8.3 STATION DISTRIBUTION

8.3.1 13.8 kV SYSTEM

8.3.1.1 Design Basis

The 13.8 kV system is designed to function reliably and supply power to plant auxiliaries during normal operation and under accident conditions. The system supplies power to the RCPs directly and to the 4.16 kV system through voltage regulators and unit service transformers.

8.3.1.2 Description and Operation

The plant 13.8 kV system is shown on Figure 8-1, Electrical Main Single Line Diagram. A description can be found in Table 8-2.

The 13.8 kV system for the plant consists of three plant service transformers (P-13000-1, P-13000-2 and P-13000-3), five service busses, six voltage regulators with associated transfer switches, and eight RCP busses. The capacities of the three plant service transformers and associated switchgear and cable are such that any one of the transformers can supply the total auxiliary load of the plant. Each RCP is attached to separate 13.8 kV busses which are fed from either of the two service buses 12 or 22.

The ring bus design added a third Plant Service Transformer (PST), P-13000-3, and the necessary switchgear and cabling so that any combination of the three PSTs can be used through unit busses 14, 01A/B and 24 to provide power to any combination of the downstream 13 kV service busses. Current limiters are placed in service in this configuration to prevent equipment damage due to excessive short circuit currents.

In the ring bus configuration, in the event of failure of one or two of the PSTs, the RCPs and auxiliary loads will not lose their power supply.

Service Busses 11 and 21 supply power to the unit service transformers, and are equipped with bus tie breakers.

The capability of regulating plant auxiliary power distribution system voltage is provided by 13.8 kV voltage regulators. A voltage regulator with associated transfer switches are installed at the 13.8 kV level for each U-4000 transformer. The transfer switches are provided to bypass and isolate the voltage regulators during regulator maintenance. Six regulators and six transfer switches, three per unit, are located outdoors on the western side of the plant access road in the vicinity of the P-13000 Station Service Transformers. The voltage regulator units are provided with a deluge water spray system designed to the requirements of NFPA 15, Standard for Water Spray Fixed System for Fire Protection.

The unit switchgear for the RCPs is metal-clad with removable circuit breakers and is designed for indoor installation. The switchgear for Service Busses 11, 12, 21, 22 and 23 is also metal-clad with removable circuit breakers, but is designed for outdoor installation. The Unit Busses 14, 01A/B, and 24, along with Current Limiters (IS-Limiter) that are feeding Busses 11, 12, 21, and 24 are housed in weather tight Switchgear Rooms with a firewall separating Unit-1 busses from Unit-2 busses.

Relay protection, including open phase detection, ground connections, and structural safeguards are provided to assure adequate personnel protection and to prevent or limit equipment damage during system short circuits.

Operation - During normal operation, all three plant service transformers are energized and share the total plant auxiliary load. All RCP motors are fed from 13.8 kV busses.

Operation of all 13.8 kV equipment is effected and monitored in the Control Room, with the exception of site facility power feeds, which have local control and indicators but provide Control Room annunciation. Circuit breaker position is indicated by red and green lights. Typical functions annunciated are circuit breaker trip, bus undervoltage, and motor overload. Electrical indication is provided in the Control Room for bus voltage, service transformer current and power, bus current, and motor current. Control Room operation and monitoring for busses 14, 01A/B and 24 equipment is with HMI.

Testing - Portions of the system can be tested during normal operation. For example, various backup protective relays may be withdrawn from their cases for inspection, calibration, and test. While equipment is shut down, circuit breakers may be placed in the test position and the control circuit functionally tested.

8.3.2 4.16 kV SYSTEM

8.3.2.1 Design Basis

The 4.16 kV system is designed to function reliably and supply power during normal operation and under accident conditions. The system will supply power to the 4.16 kV auxiliary loads from the 13.8 kV system through the six unit service transformers. There are six 4.16 kV busses per unit, two of which supply power to the ESF. The ESF electrical system incorporates the two-channel concept, i.e., independent electrical controls and power systems supply redundant 4.16 kV ESF. The 4.16 kV ESF electrical system meets the single failure criterion defined in IEEE 279, Section 4.2, and is designed as a Class 1E system.

8.3.2.2 Description and Operation

Description - The plant 4.16 kV system is shown on Figures 8-1, 8-4, and 8-10 and in Table 8-3; it consists of seven unit service transformers (OX01, U-4000-11, U-4000-12, U-4000-13, U-4000-21, U-4000-22, and U-4000-23), fourteen 4.16 kV busses (07, 11, 12, 13, 14, 15, 16, 17, 21, 22, 23, 24, 25 and 26), the motor feeder circuits, and 480 Volt load center feeder circuits.

