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9.0 ELECTRICAL SYSTEMS

Learning Objectives:

1. State the purposes of the following:

    a. Onsite standby diesel generators
    b. Ancillary ac diesel generators
    c. Class 1E 125-Vdc distribution system
    d. Class 1E uninterruptible power supplies (UPSs)
    e. Non-Class 1E dc and UPS system

2. Describe the major differences between the onsite electrical system designs of the AP1000 and current operating Westinghouse plants.

9.1 Introduction

Onsite Power System Description

The onsite power system is comprised of the main ac power system and the dc power system. The main ac power system is a non-Class 1E system. The dc power system consists of two independent systems: the Class 1E dc system and the non-Class 1E dc system. The ac and dc onsite power system configurations are shown in Figures 9-1, 9-2, 9-4, and 9-5.

The normal ac power supply to the main ac power system is provided from the station main generator. When the main generator is not available, plant auxiliary power is provided from the switchyard by backfeeding through the main step-up and unit auxiliary transformers. This is the preferred power supply. When neither the normal nor the preferred power supply is available, a fast bus transfer will be initiated to transfer the loads to the reserve auxiliary transformers powered by maintenance sources of power. In addition, two non-Class 1E onsite standby diesel generators supply power to selected loads in the event of a loss of the normal, preferred, and maintenance power sources.

The main generator is connected to the offsite power system by three single-phase step-up transformers. The normal power source for the plant auxiliary ac loads comes from the generator buses through two unit auxiliary transformers of identical rating. In the event of a loss of the main generator, the power is maintained without interruption from the preferred power supply by an automatic trip of the main generator breaker. Power is then provided from the switchyard to the auxiliary loads through the main and unit auxiliary transformers.

A spare single-phase main step-up transformer is provided in the transformer area. The spare can be placed in service upon failure of one phase of the main step-up transformers.

The onsite standby power system, powered by the two onsite standby diesel generators, supplies power to selected loads in the event of the loss of the other ac power sources. Those loads that are priority loads for investment protection due to their specific functions (permanent nonsafety loads) are selected for access to the onsite standby power supply. Availability of the standby power sources is not required to accomplish any safety function.

The maintenance power supplies are provided at the medium-voltage (6.9-kV) buses through normally open circuit breakers. Bus transfers to the maintenance sources are either automatic under fast transfer logic or initiated manually.

Four independent divisions of Class 1E 250-Vdc battery systems are provided for the Class 1E dc and UPS system. Each of divisions B and C has two battery banks; one battery bank is sized to supply power to safety-related loads for at least 24 hours, and the other battery bank is sized to supply power to a second set of safety-related loads for at least 72 hours following a design-basis event (including the loss of all ac power). Each of divisions A and D has one 24-hour battery bank. The loads are assigned to each battery bank, depending on their required functions, during the 72-hour coping period so that no manual or automatic load shedding is required for the first 24 hours.

Two ancillary diesel generators can provide power for Class 1E post-accident monitoring, for main control room (MCR) lighting, for MCR and instrumentation and control (I&C) room ventilation, and for refilling the passive containment cooling system (PCS) water storage tank and spent fuel pool if no other sources of ac power are available.

A single spare Class 1E battery bank is provided for both the Class 1E and the non-Class 1E battery systems, and a separate spare charger is provided for each of the systems. In order to preserve the independence of each Class 1E dc system division, plug-in, locking-type disconnects are permanently installed to prevent connection of more than one battery bank to the spare. In addition, kirk-key interlock switches are provided to prevent transfer operation of more than one switchboard at a time. The spare battery bank is located in a separate room and is capable of supplying power to the required loads on any battery being temporarily replaced with the spare.

The non-Class 1E 125-Vdc power system provides continuous, reliable power to the plant nonsafety-related dc loads. Operation of the non-Class 1E dc system is not required to accomplish any safety function.

