CHAPTER 8.0 - ELECTRIC POWER

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

CHAPTER 8.0 - ELECTRIC POWER

LIST OF TABLES

CHAPTER 8.0 - ELECTRIC POWER

LIST OF FIGURES

CHAPTER 8.0 – ELECTRIC POWER

DRAWINGS CITED IN THIS CHAPTER

*The listed drawings are included as "General References" only; i.e., refer to the drawings to obtain additional detail or to obtain background information. These drawings are not part of the UFSAR. They are controlled by the Controlled Documents Program.

DRAWING*	SUBJECT
6E-0-4001	Byron Station One-Line Diagram
6E-1-4002E	Single Line Diagram, 120Vac ESF Instrument Inverter Bus 111 and 113, 125Vdc ESF Distribution Center 111, Byron Station Unit 1
6E-1-4002F	Single Line Diagram, 120Vac ESF Instrument Inverter Bus 112 and 114, 125Vac ESF Distribution Center 112, Byron Station Unit 1
6E-1-4008E	Key Diagram, 480V Auxiliary Building ESF MCC 131X2 (1AP25E) and 131X2A (1AP25E-A), Byron Station Unit 1
6E-1-4030DG01	Schematic Diagram, Diesel Generator 1A Feed to 4.16kV ESF Switchgear Bus 141 ACB #1413, Byron Station Unit 1
6E-1-4030DG02	Schematic Diagram, Diesel Generator 1B Feed to 4.16kV ESF Switchgear Bus 142 ACB #1423, Byron Station Unit 1
6E-1-4030SI11	Schematic Diagram, Accumulators 1A and 1B Discharge Isolation Valves 1SI-8808A/-8808B, Byron Station Unit 1
6E-1-4030SI33	480V Feed to ECCS Water Supply Isolation Valves at MCC 131X1A and 131X2A, Byron Station Unit 1
20E-0-4001	Braidwood Station One-Line Diagram
20E-0-4002E	Single Line Diagram, 120Vac ESF Instrument Inverter Bus 111 and 113, 125Vac ESF Distribution Center 111, Braidwood Station Unit 1
20E-0-4002F	Single Line Diagram, 120Vac ESF Instrument Inverter Bus 112 and 114, 125Vdc ESF Distribution Center 112, Braidwood Station Unit 1
20E-0-4008E	Key Diagram, 480V Auxiliary Building ESF MCC 131X2 (1AP25E) and 131X2A (1AP25E-A), Braidwood Station Unit 1

DRAWINGS CITED IN THIS CHAPTER* (Cont'd)

DRAWING*	SUBJECT
20E-1-4030DG01	Schematic Diagram, Diesel Generator 1A Feed to 4.16kV ESF Switchgear Bus 141 ACB # 1413, Braidwood Station Unit 1
20E-1-4030DG02	Schematic Diagram, Diesel Generator 1B Feed to 4.16 kV ESF Swtichgear Bus 142 ACB #1423, Braidwood Station Unit 1
20E-1-4030SI11	Schematic Diagram, Accumulators 1A and 1B Discharge Isolation Valves 1SI-8808A/-8808B, Braidwood Station Unit 1
20E-1-4030SI33	480V Feed to ECCS Water Supply Isolation Valves at MCC 131X1A and 131X2A, Braidwood Station Unit 1

CHAPTER 8.0 - ELECTRIC POWER

8.1 INTRODUCTION

The electric power system connections to the Byron/Braidwood Stations, described in detail in Section 8.2, are designed to provide a diversity of reliable power sources which are physically and electrically isolated so that any single failure will affect one source of supply only and will not propagate to alternate sources. The onsite electric power system is described in detail in Section 8.3.

The station auxiliary electric power system is designed to provide electrical isolation and physical separation of the redundant power supplies for station requirements which are important to plant safety. Means are provided for automatic isolation of system faults.

In the event of total loss of auxiliary power from offsite sources, auxiliary power required for safe shutdown will be supplied from diesel generators located on site. The diesel generators are physically and electrically independent. Redundant loads, important to plant safety, are split and diversified between redundant ESF switchgear groups. Redundant batteries are provided as sources of control power for the ESF electric power systems. The safety loads that require electric power to perform their safety function are identified by function in Table 8.3-5.

The functions of these safety loads are described in Chapter 6.0 and Chapter 7.0, with the emergency core cooling system being described in Section 6.3.

Conformance of the engineered safety features electric system to various industry standards and NRC guidance documents is indicated in Table 8.1-1.

The safety design bases used for the Class 1E electric systems are given in Table 1, "Design Basis Events," of IEEE 308-1971, "IEEE Standard Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations."

The plant consists of two main generating units designated as Unit 1 and Unit 2. Each main generator is directly connected to two half-size main power transformers through an isolated phase electrical bus duct. The two half-size main power transformers are connected in parallel at their high and low voltage terminals and transform the output of each generator from a generator voltage of nominal 25-kV to a nominal 345-kV transmission system voltage.

The output of each unit's main power transformer is connected to a 345-kV switchyard section consisting of circuit breakers, disconnect switches, buses, and associated equipment arranged in a double ring bus configuration as shown in Figure 8.2-1 for Byron and Figure 8.2-5 for Braidwood. Overhead 345-kV transmission lines distribute power to the various points of the transmission system.

The 345-kV system provides power to each unit's two system auxiliary power transformers. Each unit's set of system auxiliary transformers has sufficient capacity to handle the auxiliary power requirements of the unit when operating at full load. Each unit's system auxiliary power supplies are available to all safety auxiliary equipment of both units and, therefore, serve as the second source of offsite power to the other unit.

Normal auxiliary power for each unit is supplied from the unit auxiliary power transformers, which are connected to the main generator leads, and from the system auxiliary power transformers, which are connected to a 345-kV ring bus. Startup auxiliary power is provided through the system auxiliary power transformers via the 345-kV switchyard ring bus.

Offsite (Preferred) Power Systems - Summary Description

The Commonwealth Edison transmission system is connected to the Eastern Interconnection Transmission Network and is under the control of the Regional Transmission Organization, PJM.

The 345-kV transmission lines connect the Byron Station to the transmission system, as shown in Figure 8.2-1.

Electric energy generated at the station is stepped up to 345-Kv by the main power transformers and fed into the station's 345-kV transmission terminal. The 345-kV overhead lines exit the station via three separate rights-of-way and are connected into Commonwealth Edison's 345-kV system as shown on Figure 8.2-2.

The preferred power system is considered as having three major sections, each of which must provide two physically separate and electrically independent circuit paths between the onsite power system and the transmission network (the transmission network excludes the station switchyard). The three sections are:

1. The transmission lines entering the station switchyard from the transmission network.
2. The station switchyard. (A common switchyard is allowed by GDC 17).
3. The overhead transmission lines, SATs, buses between the switchyard, and the onsite power system.

Two physically separate and electrically independent circuits are provided for each unit, one via the unit's assigned system auxiliary transformers and the other from the system auxiliary transformers of the other unit.

Offsite (Preferred) Power Systems - Summary Description

The Commonwealth Edison transmission system is connected to the Eastern Interconnection Transmission Network and is under the control of the Regional Transmission Organization, PJM.

The 345-kV transmission lines connect the Braidwood Station to the transmission system, as shown in Figure 8.2-5.

Electric energy generated at the station is stepped up to 345-kV by the main power transformers and fed into the station's 345-kV transmission terminal. The 345-kV overhead lines exit the station via separate rights-of-way and are connected into Commonwealth Edison's 345-kV system as shown on Figure 8.2-6.

The preferred power system is considered as having three major sections, each of which must provide two physically separate and electrically independent circuit paths between the onsite power system and the transmission network (the transmission network excludes the station switchyard). The three sections are:

1. The transmission lines entering the station switchyard from the transmission network.

2. The station switchyard. (A common switchyard is allowed by GDC 17).

3. The overhead transmission lines, SATs, buses between the switchyard, and the onsite power system.

Two physically separate and electrically independent circuits are provided for each unit, one via the unit's assigned system auxiliary transformers and the other from the system auxiliary transformers of the other unit.

Onsite Power Systems

The main turbine-generator power system is designed for the generation of electric power: (1) for distribution to the offsite power system, and (2) to provide an independent source of onsite power for the onsite station auxiliary electric power system.

Loads important to plant safety are divided into redundant groups (Division 11 [21] and 12 [22] for Unit 1 [Unit 2]) and are fed from redundant Class 1E engineered safety feature (ESF) switchgear groups.

In the event of loss of the unit's offsite auxiliary power, the auxiliary power required for safe shutdown is supplied automatically from redundant Class 1E diesel-generators located on the site. The diesel generators are physically and electrically independent.

Batteries are provided as sources of control power for the ESF electrical power systems. The engineered safety features electric systems are designed in accordance with IEEE standards insofar as they apply except as otherwise indicated in the text.

There are no provisions for startup without offsite power. A number of stations on the Commonwealth Edison system have "black start" capability to supply adequate startup power to the remaining stations through various transmission system emergency configurations.

Auxiliary A-C Power System

The basic function of the auxiliary a-c power system is to provide power for plant auxiliaries during startup, operation, and shutdown and to provide highly reliable redundant power sources for loads which are necessary to plant safety. The auxiliary a-c power systems for the two-unit plant are shown in Drawings 6E-0-4001, "Byron Station One Line Diagram," and 20E-0-4001, "Braidwood Station One Line Diagram".

Two unit auxiliary transformers (Braidwood and Byron Unit 2: 23.7 - 6.9/4.16-kV, Byron Unit 1: 25.0 – 7.245/4.368-kV) are provided for each unit. These transformers are connected directly to the main generator buses by isolated phase bus duct. They are the normal power sources for the non-safety-related 4160-volt buses.

Two system auxiliary transformers (345-6.9/4.16-kV) are also provided for each unit. Each transformer is normally energized, providing offsite power to an engineered safety features (ESF) 4160-volt bus of the unit. Each transformer also serves as a second source of offsite power for the corresponding ESF bus of the other unit.

Each system auxiliary transformer and unit auxiliary transformer can serve as a power source for the unit's non-safety-related 6900-volt buses.

The unit's four non-safety-related 6900-volt switchgear serve the reactor coolant pumps as well as other large auxiliary loads. Each-6900 volt switchgear group has a feed from a unit auxiliary transformer (UAT) and a system auxiliary transformer (SAT). Automatic transfer is provided in the event of the loss of either power source.

Each unit has four 4160-volt switchgear. Two buses (141 and 142 for Unit 1; 241 and 242 for Unit 2) supply power to ESF loads as well as certain essential (but not safety-related) loads (such as lighting and the turbine bearing oil pump). The other two buses supply power to large, non-safety-related, auxiliary loads as well as small, non-safety-related loads. All non-safety-related loads that require access to the diesel-generators are fed from these buses. A cross-tie breaker between the 4160-volt ESF bus and the 4160-volt non-safety-related bus may be manually closed (by operator action) in the event of the loss of both the UAT and SAT power sources to feed these loads.

Each 4160-volt ESF bus has (1) a normal feed from the system auxiliary transformer, (2) a second (reserve) feed from the other unit's SAT, and (3) an emergency feed from its respective diesel generator. Upon a loss of the ESF bus's normal offsite power supply (the SAT), the respective diesel generator will start automatically and provide power to the bus. The operator may manually synchronize the second offsite power source to the ESF bus.

Each 4160-volt non-safety-related bus has a feed from (1) the respective unit's system auxiliary transformer, (2) the respective unit's unit auxiliary transformer, and (3) the respective ESF bus. These buses are normally fed from either the UAT or SAT. Automatic transfer from the UAT to the SAT, or vice versa, is provided in the event of loss of either power source. If both the UAT and SAT are lost, the cross-tie breaker to the 4160-volt ESF bus can be manually closed (by operator action) to provide power to certain non-safety-related, but essential loads within the capability of the diesel generator.

Unit Class 1E A-C Power System

All of the ESF equipment required to shut down the reactor safely and to remove reactor decay heat for extended periods of time following a loss of offsite power and/or a loss-of-coolant accident are supplied with a-c power from the Class 1E a-c power system. The unit Class 1E a-c power system is divided into two divisions (Divisions 11 and 12 for Unit 1; Divisions 21 and 22 for Unit 2), each of which is supplied from a

4160-volt bus (141 and 142, for Unit 1, respectively; 241 and 242 for Unit 2, respectively).

Each ESF group of each unit is supplied standby power from an individual diesel-generator unit. With this arrangement, alternate or redundant components of all ESF systems are supplied

from separate switch groups so that no single failure can jeopardize the proper functioning of redundant ESF loads.

The assignment of ESF loads to the two electrical divisions for each unit is indicated in Table 8.3-5. The division of the ESF loads among the system buses is such that the total loss of one of the two electrical divisions cannot prevent the safe shutdown of the reactor under any normal or abnormal design condition.

In the event of a loss of offsite power, 4160-volt ESF bus undervoltage relays automatically trip the bus's offsite supply circuit breakers and non-safety-related 4160-volt bus tie breaker, shed all significant ESF loads, and automatically start the diesel-generator. The diesel-generator supply circuit breaker closes automatically when the diesel-generator is up to rated speed and voltage, provided all other source breakers are open. Provisions are made for sequential starting of required ESF loads within the diesel-generator's capability.

Unit Class 1E D-C Power System

A 125-volt battery is provided for each ESF division in each unit to supply control power to the reactor trip switchgear, MCB ESF sections, ESF switchgear control systems, and other safety-related systems requiring d-c power.

Each unit is provided with two physically separate and electrically isolated sources of 125-Vdc ESF power (each with its own battery, battery charger, and distribution bus). Drawings 6E-0-4001 and 20E-0-4001 show the single-line of the Unit 1 and 2 125-Vdc systems.

Unit Non-Class 1E D-C System

One 48-Vdc system is required for operation of equipment at the river screen house.

The control power for the 345-kV switchyard breakers is supplied by two 125-volt batteries (not safety-related) located in the switchyard relay house. The two feeds from each battery to the switchyard breakers are supplied by separate cables to establish two separate trip circuits for each breaker; i.e., each breaker has two trip coils. Each trip coil is operated from a separate protective relay package.

Each unit is provided with a 250-Vdc system for use with essential non-safety-related auxiliaries as described in Subsection 8.3.2.1.

Identification of Class 1E Loads

Nuclear safety-related systems and components that require electrical power to perform their nuclear safety function are defined as Class 1E loads.

8.1.1 Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution System

An acceptable degree of independence between redundant standby (onsite) power sources and between their distribution system is described in the following subsections.

a. Independent Load Assignment

Each Class 1E Load (a-c or d-c) is assigned to an ESF Division 11 or 12 (21 or 22) load group. Assignment is determined by the nuclear safety functional redundancy of the load. The loss of a single division does not prevent the performance of the minimum safety functions required for a safe shutdown.

b. Independent Class 1E A-C Sources

Each ESF division a-c load group has a feed from two auxiliary transformers (offsite) and from one diesel generator (onsite) as shown in Drawings 6E-0-4001 and 20E-0-4001.

The diesel-generator circuit breaker will not close automatically unless other source circuit breakers to that load group are open as shown in Drawings 6E-1-4030DG01, 20E-1-4030DG01, 6E-1-4030DG02, and 20E-1-4030DG02.

c. Independence of Class 1E D-C Sources

Each ESF division d-c load group has a feed from one battery charger and one battery as shown in Drawings 6E-0-4001 and 20E-0-4001.

The redundant d-c load groups cannot be connected to each other. The d-c battery-charger combination of one ESF division cannot be connected to another ESF redundant division. Each d-c load group of one unit can be connected to the corresponding nonredundant d-c load group of the second unit and satisfy the design load.

d. Independence of Standby Sources

The diesel-generator circuit breaker will close to its associated load group automatically only if the other source circuit breakers to the load group are open.

When the diesel-generator circuit breaker is closed, no other source breaker will close automatically. The redundant buses independent configuration ensures that no means exist for connecting redundant load groups with each other.

Each of the redundant load groups is fed from only one diesel generator. No means are provided for transferring loads between the redundant diesel generators.

Paralleling of the redundant diesel generators by manual breaker actuation can only be accomplished if the disconnect link between the SATs is installed. Therefore, the probability of paralleling of the redundant diesel generator manually by an operator error during loss of offsite power is very remote.

e. Prime Mover

Division 11 and 12 (21 and 22) diesel-generators are provided with only one prime mover for each generator.

Compliance with Regulatory Guide 1.6 is discussed in Appendix A.

8.1.2 Selection of Diesel-Generator Set Capacity For Standby Power Supplies

Diesel-generator sets are selected as the onsite standby power supply with sufficient capacity and margin to assure that acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded, that the core is cooled, and that containment integrity and other vital functions are maintained in postulated accidents.

The diesel generator load rating for continuous duty is 5500 kW (6875 kVA, 0.8 power factor).

The 2000-hour rating of each standby diesel generator is 5935 kW (7419 kVA, 0.8 power factor), and the 2-hour rating is 6050 kW.

Table 8.3-5 shows the loads for each of the diesel generator sets, for LOCA conditions, and for safe shutdown conditions. Actual diesel generator loading during a LOOP coincident with a LOCA condition, however, is monitored by the Electrical Load Monitoring System for Alternating Current Loads (ELMS-AC) (Braidwood only) and ELMS-AC and/or Electrical Transient Analysis Program (ETAP) (Byron only).

During preoperational testing, the predicted standby diesel generator loads for each ESF division is verified, as well as the capability of the diesel generators to carry these loads.

Acceleration requirements, voltage and frequency dips, etc., were incorporated in the diesel generator specification.

During preoperational testing, it was verified that the diesel generators are capable of starting and accelerating to rated speed, and accepting, in the required sequence, all the needed ESF and emergency shutdown loads, while maintaining the voltage and frequency within the specified limits. During these tests, the overspeed limits were verified.

The suitability of each standby diesel-generator was confirmed by prototype qualification test data and by preoperational tests.

Compliance with Regulatory Guide 1.9 is discussed in Appendix A.

8.1.3 Periodic Testing of Protection System Actuation Functions (Regulatory Guide 1.22)

The protection system, including the actuation devices and actuated equipment, is designed to permit periodic testing.

All safety actuation circuitry is provided with a capability for testing with the reactor at power with the following exceptions:

a. generation of a reactor trip by tripping the reactor coolant pump breakers,

b. generation of a reactor trip by tripping the turbine,

c. generation of a reactor trip by use of the manual trip switch,

d. generation of a reactor trip by manually actuating the safety injection system,

e. generation of safety injection signal by use of the manual safety injection switch, and

f. generation of containment spray signal by use of the manual spray actuation switch.

Exception to testing the devices listed above is taken, where it has been determined that:

a. The present position is that it is not a "practicable system design" to provide equipment to bypass a device such as a reactor coolant pump breaker solely to test the device. In the case of testing the manual initiation switches, the design for test capability would require that switches be provided on a train or sequential basis. This complicates the operator action required to actuate the function manually.

b. The probability that the protection system will fail to initiate the operation of the equipment is, and can be maintained, acceptably low without testing the equipment during reactor operation. Probabilities have been established by the use of general failure data based on continuous operation. Specific probability analyses can be provided on a plant basis at the request of the Commission.

c. The equipment can routinely be tested when the reactor is shut down.

In all the cases discussed, it is only the device function which is not tested. The logic associated with the devices has the capability for testing at power. Further information related to the subject of periodic testing of protection system actuations functions is presented in Section 7.1.

Compliance with Regulatory Guide 1.22 is discussed in Appendix A.

8.1.4 Seismic Design Classification

Information concerning the seismic design classification of electrical systems and components of the Byron/Braidwood Stations, intended to withstand the effects of the safe shutdown earthquake (SSE), is presented in Section 3.10.

Compliance with Regulatory Guide 1.29 is discussed in Appendix A.

8.1.5 Quality Assurance Requirements for the Installation, Inspection and Testing of Instrumentation and Electric Equipment

Quality assurance requirements for testing, inspection, and proper installation of electrical and instrumentation equipment are described for various subsystems in Section 8.3. Preoperational tests that demonstrate functional performance are identified in Chapter 14.0.

Startup tests are also covered in Chapter 14.0. Each of these tests on safety-related equipment complies with the test and evaluation requirements of Commonwealth Edison's Quality Assurance Manual.

Compliance with NQA-1-1994, Subpart 2.4 is discussed in Appendix A under Regulatory Guide 1.30.

8.1.6 Use of IEEE Standard 308-1971, "Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations"

IEEE 308-1971 provides criteria that may be used in establishing some of the bases for the design of electric power systems, except that conflicts with General Design Criterion 17 should be resolved by:

a. provision of one immediate access and one delayed access circuit from the transmission network; and

b. the capacity of the battery charger supply should be based on: the largest combined demands of the various steady-state loads and enough charging capacity to restore the battery from the minimum design charge state to a fully charged state, irrespective of the status of the plant.

At least two physically independent 345-kV transmission lines occupying separate rights-of-way are available to each of the two reactor units. One circuit is normally connected to the 4.16-kV ESF buses, and the other circuit is available as a delayed access circuit from the system auxiliary transformers of the opposite unit. No single event, such as a breaker failing open, a bus fault in the switchyard, or a failure on a transmission tower, will cause simultaneous loss of both offsite power sources. Switchyard power is available to both units as long as at least one 345-kV transmission line is available at the switchyard (Section 8.2).

The time schedule for performing inspections and measurements is established in accordance with the requirements of IEEE Standards 450-1995 and 308-1971. The batteries will be discharge tested periodically in accordance with the requirements of Technical Specifications.

Compliance with Regulatory Guides 1.32 and 1.93 is discussed in Appendix A.

8.1.7 Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants

To the extent practicable, motors and auxiliary equipment that are part of the installed motor assembly have been qualified in accordance with IEEE 334-1971.

The qualification tests have simulated as closely as practicable all design-basis events which affect operation of the motors and auxiliary equipment.

Compliance with Regulatory Guide 1.40 is discussed in Appendix A.

8.1.8 Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments

An acceptable testing program to verify the existence of independence among redundant onsite power sources and their load groups was instituted through preoperational testing conducted for both energized and deenergized conditions of the load group not under test (Chapter 14.0).

Compliance with Regulatory Guide 1.41 is discussed in Appendix A.

8.1.9 Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems (Regulatory Guide 1.47)

Bypass or test of reactor trip system or ESFAS logic channels is automatically indicated on the main control board (trip status and bypass permissive lights), except for the containment ventilation radiation monitor.

Compliance with Regulatory Guide 1.47 is discussed in Appendix A.

8.1.10 Application of the Single-Failure Criterion to Nuclear Power Plant Protection System (Regulatory Guide 1.53)

It is shown in Chapter 7.0 that the reactor protection system complies with the requirements of Section 4.2 of IEEE 279-1971 (also designated ANSI N42.7-1972) and IEEE 379-1972 with respect to satisfying the single-failure criteria.

Where a single failure can result in components performing undesirable mechanical motion of manually controlled electrically-operated valves, administrative controls or operator action provisions are provided to disconnect power to the valve or the valve's electric system.

For the safety injection (SI) system valves (except for SI8808A-D) listed in Table 8.1-2, operator action is required to close a feeder contactor by means of a manually operated control switch at the main control board. Electric power will then be restored to the line side of valve motor starters and in the event valve operation is necessary, power will be available. Redundant valve position indication is provided for the operators assistance in meeting the time requirements for the plant condition.

This design utilizes a power lockout "circuit breaker-starter" in series with the "circuit breaker-starter" for each of the SI MOV valves. This power lockout starter can be controlled from the main control room.

Example: Motor-operated valve 1SI8802B

1. The power lockout feature is the starter at MCC 132X4, compartment K2 (which is the upstream starter for MOV 1SI8802B), see key diagrams 6E-1-4008AA and 20E-1-4008AA.

2. This starter contact can be opened or closed by the selector switch at the main control room panel 1PM06J (see schematic drawings 6E-1-4030 SI34 and 20E-1-4030 SI34). This feature meets Branch Technical Position ICSB-18, paragraph B.3.

3. The starter for MOV 1SI8802B is at MCC 132X4A, compartment L2 which is downstream of the power lockout starter as mentioned in Item 1 (see drawings 6E-1-4008AA and 20E-1-4008AA).

4. When the power lockout starter contact opens (as mentioned in Item 2) there is no electrical power supply furnished to valve motor 1SI8802B (see drawings 6E-1-4008AA and 20E-1-4008AA) or there is no power supply furnished to the control transformer which supplies the power supply to the control circuit.

5. During power lockout, if any signal is present, it will not change the valve position since there is no power to the motor or control circuit.

   Also if the 3-phase starter contact (O) gets stuck in the close position, the valve will not change position since there is no electric power to the valve motor.

Because of the design which is explained in Items 1 through 5, there is no need to rack the circuit breaker out or separate the control circuit.

However, for the reactor coolant loop stop valves (RC8001A-D and RC8002A-D), the safety injection system accumulator isolation valves (SI8808A-D), and the containment purge isolation valves (VQ001A-B and VQ002A-B) listed in Table 8.1-2, the individual breaker for each valve (located at the respective MCC compartment) is maintained manually deenergized (opened) and administratively controlled. This precaution assures that these valves always remain in the correct position during Modes 1, 2, 3, and 4 for the RC and VQ valves and during Modes 1, 2, and 3 for the safety injection system accumulator isolation valves. The individual breakers for the essential service water (SX) return valves, in Braidwood Table 8.1-2, are also maintained manually deenergized and administratively controlled. This method of power lockout is acceptable because the RC, SI8808A-D, VQ, and SX valves are not “active” valves as defined in Branch Technical Position ICSB-18.

All motor-operated valves that require power lockout to meet Branch Technical Position ICSB-18 are listed in Table 8.1-2.

Technical Specification surveillances verify that each valve is in the required position, with the exception of the Braidwood SX165A/B valves, which were removed from the Technical Specifications by Braidwood Amendment 62.

Conformance to Regulatory Guide 1.53 is discussed in Appendix A.

8.1.11 Manual Initiation of Protective Actions (Regulatory Guide 1.62)

Manual initiation of each protective action at the system level is provided in a manner such that initiation accomplishes all action performed by automatic initiation, and that protective action at the system goes to completion once manually initiated. Manual initiation is performed by readily accessible switches located in the control room and a minimum of equipment is used in common with automatically initiated protective action.

