34BBD (5)
6.9 kV Switchgear	1	31BBH (4)
6.9 kV Switchgear	2	32BBH (4)
6.9 kV Switchgear	3	33BBH (4), 33BBG (4)
6.9 kV Switchgear	4	34BBH (4), 34BBG (4)
480V Load Center	1	31BFA (4), 31BFB (4), 31BFC (4), 31BFD (1), 31BFX (4), 31BFE (3) [[31BFG (5), 31BFF (5)]]
480V Load Center	2	32BFA (4), 32BFB (4), 32BFC (4), 32BFD (1), 32BFX (4), 32BFE (3) [[32BFG (5), 32BFF (5)]]
480V Load Center	3	33BFA (4), 33BFD (1), [[33BFG (5), 33BFF (5)]]
480V Load Center	4	34BFA (4), 34BFD (1), 34BFE (3) [[34BFG (5), 34BFF (5)]]

Notes:

1. Equipment located in the Safeguards Buildings.
2. Deleted.
3. Equipment located in the Radioactive Waste Processing Building.
4. Equipment located in the TI Switchgear Building.
5. Equipment located in the Cooling Tower Area.

Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads
Sheet 1 of 6

Time Seq. (s) [13]	Load Description [8] [15] [19]	Volts	Rating (hp/kW) [3]	Alternate Feed Load (kW) [1] [12]	Operating Load LOOP (kW) [1] [12]	Operating Load DBA/ LOOP (kW) [1] [12]
Load Step Group 1						
0	Start Signal					
15	EDG reaches rated speed and voltage/output breaker closes					
15	Emergency power generating building electric room supply fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building fuel oil storage tank room fan	480	13.4 Bhp		11.1	11.1
15	EDG starting air compressor	480	61 Bhp		50.6	50.6
15	EDG auxiliary loads	480	9.7 kW		9.7	9.7
15	Vent stack monitoring	480	13 kW		13	13
15	Division 1 EUPS battery charger [4]	480	106 kW		106	106
15	Annulus ventilation heating unit	480	6 kW		4.2 [2]	4.2 [2]
15	Annulus ventilation fan	480	4.3 Bhp		3.6	3.6
15	KAA/LAR valve room cooling fan	480	5 Bhp		4.1	4.1
15	Extra boration room cooling fan	480	14 Bhp		11.6	11.6
15	Fuel pool cooling punp room cooling fan	480	7.75 Bhp		6.4	6.4
15	Fuel pool cooling punp room cooling fan	480	7.75 Bhp		6.4	6.4
15	Fuel building ventilation heating unit [7]	480	15 kW		0	0
15	Safety chilled water pump [6]	480	100 Bhp		82.9	82.9
15	Safety chilled water pump [6]	480	100 Bhp		82.9	82.9

Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads
Sheet 2 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Safety chiller condenser fans	480	240 kW		240	240
15	Main control room air conditioning fan	480	27 Bhp		22.4	22.4
15	Main control room air conditioning filtration unit heater (11)	480	10 kW			7 (2)
15	Main control room air conditioning iodine filtration fan (11)	480	10 Bhp			8.3
15	Safeguard building ventilation heaters (7)	480	210 kW		0	0
15	Safeguard building ventilation supply fan	480	78 Bhp		64.7	64.7
15	Safeguard building ventilation return fan	480	43 Bhp		35.6	35.6
15	Main control room air conditioning fan	480	27 Bhp	22.4		
15	Safeguard building battery exhaust fan	480	7 Bhp		5.8	5.8
15	Emergency feed water room ventilation recirculation fan	480	2 Bhp		1.7	1.7
15	Emergency lighting panels (18)	480	165.7 kW		165.7	165.7
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1

Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads
Sheet 3 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Division 2 EUPS battery charger	480	106 kW	106		
15	Reactor building ventilation filtration fan	480	10 Bhp	8.3		
15	KAA/LAR valve room cooling fan	480	5 Bhp	4.1		
15	Safeguard building ventilation heaters (7)	480	180 kW	0		
15	Safeguard building ventilation supply fan	480	72 Bhp	59.7		
15	Safeguard building ventilation return fan	480	43 Bhp	35.6		
15	Safeguard building battery exhaust fan	480	6 Bhp	5		
15	Emergency feed water ventilation recirculation fan	480	2 Bhp	1.7		
15	KAA pump room recirculation fan	480	2 Bhp	1.7		
15	Emergency lighting panels (18)	480	86.7 kW	86.7		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		

Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads
Sheet 4 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Additional connected alternate feed loads	480	73.7 kW	73.7		
15	Reactor building ventilation filtration fan	480	11 Bhp		9.1	9.1
15	Reactor building filtration heating	480	25 kW		25	25
15	Reactor building pit fan (18)	480	14 Bhp		11.6	11.6
15	Reactor building pit fan (18)	480	14 Bhp		11.6	11.6
15	MHSI/LHSI room recirculation fan	480	5 Bhp		4.1	4.1
15	JMU/KUL sample room recirculation fan	480	5 Bhp		4.1	4.1
15	Main control room air conditioning heaters (7)	480	21 kW		0	0
15	Safeguard building controlled-area ventilation system heating unit	480	21 kW			14.7 (2)
15	Safeguard building controlled-area fan	480	9 Bhp			7.5
15	Essential service water building ventilation and auxiliaries	480	110 kW		85.6(2) (12)	85.6(2) (12)
15	Essential service water building recirculation fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building supply fan 1	480	100 hp		82.9	82.9
15	Emergency power generating building supply fan 2	480	100 hp		82.9	82.9
15	Emergency power generating building exhaust fan 1	480	75 hp		62.2	62.2

Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads
Sheet 5 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Emergency power generating building exhaust fan 2	480	75 hp		62.2	62.2
15	Additional connected loads	480	90.9 kW		90.9	90.9
15	Load contribution from transformer and cable losses		160 kW	40	120	120
Subtotal Load Step Group 1				469.7 (10)	1622.0	1659.5
Load Step Group 2 (17)						
20	MHSI pump	6.9 kV	700 hp			580
Subtotal Load Step Group 2						580
Load Step Group 3 (17)						
25	LHSI pump	6.9 kV	500 hp			414
Subtotal Load Step Group 3						414
Load Step Group 4 (14)						
30	CCW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 4					1036	1036
Load Step Group 5 (14)						
35	ESW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 5					1036	1036
Load Step Group 6 (14)						
40	EFW pump	6.9 kV	700 hp		(5)	580
Subtotal Load Step Group 6					(5)	580

Table 8.3-4—Division 1 Emergency Diesel Generator Nominal Loads
Sheet 6 of 6

Time Seq. (s) [13]	Load Description [8] [15] [19]	Volts	Rating (hp/kW) [3]	Alternate Feed Load (kW) [1] [12]	Operating Load LOOP (kW) [1] [12]	Operating Load DBA/ LOOP (kW) [1] [12]
Load Step Group 7 [14]						
45	Division 1 safety chilled water compressor	6.9 kV	900 kW		1000	1000
Subtotal Load Step Group 7					1000	1000
Load Step Group 8 [14]						
50	Essential service water UHS fan 1	480	250 hp		207.2	207.2
50	Essential service water UHS fan 2	480	250 hp		207.2	207.2
Subtotal Load Step Group 8					414.4	414.4
Subtotal Alternate Feed Loads				469.7		
Total Automatically Sequenced Loads without alternate feed installed					5108.7	6721.0
Total Automatically Sequenced Loads with alternate feed installed					5578.4	7190.7
Additional Manually Connected Loads						
	Emergency pressurizer heaters [16]	480	144 kW		144	
	Extra boration pump	480	163 Bhp		0 [20]	0 [20]
	Fuel pool cooling pump [21]	480	137 Bhp		113.6	113.6
Total Manually Connected Loads					257.6	113.6
Total Division 1 EDG Loading					5835.9	7304.3

Notes:

1. The kW rating derived from hp rating multiplied by 0.746 conversion factor. Indicated hp is considered rated. Where brake horsepower (Bhp) is indicated, this is from the system mechanical requirements.

2. A diversity factor of 0.7 is assumed in load contribution due to cyclical nature of load.

3. Motor efficiencies estimated at 90 percent.

4. One EUPS battery charger is in service with the other battery charger in standby. Contribution to EDG loading is calculated considering only one battery charger.

5. During a LOOP-only EDG loading sequence, the EFW start is prevented until load step group six, which occurs at 30 seconds. At load step six, the start inhibit is removed and the EFW pump start sequence is based on steam generator low level initiation. If a steam generator low level initiation exists, EFW pump start is given priority over subsequent load steps.
   During a LOOP/LOCA condition, the EFW pump is started at the sequence step indicated.

6. The divisional safety chilled water pumps and chiller are assumed operating for EDG loading purposes.

7. Worst case EDG loading occurs during summer operation when safety chilled water loading is highest. Area heater loads are shown, but do not contribute to overall EDG loading since operating conditions where heater operation is expected does not reflect bounding EDG loading scenario.

8. Loads represented in load groups are assumed running during the time duration assumed for accident analysis and mechanical system operational requirements, with the exception of motor-operated valves and dampers. Motor-operated valves and dampers are momentary loads, and are powered within EDG short-term ratings. Manually connected intermittent loads are applied following load sequencing, in accordance with approved operating procedures and their load contributions are within EDG long-term rating.

9. Deleted.

10. Alternate feed loads contributing to EDG loading are shown in the automatic sequenced loads with alternate feed installed totals.

11. Load only operated if control room high radiation signal present.

12. Efficiency estimated at 90 percent for motor loads.

13. EDG output breaker closure of T=15 seconds is an estimated time. Subsequent timing steps are based on EDG output breaker and occur in the sequence time interval after the output breaker closure.

14. During a LOOP-only condition, load steps two, three and six (based on steam generator level) are omitted resulting in the loading of this step earlier than LOOP/LOCA condition.

A. During a LOOP-only sequence the steps are at the indicated time:

1. Step 4 20 seconds
2. Step 5 25 seconds
3. Step 7 30 seconds
4. Step 8 35 seconds

B. If an SI actuation occurs before closure of the EDG output breaker, the LOOP/LOCA sequence is followed.

C. If an SI actuation occurs after closure of the EDG output breaker, the sequence is interrupted and the DBA/LOOP sequence load steps two through six are performed. Following performance of load step six, the sequence is re-started where interrupted and performed to completion.