The 4.16 kV busses consist of metal-clad switchgear assemblies with draw out circuit breakers. Relay protection, including open phase detection for the 4.16 kV buses that feed the ESF loads, ground connections, and structural safeguards are provided to assure adequate personnel protection and to prevent or limit equipment damage during system short circuits. This equipment, except open phase detection associated relying is designed to function properly while subject to SSE accelerations.

Two of the 4.16 kV busses for each unit (11 and 14 for Unit 1, 21 and 24 for Unit 2) supply power to ESF. The two busses feed redundant equipment. Each of the two busses per unit can be supplied from separate EDGs. These busses are located in separate Seismic Category I rooms. Feeder cables from the EDGs and from ESF equipment are also located within Seismic Category I structures, and separation is maintained between the feeder cables of the two busses.

Operation - Whenever offsite power is available, the 4.16 kV system is supplied by the 13.8 kV system through the six unit service transformers. Each 4.16 kV bus can be fed from either of two 13.8 kV sources of auxiliary power through different unit service transformers. Normally, Busses 11, 12, and 13 are fed from unit Service Transformer U-4000-11, Bus 14 from U-4000-21, Bus 21 from U-4000-12, Busses 22, 23, and 24 from U-4000-22, Busses 15 and 16 from U-4000-13, and Busses 25 and 26 from U-4000-23. Transfers, if required, are performed manually.

The ESF busses are equipped with one set of undervoltage sensing relays, and upon receipt of a two-out-of-four logic signal, the diesel generators are energized to supply power (Section 8.4.1).

With the exception of the non-Class 1E feeders to the South Service Building, the Control Room Chilled Water System, and the Access Control Expansion Area, all 4.16 kV equipment can be operated from the Control Room. Breaker status is indicated in the Control Room by red and green lights. Typical functions annunciated are circuit breaker trip, motor overload, bus undervoltage and, for most breakers feeding Class 1E loads, blocked auto start due to lockout or discharged springs. Electrical parameters such as bus voltage, bus current, motor current, and transformer current and power are displayed in the Control Room.

Testing - The 4.16 kV ESF are designed to permit testing during normal plant operation.

8.3.3 480 VOLT SYSTEM

8.3.3.1 Design Basis

The 480 Volt system is designed to function reliably and supply power during normal operation and under accident conditions. The system will supply power to the 480 Volt auxiliary loads from the 4.16 kV system through the 4160/480 Volt unit service transformers. Four of the unit load centers and two motor control centers (MCCs) supply power to the ESF. The ESF electrical system incorporates the two-channel concept, i.e., independent electrical controls and power systems supply redundant 480 Volt ESF. The 480 Volt ESF electrical system meets the single failure criterion as defined in IEEE 279, Section 4.2, and is designed as a Class 1E system.

8.3.3.2 Description and Operation

Description - The 480 Volt system is shown on Figures 8-1, 8-3, and 8-11, Single Line, Meter and Relay Diagrams, 480 Volt Unit Busses. The system is also described in Table 8-4.

The 480 Volt system for the plant consists of double-ended unit load centers, single-ended unit load centers, and MCCs. Power for each load center bus is supplied from a separate 4.16 kV/480 Volt unit service transformer. The MCC feeders from the 480 Volt load center busses are arranged so that each end of a double-ended MCC is fed from a different 480 Volt load center bus.

The 480 Volt unit load centers consist of metal-clad switchgear with draw-out air circuit breakers. The MCCs are metal enclosed with removable starter and breaker combination modules. Relay protection, ground connections, and structural safeguards are provided to assure adequate personnel protection and to prevent or limit equipment damage during system short circuits. This equipment is designed to function properly while subjected to SSE accelerations.

Four of the 480 Volt unit load centers for each unit (11A, 11B, 14A, and 14B for Unit 1; 21A, 21B, 24A, and 24B for Unit 2) supply power to ESF. Busses 11A/B and busses 14A/B feed redundant ESF. The redundant busses are supplied from separate EDGs through the 4.16 kV/480 Volt unit service transformers. Similarly, two of the MCCs for each unit (MCC 104R and MCC 114R for Unit 1, MCC 204R and MCC 214R for Unit 2) supply power to redundant ESF. Each of the two busses per unit are supplied from separate EDGs via the 480 Volt unit load centers. Redundant ESF 480 Volt busses are located in separate Seismic Category I rooms. Feeder cables from ESF equipment are also located within Seismic Category I structures, and separation is maintained between the feeder cables of the two redundant systems.