For additional discussion on this subject, see Subsection 7.1.2.

8.1.12 Electrical Penetrations

The Byron/Braidwood Stations' electrical penetrations are designed to withstand, without loss of mechanical integrity, the maximum possible fault current versus time conditions (which could occur due to a single random failure of a circuit overload protection device) within the two leads of any one single-phase circuit or the three leads of any one three-phase circuit. The penetrations are designed with oversized conductors through the penetration seals such that they can withstand the maximum fault current versus time condition from the time the fault occurs through the time required for operation of the backup protection device if not interrupted by the primary protective device.

The Byron/Braidwood design specification (Construction Permit was issued December 31, 1975) requires the penetration vendors to meet all requirements of Regulatory Guide 1.63, Rev. 0.

Each type of typical circuits that penetrate the reactor containment is identified in the following paragraphs with a description of the primary and backup protection systems provided for the circuits and the fault-current-versus-time that the penetrations are qualified to. Both the primary and backup protection devices are selected and set to clear faults, up to the maximum calculated fault current, without exceeding the current and related time interval for which the penetrations are qualified to for maintaining mechanical integrity. In addition, the primary and secondary protection devices are selected with time-current tripping characteristics that will provide time-current thermal protection for the penetration conductors up to the maximum calculated fault current.

The Byron/Braidwood Unit 1 electrical penetrations are manufactured by Conax Corporation, whereas Byron/Braidwood Unit 2 electrical penetrations are manufactured by either Conax Corporation, Bunker Ramo (Amphenol SAMS) or Bunker Ramo (Amphenol SAMS) with Conax adaptor modules. It must be noted that there is no need to maintain the Conax penetrations pressurized during normal operation to ensure electrical functionality during a LOCA. However, there is a need to maintain the Bunker Ramo penetrations pressurized during normal operation to assure electrical functionality during a LOCA.

1. Medium Voltage (6.9-kV) Power Service Penetrations

The primary protection consists of the 6900-V feeder air circuit breaker that feeds the penetration directly. This breaker utilizes Westinghouse COM-5 and COM-11 relays for its penetration protection scheme.

The backup protection consists of the 6900-V main bus (to which the penetration feeder breaker is connected) supply air circuit breaker. This breaker utilizes two Westinghouse CO-6 or CO-9 relays for its penetration protection scheme.

Both Conax and Bunker Ramo (Amphenol SAMS) penetrations have been qualified and can withstand a short circuit of 44,000 amperes symmetrical for a period of 0.5 seconds or a short circuit of 40,840 amperes symmetrical for a period of 0.845 second.

2. Low Voltage Power Service Penetrations

These penetrations are further subdivided into the following:

a. Circuits energized directly from 480-V ESF substations

The primary protection consists of the 480-V feeder circuit breaker that feeds the penetration directly.

The backup protection consists of the 4160-V supply air circuit breaker that feeds the entire 480-V substation. This breaker utilizes three Westinghouse CO-9 relays for its penetration protection scheme.

The Byron/Braidwood Unit 1 penetrations (500 MCM conductors) have been qualified and can withstand a short circuit of 22,000 amperes (symmetrical) for 0.5 second or a short circuit of 21,500 amperes (symmetrical) for a period of 0.52 second.

The Byron/Braidwood Unit 2 penetrations (500 MCM conductors) have been qualified and can withstand a short circuit of 42,000 amperes (symmetrical) for 0.5 second or a short circuit of 21,500 amperes (symmetrical) for a period of 1.9 seconds.

b. Circuits energized from 480-V pressurizer heater distribution cabinets

The primary protection consists of a 480-V feeder molded case air circuit breaker that feeds the penetration directly.

The backup protection consists of another molded case air circuit breaker similar (and connected in series) to that provided for primary protection.

The Byron/Braidwood Unit 1 penetrations (#2 AWG conductors) have been qualified and can withstand a short circuit of 12,000 amperes (symmetrical) for a period of 0.19 second or a short circuit of 11,211 amperes (symmetrical) for a period of 0.2 second.

The Byron/Braidwood Unit 2 penetrations (1/0 AWG conductors) have been qualified and can withstand a short circuit of 27,000 amperes (symmetrical) for a period of 0.075 second or a short circuit of 11,211 amperes (symmetrical) for a period of 0.435 second.

c. Non-safety-related circuits energized from 480-V substations

The primary protection consists of the 480-V load circuit breaker that feeds the penetration directly.

The backup protection consists of the 480-V main bus (to which the penetration feeder breaker is connected) feeder circuit breaker or by use of fuses in series with the load circuit breaker.

The Byron/Braidwood Unit 1 penetrations (500 MCM conductors) have been qualified and can withstand a short circuit of 22,000 amperes (symmetrical) for a period of 0.5 second or a short circuit of 8203 amperes (symmetrical) for 3.6 seconds.

The Byron/Braidwood Unit 2 penetrations (500 MCM conductors) have been qualified and can withstand a short circuit of 42,000 amperes (symmetrical) for a period of 0.5 second or a short circuit of 8203 amperes (symmetrical) for 13 seconds.

d. Circuits energized directly from 480-V ESF motor control centers

The primary protection consists of a 480-V feeder circuit breaker that feeds the penetration directly.

The backup protection consists of another molded case air circuit breaker similar (and connected in series) to that provided for primary protection. The overload heater at the starter (where furnished) also provides backup protection for low magnitude fault currents.

The Byron/Braidwood Units 1 and 2 penetrations have been qualified and have the fault current versus time capabilities shown in Table 8.1-3.

e. Non-safety-related circuits energized directly from 480-V motor control centers

The primary protection consists of a 480-V feeder molded case air circuit breaker that feeds the penetration directly.

The backup protection consists of another molded case air circuit breaker similar (and connected in series) to that provided for primary protection. The overload heater at the starter (where furnished) also provides backup protection for low-magnitude fault currents.

The Byron/Braidwood Units 1 and 2 penetrations have been qualified and have the fault current versus time capabilities shown in Table 8.1-3.

3. Low Voltage Control Service Penetrations

These penetrations are further subdivided into the following:

a. Circuits energized directly from 120/208-Vac distribution panels at 480-V MCCs

The primary protection consists of a 120-V feeder molded case air circuit breaker that feeds the penetration directly.

The backup protection consists of another molded case air circuit breaker similar (and connected in series) to that provided for primary protection.

The Byron/Braidwood Unit 1 penetrations (#14 AWG conductors) have been qualified and can withstand a short circuit current of 1200 amperes (symmetrical) for a period of 0.032 second, or a short circuit current of 554 amperes for a period of 0.15 second.

The Byron/Braidwood Unit 2 penetrations (#14 AWG conductors) have been qualified and can withstand a short circuit current of 1,600 amperes (symmetrical) for a period of 0.03 second or a short circuit current of 554 amperes for a period of 0.25 second.

b. <u>120-Vac control circuits energized from the 480-120 V control power transformers in the motor control centers</u>

The primary protection consists of a nonrenewable cartridge-type fuse in the control transformer's 120-V secondary leads that feed the penetrations directly. The backup protection consists of another fuse similar (and connected in series) to that provided for primary protection.

The Byron/Braidwood Unit 1 penetrations (#14 AWG conductors) have been qualified and can withstand a short circuit current of 1200 amperes (symmetrical) for a period of 0.032 second, or a short circuit of 40 amperes for a period of 28.8 seconds.

The Byron/Braidwood Unit 2 penetrations (#14 AWG conductors) have been qualified and can withstand a short circuit of 1600 amperes (symmetrical) for a period of 0.03 second, or a short circuit of 40 amperes for a period of 48 seconds.

4. <u>Low Voltage Shielded Instrumentation Service Penetrations</u>

The short circuit current through these penetrations will not exceed their continuous current rating.

5. <u>Neutron Monitoring Service Penetrations</u>

The short circuit current through these penetrations will not exceed their continuous current rating.

6. <u>Circuits Energized from 125 Vdc Distribution Panels</u>

The 125-Vdc emergency lighting cabinet is the only such load. The primary protection consists of a 125-Vdc molded case air circuit breaker that feeds the penetration directly. The backup protection consists of another molded case air circuit breaker similar (and connected in series) to that provided for primary protection.

7. Circuits (Solenoid Operated Valves) Energized From 125 Vdc Distribution Panels

The primary protection consists of a nonrenewable cartridge-type fuse that feeds the penetration directly. The backup protection consists of another fuse similar (and connected in series) to that provided for primary protection.

8. Rod Control System Lift and Gripper Coil Circuits

The primary and backup protection for the rod control system lift and gripper coil circuits consists of fuses connected in series.

9. Rod Position Indication Data Circuits

The primary and backup protection for the rod position indication data cabinets consists of two 120-Vac molded case air circuit breakers connected in series.

10. There are no provisions for periodic testing of penetration or fuses under simulated fault conditions because such testing would be detrimental to the penetration and fuses. The circuit breakers that provide the primary and backup protection will be periodically tested under simulated fault conditions to demonstrate that the overall coordination scheme remains within the specified limits.

The test interval will be at least once every 18 months during refueling outages.

Conformance to Regulatory Guide 1.63 is discussed in Appendix A.

8.1.13 Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants

To the extent practicable, the electric and mechanical components integral to the electric valve operator mechanism and required to operate and control valve action inside the containment have been tested in accordance with IEEE 382-1972.

Although in some instances, stem mounted switches are not environmentally tested along with the valve-motor operator, they are still tested in accordance with the subject standard.

Compliance with Regulatory Guide 1.73 is discussed in Appendix A.

8.1.14 Physical Independence of Electric Systems

The physical independence of the circuits and electrical equipment comprising or associated with Class 1E power systems, protection systems, systems actuated or controlled by the protection system, and auxiliary or supporting systems that must be operable for the protection systems to perform their safety-related function are discussed in Subsection 8.3.1.4.

The physical identification of safety-related equipment is discussed in Subsection 8.3.1.3.

Compliance with Regulatory Guide 1.75 is discussed in Appendix A.

8.1.15 Shared Emergency and Shutdown Electric systems for Multi-Unit Nuclear Power Plants

The criteria followed in designing the two unit station is that each unit shall operate independently of the other and malfunction of equipment or operator error in one unit will not initiate a malfunction or error in the other unit nor affect the continued operation of the other unit.

Compliance with Regulatory Guide 1.81 is discussed in Appendix A.

8.1.16 Qualification of Class 1E Equipment for Nuclear Power Plants

With regard to environmental qualification of instrumentation, control, and electrical equipment important to safety, the Licensee complies with the intent of IEEE 323-1974. Additional information is provided in Section 3.11.

Compliance with Regulatory Guide 1.89 is discussed in Appendix A.

8.1.17 Availability of Electric Power Sources

During abnormal electric power source configurations, plant operations are limited as described in the Technical Specifications.

Compliance with Regulatory Guide 1.93 is discussed in Appendix A.

8.1.18 Conformance to IEEE 338-1975 (Periodic Testing of Nuclear Power Generating Station Class 1E Power and Protection System)

Conformance to this standard is addressed in Subsection 8.3.1.2.

8.1.19 Conformance to IEEE 344-1971 (Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Station)

Conformance to this standard is addressed in Section 3.10.

8.1.20 Conformance to IEEE 387-1984 (Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations)

Vendor qualification tests, preoperational testing, and periodic testing during normal plant operation conform to those procedures described in this standard, except as noted in Subsection 8.3.1.2, Chapter 14.0, and the Technical Specifications.

8.1.21 Conformance to IEEE 420-1973 (IEEE Trial-Use Guide for Class 1E Control Switchboards for Nuclear Power Generating Stations)

Class 1E control switchboards conform to this standard with the following clarification to Paragraph 4.6.1.2: Splices may be used on individual conductors of external field run cables within switchboards for the purpose of extending individual conductors to their point of termination.

TABLE 8.1-1

LISTING OF APPLICABLE CRITERIA

	CRITERIA		TITLE	CONFORMANCE DISCUSSED IN
1.	10 CFR Part 10			
	a.	10 CFR 50.34	Contents of Applications: Technical Information	All Chapters of UFSAR
	b.	10 CFR 50.36	Technical Specifications	Technical Specifications
	c.	10 CFR 50.55a	Codes and Standards	See Response of IEEE Standard 279 Below
2.	General Design Criteria (GDC), Appendix A to 10 CFR Part 50			
	a.	GDC-1	Quality Standards and Records	Section 3.1
	b.	GDC-2	Design Bases for Protection Against Natural Phenomena	Section 3.1
	c.	GDC-3	Fire Protection	Section 3.1
	d.	GDC-4	Environmental and Missile Design Bases	Section 3.1
	e.	GDC-5	Sharing of Structures, Systems, and Components	Section 3.1
	f.	GDC-13	Instrumentation and Control	Section 3.1

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA		TITLE	CONFORMANCE DISCUSSED IN
	g. GDC-17	Electric Power Systems	Section 3.1
	h. GDC-18	Inspection and Testing of Electrical Power Systems	Section 3.1
	i. GDC-21	Protection System Reliability and Testability	Section 3.1
	j. GDC-22	Protection System Independence	Section 3.1
	k. GDC-33	Reactor Coolant Make-up	Section 3.1
	l. GDC-34	Residual Heat Removal	Section 3.1
	m. GDC-35	Emergency Core Cooling	Section 3.1
	n. GDC-38	Containment Heat Removal	Section 3.1
	o. GDC-41	Containment Atmospheric Clean-up	Section 3.1
	p. GDC-44	Cooling Water	Section 3.1
3.	Institute of Electrical and Electronics Engineers (IEEE) Standards:		
	a. IEEE Std. 279 (ANSI N42.7)	Criteria for Protection Systems for Nuclear Power Generating Systems	Subsections 8.1.11, 8.3.1.2 and 8.3.1.4.1
	b. IEEE Std. 308	Criteria for Class 1E Electrical Systems for Nuclear Power Generating Stations	See Response to R.G. 1.32 below

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA		TITLE	CONFORMANCE DISCUSSED IN
c.	IEEE Std. 317	Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations	See Response to R.G. 1.63 below
d.	IEEE Std. 323	Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations	See Response to R.G. 1.89 below. Also see Subsection 8.3.1.2
e.	IEEE Std. 334	Standard for Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations	See Response to R.G. 1.40 below. Also see Subsection 8.1.19
f.	IEEE Std. 336 (NQA-1-1994, Subpart 2.4)	Installation, Inspection and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations	See Response to (NQA-1-1994, Subpart 2.4) below
g.	IEEE Std. 338	Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems	See Response to R.G. 1.118 below. Also see Subsections 8.1.18 and 8.3.1.2
h.	IEEE Std. 344 (ANSI N41.7)	Guide for Seismic Qualification of Class 1 Electrical Equipment for Nuclear Power Generating Stations	See Response to R.G. 1.100 below. Also see Subsection 8.1.19
i.	IEEE Std. 379 (ANSI N41.2)	Guide for the Application of the Single Failure Criterion to Nuclear Power Generating Station Protection System	See Response to R.G. 1.53 below

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA		TITLE	CONFORMANCE DISCUSSED IN
j.	IEEE Std. 382	Trial-Use Guide for the Type-Test of Class 1 Electric Valve Operators for Nuclear Power Generating Stations (ANSI N416)	See Response to R.G. 1.73 below
k.	IEEE Std. 383	Standard for Type-Test of Class 1E Electric Cable Field Splices, and Connections for Nuclear Power Generating Stations	Subsections 8.3.1.4.1.2 and 8.3.3
l.	IEEE Std. 384 (ANSI N41.14)	Criteria for Separation of Class 1E Equipment and Circuits	See Response to R.G. 1.75 below
m.	IEEE Std. 387 (ANSI N41.13)	Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Stations	Subsections 8.1.20 and 8.3.1
n.	IEEE Std. 415	Planning of Pre-Operational Testing Programs for Class 1E Power Systems for Nuclear Power Generating Stations, IEEE Guide for	Chapter 14.0
o.	IEEE Std. 420	Trial-Use Guide for Class 1E Control Switchboards for Nuclear Power Generating Stations (ANSI N41.7)	Subsection 8.3.1
p.	IEEE Std. 450	Recommended Practice for Maintenance, Testing and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries	See Response to R.G. 1.129 below
q.	IEEE Std. 484	Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants	See Response to R.G. 1.128 below. Also see Subsection 8.3.2

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA	TITLE	CONFORMANCE DISCUSSED IN
r. IEEE Std. 485	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations	Subsection 8.3.2
s. IEEE Std. 946	Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations	Subsection 8.3.2

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA		TITLE	CONFORMANCE DISCUSSED IN
4.	Regulatory Guides (RG)		
a.	RG 1.6	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems	Appendix A
b.	RG 1.9	Selection of Diesel Generator Set Capacity for Standby Power Supplies	Appendix A
c.	RG 1.29	Seismic Design Classification	Appendix A
d.	NQA-1-1994, Subpart 2.4 (Supersedes RG 1.30)	Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities	Appendix A
e.	RG 1.32	Use of IEEE Std. 308, "Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations"	Appendix A
f.	RG 1.40	Qualification Tests for Continuous-Duty Motors Installed Inside the Containment of Water Cooled Nuclear Power Plants	Appendix A
g.	RG 1.41	Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments	Appendix A
h.	RG 1.47	Bypassed and Inoperable Status Indications for Nuclear Power Plant Safety Systems	Appendix A
i.	RG 1.53	Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems	Appendix A

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA	TITLE	CONFORMANCE DISCUSSED IN
j. RG 1.63	Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Plants	Appendix A
k. RG 1.68	Preoperational and Initial Start-up Test Programs for Water-Cooled Power Reactors	Appendix A
l. RG 1.70	Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants	Appendix A
m. RG 1.73	Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants	Appendix A
n. RG 1.75	Physical Independence of Electric Systems	Appendix A
o. RG 1.81	Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants	Appendix A
p. RG 1.89	Qualification of Class 1E Equipment for Nuclear Power Plants	Appendix A
q. RG 1.93	Availability of Electric Power Sources	Appendix A
r. RG 1.100	Seismic Qualification of Electric Equipment for Nuclear Power Plants	Appendix A
s. RG 1.106	Thermal Overload Protection for Electric Motors on Motor-Operated Valves	Appendix A
t. RG 1.108	Periodic Testing of Diesel Generators Used as Onsite Power Systems at Nuclear Power Plants	Appendix A

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA		TITLE	CONFORMANCE DISCUSSED IN
u.	RG 1.118	Periodic Testing of Electric Power and Protection System	Appendix A
v.	RG 1.120	Fire Protection Guidelines for Nuclear Power Plants	Appendix A
w.	RG 1.128	Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants	Appendix A
x.	RG 1.129	Maintenance, Testing and Replacement of Large Lead Storage Batteries for Nuclear Power Plants	Appendix A
y.	RG 1.155	Station Blackout	Appendix A
5.	Branch Technical Positions (BTP) ICSB		
a.	BTP ICSB 2 (PSB)	Diesel-Generator Reliability Qualification Testing	Subsections 8.1.20 and 8.3.1
b.	BTP ICSB 6 (PSB)	Capacity Test Requirements of Station Batteries-Technical Specifications	Technical Specifications
c.	BTP ICSB 8 (PSB)	Use of Diesel-Generator Sets for Peaking	Subsection 8.3.1
d.	BTP ICSB 11 (PSB)	Stability of Offsite Power Systems	Subsection 8.3.1
e.	BTP ICSB 15 (PSB)	Reactor Coolant Pump Breaker Qualification	Subsection 8.1.16

TABLE 8.1-1 (Cont'd)

LISTING OF APPLICABLE CRITERIA

CRITERIA	TITLE	CONFORMANCE DISCUSSED IN
f. BTP ICSB 17 (PSB)	Diesel Generator Protective Trip Circuit Bypasses	Table 8.3-7 and Subsection 8.3.1
g. BTP ICSB 18 (PSB)	Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves	Subsection 8.1.10
h. BTP ICSB 21	Guidance for Application of RG 1.47	Subsection 8.1.9

TABLE 8.1-2

MOTOR-OPERATED VALVES REQUIRING POWER LOCKOUT

All motor-operated valves within the (total) scope of design that require power lockout to meet the Branch Technical Position ICSB-18 are listed as follows:

VALVE NO.	VALVE NO.
SI8840	SI8808B
SI8835	SI8808C
SI8806	SI8808D
SI8809A	SI8809B
SI8802A	SI8813
SI8808A	SI8802B
RC8001A	VQ001A
RC8001B	VQ001B
RC8001C	VQ002A
RC8001D	VQ002B
RC8002A	
RC8002B	
RC8002C	
RC8002D	

TABLE 8.1-2 (Cont'd)

MOTOR-OPERATED VALVES REQUIRING POWER LOCKOUT

All motor-operated valves within the (total) scope of design that require power lockout to meet the Branch Technical Position ICSB-18 are listed as follows:

VALVE NO.	VALVE NO.
SI8840	SI8808B
SI8835	SI8808C
SI8806	SI8808D
SI8809A	SI8809B
SI8802A	SI8813
SI8808A	SI8802B
RC8001A	VQ001A
RC8001B	VQ001B
RC8001C	VQ002A
RC8001D	VQ002B
RC8002A	SX165A
RC8002B	SX165B
RC8002C	
RC8002D	

TABLE 8.1-3

PENETRATION CONDUCTOR AND FAULT CURRENT DATA

FIELD CABLE SIZE	UNIT 1 (CONAX) PENETRATION FAULT CURRENT VERSUS TIME CAPABILITIES (SHORT CIRCUIT SYMMETRICAL AMPS)	UNIT 1 (CONAX) PENETRATION CONDUCTOR SIZE	UNIT 2 (BUNKER RAMO) PENETRATION FAULT CURRENT VERSUS TIME CAPABILITIES (SHORT CIRCUIT SYMMETRICAL AMPS)	UNIT 2 (BUNKER RAMO) PENETRATION CONDUCTOR SIZE
#10AWG	5,200A for 0.5 sec. or 3,026A for 1.5 sec	#2AWG	27,000A for 0.03 sec or 3,026A for 2.4 sec	#2AWG
#6AWG	5,200A for 0.5 sec or 6,407A for 0.33 sec	#2AWG	27,000A for 0.03 sec or 6,407A for 0.53 sec	#2AWG
#2AWG	12,000A for 0.19 sec or 8,135A for 0.4 sec	#2AWG	27,000A for 0.075 sec or 8,135A for 0.826 sec	1/0 AWG
#2AWG	9,500A for 0.5 sec or 10,094A for 0.44 sec	2/0 AWG	27,000A for 0.075 sec Or 10,094A for 0.53 sec	1/0 AWG
#10AWG	8,000A for 0.1 sec or 3,984A for 0.4 sec	#4AWG	27,000A for 0.03 sec or 3,984A for 1.37 sec	#2AWG
#6AWG	8,000A for 0.1 sec or 7,119A for 0.126 sec	#4AWG	27,000A for 0.03 sec or 7,119A for 0.43 sec	#2AWG

TABLE 8.1-3

PENETRATION CONDUCTOR AND FAULT CURRENT DATA

FIELD CABLE SIZE	UNIT 1 (CONAX) PENETRATION: FAULT CURRENT VERSUS TIME CAPABILITIES (SHORT CIRCUIT SYMMETRICAL AMPS)	UNIT 1 (CONAX) PENETRATION: CONDUCTOR SIZE	UNIT 2 (BUNKER RAMO) PENETRATION: FAULT CURRENT VERSUS TIME CAPABILITIES (SHORT CRICUIT SYMMETRICAL AMPS)	UNIT 2 (BUNKER RAMO) PENETRATION: CONDUCTOR SIZE
#2AWG	12,000 for 0.19 sec or 9,836A for 0.28 sec	#2AWG	27,000A for 0.075 sec or 9,836A for 0.56 sec	1/0 AWG
1/0 AWG	14,200A for 0.5 sec or 13,180A for 0.58 sec	2/0 AWG	27,000A for 0.12 sec or 13,180A for 0.5 sec	2/0 AWG
#10AWG	8,000A for 0.1 sec or 3,984A for 0.4 sec	#4AWG	27,000A for 0.03 sec or 3,984A for 1.37 sec	#2AWG
#6AWG	8,000A for 0.1 sec or 4,444A for 0.32 sec	#4AWG	27,000A for 0.03 sec or 4,444 for 1.1 sec	#2AWG
4/0 AWG	18,600A for 0.5 sec or 12,163A for 1.17 sec	250 MCM	27,000A for 0.3 sec or 12,163A for 1.48 sec	4/0 AWG
350 MCM	22,000A for 0.5 sec or 10,924A for 2 sec	500 MCM	42,000A for 0.5 sec or 10,924A for 7 sec	500 MCM

8.2 OFFSITE (PREFERRED) POWER SYSTEM

8.2.1 Description

Electric energy generated at the station is transformed from generator voltage to a nominal 345-kV transmission system voltage by the main power transformers. The main power transformers are connected via intermediate transmission towers to the station's 345-kV transmission terminal. A one line diagram of the 345-kV bus arrangement is shown on Figure 8.2-1. The 345-kV overhead lines exit the station transmission terminal on three separate rights-of-way as shown on Figure 8.2-2.

The transmission line structures are designed for heavy ice loadings, high wind, and broken wire loadings. Dampers are installed on all conductors and static wires to control high frequency vibration. Figure 8.2-3 shows the transmission line routing on the site property, and Figure 8.2-2 indicates the general routes and lengths of transmission lines from the station to major substations on the Commonwealth Edison grid. No other transmission lines cross over these lines and as the lines enter the station via three separate rights-of-way a structural failure in any one line will not result in the loss of the transmission lines entering the site via the other two rights-of-way.

The preferred power system is considered as having three major sections, each of which must provide two physically separate and electrically independent circuit paths between the onsite power system and the transmission network (the transmission network excludes the station switchyard). The three sections are:

1. The transmission lines entering the station switchyard from the transmission network.

2. The station switchyard. (A common switchyard is allowed by GDC 17).

3. The overhead transmission lines, SATs, buses between the switchyard, and the onsite power system.

The station's 345-kV switchyard ring buses are continuously energized and serve as the power source for the station's safety loads. The two power circuits from the 345-kV switchyard ring buses to each unit's Class 1E distribution system enter through two physically separate rights of way with independent transmission line structures. These lines enter the switchyard from the opposite sides to the lines leaving the switchyard and terminate at transformers located on the opposite sides of the reactor buildings. There are no other lines crossing these preferred power lines. A single event will <u>not</u> simultaneously affect both circuits in such a way that neither can be returned to service within the time limit to exceed any design limits. The system auxiliary transformers step the 345-kV system voltage down to the station 4160-volt and 6900-volt power systems. Each pair of system auxiliary transformers is sized to provide the total auxiliary power for one unit plus the ESF auxiliary power for the other unit.

