8.0 ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 UTILITY GRID DESCRIPTION

Carolina Power & Light Company (CP&L), now Duke Energy Progress, is an investor-owned electric utility serving a 30,000 square mile area of North and South Carolina. The Company's electrical grid consists of nuclear, fossil, and hydro generating facilities and an extensive 500/230/115 kV bulk power transmission system.

Carolina Power & Light Company maintains multiple direct interconnections with neighboring utilities. Carolina Power & Light Company participates as a member of the Virginia-Carolinas Reliability Subregion (VACAR) of the Southeastern Electric Reliability Council (SERC). These interconnections with neighboring utilities serve to increase the reliability of CP&L's electrical grid.

The output of the Unit is connected to the CP&L transmission system via eight 230 kV transmission circuits (see Figures 8.2.1-1 and 8.2.1-2). The start-up and shutdown power is derived from the grid via the 230 kV transmission system, as described in Section 8.2.

8.1.2 OFFSITE POWER SYSTEM

Power is supplied form the main generator to the switchyard through a main transformer bank. The main generator is directly connected to the main transformer bank through a 22 kV bus system. The leads from the main transformer bank high voltage terminals are connected to the 230 kV switchyard.

The Plant Electric Power Distribution System receives power under normal operating conditions from the main generator through two unit auxiliary transformers.

For start-up and shutdown, when the main generator is unavailable, power is obtained through two start-up transformers from the grid through the 230 kV switchyard. Each start-up transformer is supplied with a separate 230 kV overhead line from the 230 kV switchyard. These two transformers have sufficient capacity to provide for start-up and full load operation of the Unit. They also provide two separate sources of preferred (offsite) power to the Unit.

An additional path of power supply from the high voltage grid to the Plant Electric Power Distribution System can be made available after disconnecting the main generator from the 22 kV bus by opening the disconnect links. The 22 kV bus power supply is thereby rearranged from its normal configuration into a configuration such that power can be fed from the offsite power system through the main transformer bank to the unit auxiliary transformer, leaving the main generator disconnected.

The Offsite Power System is discussed in more detail in Section 8.2.

8.1.3 ONSITE POWER SYSTEM

The Onsite Power System includes two 6.9 kV ESF buses (1A-SA and 1B-SB), two diesel generators (1A-SA and 1B-SB), several 480V buses (supplying loads directly and through motor

control centers), two 125V DC ESF batteries (1A-SA and 1B-SB), four 120V AC ESF uninterruptible buses, two 125V DC ESF buses, and several ESF 208Y/120V power distribution panels. The main one line diagram, Figure 8.1.3-1, auxiliary one line diagram, Figure 8.1.3-2, and the 125V DC, 250V DC and 120V AC one line diagram, Figure 8.1.3-3, show the complete Onsite Power System configuration.

The two ESF buses supply all of the safety related loads. The normal source of power for the ESF buses is the main generator/unit auxiliary transformer. When this source of power is not available, power will be supplied to these buses from the 230 KV switchyard through the start-up transformers or with the generator disconnect links removed, from the main and unit auxiliary transformers. When neither of these sources is available, power to the two ESF buses will be supplied from diesel generators (one diesel generator for each ESF bus).

Two independent redundant divisions of ESF equipment are provided in the onsite system. Should the preferred source of power to either of these redundant divisions be lost, the onsite system will receive power automatically from the appropriate diesel generator. Upon loss of the 6.9 kV unit auxiliary buses, all non-safety related loads will be automatically disconnected from the onsite system, and all safety related loads will be automatically disconnected from the ESF buses. The disconnected safety related loads will then be reconnected to the ESF buses in a sequential manner as described in Section 8.3. Each redundant ESF division can supply sufficient power to its safety related loads to enable safe shutdown of the reactor and/or mitigate the consequences of a design basis accident. The Onsite Power System is discussed in more detail in Section 8.3. The safety related loads are listed in Table 8.1.3-1 (AC loads) and Table 8.3.2-1 (DC loads).

8.1.4 DESIGN BASES

8.1.4.1 Offsite Power System

The Offsite Power System is designed to:

a) Provide a reliable source of auxiliary power for start-up, operation and shutdown of the plant.

b) Provide for transmission of the SHNPP output to the CP&L's grid.

c) Comply with NRC General Design Criterion 17 (Electric Power Systems) by providing two electrically and physically independent transmission circuits from the grid to the Plant Electric Power Distribution System; each circuit is designed to be available within a few cycles following a design accident to assure that vital safety functions are maintained.

d) Minimize the probability that loss of one preferred offsite power source will cause the loss of the other, or of the Onsite Power System.

8.1.4.2 Onsite Power System

The Onsite Power System is designed to:

a) Provide a reliable source of auxiliary power for safe shutdown of the reactor, assuming loss of offsite power and a single failure in the Onsite Power System.

b) Provide independent, redundant and testable power supplies, each with its own distribution system, so that the required safety function can be performed by either power supply, assuming a single failure in the other power supply or in its distribution system.

c) Provide for testing the operability and functional performance of the components of each system and of the systems themselves.

d) Be capable of withstanding the effects of the design basis wind, design basis tornado, probable maximum flood and safe shutdown earthquake without loss of power to safety related components essential to safe shutdown or to maintaining the plant in a safe condition, assuming a loss of offsite power and a single failure of an onsite power supply system.

e) Minimize the probability that loss of one onsite power supply or of its distribution system will cause loss of the other onsite supply, of the other onsite distribution system or of the Offsite Power System.

There is no non-class 1E equipment utilized for which credit is taken during or following a design basis accident for safe shutdown, nor for maintaining the plant in a safe condition. With the exception of during D/G test mode the non-class 1E relay and its power supply, receiving signal from UAT and SAT breaker position or SAT breaker position and generator lock out, will trip the D/G output breaker and the non-safety bus to ESF bus tie breaker.

Details of seismic design and testing are provided in Section 3.10.

8.1.4.3 Criteria, Codes and Standards

The electrical power systems and equipment are designed in accordance with the following criteria with a level of implementation as described in Sections 8.3.1.2 and 8.3.2.2. Wherever alternative approaches are used to meet the intent of some specific recommendations of the following NRC Regulatory Guides and IEEE Standards, the method of attaining an acceptable level of safety is found in Sections 8.3.1.2 and 8.3.2.2.

a) The applicable General Design Criteria, as listed in 10CFR Part 50, Appendix A, are discussed in Section 3.1.

b) IEEE Standards:

1) IEEE Std 279 - 1971 - Criteria for Protection Systems for Nuclear Power Generating Stations.