Uninterruptible power supplies (UPSs) to the four independent divisions of the Class 1E 120-Vac instrument buses are included in the Class 1E dc system. The normal power to each uninterruptible power supply comes from its respective Class 1E 250-Vdc bus. The backup power comes from the main ac power system through a Class 1E 480-208Y/120V voltage regulating transformer. The same configuration applies for the uninterruptible power to the nondivisional, non-Class 1E 120-Vac instrument buses. The normal power to each non-Class 1E uninterruptible power supply comes from a non-Class 1E 125-Vdc bus, and the backup power comes from the main ac power system through a voltage regulating transformer.

Safety-Related Loads

The safety-related loads requiring Class 1E power are listed in Tables 9-1, 9-2, 9-3 and 9-4. Safety-related loads are powered from the Class 1E 250-Vdc batteries and the associated Class 1E 120-Vac instrument buses.

9.2 Onsite AC Power Systems

9.2.1 Introduction

The onsite ac power system is a non-Class 1E system including normal, preferred, maintenance, and standby power supplies. The normal, preferred, and maintenance power supplies are included in the main ac power system. The standby power supplies are included in the onsite standby power system. The Class 1E and non-Class 1E 208/120-Vac instrumentation power supplies are described in section 9.3 as a part of uninterruptible power supplies from the dc power systems.

9.2.2 Description

The main ac power system is a non-Class 1E system and does not perform any safety-related functions. It has nominal bus voltage ratings of 6.9 kV, 480 V, 277 V, 208 V, and 120 V. Figure 9-1 shows the main generator, transformers, feeders, buses, and their connections.

During power generation, the turbine-generator normally supplies electric power to the plant auxiliary loads through the unit auxiliary transformers. The plant is designed to sustain a load rejection from 100-percent power with the turbine-generator continuing stable operation while supplying the plant house loads. The load rejection feature does not perform any safety function.

During plant startup, shutdown, and maintenance, the generator breaker remains open. The main ac power is provided by the preferred power supply from the high-voltage switchyard (switchyard voltage is site specific) through the plant main step-up transformers and two unit auxiliary transformers. Each unit auxiliary transformer supplies power to about 50 percent of the plant loads.

A maintenance source is provided to supply power through two reserve auxiliary transformers. The maintenance source and the associated reserve auxiliary transformer primary voltage are site specific. The reserve auxiliary transformers are sized so that they can be used in place of the unit auxiliary transformers.

Each of unit auxiliary transformers 2A and 2B has two identically rated 6.9-kV secondary windings. The secondaries of the auxiliary transformers are connected to the 6.9-kV switchgear buses by nonsegregated phase buses. The primary of each unit auxiliary transformer is connected to the main generator isolated phase bus duct tap. The 6.9-kV switchgear designations, locations, connections, and connected loads are shown in Figure 9-1. The buses tagged with odd numbers (ES1, ES3, etc.) are connected to unit auxiliary transformer 2A, and the buses tagged with even numbers (ES2, ES4, etc.) are connected to unit auxiliary transformer 2B. Each 6.9-

kV bus is provided with access to the maintenance source through a normally open circuit breaker connecting the bus to a reserve auxiliary transformer. A bus transfer to the maintenance source is manual or automatic through a fast bus transfer scheme.

The third unit auxiliary transformer, 2C, is a two-winding transformer sized to accommodate the electric boiler and site-specific loads. Bus ES7 is connected to this transformer. ES7 cannot be connected to a maintenance source.

The arrangement of the 6.9-kV buses permits feeding functionally redundant pumps or groups of loads from separate buses and enhances the plant operational flexibility. The 6.9-kV switchgear powers large motors and the load center transformers. There are two switchgear (ES1 and ES2) located in the annex building, and five (ES3, ES4, ES5, ES6, and ES7) in the turbine building.

The main step-up transformers have protective devices for sudden pressure, neutral overcurrent, and differential current. The unit auxiliary transformers have protective devices for sudden pressure, overcurrent, differential current, and neutral overcurrent. If one of these devices senses a fault condition, the following actions will be automatically taken:

- Trip high-side (grid) breaker.
- Trip generator breaker.
- Trip exciter field breaker.
- Trip the 6.9-kV buses connected to the faulted transformer.
- Initiate a fast bus transfer of 6.9-kV buses ES1 – ES6.

