TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

9.0 ELECTRICAL SYSTEMS

Learning Objectives:

1. State the purposes of the following:

   a. Onsite standby gas turbine generators
   b. Alternate ac gas turbine generators
   c. Class 1E onsite ac power system
   d. Non-Class 1E onsite ac power system
   e. Class 1E dc power system
   f. Non-Class 1E dc power system

2. Describe the major differences between the electrical system design of the US-APWR and those of currently operating PWRs.

9.1 Overview

9.1.1 General

Offsite electric power is provided to the US-APWR plant site from the grid by at least two physically independent transmission lines. During plant startups and shutdowns and during all postulated accident conditions, electric power is supplied to the plant site from the plant high voltage switchyard through two physically independent transmission tie lines. One of these two transmission tie lines connects to the high voltage side of the main transformer (MT), and the other connects to the high voltage sides of the reserve auxiliary transformers (RATs). The main generator (MG) is connected to the low voltage side of the MT and the high voltage side of the unit auxiliary transformers (UATs). There is a generator load break switch (GLBS) between the MG and the MT. When the MG is on line, it provides power to the onsite nonsafety-related electric power system through the UATs. When the GLBS is open, offsite power to the onsite nonsafety-related electric power system is provided through the MT and the UATs. With the GLBS either open or closed, offsite power to the onsite safety-related electric power system is provided through the RATs. If power is not available through the UATs, offsite power is provided to both the safety-related and the nonsafety-related onsite electric power systems through the RATs. Similarly, if power is not available through the RATs, offsite power is provided to both the safety-related and the nonsafety-related onsite electric power systems through the UATs.

The onsite electric power system provides power to all plant auxiliary and service loads. The onsite electric power system is comprised of alternating current (ac) and direct current (dc) systems. Both ac and dc onsite electric power systems have a safety-related Class 1E power system feeding all Class 1E loads, and a nonsafety-related non-Class 1E power system feeding all non-Class 1E loads. The Class 1E onsite power system has four independent trains. Each train of the Class 1E ac onsite power system, in addition to its connection to offsite power sources from the grid, has an onsite emergency power source, consisting of a generator driven by a gas turbine. Each train of the Class 1E dc onsite power distribution system, in addition to its connection to the corresponding ac train through a battery charger, is provided with a dedicated Class 1E battery power source.

The reference plant has two circuits connected to offsite power sources, four onsite Class 1E emergency gas turbine generator (GTG) power sources, two onsite non-Class 1E GTG power sources, and four Class 1E and four non-Class 1E dc battery power sources. The non-Class 1E GTGs provide power to all electrical loads that are required to safely shut down the unit and keep it in a safe-shutdown mode upon the loss of all offsite and all other onsite ac power sources.

Figure 9-1 is a simplified electrical one-line diagram depicting the ac and dc onsite and offsite electric power system for the reference plant.

9.1.2 Utility Power Grid Description

The plant operating company's grid system and its interconnections to other grid systems and generating stations are site specific and not within the scope of the reference plant design.

9.1.3 Offsite Power System Description

Offsite power sources are the preferred sources of power for the safety-related Class 1E onsite electric power system. The normal preferred source is grid power through the RATs to the safety-related Class 1E 6.9-kV buses. The alternate preferred source is grid power backfed through the MT and through the UATs to the safety-related Class 1E 6.9-kV buses.

The major components of the offsite electric power system include the circuit breakers in the switchyard, the transmission tie lines between the switchyard and the plant, the MT, the isolated-phase bus duct (IPB), the GLBS, the UATs, the RATs, and the transformer connections to the 13.8-kV and 6.9-kV buses. The offsite power system begins at the terminals on the transmission-line sides of the circuit breakers in the switchyard connecting to the transmission systems. It ends at the line-side terminals of the main power supply circuit breakers feeding the 13.8-kV and 6.9-kV buses, and at the terminals on the MG side of the GLBS.

During plant startups and normal and emergency shutdowns, including all postulated accident conditions, the offsite power system brings power from the offsite transmission system to the onsite electric power system. During normal plant operation, the offsite power system transmits generated power to the offsite transmission system and provides power to plant auxiliary and service loads through the onsite electric power system.

The components of the offsite power system that are associated with the normal preferred power supply (PPS), and the components that are associated with the alternate preferred power supply, are physically separated and designed to exclude, to the extent practical, the potential for simultaneous failure of the normal and alternate preferred power supply systems under operating and postulated accident conditions.

9.1.4 Onsite Power System Description

The onsite power system consists of an ac power system and a dc power system. Both systems are comprised of Class 1E and non-Class 1E subsystems. All plant auxiliary and service loads are powered from the onsite power system. Two independent power circuits of the offsite power system can supply power to the onsite power system. Four Class 1E GTGs provide backup power to the ac Class 1E onsite power system. The reference plant also has two non-Class 1E GTGs as alternate alternating current (AAC) power sources. Each of the Class 1E and non-Class 1E dc subsystems is normally powered by battery chargers connected to the onsite ac power system. When power from the battery chargers is not available, the onsite dc power system is supplied by station batteries.

There are two non-Class 1E 13.8-kV medium voltage (MV) buses, four non-Class 1E 6.9-kV MV buses, two non-Class 1E 6.9-kV MV permanent buses, and four Class 1E 6.9-kV MV buses. All low voltage buses are supplied from the MV buses. Each of the Class 1E 6.9-kV MV buses has its own onsite Class 1E standby emergency power source. Similarly, each of the non-Class 1E 6.9-kV MV permanent buses has its own onsite non-Class 1E standby emergency power source, designated as an AAC power source. All MV buses can be powered from either a UAT or an RAT.

There are four two-winding UATs. The high voltage sides of these transformers are connected to the main generator isolated-phase bus downstream of the GLBS. During normal power operation of the plant with the GLBS closed, the MG provides power to the eight non-Class 1E MV buses through the UATs. During all other modes of plant operation with the GLBS open, including postulated accidents (PAs), these MV buses are backfed through the MT and UATs from offsite power.

There are four three-winding RATs. The high voltage sides of these transformers are connected to the high voltage transmission tie line from the switchyard. The transmission tie-line voltage level is site specific. During all modes of plant operation including startups, normal and emergency shutdowns, and PAs, the four Class 1E MV buses are powered via the RATs from offsite power. The RATs constitute the normal preferred power source for all plant safety-related auxiliary and service loads.

Each of the safety-related and nonsafety-related MV buses is connected to both a UAT and an RAT. For each Class 1E MV bus, power from an RAT is the normal preferred source and power from a UAT is the alternate preferred source. Each safety-related MV bus also has its own backup emergency power supply from a safety-related Class 1E GTG. Each MV permanent bus also has its own backup emergency power supply from a dedicated non-Class 1E GTG.

In addition to the 13.8-kV and 6.9-kV buses, the onsite power distribution system also has lower voltage (480-V ac, 208/120-V ac, 125-V dc) power distribution systems. The MV buses feed the 480-V load center buses through the station service transformers (SSTs). The 480-V load center buses feed all 480-V motor control center (MCC) buses except the 480-V ac motor-operated valve (MOV) MCCs, which are supplied from the inverters. The 480-V MCC buses feed the 208/120-V buses through distribution transformers. The 480-V MCC buses also feed the 125-V dc buses through battery chargers. The safety-related MV buses feed the corresponding safety-related low voltage buses, and the nonsafety-related MV buses feed the nonsafety-related low voltage buses.

The onsite power distribution system also includes both safety and nonsafety instrumentation and control (I&C) power supply systems. The I&C power supplies are 120-V ac uninterruptible power supplies (UPSs). The UPSs are normally powered from 480-V MCCs through inverters, with battery backup.

9.1.4.1 Safety Systems

Each of the Class 1E ac and dc onsite power systems consists of four completely independent power supply systems, identified as the A, B, C, and D trains. In general, the plant safety-related loads are also divided into four redundant load groups (four 50% subsystems). Each load group is served by a corresponding train of the power supply system. The safety systems that have four load groups require any two out of the four load groups to be operable to perform the applicable safety function. Some safety-related ac and dc loads are divided into two redundant load groups (two 100% subsystems). The safety systems that have two load groups require one out of the two load groups to be operable to perform the applicable safety function. These two 100% ac load groups are served by Class 1E 480-V load center buses A1 and D1. The A1 load center bus is normally connected to the train A Class 1E 480-V load center. During a maintenance outage of the train A GTG, the A1 load center is manually connected to the train B Class 1E 480-V load center. Similarly, the D1 load center bus is normally connected to the train D Class 1E 480-V load center. During a maintenance outage of the train D GTG, the D1 load center is manually connected to the train C Class 1E 480-V load center. The two 100% dc load groups are served by Class 1E 125-V dc buses A1 and D1. The A1 dc bus is normally connected to the train A Class 1E 125-V dc bus. During a maintenance outage of the train A GTG, the A1 dc bus is manually connected to the train B Class 1E 125-V dc bus. The D1 bus connection is similar to that of the A1 bus. The onsite ac and dc distribution configuration provides for the safe shutdown of the plant with any two safety-related power supply trains, assuming a single failure which disables one train coincident with online maintenance of a Class 1E GTG in any other train.

9.1.4.2 Nonsafety Systems

The majority of the plant nonsafety auxiliary and service loads is divided into two or more load groups for improved plant performance and reliability. Accordingly, the nonsafety-related ac, dc and I&C power supply systems are also divided into two or more redundant groups. However, there are no specific physical separation or electrical isolation requirements for these redundant groups. Nonsafety-related power distribution system buses are designated with the prefix “N” or “P.” The P buses can be powered from the alternate ac power sources. The N and P buses are electrically isolated and physically separated from all trains of the Class 1E safety-related power distribution system.

9.2 Offsite Power System

9.2.1 Transmission System

The transmission system is not within the scope of the US-APWR electrical design. The COL applicant is to implement the transmission system interfaces for the US-APWR.