2) IEEE Std 308 - 1971 - Criteria for IE Electric Systems for Nuclear Power Generating Stations.

3) IEEE Std 317 - 1976 - Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

4) IEEE Std 323 - (for applicable issue date, refer to Sections 3.10 and 3.11) Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations.

5) IEEE Std 334 - 1974 - Standard for Type Test of Continuous Duty Class IE Motors for Nuclear Power Generating Stations.

6) IEEE Std 336 - 1971 - Installation, Inspection and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations.

7) IEEE Std 338 - 1975 - Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems.

8) IEEE Std 344 - 1975 - Guide for Seismic Qualification of Class I Electrical Equipment for Nuclear Power Generating Stations.

9) IEEE Std 379 - 1977 - Guide for the Application of the Single Failure Criterion to Nuclear Power Generating Station Protection Systems.

10) IEEE Std 382 - 1972 - Trial-Use Guide for the Type-Test of Class 1 Electric Valve Operators for Nuclear Power Generating Stations.

11) IEEE Std 383 - 1974 - Standard for Type Test of Class IE Electric Cable, Field Splices, and Connections for Nuclear Power Generating Stations.

12) IEEE Std 384 - 1974 - Criteria for Separation of Class IE Equipment and Circuits.

13) IEEE Std 387 - 1977 - Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Stations.

14) IEEE Std 415 - 1976 - Planning of Pre-Operational Testing Programs for Class IE Power Systems for Nuclear Power Generating Stations.

15) IEEE Std 420 - 1973 - Trial-Use Guide for Class IE Control Switchboards for Nuclear Power Generating Stations.

16) IEEE Std 450 1975 - Recommended Practice for Maintenance, Testing and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries.

17) IEEE Std 484 - 1975 - Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants.

c) REGULATORY GUIDES (RG) - For the discussion of applicability and implementation of the following Regulatory Guides, refer to Section 1.8:

1) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and between their Distribution Systems.

2) RG 1.9 - Selection of Diesel Generator Set Capacity for Standby Power Supplies.

3) RG 1.22 - Periodic Testing of Protection System Actuation Functions

4) RG 1.29 - Seismic Design Classification

5) RG 1.30 - Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment.

6) RG 1.32 - Use of IEEE Std 308, "Criteria for Class IE Electric Systems for Nuclear Power Generating Stations".

7) RG 1.40 - Qualification Tests for Continuous Duty Motors Installed Inside the Containment of Water Cooled Nuclear Power Plants.

8) RG 1.41 - Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments.

9) RG 1.47 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.

10) RG 1.53 - Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems.

11) RG 1.62 - Manual Initiation of Protective Actions.

12) RG 1.63 - Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Plants.

13) RG 1.68 - Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors.

14) RG 1.70 - Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants

15) RG 1.73 - Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants.

16) RG 1.75 - Physical Independence of Electric Systems.

17) Intentionally deleted.

18) RG 1.89 - Qualification of Class 1E Equipment for Nuclear Power Plants.

19) Intentionally Deleted

20) RG 1.100 - Seismic Qualification of Electric Equipment for Nuclear Power Plants.

21) RG 1.106 - Thermal Overload Protection for Electric Motors on Motor-Operated Valves.

22) RG 1.108 - Periodic Testing of Diesel Generators Used as Onsite Power Systems at Nuclear Power Plants.

23) RG 1.118 - Periodic Testing of Electrical Power and Protection Systems.

24) Intentionally Deleted

25) Intentionally Deleted

26) Intentionally Deleted

d) BRANCH TECHNICAL POSITIONS (BTP) ICSB - 11/75

1) BTP EICSB 2 (PSB) Diesel-Generator Reliability Qualification Testing.

2) BTP EICSB 6 (PSB) Capacity Test Requirements of Station Batteries-Technical Specifications.

3) BTP EICSB 8 (PSB) Use of Diesel-Generator Sets for Peaking.

4) BTP EICSB 11 (PSB) Stability of Offsite Power Systems.

5) BTP EICSB 15 (PSB) Reactor Coolant Pump Breaker Qualification.

6) BTP EICSB 17 (PSB) Diesel Generator Protective Trip Circuit Bypasses.

7) BTP EICSB 18 (PSB) Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves.

8) BTP EICSB 21 Guidance for Application of RG 1.47.

e) NUREG – 0737 Clarification of TMI Action Plan Requirements.

f) In addition to the above, all transmission lines and substations are designed and constructed in accordance with applicable industry standards, including those of the Carolina Power & Light Company. All electrical equipment, both onsite and offsite, is designed and manufactured to applicable ANSI, NEMA, IEEE and other industry standards.

8.2 OFFSITE POWER SYSTEM

8.2.1 DESCRIPTION

This section provides a description of the Offsite Power System and its components and a discussion of system compliance with the design criteria given in Section 8.1.4 "Design Bases." Information presented in this section is given for the SHNPP Unit.

8.2.1.1 Transmission Lines

The Shearon Harris Nuclear Power Plant is connected to the Carolina Power & Light Company (now Duke Energy Progress) transmission grid by eight 230 kV transmission lines. Figures 8.2.1-1 and 8.2.1-2 show how the SHNPP is connected into CP&L's transmission system. A list of the transmission lines connecting the SHNPP to the CP&L transmission system is given in Table 8.2.1-1. This table includes line termination points, voltage, rated MVA, and approximate length.

All transmission line structures and support systems are designed for the following load cases:

1. National Electrical Safety Code Medium Loading (1/4" Radial Ice + 40 mph Wind + Overload capacity factors)

2. CP&L High Wind Loading of 90 mph wind on bare wires and structures.

3. CP&L Heavy Ice Loading (1" Radial Ice, No Wind)

Loadings are applied to all conductor spans and shield wires for all cases rather than incorporating a gust and span reduction factor.

The highest observed wind speed recorded at the Raleigh-Durham Weather Service was a 79 mph wind in September 1996. A climatic review of the plant site area indicates the ice in Case 3 is 35% greater than the greatest radial thickness (.74 inches) on utility wires observed during the nine winters between 1928 and 1937.

All transmission line structures and support systems are designed above the maximum observed occurrences within the service area, therefore, no significant problems are expected with line icing or other heavy loading conditions.