Operation - During normal operation all incoming bus breakers and MCC feeder breakers are closed. The tie breakers between MCCs 104R-114R, 101AT-101BT, 204R-214R, and 201AT-201BT are normally open and are closed only for emergency or maintenance.

Key interlocks are provided to prevent simultaneous closure of the tie breakers and both MCC feeder breakers. The operation of the bus tie is a manual function only.

The 480 Volt ESF busses are supplied with power from the diesel generators through the 4.16 kV/480 Volt service transformers in case of failure of the preferred source of power to the 4.16 kV busses (Section 8.4.1).

Operation of ESF equipment may be controlled from the Control Room as may other essential equipment. The status of this equipment (breaker and starter position) is indicated by red and green lights in the Control Room. All equipment has local indication of breaker or starter status. Circuit breaker trip and motor overload are annunciated in the Control Room. Electrical indication for bus voltage and bus current is provided in the Control Room.

Testing - The 480 Volt ESF are designed to permit testing during normal plant operation.

8.3.4 CONTROL ELEMENT ASSEMBLY POWER SUPPLY

8.3.4.1 Design Basis

The control element assembly (CEA) power supply is designed as a stable, reliable power supply for the CEAs.

8.3.4.2 Description and Operation

The CEA power supply for one unit consists of two ride-through flywheel motor-generator power systems. The motor-generator sets have the capability, individually or in parallel, to hold all the control elements and sustain the motion of any element already being stepped during a one second transient in the station service voltage. Each motor-generator set is connected to a different 480 Volt load center.

8.3.5 125 VOLT DC AND VITAL 120 VOLT AC SYSTEMS

8.3.5.1 Design Basis

The 125 Volt DC and vital AC systems are designed to furnish continuous power to the plant vital instrumentation and control systems regardless of auxiliary electrical system condition. The reliability of the system is increased by redundancy of vital equipment and circuits.

8.3.5.2 Description and Operation

Description - The 125 Volt DC and 120 Volt vital AC systems are shown on Figure 8-5, Single Line Diagram (Section 8.4.3). System data can also be found in Table 8-5.

The 125 Volt DC and 120 Volt vital AC systems for the plant are divided into four independent and isolated channels. Each channel consists of one battery, two battery chargers, one DC bus, multiple DC unit control panels, and two dual inverters. Each inverter has an associated vital AC distribution panelboard. Power to the DC bus, DC unit control panels, and dual inverters is supplied by the station batteries (Table 8-10) and/or the battery chargers.

Each battery charger is fully rated and can recharge a discharged battery while at the same time supplying the steady state power requirements of the system.

A reserve 125 Volt DC system for the plant is completely independent and isolated from all four separation groups, yet is capable of replacing any of the 125 Volt DC batteries. This system consists of one battery, one battery charger and the associated DC switching equipment. Only the battery may be transferred for replacement duty.

As shown on Figure 8-9, the 125 Volt DC Busses 11 and 22 are a part of Load Group A, and 125 Volt DC Busses 12 and 21 are a part of Load Group B. The 125 Volt DC Bus 11 provides control power for equipment associated with Load Group A for both units. The 125 Volt DC Bus 21 provides control power for equipment associated with Load Group B for both units. The 125 Volt DC Busses 12 and 22 are used to supply power to the computer inverters, Control Room emergency lighting, and two channels of the 120 Volt vital AC system. The 125 Volt DC Bus 01 is not associated with a load group except while connected to one of the DC busses.

There is one battery charger fed from Unit 1 and another battery charger fed from Unit 2 connected to each 125 Volt DC bus. The AC power for both battery chargers per bus is obtained from the same load group. The reserve battery is connected to its own charger when it is not connected to a safety-related 125 Volt DC bus.

The 120 Volt vital AC system provided for each unit has four separate distribution panelboards which provide power for the four RPS channels and the four ESF and auxiliary feedwater actuation systems channels. Each panelboard is supplied by a dual inverter with its own DC feeder from a separate battery. Each dual inverter has two built-in independent inverters, one to serve as primary and the other as backup. In the dual inverter, 120 Volt AC power output can be manually switched from primary inverter to backup inverter. Each 120 Volt AC distribution panelboard can be manually switched from the dual inverter to a 120 Volt AC bus fed from an ESF MCC through a regulating transformer.

The 125 Volt DC system and the 120 Volt vital AC system are ungrounded and equipped with ground detectors.

Each of the four 125 Volt DC power sources is equipped with the following instrumentation in the Control Room to enable continual operator assessment of 125 Volt DC power source condition.

a. DC bus undervoltage alarm
b. Battery current indication

c. Charger current indication

d. Charger malfunction alarm (including input AC undervoltage, output DC undervoltage and output DC overvoltage)

e. DC bus voltage indication, and

f. DC ground indication

The undervoltage relay features an extra high dropout characteristic and is designed specifically to monitor the charging supply for a station battery and sound an alarm if this supply fails.