The reserve auxiliary transformers have protective devices for sudden pressure, overcurrent, and differential current. Each reserve auxiliary transformer protective device trips the associated reserve supply breaker and any 6.9-kV buses connected to that transformer.

The onsite standby power system, powered by the two onsite standby diesel generators, supplies power to selected loads in the event of the loss of the normal, preferred, and maintenance ac power supplies. Those loads that are priority loads for defense-in-depth functions based on their specific functions (permanent nonsafety loads) are assigned to buses ES1 and ES2. These plant permanent nonsafety loads are divided into two functionally redundant load groups (the degree of redundancy for each load is described in the section for its respective system). Each load group is connected to either bus ES1 or bus ES2. Each bus is backed by a non-Class 1E onsite standby diesel generator. In the event of a loss of voltage on bus E1 or bus E2, the associated diesel generator is automatically started and connected to that bus. In the event that a fast transfer for a particular bus initiates but fails to complete, the associated diesel generator starts on an undervoltage signal; however, if a successful residual voltage transfer occurs, the diesel generator does not connect to the bus because the successful residual voltage transfer resumes power to the bus before the diesel connection time of two minutes has elapsed. The source incoming breakers on switchgear ES1 and ES2 are interlocked to prevent inadvertent connection of the onsite standby diesel generators and preferred/maintenance ac power sources to the 6.9-kV buses at the same time.

Each diesel generator, however, is capable of being manually paralleled with the preferred power supply for periodic testing. Design provisions protect the diesel generators from excessive loading beyond the design maximum rating, should the preferred power be lost during periodic testing. The control scheme, while protecting the diesel generators from excessive loading, does not compromise the onsite power supply capabilities to support the defense-in-depth loads.

The reactor coolant pumps (RCPs) are powered from the four switchgear buses located in the turbine building, one RCP per bus. Variable-speed drives are provided for RCP startup and for RCP operation when the reactor trip breakers are open. During normal power operation (reactor trip breakers are closed), 60-Hz power is provided directly to the RCPs, and the variable-speed drives are not connected.

Each RCP is powered through two Class 1E circuit breakers connected in series. These are the only Class 1E circuit breakers in the main ac power system; they satisfy the safety-related tripping requirement for these pumps. The reactor coolant pumps connected to a common steam generator are powered from two different auxiliary transformers. The bus assignments for the reactor coolant pumps are shown in Figure 9-1.

The 480-V load centers supply power to selected 460-V motor loads and to motor control centers. Bus tie breakers are provided between two 480-V load centers which serve predominantly redundant loads. This intertie allows restoration of power to selected loads in the event of a failure of or maintenance on a single load center transformer. The bus tie breakers are interlocked with the corresponding bus source incoming breakers so that one of the two bus source incoming breakers must be opened before the associated tie breaker is closed.

The 480-V motor control centers supply power to 460-V motors not powered directly from load centers, while the 480/277-V and 208/120-V distribution panels provide power for miscellaneous loads such as unit heaters, space heaters, and the lighting system. The motor control centers also provide ac power to the Class 1E battery chargers for the Class 1E dc power system described in section 9.3.

Two ancillary ac diesel generators, located in the annex building, provide ac power for Class 1E post-accident monitoring, MCR lighting, MCR and I&C room ventilation, and refilling the PCS water storage tank and the spent fuel pool, when all other sources of power are not available.

Each ancillary ac generator output is connected to a distribution panel. The distribution panel is located in the room housing the diesel generator. The distribution panels have incoming and outgoing feeder circuit breakers as shown in Figure 9-3. The outgoing feeder circuit breakers are connected to cables which are routed to the divisions B and C voltage regulating transformers and to the PCS pumps. Each distribution panel has the following outgoing connections:

- A connection for a Class 1E voltage regulating transformer to power the post-accident monitoring loads, the lighting in the main control room, and ventilation in the main control room and division B (or C) I&C room.

- A connection for a PCS recirculation pump, to enable refilling the PCS water storage tank and the spent fuel pool.

- A connection for local loads to support operation of the ancillary generator (lighting and fuel tank heating).

- A temporary connection for a test load device (e.g., load resistor).

See Figure 9-3 for connections to post-72-hour loads.