The transmission lines are designed for an insulation level that will minimize lightning flashover. Historically, the Piedmont area of North Carolina has experienced an average of 45 thunderstorm days per year. Experience with over 2,000 miles of 230 kV lines indicates that CP&L's transmission lines are "lightning free" by the utility industry definition of less than one lightning outage per 100 miles of line per year. It is expected that the SHNPP transmission lines will have similar operating characteristics and will, therefore, also be lightning free.

Galloping conductors are considered a rare phenomenon in this area and should not affect the reliability of the SHNPP transmission lines. The conductor configuration reduces the probability of flashover resulting from galloping conductors.

The off-site (preferred) power system for the SHNPP consists of the CP&L transmission network (grid), the 230 kV switchyard, two 230/6.9 kV start-up transformer circuits, 6.9 kV Non-Class 1E switchgear, and 6.9 kV Nuclear Safety Class 1E busses. The two start-up transformer circuits from the switchyard to the start-up transformers consists of 230 kV overhead lines, and from the start-up transformers to the 6.9 kV switchgear, 6.9 kV non-segregated bus ducts. Sufficient separation is maintained between the two startup transformer circuits (from the switchyard to the on-site Class 1E power system) so that each circuit acts as an independent connection to the off-site power system.

Eight 230 kV transmission lines connect the switchyard to the transmission network. All eight transmission lines have been constructed and are currently energized. Transmission line routing near the plant is shown in Figure 8.2.1-1.

The Harris Plant occurs on the transitional zone between North Carolina's coastal plain and piedmont physiographic regions. Therefore, the Harris Transmission Lines traverse both regions. The coastal plain ranges from nearly flat to very gently rolling. The piedmont region is gently rolling with most steep slopes occurring around drainage ways. The terrain associated with all Harris Transmission Lines is not considered rugged. Slopes are no greater than 45% as most areas are gently rolling with no prominent hills. The terrain is most broken near large streams where elevation differences range from 50 to 100 feet between the highest and lowest elevations.

Consequently, there are no safety related problems resulting from the terrain and no unusual features that require special design plans. As a result, the lines have been constructed using standard designs and routine engineering guidelines that have proven safe and reliable through experience.

The eight transmission lines that are currently in service are the 230 kV lines to Cape Fear North, Cape Fear South, Ft. Bragg Woodruff St., Erwin, Siler City, Apex US #1, Wake, and Research Triangle Park (RTP). The lines come from seven different substations and approach the plant from different directions. As they enter the plant area, five circuits share a common right-of-way. In that common corridor, the lines are spaced sufficiently far apart to preclude the possibility of one line's failure causing the failure of more than one other line.

Figure 8.2.1-2 illustrates an overview of the area near the 230 kV Switchyard where common corridors are shared. All transmission lines associated with the SHNPP, the steel and wood structure sections, and the structure locations are shown. Figure 8.2.1-3 shows a cross-section sketch at area A of Figure 8.2.1-2 along the initial common corridor in the steel H frame section. Included are the fall line renderings which show the fall zone for each structure. It should be noted that the fall zone shows a worse case situation and that a steel structure failure at ground level and falling perpendicular to the corridor is highly unlikely. Figure 8.2.1-4 illustrates a cross-section sketch at area B of Figure 8.2.1-2 along the second common corridor having four wood H-frame transmission lines. Included are fall line rendering which show the fall zone for each structure. Figure 8.2.1-5 shows the fall line rendering for a cross-section sketch at area C of Figure 8.2.1-2 for three transmission lines in close proximity as they leave the Harris Plant area. The rendering demonstrates that the Apex US#1 Line could impact both the Wake and RTP Lines if the structures were to fall in opposite directions. This would only be expected to occur in a severe weather condition, such as a tornado where wind shifts could rapidly occur in a single event. However, even if this catastrophic event were to cause an outage on all three of these transmission lines, the fault would only cause the loss of one of the two redundant feeds to one of the two startup transformers. Five lines would still remain to provide off-site power to both startup transformers for safe shut-down. This meets the General Design Criterion 17 to "provide two, physically independent transmission circuits (not necessarily on separate rights of way) designed and located so as to minimize, to the extent practical, the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions."

Two transmission lines must cross each other while gaining access to the plant. The Siler City 230 kV line crosses the Cape Fear North 230 kV line approximately three miles southwest of the 230 kV switchyard. If an outage occurred on these two lines, six other 230 kV lines would

remain to supply the preferred power sources. Since there are eight 230 kV lines into the switchyard, the spacing is sufficient and there is only one line crossing, no single failure of a 230 kV line would preclude the ability to provide off site power to the plant for safe shut down. We conclude that the routing of the transmission circuits is in accordance with General Design Criterion 17 and is, therefore, acceptable.

Sections 8.3.1.2.2 and 8.3.1.1.2.12 and Chapter 14 of the FSAR address GDC-18 regarding Onsite System circuits that supply safety loads from the transmission network.

8.2.1.2 Substation

The 230 kV switchyard is located approximately 500 ft. south of the Turbine Building. The 230 kV switchyard accepts the electrical output of the Unit and supplies the 230 kV transmission system via eight 230 kV transmission lines

The full development of the 230 kV switchyard (see Figure 8.2.1-6) utilizes breaker-and-a-half and double-breaker schemes with the Unit connected in a double breaker scheme. The breaker-and-a-half scheme and the double breaker scheme offer the following operating flexibility:

a) Any transmission line into the switchyard can be cleared either under normal or fault conditions without affecting any other transmission line or bus.

b) Either bus can be cleared under normal or fault conditions without interruption of any transmission line or the other bus.

c) Any circuit breaker can be isolated for maintenance or inspection without interruption of any transmission line or bus.

d) A fault in a tie breaker or failure of the breaker to trip for a line fault will result only in the loss of its two adjacent circuits until it can be isolated by disconnect switches.

e) A fault in a bus-side breaker or failure of the breaker to trip for a line or generator fault will result only in the loss of the adjacent circuit and the adjacent bus until it can be isolated by disconnect switches.

The 230 kV switchyard provides power through the start-up transformers for the Unit's auxiliary system for start-up, emergency or controlled shutdown, or any time power is not available from the Unit's auxiliary transformers.

The Harris Plant 230kV Switchyard power circuit breakers are manufactured by HVB, Mitsubishi and ABB and are all rated 3000 amperes 60Hz with a current interrupting time of two (2) cycles on a 60Hz basis. The breakers have operating characteristics as described below.