15. Loads are safety-related loads, unless otherwise indicated.

16. Non-safety-related load that can be manually applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

17. Load steps 2 and 3 are started by the load sequencer as indicated by an SI signal. Should a LOOP occur subsequent to starting LOCA mitigation loads, the sequence is reset and restarts at the closure of the EDG output breaker.

18. Non-safety-related load that is automatically applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

19. The inrush current for motor starting studies during EDG load sequencing is represented by locked-rotor impedance, which draws the maximum possible current from the system and has the most severe effect on other loads. Following the acceleration period, the motors represented in the load step are changed to a constant KVA load.

20. Contribution to EDG loading is not credited in total division 1 EDG loading column as this load is not credited to operate concurrently with MHSI and LHSI at rated power.

21. One fuel pool cooling pump in service, the other pump is in standby. Contribution to EDG loading is calculated considering only the inservice pump.

Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads
Sheet 1 of 6

Time Seq. (s) [13]	Load Description [8] [15] [19]	Volts	Rating (hp/kW) [3]	Alternate Feed Load (kW) [1] [12]	Operating Load LOOP (kW) [1] [12]	Operating Load DBA/ LOOP (kW) [1] [12]
Load Step Group 1						
0	Start Signal					
15	EDG reaches rated speed and voltage/output breaker closes					
15	Emergency power generating building electric room supply fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building fuel oil storage tank room fan	480	13.4 Bhp		11.1	11.1
15	EDG starting air compressor	480	61 Bhp		50.6	50.6
15	EDG auxiliary loads	480	9.7 kW		9.7	9.7
15	Main control room air conditioning fan	480	27 Bhp		22.4	22.4
15	MHSI/LHSI room recirculation fan	480	5 Bhp		4.1	4.1
15	Main control room air conditioning heaters [7]	480	21 kW		0	0
15	Division 2 EUPS battery charger [4]	480	106 kW		106	106
15	Reactor building ventilation filtration fan	480	10 Bhp		8.3	8.3
15	KAA/LAR valve room cooling fan	480	5 Bhp		4.1	4.1
15	Safety chilled water pump [6]	480	100 Bhp		82.9	82.9
15	Safety chilled water pump [6]	480	100 Bhp		82.9	82.9
15	Safeguard building ventilation heaters [7]	480	180 kW		0	0
15	Safeguard building ventilation supply fan	480	72 Bhp		59.7	59.7
15	Safeguard building ventilation return fan	480	43 Bhp		35.6	35.6

Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads
Sheet 2 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Safeguard building battery exhaust fan	480	6 Bhp		5	5
15	Emergency feed water ventilation recirculation fan	480	2 Bhp		1.7	1.7
15	KAA pump room recirculation fan	480	2 Bhp		1.7	1.7
15	Emergency lighting panels (18)	480	86.7 kW		86.7	86.7
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Division 1 EUPS battery charger (4)	480	106 kW	106		
15	Annulus ventilation heating unit	480	6 kW	4.2 (2)		
15	Annulus ventilation fan	480	4.3 Bhp	3.6		
15	KAA/LAR valve room cooling fan	480	5 Bhp	4.1		
15	Extra boration room cooling fan	480	14 Bhp	11.6		
15	Fuel pool cooling pump room cooling fan	480	7.75 Bhp	6.4		

Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads
Sheet 3 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Fuel pool cooling pump room cooling fan	480	7.75 Bhp	6.4		
15	Fuel building ventilation heating unit (7)	480	15 kW	0		
15	Main control room air conditioning fan	480	27 Bhp	22.4		
15	Main control room air conditioning filtration unit heater (11)	480	10 kW	7 (2)		
15	Main control room air conditioning iodine train fan (11)	480	10 Bhp	8.3		
15	Safeguard building ventilation heaters (7)	480	210 kW	0		
15	Safeguard building ventilation supply fan	480	78 Bhp	64.7		
15	Safeguard building ventilation return fan	480	43 Bhp	35.6		
15	Safeguard building battery exhaust fan	480	7 Bhp	5.8		
15	Emergency feed water room ventilation recirculation fan	480	2 Bhp	1.7		
15	Emergency lighting panels (18)	480	165.7 kW	165.7		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		

Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads
Sheet 4 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Reactor building ventilation filtration fan	480	11 Bhp	9.1		
15	Reactor building filtration heating	480	25 kW	25		
15	Additional alternate feed connected loads	480	72.6 kW	72.6		
15	Essential service water building ventilation and auxiliaries	480	110 kW		85.6 (2) (12)	85.6 (2) (12)
15	Safeguard building controlled-area ventilation system heating unit	480	21 kW	14.7 (2)		
15	Safeguard building controlled-area fan	480	9 Bhp	7.5		
15	Essential service water building recirculation fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building supply fan 1	480	100 hp		82.9	82.9
15	Emergency power generating building supply fan 2	480	100 hp		82.9	82.9
15	Emergency power generating building exhaust fan 1	480	75 hp		62.2	62.2
15	Emergency power generating building exhaust fan 2	480	75 hp		62.2	62.2
15	Additional connected loads	480	84.4 kW		84.4	84.4

Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads
Sheet 5 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Lighting (18)	480	300 kW		300	300
15	Reserved for special use (18)	480	125 kW		125	125
15	Load contribution from transformer and cable losses		160 kW	40	120	120
Subtotal Load Step Group 1				647.2 (10)	1619.0	1619.0
Load Step Group 2 (17)						
20	MHSI pump	6.9 kV	700 hp			580
Subtotal Load Step Group 2						580
Load Step Group 3 (17)						
25	LHSI pump	6.9 kV	500 hp			414
Subtotal Load Step Group 3						414
Load Step Group 4 (14)						
30	CCW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 4					1036	1036
Load Step Group 5 (14)						
35	ESW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 5					1036	1036
Load Step Group 6 (14)						
40	EFW pump	6.9 kV	700 hp		(5)	580
Subtotal Load Step Group 6					(5)	580
Load Step Group 7 (14)						

Table 8.3-5—Division 2 Emergency Diesel Generator Nominal Loads
Sheet 6 of 6

Time Seq. (s) [13]	Load Description [8] [15] [19]	Volts	Rating (hp/kW) [3]	Alternate Feed Load (kW) [1] [12]	Operating Load LOOP (kW) [1] [12]	Operating Load DBA/ LOOP (kW) [1] [12]
45	Division 2 safety chilled water compressor	6.9 kV	900 kW		1000	1000
Subtotal Load Step Group 7					1000	1000
Load Step Group 8 [14]						
50	Essential service water UHS fan 1	480	250 hp		207.2	207.2
50	Essential service water UHS fan 2	480	250 hp		207.2	207.2
Subtotal Load Step Group 8					414.4	414.4
Subtotal Alternate Feed Loads				647.2		
Total Automatically Sequenced Loads without alternate feed installed					5105.6	6680.5
Total Automatically Sequenced Loads with alternate feed installed					5752.9	7327.8
Additional Manually Connected Loads						
	Extra boration pump	480	163 Bhp	0 [20]		
	Fuel pool cooling pump [21]	480	137 Bhp	113.6		
	Emergency pressurizer heaters [16]	480	144 kW		144	
Total Manually Connected Loads				113.6	144	
Total Division 2 EDG Loading					6010.4	7441.3

Notes:

1. The kW rating derived from hp rating multiplied by 0.746 conversion factor. Indicated hp is considered rated. Where brake horsepower (Bhp) is indicated, this is from the system mechanical requirements.

2. A diversity factor of 0.7 is assumed in load contribution due to cyclical nature of load.

3. Motor efficiencies estimated at 90 percent.

4. One EUPS battery charger is in service with the other battery charger in standby. Contribution to EDG loading is calculated considering only one battery charger.

5. During a LOOP-only EDG loading sequence, the EFW start is prevented until load step group six, which occurs at 30 seconds. At load step six, the start inhibit is removed and the EFW pump start sequence is based on steam generator low level initiation. If a steam generator low level initiation exists, EFW pump start is given priority over subsequent load steps.
   During a LOOP/LOCA condition, the EFW pump is started at the sequence step indicated.

6. The divisional safety chilled water pumps and chiller are assumed operating for EDG loading purposes.

7. Worst case EDG loading occurs during summer operation when safety chilled water loading is highest. Area heater loads are shown, but do not contribute to overall EDG loading since operating conditions where heater operation is expected does not reflect bounding EDG loading scenario.

8. Loads represented in load groups are assumed running during the time duration assumed for accident analysis and mechanical system operational requirements, with the exception of motor-operated valves and dampers. Motor-operated valves and dampers are momentary loads, and are powered within EDG short-term ratings. Manually connected intermittent loads are applied following load sequencing, in accordance with approved operating procedures and their load contributions are within EDG long-term rating.

9. Deleted.

10. Alternate feed loads contributing to EDG loading are shown in the automatic sequenced loads with alternate feed installed totals.

11. Load only operated if control room high radiation signal present.

12. Efficiency estimated at 90 percent for motor loads.

13. EDG output breaker closure of T=15 seconds is an estimated time. Subsequent timing steps are based on EDG output breaker and occur in the sequence time interval after the output breaker closure.

14. During a LOOP-only condition, load steps two, three and six (based on steam generator level) are omitted resulting in the loading of this step earlier than LOOP/LOCA condition.

A. During a LOOP only sequence the steps are at the indicated time:

1. Step 4 20 seconds
2. Step 5 25 seconds
3. Step 7 30 seconds
4. Step 8 35 seconds

B. If an SI actuation occurs before closure of the EDG output breaker, the LOOP/LOCA sequence is followed.

C. If an SI actuation occurs after closure of the EDG output breaker, the sequence is interrupted and the DBA/LOOP sequence load steps two through six are performed. Following performance of load step six, the sequence is re-started where interrupted and performed to completion.

15. Loads are safety-related loads, unless otherwise indicated.

16. Non-safety-related load that can be manually applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

17. Load steps 2 and 3 are started by the load sequencer as indicated by an SI signal. Should a LOOP occur subsequent to starting LOCA mitigation loads, the sequence is reset and restarts at the closure of the EDG output breaker.

18. Non-safety-related load that is automatically applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

19. The inrush current for motor starting studies during EDG load sequencing is represented by locked-rotor impedance, which draws the maximum possible current from the system and has the most severe effect on other loads. Following the acceleration period, the motors represented in the load step are changed to a constant KVA load.

20. Contribution to EDG loading is not credited in total division 2 EDG loading column as this load is not credited to operate concurrently with MHSI and LHSI at rated power.