9.2.3 Standby AC Power Supply

9.2.3.1 Onsite Standby Diesel Generators

Two onsite standby diesel generator units, each furnished with its own support subsystems, provide power to the selected plant nonsafety-related ac loads. The power supplies to subsystem components are provided from separate sources to maintain the reliability and operability of the onsite standby power system. These onsite standby diesel generator units and their associated support systems are classified as AP1000 Class D, defense-in-depth systems.

The onsite standby diesel generators function to provide a reliable backup source of electrical power to the various plant system electrical loads. These loads represent system components that enhance an orderly plant shutdown under emergency conditions. Additional loads that are for investment protection can be manually loaded on the standby power supplies after the loads required for orderly shutdown have been satisfied.

Each diesel generator unit reaches its rated speed and voltage and is ready to accept electrical loads within 120 seconds after a start signal.

Each generator has an automatic load sequencer to enable controlled loading on the generator. The automatic load sequencer connects selected loads at predetermined intervals. This feature allows recuperation of generator voltage and frequency to rated values prior to the connection of the next load.

Each of the generators is directly coupled to the associated diesel engine. Each diesel generator unit is an independent self-contained system complete with necessary support subsystems that include:

- Diesel engine starting subsystem,
- Combustion air intake and engine exhaust subsystem,
- Engine cooling subsystem,
- Engine lubricating oil subsystem,
- Engine speed control subsystem, and
- Generator, exciter, generator protection, monitoring instruments, and controls subsystems.

The diesel generator starting air subsystem consists of an ac motor-driven, air-cooled compressor, a compressor inlet air filter, an air-cooled aftercooler, an in-line air filter, a refrigerant dryer (with a dew point at least 10°F less than the lowest normal diesel generator room temperature), and an air receiver with sufficient storage capacity for three diesel engine starts. The starting air subsystem will be consistent with manufacturer's recommendations regarding the devices to crank the engine, the duration of the cranking cycle, the number of engine revolutions per start attempt, the volume and design pressure of the air receivers, and the compressor size. The interconnecting stainless steel piping from the compressor to the diesel engine dual air starter system includes air filters, moisture drainers, and pressure regulators to provide clean, dry compressed air at normal diesel generator room temperature for engine starting.

The diesel generator combustion air intake and engine exhaust subsystem provides combustion air directly from the outside to the diesel engine while protecting it from dust, rain, snow, and environmental particulates. It then discharges exhaust gases from the engine to the outside of the diesel generator building more than 20 feet higher than the air intake. The combustion air circuit is separate from the ventilation subsystems and includes weather-protected, dry-type inlet air filters piped directly to the inlet connections of the diesel engine-mounted turbochargers. The combustion air filters are capable of reducing airborne particulate material, assuming the maximum expected airborne particulate concentration at the combustion air intake. Each engine is provided with two filters. A differential pressure gauge is installed across each filter to determine the need for filter replacement. The engine exhaust gas circuit consists of the engine exhaust gas discharge pipes from the turbocharger outlets to a single vertically mounted outdoor silencer which discharges to the atmosphere. Manufacturer's recommendations are considered in the design of features to protect the silencer module and other system components from possible clogging due to adverse atmospheric conditions, such as dust storms, rain, ice, and snow.

The diesel generator engine cooling system is an independent closed-loop cooling system, rejecting engine heat through two separate roof-mounted, fan-cooled radiators . The system consists of two separate cooling loops, each maintained at a temperature required for optimum engine performance by separate engine-driven coolant water circulating pumps. One circuit cools the engine cylinder block, jacket, and head area, while the other circuit cools the oil cooler and turbocharger aftercooler. The cooling water in each loop passes through a three-way self-contained temperature control valve which modulates the flow of water through or around the radiator, as necessary, to maintain the required water temperature. The temperature control valve has an expanding wax-type temperature-sensitive element or equivalent. The cooling circuit which cools the engine cylinder blocks, jacket, and head area includes a keep-warm circuit consisting of a temperature-controlled electric heater and an ac motor-driven water circulating pump.