The breakers manufactured by HVB are of the three-pole oil-less type using arc-quenching sulfur-hexafluoride (SF6) gas for current interruption. They are pneumatically operated with each circuit breaker having its own individual motor-driven air compressor and three compressed air reservoirs. Sufficient compressed air storage is provided for four successive

close-open circuit breaker operations, starting at normal operating pressure, without the need for compressor operation between or during these close-open operations.

The breakers manufactured by ABB are multiple-tank, SF6 puffer type circuit breakers with independent pole operation, using arc-quenching SF6 gas for current interruption. Each circuit breaker consists of three (3) single break puffer type interrupter units and three (3) hydraulically operated mechanisms. Hydraulic oil drives each mechanism, consuming energy from a stack of disc springs. Each mechanism spring is charged using a motor. The motor start is staggered on each pole to reduce the load control circuit. Each mechanism is connected to an interrupter, which allows the contacts to open and close. There is sufficient stored energy for an open-close-open sequence if the breaker is initially closed without re-charging the spring.

The breakers manufactured by Mitsubishi are multiple-tank, SF6 puffer type circuit breakers with gang-operated poles, using arc-quenching SF6 gas for current interruption. Each circuit breaker consists of three (3) single break puffer type interrupter units which are connected together to a single spring operated mechanism. The spring operated mechanism uses energy stored in a trip spring to operate the interrupter units and open the breaker. A closing spring is used to close the breaker and to recharge the trip spring. A motor is used to recharge the closing spring at the end of each closing operation. There is sufficient stored energy for an open-close-open sequence if the breaker is initially closed.

The interrupting capability is 63,000 amperes symmetrical Root Mean Square (RMS) at 230 kV for the HVB, Mitsubishi & ABB breakers. Closing and latching current capability is 101,000 amperes symmetrical RMS for the HVB, Mitsubishi & ABB breakers. Refer to FSAR Figure 8.2.1-6.

Control of all 230 kV circuit breakers associated with the generator and start-up transformers is administered from the plant Control Room. Control of all transmission line circuit breakers is administered remotely via supervisory control systems from CP&L's Energy Control Center and locally via controls in the Switchyard Control Building. The switchyard is provided with two independent 125 volt DC systems to furnish the control power for the circuit breakers (see Figure 8.2.1-7). These systems are independent of the plant DC systems, and each consists of a 125 volt battery and battery charger, located in the switchyard relay house. One additional battery charger is provided as a spare.

All 230kv Switchyard breakers, with the exception of Mitsubishi breakers used for the Main Transformer breakers, have poles that operate independently of each other, however, the relaying system is arranged to trip all three poles simultaneously for any type of fault. The aforementioned Mitsubishi breakers utilize "gang-operated" poles. The independent-pole breakers utilize two separate trip coils for each pole. The Mitsubishi gang-operated pole breakers utilize two trip coils for the breaker. These trip coils are used with two separate sets of relay protection, termed primary and back-up, and provide a high degree of operation reliability. Separate current transformers are provided for the primary and back-up relaying systems.

Primary protection for the 230 kV transmission lines is provided by directional comparison carrier relaying using a phase and ground distance relay and directional overcurrent ground relay. Additionally, backup protection is provided by a phase and ground distance relay and directional overcurrent ground relay on six of the 230 kV transmission lines. The back-up protection on the Cape Fear North and Cape Fear South 230 kV lines is provided by permissive overreaching transfer trip relaying which also utilizes a phase and ground distance relay and

directional overcurrent ground relay. The communication paths for the overreaching transfer trip relaying are audio tones transmitted via microwave. The overreaching transfer trip relaying and the directional comparison relaying on the two Cape Fear lines provide two high speed relaying schemes which meet the unit stability criteria. Additionally, first zone impedance phase and directional overcurrent ground protection is provided in the back up protection of the two Cape Fear 230 kV lines.

In addition to primary and back up relaying systems, each transmission line circuit in the 230 kV switchyard is equipped with three-shot reclosing. No instantaneous reclosing is allowed, and all automatic reclosing tests are made to a hot line only, using synchronism-check.

Each 230 kV breaker is provided with breaker failure protection. The scheme used is designed to trip all breakers adjacent to a stuck breaker.

Disconnecting switches for the 230 kV switchyard are three-pole, group-operated, vertical-break, rotating insulator type and are rated on the same continuous current basis as their associated circuit breaker. These disconnecting switches are arranged for manual, local operation only.

The 230 kV switchyard buses are each protected by a primary and back up bus differential relaying scheme. Each set of these relays trip separate lockout relays to energize separate trip coils for all circuit breakers on a faulted bus.

The control cables for all 230 kV switchyard equipment are segregated as to primary relaying and control, back up relaying and control, and 480 AC volt power circuits. All cables are routed between equipment in such a manner as to maintain the separation between primary and back-up circuits.

The following parameters and conditions of the 230 kV switchyard are monitored in the plant control room:

a) North 230 kV bus voltage

b) South 230 kV bus voltage

c) Power Circuit Breaker Open/Closed Position Indication

d) Unit and Unit Startup Transformer Power Circuit Breaker Trouble Alarms

A supervisory remote terminal unit linked to the CP&L Energy Control Center continuously monitors the following 230 kV switchyard parameters and conditions:

a) North 230 kV bus and South 230 kV bus voltages

b) Transmission line and startup transformers watts and vars

c) Power circuit breaker open/closed position indication

d) Power circuit breaker trouble alarms

e) Relay operation and status alarms

f) Switchyard battery trouble alarms

g) Generator gross, Auxiliary and Start-up Kilowatt-Hours

h) Generator gross Watts and Vars

i) Auxiliary Watts and Vars

The 230 kV switchyard area is lighted by high-mast sodium vapor lighting fixtures installed on 100-foot galvanized steel poles. These poles are designed to withstand a constant wind velocity of 100 MPH with a 1.3 gust factor. Two poles with fixtures are provided; each pole is located so that failure of one pole will not cause the simultaneous loss of both switchyard buses; and therefore, will not preclude the capability of providing off-site power to the start-up transformers.