9.2.2 Offsite Power System Description

The offsite power system is a nonsafety-related, non-Class 1E system. The plant switchyard is connected to the transmission grid by at least two electrically independent and physically isolated power circuits. As a minimum, there are two electrically isolated and physically independent power circuits connecting the plant to the switchyard. The COL applicant is to assure the availability of at least two electrically isolated and physically independent power circuits as the normal and alternate preferred power sources.

Offsite electric power is provided to the onsite power system from the grid and other generating stations by at least two physically independent transmission lines. The plant's high voltage switchyard is site specific and not a part of the reference plant design. During plant startups, shutdowns, maintenance, and all postulated accident conditions, offsite electric power can be supplied to the plant site from the plant high voltage switchyard through two physically independent transmission tie lines. One of these two transmission tie lines connects to the high voltage side of the MT, and the other connects to the high voltage sides of the RATs. The MG is connected to the low voltage side of the MT and the high voltage sides of the UATs. There is a GLBS between the MG and the MT. When the MG is on line, it provides power to the onsite nonsafety-related electric power system through the UATs. When the GLBS is open, offsite power to the onsite nonsafety-related electric power system is provided through the MT and the UATs. With the GLBS either open or closed, offsite power to the onsite safety-related electric power system is provided through the RATs. If power is not available through the UATs, offsite power is provided to both safety-related and nonsafety-related onsite electric power systems through the RATs. Similarly, if power is not available through the RATs, offsite power is provided to both safety-related and nonsafety-related onsite electric power systems through the UATs. Both the normal and the alternate preferred power sources have the capability to serve the total plant auxiliary and service loads during all modes of plant operation, including postulated accident conditions.

The MG is connected to the GLBS through an isolated-phase bus duct cooled by forced air with water cooling. The other side of the GLBS is connected to the low voltage side of the MT, also through an isolated-phase bus duct. This isolated-phase bus duct has a tap connection to the high voltage sides of the UATs through disconnect links. The MT consists of three single-phase transformers with one installed spare.

There are two non-Class 1E 13.8-kV MV buses N1 and N2, four non-Class 1E 6.9-kV MV buses N3, N4, N5 and N6, two non-Class 1E 6.9-kV MV permanent buses P1 and P2, and four Class 1E 6.9-kV MV buses A, B, C and D. MV bus N1 can be fed from UAT1 or RAT1. MV bus N2 can be fed from UAT2 or RAT2. MV buses N3, N4, A, B, and P1 can be fed from UAT3 or RAT3. MV buses N5, N6, C, D, and P2 can be fed from UAT4 or RAT4. For each MV bus, if power is lost from one source, the bus is automatically transferred to the other source by a fast or slow transfer scheme. If the replacement bus voltage is adequate, a fast transfer is initiated; if not, a slow transfer is initiated. Performance of these transfers is permitted when the bus-faulted signal is not initiated. All low voltage buses are supplied by the MV buses. Each of the 6.9-kV Class 1E MV buses has its own onsite Class 1E standby emergency power source. Similarly, each of the 6.9-kV non-Class 1E MV permanent buses has its own onsite non-Class 1E standby emergency power source, designated as an AAC power source.

There are four two-winding UATs, namely UAT1, UAT2, UAT3, and UAT4. The high voltage sides of these transformers are connected to the main generator isolated-phase bus duct downstream of the GLBS. During normal power operation, with the GLBS closed, the MG provides power to plant MV buses N1, N2, N3, N4, N5, N6, P1, and P2 through the UATs. During all other modes of plant operation with the GLBS open, including PAs, these MV buses are backfed through the MT and UATs from offsite power.

There are four three-winding RATs, namely RAT1, RAT2, RAT3, and RAT4. The high voltage sides of these transformers are connected to the high voltage transmission tie line from the switchyard. The transmission tie-line voltage is site specific. During all modes of plant operation including startup, normal and emergency shutdown, and PAs, the MV Class 1E buses A, B, C and D are powered through the RATs from offsite power. The RATs constitute the normal preferred power source for all plant safety-related auxiliary and service loads.

Each of the safety-related and nonsafety-related MV buses (13.8-kV non-Class 1E buses N1 and N2; 6.9-kV Class 1E buses A, B, C, and D; and 6.9-kV non-Class 1E buses N3, N4, N5, N6, P1, and P2) is connected to a UAT and an RAT. For each Class 1E (A, B, C, and D) MV bus, power from an RAT is the normal preferred source, and power from a UAT, backfed through the MT, is the alternate preferred source. Each safety-related MV bus also has its own backup emergency power supply from a safety-related Class 1E GTG. Each of permanent MV buses P1 and P2 also has its own backup emergency power supply from a dedicated non-Class 1E GTG.

During a coincident loss of offsite power (LOOP) and loss-of-coolant accident (LOCA), the safety-related MV buses are powered from onsite Class 1E emergency GTG power sources. The unit is also provided with alternate ac power sources for powering the loads that are needed to operate during a station blackout (SBO) event. The equipment and circuits that are associated with the offsite power system are physically independent from the onsite power system and the alternate ac sources. Any single failure in the offsite power system, in the onsite power system, or in the AAC sources will have no impact on the availability of the remaining systems.

The main transformer, UATs, and RATs are designed and constructed to withstand mechanical and thermal stresses produced by the worst-case external short circuit; they meet the corresponding requirements of IEEE Std C57.12.00.

The ratings of the MG, the GLBS, the MT, the UATs, and the RATs are as follows:

Equipment	Rating
Main generator	1,900 MVA, 26 kV, 60 Hz
Generator load break switch	28 kV, 44.4 kA, 60 Hz
Main transformer	Three single-phase transformers and one installed spare, each rated at 610 MVA for a combined rating of 1,830 MVA, 60 Hz. Low voltage side is 26 kV; high voltage side is site specific.
Unit auxiliary transformers (UAT1 and UAT2)	72 MVA, 26 – 13.8 kV, 60 Hz
Unit auxiliary transformers (UAT3 and UAT4)	53 MVA, 26 – 6.9 kV, 60 Hz
Reserve auxiliary transformers (RAT1 and RAT2)	72 MVA, 60 Hz, low voltage side 13.8 kV, high voltage side is site specific.
Reserve auxiliary transformers (RAT3 and RAT4)	53 MVA, 60 Hz, low voltage side 6.9 kV, high voltage side is site specific.

The GLBS has the capability to break the maximum credible generator full-load current. For a normal plant shutdown or an emergency shutdown in response to any design-basis event (DBE), except for an electrical fault in the 26-kV power system or associated equipment and circuits, the GLBS is opened, and power to all auxiliary and service loads is maintained without any interruption from the alternate preferred offsite power source through the UATs. During an emergency shutdown of the plant due to any electrical fault in the 26-kV system or associated equipment and circuits, the fault is isolated by opening the main circuit breakers on the high voltage side of the MT and by opening all incoming circuit breakers of the MV buses connected to the UATs, and all affected MV buses are automatically transferred to the RATs. The MV Class 1E buses would not have to transfer, since these are normally fed from the RATs. The UAT incoming breakers to these buses are locked out and blocked from closing.

Unit synchronization is normally through the GLBS. Synchrocheck relays are used to ensure proper synchronization of the unit to the offsite power system.

High voltage circuit breakers are sized and designed in accordance with IEEE Std C37.010 and C37.06. High voltage disconnecting switches are sized and designed in accordance with IEEE Std C37.32.

The MTs, UATs, and RATs have differential, overcurrent, sudden pressure, and ground overcurrent protection schemes per IEEE Std 666. The COL applicant is to provide site-specific protection schemes.

The isolated-phase bus duct provides the electrical interconnections between generator load terminals and the GLBS, between the GLBS and the MT, between the GLBS and the disconnect links on the high voltage sides of the UATs, and between the disconnect links and the UATs. Nonsegregated-phase bus ducts/cable buses provide electrical connections between the low voltage sides of the UATs and RATs and the 13.8-kV and 6.9-kV MV switchgear. The nonsegregated-phase bus ducts/cable buses from the UATs and RATs are physically separated to minimize the likelihood of simultaneous failure.

Each of the single-phase transformers of the MT is provided with disconnect links so that a failed transformer may be taken out of service and that the spare transformer can be connected. All UATs are also provided with disconnect links so that a failed transformer can be taken out of service. With one UAT or one RAT out of service, each MV bus has access to at least one offsite power source.

The MT, UATs, and RATs are all located in the transformer yard adjacent to the turbine building (Figure 9-2). Three-hour-rated fire barriers are provided between the RAT area and the MT/UAT area. Each transformer is provided with containment for collection of transformer oil in case of tank leakage or rupture.

Cables associated with the normal preferred, alternate preferred, and onsite power system circuits are physically separated from each other to minimize the potential for common-mode failure. These circuits may share a common underground duct bank.

9.2.3 Switchyard

The plant switchyard design is site specific. The COL applicant is to provide at least two physically independent power circuits between the offsite grid system and the plant's high voltage switchyard. The design of the interface is to be provided by the COL applicant. There are two physically independent transmission tie lines from the plant high voltage switchyard to the onsite transformer yard. These two power circuits are designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure under normal operating and postulated accident conditions. Each power circuit has sufficient capacity and capability to assure satisfactory operation of all safety-related loads and nonsafety-related loads.

9.3 Onsite Power Systems

The onsite power system provides power to the plant auxiliary and service loads during all modes of plant operation. The onsite power system consists of both an ac power system and a dc power system. Both the ac and dc systems include Class 1E and non-Class 1E subsystems. The onsite ac power system and its connections to the offsite power system are shown in Figure 9-1.

9.3.1 AC Power Systems

The onsite ac power system includes normal power systems powered from the offsite power sources, emergency power systems backed up by Class 1E GTGs, and permanent power systems backed up by non-Class 1E AAC GTGs.