In addition to the above instrumentation, continuous monitoring of the battery's connection to the bus and of battery circuit continuity is provided.

The 125 Volt DC system has been designed to function properly while subjected to SSE accelerations.

Operation - During normal operation, all battery chargers are energized and maintain a constant voltage to supply the batteries with sufficient current to keep them fully charged and maintain the steady state load of DC instruments, control circuits, and inverters. In the event of loss of auxiliary system power, the batteries will continue to supply the required DC and vital AC equipment. When AC power is regained from the diesel generators, the battery chargers will be re-energized and resume normal operation. The batteries are sized to supply the anticipated DC and vital AC load, without support from battery chargers, for a period of two hours (Section 8.4.3).

When the reserve battery system is not in use, the spare battery charger is energized to maintain a constant voltage to supply the battery with sufficient current to keep it fully charged. If the battery is connected to one of the 125 Volt DC busses, its charger is disconnected before the battery is connected to the bus. The reserve battery is kept then fully charged by the chargers on the associated DC bus. During the battery transfer, the DC bus voltage is maintained by these chargers.

8.3.6 250 VOLT DC EMERGENCY PUMP SYSTEM

8.3.6.1 Design Basis

The 250 Volt DC emergency pump system is designed to supply power to the various plant backup lube oil and seal oil emergency pumps in case of loss of auxiliary AC power or failure of the normal AC pumps. There are no loads connected to the 250 Volt DC bus that are related to the functioning of ESF.

8.3.6.2 Description and Operation

Description - The 250 Volt DC emergency pump system is shown on Single Line Diagram, Figure 8-5. Additional data can be found in Table 8-6.

The single 250 Volt DC emergency pump system for the plant consists of one MCC, two battery chargers, and two batteries. Only one battery is connected to the MCC. The backup battery will be used when the first battery is out-of-service. The battery chargers are sized such that in combination they are capable of supplying the continuous load of the largest connected motor. Each battery charger is fed from separate ESF 480 Volt load centers (one from Unit 1 and one from Unit 2).

Each battery consists of lead-acid cells electrically-connected in series to establish a nominal 250 Volt supply. The grid structure is of the lead-calcium design. Each battery is sized to supply the total connected load for one hour without support from battery chargers. In addition, they each are of sufficient rating to start the two largest motors simultaneously while all other motors are operating at full load without allowing the battery voltage to fall below 210 Volts.

The 250 Volt DC emergency pump system is ungrounded and equipped with ground detectors. Battery charger current and 250 Volt DC bus voltage are displayed in the Control Room. Typical functions annunciated in the Control Room are 250 Volt DC bus undervoltage and battery charger undervoltage.

Operation - During normal operation, both battery chargers are energized maintaining a constant voltage such that they supply the battery connected to the MCC with sufficient current to keep it fully charged. In case of loss of auxiliary system power or failure of a normal AC pump, the connected battery will supply the necessary power for backup pump operation. After availability of AC power from the diesel generators, the battery chargers can be manually energized to resume normal operation.

8.3.7 INSTRUMENT AC SYSTEM

8.3.7.1 Design Basis

The 208-120 Volt instrument AC system is designed to furnish power to all plant instruments other than those supplied from the DC and the vital AC systems. In addition, it is utilized as a backup supply of power for the computer and the preferred source of power for the public address system.

8.3.7.2 Description and Operation

Description - The instrument AC system for each unit is divided into two panelboard sections. Each section is supplied by a single three-phase transformer connected to an ESF MCC. In case of loss of normal auxiliary power, the transformers will automatically be energized by the EDGs. A manually operated bus tie switch has been provided between the two sections.

Operation - During normal operation, the bus tie switch is open and both transformers are energized and supply their associated panelboards. Should the power from one transformer source be interrupted, the bus tie is closed and both panelboard sections are fed from a single transformer.