8.2.1.3 Start-Up Transformers

Two half-capacity start-up transformers, identified as "A" and "B", are provided for the Unit (see Figure 8.2.1-6). These start-up transformers have the capability of supplying power to the Unit's auxiliary systems for normal start-up and shutdown or emergency shutdown. These transformers are fed by the two preferred (off-site) power sources (the North 230 kV Bus and the South 230 kV Bus) via 230 kV overhead lines. The high-voltage winding of transformer "A" is fed from the North 230 kV Bus, and the high-voltage winding of transformer "B" is fed from the South 230 kV Bus. This start up transformer arrangement affords two preferred power sources for the Unit.

The start-up transformers are each rated at 36/48/60 MVA oil air/forced air/forced oil air (OA/FA/FOA) at 55 C rise and 67.2 MVA (FOA) at 65 C rise. The high-voltage winding is rated at 230 kV, and each transformer has two low-voltage windings rated at 6.9 kV. Each low-voltage winding is rated at 18/24/30 MVA OA/FA/FOA at 55 C rise and 33.6 MVA (FOA) at 65 C rise.

The minimum safe shutdown and LOCA load requirements are shown in Table 8.3.1-2a and 8.3.1-2b. The loading shown in these tables is much less than the 18 MVA (55°C OA) rating of the 6.9 kv SUT winding that supplies each train of the emergency distribution system.

The impedance of the start-up transformers ensures adequate starting and running voltages for the SI pump motors and valve motors during the most limiting condition as demonstrated by Calculations E-6000 (AC System Voltage Study) and E5-0001 (AC MOV Torque Calculation).

Normal transfer of the source of power for the 6.9 kV auxiliary buses between the auxiliary and start-up transformers for start-up or normal shutdown is initiated by operator action from the Control Room. Emergency transfer of auxiliary buses from the auxiliary transformers to the start-up transformers is initiated by protective relay action. Normal and emergency bus transfers are described in detail in Subsection 8.3.1.1.2.4.

One spare start-up transformer, identical to the other two transformers discussed above, is provided to minimize outage time in case of a transformer failure. This transformer is located in

the transformer yard and can be placed in service within the time period specified by Regulatory Guide 1.93.

The following separation criteria apply to the start-up transformers and associated loads in order to maintain independence from each other and to ensure compliance to GDC 17 and Regulatory Guide 1.32:

1. The high-voltage circuits of each start-up transformer utilize independent overhead lines, routed separately.. The "A" and "B" circuits are terminated separately, and can be fed from either bus in the 230 kV switchyard.

2. Each transformer's low-voltage leads are run in 6.9 kV non-segregated bus ducts, rated 3,000 amperes, to their respective 6.9 kV switchgear.

3. The "A" and "B" start-up transformers are physically separated from each other to prevent a single accident (e.g., fire or explosion) from jeopardizing the operation of the other transformer (see Figure 8.2.1-8).

   Each start-up transformer is protected by differential relays, overcurrent relays, and fault pressure relays which trip a lockout relay. This lockout relay will initiate tripping of all 230 kV breakers necessary to de-energize the high-voltage winding and will trip the two 6.9 kV switchgear breakers to clear the low-voltage windings.

   A hot-spot winding temperature detector system is provided for each start-up transformer to function with the plant's data logging system. This hot-spot temperature detector connection is independent of any other alarm.

Indicators for monitoring transformer parameters are provided on each transformer and include:

1. Winding Temperature (each winding)
2. Oil Temperature
3. Oil Level
4. Gas Detector

Alarms for each start-up transformer include:

1. Winding Temperature High
2. Hot Oil
3. Low Oil
4. Low Oil Flow
5. Fault Pressure Relay Operation
6. Gas Detector

7. Pressure Relief Device
8. Loss of Normal Auxiliary Power
9. Loss of Emergency Auxiliary Power
10. Loss of Cooling Control Power
11. Fault Pressure Relay 1
12. Fault Pressure Relay 2

Indicating lamps for each alarm are provided on each transformer control cabinet and are visible without opening the cabinet door. Seal-in circuits for lamps, pushbutton reset and separate contacts for connection to the plant's annunciator and data logging systems are also provided as part of the alarm system.

8.2.1.4 Generator Main Step-Up Transformers

The main step-up transformer bank consists of three single-phase transformers, rated as follows: 425 MVA each, Oil-Directed, Air-Forced (ODAF), 65C rise, 230 kV phase-to-phase high voltage winding 21,500 volts low voltage winding. The transformer bank is connected wye on the high voltage side and delta on the low voltage side.

The high voltage windings of the transformer bank are connected to the 230 kV switchyard by overhead lines. The low voltage windings of the transformer bank are directly connected to the generator via isolated phase bus.

The isolated phase bus is rated 23 kV, 30,310 amperes, forced air (FA) cooled at 65 C rise. Provisions are made for connections to the auxiliary transformer high voltage terminals and to the potential transformer cubicle. Bolted disconnect links within the isolated phase bus are furnished so that the generator can be disconnected from the main step-up and auxiliary transformers to allow off-site emergency power to be back fed into the auxiliary system from the 230 kV switchyard (see Figure 8.2.1-9). This backfeed capability can be accomplished in approximately eight hours and can be used as a source of off-site power in the event that one of the startup transformers is out of service.

8.2.2 OFF-SITE POWER SYSTEM - ANALYSIS

8.2.2.1 System Analysis

The contiguous eastern service area of CP&L is securely connected to the Eastern United States Power Grid. Most of the companies in the United States that are east of the Rockies and some companies in Canada are connected together to form this grid. Each connecting company is a source to this grid and the grid itself serves as a source of power to all member companies during emergencies. Thus, the extremely large Eastern United States Power Grid, with its very high degree of availability, is a highly reliable source of electrical power to CP&L and all other members of the Grid. Interconnections between CP&L's eastern service area and the Eastern United States Power Grid consist of two 500 kV interconnections, twenty four 230 kV interconnections, and eight 115 kV interconnections. These interconnections, along with

CP&L's strong internal transmission network and diversified generating facilities located in different parts of the system, combine to make CP&L a very strong and reliable system.

The 965 MW Unit at SHNPP (a maximum unit net output for system analyses) is integrated into the CP&L transmission system by eight 230 kV lines: the Erwin 230 kV Line, extending southeast from the plant; the Ft. Bragg Woodruff St. 230 kV Line, extending south from the plant; the Cape Fear Plant 230 kV North and South Lines, extending southwest from the plant; the Siler City 230 kV Line, extending west from the plant; the Wake 230 kV Line, the Apex US#1 230 kV line and the RTP 230 kV Line, extending northeast from the plant. These eight lines, radiating in different directions from the plant, connect to strong and diverse parts of the CP&L system. For the greater part of their lengths, these lines are on separate rights of way. The probability of transmission grid availability to supply off site power to SHNPP is extremely high.