The onsite ac power system is supplied offsite power from the transmission system by two independent connections to the transmission system (the transmission voltages are site specific). Each offsite power connection has enough capacity and capability to power the loads required during all modes of plant operation, including plant startup, shutdown, maintenance, and postulated accident conditions. One connection to the transmission system is provided through the MT and the UATs. The UATs are also connected to the MG through a GLBS. During power operation, the GLBS is closed, the MG is connected to the transmission system through the MT, and the MG also supplies power to the UATs. The second connection to the transmission system is provided through the RATs. The voltage of the high voltage windings of the RATs is site specific. The onsite ac power systems are normally fed from either the UATs or the RATs. The MV Class 1E buses are normally fed from the RATs. The MV non-Class 1E buses are normally fed from the UATs.

Four two-winding UATs and four three-winding RATs are provided for each unit. Delta connected tertiary winding is provided for the star-star connected RATs. The tertiary winding is not loaded. The UATs are connected on the high voltage sides to the MG's output isolated-phase bus duct through disconnecting links. The disconnecting links are always closed except during UAT maintenance. UAT1, UAT2, RAT1, and RAT2 provide power to the 13.8-kV onsite ac buses, and UAT3, UAT4, RAT3, and RAT4 provide power to the 6.9-kV onsite ac buses.

Four emergency Class 1E GTGs provide backup power to the Class 1E 6.9-kV onsite ac buses. In addition, two non-Class 1E AAC GTGs provide backup power to the non-Class 1E 6.9-kV permanent buses.

The onsite ac power system provides power at nominal voltage ratings of 13.8 kV, 6.9 kV, 480 V, 208 V, and 120 V. The 13.8-kV power system is nonsafety related and non-Class 1E. The 6.9-kV, 480-V, 208-V, and 120-V ac power systems include both safety-related Class 1E and nonsafety-related non-Class 1E subsystems. The onsite ac power system arrangement shown in Figure 9-1 permits the distribution of functionally redundant load groups on separate buses for better equipment availability and operational flexibility.

9.3.1.1 Non-Class 1E Onsite AC Power System

The 13.8-kV ac system includes non-Class 1E buses N1 and N2. Bus N1 is connected to either UAT1 or RAT1, and bus N2 is connected to either UAT2 or RAT2, by nonsegregated bus duct/cable buses. The ratings of UAT1, UAT2, RAT1, and RAT2 are shown in Table 9-1.

The non-Class 1E 6.9-kV ac system includes buses N3, N4, N5, N6, P1, and P2. Buses N3, N4, and P1 are connected to either UAT3 or RAT3, and buses N5, N6, and P2 are connected to either UAT4 or RAT4, by nonsegregated bus duct/cable buses. The ratings of UAT3, UAT4, RAT3, and RAT4 are shown in Table 9-1.

The UAT and RAT ratings are adequate to meet the maximum load requirements during normal plant operation, startups, shutdowns, and design-basis events.

Non-Class 1E 6.9-kV permanent buses P1 and P2 are also connected to the non-Class 1E A-AAC GTG and B-AAC GTG, respectively. The loads which are not safety related but which are required to operate during an LOOP are connected to these buses (see Figure 9-3). The AAC GTGs have different ratings and diverse starting mechanisms, as compared to the Class 1E GTGs. The AAC GTGs are selected as non-Class 1E to minimize common-cause failures with the Class 1E GTGs. The AAC GTGs are started by dc power supplied from batteries, and the Class 1E GTGs are started by compressed air systems. The ratings of the AAC GTGs are shown in Table 9-1. Any one AAC GTG is adequate to meet the load requirements shown in Tables 9-2 and 9-3 during LOOP and SBO conditions.

Normal offsite power to non-Class 1E 13.8-kV buses N1 and N2 and to non-Class 1E 6.9-kV buses N3, N4, N5, N6, P1, and P2 is provided from the UATs, and alternate offsite power is provided from the RATs. Automatic bus transfer schemes are provided for all of these buses to automatically transfer the loads from the normal offsite power source to the alternate offsite power source in the case of a loss of normal power to a bus. Restoration of power from the alternate offsite source back to the normal offsite source is a manual operation.

An LOOP condition occurs if power from both the UATs and RATs is lost to the onsite ac power system buses. Motor loads fed from these buses are tripped by the bus undervoltage relays. However, power to non-Class 1E 6.9-kV ac permanent buses P1 and P2 is automatically restored from the A-AAC GTG and B-AAC GTG, respectively. The A-AAC GTG is started automatically by the undervoltage relays on bus P1, and the B-AAC GTG is started automatically by the undervoltage relays on bus P2 during the LOOP condition. As soon as the AAC GTGs reach their preset voltage and frequency targets, the circuit breakers connecting the A-AAC GTG and B-AAC GTG to their respective selector circuits are closed. The circuit breakers in the 6.9-kV switchgears for P1 and P2 and the disconnect switches in selector switches A and B, connecting 6.9-kV bus P1 to selector circuit A and bus P2 to selector circuit B, are normally closed. Therefore, power to 6.9-kV buses P1 and P2 is restored as soon as the circuit breakers connecting the A-AAC GTG to selector circuit A and the B-AAC GTG to selector circuit B are closed. The automatic load sequencers start the loads on permanent buses P1 and P2 as required under the LOOP condition.

Each of the AAC GTGs can also be connected manually to its respective 6.9-kV permanent bus during periodic online testing of the AAC GTGs. This can be done locally from the panels located in the power source buildings housing the AAC GTGs, or remotely from the main control room (MCR).

The 13.8-kV to 480-V, two-winding SSTs connected to 13.8-kV buses N1 and N2 provide power to non-Class 1E 480-V load center buses N1 and N2, respectively.

The 6.9-kV to 480-V, two-winding SSTs connected to 6.9-kV buses N3, N4, N5, N6, P1, and P2 provide power to non-Class 1E 480-V load center buses N3, N4, N5, N6, P1, and P2 respectively. The non-Class 1E 480-V load center buses feed the non-Class 1E MCC buses.

A tie connection is provided between all non-Class 1E 480-V load center buses so that, in the case of a loss of power from any one of the non-Class 1E SSTs, the loads on the affected load center bus can be transferred manually to any of the remaining operable load center buses.

Each reactor coolant pump (RCP) motor is connected to a non-Class 1E 6.9-kV switchgear bus (N3, N4, N5, or N6) through two circuit breakers in series. For each pump, one circuit breaker is located in the reactor building, and it is qualified for Class 1E application. The other circuit breaker has the same quality, and it is located in non-Class 1E 6.9-kV switchgear in the turbine building.

The non-Class 1E 13.8-kV switchgear N1 and N2, 6.9-kV switchgear N3, N4, N5, N6, P1, and P2, and 480-V load centers N1, N2, N3, N4, N5, N6, P1, and P2, are located in the turbine building electrical room as shown in Figure 9-2. The status of these circuit breakers is displayed in the MCR.

The A-AAC GTG and B-AAC GTG are located in dedicated rooms in separate power source buildings. The rooms for the A-AAC GTG and B-AAC GTG are thus physically separated from each other and also from the Class 1E GTG rooms. The non-Class 1E AAC GTGs have different ratings and diverse starting mechanisms compared to the Class 1E GTGs and do not share any common auxiliaries or support systems with the Class 1E GTGs. This arrangement minimizes the potential for common-cause failure between the AAC GTGs and the Class 1E GTGs. Each AAC GTG is provided with a 1.5-hour fuel oil day tank and a fuel oil storage tank. The fuel capacity is adequate for 7 days of operation. During an SBO, the power to Class 1E bus A or B is restored manually from the A-AAC GTG by closing the appropriate disconnect switch in selector circuit A and the incoming circuit breaker in Class 1E 6.9-kV switchgear A or B, to cope with the SBO condition. Similarly, during an SBO, the power to Class 1E bus C or D can also be restored manually from the B-AAC GTG by closing the appropriate disconnect switch in selector circuit B and the incoming circuit breaker in Class 1E 6.9-kV switchgear C or D. Only one safety train is required for coping with the SBO event. Table 9-3 shows the loading on an AAC GTG during an SBO. The details of switching operations to restore power to the Class 1E power system during an SBO are included in section 9.4.

The UATs, RATs, and SSTs are protected with differential relays for internal faults and time-overcurrent relays as backup protection. The incoming circuit breakers to the non-Class 1E 13.8-kV and 6.9-kV buses are provided with undervoltage and time-overcurrent protections. The feeders on the 13.8-kV and 6.9-kV buses are provided with instantaneous and time-overcurrent protection.

9.3.1.2 Class 1E Onsite AC Power System

The Class 1E onsite ac power systems provide power to the safety-related loads required during LOOPs and postulated accident conditions. The power from the transmission system to the Class 1E distribution is the preferred power source under accident and post-accident conditions. The Class 1E onsite ac power system consists of four independent and redundant trains, A, B, C, and D, as shown in Figure 9-1. Two independent connections to the offsite power system are provided to each of the Class 1E 6.9-kV ac onsite buses. Class 1E 6.9-kV buses A and B have connections to UAT3 and RAT3, and buses C and D have connections to UAT4 and RAT4 through nonsegregated bus ducts/cable buses. Each redundant train is backed up by a Class 1E GTG. The four trains are physically separated and electrically isolated from each other and also from the non-Class 1E systems in accordance with IEEE Std 384, as endorsed by RG 1.75.

The 6.9-kV to 480-V, two-winding SSTs connected to Class 1E 6.9-kV buses A, B, C, and D provide power to Class 1E 480-V load center buses A, B, C, and D, respectively. The Class 1E 480-V load center buses feed the Class 1E MCC buses, except for the Class 1E 480-V ac MOV MCCs, which are supplied from inverters. The A MOV MCC1, A MOV MCC2, B MOV MCC, C MOV MCC, D MOV MCC1, and D MOV MCC2 buses are fed from the Class 1E 125-V dc buses as shown in Figure 9-1. The Class 1E onsite ac power system includes 6.9-kV, 480-V, and 120-V ac systems. Each bus voltage is indicated in the MCR.