The transmission terminal 345-kV circuit breakers are configured to afford optimum protection for the bus in the event of a transmission line, generator, or bus fault. Relay tripping of the breakers over a microwave communication system is used for line protection for line L15501 (only). Relay tripping of the breakers over a direct fiber connection to the switchyard dual fiber ring is used for line protection for lines L0621, L0622, L0624, L0626 and L0627. Should a breaker fail to operate or primary relaying fail to trip a breaker, local breaker backup (LBB) will operate the adjacent breaker. The operation of the adjacent breaker still provides maximum reliability of power supplied to the bus as it will only isolate an additional bus section. For instance, the ring bus is configured so that a generator trip from the backup protection system will not jeopardize the availability of the system auxiliary transformer or one of the two transmission feeds to the ring bus for the unit. Control power for operation of the 345-kV breakers is provided by two 125-volt batteries located in the switchyard. The 345-kV switchyard relay house houses the 125-volt batteries and the protective relays. A single line diagram of a typical d-c control system for operation of the breakers is shown on Figure 8.2-4.

The only remote source of fire, explosion, or missiles in the area of the transmission terminal would be the circuit breakers. The worst possible failure of any circuit breaker and the microwave tower will not result in the total loss of offsite power.

Further discussion concerning the relationship between the station's offsite power system and its onsite auxiliary power system is found in Subsection 8.3.1.

8.2 OFFSITE (PREFFERRED) POWER SYSTEM

8.2.1 Description

Electric energy generated at the station is transformed from generator voltage to a nominal 345-kV transmission system voltage by the main power transformers. The main power transformers are connected via intermediate transmission towers to the station's 345-kV transmission terminal. A one line diagram of the 345-kV bus arrangement is shown on Figure 8.2-5. The 345-kV overhead lines exit the station transmission terminal on three separate rights-of-way as shown on Figure 8.2-6.

The transmission line structures are designed for heavy ice loading, high wind, and broken wire loadings. Dampers are installed on all conductors and static wires to control high frequency vibration. Figure 8.2-7 shows the transmission line routing on the site property, and Figure 8.2-6 indicates the general routes and lengths of transmission lines from the station to major substations on the Commonwealth Edison grid. As the lines enter the station via three separate rights-of-way a structural failure of any one line will not result in the loss of transmission lines entering the site via the other two rights-of-way. The transmission lines that are exposed to a crossover are the two lines to East Frankfort which pass under one 765-kV line and the lines from La Salle which pass under one 345-kV line.

The preferred power system is considered as having three major sections, each of which must provide two physically separate and electrically independent circuit paths between the onsite power system and the transmission network (the transmission network excludes the station switchyard). The three sections are:

1. The transmission lines entering the station switchyard from the transmission network.

2. The station switchyard. (A common switchyard is allowed by GDC 17).

3. The overhead transmission lines, SATs, buses between the switchyard, and the onsite power system.

The station's 345-kV switchyard ring buses are continuously energized and serve as the power source for the station's safety loads. The two power circuits from the 345-kV switchyard ring buses to each unit's Class 1E distribution system enter through two physically separate rights of way with independent transmission line structures. These lines enter the switchyard from the opposite sides to the lines leaving the switchyard and terminate at transformers located on the opposite sides of the reactor buildings. There are no other lines crossing these preferred power lines. A single event will not simultaneously affect both circuits in such a way that neither can be returned to service within the time limit to exceed any design limits. The system auxiliary transformers step the 345-kV system voltage down to the station 4160-volt and 6900-volt power systems. Each pair of system auxiliary transformers is sized to provide the total auxiliary power for one unit plus the ESF auxiliary power for the other unit.

The transmission terminal 345-kV circuit breakers are configured to afford optimum protection for the bus in the event of a transmission line, generator, or bus fault. Relay tripping of the breakers over a fiber optic communication system is used for line protection. Should a breaker fail to operate or primary relaying fail to trip a breaker, local breaker backup (LBB) will operate the adjacent breaker. The operation of the adjacent breaker still provides maximum reliability of power supplied to the bus as it will only isolate an additional bus section. For instance, the ring bus is configured so that a generator trip from the backup protection system will not jeopardize the availability of the system auxiliary transformer or one of the two transmission feeds to the ring bus for the unit. Control power for operation of the 345-kV breakers is provided by two 125-V batteries located in the switchyard. The 345-kV switchyard relay house houses the 125-volt batteries and the protective relays. A single line diagram of a typical d-c control system for operation of the breakers is shown on Figure 8.2-4.

The only remote source of fire, explosion, or missiles in the area of the transmission terminal would be the circuit breakers. The worst possible failure of any circuit breaker and the microwave tower will not result in the total loss of offsite power.

Further discussion concerning the relationship between the station's offsite power system and its onsite auxiliary power system is found in Subsection 8.3.1.

8.2.2 Analysis

The probability of losing the offsite electric power supply has been minimized by the design of the Commonwealth Edison transmission system and the Exelon Generation Company system. Increased reliability is provided through interconnections to neighboring systems. At the beginning of 1985, the Commonwealth Edison transmission system consisted, in part, of ninety-two 345-kV lines totaling 2335 miles, and three 765-kV lines totaling 90 miles. The transmission system is interconnected with neighboring electric utilities at 28 points, 9 at 138-kV, 18 at 345-kV, and 1 at 765-kV.

The interconnections between Byron and Braidwood generating stations and the Commonwealth Edison grid and the MAIN, ECAR, and MAPP grids are shown in Figures 8.2-2 and 8.2-6.

Commonwealth Edison is a member of PJM. One of the functions of PJM is to ensure that the transmission system is reliable and adequate.

This page has been intentionally deleted.

This page has been intentionally deleted.

The Transient Stability Studies are performed by the Transmission Planning Entity (PJM) periodically and on an as required basis for major transmission system modifications. The Transmission Planning Entity stability testing implements the North American Electric Reliability Corporation (NERC) Mandatory Reliability Standards including contingencies under NERC Standard TPL-001.

In addition to the NERC Standard criteria, the Transmission Planning Entity reviews and implements additional criteria testing as required by Station Specific Nuclear Plant Interface Requirement (NPIR) for planning and analyses of the electric system.

The reliability of the transmission grid is demonstrated by the performance data of the 345-kV transmission lines. The average 345-kV line in the grid experienced 1.5 forced outages per year, with an average duration of 24 hours per forced outage during 1984 covering 152 line years of exposure. For the 17 years between January 1, 1965 and December 31, 1981, the average Commonwealth Edison 345-kV line experienced 1.8 forced outages per year, with an average duration of 15.0 hours per forced outage. This 17-year period represents 826 line years of experience. The causes of the forced line outages may be summarized as follows:

		% of Forced Outages
a.	Terminal Related	
	1. Storm Damage	1.4
	2. Equipment Failure	16.0
	3. Human Error	7.8
	4. False Trip	8.4
	5. Other	7.7
b.	Line Related	
	1. Storm Damage	23.5
	2. Equipment Failure	5.9
	3. Contamination	8.4
	4. Other	6.0
c.	Unknown	14.9
		100%

The ability of the Commonwealth Edison transmission system to withstand the loss of transmission lines connecting the Byron and Braidwood 345-kV switchyards to the network has been investigated through separate stability studies for each station to demonstrate adequacy of the transmission system.

Conditions were studied for the year 1987 for Byron and 1988 for Braidwood. Both Units 1 and 2 were operating at their net capabilities of 1120 MW. The electric systems in Wisconsin, Iowa, Illinois, and Indiana were all represented in detail, while the systems in other adjacent states were represented in lesser detail.

The studies demonstrate the adequacy of the transmission system under various line contingencies on the Byron and Braidwood 345-kV lines. Contingencies studied were three phase faults near the 345-kV switchyard which are the most severe as concerns the stability of the units. Included were three phase line faults with normal clearing of the line protective systems and also phase-to-ground faults with abnormal clearing involving the failure of a relay or circuit breaker. Double line tower faults were also studied. ComEd Transmission Planning Department had conducted transient and dynamic stability studies for the addition of MWs at Byron and Braidwood stations as a result of Power Uprate and the addition of new generation by Independent Power Producer at Lee County station. Lee County Station is added between Byron and Nelson switchyards. Therefore line no. from Byron to new substation #TSS937 at Lee County will be revised to L0627 and the line no. between TSS937 and TSS155 (at Nelson) will be left with the old line no. L15501. This will revise UFSAR figures 8.2-1, 8.2-2 and 8.2-3. Stability studies have added some more contingencies and a Power System Stabilizer to Byron Unit-2. All these changes will be implemented prior to Power Uprate is effective (in year 2001 at Byron). Due to its unique position in Transmission Network Braidwood station does not have same changes as Byron except some LBB timer setting changes.

All units remained stable throughout all of the line outages mentioned above.

The nuclear plant operator is provided with operating instructions on 345kV bus voltage levels, including maximum and minimum limits. Lower voltages than indicated above may be experienced under certain transmission system conditions (e.g., some generation and transmission line outages). These conditions and their probability of occurrence are discussed below. Their effects on the voltages of safety-related buses are discussed in Subsection 8.3.1.

The frequency of the offsite power supply will be in the range of 59.9 to 60.1 Hz even under the types of system disturbances referred to below. This rather small frequency band is inherent in the large interconnected grid control, including an incident involving the sudden loss of the largest generating station. Frequencies outside this range can only occur if a system separation occurs as discussed below.

This page has been intentionally deleted.

1. The nuclear plant operator is provided with operating instructions on 345-kV bus voltage levels, including maximum and minimum limits.

   Grid system frequency is primarily under the control of PJM and is not directly under the plant operator's control. However, a frequency meter is located in the control room to allow the operator to observe the actual grid system frequency and to take appropriate emergency action, which may be required.

2. Recommended generator operating voltages are selected as a function of system load. In general, it is necessary to operate generators at a minimum voltage during light system loads and a maximum voltage during heavy system loads to obtain acceptable voltages throughout the grid. The maximum and minimum levels vary for different plants depending on their location in the system and are always selected to be within equipment limitations.

   At light system loads, the generator excitation is reduced to reach the minimum voltage, thereby somewhat reducing stability margins. However, the overall system design has sufficient margin to ensure stability following a system disturbance for this mode of operation.

   At high system loads, the generator excitation is increased to reach the maximum voltage, which in turn enhances stability. Counteracting this benefit is the high transmission system loading. Stability design margins are also adequate to compensate for this effect.

   The normal slight frequency deviation from 60 Hz of ± 0.1 Hz has a negligible effect on system stability. Significant departures from 60 Hz can only occur if a portion of the system becomes separated from the interconnected grid. Protective schemes are used to arrest the frequency deviation both for over- and underfrequency conditions to satisfactory levels.

Power grid frequency decay rates expected at Byron and Braidwood as a result of disturbances in the grid system have been evaluated. Frequency levels below 59.9 Hz will occur only in the event that the plant and an extensive part of the Commonwealth Edison system becomes separated from the Eastern Interconnection Transmission Network creating an isolated island. Such an island would result following the loss of many transmission rights-of-way. The probability of this event is considerably less than 10^{-6} per year.

For the Byron plant, the maximum decay rate under an islanding event is expected to be about 2.0 Hz/sec, requiring the concurrent outage of six rights-of-way. The Braidwood plant, because of its location with respect to other generating plants in the grid, cannot reasonably be involved in a relatively small area island with load exceeding generation. If Braidwood is included in the islanding of a multistate geographical area, which is extremely unlikely, the maximum frequency decay rate is expected to be approximately 2 Hz/sec, assuming a generation deficiency of the largest plant in the area.

The control power for the 345-kV switchyard breakers is supplied by two independent, 125-volt batteries (non-ESF) located in the switchyard relay house. The design of the 345-kV transmission line control is such that the loss of either battery or the loss of both batteries and associated feeder cables will not cause the loss of the offsite power sources. As indicated on the schematic and relay house physical drawings, two protective relay systems are used on each transmission line, and two trip coils are used on each circuit breaker to assure tripping of faulted equipment.

The physical design of the switchyard control power supplies incorporates the following features:

a. two control power supplies, each consisting of a battery, battery charger, and distribution cabinets (one supply is located at each end of the relay house).

b. two separate cable pan systems in the relay house.

c. two separate access ducts for cables to exit the relay house basement (one at each end of the building).

d. two separate concrete trough systems for feeder cable distribution in the switchyard proper.

As indicated in the station single line diagram, 6E-0-4001 and 20E-0-4001, one unit and its normal power source are connected to one 345-kV ring bus and the second unit and its normal power source are connected to another 345-kV ring bus. The normal 345-kV source to each unit supplies two system auxiliary transformers (SATs). The 4-kV winding on each SAT is the normal source to an ESF bus and also supplies some non-ESF station loads. The reserve source to any ESF bus is then supplied from the corresponding ESF bus of the alternate unit. Therefore, the normal source to one unit becomes the reserve source to the other unit.

The analysis of the switchyard breaker control system, power supply, and breaker arrangement indicates that there is no single event which could cause simultaneous failure of both power circuits to a unit. However, if the initiating event is a highly improbable failure of breaker (BT 6-7) and another breaker (BT 12-13) failed to open in clearing the fault, the local breaker backup (LBB) protection would open the next breaker downstream and the normal and reserve source of power would not be available to the ESF buses. The units should not trip, however, since the equipment required to operate the plant would be quickly transferred from the system auxiliary transformers to the unit auxiliary transformers. A manually operated disconnect switch on each side of each of these automatically operated circuit breakers would facilitate quick isolation of this low probability event. This is the second of five levels of electrical power degradation in the Regulatory Guide 1.93 evaluation. Technical Specification 3.8.1, therefore, requires at least one of these two sources to be reestablished within 24 hours.

8.2.3 References

1. NERC Standard TPL-001, “Transmission System Planning Performance Requirements.”

2. FERC Order 693, “Mandatory Reliability Standards for the Bulk-Power System,” issued March 16, 2007 (Docket No. RM06-16-000).

3. FERC Order Accepting ERO Compliance Filing, Accepting ERO/Regional Entity Delegation Agreements, and Accepting Regional Entity 2007 Business Plans, issued April 19, 2007 (Docket No. RR06-1-004).

8.3 ONSITE POWER SYSTEMS

8.3.1 Onsite A-C Power Systems

The Class 1E and non-Class 1E power distribution systems are shown on Drawing 6E-0-4001, Byron station single-line diagram, and Drawing 20E-0-4001, Braidwood station single-line diagram. These figures clearly show the interrelationship between the onsite and offsite power systems.

All switchgear (by bus nomenclature) within the scope of the Byron/Braidwood design and the associated source of control power are tabulated in Tables 8.3-1 through 8.3-4.

8.3.1.1 Description

8.3.1.1.1 Unit Non-Class 1E Auxiliary Power Systems

The loads served by the unit non-Class 1E power system are those loads that are classified non-Class 1E.

The main components of the unit non-Class 1E power system for Unit 1 (2) are:

a. unit auxiliary transformers (UAT) 141-1 (241-1) and 141-2 (241-2);

b. 6900-volt switchgear 156 (256), 157 (257), 158 (258), and 159 (259);

c. 4160-volt switchgear 143 (243) and 144 (244);

d. 480-volt switchgear associated with buses 143 (243) and 144 (244);

e. 480-volt motor control centers;

f. 480/277-Vac lighting distribution cabinets; and

g. 208/120-Vac distribution panels.

The set of two auxiliary transformers is sized to provide the required power of the unit under full load conditions. The unit auxiliary transformers are connected to the main generator by isolated phase bus duct.

The connection between UAT 141-1 (241-1) 6900-volt winding and switchgears 157 (257) and 159 (259) is made by nonsegregated bus duct, as is the connection between the UATs 4160-volt winding and switchgear 143 (243). Similarly, UAT 141-2 (241-2) is connected to 6900-volt switchgear 156 (256) and 158 (258) and to 4160-volt switchgear 144 (244). Each nonsegregated phase bus duct is sized to carry the full load of the switchgear to which it is connected. Connections between switchgear and motor control centers, and to various distribution cabinets, are made by cable.

One of the unit's two SATs is capable of furnishing startup and limited operating loads. Startup is initiated and operation is limited to the requirements set forth in Section 3.8 of the Technical Specifications. The UAT and SAT are used to support normal plant operation, as discussed in Subsection 8.3.1.1.1. When a unit is tripped, auxiliary loads supplied from the UATs are automatically transferred to that unit's SATs. Operation with one SAT out of service is discussed in Subsection 8.3.1.1.2.1.

Under normal operating conditions, the power distribution scheme of the non-Class 1E network is as follows:

a. UAT 141-1 (241-1) or SAT 142-1 (242-1) feeds 6900-volt switchgear 157 (257) through main feed breaker 1571 (2571) or 1572 (2572) and 6900-volt switchgear 159 (259) through main feed breaker 1591 (2591) or 1592 (2592).

b. UAT 141-1 (241-1) feeds 4160-volt switchgear 143 (243) through main feed breaker 1431 (2431).

c. UAT 141-2 (241-2) or SAT 142-2 (242-2) feeds 6900-volt switchgear 156 (256) through main feed breaker 1561 (2561) or 1562 (2562) and 6900-volt switchgear 158 (258) through main feed breaker 1581 (2581) or 1582 (2582).

d. UAT 141-2 (241-2) feeds 4160-volt switchgear 144 (244) through main feed breaker 1441 (2441).

Each non-Class 1E 6900-V and 4160-V switchgear can be supplied from either the UAT or the SAT. If a switchgear is supplied from the UAT and the control switch for the SAT feeder breaker is in the trip position and the UAT feeder breaker trips for some reason other than a fault on the bus, then the SAT feeder breaker will automatically close. The converse is true if the switchgear is supplied from the SAT.

The operating time for the breakers is less than 10 cycles. Operating times are as follows:

Main contacts open:		
"a" contacts	2.7 ± 0.4 cycles	4.16 kV
	2.5 ± 0.4 cycles	6.9 kV
"b" contacts	3.0 ± 0.4 cycles	
Main contacts close:	5.1 ± 0.8 cycles	4.16 kV
	6.9 ± 0.6 cycles	6.9 kV

The second source of offsite power to the ESF buses is provided by the corresponding SAT of the other unit. The tie breakers are manually operated.

Since it is Commonwealth Edison's practice to operate with approximately 50% of the load on the UATs and 50% on the SATs, each 6900-volt switchgear may be manually transferred at any time during normal plant operation to balance the load. The 4160-volt switchgear tie breakers 1411 (2411) and 1421 (2421), connecting switchgears 141 and 143 (241 and 243) and 142 and 144 (242 and 244) are open. These breakers may be manually closed upon a loss of offsite power providing access for the non-ESF loads to the diesel generator within the diesel generator's rating.

8.3.1.1.2 Unit Class 1E Power Systems

8.3.1.1.2.1 Distribution and Normal Offsite Power Sources

General Description

All unit Class 1E loads are served by the Unit Class 1E a-c power system. All safety-related loads are fed from a-c electric power sources, except those d-c loads listed in Subsection 8.3.2.

The bus arrangements and division assignments are shown in Drawings 6E-0-4001 and 20E-0-4001. Equipment separation details are described in Subsection 8.3.1.4.

The coincidental loads for shutdown and LOCA operation are shown in Table 8.3-5.

The main components of the unit Class 1E a-c power system for Unit 1 (Unit 2) are:

a. diesel-generator 1A (2A) and 1B (2B);

b. 4160-volt ESF switchgear 141 (241) and 142 (242);

c. 4160-volt ESF common component cooling pump bus;

d. four 480-volt ESF switchgear for each Byron unit (two on each Braidwood unit);

e. twelve 480-volt motor control centers (10 on each Braidwood unit);

f. 480/277-volt lighting distribution cabinets (non-safety-related); and

g. 208/120-volt distribution panels.

Redundant services fed from the unit Class 1E power system are assigned to one of two electrically and physically independent divisions as shown in Table 8.3-5.

The power supply for the fifth component cooling pump motor can be from any one of the four ESF 4160-volt ESF buses 141, 142, 241, or 242. For maintaining complete separation, a separate 4160-volt bus identified as the common component cooling pump (CCCP) bus is being provided. The CCCP bus consists of four separate 4160-volt switchgear cubicles, each connected and interlocked to only one of the four ESF divisions. Only one 4160-volt breaker is provided and this is racked into the cubicle from which the common component cooling pump motor is to be supplied from.

As shown in Table 8.3-5, each 4160-volt ESF switchgear serves as the power distribution center for all safety-related a-c loads included within the respective ESF division.

For Unit 1 (Unit 2), each 4160-volt ESF bus has three independent sources of a-c power:

a. A normal (first offsite) source from the 345-kV system through system auxiliary transformer 142-1 (242-1) directly to 4160-volt ESF bus 141 (241), and through system auxiliary transformer 142-2 (242-2) directly to 4160-volt ESF bus 142 (242).

b. A reserve (second offsite) source, in accordance with NRC General Design Criterion 17, also from the 345-kV switchyard. This reserve source is a delayed access circuit. Electric power is taken from Unit 2's (1's) system auxiliary transformer 242-1 (142-1) through 4-kV switchgear 241 (141) directly to Unit 1's (2's) 4-kV switchgear 141 (241). A similar arrangement is utilized for 4160-volt ESF bus 142 (242).

c. An emergency (onsite) source, that being diesel-generator 1A (2A) for 4160-volt ESF bus 141 (241) and diesel-generator 1B (2B) for 4160-volt ESF bus 142 (242).

Offsite Power Sources (SATs)

There is a set of two normally connected system auxiliary transformers for each unit. Each one of the system auxiliary transformers normally supplies one division. The set of two system auxiliary transformers is sized to provide the required power of the unit under startup, full load, safe shutdown, and DBA load conditions.

In the event of a failure of one system auxiliary transformer, removable links can be relocated to connect the other system auxiliary transformer to supply both divisions. This provides flexibility in the auxiliary power system. Each set of system auxiliary transformers is capable of supplying the DBA loads of both divisions of one unit and the safe shutdown loads of both divisions of the other unit simultaneously. DBA and safe shutdown loads are shown in Table 8.3-5.

One system auxiliary transformer is not capable of supplying the DBA loads and all the nonsafety loads of one unit simultaneously. Prior to single SAT operation, bus loads are evaluated to verify that DBA loads and the nonsafety loads are within the capability of the system auxiliary transformer.

The 4160-V ESF buses 141 (241) and 142 (242) will not be fed from the same SAT (parallel operation) except when one of the unit's SATs is unavailable, and the removable links are manually relocated from the transformer secondary to the bus duct cross-tie.

There is no provision for feeding a 4160-volt ESF bus from an onsite unit auxiliary transformer.

The preferred configuration for Unit 1 (Unit 2) under normal operating conditions is:

a. The 4160-volt ESF bus 141 (241) fed from the 345-kV utility grid through SAT 142-1 (242-1) and circuit breaker 1412 (2412). Unit 2 cross-tie breaker 1414 (2414) and diesel-generator feed breaker 1413 (2413) are open.

b. The 4160-volt ESF bus 142 (242) fed from the 345-kV utility grid through SAT 142-2 (242-2) and circuit breaker 1422 (2422). Unit 1 cross-tie breaker 1424

(2424) and diesel-generator feed breaker 1423 (2423) are open.

For all normal or abnormal conditions, power is supplied to the 4160-volt ESF buses either through the unit's SAT, by automatic transfer to the diesel generator on loss of the SAT, or by manual transfer to the second offsite power source.

Interlocking and permissives for manual and automatic operation of feeder breakers on 4160-volt bus 141 are briefly summarized below.

a. Breaker 1411 (Bus 141 to non-ESF Bus 143 tie breaker) close circuit is interlocked by breakers 1414, 1431 and 1432. It can only be closed manually. Automatic trips will occur on a safety injection, bus undervoltage load shed condition, or a bus fault condition.

b. Breaker 1412 (SAT 142-1 feed breaker to Bus 141) can only be closed manually and is interlocked by breakers 1414, 2412, and 2414 such that at least one of the three must be open. It interlocks the close circuit of breakers 1413, 1414, 2412 and 2414. Automatic trips will occur on a bus undervoltage load shed condition, a SAT fault, a bus fault condition, or upon a loss of phase on the feed to the SAT.

c. Breaker 1413 (1A DG feed breaker to Bus 141) will automatically close after Bus 141 has experienced undervoltage, the diesel generator has reached rated speed and voltage and three bus breakers have been tripped open. Interlocks from the three open breakers 1411, 1412, and 1414 complete the auto close circuit. Manual closure requires that the bus already be energized and that synchronization switch interlocks are established. Automatic trips are addressed in Subsection 8.3.1.2.

d. Breaker 1414 (Reserve feed breaker from Bus 241 to Bus 141) can only be closed manually and is interlocked by breakers 1412, 2412, and 2414 such that at least one of the three must be open. It also requires breaker 1411 to be open. It interlocks the close circuit of breakers 1411, 1412, 1413, 2412 and 2414. Automatic trips will occur on a bus undervoltage load shed condition, a SAT feed breaker fault, or a bus fault condition.

Similar breakers serving 4160V ESF buses 142, 241 and 242 are similarly interlocked. These procedures are typical for 4160-volt ESF buses 141, 142, 241, and 242.

Provisions are made to feed the non-Class 1E buses from the respective Class 1E buses. The tie breakers between Class 1E and non-Class 1E buses are 1411, 1421, 2411, and 2421. The breakers are interlocked to prevent closing unless all of the following conditions are satisfied: (1) the UAT breaker of the non-Class 1E bus is open, (2) the SAT breaker on the non-Class 1E bus is open, and (3) the unit interconnection breaker of the Class 1E bus is open (i.e., breakers 1431, 1432, and 1414 must all be open in order to close breaker 1411).

Control power for each 4160-volt ESF bus is taken from the respective ESF division's 125-Vdc distribution bus.