The eight 230 kV transmission lines which connect SHNPP to the CP&L system are constructed on CP&L standard structures, which through the years, have proven to be very reliable. Past experience with similar 230 kV lines on the CP&L system has shown availability to be virtually 100 percent.

The CP&L Transmission System Map, Figure 8.1.1-1, shows the interconnections between CP&L and the Eastern United States Power Grid.

As mentioned earlier, the 965 MW Unit at SHNPP (a maximum unit net output for system analyses) feeds directly into the 230 kV transmission system via eight lines: the Apex US #1 230 kV Line; the Wake 230 kV Line; the RTP 230 kV Line; the Erwin 230 kV Line; the Ft. Bragg Woodruff St. 230 kV Line; the Cape Fear Plant 230 kV South Line; the Cape Fear Plant 230 kV North Line; and the Siler City 230 kV Line. The typical power flows at SHNPP with these eight lines in service are shown on Figure 8.2.2-1. The supply for preferred power at SHNPP is the 230 kV system. Carolina Power & Light Company considers that each of the switchyard 230 kV buses - the North 230 kV bus and the South 230 kV bus - is a source of preferred power for the SHNPP Unit.

To maintain a high availability of the Eastern United States Power Grid to CP&L, Carolina Power & Light Company - 1) makes extensive studies of its internal transmission requirements, and 2) participates in joint intraregional studies with its neighbors in the SERC.

To determine the adequacy of the transmission system in the above studies, the following planning criteria have been used by Carolina Power & Light Company both in its internal planning and in its joint planning with neighboring utilities and regions.

Each system will be able to withstand the following contingencies:

1. Sudden loss of the entire generating capability at any plant.

2. Sudden loss of any large load or load center.

3. Sudden loss of all lines on a common right-of-way.

4. The delayed clearing of a three-phase fault at any point on the system due to breaker failure.

5. The outage of the most critical transmission line caused by a three-phase fault during an outage of any other critical transmission line.

Planning according to the above criteria assures a high availability of the grid and CP&L transmission system and provides a reliable off-site power supply to SHNPP.

Studies involving the planned resource and transmission expansion of CP&L and its neighboring utilities indicate that the CP&L transmission system will more than meet the above criteria and that such emergencies will not cause the complete loss of preferred power service to the SHNPP. The following is a discussion of the results of studies made to test the performance of the SHNPP 230 kV transmission under the conditions of the preceding five criteria.

1. Sudden Loss of the Entire Capability at Any Plant - An investigation was made of the joint planning studies with neighboring utilities and of the CP&L internal planning studies which involves the loss of the entire generating capacity at major plants in the region. This investigation indicates that the most adverse system condition for CP&L results from the complete loss of the Roxboro Plant generation. As a result, load flow and stability studies were conducted to investigate the effects of this emergency condition. Figure 8.2.2-2 illustrates the expected power flows on the eight line SHNPP transmission system after the loss of the Roxboro Plant generation. None of the SHNPP transmission lines are heavily loaded. The expected phase angle swings of the SHNPP Unit and other major CP&L Units resulting from the loss of the entire generation at the Roxboro Plant is shown in Figure 8.2.2-3. The phase angle swing of the SHNPP Unit is closely related to the phase angle swing that would be experienced by the preferred power source at SHNPP 230 kV bus. Only minor phase angle swings of CP&L units are noted. The greatest swing of the 230 kV system is about 21 degrees.

   Thus, it can be seen that the loss of the entire generating capability at any plant in the region will not cause the loss of either of the preferred power sources.

2. Sudden Loss of Any Large Load or Load Center - The load characteristics of CP&L and that of companies in adjacent areas are generally of a rural nature and do not have high density load concentrations. An analysis of the planned future transmission system of CP&L and its neighbors indicates that the transmission systems will be developed to distribute area loads over transmission lines so that the amount of load that will be lost due to any single event will be small and not be enough to cause the complete loss of either of SHNPP's preferred power sources. The loss of generation under criterion (1) above, imposes far greater transmission stress on the CP&L system than the loss of load.

3. Sudden Loss of All Lines on a Common Right-of-Way - The Cape Fear Plant 230 kV North Line, the Siler City 230 kV Line, the Cape Fear Plant 230 kV South Line, and the Ft. Bragg Woodruff St. 230 kV Line occupy adjacent rights of way for a distance of a little less than one mile. A sudden loss of these lines would leave the Erwin 230 kV Line, the Wake 230 kV Line, the RTP 230 kV Line, and the Apex US #1 230 kV Line to serve the Unit. Studies were made to test the effects of the sudden loss of all lines occupying a common right of way on the preferred power sources. These stability studies simulated a common three phase fault on the Cape Fear Plant 230 kV North Line, the Siler City 230 kV Line, the Cape Fear Plant 230 kV South Line, and the Ft. Bragg Woodruff St.

230 kV Line. The common fault was assumed to be cleared by normal operations of the breakers and relays protecting the four lines. The expected power flows for such an outage are shown on Figure 8.2.2-4. The power flows experienced on the remaining four lines are well within their capabilities. The phase angle swing that can be expected at the SHNPP during this event is shown on Figure 8.2.2-5. A relatively small swing of about 25 degrees results from this disturbance. Studies indicate that the SHNPP 230 kV transmission system will be stable and that such a disturbance would not cause the loss of either of the two preferred power sources.

4. Delayed Clearing of a Three-Phase Fault at Any Point on the System Due to a Breaker Failure - If a fault on any SHNPP 230 kV line is not cleared by normal breaker and relay operation, the fault is cleared in eleven cycles or less by the operation of back-up relaying. This type of fault and fault clearing imposes the most severe stability problems on the SHNPP transmission system and, as a result, imposes the greatest possibility for the loss of both 230 kV preferred power sources. A characteristic of the breaker-and-a-half scheme is that a stuck breaker adjacent to either the North 230 kV bus or the South 230 kV bus will cause the loss of the transmission line under the breaker's protection and the adjacent 230 kV bus. This results in the loss of one preferred power source. Service from the other bus or preferred power source will remain available to supply the SHNPP's safety-related facilities. Actually, only the malfunction of the breaker protecting either of the two start-up transformers would reduce service to the safety-related facilities to one supply. If any of the other bus-adjacent breakers malfunctions, the 230 kV bus and line will be lost but both start-up transformers will remain energized from the remaining 230 kV bus and will be available to supply the safety equipment needs. It is this characteristic of the breaker-and-a-half scheme that makes it so reliable with respect to providing service to the SHNPP safety equipment.