TABLE 8-2
RATINGS AND CONSTRUCTION OF 13.8 kV SYSTEM COMPONENTS

Plant Service Transformers P-13000-1 and P-13000-2 and P-13000-3 2-winding, Wye/Wye	-	500/14 kV, 3-phase, 60 Hz, 60/80/100 MVA OA/FA/FOA ONA/$ONAF_1$/$ONAF_2$
Voltage Regulators	-	13.8 kV, 3-phase, 2 MVA ± 10% voltage regulation
Transfer Switches	-	15 kV, 1200 A
Service Busses	-	1200 A continuous rating
Unit Busses	-	3000 A AND 4000 A continuous rating
Circuit Breakers	-	1200A, 3000 A and 4000 A continuous rating
Disconnect Switch	-	5000 A

TABLE 8-3
RATINGS AND CONSTRUCTION OF 4.16 kV SYSTEM COMPONENTS

Unit Service Transformers	-	13.8 kV/4.16-4.16 kV, 3-phase, 60 Hz 12/16/20 MVA, OA/FA/FOA
Bus	-	2000 A continuous rating
Incoming Breakers on Busses 12, 13, 15, 16, 22, 23, 25 & 26	-	2000 A continuous, 250 MVA interrupting
Feeder Breakers and Incoming Breakers on Busses 11, 14, 21 & 24	-	1200 A continuous, 250 MVA interrupting

TABLE 8-4

RATINGS AND CONSTRUCTION OF 480 VOLT SYSTEM COMPONENTS

480 Volt Unit Load Centers		
Transformers	-	1000 kVA or 1333 kVA, OA or AA, 3-phase, 60 Hz, 4160/480 Volts
Bus	-	1600 A continuous
Breakers, Metal-clad	-	25,000 A rms symmetrical minimum interrupting rating
480 Volt MCCs		
Horizontal Bus	-	600 A continuous, 25,000 A rms symmetrical
Vertical Bus	-	300 A continuous, 25,000 A rms symmetrical
Breakers, Molded Case	-	25,000 A rms symmetrical minimum interrupting rating

TABLE 8-5

RATINGS AND CONSTRUCTION OF 125 VOLT DC AND VITAL 120 VOLT AC SYSTEM COMPONENTS

125 Volt DC Bus	-	1200 A continuous, 10,000 A momentary
125 Volt Unit Control Panels	-	600 A continuous, 10,000 A momentary
125 Volt Bus Fuse Switches	-	10,000 A interrupting at 125 Volt DC
Battery Chargers	-	500 A continuous output
Dual Inverters	-	7.5 kVA, 0.7 P.F., 120 Volt AC continuous output, 60 Hz, single phase
Vital Instrumentation Bus Fuse Switches	-	10,000 A interrupting at 120 Volt AC
125 Volt Unit Control Panel Fuse Switches	-	10,000 A interrupting at 125 Volt DC
Battery Fuse	-	1,600 A continuous rating

TABLE 8-6

RATINGS AND CONSTRUCTION OF 250 VOLT DC EMERGENCY PUMP SYSTEM COMPONENTS

250 Volt DC Bus	-	1200 A continuous, 20,000 A momentary
250 Volt Fuse Switches	-	200,000 A interrupting at 250 Volt DC
Battery Chargers	-	150 A output
Battery Fuse	-	1200 A continuous rating
Batteries	-	Lead Calcium, 250 Volt, nominal 1950 A.H., 8-hour discharge rate at 77°F, minimum capacity is based on the following load cycle:

First minute	585 A
Next 4 minutes	270 A
Next 1 minute	1138 A
Next 54 minutes	661 A

TABLE 8-10

RATINGS AND CONSTRUCTION OF STATION BATTERIES

Reserve Battery - Cells are lead acid with lead calcium grid structure, 125 Volt, nominal 1500 Amp-hour, 8-hour discharge rate at 77°F.

Control Battery - Cells are lead acid with lead-calcium grid structure, 125 Volt, with nominal capacities of 1500 Amp-hour or 1950 Amp-hour, 8-hour discharge rate at 77°F, minimum capacity based on following load cycle:

BATTERY NO.	Two-Hour Accident Load Cycle TIME INTERVAL	AMPERES
11	First minute	512
	Second minute	451
	Next 117 minutes	250
	Last minute	325
12	First minute	291
	Second minute	272
	Next 117 minutes	286
	Last minute	319
21	First minute	473
	Second minute	394
	Next 117 minutes	225
	Last minute	319
22	First minute	317
	Second minute	299
	Next 117 minutes	311
	Last minute	341
01	Any of the above[a]	

[a] Battery 01 can be a replacement for any of the other four batteries and must be able to handle any of the load cycles shown.

The load cycle delineated above is based on anticipated breaker operations required during an accident on Unit 1 and a simultaneous undervoltage on Units 1 and 2. The load consists primarily of Control Room emergency lighting, vital bus dual inverters, plant computer inverters, DC-operated controls and instruments. The batteries are sized to carry the above loads for the duration stated after a loss of AC power.

Actual load cycle testing is performed using the two-hour scenario. Battery 01 is tested using a unique load cycle incorporating the largest discharge of any of the Stations Batteries' time intervals.