21. One fuel pool cooling pump in service, the other pump is in standby. Contribution to EDG loading is calculated considering only the inservice pump.

Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads
Sheet 1 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
Load Step Group 1						
0	Start Signal					
15	EDG reaches rated speed and voltage/output breaker closes					
15	Emergency power generating building electric room supply fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building fuel oil storage tank room fan	480	13.4 Bhp		11.1	11.1
15	EDG starting air compressor	480	61 Bhp		50.6	50.6
15	EDG auxiliary loads	480	8.7 kW		8.7	8.7
15	Main control room air conditioning fan	480	27 Bhp		22.4	22.4
15	MHSI/LHSI room recirculation fan	480	5 Bhp		4.1	4.1
15	Main control room air conditioning heaters (7)	480	21 kW		14.7(2)	14.7(2)
15	Division 3 EUPS battery charger (4)	480	106 kW		106	106
15	KAA/LAR valve room cooling fan	480	5 Bhp		4.1	4.1
15	Safety chilled water pump (6)	480	100 Bhp		82.9	82.9
15	Safety chilled water pump (6)	480	100 Bhp		82.9	82.9
15	Safeguard building ventilation heaters	480	180 kW		0	0
15	Safeguard building ventilation supply fan	480	72 Bhp		59.7	59.7
15	Safeguard building ventilation return fan	480	43 Bhp		35.6	35.6
15	Safeguard building battery exhaust fan	480	6 Bhp		5	5

Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads
Sheet 2 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Emergency feed water ventilation recirculation fan	480	2 Bhp		1.7	1.7
15	KAA pump room recirculation fan	480	2 Bhp		1.7	1.7
15	Emergency lighting panels (18)	480	155.7 kW		155.7	155.7
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Division 4 EUPS battery charger (4)	480	106 kW	106		
15	Annulus ventilation heating unit	480	6 kW	4.2 (2)		
15	Annulus ventilation fan	480	4.3 Bhp	3.6		
15	KAA/LAR valve room cooling fan	480	5 Bhp	4.1		
15	Extra boration room cooling fan	480	14 Bhp	11.6		
15	Fuel pool cooling pump room cooling fan	480	7.75 Bhp	6.4		
15	Fuel pool cooling pump room cooling fan	480	7.75 Bhp	6.4		

Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads
Sheet 3 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Fuel building ventilation heating unit (7)	480	15 kW	0		
15	Main control room air conditioning fan	480	27 Bhp	22.4		
15	Main control room air conditioning filtration unit heater (11)	480	10 kW	7 (2)		
15	Main control room air conditioning iodine train fan (11)	480	10 Bhp	8.3		
15	Safeguard building ventilation heaters (7)	480	210 kW	0		
15	Safeguard building ventilation supply fan	480	78 Bhp	64.6		
15	Safeguard building ventilation return fan	480	43 Bhp	35.6		
15	Safeguard building battery exhaust fan	480	7 Bhp	5.8		
15	Emergency feed water room ventilation recirculation fan	480	2 Bhp	1.7		
15	Emergency lighting panels (18)	480	178.7 kW	178.7		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		

Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads
Sheet 4 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Reactor building ventilation filtration fan	480	11 Bhp	9.1		
15	Reactor building filtration heating	480	25 kW	25		
15	Additional connected alternate feed loads	480	102.2 kW	102.2		
15	Safeguard building controlled-area ventilation system heating unit	480	21 kW	14.7 (2)		
15	Safeguard building controlled-area fan	480	9 Bhp	7.5		
15	Essential service water building ventilation and auxiliaries	480	110 kW		85.6(2) (12)	85.6(2) (12)
15	Essential service water building recirculation fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building supply fan 1	480	100 hp		82.9	82.9
15	Emergency power generating building supply fan 2	480	100 hp		82.9	82.9
15	Emergency power generating building exhaust fan 1	480	75 hp		62.2	62.2
15	Emergency power generating building exhaust fan 2	480	75 hp		62.2	62.2
	Additional connected loads	480	50.2 kW		50.2	50.2
15	Reserved for special use (18)	480	125 kW		125	125
15	Lighting (18)	480	300 kW		300	300

Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads
Sheet 5 of 6

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Load contribution from transformer and cable losses		160 kW	40	120	120
Subtotal Load Step Group 1				689.8 (10)	1644.5	1644.5
Load Step Group 2 (17)						
20	MHSI pump	6.9 kV	700 hp			580
Subtotal Load Step Group 2						580
Load Step Group 3 (17)						
25	LHSI pump	6.9 kV	500 hp			414
Subtotal Load Step Group 3						414
Load Step Group 4 (14)						
30	CCW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 4					1036	1036
Load Step Group 5 (14)						
35	ESW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 5					1036	1036
Load Step Group 6 (14)						
40	EFW pump	6.9 kV	700 hp		(5)	580
Subtotal Load Step Group 6					(5)	580
Load Step Group 7 (14)						
45	Division 3 safety chilled water compressor	6.9 kV	900 kW		1000	1000
Subtotal Load Step Group 7					1000	1000