   The 230 kV switchyard connects together eight 230 kV lines and two 230/6.9 kV start-up transformers to serve the Unit. For improved reliability, the switchyard has two 230 kV buses. The Unit is connected to these two buses in a double breaker scheme. The Wake and Apex US#1 230 kV lines are served from a breaker string in a breaker-and-a-half scheme. The Ft. Bragg Woodruff St. and Erwin 230 kV lines are served from another breaker string in the breaker-and-a-half scheme. The Siler City and Cape Fear South 230 kV lines are served from another breaker string in the breaker-and-a-half scheme. Similarly, the combination of the start-up A transformer and the Cape Fear North 230 kV Line and the combination of the start-up B transformer and the RTP 230 kV line operate under a breaker-and-a-half scheme.

   Due to the double breaker scheme, the Unit will not be lost for a loss of either the South 230 kV bus or the North 230 kV bus. An analysis of the elements connected to the SHNPP 230 kV switchyard indicates that the worst stability problems would be imposed by a three-phase fault on either the Wake 230 kV Line or the Apex US#1 230 kV Line in which the common breaker, that is between these two lines in the breaker and a half string, sticks. This contingency would cause the loss of both the Wake 230 kV Line and the Apex US#1 230 kV Line. Power flows expected on the SHNPP transmission during the loss of these two lines are shown on Figure 8.2.2-6. None of the five remaining 230 kV lines serving the plant will be excessively loaded. The phase angle swing experienced by the unit during this emergency is illustrated on Figure 8.2.2-7. A maximum swing of about 49 degrees is experienced during this disturbance. The system is stable and the swing is quickly dampened out. An analysis of these two

figures indicates that neither of the two preferred power sources will be lost due to normal operation of protective relays for this disturbance.

5. The Outage of the Most Critical Transmission Line Caused by a Three-Phase Fault During an Outage of Any Other Critical Transmission Line - Under the NRC single event acceptance criterion, the fault is assumed to be cleared by normal breaker and relay operation.

   A careful review of the CP&L studies was made. It was found that stuck breaker disturbances under criterion (4) above imposed far more severe conditions on the CP&L transmission system serving the SHNPP preferred power sources than outages under criterion (5).

8.2.2.2 Grid Frequency Decay Study

In order to evaluate the grid frequency variations probable at the SHNPP, Grid Frequency Decay Studies were made. To make a grid frequency decay study, it must be assumed that a major disturbance has occurred which causes a large loss of generation on the transmission system and causes a portion of the transmission system to separate or island from the rest of the Eastern United States Power Grid. With the number of interconnections that CP&L (now Duke Energy) has, it is extremely difficult to predict how Duke Energy might actually island or separate. Historical studies assumed that simultaneous separation would occur precisely at the Duke Energy interconnections (tie lines). Under actual disturbance conditions, the cascading of transmission line trips would take place over a period of time and would be extremely unlikely to occur precisely on Duke Energy interconnection boundaries. The effect of cascading would also act to reduce the rate of decay of system frequency. An Updated Grid Frequency Decay Study considered the entire SERC region and simulated the loss of a large amount of generation to produce a load-generation mismatch of approximately 25% more load than generation. This included the loss of approximately 3400 MW of generation within the Duke Energy eastern area. A 0% generation reserve to aid in frequency recovery was assumed for conservatism. The simulation was run for a period of 30 seconds to also show the post-disturbance frequency recovery. Figure 8.2.2-8 shows the resultant frequency for selected buses throughout the SERC region, which would be applicable to the SHNPP 230 kV switchyard buses.

These results indicate that the minimum frequency of the SHNPP 230 kV preferred power sources would remain above 58 hertz and the frequency would quickly recover around 60 hertz. Additionally, the rate of frequency decay is well within the 5 hertz per second criteria. In conclusion, the results of these studies demonstrate that the reactor coolant pump motors at the SHNPP will be served by a highly reliable power source, and that the maximum rate of grid frequency decay of the system is well within the acceptable limits.

8.2.2.3 Analysis of Operating Voltages

An analysis of load flow studies provides a determination of the range of steady state operating voltages at the 230 kV buses at Harris Plant. The Harris North and South 230 kV buses are considered to be the off-site power sources for the Plant. The plant is designed such that its operating voltages are optimized for maximum and minimum load conditions and voltage

variations of offsite power sources in accordance with Branch Technical Position, PSB-1, "Adequacy of Station Electric Distribution System Voltages." Revision 0 - July 1981.

An analysis was made of the data taken from stability studies which investigated the coordinated performance of the Harris Plant with the transmission grid. This analysis covers the voltage and frequency deviations that take place at the Harris 230 kV buses during a system disturbance. The selected disturbance is the most severe transient problem of all those investigated for the Harris Plant. It involves a three-phase fault on the Apex US#1 230 kV Line at Harris Plant. Under this fault condition, it is assumed that the common breaker sticks in the breaker-and-a-half scheme at the plant between the Wake and Apex US#1 230 kV Lines. Consequently, the normal fault clearing time of 4 cycles is delayed to 11 cycles because the clearing action has to come from the operation of backup relaying. This action results in the loss of service to the plant of both of these 230 kV lines at a time when maximum acceleration of the Harris Plant Unit is taking place and the need for strong transmission connections between the plant and the grid is the greatest. Reclosing of either of these Lines would be supervised by synchro-check relays to minimize additional perturbations to the Unit from reclosing into a faulted Line.

During the 11-cycle period of the fault, the voltage on the Harris 230 kV buses is close to zero. Upon clearing of the fault, the voltage immediately rises to 89 percent. During the period of maximum transient, the 230 kV voltage continues to rise. The Harris 230 kV bus voltage continues to rise to a maximum of 102.4 percent at about 40 cycles from fault inception. During the fault, the frequency at Harris 230 kV buses accelerates to a maximum of 60.6 hertz at about 11 cycles from fault inception and then decelerates to a minimum of 59.3 hertz at about 33 cycles from fault inception. The Harris Unit is stable for this disturbance. The voltage and frequency excursions of the Harris 230 kV buses are being damped out during the ten-second period of the stability study and are returning to the normal plant voltage and to the normal 60 hertz frequency that is maintained by the Eastern United States Interconnected Transmission System.