The diesel generator engine lubrication system is contained on the engine skid and includes an engine oil sump, a main engine-driven oil pump, and a continuous engine prelube system consisting of an ac and dc motor-driven prelube pump and electric heater. The prelube system maintains the engine lubrication system in service when the diesel engine is in standby mode. The lube oil is circulated through the engine and various filters and coolers to maintain the lube oil properties suitable for engine lubrication.

The diesel generator engine fuel oil system includes an engine-mounted, engine-driven fuel oil pump that takes fuel from the fuel oil day tank and pumps it through inline oil filters to the engine fuel injectors and a separate recirculation circuit with a fuel oil cooler. The recirculation circuit discharges back to the fuel oil day tank, which is maintained at the proper fuel level by the diesel fuel oil storage and transfer system.

The onsite standby diesel generators are provided with the necessary controls and indicators for local or remote monitoring of the operation of the units. Essential parameters are monitored and alarmed in the main control room.

The design of the onsite standby diesel generators does not ensure functional operability or maintenance access or support plant recovery following design-basis events. Maintenance accessibility is provided consistent with the system nonsafety-related functions and plant availability goals.

The onsite standby power supply system is shown schematically in Figure 9-1.

9.2.3.2 Ancillary AC Diesel Generators

Power for Class 1E post-accident monitoring, for MCR lighting, for MCR and divisions B and C I&C room ventilation, and for refilling the PCS water storage tank and the spent fuel pool when no other sources of power are available, is provided by two ancillary ac diesel generators located in the annex building. The ancillary generators are not needed for refilling the PCS water storage tank, for spent fuel pool makeup, or for post-accident monitoring or lighting for the first 72 hours following a loss of all other ac sources.

The generators are classified as AP1000 Class D. The generators are commercial, skid-mounted, packaged units and can be easily replaced in the event of a failure. Generator control is manual from controls integral with the diesel skid package. These generators are located in the portion of the annex building that is a Seismic Category II structure. Features of this structure which protect the function of the ancillary generators are analyzed and designed for Category 5 hurricanes, including the effects of sustained winds, maximum gusts, and associated wind-borne missiles.

The fuel for the ancillary generators is stored in a tank located in the same room as the generators. The tank is Seismic Category II and holds sufficient fuel for 4 days of operation.

9.3 DC Power Systems

9.3.1 Introduction

The plant dc power system is comprised of independent Class 1E and non-Class 1E dc power systems. Each system consists of ungrounded stationary batteries, dc distribution equipment, and uninterruptible power supplies (UPSs).

The Class 1E dc and UPS system provides reliable power for the safety-related equipment required for the plant instrumentation, control, monitoring, and other vital functions needed for shutdown of the plant. In addition, the Class 1E dc and UPS system provides power to the normal and emergency lighting in the main control room and at the remote shutdown workstation.

The Class 1E dc and UPS system is capable of providing reliable power for the safe shutdown of the plant without the support of battery chargers during a loss of all ac power sources coincident with a design-basis accident (DBA). The system is designed so that no single failure will result in a condition that will prevent the safe shutdown of the plant.

The non-Class 1E dc and UPS system provides continuous, reliable electric power to the plant non-Class 1E control and instrumentation loads and equipment that are required for plant operation and investment protection, and to the hydrogen igniters located inside containment. Operation of the non-Class 1E dc and UPS system is not required for nuclear safety. See subsection 9.3.2.3.

The batteries for the Class 1E and non-Class 1E dc and UPS systems are sized in accordance with IEEE 485. The operating voltage range of the Class 1E batteries and of the EDS5 turbine generator motor load support batteries is 210 to 280 Vdc. The maximum equalizing charge voltage for the Class 1E and EDS5 batteries is 280 Vdc. The nominal system voltage is 250 Vdc. The operating voltage range of non-Class 1E EDS1 through EDS4 batteries is 105 to 140 Vdc. The maximum equalizing charge voltage for non-Class 1E EDS1 through EDS4 batteries is 140 Vdc. The nominal system voltage is 125 Vdc for non-Class 1E EDS1 through EDS4.