Table 8.3-6—Division 3 Emergency Diesel Generator Nominal Loads
Sheet 6 of 6

Time Seq. (s) [13]	Load Description [8] [15] [19]	Volts	Rating (hp/kW) [3]	Alternate Feed Load (kW) [1] [12]	Operating Load LOOP (kW) [1] [12]	Operating Load DBA/ LOOP (kW) [1] [12]
Load Step Group 8 [14]						
50	Essential service water UHS fan 1	480	250 hp		207.2	207.2
50	Essential service water UHS fan 2	480	250 hp		207.2	207.2
Subtotal Load Step Group 8					414.4	414.4
Subtotal Alternate Feed Loads				689.8		
Total Automatically Sequenced Loads without alternate feed installed					5131.1	6706.0
Total Automatically Sequenced Loads with alternate feed installed					5821.0	7395.9
Additional Manually Connected Loads						
	Extra boration pump	480	163 Bhp	0 [20]		
	Fuel pool cooling pump [21]	480	137 Bhp	113.6		
	Emergency pressurizer heaters [16]	480	144 kW		144	
Total Manually Connected Loads				113.6	144	
Total Division 3 EDG Loading					6078.5	7509.4

Notes:

1. The kW rating derived from hp rating multiplied by 0.746 conversion factor. Indicated hp is considered rated. Where brake horsepower (Bhp) is indicated, this is from the system mechanical requirements.

2. A diversity factor of 0.7 is assumed in load contribution due to cyclical nature of load.

3. Motor efficiencies estimated at 90 percent.

4. One EUPS battery charger is in service with the other battery charger in standby. Contribution to EDG loading is calculated considering only one battery charger.

5. During a LOOP-only EDG loading sequence, the EFW start is prevented until load step group six, which occurs at 30 seconds. At load step six, the start inhibit is removed and the EFW pump start sequence is based on steam generator low level initiation. If a steam generator low level initiation exists, EFW pump start is given priority over subsequent load steps.
   During a LOOP/LOCA condition, the EFW pump is started at the sequence step indicated.

6. The divisional safety chilled water pumps and chiller are assumed operating for EDG loading purposes.

7. Worst case EDG loading occurs during summer operation when safety chilled water loading is highest. Area heater loads are shown, but do not contribute to overall EDG loading since operating conditions where heater operation is expected does not reflect bounding EDG loading scenario.

8. Loads represented in load groups are assumed running during the time duration assumed for accident analysis and mechanical system operational requirements, with the exception of motor-operated valves and dampers. Motor-operated valves and dampers are momentary loads, and are powered within EDG short-term ratings. Manually connected intermittent loads are applied following load sequencing, in accordance with approved operating procedures and their load contributions are within EDG long-term rating.

9. Deleted.

10. Alternate feed loads contributing to EDG loading are shown in the automatic sequenced loads with alternate feed installed totals.

11. Load only operated if control room high radiation signal present.

12. Efficiency estimated at 90 percent for motor loads.

13. EDG output breaker closure of T=15 seconds is an estimated time. Subsequent timing steps are based on EDG output breaker and occur in the sequence time interval after the output breaker closure.

14. During a LOOP-only condition, load steps two, three and six (based on steam generator level) are omitted resulting in the loading of this step earlier than LOOP/LOCA condition.

    A. During a LOOP-only sequence the steps are at the indicated time:

1. Step 4 20 seconds
2. Step 5 25 seconds
3. Step 7 30 seconds
4. Step 8 35 seconds

B. If an SI actuation occurs before closure of the EDG output breaker, the LOOP/LOCA sequence is followed.

C. If an SI actuation occurs after closure of the EDG output breaker, the sequence is interrupted and the DBA/LOOP sequence load steps two through six are performed. Following performance of load step six, the sequence is re-started where interrupted and performed to completion.

15. Loads are safety-related loads, unless otherwise indicated.

16. Non-safety-related load that can be manually applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

17. Load steps 2 and 3 are started by the load sequencer as indicated by an SI signal. Should a LOOP occur subsequent to starting LOCA mitigation loads, the sequence is reset and restarts at the closure of the EDG output breaker.

18. Non-safety-related load that is automatically applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

19. The inrush current for motor starting studies during EDG load sequencing is represented by locked-rotor impedance, which draws the maximum possible current from the system and has the most severe effect on other loads. Following the acceleration period, the motors represented in the load step are changed to a constant KVA load.

20. Contribution to EDG loading is not credited in total division 3 EDG loading column as this load is not credited to operate concurrently with MHSI and LHSI at rated power.

21. One fuel pool cooling pump in service, the other is in standby. Contribution to EDG loading is calculated considering only the inservice pump.

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
Sheet 1 of 7

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
Load Step Group 1						
0	Start Signal					
15	EDG reaches rated speed and voltage/output breaker closes					
15	Emergency power generating building electric room supply fan	480	10 Bhp		8.3	8.3
15	Emergency power generating building fuel oil storage tank room fan	480	13.4 Bhp		11.1	11.1
15	EDG starting air compressor	480	61 Bhp		50.6	50.6
15	EDG auxiliary loads	480	8.7 kW		8.7	8.7
15	Vent stack monitoring	480	13 kW		13	13
15	Division 4 EUPS battery charger (13)	480	106 kW		106	106
15	Annulus ventilation heating unit	480	6 kW		4.2 (2)	4.2 (2)
15	Annulus ventilation fan	480	4.3 Bhp		3.6	3.6
15	KAA/LAR valve room cooling fan	480	5 Bhp		4.1	4.1
15	Extra boration room cooling fan	480	14 Bhp		11.6	11.6
15	Fuel pool cooling punp room cooling fan	480	7.75 Bhp		6.4	6.4
15	Fuel pool cooling punp room cooling fan	480	7.75 Bhp		6.4	6.4
15	Fuel building ventilation heating unit (7)	480	15 kW		0	0
15	Safety chilled water pump (6)	480	100 Bhp		82.9	82.9
15	Safety chilled water pump (6)	480	100 Bhp		82.9	82.9

