8.0 ELECTRICAL SYSTEMS

8.1 INTRODUCTION

The electrical systems include the equipment and systems necessary to generate power and deliver it to the high voltage system. They also include facilities for providing power to, and controlling the operation of, electrically-driven plant auxiliary equipment and instrumentation.

Essential instrumentation, including the Reactor Protective System (RPS) and the Engineered Safety Features (ESF) instrumentation, is fed from vital instrumentation busses to provide continuous monitoring and control. The plant batteries provide circuit breaker control, Control Room emergency lighting, vital instrumentation power, and operating power for certain other equipment.

8.1.1 DESIGN BASIS

The plant electrical systems are designed to ensure a continuous supply of electrical power to all essential plant equipment during normal operation and under accident conditions.

All electrical systems and components vital to plant safety, including the emergency diesel generators (EDGs), are designed as Class 1E so that their integrity is not impaired by the Safe Shutdown Earthquake (SSE), high winds, or disturbances on the external electrical system.

8.1.2 DESCRIPTION AND OPERATION

The plant electrical system is shown on Figure 8-1, Main Single Line Diagram.

In order to achieve maximum reliability and efficiency of operation of the electrical systems, the following criteria are employed:

a. The main generators, described in Section 10, feed electrical power at 25 kV and 22 kV for Units 1 and 2, respectively, through forced air cooled isolated phase busses to two main unit transformers installed per unit.

b. Plant auxiliary sources of power are the three 500 kV/14 kV plant service transformers, which are fed from separate 500 kV switchyard busses and a 13 kV line from the Southern Maryland Electric Cooperative (SMECO) system. Each 500 kV/14 kV plant service transformer is capable of supplying the total (two unit) plant auxiliary load. The 13 kV SMECO line is capable of supplying the power required to maintain both units in a safe shutdown condition. It may be substituted for one of the 500 kV/13 kV circuits as one of the two required, physically independent, offsite circuits.

c. The three plant service transformers feed six 13.8 kV 2MVA ± 10% voltage regulators which feed six 13.8 kV/4.16 - 4.16 kV service transformers, three of which are capable of supplying the total plant 4.16 kV auxiliary load.

d. The 13.8 kV system consists of three 13.87kV unit buses and multiple reactor coolant pump (RCP) busses, each of which can be fed from any of the three plant service transformers. Three 13.8 kV service busses (with tie breakers) are provided for distribution to the voltage regulators and unit service transformers.

e. The plant is split into two independent load groups, each with its own power supply, busses, transformers, loads, and 125 Volt DC control power (Figure 8-9).

f. A reserve 125 Volt DC system, capable of replacing any of the 125 Volt DC batteries, if required, is provided. The system consists of one battery, one battery charger, and associated DC switching equipment.

g. The 4.16 kV system is divided into several bus sections, each of which can be supplied from either of two unit service transformers fed from different plant service transformers. The four 4.16 kV ESF busses can be supplied from the EDGs.

h. The plant has four safety-related EDGs, two dedicated to each unit. Any combination of two of the EDGs (one from each unit) is capable of supplying sufficient power for the operation of necessary ESF loads during accident conditions on one unit and shutdown loads of the alternate unit concurrent with a loss of offsite power and for the safe and orderly shutdown of both units under loss of offsite power conditions. The diesel generators start automatically on safety injection actuation signal (SIAS) or an undervoltage condition on the busses which supply vital loads, and are ready to accept loads within 10 seconds (Figure 8-6). A Station Blackout diesel generator can also be aligned to any of the four ESF busses.

i. All necessary ESF are duplicated and power supplies are so arranged that the failure to energize any one of the applicable busses, or the failure of one diesel generator to start, will not prevent the proper operation of the ESF systems.

j. The ESF electrical system has been designed to satisfy the single failure criterion as defined Institute of Electrical and Electronic Engineers (IEEE) 279, Section 4.2.

k. Four vital AC instrument busses per unit are provided for essential instrumentation and reactor protection circuits. Each vital bus is fed from a separate battery supply through a dual static inverter.

l. The design criteria for all electrical control cable and safety-related equipment power cable are that the cable shall not fail when subjected to associated accident conditions after the long-term, normal operating conditions.

m. Power cables in 13.8 kV service are HT Kerite Permashield insulated cables rated at 15 kV or equivalent. Cables are single conductor shielded and provided with Kerite type FR fire resistant jackets or equivalent.