9.3.2 Description

9.3.2.1 Class 1E DC Distribution

There are four independent, Class 1E 250-Vdc divisions: A, B, C, and D. Each of divisions A and D includes one battery bank, one switchboard, and one battery charger. The battery bank is connected to a Class 1E dc switchboard through a set of fuses and a disconnect switch. Divisions B and C each include two battery banks, two switchboards, and two battery chargers. The first battery bank in each of the four divisions, designated as a 24-hour battery bank, provides power to the loads required for the first 24 hours following a loss of all ac power sources concurrent with a design-basis accident (DBA). The second battery bank in each of divisions B and C, designated as a 72-hour battery bank, powers those loads required for the first 72 hours following the same event. Each switchboard connected with a 24-hour battery bank supplies power to an inverter, a 250-Vdc distribution panel, and a 250-Vdc motor control center. Each switchboard connected with a 72-hour battery bank supplies power to an inverter. No load shedding or load management program is needed to maintain power during the required 24-hour safety actuation period.

A single spare battery bank with a spare battery charger is provided for the Class 1E dc and UPS system. In the case of a failure or unavailability of the normal battery bank and the battery charger, permanently installed cable connections allow the spare to be connected to the affected bus by a plug-in, locking-type disconnect along with kirk-key interlock switches. The plug-in, locking-type disconnect and kirk-key interlock switches permit connection of only one battery bank and battery charger at a time, so that the independence of each battery division is preserved. The spare battery and the battery charger can also be utilized as a substitute when offline testing, maintenance and equalization of an operational battery bank is desired. Each 125-Vdc Class 1E battery division and the spare battery bank are separately housed.

Each battery bank, including the spare, has a battery monitor system that detects battery-open circuit conditions and monitors battery voltage. The battery monitor provides a trouble alarm in the main control room. The battery monitors are not required to support any safety-related function. Monitoring and alarming of dc current and voltages is through the plant control system, which includes a battery discharge rate alarm. The AP1000 design generally includes fusible disconnect switches in the Class 1E dc system. If molded-case circuit breakers are used for dc applications, they will be sized to meet the dc interrupting rating requirements.

The Class 1E dc switchboards employ fusible disconnect switches and have adequate short- circuit and continuous-current ratings. The main bus bars are braced to withstand the mechanical forces resulting from a short-circuit current. Fused transfer switch boxes, equipped with double-pole, double-throw transfer switches, are provided to facilitate battery testing and maintenance.

Battery chargers are connected to dc switchboard buses. The input ac power for the Class 1E dc battery chargers is supplied from non-Class 1E 480-Vac diesel generator-backed motor control centers. The battery chargers provide the required isolation between the non-Class 1E ac and the Class 1E dc electrical systems. Each battery charger has an input ac and output dc circuit breaker for the purpose of power source isolation and required protection. Each battery charger prevents the ac supply from becoming a load on the battery due to a power feedback as a result of the loss of ac power to the charger. Each battery charger has a built-in current limiting circuit, adjustable between 110 to 125 percent of its rating, to hold down the output current in the event of a short circuit or overload on the dc side. The output of the charger is ungrounded and filtered. The output float and equalizing voltages are adjustable. Each battery charger has an equalizing timer and a manual bypass switch to permit periodic equalizing charges. Each charger is capable of providing the continuous demand on its associated dc system while providing sufficient power to charge a fully discharged battery within a 24-hour period. The battery chargers are provided with a common failure/trouble alarm.

The Class 1E dc motor control centers operate as a 250-Vdc-nominal, two-wire, ungrounded system. The dc motor control centers provide branch circuit protection for the dc motor-operated valves. Motor-operated valves are protected by thermal overload devices in accordance with Regulatory Guide 1.106. Motor overload condition is annunciated in the main control room. The loads fed from the motor control centers are protected against a short-circuit fault by fusible disconnect switches. Reduced-voltage motor controllers limit the starting current to approximately 500 percent of rated current for motors equal to or larger than 5 HP.

The Class 1E dc distribution panels provide power distribution and tripping capability between the 250-Vdc power sources and the assigned safeguard loads indicated in Figure 9-4.