The Class 1E 6.9-kV bus in each train is provided with offsite power from two connections to the transmission system, one through the RAT and the other through the UAT. The normal preferred offsite power is provided from the RATs, and the alternate preferred offsite power is provided from the UATs. Each offsite power circuit is capable of supplying the Class 1E load requirements during all plant operating conditions, anticipated operational occurrences, and design-basis events. Any two Class 1E trains, including the power sources, are adequate to supply the loads required during LOOP and LOCA conditions occurring simultaneously.

Class 1E 6.9-kV buses A, B, C, and D are backed up by Class 1E GTGs A, B, C, and D, respectively. The rating of the Class 1E GTGs is shown in Table 9-1. In the case of an LOOP to any Class 1E 6.9-kV bus, the undervoltage relays on the bus trip all the motor loads connected to that bus and start the Class 1E GTG associated with that bus. Power to the Class 1E bus is restored automatically when the Class 1E GTG circuit breaker closes after the Class 1E GTG reaches its voltage and frequency targets. The required loads on the bus are automatically started in sequence by the load sequencer.

The 6.9-kV to 480-V Class 1E SSTs A, B, C, and D provide power to the 480-V Class 1E load centers A, B, C, and D, respectively.

Four-train safety system loads are distributed on redundant Class 1E trains A, B, C, and D. Two-train safety system loads are distributed on Class 1E 480-V buses A1 and D1. A1 buses are normally powered by train A and can be powered from train B. Similarly, D1 buses are normally powered by train D and can be powered from train C.

The availability of power from any two trains is adequate to meet the load requirements during all design-basis events, such as an LOOP and a LOCA occurring simultaneously. No automatic tie connections are provided between redundant Class 1E trains A, B, C, and D. The distribution of loads on Class 1E ac buses A, B, C, and D is shown in Figure 9-4.

Class 1E 6.9-kV buses A, B, C, and D are also provided with connections to 6.9-kV non-Class 1E AAC GTGs A and B. Class 1E 6.9-kV buses A and B can be connected to the A-AAC GTG, and Class 1E 6.9-kV buses C and D can be connected to the B-AAC GTG, during an SBO condition. Switching operations to restore power to the Class 1E power system during an SBO are described in section 9.4.

Two independent connections to the offsite power system are provided to each of the 6.9-kV ac onsite Class 1E buses, A, B, C, and D. These two connections are designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure under operating, postulated accident, and environmental conditions. The connections from the non-Class 1E offsite power sources are electrically isolated from the Class 1E buses through Class 1E circuit breakers in the Class 1E 6.9-kV switchgear. In the case of a loss of power from an RAT to any Class 1E 6.9-kV bus, that bus is automatically transferred to the appropriate UAT if available, or to the associated Class 1E GTG. RAT protective relays initiate an automatic fast transfer of a Class 1E bus from the normal RAT supply to the appropriate UAT. An undervoltage signal on a Class 1E bus trips the bus motor loads, starts the associated Class 1E GTG, and initiates a slow transfer (after one second) to the appropriate UAT. If the UAT does not restore the Class 1E bus voltage, the GTG supplies the bus. Once the bus voltage is restored, bus loads are restarted by the LOOP load sequencer. The automatic bus transfer, load shedding, and load sequencing schemes for the redundant Class 1E trains are independent.

The connection between each Class 1E 6.9-kV bus and one of the non-Class 1E AAC GTGs (A or B) is provided through two isolation devices in series which are normally open: a Class 1E circuit breaker provided at the Class 1E 6.9-kV switchgear end and a non-Class 1E disconnect switch in non-Class 1E selector circuit A or B. The connections between the Class 1E 6.9-kV buses and non-Class 1E selector circuits are administratively controlled and are closed manually during an SBO condition. Class 1E 6.9-kV bus A or B can be connected to the A-AAC GTG, and Class 1E 6.9-kV bus C or D can be connected to the B-AAC GTG, during an SBO condition.

The major distribution equipment of each Class 1E train is located in a physically separate room. Redundant safe shutdown components and the associated redundant Class 1E electrical trains are separated from the other Class 1E trains and from non-Class 1E systems by three-hour-rated fire barriers to preserve the capability to safely shutdown the plant following a fire. Access to the Class 1E power equipment areas is administratively controlled. The reactor building and safety-related power source buildings are structurally designed to meet seismic category I requirements as defined in RG 1.29. These structures are designed to withstand the effects of natural phenomena such as hurricanes, floods, tornados, tsunamis, and earthquakes without the loss of capability to perform safety functions by housed equipment. They are also designed to withstand the effects of postulated internal events such as fires and flooding without the loss of capability to perform safety functions by housed equipment. The orientation of the reactor building and safety-related power source buildings, where Class 1E onsite power system components are located, is such that the probability of a turbine missile striking the reactor building or power source buildings is minimized. The Class 1E onsite power system components are also protected from internally generated missiles and tornado-generated missiles. Safety-related components are protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, as a result from equipment failure or events and conditions outside the nuclear power unit. Class 1E equipment important to safety is protected from the dynamic effects of pipe rupture.

Auxiliary support systems such as fuel oil systems, compressed air systems, and control power supplies are also separate and independent for each Class 1E train. The Class 1E power to an auxiliary support system is derived from the same train that it serves. The heating, ventilation, and air conditioning (HVAC) systems that support operation of a particular train of Class 1E ac distribution equipment are powered from that train.

The four Class 1E trains are electrically isolated from the offsite power supplies and from each other. The power sources to the Class 1E 6.9-kV buses are not operated in parallel except for a short period of time during the testing of a Class 1E GTG in parallel with an offsite source. There are no automatic tie connections between the redundant Class 1E trains. The manual tie connections between the train B load center and train A load center A1, and between the train C load center and train D load center D1, are closed manually only during the maintenance of the Class 1E A-GTG or Class 1E D-GTG. The tie circuit breakers are mechanically interlocked to prevent parallel connection of load center A1 to load centers A and B, and load center D1 to load centers C and D.

Non-Class 1E loads, except for the emergency lighting and pressurizer heater circuits, are not supplied from the Class 1E power system. The circuits for non-Class 1E loads are electrically isolated from the Class 1E power system by Class 1E isolation devices.

Independent cable routes are provided for each Class 1E train in conformance with IEEE Std 384, as endorsed by RG 1.75, to preclude failure in redundant trains.

The power supply arrangement described above ensures that the physical separation and electrical isolation of redundant Class 1E trains is not compromised, and any single failure in one train does not affect the redundant trains.

9.3.1.3 Class 1E Standby Power Sources

GTGs are the Class 1E standby power sources for the US-APWR. The design of the Class 1E standby power sources for the US-APWR is based on the advantages listed below:

- The GTG is more reliable and has fewer components and auxiliary systems than diesel generators.
- The GTGs do not have cooling water requirements.
- The GTGs need less space than diesel generators.

- The GTGs require less maintenance than diesel generator units.

The GTG starting time is less than 100 seconds, compared to the 10-second starting time for a diesel generator. Based on the safety analysis of the US-APWR involving advanced accumulators, the required starting time for the emergency Class 1E standby source is 100 seconds. Therefore, a less-than-100-seconds starting time is acceptable.

GTGs have rarely been used in the past in Class 1E standby power supply applications. The GTGs will be qualified for Class 1E application as standby emergency power sources using applicable standards and regulations.

The plant has four redundant Class 1E trains, with identical safety-related equipment on each train. Each redundant Class 1E power supply train is provided with a dedicated and independent Class 1E GTG aligned to the Class 1E 6.9-kV bus in that train. The Class 1E GTG rating is shown in Table 9-1. The availability of power from any two Class 1E GTGs to the associated Class 1E trains is adequate to meet the maximum emergency load requirements during LOOP and LOOP plus LOCA conditions (see Table 9-4). The Class 1E GTGs meet or exceed the requirements of RG 1.9.

The Class 1E GTG in each train is physically separated and electrically isolated from the Class 1E GTGs of the other trains. The Class 1E GTGs are housed in separate rooms of the power source buildings, which are Seismic Category I structures. The power and control cables from each Class 1E GTG to its respective Class 1E 6.9-kV bus are routed through paths that are physically separate from those of the other GTGs. This arrangement minimizes the potential for a common-cause failure, such as a missile, fire, flooding, etc., affecting more than one redundant Class 1E GTG.

A Class 1E GTG is started by one of the following methods:

- Automatic starting by an ECCS actuation signal,
- Automatic starting by an undervoltage signal on the Class 1E 6.9-kV bus to which the Class 1E GTG is connected,
- Automatic starting by a degraded grid voltage signal on the Class 1E 6.9-kV bus to which the Class 1E GTG is connected,
- Manual starting from the MCR,
- Manual starting from the Class 1E GTG room in the power source building, or
- Manual starting from the remote shutdown room in the reactor building.

A Class 1E GTG starts and is ready to accept loads in less than 100 seconds after receiving the start signal. Power from the Class 1E GTGs to the Class 1E 6.9-kV buses is restored in accordance with automatic load sequencing.

Class 1E GTG Starting Systems

The starting system for each Class 1E GTG is a compressed air system. The starting system for each Class 1E GTG is independent and physically separate.

Fuel Oil Storage and Transfer Systems

Each Class 1E GTG is provided with a dedicated and independent fuel oil supply system, fuel oil day tank, and underground storage tank. The fuel oil systems are not shared between the GTGs in an effort to minimize the potential for common-cause failure of the GTGs.

The day tank capacity is adequate for 1.5 hours of operation of a Class 1E GTG at the maximum required loading.

The maximum expected loading for a Class 1E GTG occurs under LOOP plus LOCA conditions. The electrical power and control circuit power supplies for the Class 1E fuel oil system are provided from the Class 1E power systems of the same train.