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
Sheet 2 of 7

Time Seq. (s) [13]	Load Description [8] [15] [19]	Volts	Rating (hp/kW) [3]	Alternate Feed Load (kW) [1] [12]	Operating Load LOOP (kW) [1] [12]	Operating Load DBA/ LOOP (kW) [1] [12]
15	Safety chiller condenser fans	480	240 kW		240	240
15	Main control room air conditioning fan	480	27 Bhp		22.4	22.4
15	Main control room air conditioning filtration unit heater [11]	480	10 kW			7 [2]
15	Main control room air conditioning iodine filtration fan [11]	480	10 Bhp			8.3
15	Safeguard building ventilation heaters [7]	480	210 kW		0	0
15	Safeguard building ventilation supply fan	480	78 Bhp		64.7	64.7
15	Safeguard building ventilation return fan	480	43 Bhp		35.6	35.6
15	Safeguard building battery exhaust fan	480	7 Bhp		5.8	5.8
15	Emergency feed water room ventilation recirculation fan	480	2 Bhp		1.7	1.7
15	Emergency lighting panels [18]	480	178.7 kW		178.7	178.7
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
Sheet 3 of 7

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Component cooling water valve hydraulic pump	480	5 Bhp		4.1	4.1
15	Division 3 EUPS battery charger	480	106 kW	106		
15	KAA/LAR valve room cooling fan	480	5 Bhp	4.1		
15	Safeguard building ventilation heaters (7)	480	180 kW	0		
15	Safeguard building ventilation supply fan	480	72 Bhp	59.7		
15	Safeguard building ventilation return fan	480	43 Bhp	35.6		
15	Main control room air conditioning fan	480	27 Bhp	22.4		
15	Safeguard building battery exhaust fan	480	6 Bhp	5		
15	Emergency feed water ventilation recirculation fan KAA pump room recirculation fan	480	2 Bhp	1.7		
15	KAA pump room recirculation fan	480	2 Bhp	1.7		
15	Emergency lighting panels (18)	480	155.7 kW	155.7		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
Sheet 4 of 7

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Component cooling water valve hydraulic pump	480	5 Bhp	4.1		
15	Additional connected alternate feed loads	480	39 kW	39		
15	Reactor building ventilation filtration fan	480	11 Bhp		9.1	9.1
15	Reactor building filtration heating	480	25 kW		25	25
15	Reactor building pit fan (18)	480	14 Bhp		11.6	11.6
15	Reactor building pit fan (18)	480	14 Bhp		11.6	11.6
15	MHSI/LHSI room recirculation fan	480	5 Bhp		4.1	4.1
15	JMU/KUL sample room recirculation fan	480	5 Bhp		4.1	4.1
15	Main control room air conditioning heaters (7)	480	21 kW		0	0
15	Severe accident sampling system	480	28 kW			28
15	Safeguard building ventilation recirculation fan	480	3 Bhp		2.5	2.5
15	Essential service water building ventilation and auxiliaries	480	110 kW		85.6 (2) (12)	85.6 (2) (12)
15	Essential service water building recirculation fan	480	10 Bhp		8.3	8.3
15	Safeguard building controlled-area ventilation system heating unit	480	21 kW			14.7 (2)
15	Safeguard building controlled-area fan	480	9 Bhp			7.5

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
Sheet 5 of 7

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
15	Emergency power generating building supply fan 1	480	100 hp		82.9	82.9
15	Emergency power generating building supply fan 2	480	100 hp		82.9	82.9
15	Emergency power generating building exhaust fan 1	480	75 hp		62.2	62.2
15	Emergency power generating building exhaust fan 2	480	75 hp		62.2	62.2
15	Additional connected loads	480	179.8 kW		179.8	179.8
15	Load contribution from transformer and cable losses		160 kW	40	120	120
Subtotal Load Step Group 1				495.7 (10)	1725.4	1790.0
Load Step Group 2 (17)						
20	MHSI pump	6.9 kV	700 hp			580
Subtotal Load Step Group 2						580
Load Step Group 3 (17)						
25	LHSI pump	6.9 kV	500 hp			414
Subtotal Load Step Group 3						414
Load Step Group 4 (14)						
30	CCW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 4					1036	1036

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
Sheet 6 of 7

Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
Load Step Group 5 (14)						
35	ESW pump	6.9 kV	1250 hp		1036	1036
Subtotal Load Step Group 5					1036	1036
Load Step Group 6 (14)						
40	EFW pump	6.9 kV	700 hp		(5)	580
Subtotal Load Step Group 6					(5)	580
Load Step Group 7 (14)						
45	Division 4 safety chilled water compressor	6.9 kV	900 kW		1000	1000
Subtotal Load Step Group 7					1000	1000
Load Step Group 8 (14)						
50	Essential service water UHS fan 1	480	250 hp		207.2	207.2
50	Essential service water UHS fan 2	480	250 hp		207.2	207.2
Subtotal Load Step Group 8					414.4	414.4
Subtotal Alternate Feed Loads				495.7		
Total Automatically Sequenced Loads without alternate feed installed					5212.1	6851.6
Total Automatically Sequenced Loads with alternate feed installed					5707.8	7347.3
Additional Manually Connected Loads						
	Emergency pressurizer heaters (16)	480	144 kW		144	
	Extra boration pump	480	163 Bhp		0 (20)	0 (20)
	Fuel pool cooling pump (21)	480	137 Bhp		113.6	113.6