9.3.2.2 Class 1E Uninterruptible Power Supplies

The Class 1E UPSs provide power at 208 Y/120 Vac to four independent divisions of Class 1E instrument and control power buses. Divisions A and D each consist of one Class 1E inverter associated with an instrument and control distribution panel and a backup voltage regulating transformer with a distribution panel. The inverter is powered from the respective 24-hour battery bank switchboard. Divisions B and C each consist of two inverters, two instrument and control distribution panels, and a voltage regulating transformer with a distribution panel. One inverter is powered by the 24-hour battery bank switchboard, and the other by the 72-hour battery bank switchboard. For system configuration and equipment rating, see Figure 9-4. Under normal operation, the Class 1E inverters receive power from the associated battery banks. If an inverter is inoperable or the Class 1E 250-Vdc input to the inverter is unavailable, the power is transferred automatically to the backup ac source by a static transfer switch featuring a make-before-break contact arrangement. The backup power is received from a diesel generator-backed non-Class 1E 480-Vac bus through a Class 1E voltage regulating transformer. In addition, a manual mechanical bypass switch is provided to allow connection of the backup power source when the inverter is removed from service for maintenance.

In order to supply power during the post-72-hour period following a design-basis accident, provisions are made to connect ancillary ac generators to the Class 1E voltage regulating transformers (for divisions B and C only). The ancillary generators power the Class 1E post-accident monitoring systems, the lighting in the main control room, and ventilation in the MCR and divisions B and C I&C rooms.

9.3.2.3 Non-Class 1E DC and UPS System

The non-Class 1E dc and UPS system consists of the electric power supplies and distribution equipment that provide dc and uninterruptible ac power to the plant non-Class 1E dc and ac loads that are critical for plant operation and investment protection, and to the hydrogen igniters located inside containment. The non-class 1E dc and UPS system is comprised of two subsystems representing two separate power supply trains. The subsystems are located in separate rooms in the annex building. Figure 9-5 represents the distribution configuration.

EDS1 and 3 constitute one subsystem, and EDS2 and 4 constitute the other. Each subsystem consists of separate dc distribution buses. These two buses can be connected by normally open circuit breakers to enhance the power supply source availability.

Each dc subsystem includes battery chargers, stationary batteries, dc distribution equipment, and associated monitoring and protection devices.

DC buses 1, 2, 3, and 4 (See Figure 9-5) provide 125-Vdc power to the associated inverter units that supply ac power to the non-Class 1E uninterruptible power supply ac system. An alternate regulated ac power source for each UPS bus is supplied from an associated regulating transformer. DC bus 5 supplies large dc motors. This configuration isolates the large motors.

The onsite standby diesel generator-backed 480-Vac distribution system provides the normal ac power to the battery chargers. Industry standard stationary batteries that are similar to the Class 1E design are provided to serve as dc power sources in case the battery chargers fail to supply the dc distribution bus system loads. The batteries are sized to supply the system loads for a period of at least two hours after a loss of all ac power sources.

Each dc distribution switchboard houses the dc feeder protection device, dc bus ground-fault detection, and appropriate metering. The component design and the current interrupting device selection follow the circuit coordination principles.

The non-Class 1E dc and UPS system is designed to meet the quality guidelines established by Generic Letter 85-06, "Quality Assurance Guidance for ATWS Equipment that is not Safety-Related."

Each of non-Class 1E dc distribution subsystem buses EDS1, 2, 3, and 4 has provisions to allow the connection of a spare non-Class 1E battery charger should its non-Class 1E battery charger be unavailable due to maintenance, testing, or failure. Bus EDS5 does not require this capability because the only load on its associated charger is the battery.

The non-Class 1E dc system uses the Class 1E spare battery bank as a temporary replacement for any primary non-Class 1E battery bank. In this design configuration, the spare Class 1E battery bank would be connected to the non-Class 1E dc bus but could not simultaneously supply Class 1E safety loads nor perform safety-related functions. For EDS1 through EDS4, this is accomplished by opening the disconnect switch between the two 125-Vdc battery cell strings, which together comprise the 250-Vdc spare battery. Additionally, the design includes two current interrupting devices placed in series with the main feed from the spare battery that are fault-current activated. This feature preserves the spare Class 1E battery integrity should the non-Class 1E bus experience an electrical fault. This arrangement does not degrade the electrical independence of the Class 1E safety circuits.

