8.6 250-V DC POWER SUPPLY AND DISTRIBUTION

8.6.1 Safety Objective

The safety objective of the 250-V DC power system is to provide a highly reliable source of control power and motive power as required for the Engineered Safeguards System (ESS) so that no single credible event can disable the containment isolation and core standby cooling functions and their supporting control power sources and circuits.

8.6.2 Safety Design Basis

1. The ESS 250-V DC power system shall be designed with adequate independence and redundancy so that the failure of any single active component will not prevent the required ESS from functioning.

2. Battery capacity shall be adequate so that any two unit batteries can supply for 30 minutes, without chargers available, the DC power required to supply DC loads required for shutdown and cooldown of all three units in the event of the loss of offsite power and a design basis accident in any one unit.

3. The ESS that are supplied from the 250-V DC power system shall be designed to operate at the required minimum voltage for individual components.

4. The ESS 250-V DC power system shall be capable of withstanding the design basis earthquake without impairment of its function.

5. The ESS 250-V DC power system shall be designed so that any component, including battery charger, battery, distribution center, and interconnecting wiring, can be tested without disabling any required ESS.

8.6.3 Description

The 250-V DC power system consists of two subsystems, a six battery plant system, and a five battery control power system (shutdown board batteries).

1. The plant batteries are further categorized as unit batteries (Batteries 1, 2, and 3) and station batteries (Batteries 4, 5, and 6). The ESS loads for the three unit plant are supplied from Unit Batteries 1, 2, and 3. Batteries 1, 2, and 3 also supply some non-safety-related loads, but Batteries 4, 5, and 6 only supply non-safety-related loads.

   The 250-V DC unit system consists of three 120-cell lead-acid batteries (one Class 1E battery and battery charger per unit and one Class 1E spare battery

charger common with the station system) together with the associated circuitry, switches, indicators, and alarms (Figure 8.6-1a).

The 250-V DC station system consists of three 120-cell lead-acid batteries (one Non-Class 1E battery and battery charger per unit and one Class 1E spare battery charger common with the Unit system) together with the associated circuitry, switches, indicators, and alarms (Figure 8.6-1f).

2. The 250-V DC control power supply system (Shutdown Board Batteries SB-A, SB-B, SB-C, SB-D, and SB-3EB) consists of five 120-cell lead-acid batteries (one battery and battery charger for each shutdown board, and one spare battery charger), together with the associated circuitry, switches, indicators, and alarms (Figure 8.6-1a). The batteries also supply 480-V shutdown boards for Units 1 and 2 and ATWS.

250-V Plant DC System

The battery chargers are of the solid-state, rectifier type, capable of working independently. Each charger is capable of automatically regulating output voltage. Each battery charger has the capacity to furnish floating, equalizing, and fast charge in accordance with the battery manufacturer's recommendations.

Each battery charger provides the 250-V DC supply during normal operations, keeps its associated battery fully charged at all times, and recharges the battery after a discharge. On loss of power to the charger, the battery supplies all required loads. Each battery is equipped with a low-voltage alarm which is actuated before battery voltage falls to 240-V.

Each of the batteries for the 250-V DC system consists of 120 lead-calcium grid type cells.

The unit batteries have a 1-minute rating of 2080 amperes and an 8-hour discharge rating of 2320 ampere-hours.

The station batteries have a 1-minute rating of 2240 amperes and an 8-hour discharge rating of 2320 ampere-hours.

All ratings are to a final terminal voltage of 210-V at a temperature of 77°F.

The three unit batteries have engineered safeguards control loads for the three units distributed among them so that redundant subsystems on each unit have separate normal and alternate power supplies. The battery board buses, motor-operated valve boards, and distribution panels supply nominal 250-V DC power to their loads

without interruption unless the supply battery is discharged and power to the charger is lost. All transfers from normal to alternate sources are done manually, under administrative control procedures.

The major connected loads for the 250-V DC power system are listed in Table 8.6-1, Figure 8.6-5, and Figure 8.6-6. The batteries in the 250-V plant DC system have the capacity to carry all their required selected loads for 30 minutes without recharging. Each charger shall be sized to recharge its battery from the design minimum charge, based on actual duty cycle ampere-hour discharge, in approximately 12 hours under normal load conditions.

A typical arrangement of the 250-V plant DC system for one unit is shown in Figure 8.6-2a; and the interconnection scheme for this same portion for all three units, illustrating separation requirements, is shown in Figure 8.6-3.

250-V DC Control Power Supply System (for shutdown boards)

The 250-V DC control power battery chargers have similar characteristics to the chargers of the plant system except for size.