Each day tank is located inside the associated Class 1E GTG room in the power supply building. The fuel level in the day tank is maintained automatically by the fuel transfer pumps, which pump fuel from the storage tank on day tank low level. Each day tank is provided with two fuel transfer pumps.

The storage tank capacity is adequate to meet the maximum load demand on the associated Class 1E GTG for seven days. One independent and dedicated storage tank is provided for each Class 1E GTG. The storage tanks are located outside of the power supply buildings.

Cooling Water Systems

Each GTG does not need a cooling water system.

Instrumentation and Control

Equipment is provided for the following operations:

- Manual starting and stopping,
- Manual and automatic synchronization,
- Manual frequency and voltage setting,
- Emergency stop in the Class 1E GTG room, and
- Voltage regulator manually actuated droop and reset.

A selector switch is provided in each Class 1E GTG room for local/remote control selection. With the switch in its normal remote position, the engineered safety features actuation system starts the GTG when it senses an accident or loss of preferred power. The selector switch is placed in the local position to allow manual operation of the Class 1E GTG locally when it is undergoing maintenance. With the selector switch in manual, the local manual start switch is used to start the Class 1E

GTG. Equipment is also provided locally in the remote shutdown room for manually starting each Class 1E GTG in case of an MCR evacuation.

9.3.1.4 Control Rod Power Supply

Electric power to the control rod drive mechanisms (CRDMs) is supplied by two full-capacity motor generator sets. One motor generator set is powered from non-Class 1E 480-V bus N3, and the other is powered from bus N5.

Each generator is driven by a 132-kW (≈177-HP) induction motor. The ac power is distributed to the rod control power cabinets through two Class 1E series-connected reactor trip breaker sets, each of which is located in a separate fire area.

9.3.1.5 Class 1E 480-V AC Inverter Supply to MOVs

The Class 1E ac MCCs which supply motor-operated valves requiring Class 1E uninterrupted 480-V ac power are fed from 60-kVA, 480-V ac, 3-phase, 60-Hz inverters. There are six such MCCs and six MOV inverters, two each associated with Class 1E trains A and train D and one each associated with trains B and C. Each inverter is connected to the Class 1E 125-V dc bus in the associated train, as shown in Figure 9-1.

In the event of a postulated LOCA and coincident LOOP, the battery-charger input power to the MOV inverters may be lost for up to 100 seconds until the onsite Class 1E GTGs are ready to accept loads. Each MOV is started at the required time by the automatic starting signal for equalization of dc current. The 125V-dc batteries and the MOV inverters are sized for the continuous operating load and the coincident starting load of all MOVs actuated by an engineered safety features actuation signal.

9.3.1.6 Class 1E 120-V AC I&C Power Supply

There are four independent Class 1E 120-V ac I&C power supply trains, A, B, C, and D, which supply the four trains of the protection and reactor control systems, as shown in Figure 9-5. Each train consists of a UPS, a bypass transformer, a switching circuit, and a 120-V ac distribution panel. The inputs to the UPS and the bypass transformer in each train are obtained from the ac and dc buses associated with that train.

UPS units A, B, C, and D are connected to 120-V ac distribution panels A, B, C, and D, respectively, through the associated switching circuits. Bypass transformers A, B, C, and D are also connected to 120-V ac distribution panels A, B, C, and D, respectively, through the associated switching circuits.

Normally 120-V ac distribution panels A, B, C, and D are fed from 50-kVA, 1-phase UPS units A, B, C, and D, respectively. Normally a 120-V ac bus is fed from the inverter of its associated UPS. When the inverter fails or is out of service for maintenance, the 120-V ac bus is transferred to the bypass transformer by the static switch or manually through synchronizing, without interruption of power to the loads.

The static switch has the capability of automatically transferring the load back to the inverter after the inverter output has returned to normal.

During an LOOP, the UPS units are powered by the Class 1E batteries, and power to the 120-V ac distribution panels is maintained without interruption.

9.3.1.7 Non-Class 1E 120-V AC I&C Power Supply

The non-Class 1E 120-V ac I&C power supply is designed to furnish reliable power to all nonsafety-related plant instruments and controls. There are nine non-Class 1E 120-V ac I&C power supply subsystems, as shown in Figure 9-6. Each subsystem consists of a UPS unit with an inverter and a bypass transformer, bypass switches, and a 120-V ac distribution panel. The ac inputs to the inverter and the bypass transformer are provided from different MCCs connected to 480-V ac permanent buses P1 and P2. This arrangement results in the availability of ac power to the UPSs from either of permanent buses P1 or P2.

Each UPS is connected to a 120-V ac distribution panel. Normally a 120-V ac bus is fed from the inverter of the associated UPS. When the inverter fails or is unavailable due to maintenance, the 120-V ac bus is transferred to the bypass transformer by a static switch or manually through synchronizing, without interruption of power to the supplied loads.

When an LOOP occurs, the inverters are fed from batteries associated with non-Class 1E dc switchboards until the AAC GTGs start and begin accepting loads. The ac input power to the inverters and/or the bypass transformers is then automatically restored.

The non-Class 1E UPSs are rated as 120-V ac, 1-phase, 60-kVA units.

9.3.2 DC Power System

The onsite dc power system provides a reliable source of continuous power for controls, instrumentation, and dc motors. The onsite dc power system is comprised of independent Class 1E and non-Class 1E dc power systems. The Class 1E dc power system is comprised of four independent systems, one for each safety train. The non-Class 1E dc power system is also comprised of four separate dc power systems. Each Class 1E and non-Class 1E dc power system is provided with its own battery, battery charger, and power distribution equipment.

The Class 1E dc power system provides reliable continuous power to the plant safety system dc loads and to the Class 1E I&C power supply system. In addition, it provides power to the emergency lighting systems for the vital areas. The non-Class 1E dc power system provides reliable continuous dc power to the plant nonsafety system dc loads and to the non-Class 1E I&C power supply system. Operation of the non-Class 1E dc power system is not required for coping with design-basis events.

9.3.2.1 Class 1E DC Power System

The Class 1E dc power system consists of four independent power supply systems, identified as the A, B, C, and D trains. The system configuration is depicted in Figure 9-7. Each system consists of a main distribution switchboard fed from a battery and a battery charger. During normal operation, the dc system is powered by the battery charger, and the battery is in a float-charge condition. Each battery charger is fed from a Class 1E 480-V MCC of the same train. During all normal and emergency plant operating and shutdown conditions, the battery chargers are continuously powered from the 480-V Class 1E MCCs, which are continuously powered from either offsite or onsite emergency power sources. In the case of an LOOP, or an LOOP and coincident LOCA, the ac power supply to the battery chargers is restored within 100 seconds, the maximum time required for the onsite Class 1E GTGs to be started. For conservatism, each battery is sized to carry the worst-case dc load profile for a duration of two hours, assuming the loss of the associated battery charger. The loading conditions for an LOOP and for an LOOP concurrent with a LOCA have been considered to determine the worst-case load profile for the battery. In addition, the adequacy of the battery for SBO loading conditions for a duration of one hour is verified. Each battery charger is sized to carry the normal dc system load and simultaneously recharge a design-basis discharged battery to 95% of full rated capacity within 24 hours. The dc system is ungrounded with a nominal system voltage of 125 V. The maximum and minimum voltages at the battery terminals are 140 V and 108 V, respectively.

Four Class 1E safety battery chargers, one for each train, are connected to the Class 1E 125-V dc switchboard buses. In addition, there are two installed non-Class 1E spare battery chargers, spare battery charger AB for trains A and B and spare battery charger CD for trains C and D. Spare battery charger AB can temporarily replace either of Class 1E battery chargers A and B. Similarly, spare battery charger CD can temporarily replace either of Class 1E battery chargers C and D. Spare battery charger AB is powered from either of 480-V MCC permanent buses P11 and P22. Similarly, spare battery charger CD is powered from either of 480-V MCC permanent buses P21 and P12. During an LOOP, the non-Class 1E MCC permanent buses are powered from AAC sources. Each spare battery charger has two mechanically interlocked input circuit breakers and two mechanically interlocked output circuit breakers. Each of two non-Class 1E circuits from each spare charger is routed to a separate Class 1E 125-V dc switchboard. Each Class 1E 125-V dc switchboard has two mechanically interlocked input circuit breakers. The normal input to the Class 1E 125-V dc switchboard is from the Class 1E battery charger, and the alternate input is from the non-Class 1E spare battery charger. These mechanical interlock features preclude parallel operation of the normal and spare chargers, a spare battery charger feeding two switchboards, and two MCCs feeding one battery charger. The spare battery chargers have the same capacity as that of the Class 1E battery chargers.

The Class 1E dc power systems are designed as safety-related equipment in accordance with IEEE Std 308 and IEEE Std 946. The system design and all equipment and circuits are in compliance with applicable GDC, IEEE standards, and regulatory guides. The scope of compliance includes physical separation, electrical isolation, equipment environmental qualification, effects of single failure, capacities of the batteries and battery chargers, instrumentation and protective devices, and surveillance test requirements. The Class 1E batteries are sized in accordance with IEEE Std 485, and their installation conforms to the guidance of IEEE Std 484. The initial and routine testing of the batteries will be performed following manufacturer's recommendations and IEEE Std 450. The Class 1E dc system is designed so that no single failure in any train of the 125-V dc system, while a separate train has been taken out of service for maintenance or repair, results in conditions that prevent the safe shutdown of the plant. Nominal ratings of major Class 1E dc equipment are shown in Table 9-5.

The equipment and circuit layout of the dc system provide physical separation of the equipment, cabling, and instrumentation essential to plant safety. The batteries are located in temperature-controlled ventilated rooms, and they are separated from each other and from the battery chargers and other power distribution equipment. All components of the system are located in Seismic Category I structures.