9.3.3 Separation and Ventilation

For the Class 1E dc system, the 24-hour and 72-hour battery banks are housed in the auxiliary building in ventilated rooms apart from the chargers and distribution equipment. The battery rooms are ventilated to limit hydrogen accumulation.

The four divisions are independent, they are located in separate rooms, they cannot be interconnected, and their circuits are routed in dedicated, physically separated raceways. This level of electrical and physical separation prevents the failure or unavailability of a single battery, battery charger, or inverter from adversely affecting a redundant division.

9.3.4 Maintenance and Testing

Components of the 125-Vdc and 250-Vdc systems undergo periodic maintenance tests to determine the condition of the system. Batteries are checked for electrolyte level, specific gravity, and cell voltage, and they are visually inspected.

The surveillance testing of the Class 1E 250-Vdc system is performed as required by the Technical Specifications.

Table 9-1

250V DC CLASS 1E DIVISION A BATTERY NOMINAL LOAD REQUIREMENTS

Load Description	Power Required (kW)	
	Momentary	**Continuous**
Bus IDSA DS 1 (24 hr Battery Bank)		
Inverter		
Protection and Safety Monitoring System	0	10.6
Emergency Lighting	0	0.3
Containment High Range Monitor	0	0.1
Subtotal	0	11.0
250 Vdc Panel		
Reactor Trip Swgr & Solenoid Valves	7	0.5
250 Vdc MCC		
Motor-operated Valves	453	
Total	460	11.5

Table 9-2

250V DC CLASS 1E DIVISION B BATTERY NOMINAL LOAD REQUIREMENTS

Load Description	Power Required (kW)	
	Momentary	**Continuous**
Bus IDSB DS 1 (24 hr Battery Bank)		
Inverter		
Protection and Safety Monitoring System	0	10.1
Emergency Lighting and Panel Lighting	0	0.5
Subtotal	0	10.6
250 Vdc Panel		
Reactor Trip Swgr, RCP Trip & Solenoid Valves	12	0.8
250 Vdc MCC		
Motor Operated Valves	290	
Total	302	11.4
BUS IDSB DS 2 (72 hr Battery Bank)		
Inverter		
Protection and Safety Monitoring System	0	3.15
Emergency Lighting and Panel Lighting	0	0.63
Containment High Range Monitor	0	0.12
MCR Supply Duct Radiation Monitor	1.8	0.24
Total	1.8	4.14

Table 9-3

250V DC CLASS 1E DIVISION C BATTERY NOMINAL LOAD REQUIREMENTS

Load Description	Power Required (kW) Momentary	Power Required (kW) Continuous
Bus IDSC DS 1 (24 hr Battery Bank)		
Inverter		
Protection and Safety Monitoring System	0	10.1
Emergency Lighting and Panel Lighting	0	0.5
Subtotal	0	10.6
250 Vdc Panel		
Reactor Trip Swgr, RCP Trip & Solenoid Valves	12	0.5
250 Vdc MCC		
Motor-operated Valves	173	
Total	185	11.1
BUS IDSC DS 2 (72 hr Battery Bank)		
Inverter		
Protection and Safety Monitoring System	0	3.15
Emergency Lighting and Panel Lighting	0	0.63
Containment High Range Monitor	0	0.12
MCR Supply Duct Radiation Monitor	1.8	0.24
Total	1.8	4.14

Table 9-4

250V DC CLASS 1E DIVISION D BATTERY NOMINAL LOAD REQUIREMENTS

Load Description	Power Required (kW)	
	Momentary	**Continuous**
Bus IDSD DS 1 (24 hr Battery Bank)		
Inverter		
Protection and Safety Monitoring System	0	10.6
Emergency Lighting	0	0.3
Containment High Range Monitor	0	0.1
Subtotal	0	11.0
250 Vdc Panel		
Reactor Trip Swgr & Solenoid Valves	6	0.8
250 Vdc MCC		
Motor Operated Valves	380	
Total	386	11.8