n. Power cables in 4.16 kV service are HT or HV Kerite insulated cables rated at 5 kV. Cables are triplexed or single conductor, nonshielded, and provided with Kerite type NS neoprene or CSPE sheath jackets.

o. Control cables are of multiconductor construction with either cross-linked polyethylene, ethylene propylene rubber or silicon rubber insulation with jackets of Hypalon, neoprene or asbestos braid. Control cables are rated at 600 Volts. Low voltage instrumentation cables are of multiconductor construction with either cross-linked polyethylene, ethylene propylene rubber or silicon rubber insulation with jackets of Hypalon, neoprene or asbestos braid with voltage ratings suitable for the application. Specialty low voltage instrumentation cables are supplied by OEM with unique constructions and voltage ratings specific for their equipment. Control cables for use in underground ducts are insulated with cross-linked polyethylene, and jacketed with neoprene, hypalon or, polyvinyl chloride. Low voltage instrument cables have total coverage electrostatic shielding, or electrostatic shielding covering individual twisted pairs or triads.

p. The normal current rating of all insulated conductors is limited to the continuous value which does not cause excessive insulation deterioration from heating. Selection of conductor sizes is based on "Power Cable Ampacities," published by the Insulated Power Cable Engineers Association.

q. All cables, terminations and splices within the containment associated with safety-related equipment are qualified by being type tested for the loss-of-coolant accident (LOCA) environmental conditions.

r. The electrical systems have been designed in accordance with "IEEE Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations," IEEE No. 308 - 1974.

s. Electrical penetration qualification tests were combined using the postulated worst combination of environmental conditions as described in Section 14.20. The electrical penetrations were tested to verify leak integrity and also electrical integrity on those penetrations carrying ESF or reactor protective circuits. All materials used in the construction of electrical penetrations were qualified for radiation exposure of 10^8 rads either by materials manufacturer's or the penetration manufacturer's tests.

Electrical penetration assemblies were supplied by the Amphenol Corporation and the Conax Buffalo Corporation.

The Amphenol Type 1, 15 kV, medium voltage power prototype penetration canister was tested by enclosing the inside containment end of the canister in a tank and subjecting it to steam made with 1720 ppm borated water. The penetration was subjected to 275°F, at 41 psig for 15 minutes. This temperature was reached within 30 seconds. The next 45 minutes the penetration was at 260°F, at 33 psig. The following 23 hours were above 250°F, at 30 psig. Throughout the entire test the leak rate was monitored using helium and found to be within the required $1x10^{-6}$ standard cubic centimeters per second of dry helium.

The Amphenol Types 1, 2, and 3, low voltage power, control and instrumentation, thermocouple and coaxial penetration canisters were tested in a prototype canister containing two coaxial conductors and three or more of each other type of conductor.

The test was performed in the same manner as on the Amphenol Type 1, except that during the first 15 minutes the unit was subject to 279°F, at 44 psig, the next 45 minutes 265°F, at 35 psig, the next 23 hours were above 250°F, at 30 psig. The leak rate again was within $1x10^{-6}$ standard cubic centimeters per second of dry helium. During the test, the 480 Volt power conductors and the 120 Volt control and instrumentation conductors were energized at their operating voltage and there was no excessive leakage current. The power, control, and instrumentation conductors were also terminated in the manner they will be in the field in order to qualify the termination methods to be used inside containment.

All Amphenol prototype canister penetration assemblies successfully passed the environmental test as described above.

Conax Type 1, 2, and 4 penetration assemblies are header plate type and were designed, fabricated and prototype-tested to withstand Design Basis Event environmental conditions described in Section 14.20.

All Conax penetration assemblies successfully passed Design Basis Event environmental testing.

8.1.3 SHARED ELECTRICAL EQUIPMENT

The following electrical auxiliary system equipment is shared by Units 1 and 2.

a. Service Transformer P-13000-1, P-13000-2, P-13000-3.

a1. 13kV Unit Bus 14, 01A/B, and 24

b. 13 kV Service Bus 11 and 21

c. 13 kV Service Bus 12 and 22

d. 500 kV Red Bus

e. 500 kV Black Bus

f. 125 Volt DC Plant Control Batteries 01, 11, 12, 21 and 22

g. 250 Volt DC Emergency Pump Battery 13 and 23
h. 125 Volt DC Busses 11, 12, 21, and 22
i. 250 Volt DC Bus 13
j. 0C Diesel Generator
k. 125 Volt DC Unit Control Panel 24