Circuit Protection Features

Power supply circuits fed from 4160-volt ESF switchgear, 480-volt ESF switchgear, and ESF motor control centers are designed with fault protection devices to disconnect circuit faults from power sources, to disconnect the faulted component with minimum disturbance to the unfaulted portions of the system.

All power circuits fed by the 4160-volt switchgear are protected from phase-to-phase and phase-to-ground faults by relays within the switchgear. Table 8.3-6 lists the function and action of devices protecting each piece of safety-related equipment.

Equipment fed from 480-volt ESF switchgear is protected by instantaneous and time overcurrent devices.

Safety-related motor loads fed by 480-volt ESF motor control centers are provided short circuit protection by instantaneous circuit breakers and overload protection by thermal overload relays within the MCC combination starter. Thermal-magnetic circuit breakers in the motor control center feed and protect resistive loads (i.e., heaters, lighting, 120-Vac distribution panels).

Relay trip setpoint drift problems are prevented by a combination of design, procedures, and periodic testing.

The appropriate department develops the original relay settings for the plant. These are based on fault studies, equipment characteristics, (i.e., motor curves, pump curves) etc.

The relay settings are submitted to the appropriate department. The appropriate department does an independent fault study, verifies the applicable relay characteristics, and using appropriate equipment characteristics, establishes that the protective device settings:

a. properly protect for faults on the equipment in question, and

b. properly coordinate with bus, bus tie, or supply source relaying.

The appropriate department transmits protective relay setting orders to field personnel who actually place the settings on the relays. Protective relays are set by qualified field personnel per approved and controlled procedures.

The qualified field personnel perform a relay acceptance test according to the manufacturer's relay instruction manual, and then calibrate the relay in accordance with the relay setting order issued by the appropriate department.

After the settings have been made, but before placing the relay in service, the relay operating tap and time adjustments are verified to be correct. These actions are documented on the applicable electrical data form, which is initialed and dated by the qualified personnel making the final inspection.

Protective relay tests are performed on the time interval specified by the applicable Technical Specifications.

Specifications for ESF pump motors are discussed in Subsection 7.1.2.

8.3.1.1.2.2 Emergency Onsite Power Sources (Diesel Generators)

The onsite (emergency) a-c power system for each unit consists of two diesel generators, one for each ESF division. The diesel generators provide an independent emergency source of power in the event of a complete loss of offsite power. The diesel generator supplies all of the electrical loads which are required for reactor safe shutdown either with or without a loss-of-coolant accident (LOCA).

Each diesel generator unit consists of a diesel engine, an electrical generator and fuel oil, lubricating oil, combustion air, cooling water and diesel-generator room ventilation support systems which must all be functional when a diesel start signal is received. Short term unavailability of the diesel-generator room ventilation fans and dampers is bounded by the HELB analysis (See Subsection 9.4.5.2.1.3.e.). The diesel engine, a Cooper-Bessemer KSV-20-T diesel, is rated at 7680 hp at 600 rpm when using a turbocharger. The twenty cylinder engine has a 13.5 inch bore with a 16.5 inch stroke and is arranged in a "v" bank configuration with ten cylinders assigned to each bank. The engine is classified as a four cycle machine in that the crankshaft makes two complete revolutions for each power stroke of a piston. The crankshaft is mated directly to the generator rotor at the flywheel and drives the generator along with the following engine components: fuel oil pump, main lubricating oil pump, main cooling water pump, the mechanical and overspeed governors, and the camshafts which control impulse pumps and valve timing.

The electrical generator is an Electric Products Model 1160, horizontal engine type, AC synchronous generator and is classified as Safety Category I, Class 1E. One end of the generator is supported by its connection to the crankshaft of the flywheel; the other end being supported by a bearing mounted in a pedestal. The generator is rated for 5500-kw at a 0.8 power factor and produces 4160-volts at 60 Hertz for 3-phase distribution.

The support systems are integral to the diesel generator except for essential service water which is required for removing heat from the engine's jacket water cooling system and diesel-generator room ventilation which maintain proper room temperature and venting capability.

The diesel-generator support systems consisting of the diesel fuel oil system, the diesel engine cooling water system, the diesel starting air system, the diesel engine lubrication system, and the diesel engine combustion air and exhaust systems are discussed in Subsections 9.5.4 through 9.5.8, respectively. The essential service water system is described in Subsection 9.2.1. The diesel-generator room ventilation system is described in Subsection 9.4.5.2.

Diesel Generator Capacity

Each diesel generator has ample capacity to sequentially start and accelerate all needed engineered safety features and emergency shutdown loads in the event of the simultaneous occurrence of a total loss of offsite power, and a loss-of-coolant accident. Table 8.3-5 details the loading sequence of each diesel generator under the circumstances noted in the table.

The Unit 1 loads listed on Divisions 11 and 12 are the loads required in the event of a loss of offsite power coincident with a loss-of-coolant accident. The Unit 2 loads listed on Divisions 21 and 22 are the loads required in the event of a loss of offsite power and no loss-of-coolant accident. In addition, the loads designated by note (e) (A.5., B.2., and C.3.) on Table 8.3-5 are also required in the event of loss of offsite power with no loss-of-coolant accident but are powered from Unit 1, as shown, unless there is an outage on Unit 1 as explained in note e.

The horsepower and kW loads listed in Table 8.3-5 and shown on reference drawings listed in Drawings 6E-0-4001 and 20E-0-4001 are the nameplate ratings for each load. Diesel generator loading is evaluated and monitored by the Electrical Load Monitoring System for Alternating Current Loads (ELMS-AC) (Braidwood only) and ELMS-AC and/or Electrical Transient Analysis Program (ETAP) (Byron only). The horsepower values used in the ELMS-AC and/or ETAP models for determination of Diesel Generator loading are calculated based upon the maximum flow during the injection phase. The ELMS-AC and/or ETAP program applies the manufacturers' motor efficiencies and power factors in the conversion of brake horsepower input to generator output required to power safety-related loads. Actual test data were used, where available. Individual load requirements in the ELMS-AC and/or ETAP diesel generator models are updated as required to reflect changes in the plant.

Motor operated valve loads are considered to be of insufficient size and duration to have an impact upon the size and loading of the diesel generators. Therefore, the motor operated valve load will not be listed on Table 8.3-5 since it will not be included in the total coincidental BHP on each bus.

The "other loads" listed for Byron and for Braidwood in Table 8.3-5 are the loads on reference drawings shown in Drawings 6E-0-4001 and 20E-0-4001 which are not listed as individual loads in the table. These "other loads" (a) are not required during a LOCA, (b) are not required for hot shutdown, (c) are not automatically connected to the ESF buses, and (d) are applied manually by the operator within the capability of the diesel generators.

The diesel generator design specification conformance to the position of Regulatory Guide 1.9 is discussed in Appendix A.

The diesel generator is designed to attain rated voltage and frequency and be ready to accept load 10 seconds after the receipt of an automatic start signal. Automatic starting is described later in this section under Diesel Generator Operation.

Station Blackout - Diesel Generator Capacity

Byron and Braidwood Stations are able to withstand and recover from a station blackout of 4 hours in accordance with the requirements of Regulatory Guide 1.155. In the event of a station blackout, either one of the two emergency diesel generators for each unit serves as an alternate a-c power source for the opposite unit. The alternate a-c power source is available within 10 minutes of the onset of the station blackout event and has sufficient capacity and capability to operate equipment necessary to bring and maintain the station in a safe shutdown condition.

Each unit of the Byron and Braidwood Stations has two emergency diesel generators that provide power to emergency 4.16-kV buses (Divisions 11 and 12 for Unit 1, and Divisions 21 and 22 for Unit 2). There is a manual cross-tie capability between Division 11 of Unit 1 and Division 21 of Unit 2 and, similarly, between Division 12 of Unit 1 and Division 22 of Unit 2. Upon loss of offsite power and failure of both diesel generators to start on one unit, either one of the other unit's diesel generators is capable of providing power for safe shutdown of both units for a 4-hour duration. A worst case emergency diesel generator loading scenario was used in the station blackout analysis. Equipment necessary for safe shutdown during the station blackout coping duration is available and adequate no matter which emergency diesel generator is used as the alternate a-c source. Total emergency diesel generator loading for station blackout is within the 2000-hour rating of the emergency diesel generator. All equipment required for station blackout is capable of being powered from a single remaining diesel generator. The capability for providing power to the blacked-out unit is possible with manual operation of cross-tie switchgear breakers from the main control room.

Diesel Generator Control Panel

Most of the diesel engine generator control equipment, located in the diesel engine generator room, is mounted on the engine generator control cabinet, which is a NEMA Type 12 (dust tight) enclosure. The remaining control equipment (level switches, thermostats, pressure switches) is mounted on the engine generator unit in weatherproof, NEMA 4 (dust tight), and NEMA 7 "explosion proof" (Class I, Division 1, Group D) enclosures.

The control panel for the diesel generator is a free-standing floor mounted panel mounted on an independent skid approximately 11 feet 6 inches from the diesel generator skid. This control panel houses control for such things as the generator, pump motors, and unit starting solenoids, as well as relays, monitoring equipment, and alarms for the diesel generator.

The design of the floor slab in the diesel generator rooms is such that the slab mass has been proportioned to the equipment mass to minimize vibration and impact loading. This design philosophy is used instead of isolating floor slabs in order to minimize vibration.

Critical instruments which can trip the diesel generator when in emergency mode, include generator differential trip and engine overspeed. The generator differential trip device is located off the engine in the switchgear. The overspeed device is located on the engine. However, the overspeed alarm indication circuits are located in the free standing control panel previously described.

Noncritical instruments such as RTDs, thermocouples, sensors, ratio relays, and switches for alarms and monitoring equipment on the diesel generator control panel are directly mounted on the engine. This is to prevent process fluids (i.e., lube oil, jacket water, etc.) from entering and contaminating the control panel. Temperature switches (connected to associated RTDs) and pressure switches (connected to associated process piping) are mounted on gauge boards located on the engine frame and wired to the control panel. Process system pressures are provided by a pneumatic signal to indicators on the control panel. Sensors for monitoring such things as crankcase oil level and engine speed are required to be mounted on the engine and wired to the control panel.

Diesel Generator Alarms

Table 8.3-7 shows the protective and supervisory function for each diesel generator.

Each diesel engine generator set has a "Fail to Start or Engine Trouble" alarm on the main control board. Each local annunciator panel has two types of windows, one that indicates a trip condition and another that annunciates abnormal conditions. Both types of trip and alarm conditions cause "Fail to Start or Engine Trouble" to be annunciated in the control room.

Each engine control panel is equipped with a switch for starting and stopping the engine locally. A lockout switch is also provided to disconnect the remote control switch and the automatic starting signal when servicing the engine. The lockout switch has an additional set of contacts for actuating the remote "Differential, Lockout, or Overspeed" annunciator in the control room.

The following trip conditions are locally annunciated following receipt of a start (i.e., either manual or emergency signal) with a simultaneous "Fail to Start or Engine Trouble Alarm" annunciated in the control room:

a. Engine Lube Oil Pressure Low,

b. Turbocharger Lube Oil Pressure Low,

c. Bearing High Temperature,

d. Loss of Field,

e. Turbocharger Thrust Bearing Failure,

f. High Jacket Water Temperature,

g. Overspeed, (Active Trip in Emergency Mode)

h. Generator Ground Fault,

i. Generator Differential, (Active Trip in Emergency Mode)

j. High Crankcase Pressure,

k. Generator Overload,

l. Reverse Power,

m. Incomplete Sequence, and

n. Under Frequency.

The above condition or conditions can be reset and the engine restarted. However, if restarted in the manual mode, the engine will again trip if the same running conditions exist.

Following an automatic start, the engine generator set will trip only if the following occur:

a. Generator Differential, or

b. Overspeed.

The above trips separately actuate the "Differential, Lockout, or Overspeed" annunciator in the control room. Lockout refers to placing the local panel remote-local-maintenance outage selector switch in the maintenance outage position.

The following conditions are locally annunciated subsequent to either a manual or an automatic start, with simultaneous "Fail to Start or Engine Trouble" annunciation in the control room:

a. Engine Lube Oil Pressure Low,

b. Turbocharger Lube Oil Pressure Low,

c. Engine Lube Oil Temperature Off Normal,

d. Engine Crankcase Level Low,

e. Jacket Water Temperature Off Normal,

f. Jacket Water Pressure Low,

g. Fuel Oil Pressure Low,

h. Filters/Strainers High Differential Pressure,

i. Starting Air System Low Pressure or Malfunction,

j. Air Dryer High Temperature,

k. Standpipe Level Low,

l. Day Tank Level Low,

m. MCC not Proper for Automatic Operation,

n. Emergency Mode Control Manual,

o. Fuel Oil Transfer Pump Suction Strainer D/P High,

p. Service Water Inlet Valve Not Open,

q. Essential Service Water Flow Low, and

r. Magnetic Pickup Unit (MPU) #1 and/or MPU #2 Failure.

Each diesel fuel oil day tank has two level switches. The higher switch automatically starts one of two redundant fuel oil transfer pumps as determined by the transfer switch position. The lower switch annunciates low level on the local panel and simultaneously annunciates "Fail to Start or Engine Trouble" in the control room.

The following conditions alarm locally and/or in the control room to inform the operator of conditions that may render a diesel generator unable to respond to an automatic emergency start signal:

a. Diesel Generator A Output Breaker Not Available.

b. Diesel Generator B Output Breaker Not Available.

c. Diesel Generator A Engine/Generator DC Control Power Off.

d. Diesel Generator B Engine/Generator DC Control Power Off.

e. Diesel Generator A Control Switch Maintenance Lockout.

f. Diesel Generator B Control Switch Maintenance Lockout.

g. Diesel Generator A Service Water Flow Low.

h. Diesel Generator B Service Water Flow Low.

i. Diesel Oil Storage Tank A Level Low.

j. Diesel Oil Storage Tank B Level Low.

k. Diesel Oil Storage Tank C Level Low (Unit 1 only).

l. Diesel Oil Storage Tank D Level Low (Unit 1 only).

m. Diesel Oil Day Tank A Level Low.

n. Diesel Oil Day Tank B Level Low.

Diesel Generator Operation

Synchronizing is not required during emergency operation. Synchronization is normally performed, however, to restore offsite power in the manual emergency mode of operation. The diesel generators are designed for air-over-piston start, and each diesel is provided with duplicate starting air compressors and accumulators. Each diesel generator has a starting control system, initiated either manually or automatically, which is energized from the 125-Vdc distribution bus of each diesel generator's own ESF division. Manual control is afforded for starting by a control switch on the main control board or a control switch on the diesel generator's separate local control panel. A three-position REMOTE-LOCAL-MAINTENANCE OUTAGE selector switch, located on the local control panel, is used to select the mode of manual control; its position is monitored by indicating lights and a maintenance outage alarm in the main control room.

In the event of a loss of all offsite power to the Class 1E power system, each diesel-generator set is automatically started. Controls and circuitry for starting and loading each redundant diesel generator set are electrically and physically independent. Automatic starting and loading of the diesel generator is as follows:

a. A diesel generator is automatically started by any one of the following:

    1. automatic safety injection signal,

    2. manual safety injection actuation by push buttons, or

    3. undervoltage on the 4160-volt ESF bus served by the diesel generator.

b. Upon a loss of voltage on a 4160-volt ESF bus due to a loss of offsite power but with no reactor accident, undervoltage relays automatically start the diesel generator and trip all loads on the bus except the 4160/480 volt ESF transformers, which represent a small percentage of the total bus load. Sequential loading of the diesel generator is automatically performed with services required for the safe shutdown of the reactor.

c. In the event of a design-basis accident (LOCA), but with sustained offsite power, ESF actuation signals will simultaneously start the necessary safety-related equipment (including diesel generators). A confirmatory signal is used to trip tie breakers 1411 (2411) and 1421 (2421) to ensure that non-Class lE buses 143 (243) and 144 (244) are not connected to isolated ESF buses 141 (241) and 142 (242).

d. In the event of a design-basis accident (LOCA) coincident with a loss of offsite power, undervoltage relays on each 4160-volt ESF bus will open the SAT feed breaker, shed all loads on that bus except for the 4160-480 volt auxiliary transformers, and start the associated diesel generator. After the diesel generator has reached rated speed and voltage, the diesel generator feed breaker (e.g., ACB #1413 on bus 141) will automatically close. The engineered safety feature actuation system will sequentially load the diesel generator as outlined in Table 8.3-5. The operator can manually further load the diesel generator with other essential loads (also shown in Table 8.3-5) within the diesel generator's design capacity.

The automatic loading of the emergency bus is accomplished by the sequencing panels. There is one panel per diesel generator. The sequencing panels are electrically and physically separated per electrical division.

The sequence circuit uses relays and timers to accomplish the function of sequencing. Upon loss of offsite power, the emergency bus undervoltage relay (via auxiliary relays): a) trips all loads on the bus except the 4160-480V transformers, b) trips the feed breakers to the emergency bus, and c) interrupts power to the sequencing control circuit to ensure that the circuit resets, if in testing mode. Sequencing will begin provided: 1) the diesel-generator breaker has closed and power is restored to the sequencing circuit, and b) inter-unit (cross tie) feed breaker and SAT breaker are open. Sequencing is accomplished via timers whose contacts energize relays which in turn interlock the start circuits of the required loads. The time intervals for sequencing load are as indicated in Table 8.3-5.

The sequencing circuit will not have power for 10 seconds while the diesel is coming up to speed and an additional 2 second delay for switching and actuation of the sequencer logic. Therefore, there is a 12 second difference between the time settings in the sequencer circuit and those in Table 8.3-5.

During a safety injection signal with sustained offsite power, the required loads are started immediately. With sustained offsite power, the timers are bypassed and the relays are energized directly by the safety injection signal (K608) via an auxiliary relay. The timer bypass circuit is blocked on loss of offsite power by a) the affected unit SAT feed breaker (52/a contact), and b) the inter-unit (cross-tie) breakers 52/a contacts in series with the opposite unit SAT feed breaker (52/a contact).

The conditions required to connect the diesel generator to the emergency bus are as follows (Ref. Typical Schematics 6E-1-4030DG02 and 20E-1-4030DG02):

<u>Automatic</u>

a. Diesel generator breaker control switch in after trip.

b. SAT breaker open (52/b-1422) and not locked out (486-1422)

c. Inter-unit feed breaker open (52/b-1421)

d. Cross-tie breaker open (52/b-1424) and not locked out (486-1424X)

e. Diesel generator breaker not locked out (486-1423)

f. Diesel generator reaches rated voltage and speed (DG1BX)

g. Diesel generator reaches rated speed and voltage with the diesel breaker open (52/b-1423)(DG1BX1) and bus undervoltage (427-B142X4).

<u>Manual</u> (to parallel the diesel generator to an energized bus)

a. Control switch at main control board closed (CS/C)

b. Synchronizing switch closed (SS/ON)

c. Synchro-check relay contact (HACR-1) closed

d. Diesel generator reaches rated speed and voltage (DG1BX)

e. Feed from SAT breaker not locked out (486-1422)

f. Diesel generator breaker not locked out (486-1423)

g. Cross-tie breaker not locked out (486-1424X).

After the preferred power source has been restored, the operator may synchronize the power sources and close the SAT feed breaker.

There is neither a provision for automatically connecting one ESF load group to its redundant counterpart under emergency conditions, nor a provision for automatically transferring safety-related loads between redundant standby power sources.

Testing and Maintenance

Shop tests were performed on each diesel generator prior to shipment and were site tested. Results of these tests demonstrated each machine's ability to conform to acceptance criteria regarding voltage and frequency recovery characteristics, and failures per a given number of successful starts (also see Subsection 8.1.20).

The diesel-generator qualification testing program satisfies Position 5 of Regulatory Guides 1.6 and 1.9 and Branch Technical Positions ICSB2. Documentation is available upon request.

The design of the diesel generators complies with the design requirements of IEEE-387-1984 Section 5.5.2.2 and Regulatory Guide 1.9 Position C.1.5. The diesel generator system design includes emergency override of the test mode for both accident conditions (safety injection) and loss of offsite power (LOOP) to permit response to bona fide emergency signals and return control of the diesel generator to the automatic control system. Upon receipt of either a safety injection signal or a loss of off-site power signal, the governor is automatically shifted from droop to the isochronous mode and the voltage regulator is shifted to the automatic mode. The diesel generator breaker controls trip the breaker upon receipt of a safety injection signal concurrent with the diesel generator operating in the test mode. Also, the diesel generator breaker control scheme trips the diesel generator breaker on overcurrent, underfrequency, loss of field, generator neutral ground and reverse power, during LOOP conditions with no safety injection signal present. This logic prevents potential damage of the ECCS equipment to ensure that the ECCS equipment is available in the event of an actual safety injection with or without a LOOP.

Though no load operation is necessary at times (i.e., warm-up periods), surveillance procedures minimize diesel generator operation with less than 25% of rated load. The duration of no load operation is maintained below the manufacturer's recommended maximum. The time limitation for operating a diesel generator at rated speed and no load is 3000 hours per year. The diesel generators are run for 15 to 30 minutes at 75% load following each 6 hours of continuous no load operation.

As stated in Section 8.1.2 and tabulated in Table 8.3-5, the 2000-hour rating of each standby diesel generator is 5935 kW. These automatically connected loads are demonstrated to be within the 2000-hour rating every 18 months.

Surveillance testing is specified in the Technical Specifications and meets the recommendations of the diesel generator manufacturer and applicable NRC guides, with exceptions noted. See Appendix A for further discussion of Regulatory Guide 1.9. In accordance with Branch Technical Position ICSB 8 (PSB), the potential for common failure modes should preclude the interconnection of onsite and offsite power sources except for short periods for the purpose of load (surveillance) testing. Frequent interconnection of the preferred (offsite) and standby power supplies (onsite diesel generators) increases the probability of their common mode failure. Therefore, the use of emergency diesel generators for purposes other than that of supplying standby power when needed is prohibited and in particular, emergency diesel generators should not be used for peaking service.

Preventive maintenance on the diesel generators shall be performed in accordance with the manufacturer's recommendations unless a documented technical justification exists for not performing a vendor recommended preventive maintenance item. Components which repeatedly malfunction or require constant attention will be investigated as required. Maintenance is performed under the supervision of a Maintenance Supervisor.

Each station keeps "Work Request" files (electronic database files) for each diesel generator. Review of these files identifies components which repeatedly fail.

Training and Operation

Personnel training on the diesel generators is provided by the station training department. Diesel generator control and instrumentation training is also provided by the station training department.

Operation is performed by or under the cognizance of a licensed operator in the control room. Local operational requirements, functional verifications, and equipment monitoring is performed by an equipment operator as directed by the cognizant licensed operator in accordance with station procedures. Upon completion of repairs or maintenance and prior to starting and loading the diesel generator, applicable operating procedures are used to verify that the diesel generator is ready for operation. Further qualification specifications for the above personnel can be found in Subsection 13.1.3.

This page was deleted intentionally.

8.3.1.1.2.3 Instrument and Control Power System

The instrument and control power system provides reliable 120-volt a-c power to equipment and systems which must remain in operation during a momentary or complete loss of a-c power. These systems include the reactor trip system as well as certain other non-safety-related loads such as control room recorders. Also see Subsection 7.1.2.1.3.

A 120-Vdc inverter provides a reliable supply of power for each ESF division's 120-Vac instrumentation. Redundancy within the inverter equipment is established by a normal 480-volt, 3-phase, 60 Hz input feed from a Class 1E Power System motor control center, and a reserve 125-Vdc feed from the respective ESF division's 125-Vdc distribution bus. The inverter and associated power feeds for each ESF division are shown in single-line form on drawings 6E-1-4002E, 20E-1-4002E, 6E-1-4002F, and 20E-1-4002F. If an inverter is taken out of service, a 480-120 volt (constant voltage) transformer being fed from a 480-volt ESF motor control center will supply power to the bus. The instrument inverters and Constant Voltage Transformers (CVT) are inter-connected to allow either a manual or automatic transfer of Instrument Bus power between the inverter and CVT.

The following compensatory actions are taken when an instrument bus inverter is inoperable as described in Byron License Amendment 135 and Braidwood License Amendment 129 dated November 19, 2003:

1. Entry into the extended inverter Completion Time will not be planned concurrent with EDG maintenance on the associated train, and

2. Entry into the extended inverter Completion Time will not be planned concurrent with planned maintenance on another RPS/ESFAS channel that could result in that channel being in a tripped condition.

These actions are taken because it is recognized that with an inverter inoperable and the instrument bus being powered by the constant voltage transformer, instrument power for that train is dependent on power from the associated EDG following a loss of offsite power event as noted in the License Amendment Safety Evaluation.

Non-safety-related loads are fed from 120-volt distribution panels either locally mounted or located in 480-volt motor control centers.

8.3.1.2 Analysis

The designs of the onsite and offsite electric power systems are in compliance with General Design Criteria 17 and 18.

Each unit has the required onsite power systems with sufficient independence, redundancy, and testability to ensure performance of their safety functions assuming a single failure. Two physically and electrically independent power distribution systems per unit, i.e., ESF divisions, are each fed by a standby diesel generator upon a loss of offsite power. The diesel generators have been sized as described in Subsection 8.1.2 to meet the maximum expected horsepower requirements during a design-basis accident. Each ESF division is also served by a separate 125-Vdc battery source to provide power to safety-related d-c loads and control circuits.

Two physically independent offsite power sources serve each ESF distribution system as required by General Design Criterion 17. The first offsite source (unit SAT) serves as the normal feed to an ESF division, while the second offsite source (other unit's SAT) can be made available manually by operator action.

The arrangement of the station auxiliary power systems provides for complete electrical isolation and physical separation of each unit's redundant power supplies and distribution system required for safety-related loads. Each separate power source, diesel generator and offsite is physically and electrically independent up to the point of connection to the 4160-volt ESF buses, except when links are installed. Redundant loads important to plant safety are split between ESF divisions and shown in Drawings 6E-0-4001 and 20E-0-4001. These redundant loads are physically separated to maintain independence and to minimize the possibility of common mode failure. All Class 1E equipment is located in Seismic Category I structures. The ESF electrical systems are designed in accordance with IEEE Standards 279-1971 and 308-1974.