Class 1E Batteries

Each of the 125-V dc Class 1E batteries has sufficient stored capacity, without reliance on the associated battery charger, to independently supply power to the safety-related loads continuously for two hours. The batteries are sized in accordance with the method recommended in IEEE Std 485. The worst-case duty cycle is based on the loading requirements subsequent to an LOOP and an LOOP concurrent with a LOCA. In addition, the adequacy of the battery for an SBO loading condition for a duration of one hour is verified. The design bases for the battery sizing are 65°F ambient temperature, 25% aging factor, 1.8-V-per-cell end voltage, and 10% design margin. The allowable minimum and maximum battery terminal voltages are 108 V (1.8 V per cell) and 140 V (2.33 V per cell), respectively. The maximum equalizing charge voltage is limited to 140 V dc, as recommended by industry standards for lead-acid batteries. The I&C power supply system inverters are designed to supply 120-V ac power with dc power less than 140-V and more than 108-V at the battery terminals.

The batteries are installed in accordance with IEEE Std 484 and are qualified per IEEE Std 535. Each battery is located in a separate battery room in a power source building. The battery rooms are ventilated to the outside to preclude a hydrogen concentration of more than 1%. A safety-related ventilation system is provided for each Class 1E battery room. A safety-related heating system is provided to maintain the battery room temperatures at no less than 65°F. The battery banks are designed to permit the inspection and replacement of individual cells.

Class 1E Battery Chargers

Each of four Class 1E safety battery chargers, one for each train, is connected to a Class 1E 125-V dc switchboard bus. In addition, there are two installed non-Class 1E spare battery chargers, spare battery charger AB for trains A and B and spare battery charger CD for trains C and D. Spare battery charger AB can temporarily replace either of Class 1E battery chargers A and B. Similarly, spare battery charger CD can temporarily replace either of Class 1E battery chargers C and D. When used, a non-Class 1E spare battery charger is manually placed in service. Each

Class 1E battery charger is located in a separate room in a power source building, adjacent to the battery room of the same train. Spare battery chargers AB and CD are located in separate rooms of separate power source buildings. The battery chargers are full-wave, silicon-controlled rectifiers, housed in NEMA 1 ventilated freestanding enclosures. The battery chargers operate from 480-V ac, 3-phase, 60-Hz power supplies, and are capable of float charging the batteries with the provision for manual equalization of the batteries.

Each battery charger has the capacity to recharge its battery from the design minimum charge to a 95% charged condition within 24 hours and to simultaneously supply the normal dc loads of the associated 125-V dc switchboard bus. Each battery charger has an input ac and an output dc circuit breaker for the purpose of power source isolation and required protection. The battery chargers are of the constant voltage type, with adjustable output voltage. The output float and equalizing voltages are adjustable. The battery charger output voltage variation is limited to ±1% with or without the battery connected. The battery charger output is ungrounded and filtered.

The battery charger output is of the current-limiting type, adjustable between 110 and 125% of its rating, in order to hold down the output current in the event of a short circuit or overload on the dc side. Each battery charger has built-in blocking diodes to prevent the associated battery charger or the ac system from becoming a load on the battery.

Class 1E DC Distribution System Equipment

Each train of the Class 1E dc power system has a main distribution switchboard, located in a separate Class 1E battery charger room of a power source building adjacent to the battery room of the same train. Each switchboard is connected to its associated battery and battery charger of the same train, as depicted in Figure 9-7. The Class 1E switchboards employ fusible disconnect switches as input and output circuit protection devices. The major dc loads are fed directly from the dc switchboard, and smaller dc loads are fed from dc panelboards connected to the dc switchboard.

9.3.2.2 Non-Class 1E DC Power System

The non-Class 1E dc power system consists of four separate power supply systems, identified as N1, N2, N3, and N4. The non-Class 1E dc power system configurations are depicted in Figure 9-8. Each system consists of a main distribution switchboard, fed from a battery and a battery charger. In addition, there are two spare battery chargers, the N12 battery charger for buses N1 and N2 and the N34 battery charger for buses N3 and N4. During normal operation of the dc power system, the batteries are in the float-charge condition, and the system is powered by the battery chargers connected to the permanent 480-V ac system. The N1 and N3 battery chargers are fed from 480-V permanent MCCs P11 and P12, respectively. The P11 and P12 MCCs are normally fed from RAT3, from UAT3 when RAT3 is unavailable, and from the A-AAC gas turbine generator during an LOOP. Similarly, the N2 and N4 battery chargers are fed from 480-V permanent MCCs P21 and P22, respectively. The P21 and P22 MCCs are normally fed from RAT4, from UAT4 when RAT4 is unavailable, and from the B-AAC gas-turbine generator during an LOOP.

Spare battery charger N12 is powered from 480-V MCC bus N3, or from 480-V permanent MCC bus P12 via a manual transfer switch. MCC bus N3 is normally fed from UAT3, and from RAT3 when UAT3 is unavailable. Bus P12 is normally fed from UAT3, from RAT3 when UAT3 is unavailable, and from the A-AAC gas turbine generator during an LOOP or an SBO condition. Similarly, spare battery charger N34 is powered from 480-V MCC bus N4 or from 480-V permanent MCC bus P21 via a manual transfer switch. MCC bus N4 is normally fed from UAT4, and from RAT4 when UAT4 is unavailable. Bus P21 is normally fed from UAT4, from RAT4 when UAT4 is unavailable, and from the B-AAC gas turbine generator during an LOOP or an SBO condition.

During all normal and emergency plant operating and shutdown conditions, the battery chargers are continuously powered from the 480-V permanent MCCs, which are continuously powered from either offsite or onsite AAC power sources. In the case of an LOOP or SBO condition, the non-Class 1E battery chargers are available within 100 seconds, the maximum time required for the onsite AAC power sources to be operating and providing power to the battery chargers. During this 100-second period, the batteries provide power to the dc power system. For conservatism, each battery is sized to carry the worst-case dc load profile for a duration of one hour, assuming the failure of the associated battery charger and the unavailability of the spare charger. The loading conditions following an LOOP and an SBO have been considered to determine the worst-case load profile for the battery. Each battery charger is sized to carry the normal dc system load and simultaneously recharge a design-basis discharged battery to 95% of full rated capacity within 24 hours. The dc system is ungrounded with a nominal system voltage 125 V. The maximum and minimum voltages at the battery terminals are 140 V and 108 V, respectively.

The design of the non-Class 1E dc power systems conforms to the recommended guidance of IEEE Std 946. The system design and all equipment and circuits are in compliance with applicable IEEE standards. The non-Class 1E batteries are sized in accordance with IEEE Std 485, and their installation conforms to the guidance of IEEE Std 484. The initial and routine testing of the batteries will be performed following manufacturer's recommendations and IEEE Std 450. The non-Class 1E dc system is not specifically designed to withstand a single active failure; however, it is divided into four separate power supply systems corresponding to four separate ac and dc load and power supply groups. Nominal ratings of major non-Class 1E equipment are shown in Table 9-5.

The batteries are located in ventilated rooms, away from the associated battery chargers and power distribution equipment. The equipment and components of the system are located in the auxiliary building and the turbine building.

9.4 Station Blackout

9.4.1 Station Blackout Coping Analysis

The SBO rule of 10 CFR 50.63 requires each plant to specify an SBO coping duration based on the redundancy of onsite emergency ac power sources, the reliability of the onsite emergency ac power sources, the expected frequency of LOOPs, and the probable time needed to restore offsite power. Based on (1) a conservatively selected plant grid and switchyard configuration (site specific and not part of the US-APWR design); (2) four redundant and independent emergency Class 1E GTGs, with any two adequate to supply ac-powered decay heat removal systems; and (3) a GTG minimum targeted reliability of 0.95 determined in accordance with RG 1.155; the US-APWR's SBO coping duration is eight hours.

During an SBO, all offsite ac sources and all onsite Class 1E GTGs are assumed to be inoperable. Since the provision of AAC sources constitutes an acceptable capability to withstand an SBO in accordance with 10 CFR 50.63(c)(2), two non-Class 1E GTGs are provided as AAC sources. In accordance with 10 CFR 50.63(c)(2), an analysis is required to demonstrate that the plant has the capability to cope with an SBO from the onset of the SBO until the AAC source and the required shutdown equipment are started and lined up to operate. In the US-APWR design, power to the shutdown buses can be restored from the AAC sources within 60 minutes; hence, a coping analysis for a duration of 60 minutes is performed. The availability of power from one AAC GTG to one Class 1E 6.9-kV bus within 60 minutes is verified by actual field testing.

Two GTGs, each with a different rating and diverse starting mechanism from those of the Class 1E GTGs, are provided as AAC sources. These AAC GTGs are independent from the Class 1E GTGs and do not share any common auxiliaries or support systems. The AAC GTGs are not normally connected to the plant offsite or onsite power systems. The AAC GTGs are electrically isolated from the emergency Class 1E power supply systems by non-Class 1E disconnect switches and Class 1E circuit breakers. The disconnect switches and Class 1E circuit breakers which would connect the AAC GTGs to the Class 1E buses are normally open; one switch and one breaker would be manually closed during an SBO to restore the power supply to one of the Class 1E 6.9-kV buses (A or B, or C or D). An AAC GTG is automatically started by an undervoltage signal on 6.9-kV permanent bus P1 or P2 and connected to the respective permanent bus during an LOOP. An AAC GTG can also be manually started and connected to a Class 1E emergency bus. Each AAC GTG starts, reaches the rated frequency and voltage, and is ready to be loaded within 100 seconds. Each AAC source is capable of providing adequate power to the emergency shutdown buses. The power supply from the AAC GTG to one of the Class 1E buses can be restored within 60 minutes. Since the power supply from an AAC GTG to a Class 1E bus cannot be restored within 10 minutes (which would require no coping analysis, in accordance with 10 CFR 50.63(c)(2)), the following coping analysis is performed for the US-APWR in accordance with the requirements of Section C.3.2 of RG 1.155:

1. After an SBO occurs, all ac power sources, including all Class 1E GTGs, are lost, except for the UPSs. Power from an AAC GTG is restored to the Class 1E power

system within 60 minutes. During the 60 minutes, no pumps or fans powered by the Class 1E 6.9-kV and 480-V ac buses can be operated.