The batteries for the 250-V control power supply are of the lead-calcium grid construction. They have a one-minute rating of 500 amperes and an eight-hour discharge rating of 410 ampere hours, both ratings to a terminal voltage of 210-V at 77°F. Although the safety-design basis requirement for battery capacity is 30 minutes, the batteries have a greater (three hour rating of 108 ampere to a terminal voltage of 210-V at 77°F) capacity to supply all required loads allowing ample time for corrective action if a charger malfunction occurs.

Normal 250-V DC control power for 4160-V shutdown boards A, B, C, D, and 3EB is supplied by one of the DC control power supplies with an alternate supply from one of the unit battery boards through a manual transfer switch. 250-V DC control power for 480-V shutdown boards 1A, 2A, 1B, and 2B is supplied by one of the DC control power supplies with an alternate supply from one of the battery boards through a manual transfer switch. 250-V DC control power for 4160-V shutdown boards 3EA, 3EC, and 3ED, 480-V shutdown boards 3A and 3B, 480-V HVAC board B, the bus-tie board, and the cooling tower switchgear is from the unit battery boards. Alternate supplies have been provided through manual transfer switches. Separations between redundant control power circuits are maintained external to and within the switchgear. The major connected loads for the 250-V DC control power system are listed in Table 8.6-1 and Figure 8.6-5.

The batteries in the 250-V DC control power supplies have the capacity to carry all their required loads for 30 minutes without recharging. Each charger is sized to

recharge its battery from the design minimum charge, based on actual ampere-hour removed, in approximately 12 hours under normal load conditions.

The typical arrangement for 250-V DC control power supplies A, B, C, D, and 3EB is shown in Figures 8.6-2b and 8.6-2c. The key diagrams for the boards are shown in Figures 8.6-1a, b, d, and e.

8.6.4 Safety Evaluation

8.6.4.1 General

The system is arranged and powered so that the probability of failure of power to any single battery board bus or shutdown board control bus is very low and that such a failure does not prevent the safe shutdown and cooldown of all three units in the event of the loss of offsite power and a design basis accident in any one unit. The system is designed to meet the intent of the IEEE criteria for nuclear power plant protection systems (IEEE-279).

Each battery, and its associated equipment, is easily accessible for inspection and testing. The DC system is ungrounded and has a ground detection alarm. The most probable mode of battery failure would be deterioration of a single cell which can be detected well in advance by standard, routine battery inspections and testing. The system is designed so that the batteries cannot be paralleled.

Each ESS battery and its associated earthquake-type racks and holddown bolts are designed as Class I equipment in accordance with Appendix C, "Structural Qualification of Subsystems and Components."

8.6.4.1.1 Plant DC System

Each ESS 250-V DC unit battery board bus can be supplied from its own battery charger or from the spare charger. Each station battery board bus can be supplied from its own charger or from the spare charger. The charger switching is done manually and without normally paralleling the chargers; however, chargers are designed to operate in parallel. The chargers can be powered from normal plant auxiliary power or from the standby diesel-driven generator system.

Zero-resistance short circuits at the battery board or any point downstream can be cleared by the breakers operating within their ratings. The unit batteries are located in the control building each in its own ventilated, unit battery room. The station batteries are located in the Turbine Building. The station batteries supply loads that are not essential for safe shutdown and cooldown of the nuclear system and are not considered in the accident load calculations.

8.6.4.1.2 Shutdown Board Control Power Supply

Each 250-V DC control power supply can receive power from its own battery, battery charger, or from a spare charger. The chargers are powered from normal plant auxiliary power or from the standby diesel-driven generator system. Zero-resistance short circuits between the control power supply and the shutdown board are cleared by fuses located in the respective control power supply A, B, C, D, or 3EB. Each power supply is located in the Reactor Building or Diesel Generator Building near the shutdown board it supplies. Each battery is located in its own independently ventilated battery room.

8.6.4.2 Loss of One 250-V DC Unit Battery

The ESS 250-V DC system is arranged, and the batteries sized, such that the loss of any one unit battery will not prevent the safe shutdown and cooldown of all three units in the event of the loss of offsite power and a design basis accident in any one unit. Loss of control power to any engineered safeguards control circuit is annunciated in the Main Control Room of the unit affected.

8.6.4.3 Loss of One 250-V DC Control Power Supply Battery

The loss of one battery affects normal control power for the 480-V and 4160-V shutdown board which it supplies. Complete loss of the control power to these shutdown boards results in loss of only those engineered safeguards supplied by these boards, which is acceptable.

8.6.5 Inspection and Testing

Routine service and testing are based upon the recommendations of the manufacturer and sound maintenance practices. Typical inspections include visual examinations for leaks and corrosion and a check of all batteries for uniformity, as well as values of cell voltage, specific gravity of electrolyte, and electrolyte level. The 250-V DC System is arranged and sized so that any one battery or battery charger may be removed from service for testing or repair without loss of capability to supply DC loads required for shutdown and cooldown of all three units in the event of the loss of offsite power and a design basis accident in any one unit.