There are two redundant and independent 4-kV emergency buses and each has three levels of undervoltage protection: 1) loss of power, 2) degraded grid voltage and 3) low degraded grid voltage. The relays are connected to the existing potential transformers on the bus. The first level of undervoltage protection is provided by induction disk type undervoltage relays. The second and third levels of undervoltage protection are provided by instantaneous undervoltage relays with delayed drop-out.

The voltage and time setpoints are determined from an analysis of the voltage requirements of the safety-related loads and actual field measurements of bus voltages under various motor starting conditions. The approximate pickup voltage for the first level of protection is 70% of rated voltage. The setting for the second level of undervoltage protection is 92.5% of rated voltage at Byron and 95.8% at Braidwood. There is a 10-second time delay to avoid alarms on transients, and if the degraded voltage is not corrected, the bus automatically disconnects from the offsite power source 5 minutes after the alarm and connects to its onsite diesel generator. The setting for the third level of undervoltage protection is 76% of rated voltage at Byron and 78% of rated voltage at Braidwood. There is a 3 second time delay to avoid actuation on transients.

During a sustained degraded grid voltage condition, the subsequent occurrence of a SI (accident) signal (immediately) trips the offsite power supply to the 4-kV ESF buses.

Testing is conducted during refueling outages so spurious trips during testing will not affect plant operation.

The circuit is designed to prevent automatic load shedding of the emergency power buses once the onsite sources are supplying power to all sequenced loads on the buses. The load shed interlock feature uses the "b" contact of the respective diesel generator breaker. This interlock defeats the load shedding feature while the loads are being fed from the onsite power source. The load shed feature is reinstated when the diesel generator breaker is open and the loads are fed from the offsite source.

The licensee has completed a voltage study for both the Byron and Braidwood Station auxiliary power systems. The setpoint for the second level of undervoltage relay was calculated as 3847 volts at Byron and 3987 volts at Braidwood. The setpoint for the third level of undervoltage relay was calculated as 3160.15 volts at Byron and 3244.20 volts at Braidwood.

The voltage analysis performed to calculate the setpoint is based on the following conditions:

1. Grid voltage at minimum anticipated voltage
2. All 4160/480 volt transformers are set on tap 4 (4055/480V) at Byron and on tap 3 (4160/480V) at Braidwood
3. SAT (TR 142-1 and 142-2) is carrying shut down and LOCA loads
4. Bus loads are calculated using motor brake horsepower.

The above setpoint is based on the maximum positive and negative tolerances of the relay and a minimum voltage of 90% on the terminal of Class 1E motors.

The standby a-c power source (diesel generator) is completely independent of any auxiliary transformer sources of supply in the performance of its required function. It is capable of supplying power to the unit's electrical loads which are necessary for safe shutdown in the event of a design-basis accident (LOCA). Due to the redundancy of the unit's ESF division and diesel generators, the loss of any one of the diesel generators will not prevent the safe shutdown of the unit. The total standby a-c power system, including diesel generators and distribution equipment, satisfies single-failure criteria.

The diesel generators are isolated from one another by a 12-inch thick wall constructed of hollow concrete blocks. The wall is seismically designed and carries a 3-hour fire rating. All piping penetrations are fire stopped. All HVAC penetrations utilize two, 1-1/2 hour fire dampers in series in the concrete wall common to the turbine building. The space between the block wall and ceiling is packed with thermofiber insulation.

Some diesel oil system piping associated with one emergency diesel generator is routed through rooms associated with the redundant emergency diesel generator. Each diesel is affected to some extent. Affected piping may include one or more of the following lines: fill lines, drain lines, vent lines, overflow lines, and instrument lines. Calculations have determined that even if this DO piping is unprotected, a fire in this zone does not affect the operability of the redundant diesel generator; therefore, a fire in this zone will not affect the ability to safely shutdown the plant. However, fire wrap is added as a conservative measure on most DO lines associated with the ESF train credited for safe shutdown. Thus, operability of one of the redundant emergency diesel generators is assured for all postulated design basis events.

The wall isolating the diesel generators is not designed to contain flooding of a diesel generator room. Five, 4-inch diameter floor drains are provided in each room with the exception of the 2B diesel generator room which has four, 4-inch diameter floor drains.

The only high energy line in the diesel-generator room is the 32-inch OD exhaust pipe which is seismically qualified and provided with expansion joints to accommodate thermal growth at 950°F. The line has 8-inch thick ceramic fibrous blanket type insulation. The blankets are 1-inch thick and have staggered joints. Stainless steel jacketing is provided.

At Byron, the moderate energy lines are the 10-inch nominal OD essential service water lines which provide cooling water to the diesel engine and the starting air (250 psig) piping embedded in the concrete floor between the accumulators and the engine/generator skid and the diesel oil lines connected to the diesel engine. These moderate energy lines are also seismically qualified. The maximum size crack postulated would result in a maximum inflow of 284 gpm into the diesel generator rooms.

In addition to the lines listed above, the moderate energy lines at Braidwood also include 2-inch main steam lines. The limiting postulated crack at Braidwood would result in a maximum inflow of 0.083 ft^3/sec, or approximately 38 gpm in the diesel generator rooms.

Line breaks in the steam tunnel will not affect the diesel generators because the steam tunnel is designed to prevent steam or water releases from entering the auxiliary building. The analysis of a postulated break in the main steam tunnel is included in Section C3.6.

The flooding of the turbine building due to any internal or external causes will have no effect on diesel generator operation. The doors to the main oil storage rooms are watertight. The maximum flood level in the turbine building is below grade which ensures that the diesel generators will remain dry and operable.

If floodwater from external causes was to reach the doors to the diesel generator rooms before draining to the lower elevation of the turbine building, HELB requirements for the doors to be normally closed will ensure only minor water leakage into the room. In addition, the Emergency Diesel Generator rooms have thresholds installed that may provide additional flood protection.

Internally generated missiles postulated due to a crank case explosion or air receiver failure are discussed in Subsection 3.5.1.1.1. There are twelve explosion doors in the crankcase of each engine. In addition, twelve crankcase explosion relief valves relieve a primary explosion while protecting operating personnel plus preventing entry of fresh air into the crankcase that could cause a secondary explosion. Air receivers are assumed to fail by cracking open to relieve pressure rather than fragmenting.

The crankcase vent lines are exposed to tornado missiles external to the plant. A discussion of the impact of crankcase vent line blockage is included in Section 3.5.4.3. There is no increase in the potential for a crankcase explosion due to this blockage.

The diesel generators and their controls were not affected by dust. All major construction in Unit 2 (which would generate concrete dust) was complete before Unit 1 went into operation. The diesel engine generator local control panel was cleaned of dust prior to operation.

Thus, due to the outside location of the ventilation air intake, the control equipment enclosure, the short time interval between the Unit 1 and 2 schedule, and the general house cleaning, accumulation of dust on electrical device contacts was not anticipated.

Lack of essential service water flow at the time the diesel generator starts will not prevent accomplishment of its safety function. The diesel generator engines were specified and designed to operate for 5 minutes without a supply of cooling water. Only lack of closed cycle coolant, lube oil, fuel oil, or starting air, or a malfunction at operating speed will render the engine and generator incapable of responding to an automatic signal to start providing the selector switches are positioned to receive an automatic start signal.

The loss of either offsite power, onsite power, or power generated by the unit will in no way preclude the availability of the other power sources.

Class lE equipment is environmentally qualified to meet the intent of IEEE 323-1974 to the maximum extent possible (see Section 3.11).

In the event of the simultaneous occurrence of (on Byron - Unit 1 for example):

a. diesel-generator 1A undergoing full-load testing and being operated in parallel with the preferred power source (SAT 142-1) on a 4160-volt ESF bus 141,

b. loss of offsite power from the switchyard to both ESF divisions, and

c. a design-basis accident (LOCA),

no single failure will preclude the isolation of one ESF division's standby power source from its redundant counterpart. The safety injection signal (resulting from the LOCA) will automatically start diesel-generator 1B. The tripping of both switchyard breakers BT5-6 and BT6-7 results in the tripping of the SAT feed breaker on each 4160-volt ESF bus (i.e., breaker 1412 on bus 141, and breaker 1422 on bus 142). Undervoltage relays on 4160-volt ESF bus 142 open the bus's main feed, unit cross tie, and non-Class 1E bus tie breakers, and close the diesel-generator feed breaker after the diesel generator has reached rated speed and voltage. Through this procedure, each 4160-volt ESF bus is successfully isolated and fed by its respective diesel generator.

A transformer fault will not prevent the diesel generator breaker from closing. The D/G breaker cannot be closed if there is a fault on the bus. Lockout relay 486/1412 will operate due to a bus fault but not a transformer fault.

In the event of a stuck-closed feeder breaker, the diesel generator breaker is prevented from closing by interlocks. Auxiliary contacts of breakers 1412, 1414 and 1411 interlock the automatic closing circuit. The only way the D/G breaker can be closed under the stated condition is by synchronizing and manually closing the breaker.

The diesel generator will trip on generator differential.

The differential relay actuates the lock-out relay (device 486-1413) which trips the breaker. The lockout relay directly trips the breaker. Breaker trips on bus fault, overcurrent, reverse power, the diesel generator shutdown relay which are "ANDED" with a safety injection "NOT" signal. In this way, the differential trip is retained during normal and accident (safety injection) conditions and the other trips are bypassed by the safety injection signal.

The Byron/Braidwood design utilizes a load sequencer only when the onsite (diesel generator) power source is being used. The necessary loads are connected simultaneously (block load) when the offsite power source is in use.

All Class lE equipment and systems important to plant safety are designed to permit periodic testing during power operation in accordance with General Design Criterion 18. Preoperational and initial startup test programs for the standby power system and its supporting systems are described in Chapter 14.0. Each safety-related electrical control and power system including all safety-related equipment, is designed to facilitate periodic functional testing during plant operation. The testing of these systems and components are in accordance with IEEE Standards 279-1971 and 338-1975. Tests have been designed to demonstrate performance reliability of each diesel generator with respect to the expected parameters of operation and environment during a design-basis accident and/or a loss of offsite power. Prototype qualification made on one diesel generator consisting of 300 start and sequential loading tests with no more than three failures is performed to demonstrate type reliability. Loading for prototype testing is the kW equivalent of the ECCS loads. Testing of each of the remaining three diesel-generator sets purchased by Commonwealth Edison included at least two starting and loading tests. Plant preoperational testing is described in Chapter 14.0 and availability testing during normal plant operation of the diesel generators is in accordance with the recommendations of the diesel generator manufacturer and applicable NRC guides, with exceptions noted. See Appendix A for further discussion of Regulatory Guide 1.9. Each diesel generator is periodically tested as described in the Technical Specifications.

8.3.1.3 Physical Identification of Safety-Related Equipment

8.3.1.3.1 General

Color coded nameplates or labels are used to distinguish between Class lE and non-Class 1E components and between components of different divisions, as shown in Table 8.3-8. Cables are routed through independent cable tray systems according to the separation criteria stated in Subsection 8.3.1.4.3.

8.3.1.3.2 <u>Raceway Identification</u>

The cable tray system is distinctively identified throughout the plant in accordance with IEEE Standard 384-1974. Each tray is marked with a colored alpha-numeric segregation code consisting of characters which are 2 inches high (or maximum feasible size for conduits). The markings are placed in intervals not exceeding 15 feet and at entry and exit points of enclosed areas. Each tray's or conduit's segregation code and its color is determined by Table 8.3-8. Engineered safety features (ESF) and reactor trip system (RTS) trays and conduit were marked prior to the installation of cables in them.

8.3.1.3.3 <u>Equipment Identification</u>

Nameplates with engraved characters identify each item of safety-related equipment. Each nameplate is either color coded as in Table 8.3-8 or has black characters on white background.

8.3.1.3.4 <u>Cable Identification</u>

All power, control, and instrumentation cables are identified by a unique number of permanent color-coded tags at each terminating point in switchboards, switchgear, motor control centers, motor conduit boxes, control cabinets, equipment cubicles, etc., and in all intervening manholes, cable rooms, pull boxes, etc. The tags are color-coded as in Table 8.3-8, allowing positive identification of safety-related cables.

Additional verification can be obtained as described below.

The cables can be divided into three categories: (a) those purchased under separate cable specifications (representing approximately 95% of the cables), (b) those supplied by equipment vendors with the equipment (representing approximately 5% of the cables), and (c) those purchased under Nuclear Electrical Material Standard N-EM-0035 (representing cables procured and installed after the initial fuel load).

a. The cables purchased by the separate cable specifications are supplied with the following information marked on the jacket:

   Manufacturer, number of conductors, conductor size, voltage rating, specification number, purchase order number, cable type code, station reel number and sequential footage.

   These markings are imprinted on the jacket every 30 inches for power and control cable and every 24 inches for instrumentation cable.

After the electrical installation contractor installs a cable, the contractor records (in addition to other information) the cable reel number, the beginning footage marker and the end footage marker on the cable pull card. A cross reference index is available at each site which lists (in sequence) the cable type code, cable reel number, cable footage markings, cable number, and the cable segregation code. This index allows an inspector to verify the installation (including separation) of any cable by using the following procedure:

1) For the selected cable, note the cable type code, reel number, and sequential footage markings on the jacket.

2) Enter the cross reference index at the cable type code and cable reel number. Locate the corresponding sequential footage, opposite which are both the cable number and segregation code.

3) Compare the segregation code in the index with the segregation code marked on the cable tray in which the cable was found.

4) If the segregation code of the cable (in the cross-index) agrees with the mark on the tray, the cable separation is correct. If the segregation code of the cable (in the cross-index) does not agree with the mark on the tray, the cable segregation is not correct.

b. The cables supplied by equipment vendors are identified with tags as described above.

c. The cables purchased under Electrical Material Standard N-EM-0035 (representing cables procured and installed after the initial fuel load) are supplied with the following information marked on the jacket:

Manufacturer, number of conductors, size, voltage, number, and sequential footage or unique reel number traceable to test documentation.

Station procedures are in place that administratively control the required routings.

8.3.1.3.5 <u>Junction Box Identification</u>

Junction boxes are identified by nameplates or labels. Each nameplate or label is either color coded as in Table 8.3-8 or has black characters on white background.

8.3.1.4 Physical Independence of Redundant Systems

8.3.1.4.1 Criteria and Design Basis

The power, control, and instrumentation cables for redundant circuits associated with the engineered safety features (ESF) system and the reactor trip system are physically separated in accordance with IEEE Standards 279-1971 and 384-1974 to assure that no single design-basis event will prevent operation of redundant systems. Physical separation of cables is obtained by the division of the containment penetrations, cable tray system, and conduit system into two ESF divisions, two non-Class 1E divisions, and four reactor trip and control channels. Class 1E equipment with redundant safety functions are physically separated in accordance with IEEE 384-1974. Non-Class 1E components used in Class 1E systems that are fed by Class 1E power sources are designed so that their failure will not affect the availability of the Class 1E system.

8.3.1.4.1.1 Cable Tray, Cable Penetrations, and Conduit System Design Basis

Steel cable trays are provided throughout the station. Cable ampacities were determined in accordance with the standards of the Insulated Power Cable Engineers Association (IPCEA) as detailed in Subsection 8.3.1.4.1.2. The cable trays are of the solid-bottom, uncovered type and are generally 6 inches maximum in depth. Exceptions to the solid-bottom trays are the open-bottom, ladder-type tray construction that is used (1) to facilitate cable entry to equipment (e.g., switchgear, motor control centers, etc.), and (2) to allow the routing of cables from one tray to another directly above or below.

Trays with more than a 6-inch depth are installed in some instances (e.g., cable tray risers, tray intersections, at the interface between the tray systems and the reactor containment electrical penetrations, etc.). The trays of increased depth were provided to allow for an orderly arrangement of cables within the trays. In each case, the deviations from the basis cable tray system design were limited by the allowable cable tray loading (for both physical and thermal considerations).

Solid covers are provided for all instrumentation cable trays. Solid covers are provided for power cable trays wherever (1) the power cable trays passed below control cable and/or instrumentation cable trays, or (2) the power cable trays were involved in approved reduced separation from the stated design objectives in Subsection 8.3.1.4.2.2.

Cable Tray Loading

The quantity of cable in any cable tray (power, control, or instrumentation) does not exceed the maximum number determined by the simultaneous application of the following three restraints:

a. Conductor Temperature (Heat Generation)

   The quantity of cable in any cable tray (power, control, or instrumentation) may be limited by the allowable conductor temperatures. The conductor temperatures are held within the cable rating by assigning conductor ampacities which include the effect of appropriate derating factors (as described under "Cable Derating").

b. Tray Capacity

The quantity of cable in any tray (power, control, or instrumentation) is limited by the net usable cross-sectional area of that tray. All cables are below the level of the top of the side rail of the tray.

Cable insulation is protected by an overall jacket. Calculations were performed (after the cable was selected and after the trays were designed) to demonstrate that there will be no failure of cable insulation of the bottom layers of cable due to compacting (plastic flow) over the design life of the plant. These calculations verified that the loading was conservative, and for the worst possible case, the stress produced in the cable is less than the allowable stress which the cable supplier recommended.

c. Structural (Loading-Bearing) Capacity of Trays and Supports

The quantity of cable in any tray (power, control, or instrumentation) may be limited by the structural capacity of the trays and their supports. The total loading does not exceed the allowable stress for the materials used under either the static or the seismic loading conditions and detailed in Section 3.10.

Cable Penetrations

The electrical penetrations are arranged in four groups, Groups 2 and 4 on the upper floor and Groups 1 and 3 on the lower floor, with a concrete floor between the upper and lower groups on the auxiliary building side. The two groups on each floor are spaced approximately 40 feet apart.

Cable separation criteria are applied as follows:

a. Group 1: ESF Division 11 Cables

Non-Safety-Related Division 11 Cables

Reactor Trip Channel I Instrumentation

b. Group 2: ESF Division 12 Cables

Non-Safety-Related Division 12 Cables

Reactor Trip Channel II Instrumentation

c. Group 3: ESF Division 11 Cables

Non-Safety-Related Division 11 Cables

Reactor Trip Channel III Instrumentation

d. Group 4: ESF Division 12 Cables

Non-Safety-Related Division 12 Cables

Reactor Trip Channel IV Instrumentation

The electrical penetrations meet the requirements of IEEE 317-1972 and IEEE 384-1974.

Conduits

Conduit is rigid steel or flexible conduit and is sized in accordance with the National Electric Code.

8.3.1.4.1.2 Cable Definitions and Rating Design Basis

Cable Definitions

a. Power Cables

Power cables are defined as those cables which provide electrical energy for motive power or heating to all 6600-Vac, 4000-Vac, 460-Vac, 208-Vac, 250-Vdc, and 125-Vdc loads. Cables which provide power from electrical energy sources to power distribution panels, regardless of voltage, are included in this definition with the exception noted in Subsection 8.3.1.4.1.2 item b. Generally, #6 AWG cables and larger conductors are included in this category. Some 600-volt, #10 and #14 AWG conductor cables are also included in this category; e.g., power feeds to valve motor operators.

b. Control Cables

Control cables are defined as those 120-Vac and 125-Vdc circuits (for example) responsible for the automatic or manual initiation of auxiliary electrical functions and the electrical indication of the status or position of auxiliary components. When applying this criterion, cables which supply electrical energy from distribution panels to 120-Vac and 125-Vdc instrumentation, control, and alarm circuits are treated as control cables. Generally, all 600-volt (insulation class) cables feeding 120-Vac or 125-Vdc distribution circuits sized with #14 or #10 AWG conductors, are considered control cables.

c. Instrumentation Cables

Instrumentation (signal) cables are defined as those cables conducting low-level instrumentation and control signals. These signals are either analog or digital. Typically, those cables which carry signals from thermocouples, resistance temperature detectors, transducers, neutron monitors, etc. to E/P converters, indicators, recorders, and computer input circuits, carrying signals of less than 50 milliamperes are included in this category.

Generally, instrumentation cables are one of the following types:

1. #16 AWG, twisted, shielded conductor pairs;

2. #20 AWG, chromel-constantan conductor pairs; and

3. coaxial or triaxial.

Rating Design Bases

a. Cable Derating (Cable Ampacities)

The allowable current-carrying capacities (ampacities) for the various power cables and control cables (where applicable) are in accordance with ICEA P-46-426, 1962 "Power Cable Ampacities Volume I - Copper Conductors" and P-54-440, 1972 "Ampacities - Cables in Open-Top Cable Trays." The specific ampacity for each cable size was determined by applying the appropriate derating factors, thus obtaining the ampacity for cables in so1id metal trays without maintained spacing. For applications inside the containment, the ampacities were further adjusted (reduced) to account for the higher expected ambient temperature.

b. Cable Construction

Safety-related cable installed during construction and the first few years of operation for the balance-of-plant systems is of the following design and manufacturer. Power and control cables are manufactured by Okonite (Cat. No. Okolon) and is of EPR/HYP construction. Instrumentation cable is manufactured by Samuel

Moore (no Cat. No.) and is of EPDM/HYP construction. For both types of cable, the jacket material is Hypalon (chlorosulfonated polyethylene). Future safety-related cable purchases may be from different cable manufacturers and may be constructed from various jacket and insulation types.

All of the cable supplied by Okonite and Samuel Moore has been qualified by the respective manufacturer to the requirements of IEEE 383-1974, and IEEE 323-1974. Future safety-related cable purchased for the balance-of-plant systems are qualified to the above standards.

8.3.1.4.2 Physical Separation Criteria

8.3.1.4.2.1 Class 1E Equipment Separation

Class 1E components of an ESF division are physically separated from Class 1E components of the unit's other ESF division as well as from non-Class 1E components that could cause loss of redundancy as the result of a design-basis event effecting failure of these components. The separation of Class 1E components is in compliance with IEEE 384-1974. Redundant Class 1E power sources and electrical distribution equipment are located in physically separate Seismic Category I areas.

The main control board (MCB) is segregated into separate sections for control of the plant main power generation and auxiliary systems. Each section containing wiring and control equipment for a specific ESF division is physically separated by fireproof barriers or the required spatial distance from other sections of the MCB.

8.3.1.4.2.2 Raceway Separation Criteria

Cable Tray Segregation

a. ESF and non-safety-related divisional trays are separated into four divisions per unit:

   1. ESF division 11 (21) (for segregation code 1E and 1A cables),

   2. ESF division 12 (22) (for segregation code 2E and 2A cables),

   3. Non-safety-related division 11 (21) (for segregation code 1B cables), and

   4. Non-safety-related division 12 (22) (for segregation code 2B cables).

b. Trays for reactor trip systems (RTS) are separated into four channels, each separate from the other channels, and separated from all other trays, as follows:

1. RTS channel I (for segregation code cables 1R and 1N),

2. RTS channel II (for segregation code cables 2R and 2N),

3. RTS channel III (for segregation code cables 3R and 3N), and

4. RTS channel IV (for segregation code cables 4R and 4N).

   Note: NIS signal (Triaxial) cables are run in rigid iron conduit.

c. Cable ladder (rack) trays are installed above 480-volt MCCs and 480-volt switchgear, rod position indication data cabinet, and reactor head area, where top entry is required. Power and control cable segregation is maintained, where practical, to the point of entering this equipment.

Cable Tray Separation

a. Minimum spacings for engineered safety features (ESF) divisions and reactor trip system (RTS) channels are:

1. Between redundant ESF divisions or redundant RTS channels: vertical - (5 feet 0 inch) metal to metal, horizontal - (3 feet 0 inch) metal to metal. This separation requirement holds for general plant areas.

2. Between redundant ESF divisions or redundant RTS channels: vertical - (3 feet 0 inch) metal to metal, horizontal - (1 foot 0 inch) metal to metal. This separation requirement holds for the cable spreading areas and for those other areas where high energy electrical equipment (switchgear, transformers, rotating equipment, etc.) is excluded and power cables are installed in enclosed raceways that qualify as barriers or there are no power cables.

3. Between power trays within the same ESF division (or between control trays in the same ESF division or between instrument trays in the same ESF division or between trays in the same RTS channel): vertical - (1 foot 0 inch) metal to metal, horizontal - (3 inches) metal to metal. The above separation distances also apply between power and control trays of the same ESF division. This separation is not a requirement but is included as good design practice for ease of installation.

4. Horizontal and vertical spacing between power and instrument trays within the same division are a minimum of (1 foot 8 inches) metal to metal.

5. Horizontal and vertical spacing between control and instrument trays within the same division are a minimum of (1 foot 0 inch) metal to metal.

6. In the case of a power or control cable tray passing (crosswise) over or under an instrument cable tray within the same division, the minimum vertical spacing is 6 inches. Where termination or space limitations preclude maintaining the 6 inch separation, the power or control cables are run in enclosed raceways that qualify as barriers. The minimum distance between these enclosed raceways is 1 inch.

b. Basis for separation between non-safety-related cable trays and between non-safety-related and safety-related cable trays:

1. 3 inches horizontal, metal to metal; and 12 inches vertical, metal to metal;

2. horizontal and vertical spacing between power and instrument trays are a minimum of (1 foot 8 inches) metal to metal;

3. horizontal and vertical spacing between control and instrument trays are a minimum of (1 foot 0 inch) metal to metal;

4. in the case of a power or control cable tray passing (crosswise) over or under an instrument cable tray, the minimum vertical spacing is 6 inches; and

5. cable trays are of steel construction with solid steel bottoms and sides providing a barrier between cables in trays.

c. Where termination arrangements or space limitations preclude maintaining the above space separations, the redundant cables are run in enclosed raceways that qualify as barriers, or other barriers shall be provided between redundant cables. The minimum distance between these redundant enclosed raceways and between barriers and raceways is 1 inch.

d. Basis for separation between cables in free-air and cables in cable trays:

1. Safety-related cables in free-air may come in contact with a cable tray containing non-safety-related cables.

2. Non-safety-related cables in free-air may come in contact with a cable tray containing safety-related cables.

Conduit Segregation

All conduit qualifies as a barrier. The same rules have been applied to conduit segregation as were applied to cable tray segregation.