2. Plant systems are kept in a safe condition as described below:

   (a) Core and reactor coolant system (RCS) condition

   Until an AAC GTG restores the Class 1E power system within, all pumps and fans cannot be operated. However, during this time, the plant is in a condition similar to hot shutdown. The operation of turbine-driven (T/D) emergency feedwater (EFW) pump(s) and main steam relief valves removes the decay heat of the core through natural circulation of the reactor coolant.

   (b) RCP seals

   RCP seal integrity is maintained for at least one hour without water cooling. There is no LOCA considered in this condition.

   (c) Integrity of electrical cabinets

   Until an AAC GTG restores power to the Class 1E power system, the Class 1E electrical room HVAC system cannot be operated. However, all Class 1E electrical cabinets and I&C cabinets are rated to keep their integrity up to a room temperature of 50°C. The temperatures of the Class 1E electrical and I&C rooms do not reach 50°C within one hour even without HVAC.

3. After an AAC GTG has restored power to the Class 1E power system, the following operations are performed, keeping the plant in a safe shutdown condition for the long term:

Function	Action
Reactivity control	Supplying boric acid tank (BAT) water by using charging pump
RCS makeup	Supplying water of refueling water auxiliary tank by using charging pump
RCS pressure control	Pressurizing by using pressurizer backup heaters and depressurizing by using safety depressurization valve (SDV)
Decay heat removal	Supplying EFW pit water with T/D EFW pump and steam relief with main steam relief valve
Cooling of RCP seals	RCP seal injection with charging pump (water source is refueling water auxiliary tank)
Supporting systems	I&C, cooling systems, HVAC

The plant can be kept in a safe shutdown condition with the above operations performed by only one Class 1E train.

9.4.2 Alternate AC Power Sources

The AAC power sources and their connections to the onsite and offsite ac power systems meet the requirements of RG 1.155. Two full-capacity, 4000-kW, 6.9-kV non-Class 1E GTGs (A and B) are provided as AAC sources, and either of these two GTGs can meet the SBO load requirements shown in Table 9-3 for the time required to bring the plant to a safe shutdown condition and maintain it there. Two AAC GTGs are provided for operational flexibility and enhanced reliability, even though the provision of one AAC GTG is adequate to meet the requirements of RG 1.155, which does not require the application of the single-failure criterion to AAC power sources. Hence, the provision of two 100%-capacity AAC sources provides the US-APWR with greater reliability for coping with an SBO event than what is intended by RG 1.155. The AAC power sources reach set voltage and frequency within 100 seconds after receiving their starting signals.

To minimize the potential for common-mode failures with the Class 1E GTGs, GTGs with different ratings and diverse starting systems are provided as AAC sources. The auxiliary and support systems for the AAC GTGs are also independent and separate from those of the Class 1E GTGs to minimize the potential for common-mode failures. Completely separate and independent fuel supply systems and onsite fuel storage tanks are provided for the Class 1E GTGs and for the non-Class 1E AAC GTGs.

The A-AAC GTG and B-AAC GTG are located in separate power source buildings. The A-AAC GTG is connected to non-Class 1E 6.9-kV permanent bus P1 through selector circuit A. Similarly, the B-AAC GTG is connected to non-Class 1E 6.9-kV permanent bus P2 through selector circuit B. The selector circuit consists of one circuit breaker connected to the AAC source and three disconnect switches. Closing a disconnect switch in selector circuit A connects the A-AAC GTG to either of 6.9-kV buses P1, A, and B; closing a disconnect switch in selector circuit B connects the B-AAC GTG to either of 6.9-kV buses P2, C and D, as shown in Figure 9-1.

The A-AAC GTG and B-AAC GTG are connected to the circuit breakers in selector circuits A and B, respectively. The selector circuits are located in the power source buildings. The non-Class 1E 6.9-kV and 480-V permanent power supply systems P1 and P2 are located in the turbine building electrical rooms. The AAC GTG circuit breakers in the selector circuits are normally open, and the AAC power sources are not normally connected directly to the plant offsite or onsite power system. The non-Class 1E disconnect switches in the selector circuits and the Class 1E incoming circuit breakers in the Class 1E MV switchgear from the AAC GTGs are normally open and do not have any automatic closing function. They perform the isolation between the Class 1E and non-Class 1E systems. This meets RG 1.155, Appendix B requirements for isolation between AAC sources and the onsite and offsite power systems.

The ratings and starting mechanisms of the AAC sources, which are diverse from those of the emergency ac power sources, the location of AAC sources in separate rooms, the independent auxiliaries, and the interconnections to the offsite and onsite emergency ac power systems ensure that no single point of vulnerability exists. Therefore, a weather-related event or a single failure could not disable all onsite emergency ac sources and offsite ac power supplies simultaneously along with all AAC sources.

The AAC sources can be started and connected manually to onsite Class 1E MV buses within 60 minutes during SBO conditions.

The restoration of power from either of the AAC sources to any one of the onsite Class 1E MV buses (A-AAC GTG supplying Class 1E 6.9-kV bus A or B, or B-AAC GTG supplying 6.9-kV Class 1E bus C or D) is adequate to cope with the SBO condition. The sequence of switching operations for restoring power to Class 1E 6.9-kV bus A or B from the A-AAC GTG during an SBO is described in the following procedure. The sequence of switching operations for restoring power from the B-AAC GTG to Class 1E 6.9-kV bus C or D during an SBO is similar.

1. The A-AAC GTG is started automatically by the undervoltage signal on 6.9-kV permanent bus P1 due to an LOOP.

2. The incoming breakers from the offsite power supply sources to 6.9-kV permanent bus P1 are tripped and locked out by the undervoltage signal on bus P1.

3. The selector circuit disconnect switch which connects to the incoming circuit breaker on non-Class 1E 6.9-kV permanent bus P1 is normally closed.

4. Circuit breaker A in selector circuit A for the A-AAC GTG is closed automatically after the A-AAC GTG reaches the set voltage and frequency, and the A-AAC GTG powers 6.9-kV permanent bus P1 automatically. The loads on the non-Class 1E 6.9-kV and 480-V permanent buses P1 are started automatically by the LOOP sequencer.

5. The disconnect switches in selector circuit A and the incoming circuit breakers from the A-AAC to the Class 1E 6.9-kV switchgear are normally open. Hence, power from the AAC source is not supplied automatically to onsite Class 1E 6.9-kV bus A or B.

6. An undervoltage signal trips most of the ac loads on Class 1E 6.9-kV buses A and B, but the feeders to the 480-V load centers, battery chargers, and emergency lighting remain closed. Before restoring power to a Class 1E bus from the A-AAC GTG, the operators manually trip loads that are being supplied by non-Class 1E permanent bus P1.

7. Power is restored to Class 1E 6.9-kV bus A or B from the A-AAC GTG by manually closing the associated disconnect switch in selector circuit A and the Class 1E incoming circuit breaker for bus A or B from the A-AAC GTG.

8. After restoration of power to 6.9-kV Class 1E bus A or B from the A-AAC GTG, the required loads on 6.9-kV and 480-V Class 1E bus A or B, as shown in Table 9-3, are started manually.

The AAC GTGs have enough fuel capacity to supply power to the required SBO loads for 8 hours.

Power sources sufficient for achieving and maintaining cold shutdown are available when both AAC GTGs have started, and the second AAC GTG is connected to another Class 1E bus in a manner that is similar to the way the first AAC GTG has been connected.

Table 9-1 Electrical Equipment Ratings - Component Data (Sheet 1 of 3)

Main ac Power System (Nominal Values)

1.	Main Transformer (MT) Quantity MVA rating Low voltage winding High voltage winding	Three single phase units (Besides one spare) 1 phase 610MVA (3 phase 1830MVA) 26kV The high voltage rating is site specific (COL Applicant to provide)	
2.	Unit Auxiliary Transformers (UATs)	UAT1, 2	UAT3, 4
	Quantity MVA rating Low voltage winding High voltage winding On-Load Tap Changer (OLTC)	Two 3 phase, 2 winding units 72MVA 13.8kV 26kV Provided on high voltage side	Two 3 phase, 2 winding units 53MVA 6.9kV 26kV Provided on high voltage side
3.	Reserve Auxiliary Transformers (RATs)	RAT1, 2	RAT3, 4
	Quantity MVA rating Low voltage winding High voltage winding On-Load Tap Changer (OLTC)	Two 3 phase, 3 winding units (including delta tertiary winding) 72MVA 13.8kV (by COL applicant) Provided on high voltage side	Two 3 phase, 3 winding units (including delta tertiary winding) 53MVA 6.9kV (by COL applicant) Provided on high voltage side

Table 9-1 Electrical Equipment Ratings - Component Data (Sheet 2 of 3)

Main ac Power System (Nominal Values)

4.	Generator Load Break Switch (GLBS)	
	Rated Voltage	Over 28kV
	Rated Current	Over 44.4kA
	Rated Frequency	60Hz
5.	Isolated Phase Busduct (IPB) – Main Circuit	
	Type	Forced air cooling (cooling air is cooled by water)
	Rated voltage	Over 28kV
	Rated current	Over 44.4kA
	Rated frequency	60Hz
6.	Isolated Phase Busduct (IPB) – Branch Circuit	
	Type	Forced air cooling (cooling air is cooled by water)
	Rated voltage	Over 28kV
	Rated current	Over 5900A
	Rated frequency	60Hz
7.	13.8kV Medium Voltage System	Non-Class 1E
	Switchgear	N1 & N2
	Type	Metal Clad
	Rated current	3000A
	Circuit Breaker	
	Maximum voltage	15kV
	Rated short-circuit current	50kA
	Peak current (C & L crest)	130kA
	Control power	125V dc