Table 8.3-7—Division 4 Emergency Diesel Generator Nominal Loads
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Time Seq. (s) (13)	Load Description (8) (15) (19)	Volts	Rating (hp/kW) (3)	Alternate Feed Load (kW) (1) (12)	Operating Load LOOP (kW) (1) (12)	Operating Load DBA/ LOOP (kW) (1) (12)
	Severe accident heat removal pump (16)	6.9 kV	400 hp		0 (20)	0 (20)
Total Manually Connected Loads					257.6	113.6
Total Division 4 EDG Loading					5965.3	7460.8

Notes:

1. The kW rating derived from hp rating multiplied by 0.746 conversion factor. Indicated hp is considered rated. Where brake horsepower (Bhp) is indicated, this is from the system mechanical requirements.

2. A diversity factor of 0.7 is assumed in load contribution due to cyclical nature of load.

3. Motor efficiencies estimated at 90 percent.

4. One EUPS battery charger is in service with the other battery charger in standby. Contribution to EDG loading is calculated considering only one battery charger.

5. During a LOOP-only EDG loading sequence, the EFW start is prevented until load step group six, which occurs at 30 seconds. At load step six, the start inhibit is removed and the EFW pump start sequence is based on steam generator low level initiation. If a steam generator low level initiation exists, EFW pump start is given priority over subsequent load steps.
   During a LOOP/LOCA condition, the EFW pump is started at the sequence step indicated.

6. The divisional safety chilled water pumps and chiller are assumed operating for EDG loading purposes.

7. Worst case EDG loading occurs during summer operation when safety chilled water loading is highest. Area heater loads are shown, but do not contribute to overall EDG loading since operating conditions where heater operation is expected does not reflect bounding EDG loading scenario.

8. Loads represented in load groups are assumed running during the time duration assumed for accident analysis and mechanical system operational requirements, with the exception of motor-operated valves and dampers. Motor-operated valves and dampers are momentary loads, and are powered within EDG short-term ratings. Manually connected intermittent loads are applied following load sequencing, in accordance with approved operating procedures and their load contributions are within EDG long-term rating.

9. Deleted.

10. Alternate feed loads contributing to EDG loading are shown in the automatic sequenced loads with alternate feed installed totals.

11. Load only operated if control room high radiation signal present.

12. Efficiency estimated at 90 percent for motor loads.

13. EDG output breaker closure of T=15 seconds is an estimated time. Subsequent timing steps are based on EDG output breaker and occur in the sequence time interval after the output breaker closure.

14. During a LOOP-only condition load steps two, three and six (based on steam generator level) are omitted resulting in the loading of this step earlier than LOOP/LOCA condition.

    A. During a LOOP-only sequence the steps are at the indicated time:

        1. Step 4 20 seconds

        2. Step 5 25 seconds

        3. Step 7 30 seconds

        4. Step 8 35 seconds

    B. If an SI actuation occurs before closure of the EDG output breaker, the LOOP/LOCA sequence is followed.

    C. If an SI actuation occurs after closure of the EDG output breaker, the sequence is interrupted and the DBA/LOOP sequence load steps two through six are performed. Following performance of load step six, the sequence is re-started where interrupted and performed to completion.

15. Loads are safety-related loads, unless otherwise indicated.

16. Non-safety-related load that can be manually applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

17. Load steps 2 and 3 are started by the load sequencer as indicated by an SI signal. Should a LOOP occur subsequent to starting LOCA mitigation loads, the sequence is reset and restarts at the closure of the EDG output breaker.

18. Non-safety-related load that is automatically applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

19. The inrush current for motor starting studies during EDG load sequencing is represented by locked-rotor impedance, which draws the maximum possible current from the system and has the most severe effect on other loads. Following the acceleration period, the motors represented in the load step are changed to a constant KVA load.

20. Contribution to EDG loading is not credited in total division 4 EDG loading column as this load is not credited to operate concurrently with MHSI and LHSI at rated power.

21. One fuel pool cooling pump in service, the other is in standby. Contribution to EDG loading is calculated considering only the inservice pump.

Table 8.3-8—Emergency Diesel Generator Indications and Alarms

Parameter	Indication		Alarm	
	Control Room	Local	Control Room	Local
Voltage	X	X		
Frequency	X	X		
Current	X	X		
Power	X	X		
Reactive Power	X	X		
Winding Temperature		X		
Unit Running	X	X		
Power Factor		X		
Field Current	X	X		
Field Voltage	X	X		
Control Voltage			X	X
Breaker Position	X	X		
Starting Air Pressure		X	X	X
Lubricating System Pressure		X	X	X
Fuel Oil Pressure		X	X	X
Cooling Water Pressure		X	X	X
Cooling Water Temperature		X	X	X
Outboard Bearing Temperature		X	X	X