Conduit Separation

a. All power, control, and instrumentation cables are run in separate conduit.

b. The minimum allowable separation between conduit in redundant ESF divisions is 12 inches. However, where practical, the separation between conduits in redundant ESF divisions is the same as for cable trays. Where termination or space limitations preclude maintaining the minimum space separations for conduit or between conduit and tray, the redundant ESF division, redundant RPS channel, and non-safety related cables are run in enclosed raceways that qualify as barriers, or other barriers are provided between these cables. The minimum distance between the redundant ESF or RPS conduits or between safety or non-safety related conduits and between trays, conduits and barriers is 1 inch.

c. For instrument conduit within the same ESF division, or related RTS channel, the following separation distances apply:

   1. Minimum vertical and horizontal separation between instrument conduit and control cable conduit is 1 inch.

   2. Minimum vertical and horizontal separation between instrument conduit and power cable conduit is:

      (a) Shielded instrument cables in conduit running parallel to power cables in conduit where the parallel run is less than 100 feet have 1-inch minimum separation. If the conduits run parallel for a distance greater than 100 feet, 1-inch separation is used in some cases for a distance not exceeding 100 feet, the remaining separation is 3 inches minimum. Where practical, the 3-inch minimum separation has been maintained.

(b) Unshielded instrument cables in conduit are run a minimum of 3 inches from control cables in conduit and 20 inches from power cables in conduit.

d. The minimum vertical and horizontal separation between conduit in redundant RTS and NIS channels in general plant areas is 24 inches.

Nuclear instrumentation signal (triaxial) cables are run in steel conduit.

e. Nuclear instrumentation system (NIS) triaxial cable conduit is separated from electrical noise sources by the following distances:

   1. control or low voltage power cable in conduit - 24 inches.

   2. medium voltage power cables in conduit - 6 feet (72 inches); and

   3. control, low, and medium voltage cables in trays - 6 feet (72 inches).

f. Where instrument cable (other than NIS triaxial) conduit and cable trays within the same division are installed adjacent to each other, the following separations apply:

   1. instrument conduit to power cable tray - 20 inches,

   2. instrument conduit to control cable tray - 3 inches,

   3. control cable conduit to instrument cable tray - 12 inches, and

   4. power cable conduit to instrument cable tray – 20 inches.

   5. For instrument cable tray or conduit passing crosswise over or under a power or control tray or conduit, the minimum spacing is 1”. Where practical, the 3” separation is maintained.

g. For cables in free-air to cables in conduit, the following separation distances apply:

   1. Safety-related cables in free-air may come in contact with a conduit containing non-safety-related cables.

   2. Non-safety-related cables in free-air may come in contact with a conduit containing safety-related cables.

8.3.1.4.3 Cable Separation Criteria

Cable Segregation

A segregation code assigned to each cable is used to check all cables routed in cable trays or conduit for compliance with the required segregation. This cable segregation code appears in the installation cable tabulation and on applicable physical installation drawings. The segregation code consists of one or more characters as indicated in the following summary:

Unit Number	Type	Division	Category
1	P	1	E
2	C	2	B
	K	3	R
		4	N
		A	A

Type: P = Power
C = Control
K = Instrumentation

Division: ESF or Non-Safety-Related Divisions 1 or 2

RTS Input Channels 1, 2, 3, or 4

RTS Output Channels A or B

Nuclear Instrument Channels 1, 2, 3, or 4

Category: E = Engineered Safety Feature

B = Non-Safety-Related

R = Reactor Trip

N = Neutron Monitoring

A = Associated Cables that share a power supply, enclosure, or raceway with Class 1E cables (Cable Category only).

Cable separation is accomplished using this segregation coding of each cable. Each cable associated with safety-related equipment is classified as Class 1E and so segregated. These cables are assigned to ESF Division 11 (21) or 12 (22). Each non-Class 1E cable which has any part of its length in a Division 11 (21) or 12 (22) tray, connects to a Class 1E power system, shares an enclosure with a Class 1E circuit, or is not physically separated from Class 1E cables by acceptable distance or barriers, is a division-associated cable (Category A).

Cable Routing

Cables associated with the ESF equipment are routed only in cable trays associated with their respective divisions. A cable associated with ESF equipment of one division has no portion of its run in any cable tray assigned to another ESF division. The following cable and tray segregation code rules have been adhered to in the routing of all cables:

a. Unit number for a cable and the tray that it is run in shall agree. All exceptions (e.g., cables for services which are common to two units) shall be documented and approved.

b. Type and division codes of a cable must agree with the corresponding codes for the tray.

c. Cable category code must agree with the tray category code insofar as the following summary specifies:

Cable Category	Tray Category E	B	R	N
E	X			
B		X		
R			X	X
N			X	X
*A	X			

*All "A" cables in Safety Category II structures shall be installed in conduit.

In the case of Class 1E cables associated with redundant ESF equipment entering a common control switchboard, such as the unit's main control board, the installation of barriers and the physical separation of the board's internal wiring are in compliance with those procedures set forth in IEEE 420-1973.

8.3.1.4.4 Class 1E Equipment in Remote Structures

The only Class 1E cabling leaving one Seismic Category I building and entering another Seismic Category I building is that which passes between the auxiliary building and either the essential service water cooling towers or the river screen house. These cables are housed in a buried reinforced concrete duct run. The design criteria for such structures have been supplied in Subsection 3.7.3.12.

River Screen House

Each of the redundant diesel-driven essential service water makeup pumps are electrically started by their integrated battery starting system. Remote automatic starting signals from the essential service water cooling tower basin and remote manual starting circuits from the control room are run in cables which are routed in separate ducts and steel conduit. The ducts are installed in Seismic Category I duct banks, manholes, and concrete pipe encasements to the Category I river screen house. Duct and steel conduit form a transition at the river screen house where the Class 1E cables are routed to their actuation function by Seismic Category I installed conduit.

The installed cables meet the requirements of IEEE-383 and are sized to perform their control function.

Essential Service Water Cooling Tower

Each of the two essential service water cooling towers are furnished with four cells per tower with one fan motor per cell. Two fan motors on each tower are fed power from Division 1 from Unit 1 and the other two fans on the same tower are fed power from Unit 2. Each tower contains 100% essential service water cooling fan redundancy.

Four unit substations (two per cooling tower) are located at the cooling tower. Power and control cables from the station to the cooling tower are installed in separate ducts in which Division 1 from Unit 1 and Division 1 from Unit 2 ducts are run in Seismic Category I duct banks with a similar arrangement for Division 2.

Where the ducts terminate at a manhole, four separate Category I manhole compartments are furnished to comply with cable separation requirements. The cables are seismically supported on saddle arrangements. The duct runs are stopped and the manholes are provided with sumps for water removal.

Cables entering the Category I cooling tower electrical equipment rooms are routed in steel conduit and cable trays that are mounted on Seismic Category I supports. Cable feeding the fan motors, in the proximity of the fans, are installed in steel conduit which is embedded in concrete.

The installed cables meet the requirements of IEEE-383 and are sized to perform their control function.

Cables are designed to operate in wet and dry conditions.

8.3.1.4.4 Class 1E Equipment in Remote Structures

There is no Class 1E equipment in remote structures at the Braidwood Station.

8.3.2 D-C Power System

8.3.2.1 Description

The d-c power system provides d-c control and motive power for vital equipment during all normal as well as emergency conditions of the plant. The system is designed to meet the requirements of General Design Criteria (GDC) 17 and 18. Drawings 6E-0-4001 and 20E-0-4001 show the single line diagrams of Units 1 and 2 125-Vdc systems.

The d-c power system consists of the following subsystems:

a. Two non-Class 1E 250-Vdc systems (each with its own battery, battery charger, and associated equipment) which supply power to the generator air side seal oil pumps, turbine d-c emergency bearing oil pumps, steam generator feed pump turbine emergency bearing oil pumps, and plant computer for Unit 1 and Unit 2 respectively.

b. One non-Class 1E 48-Vdc system at the river screen house (with its own battery, battery charger, and associated equipment) which supplies d-c control power to the river screen house switchgear.

c. Two non-Class 1E 125-Vdc systems at the switchyard relay house which supplies d-c control power to the 345-kV switchyard circuit breakers.

d. One non-Class lE 125-Vdc system which supplies power to the technical support center computer and peripheral loads and the security computer.

e. Four Class 1E 125-Vdc power systems which are described in the following sections.

f. Two Class 1E 24-Vdc systems which provide control power and diesel engine starting capacity for the diesel engine-driven auxiliary feedwater pumps, which are described in the following sections.

g. Two Class 1E 24-Vdc systems which provide control power and diesel engine starting capacity for the diesel engine-driven Essential Service Water makeup pumps, which are described in the following sections (Byron only).

8.3.2.1.1 Class 1E 125-Vdc Power Systems

Each unit is provided with two sources of Class 1E 125-Vdc power. They are electrically isolated and physically separated so that any failure involving one source cannot jeopardize the function of the other source.

The 125-Vdc batteries, racks, chargers, distribution panels, and battery room ventilation equipment are classified as Safety Category I and meet Byron/Braidwood seismic requirements.

This page has been intentionally deleted

The Class 1E 125-V battery systems supply power to Class 1E loads without interruption during normal operations or DBA conditions. Each Class 1E 125-Vdc system consists of one battery, one main distribution bus with molded-case circuit breakers, one static battery charger, and local distribution panels. Redundancy and independence of components precludes the loss of both systems as a result of a single failure. For Unit 1, Battery 111 supplies ESF Division 11 load requirements; Battery 112 supplies ESF Division 12 load requirements. There are no bus ties or sharing of power supplies between redundant trains.

Each Class 1E 125-V battery, battery charger, and distribution panel associated with one ESF division is located in a Seismic Category I room, physically separated from the redundant equipment. Electrical separation is also maintained to ensure that a single failure in one train does not cause failure in the redundant train. There is no sharing between redundant Class 1E trains of equipment, such as batteries, battery chargers, or distribution panels.

Each Class 1E 125-Vdc system has the capacity to continuously supply all the connected normal running load while maintaining its respective battery in a fully charged condition. Each C&D battery has a guaranteed nominal rating of 2320 ampere-hours at the 8-hour rate to an end voltage of 1.75 volts per cell. Each battery was sized based upon supplying the design duty cycle (1-hour overall duration) in the event of a loss of offsite a-c power concurrent with a LOCA and a single failure of a diesel generator. The actual load magnitudes and durations for the d-c system loads are monitored by the electrical load monitoring system for direct current loads (ELMS-DC). The ELMS-DC is a controlled program/database that tabulates the loading of the 125-Vdc safety-related buses and the capability of the batteries to supply that load. The batteries are sized in accordance with IEEE 485-1983.

The primary sources of the Class 1E d-c power system are the battery chargers. These battery chargers are sized to meet the requirements of IEEE 946-1992 and are rated to supply their associated d-c loads while fully recharging the battery. Each battery charger is fed from a 480-Vac ESF switchgear bus of the same division. This meets the recommendations of position C.1.b of Regulatory Guide 1.32.

One 400-ampere capacity static battery charger supplied by a Class 1E 480-Vac switchgear bus is provided for each Class 1E 125-V battery system. Protection is incorporated in the battery chargers to preclude the a-c supply source from becoming a load on the battery as a result of power feedback upon loss of a-c input power. Backup protection is incorporated by an overvoltage relay mounted on the charger, which trips the charger supply and annunciates the tripped condition in the control room.

Each battery charger is capable of floating the battery on the bus or recharging a completely discharged battery while supplying the largest combined demands of the various steady-state loads under all plant operating conditions.

The battery chargers do not have the capability of supplying the loads if the battery is disconnected.

Drawings 6E-0-4001 and 20E-0-4001 show that the battery chargers are automatically disconnected when the batteries are disconnected.

The batteries are located in separate rooms. The rooms are described in the Byron/Braidwood Fire Protection Report, Subsection 2.3.5 (Reference 1). All battery areas are ventilated to prevent the accumulation of gases produced during charging operations. Each Class 1E 125-V battery area is provided with an independent safety-related ventilation system. A separate safety-related exhaust fan and duct is provided for each Class 1E battery area. The ventilation system serving the rooms housing the batteries and the battery chargers and distribution panels are described in Subsection 9.4.5.3.

Each 125-Vdc system has its own independent instrumentation:

a. d-c voltmeter at the MCB to measure the voltage at the 125-Vdc distribution center bus;

b. d-c voltmeter with a selector switch to measure the d-c output voltage of the battery charger and the bus voltage;

c. d-c ammeter to measure the d-c output current of the battery charger;

d. d-c ammeter to measure the d-c current of the battery;

e. power failure alarm relay which indicates a loss of a-c power to the battery charger (alarms at the main control room);

f. charger d-c output failure alarm relay (alarms at the main control room);

g. charger low d-c voltage alarm relay (alarms at the main control room);

h. charger high d-c voltage shutdown relay;

i. recording ground-detector voltmeter and alarm (alarms at the main control room);

j. breaker trip alarms on the battery and battery charger breakers and an alarm indicating that the bus tie breaker is closed (alarms at the main control room); and

k. 125-Vdc bus undervoltage alarm relay (alarms at the main control room).

This page has been intentionally deleted

The following protection is provided against overcharging:

a. A high-voltage shutdown relay opens the main a-c supply breaker to the charger on high d-c output voltage. The high voltage shutdown relay can be set as high as 15% over the battery float voltage.

b. A d-c voltmeter provides a visual check on battery voltage. No overvoltage alarms are provided.

The tie between 125-Vdc ESF buses 111 and 211 and the tie between buses 112 and 212 are each provided with two normally locked open, manually operated circuit breakers. The ties are provided so that the nonredundant d-c buses of Unit 1 and Unit 2 can be interconnected during maintenance and testing operations on the battery and/or battery charger associated with either bus 111 (211) or bus 112 (212). No interlocks are provided since the interconnected buses are not redundant. However, procedural and administrative controls are used to limit the connective load to an allowable amount (200 amps) based on not exceeding the battery capacity. Tie breaker closed alarms are provided.

The d-c power supplies are separate and independent for Unit 1 and Unit 2. Each supply is of sufficient capacity to meet the design duty cycle. While it is possible to interconnect the Unit 1 and Unit 2 power supplies, they will remain disconnected, except for the following circumstances: (1) when a d-c power supply must be taken out of service for the purposes of maintenance and/or testing, or (2) in the event of a failure of a d-c supply source.

The interconnection between each unit's Class 1E 125-Vdc systems, via the cross-tie, is limited by procedural and administrative controls. These controls ensure that combinations of maintenance and test operations will not preclude the system capabilities to supply power to the ESF d-c loads. The criteria specifying the allowable combinations of maintenance and test operations are governed by the plant Technical Specifications. Coordination between unit operations required during maintenance and testing are governed by administrative controls. The provisions of administratively controlled, manually actuated, interconnections between the nonredundant Class 1E d-c buses affects (i.e., increase) the overall reliability and availability of the d-c systems for each unit in that it provides a means for manually providing power to a d-c bus at a time when it would otherwise have to be out-of-service (e.g., to perform a battery discharge test during a refueling outage, to replace a damaged cell, etc.).

During normal operation, the batteries are kept fully charged by the battery chargers. Periodically, the voltage is raised for equalization of the charge on the individual battery cell.

This page has been intentionally deleted

Readings of the battery voltage level during the equalization charge are recorded. The instrumentation (and the related alarms) provides reliable supervision of the condition of the overall d-c system, but does not (by itself) provide adequate information on the condition of the battery (a component). The condition of the battery was tested initially as noted in Chapter 14.0 and periodically monitored and tested as noted in Technical Specifications. The time schedule for performing inspections, measurements, and tests is established in accordance with the requirements of IEEE Standards 450-1995 and 308-1978. The minimum load profile for performing Service Tests is established by the most current revision of the ELMS-DC (i.e., the design duty cycle).

The batteries will be discharge tested periodically in accordance with the requirements of Technical Specifications.

The d-c power system is designed and applied so that when operated within its rating under specified environmental conditions and when maintained in accordance with an approved schedule (including replacements of components when necessary), it will perform its functions for the 40-year life of the plant.

8.3.2.1.2 Class 1E 24-Vdc AFW Pump Diesel Batteries

The d-c power system for the diesel-driven auxiliary feedwater pump consists of two complete sets of 24-Vdc batteries, battery chargers, battery racks, cables, and necessary accessories. The complete system is located in the room with the diesel-driven auxiliary feedwater pump.

The battery chargers are powered from two separate ESF motor control centers of the same division as the diesel-driven pump.

Each battery has sufficient capacity to run the diesel through four cranking cycles of 5 seconds each before the cranking timer times out and an overcrank and fail-to-start alarm is initiated. The minimum sufficient battery capacities and minimum battery/charger configurations for starting and running the diesel driven AFW pump are specified in an approved safety-related calculation.

The battery chargers are of the full-wave rectifier voltage regulated type with voltmeter, ammeter, and thermal cutout designed for continuous floating duty on the storage batteries. Chargers are for 120-V, 60-Hz, single-phase a-c power supply, and have an isolation transformer to ensure that the batteries are completely isolated from the a-c power system. Operation of the battery chargers is automatic and includes regulation to maintain the output voltage substantially constant within the rated current range and independent of a-c supply voltage.

There is no separate ventilating system for the d-c power system. The diesel-driven auxiliary feedwater pump room ventilation consists of a diesel-driven fan when the diesel is running and a separate motor-driven fan when the diesel is not running.

Batteries and chargers are tested during the normal plant maintenance program.

8.3.2.1.3 Non-Safety-Related 125-Vdc Loads

To provide maximum isolation and separation between ESF and non-safety-related loads, a separate distribution bus is provided for the non-safety-related loads. The isolation of the non-safety-related loads from the safety-related (Class 1E) bus, as the result of a fault on non-safety-related circuits, is performed by 1E fuses (2 in series), qualified to Class 1E requirements, operated by overcurrent. In the event of a failure of a non-safety-related load, its distribution breaker will trip. The Class 1E fuses feeding the non-safety-related distribution bus provide redundant means of tripping the loads.

8.3.2.1.4 Class 1E 24-Vdc SX Makeup Pump Batteries (Byron Only)

The D-C power system for the diesel-driven Essential Service Water makeup pump consists of four sets of 24-Vdc batteries, four battery charges, battery racks, cables, and necessary accessories.

The complete system is located in River Screen House with the diesel-driven Essential Service Water makeup pumps. The battery chargers are powered from two separate non-ESF motor control centers located in the River Screen House.

Each battery has sufficient capacity to run the diesel through four cranking cycles of 5 seconds each before the cranking timer times out and an overcrank and fail to start alarm is initiated. The minimum sufficient battery capacities and minimum battery/charger configurations for starting and running the diesel driven Essential Service Water makeup pumps are specified in an approved safety-related calculation.

The battery chargers are of the full wave rectifier voltage regulated type with voltmeter, ammeter, and thermal cutout designed for continuous floating duty on the storage batteries. Chargers are for 120-V, 60 Hz, single-phase a-c power supply, and have an isolation transformer to ensure that the batteries are completely isolated from the A-C power system. Operation of the battery chargers is automatic and includes regulation to maintain the output voltage substantially constant within the rated current range and independent of A-C supply voltage.

Batteries and chargers are tested during the normal plant maintenance program.

8.3.2.2 Analysis

Each division of the Class 1E a-c power system is provided with control and d-c motive power from a corresponding division of the Class 1E d-c power system. The 480-Vac feed to each battery charger is supplied from a 480-V ESF bus in the same division as the charger. In this way, separation between the independent divisions is maintained, and the power provided to the charger can be from either offsite or onsite sources.

The four batteries and associated distribution panels supply 125-Vdc control power to the ESF switchgear and diesel generators as shown in Table 8.3-10. A second (reserve) d-c feeder (but from the same d-c source) is provided to each ESF control bus so that, in the event of a d-c feed cable failure, the control power can be manually transferred to the reserve feeder.

The Class 1E d-c systems are testable, independent, and conform to the requirements of Regulatory Guides 1.6 and 1.32. These systems meet the requirements of General Design Criteria 5, 17, and 18.

8.3.3 Fire Protection for Cable Systems

The construction of Class 1E cables of the types furnished for Byron and Braidwood have passed the flame tests of IEEE 383-1974.

Additional information pertaining to fire protection for cable systems is addressed in the B/B Fire Protection Report, Appendix A5.2 (Reference 1).

8.3.4 References

1. Commonwealth Edison Company,"Byron/Braidwood Stations Fire Protection Report in Response to Appendix A of BTP APCS 9.5-1" (current amendment).

TABLE 8.3-1

BYRON UNIT 1 D-C CONTROL POWER SOURCE

6.9-kV BUS NUMBER	MAIN	RESERVE
156	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Rear)
157	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Rear)
158	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Rear)
159	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Rear)

4160-V BUS NUMBER	MAIN	RESERVE
141	125-Vdc Dist. Panel 111 (Front)	Panel 111 (Rear)
142	125-Vdc Dist. Panel 112 (Front)	Panel 112 (Rear)
143	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Rear)
144	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Rear)
045-1	48-Vdc Dist. Panel 013	48-Vdc Dist. Panel 013
045-2	48-Vdc Dist. Panel 013	48-Vdc Dist. Panel 013

Common CC Pump Swgr 0CC01E 125-Vdc from Bus 141 or 142 "0" CC Pp Swgr.

480-V BUS NUMBER	MAIN	RESERVE
131Z	125-Vdc Dist. Panel 111 (Front)	Panel 111 (Rear)
131X	125-Vdc Dist. Panel 111 (Front)	Panel 111 (Rear)
132Z	125-Vdc Dist. Panel 112 (Front)	Panel 112 (Rear)
132X	125-Vdc Dist. Panel 112 (Front)	Panel 112 (Rear)
133X	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Front)
133Y	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Front)
133Z	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Front)
133V	125-Vdc Dist. Panel 113 (Rear)	Panel 113 (Rear)

480-V BUS NUMBER	MAIN	RESERVE
033W	125-Vdc Dist. Panel 113 (Rear)	Panel 213 (Rear)
134X	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Front)
134Y	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Front)
134Z	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Front)
134V	125-Vdc Dist. Panel 114 (Rear)	Panel 114 (Rear)
034W	125-Vdc Dist. Panel 114 (Rear)	Panel 214 (Rear)
034R	125-Vdc Dist. Panel 114 (Front)	Panel 214 (Front)
034P	125-Vdc Dist. Panel 114 (Front)	Panel 214 (Front)

TABLE 8.3-2

BYRON UNIT 2 D-C CONTROL POWER SOURCE

6.9-kV BUS NUMBER	MAIN	RESERVE
256	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Rear)
257	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Rear)
258	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Rear)
259	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Rear)
4160-V BUS NUMBER		
241	125-Vdc Dist. Panel 211 (Front)	Panel 211 (Rear)
242	125-Vdc Dist. Panel 212 (Front)	Panel 212 (Rear)
243	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Rear)
244	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Rear)

Common CC Pump Swgr 0CC01E 125-Vdc from Bus 241 or 242 "0" CC Pp Swgr.

480-V BUS NUMBER	MAIN	RESERVE
231X	125-Vdc Dist. Panel 211 (Front)	Panel 211 (Rear)
231Z	125-Vdc Dist. Panel 211 (Front)	Panel 211 (Rear)
232X	125-Vdc Dist. Panel 212 (Front)	Panel 212 (Rear)
232Z	125-Vdc Dist. Panel 212 (Front)	Panel 212 (Rear)
233X	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Front)
233Y	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Front)
233Z	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Front)
233V	125-Vdc Dist. Panel 213 (Rear)	Panel 213 (Rear)
234X	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Front)
234Y	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Front)
480-V BUS NUMBER		
234Z	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Front)
234V	125-Vdc Dist. Panel 214 (Rear)	Panel 214 (Rear)

TABLE 8.3-3

BRAIDWOOD UNIT 1 D-C CONTROL POWER SOURCE

6.9-kV BUS NUMBER	MAIN	RESERVE
156	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Rear)
157	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Rear)
158	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Rear)
159	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Rear)
4160-V BUS NUMBER		
141	125-Vdc Dist. Panel 111 (Front)	Panel 111 (Rear)
142	125-Vdc Dist. Panel 112 (Front)	Panel 112 (Rear)
143	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Rear)
144	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Rear)
045	48-Vdc Dist. Panel 013	48-Vdc Dist. Panel 013

Common CC Pump Swgr 0CC01E 125-Vdc from Bus 141 or 142 "0" CC Pp Swgr.

480-V BUS NUMBER	MAIN	RESERVE
131X	125-Vdc Dist. Panel 111 (Front)	Panel 111 (Rear)
132X	125-Vdc Dist. Panel 112 (Front)	Panel 112 (Rear)
133X	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Front)
133Y	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Front)
133Z	125-Vdc Dist. Panel 113 (Front)	Panel 113 (Front)
133V	125-Vdc Dist. Panel 113 (Rear)	Panel 113 (Rear)
033W	125-Vdc Dist. Panel 113 (Rear)	Panel 213 (Rear)
134X	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Front)
134Y	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Front)
134Z	125-Vdc Dist. Panel 114 (Front)	Panel 114 (Front)
134V	125-Vdc Dist. Panel 114 (Rear)	Panel 114 (Rear)
034W	125-Vdc Dist. Panel 114 (Rear)	Panel 214 (Rear)
034R	125-Vdc Dist. Panel 114 (Front)	Panel 214 (Front)
034P	125-Vdc Dist. Panel 114 (Front)	Panel 214 (Front)

TABLE 8.3-4

BRAIDWOOD UNIT 2 D-C CONTROL POWER SOURCE

6.9-kV BUS NUMBER	MAIN	RESERVE
256	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Rear)
257	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Rear)
258	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Rear)
259	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Rear)
4160-V BUS NUMBER		
241	125-Vdc Dist. Panel 211 (Front)	Panel 211 (Rear)
242	125-Vdc Dist. Panel 212 (Front)	Panel 212 (Rear)
243	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Rear)
244	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Rear)

Common CC Pump Swgr 0CC01E 125-Vdc from Bus 241 or 242 "0" CC Pp Swgr.