Table 9-1 Electrical Equipment Ratings - Component Data (Sheet 3 of 3)

Main ac Power System (Nominal Values)

8.	6.9kV Medium Voltage System	Class 1E	Non-Class 1E	Non-Class 1E permanent
	Switchgear Type Rated current	A, B, C & D Metal Clad 1200A	N3, N4, N5 & N6 Metal Clad 3000A	P1 & P2 Metal Clad 2000A
	Circuit Breakers Maximum voltage Rated short-circuit current Peak current (C & L Crest) Control power	 8.25kV 63kA 170kA 125V dc	 8.25kV 63kA 170kA 125V dc	 8.25kV 63kA 170kA 125V dc
9.	Low Voltage System (Load Center)	Class 1E	Non-Class 1E	Non-Class 1E permanent
	Circuit Breaker Type Rated short-circuit current Rated current Station service transformer Control power	Air Circuit Breaker 65kA 4000A A, B, C & D 2500kVA 125V dc	Air Circuit Breaker 65kA 4000A N1, N2, N3, N4, N5 & N6 2500kVA 125V dc	Air Circuit Breaker 65kA 4000A P1 & P2 2500kVA 125V dc
10.	480V ac Motor Control Centers Circuit Breaker Type Rated short circuit current Rated current	 MCCB 65kA 1000A		
11.	Gas Turbine Generators	Class 1E		Non-Class 1E AAC
	Rated voltage Rated output	6.9kV 4500kW		6.9kV 4000kW

Table 9-2 Electrical Load Distribution - AAC GTG Loading (LOOP Condition)

A-AAC GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOOP							
							Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
Turbine Component Cooling Water Pump	1	560	591	90	85	95	1	591	368	696	1	591	368	696
Control Rod Drive Mechanism Cooling Fan	1	315	333	90	85	95	1	333	207	392	1	333	207	392
Non-Essential Chiller Unit	2	450	475	90	85	95	1	475	295	559	1	475	295	559
Reactor Cavity Cooling Fan	1	110	123	85	80	95	1	123	93	154	1	123	93	154
Turning Oil Pump	1	160	179	85	80	95	1	179	135	224	1	179	135	224
Containment Fan Cooler Unit Fan	2	200	224	85	80	95	2	448	336	560	2	448	336	560
Non-Essential Chilled Water System Cooling Tower Fan	2	120	134	85	80	95	1	134	101	168	1	134	101	168
Non-Essential Chilled Water System Cooling Tower Pump	2	110	123	85	80	95	1	123	93	154	1	123	93	154
Motor Control Centers (P11&P12)	2						2	1430	887	1683	2	1430	887	1683
Total								3836	2515	4590		3836	2515	4590

B-AAC GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOOP							
							Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
Turbine Component Cooling Water Pump	1	560	591	90	85	95	1	591	368	696	1	591	368	696
Control Rod Drive Mechanism Cooling Fan	1	315	333	90	85	95	1	333	207	392	1	333	207	392
Non-Essential Chiller Unit	2	450	475	90	85	95	1	475	295	559	1	475	295	559
Reactor Cavity Cooling Fan	1	110	123	85	80	95	1	123	93	154	1	123	93	154
Containment Fan Cooler Unit Fan	2	200	224	85	80	95	2	448	336	560	2	448	336	560
Non-Essential Chilled Water System Cooling Tower Fan	2	120	134	85	80	95	1	134	101	168	1	134	101	168
Non-Essential Chilled Water System Cooling Tower Pump	2	110	123	85	80	95	1	123	93	154	1	123	93	154
Motor Control Centers (P21&P22)	2						2	1430	887	1683	2	1430	887	1683
Total								3657	2380	4366		3657	2380	4366

Table 9-3 Electrical Load Distribution - AAC GTG Loading (SBO Condition)

AAC GTG

Bus	Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	SBO							
								Hot Standby				Cold Shutdown			
								A or B AAC GTG				A and B AAC GTG			
								Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
Class 1E Bus	Component Cooling Water Pump	1	610	644	90	85	95	1	644	400	758	1	644	400	758
	Essential Service Water Pump	1	720	760	90	85	95	1	760	473	895	1	760	473	895
	Containment Spray/Residual Heat Removal Pump	1	400	422	90	85	95	0	-	-	-	1	422	263	497
	Charging Pump	1	820	866	90	85	95	1	866	537	1019	1	866	537	1019
	Class 1E Electrical Room Air Handling Unit Fan	1	80	89	85	80	95	1	89	68	112	1	89	68	112
	Essential Chiller Unit	1	290	324	85	80	95	1	324	243	405	1	324	243	405
	Class 1E Electrical Room Air Handling Unit Electrical Heater	1	250	250	100	100	100	0	-	-	-	0	-	-	-
	Pressurizer Heater	1	562	562	100	100	100	0	-	-	-	0	-	-	-
	Motor Control Center	2						2	400	249	471	2	500	311	589
	Subtotal								3083	1970	3660		3605	2295	4275
	AAC Supporting equipment								80	60	100		80	60	100
Total									3163	2030	3760		3685	2355	4375

Table 9-4 Electrical Load Distribution - Class 1E GTG Loading

A Class 1E GTG (Similar to D)

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOCA Concurrent with a LOOP				LOOP							
											Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
A Safety Injection Pump	1	900	950	90	85	95	1	950	589	1118	0	-	-	-	0	-	-	-
A Component Cooling Water Pump	1	610	644	90	85	95	1	644	400	758	1	644	400	758	1	644	400	758
A Essential Service Water Pump	1	720	760	90	85	95	1	760	473	895	1	760	473	895	1	760	473	895
A Containment Spray/Residual Heat Removal Pump	1	400	422	90	85	95	1	422	263	497	0	-	-	-	1	422	263	497
A Charging Pump	1	820	866	90	85	95	0	-	-	-	1	866	537	1019	1	866	537	1019
A Class 1E Electrical Room Air Handling Unit Fan	1	80	89	85	80	95	1	89	68	112	1	89	68	112	1	89	68	112
A Essential Chiller Unit	1	290	324	85	80	95	1	324	243	405	1	324	243	405	1	324	243	405
A Spent Fuel Pit Pump	1	230	257	85	80	95	0	-	-	-	1	(257)	(193)	(322)	1	(257)	(193)	(322)
A Class 1E Electrical Room Air Handling Unit Electrical Heater	1	250	250	100	100	100	0	-	-	-	0	-	-	-	0	-	-	-
A Pressurizer Heater (Back-up)	1	562	562	100	100	100	0	-	-	-	1	562	0	562	0	-	-	-
Motor Control Centers (A&A1)	2						2	550	343	648	2	500	311	589	2	500	311	589
Total								3739	2379	4433		3745	2032	4340		3605	2295	4275

( ):This load is started by manually if GTG has necessary margin after completing automatic load sequence.

B Class 1E GTG (Similar to C)

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOCA Concurrent with a LOOP				LOOP							
											Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
B Safety Injection Pump	1	900	950	90	85	95	1	950	589	1118	0	-	-	-	0	-	-	-
B Component Cooling Water Pump	1	610	644	90	85	95	1	644	400	758	1	644	400	758	1	644	400	758
B Essential Service Water Pump	1	720	760	90	85	95	1	760	473	895	1	760	473	895	1	760	473	895
B Containment Spray/Residual Heat Removal Pump	1	400	422	90	85	95	1	422	263	497	0	-	-	-	1	422	263	497
B Emergency Feed Water Pump	1	590	475	90	85	73	1	475	295	559	1	475	295	559	0	-	-	-
B Class 1E Electrical Room Air Handling Unit Fan	1	80	89	85	80	95	1	89	68	112	1	89	68	112	1	89	68	112
B Essential Chiller Unit	1	290	324	85	80	95	1	324	243	405	1	324	243	405	1	324	243	405
A Spent Fuel Pit Pump	1	230	257	85	80	95	0	-	-	-	1	(257)	(193)	(322)	1	(257)	(193)	(322)
B Class 1E Electrical Room Air Handling Unit Electrical Heater	1	250	250	100	100	100	0	-	-	-	0	-	-	-	0	-	-	-
B Pressurizer Heater (Back-up)	1	562	562	100	100	100	0	-	-	-	1	562	0	562	0	-	-	-
Motor Control Centers (B&A1)	2						2	550	343	648	2	500	311	589	2	500	311	589
Total								4214	2674	4992		3354	1790	3880		2739	1758	3256

( ): This load is started by manually if GTG has necessary margin after completing automatic load sequence.

Table 9-5 Electrical Equipment Ratings - Component Data (Sheet 1 of 2) Class 1E DC Power System (Nominal Values)

a. Battery Bank 4 - 125Vdc, 2 strings of 60 flooded lead acid cells, 5000Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating
b. Battery Charger 4 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 700A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge
c. Switchboard 4 – 125Vdc, Main bus 3000A, 50kA short circuit
d. Panelboards 4 - Main bus 225A continuous, 40kA short circuit
e. **Spare Battery Charger** (Non-class 1E) 2 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 700A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge

*: Actual Ah rating is decided in accordance with manufacturer’s specification.

Table 9-5 Electrical Equipment Ratings - Component Data (Sheet 2 of 2) Non-Class 1E DC Power System (Nominal Values)

a. Battery Bank 2 - 125Vdc 60 flooded lead acid cells, 3600Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating 1 - 125Vdc 60 flooded lead acid cells, 2400Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating 1 - 125Vdc 60 flooded lead acid cells, 4300Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating
b. Battery Charger 4 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 200A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge
c. Switchboard 1 – 125Vdc, Main Bus 2000A, 40kA short circuit 1 – 125Vdc, Main Bus 3000A, 40kA short circuit 1 – 125Vdc, Main Bus 1600A, 40kA short circuit 1 – 125Vdc, Main Bus 2000A, 50kA short circuit
d. Spare Battery Charger 2 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 200A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge

*: Actual Ah rating is decided in accordance with manufacturer's specification.