480-V BUS NUMBER	MAIN	RESERVE
231X	125-Vdc Dist. Panel 211 (Front)	Panel 211 (Rear)
232X	125-Vdc Dist. Panel 212 (Front)	Panel 212 (Rear)
233X	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Front)
233Y	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Front)
233Z	125-Vdc Dist. Panel 213 (Front)	Panel 213 (Front)
233V	125-Vdc Dist. Panel 213 (Rear)	Panel 213 (Rear)
234X	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Front)
234Y	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Front)
234Z	125-Vdc Dist. Panel 214 (Front)	Panel 214 (Front)
234V	125-Vdc Dist. Panel 214 (Rear)	Panel 214 (Rear)

TABLE 8.3-5

LOADING ON 4160-VOLT ESF BUSES (y)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
A. 4-kV Loads (b)								
1. 4160-V/480-V Unit Substations (p)	10	4	4	-	2	2	2	2
2. Centrifugal Charging Pump	12	2	2	600	1	1	1	1
3. Safety Injection Pump	17	2	2	400	1	1	-	-
4. Residual Heat Removal Pump	22	2	2	400	1	1	-	-
5. Control Room Refrigeration Unit (e) (s)	27	2	0	461	1	1	-	-
6. Containment Spray Pump	27/52(i)	2	2	600	1	1	-	-
7. Component Cooling Pump	32	2	2	450	1	1	1	1
8. Essential Service Water Pump	37	2	2	1250	1	1	1	1
9. Motor Driven Auxiliary Feedwater Pump (c)	47	1	1	1250	1	-	1	-
10. Auxiliary Building Supply Fan	(j)	2	2	350	0	0	0	0
11. Auxiliary Building Exhaust Fan	(j)	2	2	500	0	0	0	0

TABLE 8.3-5 (Cont'd)

LOADING ON 4160-VOLT ESF BUSES (y)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
B. 480-V Switchgear Loads (d)								
1. Containment Cooling Fan (RCFC) (n)		4	4	100/150	2 (low)	2 (low)	2 (high)	2 (high)
2. Control Room HVAC System Supply Fan (e)		2	0	125	1	1	-	-
3. Diesel Gen. Room Vent Fan		2	2	125	1	1	1	1
4. Auxiliary Bldg. Charcoal Booster Fan (h)		3	3	75	0	1	1	1
5. Turbine Bearing Oil Pump (u)		1	1	100	-	0	-	1
6. ESW Cooling Tower Fan - *See note (m)		4	4	150/37.5	*	*	*	*
7. 125-Vdc Battery Charger		2	2	50 kVA	1	1	1	1
8. Cubicle Cooler Fan for Diesel Driven AFW Pump (r)		1	1	75	-	0	-	0
9. Deep Well Pump (u)		2	0	125	0	0	-	-
C. 480-V MCC Loads (d)								
1. Cubicle Cooler Fans for ECCS Loads (w)		28	28	3	14	14	6	6
2. F.H. Bldg. Charcoal Booster Fan		2	0	25	1	0	-	-
3. Control Room HVAC System (e)								
a. Return Fan		2	0	40	1	1	-	-
b. Make-up Air Filter Unit Fan		2	0	25	1	1	-	-
c. Make-Up Air Filter Unit Electric Heating Coil (t)		2	0	27.2 kW	1	1	-	-
d. Chilled Water Pump		2	0	40	1	1	-	-

TABLE 8.3-5 (Cont'd)

LOADING ON 4160-VOLT ESF BUSES (y)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
4. Diesel Oil Storage Room Exhaust Fan		4	4	3	1	1	1	1
5. Diesel Gen. Room Exhaust Fan (w)		2	2	3	0	0	0	0
6. Elec. Equip. Room Vent Fan (f)		1	1	50	-	1	-	1
7. Battery Room Exhaust Fan		2	2	3	1	1	1	1
8. ESF Switchgear Room Vent. Fan		2	2	50	1	1	1	1
9. Lower (el. 439'-0") Cable Spreading Room Vent Fan (g)		1	1	40	-	1	-	1
10. Essential Lighting		8	4	15 kVA	3	5	2	2
11. Diesel Oil Transfer Pump		4	4	2	2	2	2	2
12. D.G. Air Compressor (x)		4	4	15	0	0	0	0
13. Lube Oil Pumps for ECCS loads		7	7	2 (v)	0	0	0	0
14. 120-Vac Instrument Bus Inverter		4	4	10 kVA (z)	2	2	2	2
15. 120-Vac Instrument Bus Transformer		4	4	10 kVA	0	0	0	0
16. Control Room Refrig. Unit Oil Pump		2	0	1.5	1	1	-	-
17. Control Room Refrig. Unit Purge Compressor		2	0	2	1	1	-	-
18. D.G. Jacket Water Circ. Pump (x)		2	2	5	0	0	0	0
19. D.G. Jacket Water Heater (x)		2	2	18 kW	0	0	0	0
20. D.G. Oil Heaters (x)		2	2	12 kW	0	0	0	0
21. D.G. Pre-Lube Oil Pump (x)		2	2	15	0	0	0	0
22. D.G. Space Heater (x)		2	2	4.5 kW	0	0	0	0

TABLE 8.3-5 (Cont'd)

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED UNIT 1	NUMBER INSTALLED UNIT 2	MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD UNIT 1 ESF DIV. 11	UNIT 1 ESF DIV. 12	UNIT 2 ESF DIV. 21	UNIT 2 ESF DIV. 22
23. Hydrogen Recomb. Pwr & Contrl		2	0	60 kW	0	0	-	-
24. Cooling Tower SWGR Rm. Vent Fan		2	2	5	1	1	1	1
25. 120/208-V Distribution Panels		11	10	22.5 kVA	5	6	5	5
26. Refueling Water Purification Pump		2	0	20/15	0	0	-	-
27. Misc. Elec. Equipment Room Vent Fan		2	2	5/7.5	1	1	1	1
28. Hydrogen Monitor Analyzer Panel		2	2	2.5	0	0	0	0
29. Diesel Driven AFW Pump Jacket Water Heater (x)		1	1	5 kW	-	0	-	0
30. ESW Cooling Tower Valve Chamber Heater		2	2	10 kW	1	1	1	1
31. ESW Cooling Tower Substation Unit Heater		2	2	25 kW	1	1	1	1
32. ESW Cooling Tower Chem. Tank Room Heater		0	2	10 kW	-	-	-	2
33. ESW Cooling Tower Chem. Tank Room Exh. Fan		0	1	0.5	-	-	-	1
34. ESW Cooling Tower Acid Pump House Heater		2	0	10 kW	-	2	-	-
35. ESW Cooling Tower Acid Pumps		2	2	1.5 kVA	-	2	-	2
36. ESW Cooling Tower Deep Anode Cathodic Protection		0	1	12 kVA	-	-	1	-
37. Valves (k)		-	-	-	-	-	-	-
38. Other loads (1)		-	-	-	-	-	-	-

TABLE 8.3-5 (Cont’d)

NOTES:

a) Start times reflect 10 seconds start time for the diesel generator, 2 seconds for the bus voltage relaying interlock to reenergize the sequencer logic and programmed sequence time delay for major loads.

b) Loads are applied automatically in sequence as indicated.

c) The Train A auxiliary feedwater pump is motor driven powered from Division 11/21 ESF distribution. The B Train auxiliary feedwater pump is diesel driven.

d) Loads are energized automatically upon restoration of bus voltage.

e) Consists of two 100% systems. For purposes of operating Unit 2 during unit outage on Unit 1, the 4160-volt cross-ties can be closed to associate the control room HVAC systems with Unit 2, the operating unit.

f) The electrical equipment room vent fans serve Division 2 equipment only. Corresponding Division 1 equipment is served by ESF switchgear room vent fan.

g) Cable spreading room vent fans serve Division 2 equipment only.

h) Three out of six auxiliary building charcoal booster fans will start on SI signal from either Unit, but only two are required.

i) If containment spray actuation is not required at 27 seconds after a LOCA or steam line break, automatic start of containment spray pump is blocked until all other loads are sequenced on to the diesels (i.e., 52 seconds after the diesel generator start signal).

j) Applied manually by operator 2 hours subsequent to LOCA.

k) Loads are considered intermittent.

l) See UFSAR Section 8.3.1.1.2.2 for definition of “other loads”.

m) For the scenario identified for Table 8.3-5, the Ultimate Heat Sink Design Basis Analysis assumes that any two ESW cooling tower fans may be unavailable and that the remaining ESW cooling towers fans are operating at high speed to remove the heat load. The ESW cooling tower fans are controlled via manual operator actions, therefore, the specific fans operating are determined by the operator’s discretion.

n) Containment fan coolers (RCFC) operate at high speed during normal plant operation and are energized in high speed upon restoration of bus voltage if no safety injection signal is present. The RCFC will start at low speed 20 seconds after a safety injection signal. The 20 second time delay is developed in the breaker control circuit and will continue independent of the restoration of AC power by the diesel generators so start time is 20 seconds from SI signal and not EDG start.

p) 4160-V/480-V unit substations will be energized as soon as the bus feed breaker to the diesel generator is closed.

r) Diesel-driven AFW pump cubicle cooler fan not required until pump shuts down.

s) Control room refrigeration units have inherent time delays before the chillers will start, which are:

1. 51±4 seconds following an ESF actuation signal when the chiller is in either local or remote and is in standby.
2. 150±5 seconds after the bus has been restored when the chiller is in either local or remote and was running.

t) Control room HVAC makeup heating coil - Division 11 and Division 12 will not operate simultaneously.

TABLE 8.3-5 (Cont'd)

NOTES (cont'd):

u) The turbine bearing oil pump and deep well pump are powered from the Class 1E 480-V switchgear, however, they automatically trip on a safety injection signal concurrent with a loss of offsite power.

v) AF and CV pump lube oil pumps are rated at 2 HP, SX pump lube oil pump is rated at 0.5 HP.

w) The motor-driven auxiliary feed pump on Division 11 (21) does not have cubicle coolers.

x) This load is not required when the diesel is running.

y) Current actual EDG loading is determined using load flow studies from approved AC system analytical software. The highest EDG loading during a LOCA coincident with a LOOP is 5229 kW (5763 kVA) for the 1A EDG during the initial loading period. The highest EDG loading for a normal shutdown coincident with a LOOP is 4581 kW (5095 kVA) for the 1A EDG.

Diesel-Gen. 2 Hr. Rating (kW/kVA) 6050/7563
Diesel-Gen. 2000 Hr. Rating (kW/kVA) 5935/7419
Diesel-Gen. Continuous Rating (kW/kVA) 5500/6875

z) Instrument Bus Inverters are rated at 10 KVA. However, Instrument Bus Inverter loading is administratively limited to ≤ 7.5 KVA.

TABLE 8.3-5 (Cont'd)

LOADING ON 4160-VOLT ESF BUSES (x)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
A. 4-kV Loads (b)								
1. 4160-V/480-V Unit Substations (n)	10	2	2	-	1	1	1	1
2. Centrifugal Charging Pump	12	2	2	600	1	1	1	1
3. Safety Injection Pump	17	2	2	400	1	1	-	-
4. Residual Heat Removal Pump	22	2	2	400	1	1	-	-
5. Control Room Refrigeration Unit (e) (r)	27	2	0	461	1	1	-	-
6. Containment Spray Pump	27/52(i)	2	2	600	1	1	-	-
7. Component Cooling Pump	32	2	2	450	1	1	1	1
8. Essential Service Water Pump	37	2	2	1250	1	1	1	1
9. Motor Driven Auxiliary Feedwater Pump (c)	47	1	1	1250	1	-	1	-
10. Auxiliary Building Supply Fan	(j)	2	2	350	0	0	0	0
11. Auxiliary Building Exhaust Fan	(j)	2	2	500	0	0	0	0

TABLE 8.3-5 (Cont'd)

LOADING ON 4160-VOLT ESF BUSES (x)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
B. 480-V Switchgear Loads (d)								
1. Containment Cooling Fan (RCFC) (m)		4	4	100/150	2 (low)	2 (low)	2 (high)	2 (high)
2. Control Room HVAC System Supply Fan (e)		2	0	125	1	1	-	-
3. Diesel Gen. Room Vent Fan		2	2	125	1	1	1	1
4. Auxiliary Bldg. Charcoal Booster Fan (h)		3	3	75	0	1	1	1
5. Turbine Bearing Oil Pump (t)		1	1	100	-	0	-	1
6. 125-Vdc Battery Charger		2	2	50 kVA	1	1	1	1
7. Cubicle Cooler Fan for Diesel Driven AFW Pump (p)		1	1	75	-	0	-	0
C. 480-V MCC Loads (d)								
1. Cubicle Cooler Fans for ECCS Loads (v)		28	28	3	14	14	6	6
2. F.H. Bldg. Charcoal Booster Fan		2	0	25	1	0	-	-
3. Control Room HVAC System (e)								
a. Return Fan		2	0	40	1	1	-	-
b. Make-up Air Filter Unit Fan		2	0	25	1	1	-	-
c. Make-Up Air Filter Unit Electric Heating Coil (s)		2	0	27.2 kW	1	1	-	-
d. Chilled Water Pump		2	0	40	1	1	-	-
4. Diesel Oil Storage Room Exhaust Fan		4	4	3	1	1	1	1
5. Diesel Gen. Room Exhaust Fan (w)		2	2	3	0	0	0	0

TABLE 8.3-5 (Cont'd)

LOADING ON 4160-VOLT ESF BUSES (x)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
6. Elec. Equip. Room Vent Fan (f)		1	1	50	-	1	-	1
7. Battery Room Exhaust Fan		2	2	3	1	1	1	1
8. ESF Switchgear Room Vent. Fan		2	2	50	1	1	1	1
9. Lower (el. 439'-0") Cable Spreading Room Vent Fan (g)		1	1	40	-	1	-	1
10. Essential Lighting		8	4	15 kVA	3	5	2	2
11. Diesel Oil Transfer Pump		4	4	2	2	2	2	2
12. D.G. Air Compressor (w)		4	4	15	0	0	0	0
13. Lube Oil Pumps for ECCS loads		7	7	2 (u)	0	0	0	0
14. 120-Vac Instrument Bus Inverter		4	4	10 kVA (y)	2	2	2	2
15. 120-Vac Instrument Bus Transformer		4	4	10 kVA	0	0	0	0
16. Control Room Refrig. Unit Oil Pump		2	0	1.5	1	1	-	-
17. Control Room Refrig. Unit Purge Compressor		2	0	2	1	1	-	-
18. D.G. Jacket Water Circ. Pump (w)		2	2	5	0	0	0	0
19. D.G. Jacket Water Heater (w)		2	2	18 kW	0	0	0	0
20. D.G. Oil Heaters (w)		2	2	12 kW	0	0	0	0
21. D.G. Pre-Lube Oil Pump (w)		2	2	15	0	0	0	0
22. D.G. Space Heater (w)		2	2	4.5 kW	0	0	0	0
23. Hydrogen Recomb. Pwr & Contrl (Abandoned in place)		2	0	60 kW	0	0	-	-
24. 120/208-V Distribution Panels		7	6	22.5 kVA	3	4	3	3

TABLE 8.3-5 (Cont'd)

LOADING ON 4160-VOLT ESF BUSES (x)

LOADING ON 4160-VOLT ESF BUSES ASSUMING:
1. TOTAL LOSS OF PLANT OFFSITE POWER
2. UNIT 1 IN LOCA CONDITION
3. UNIT 2 IN HOT STANDBY CONDITION
4. ALL 4 DIESEL-GEN. SETS START

	START SEQUENCE (SEC) AFTER EDG START SIGNAL (a)	NUMBER INSTALLED		MOTOR RATED HP	NUMBER OF CONTINUOUSLY ENERGIZED LOADS DURING INITIAL PERIOD			
					UNIT 1		UNIT 2	
		UNIT 1	UNIT 2		ESF DIV. 11	ESF DIV. 12	ESF DIV. 21	ESF DIV. 22
25. Refueling Water Purification Pump		2	0	20/15	0	0	-	-
26. Misc. Elec. Equipment Room Vent Fan		2	2	5/7.5	1	1	1	1
27. Hydrogen Monitor Analyzer Panel		2	2	2.5	0	0	0	0
28. Diesel Driven AFW Pump Jacket Water Heater (w)		1	1	5 kW	-	0	-	0
29. Essential Service Water Strainer Backwash Motor		2	-	1.0	1	1	-	-
30. Valves (k)		-	-	-	-	-	-	-
31. Other loads (1)		-	-	-	-	-	-	-

TABLE 8.3-5 (Cont'd)

NOTES:

a) Start times reflect 10 seconds start time for the diesel generator, 2 seconds for the bus voltage relaying interlock to reenergize the sequencer logic and programmed sequence time delay for major loads.

b) Loads are applied automatically in sequence as indicated.

c) The Train A auxiliary feedwater pump is motor driven powered from the Division 11/21 ESF distribution. The Train B auxiliary feedwater pump is diesel driven.

d) Loads are energized automatically upon restoration of bus voltage.

e) Consists of two 100% systems. For purposes of operating Unit 2 during unit outage on Unit 1, the 4160-volt cross-ties can be closed to associate the control room HVAC systems with Unit 2, the operating unit.

f) The electrical equipment room vent fans serve Division 2 equipment only. Corresponding Division 1 equipment is served by ESF switchgear room vent fan.

g) Cable spreading room vent fans serve Division 2 equipment only.

h) Three out of six auxiliary building charcoal booster fans will start on SI signal from either Unit, but only two are required.

i) If containment spray actuation is not required at 27 seconds after a LOCA or steam line break, automatic start of containment spray pump is blocked until all other loads are sequenced on to the diesels (i.e., 52 seconds after the diesel generator start signal).

j) Applied manually by operator 2 hours subsequent to LOCA.

k) Loads are considered intermittent.

l) See UFSAR Section 8.3.1.1.2.2 for definition of "other loads".

m) Containment fan coolers (RCFC) operate at high speed during normal plant operation and are energized in high speed upon restoration of bus voltage if no safety injection signal is present. The RCFC will start at low speed 20 seconds after a safety injection signal. The 20 second time delay is developed in the breaker control circuit and will continue independent of the restoration of AC power by the diesel generators so start time is 20 seconds from SI signal and not EDG start.

n) 4160-V/480-V unit substations will be energized as soon as the bus feed breaker to the diesel generator is closed.

p) Diesel-driven AFW pump cubicle cooler fan - not required until pump shuts down.

r) Control room refrigeration units have inherent time delays before the chillers will start, which are:

1. 51 ± 4 seconds following an ESF actuation signal when the chiller is in either local or remote and is in standby.
2. 150 ± 5 seconds after the bus has been restored when the chiller is in either local or remote and was running.

s) Control room HVAC makeup heating coil - Division 11 and Division 12 will not operate simultaneously.

t) The turbine bearing oil pump is powered from the Class 1E 480-V switchgear, however, it automatically trips on a safety injection signal concurrent with a loss of offsite power.

TABLE 8.3-5 (Cont'd)

NOTES (cont'd):

u) AF and CV pump lube pumps are rated at 2.0 HP, SX pump lube oil pump rated at 0.5 HP.

v) The motor-driven auxiliary feed pump on Division 11 (21) does not have cubicle coolers.

w) This load is not required when the diesel is running.

x) Current actual EDG loading is determined using load flow studies from approved AC system analytical software. The highest EDG loading during a LOCA coincident with a LOOP is 4870 kW (5367 kVA) for the 1A EDG during the initial loading period. The highest EDG loading for a normal shutdown coincident with a LOOP is 4287 kW (4767 kVA) for the 1A EDG.

Diesel-Gen. 2 Hr. Rating (kW/kVA) 6050/7563
Diesel-Gen. 2000 Hr. Rating (kW/kVA) 5935/7419
Diesel-Gen. Continuous Rating (kW/kVA) 5500/6875

y) Instrument Bus Inverters are all rated at 10 KVA. However, Instrument Bus Inverter loading is administratively limited to 7.5 KVA.

TABLE 8.3-6

RELAY PROTECTION OF 4160-VOLT EQUIPMENT

EQUIPMENT	RELAY DEVICE	RELAY TYPE	RELAY FUNCTION	RELAY ACTION	
SAT 142-1 Feed to Bus Swgr. 141 ACB 1412	PR31-451N	CO-6	ground overcurrent)	Trip:	ACB 1412 (SAT 142-1 Feed)
	PR30A-451A	CO-7	phase overcurrent)		ACB 1413 (DG1A Feed)
	PR30C-451C	CO-7	phase overcurrent)		ACB 1414 (Res. Feed)
	PR308-451B	SSC-T	phase overcurrent)	Trip:	ACB 1414 (Res. Feed) after 5 min. delay
Swgr. 241 to Swgr. 141 ACB 1414	PR28-451N	CO-6	ground overcurrent)	Trip:	ACB 1414 (Res. Feed)
	PR27A-451A	CO-7	phase overcurrent)		
	PR27C-451C	CO-7	phase overcurrent)		
Bus Tie Swgr. 141 to Swgr. 143 ACB 1411	PR14-451N	GR-200	ground overcurrent)	Trip:	ACB 1411 (Bus Tie)
	PR13A-451A	CO-7	phase overcurrent)		
	PR13C-451C	CO-7	phase overcurrent)		
Swgr. 141 Feed to Tr. 131X ACB 1415X	PR37A-450/451A	CO-9	phase overcurrent)		
	PR37B-450/451B	CO-9	phase overcurrent)		
	PR37C-450/451C	CO-9	phase overcurrent)	Trip:	ACB 1415X
	PR38-450N	SSC-T	ground overcurrent)		
	PR1-351N	CO-6	ground overcurrent)		
Swgr. 141 Feed to Tr. 131Z ACB 1415Z (Byron only)	PR1-351N	CO-6	ground overcurrent)		
	PR1A-450/451A	CO-9	phase overcurrent)		
	PR1B-450/451B	CO-9	phase overcurrent)	Trip:	ACB 1415Z
	PR1C-450/451C	CO-9	phase overcurrent)		
	PR2-450N	SSC-T	ground overcurrent)		

TABLE 8.3-6 (Cont'd)

EQUIPMENT	RELAY DEVICE	RELAY TYPE	RELAY FUNCTION		RELAY ACTION
Bus 141	PR9A-427-B141A	CV-7	undervoltage)	Trip:	Ess. Serv. Water Pu 1A
	AND		)		Safety Injection Pump 1A
	PR9C-427-B141C	CV-7	undervoltage)		RHR Pump 1A
	PR43A-427-B141A	ITE-27N	second level)		Aux. Feedwater Pu 1A
	AND		of undervoltage)		Containment Spray Pu 1A
	PR43C-427-B141C	ITE-27N	second level)		Centrifugal Ch. Pu 1A
			of undervoltage)		Component Cooling Pu 1A
	PR44A-427-B141A	ABB-27N	third level)		Aux. Bldg. Supply Fan 0A
	AND		of undervoltage)		Aux. Bldg. Exhaust Fan 0A
	PR44C-427-B141C	ABB-27N	third level)		Cont. Rm. Chiller Compr. 0A
			of undervoltage)		Component Cooling Pu 0
					* ACB 1411 (Bus Tie)
					* ACB 1412 (SAT 142-1 Feed)
					* ACB 1414 (Res. Feed)
					Interlock: Sfgd. Seq. Train A
					ACB 1413 (DG1A Feed)

Note: Second level undervoltage relays directly trip only ACB's 1411, 1412 and 1414 after a 5 minute delay (delay is bypassed if Safety Injection occurs.)
Third level undervoltage relays directly trip only ACB's 1411, 1412 and 1414 after a 3 second delay.

EQUIPMENT	RELAY DEVICE	RELAY TYPE	RELAY FUNCTION		RELAY ACTION
					Start DG1A
SAT 142-2 Feed to	PR34-451N	CO-6	ground overcurrent)		Trip: ACB 1422 (SAT 142-2 Feed)
Swgr. 142	PR33A-451A	CO-7	phase overcurrent)		ACB 1423 (DG1B Feed)
ACB 1422	PR33C-451C	CO-7	phase overcurrent)		ACB 1424 (Res. Feed)
	PR338-451B	SSC-T	phase overcurrent)	Trip:	ACB 1424 (Res. Feed) after 5 min. delay
Reserve Feed From	PR31-451N	CO-6	ground overcurrent)		
Swgr. 242 to Swgr.	PR30A-451A	CO-7	phase overcurrent)		
142 ACB 1424	PR30C-451C	CO-7	phase overcurrent)	Trip:	ACB 1424 (Res. Feed)

* After Diesel Generator is running.

TABLE 8.3-6 (Cont'd)

EQUIPMENT	RELAY DEVICE	RELAY TYPE	RELAY FUNCTION	RELAY ACTION
Bus Tie Swgr. 142 to Swgr. 144 ACB 1421	PR15-451N PR14A-451A PR14C-451C	GR-200 CO-7 CO-7	ground overcurrent) phase overcurrent) phase overcurrent)	Trip: ACB 1421 (Bus Tie)
Swgr. 142 Feed to Tr. 132X ACB 1425X	PR28A-450/451A PR28B-450/451B PR28C-450/451C PR29-450N PR1-351N	CO-9 CO-9 CO-9 SSC-T CO-6	phase overcurrent) phase overcurrent) phase overcurrent) ground overcurrent) ground overcurrent)	Trip: ACB 1425X
Swgr. 142 Feed to Tr. 132Z ACB 1425Z (Byron only)	PR1-351N PR26A-450/451A PR26B-450/451B PR26C-450/451C PR27-450N	CO-6 CO-9 CO-9 CO-9 SSC-T	ground overcurrent) phase overcurrent) phase overcurrent) phase overcurrent) ground overcurrent)	Trip: ACB 1425Z
Bus 142	PR10A-427-B142A AND PR10C-427-B142B PR42A-427-B142A AND PR42C-427-B142C PR45A-427-B142A AND PR45C-427-B142C	CV-7 CV-7 ITE-27N ITE-27N ABB-27N ABB-27N	undervoltage)) undervoltage) second level) of undervoltage) second level) of undervoltage) third level) of undervoltage) third level) of undervoltage)	Trip: Ess. Serv. Water Pu 1B Safety Injection Pump 1B RHR Pump 1B Containment Spray Pu 1B Component Cooling Pu 1B Centrifugal Ch. Pu 1B Cont. Rm. Chiller Compr. 0B Component Cooling Pu 0 Aux. Bldg. Exhaust Fan 0B Aux. Bldg. Supply Fan 0B * ACB 1421 (Bus Tie) * ACB 1422 (SAT 142-2 Feed) * ACB 1424 (Res. Feed) Interlock: Sfgd. Seq. Train B ACB 1423 (DG1B Feed) Start DG1B

* After DG is running.

Note: Second level undervoltage relays directly trip only ACB's 1421, 1422 and 1424 after 5 minute delay (delay is bypassed if Safety Injection occurs).
Third level undervoltage relays directly trip only ACB’s 1421, 1422 and 1424 after a 3 second delay.

TABLE 8.3-6 (Cont'd)

EQUIPMENT	RELAY DEVICE	RELAY TYPE	RELAY FUNCTION	RELAY ACTION
Feeds to all Motors Bus 141 (Except AF pump 1A)	450/451A 450/451C 450N	CO-5 CO-5 SSC-T	phase overcurrent) phase overcurrent) ground overcurrent)	Trip Breaker supplying motor
Aux. Feedwater Pump 1A	PR15B-450/451B PR15A-450/451A PR15C-450/451C PR16-450N	CO-11 CO-5 CO-5 SSC-T	phase overcurrent) phase overcurrent) phase overcurrent) ground overcurrent)	Trip Aux. Feedwater Pump 1A
Feeds to Motors Bus 142	450/451A 450/451C 450N	CO-5 CO-5 SSC-T	phase overcurrent) phase overcurrent) ground overcurrent)	Trip Breaker supplying motor
DG1A Feed to Swgr. 141 ACB 1413	PR12A-451DG1A PR12B-451DG1A PR12C-451DG1A	CO-6 CO-6 CO-6	phase overcurrent) phase overcurrent) phase overcurrent)	Trip: ACB 1413 (DG1A) via the generator shutdown relay
DG1A Feed to Swgr. 141 ACB 1413	PR10-487-DG1A	SA-1	differential)	Trip: ACB 1413 (DG1A)
DG1B Feed to Swgr. 142 ACB 1423	PR13A-451DG1B PR13B-451DG1B PR13C-451DG1B	CO-6 CO-6 CO-6	phase overcurrent) phase overcurrent) phase overcurrent)	Trip: ACB 1423 (DG1B) via the generator shutdown relay
DG1B Feed to Swgr. 142 ACB 1423	PR11-487-DG1B	SA-1	differential)	Trip: ACB 1423 (DG1B)

TABLE 8.3-7

TABULATION OF DIESEL-GENERATOR SUPERVISORY

AND PROTECTIVE FUNCTIONS

TROUBLE EVENT	FUNCTION DURING TESTING (MANUAL START)	FUNCTION DURING EMERGENCY (AUTOMATIC START)
Engine lube oil low pressure	Alarm, trip	Alarm
Turbo lube oil low pressure	Alarm, trip	Alarm
Fuel oil low pressure	Alarm	Alarm
Jacket water low pressure	Alarm	Alarm
Filter/strainer high differential pressure	Alarm	Alarm
Engine lube oil temperature off normal	Alarm	Alarm
Main connecting rod and generator bearing high temperature	Alarm, trip	Alarm
Turbo thrust bearing failure	Alarm, trip	Alarm
Jacket water high temperature	Alarm, trip	Alarm
Overspeed	Alarm, trip	Alarm, trip
Crank case high pressure	Alarm, trip	Alarm
Crank case low level	Alarm	Alarm
Generator differential current	Alarm, trip	Alarm, trip
Generator ground fault	Alarm, trip	Alarm, trip*
Generator overcurrent	Alarm, trip	Alarm, trip*
Generator trip	Alarm	Alarm
Incomplete Sequence	Alarm, trip	Alarm

* Breaker trips; diesel does not shut down on auto start caused only by ESF bus undervoltage. When auto start is caused by safety injection signal, diesel does not shut down and breaker does not trip.

TABLE 8.3-7 (Cont'd)

TROUBLE EVENT	FUNCTION DURING TESTING (MANUAL START)	FUNCTION DURING EMERGENCY (AUTOMATIC START)
Loss of field	Alarm, trip	Alarm, trip*
Reverse Power	Alarm, trip	Alarm, trip*
Underfrequency	Alarm, trip	Alarm, trip*

* Breaker trips; diesel does not shut down on auto start caused only by ESF bus undervoltage. When auto start is caused by safety injection signal, diesel does not shut down and breaker does not trip.

TABLE 8.3-8

CABLE AND EQUIPMENT COLOR CODING

SEGREGATION CODE		COLOR	APPLICATION	
1E	(ESF-1)	Green	Cable Tags	Color-coded, self-laminated, wrap-around, cable tags giving cable number.
2E	(ESF-2)	Brown		
1B	(Non-Safety-Related, Div. 1)	Green letters on white	Cable Tray and Conduit Identification	Color coded markers shall be used for marking cable trays and conduit.
2B	(Non-Safety-Related, Div. 2)	Brown letters on white		
1R	(Input Channel 1)	Red		
2R	(Input Channel 2)	Orange		
3R	(Input Channel 3)	Blue		
4R	(Input Channel 4)	Yellow		
1N	(Neutron Monitoring)	Red		
2N	(Neutron Monitoring)	Orange		
3N	(Neutron Monitoring)	Blue		

TABLE 8.3-8 (Cont'd)

SEGREGATION CODE		COLOR	APPLICATION	
4N	(Neutron Monitoring)	Yellow	Nameplates for Instrument and Control Devices	Color-coded nameplates with engraved black characters, except that 1R, 3R, 1N, and 3N have white characters, and 1B and 2B have white characters on a black background.
1A	(Non-Safety-Related Service From Class 1E SW. Groups)	Green		
2A	(Non-Safety-Related Service From Class 1E SW. Groups)	Brown		

Table 8.3-9 has been deleted intentionally

TABLE 8.3-10

ENGINEERED SAFETY FEATURE EQUIPMENT

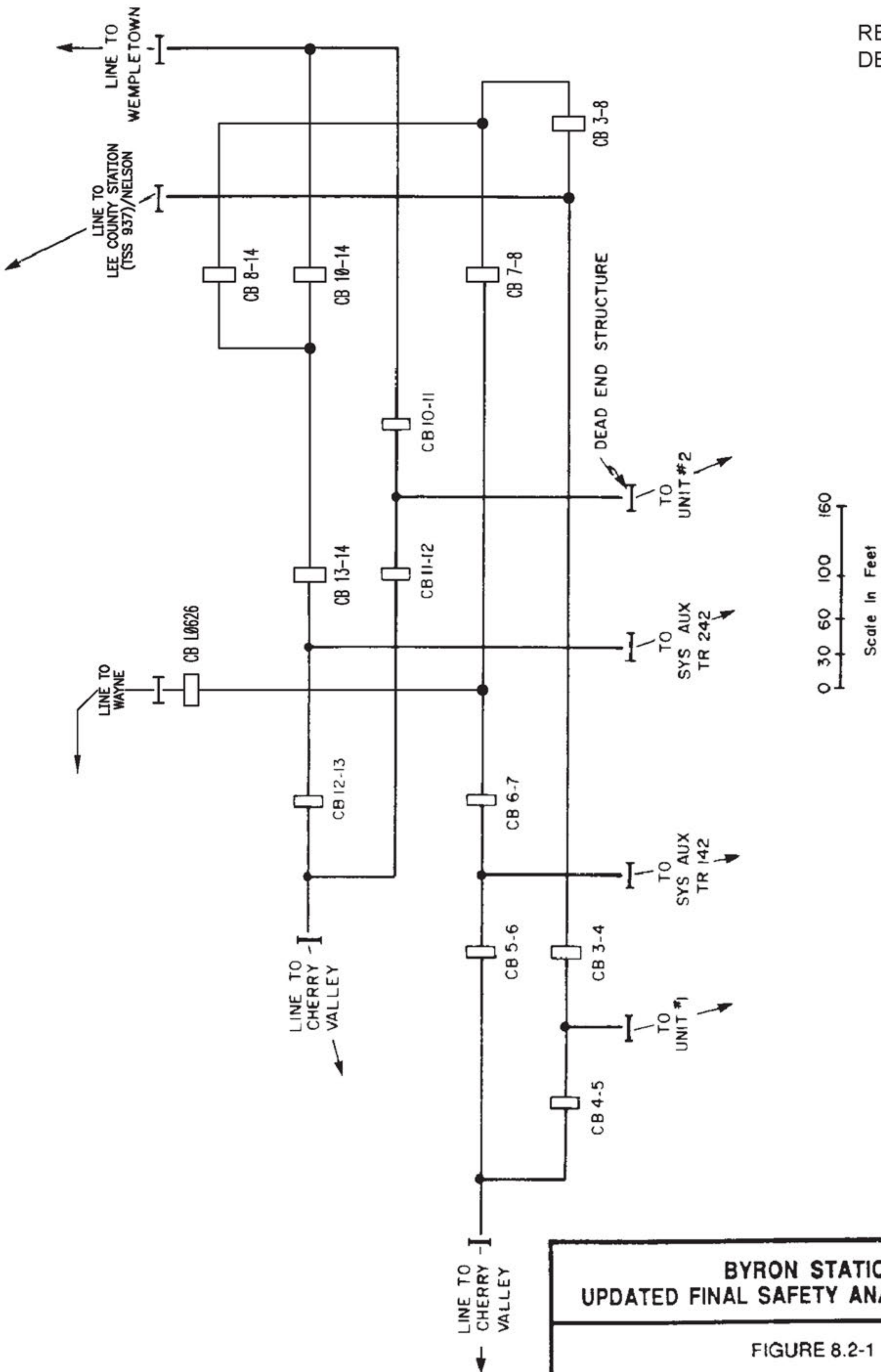
UNIT	BATTERY NUMBER	DISTRIBUTION PANEL NUMBER	DIESEL NUMBER	4160-V SWGR. BUSES	480-V SWGR. BUSES	ESF DIVISION NUMBER
1	111	111	1A	141	131X&Z	11
1	112	112	1B	142	132X&Z	12
2	211	211	2A	241	231X&Z	21
2	212	212	2B	242	232X&Z	22

TABLE 8.3-10

ENGINEERED SAFETY FEATURE EQUIPMENT

UNIT	BATTERY NUMBER	DISTRIBUTION PANEL NUMBER	DIESEL NUMBER	4160-V SWGR. BUSES	480-V SWGR. BUSES	ESF DIVISION NUMBER
1	111	111	1A	141	131X	11
1	112	112	1B	142	132X	12
2	211	211	2A	241	231X	21
2	212	212	2B	242	232X	22

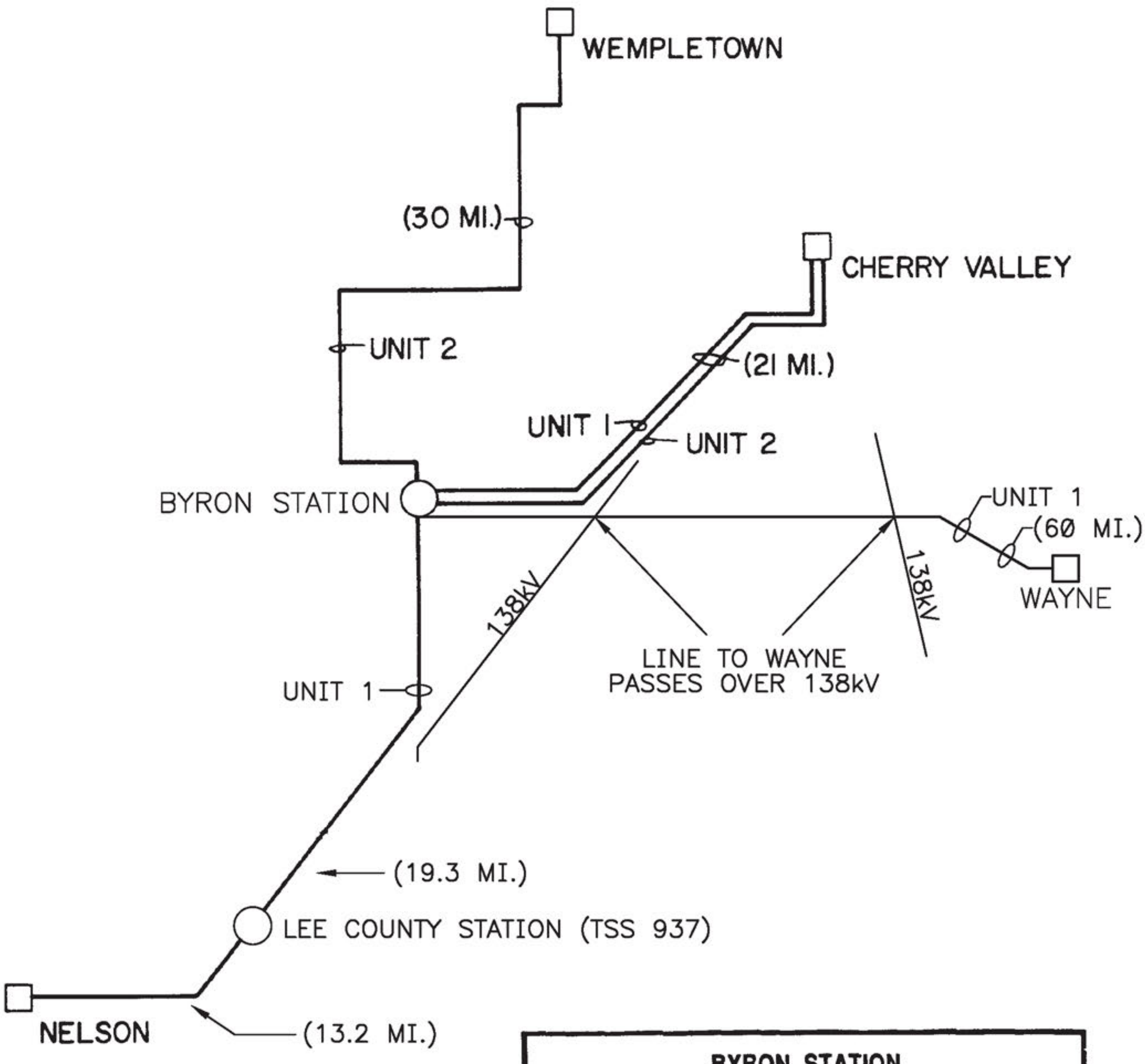
REVISION 17
DECEMBER 2018



BYRON STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-1

345-KV SWITCHGEAR BUS ARRANGEMENT



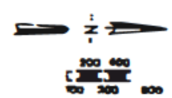
BYRON STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-2

TRANSMISSION SYSTEM INTERCONNECTIONS

REVISION 17
DECEMBER 2018

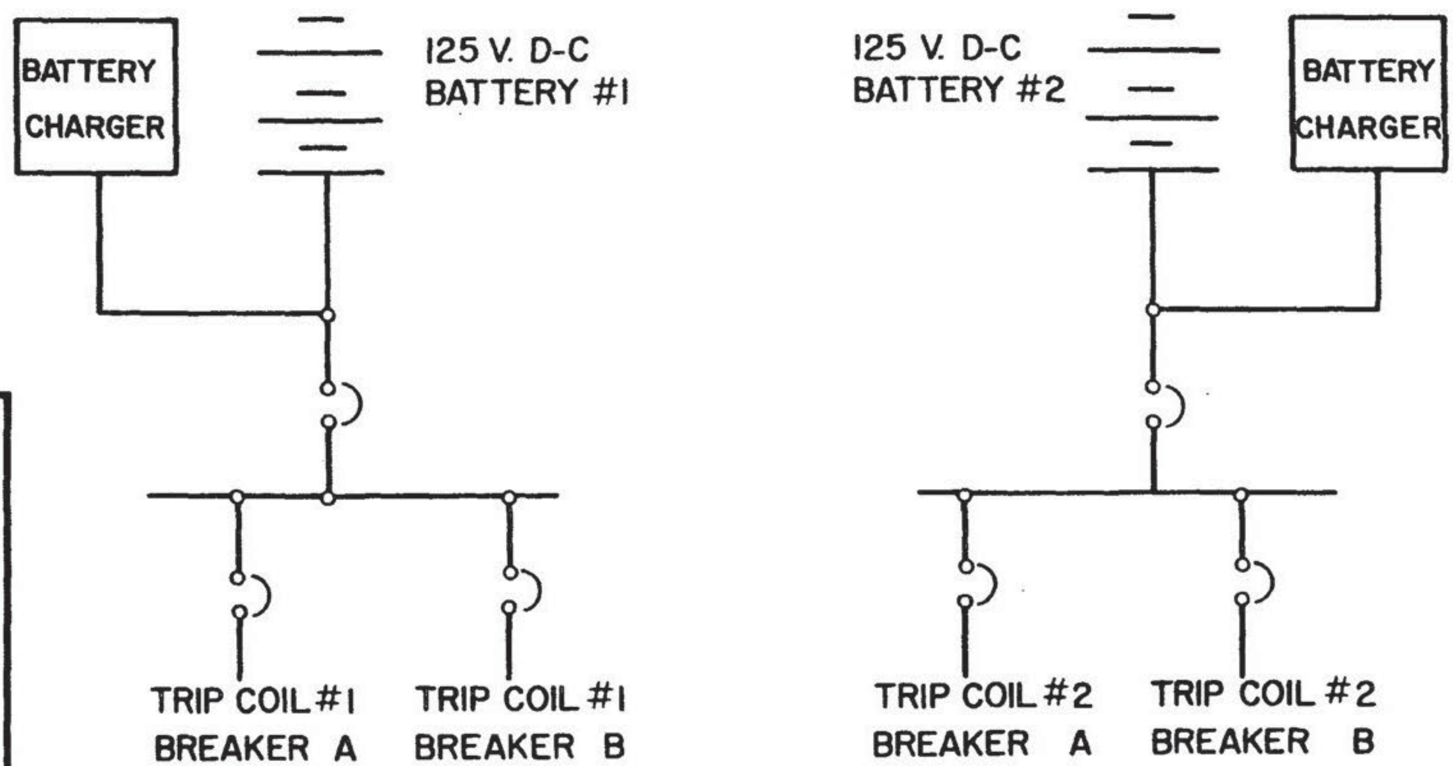
Security - Related Information Withheld Under 10 CFR 2.390



BYRON STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8 2-3

PROPERTY PLAN

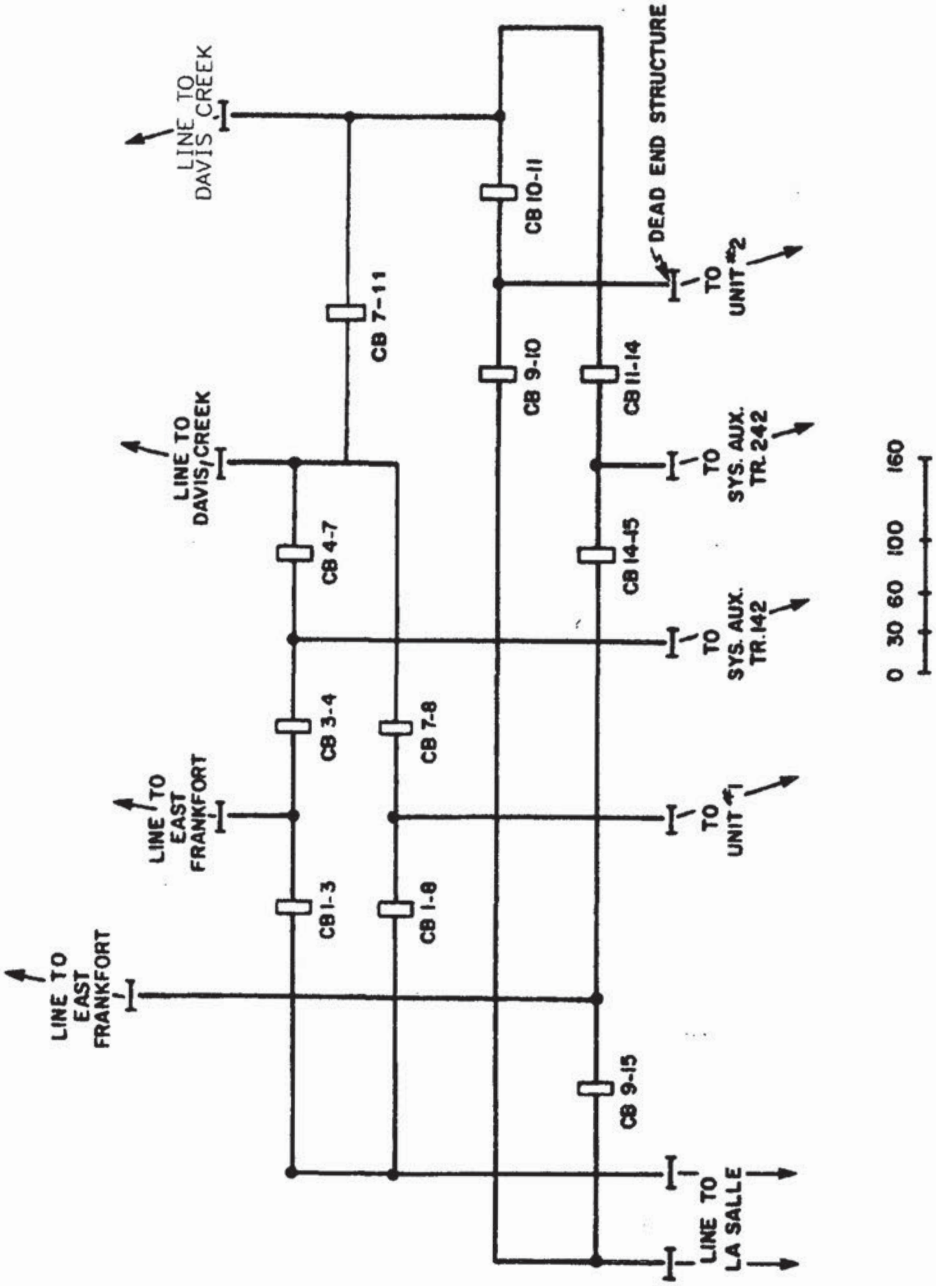


BYRON/BRAIDWOOD STATIONS
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-4

DIAGRAM OF SWITCHYARD
D-C CONTROL SYSTEM

REVISION 8
DECEMBER 2000

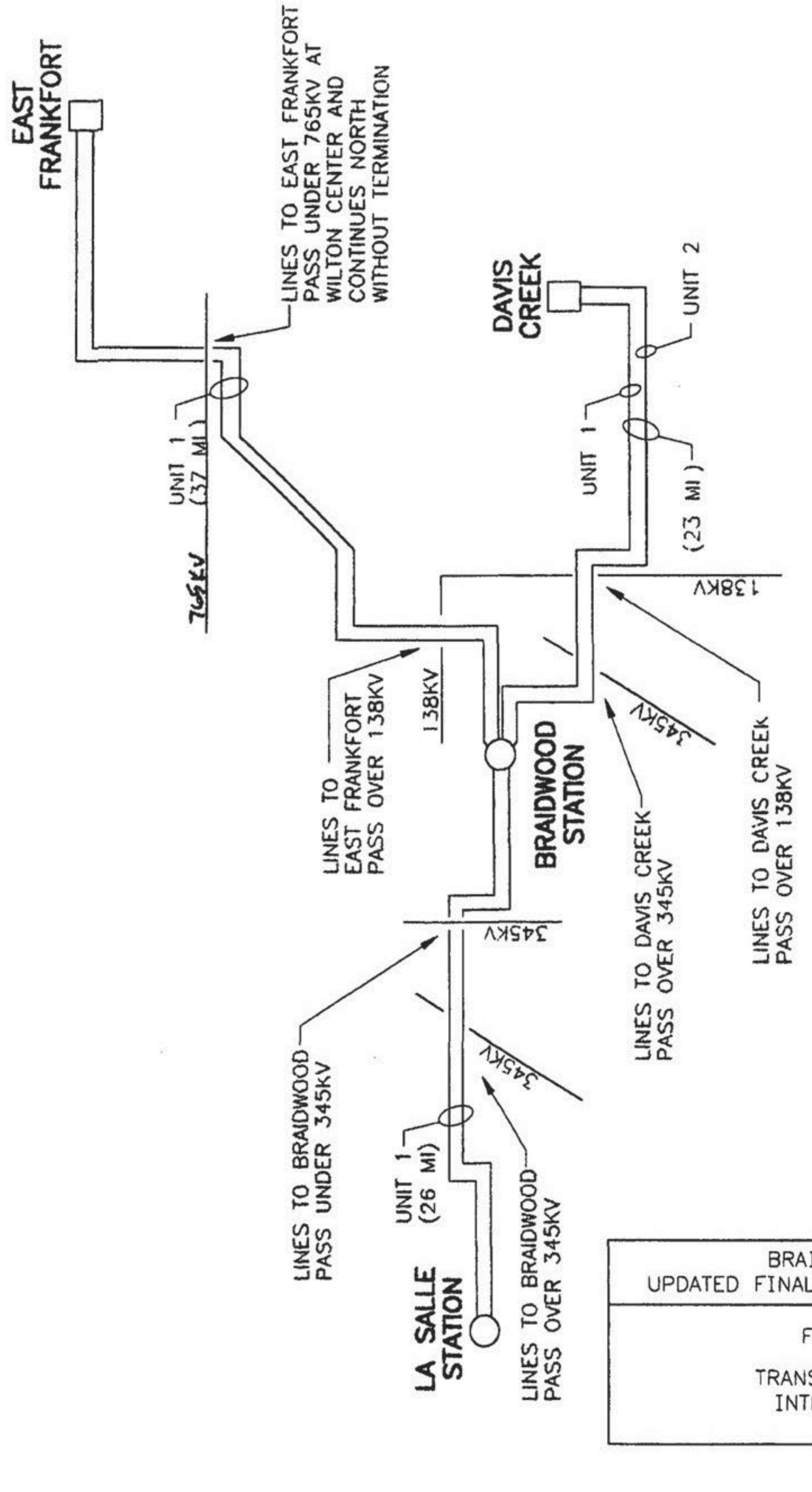


BRAIDWOOD STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-5

345-KV SWITCHGEAR BUS
ARRANGEMENT

REVISION 8
DECEMBER 2000



BRAIDWOOD STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-6

TRANSMISSION SYSTEM
INTERCONNECTIONS

REVISION 8
DECEMBER 2000

Security -Related Information Withheld Under 10 CFR 2.390

0 1000 2000 3000 4000
SCALE

BRAIDWOOD STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-7

PROPERTY PLAN

Figures 8.3-1 through 8.3-6 have been deleted intentionally.