The spread between the maximum and minimum voltage and frequency excursions at the Harris 230 kV buses occurring during the most adverse operating condition are not extreme and will not cause unsatisfactory operation of the plant's electrical equipment if such an emergency occurs.

8.3 ONSITE POWER SYSTEMS[1]

8.3.1 AC POWER SYSTEMS

8.3.1.1 Description

8.3.1.1.1 General

The Unit electrical distribution system consists of various auxiliary power systems which provide reliable power to all Unit auxiliary electrical loads, sufficient for all normal operating and

---

[1] Further information is contained in the TMI Appendix.

shutdown conditions. The systems are provided with sufficient power sources, switching capability, circuit protection and redundancy to accomplish this reliability.

The onsite AC power distribution system receives power under normal operating conditions through the Unit auxiliary transformers. Under start-up and shutdown conditions, power is supplied through the start-up transformers. Two non-safety-related 6.9 kV switchgear buses (ID and IE) provide the path of power from these transformers to the onsite power distribution system. Should the preferred (offsite) power from these buses be unavailable, onsite power is supplied directly to the onsite power distribution system from two emergency diesel generators (1A-SA and 1B-SB).

The onsite power system consists of two 6.9 kV diesel generators (1A-SA and 1B-SB), two 6.9 kV ESF buses (1A-SA and 1B-SB), various ESF and non-ESF 480V buses, motor control centers, 208/120V power panels, a Dedicated Shutdown Diesel Generator and a DC Power System. The DC Power System is described in Section 8.3.2. The AC Power System configuration and busing arrangements are shown on Figure 8.1.3-1 (Main One Line Diagram), Figure 8.1.3-2 (Auxiliary One Line Diagram), and Figure 8.1.3-3 (125V DC, 250V DC and 120V AC One Line Diagram). Identification of the safety related AC loads is given in Table 8.1.3-1. In addition, further detailed one line diagrams identifying safety loads are included in Drawing CAR-2166-B-041.

All safety-related electrical distribution equipment, including the raceway system and the safety-related loads are designed to meet seismic requirements as detailed in Section 3.10. In addition, all safety-related equipment meets environmental requirements as detailed in Section 3.11. There is no electrical equipment located below the flood level postulated during a LOCA.

8.3.1.1.1.1 6.9 kV Auxiliary System

The two 6.9 kV ESF buses 1A-SA and 1B-SB supply equipment essential for safe shutdown of the plant. These two buses receive power either from the non-safety-related buses ID and IE or from the diesel generators (1A-SA and 1B-SB). Either bus 1A-SA and 1B-SB can supply sufficient power to shutdown the plant and to maintain the plant in a safe condition, under normal and design accident conditions.

The 6.9 kV ESF buses are of indoor, three-phase, metal-clad construction, with drawout magnetic air or vacuum circuit-breakers. The circuit-breakers operate from 125 V DC control power which is supplied by the safety-related 125V DC system of the appropriate division (A or B) as described in Section 8.3.2. Each breaker may be electrically operated from the Control Room by the operator and may be automatically operated in conjunction with the emergency load sequencer (see Section 8.3.1.1.2.8) and/or protective relay operation, when in the "connected" position. In the "test" position, local electrical operation is possible, but the main power circuit will not be completed when the breaker closes. Breaker status is indicated by red (closed) and green (tripped or open) indicating lights in the Control Room and at the switchgear. These lights (either lamp lit) also monitor the breaker trip circuit power supply. For those breakers feeding motor loads, the breaker closing circuit is also monitored. Loss of closing circuit power supply and/or a malfunction of the charging mechanism are annunciated. Bus and breaker ratings are listed in Table 8.3.1-1. All buses and breakers have a short circuit rating which is greater than the maximum available short circuit current.

Power cables for the 6.9 kV auxiliary system are shielded and rated 15 kV, 90C with ethylene-propylene rubber insulation, a chlorinated polyethylene jacket and copper conductors. The cables are sized to carry the maximum available short circuit current for the time required for the circuit breaker or fuse to clear a fault.

The 6.9 kV ESF switchgear is located within switchgear rooms in the Reactor Auxiliary Building, which is a Seismic Category I structure and is protected from potential missile hazards. Physical separation is maintained in the location and installation of the ESF switchgear for the redundant systems. ESF Division A switchgear is located in a separate room from switchgear of ESF Division B.

8.3.1.1.1.2 480 Volt Auxiliary System

The 480V ESF auxiliary system receives power from the 6.9 kV system through dry type, three-phase indoor transformers. The arrangement of the ESF portions of the 480V auxiliary system is shown on Figure 8.1.3-2.

The 480V ESF auxiliary system consists of four power centers, several motor control centers (MCCs), the safety related loads and interconnecting cables. Two non-safety-related power centers, two non-safety- related MCCs, and the emergency lighting panels (non-Class IE) are also included in the 480V ESF system.

Each of the power centers includes a 6900-480V, three-phase, delta wye, indoor, dry type transformer, rated as given in Table 8.3.1-1, and connected to the power center bus through a circuit breaker. Current limiting reactors are provided where necessary to limit the available short circuit current to an acceptable level at a section of the power center bus intended for the connection of MCC feeder circuits. The use of power center reactors has been governed by the quantity of MCC's connected, the short circuit ratings of the MCC buses and circuit breakers, and the impedance of the cable to the MCC.

All power center breakers are of metal-enclosed, drawout construction, arranged for local operation when in the "test" position and for remote and/or automatic operation when in the "connected" position. Control power is furnished at 125V DC from the appropriate ESF division battery. Breaker status in the "connected" position is indicated by red (closed) and green (tripped or open) indicating lights in the Control Room, ACP or Aux Transfer Panel as applicable and, locally at the Power Center. With the breaker closed, the red (closed) light also monitors the breaker trip circuit power supply.

MCCs consist of metal enclosed groups of motor starters, contactors, feeder circuit-breakers, 208/120V dry type distribution transformers, power panels, and control devices, assembled in a common structure with horizontal and vertical buses. Incoming feeder reactors are used where necessary to limit the available short circuit current to an acceptable level.

Feeder circuit breakers in MCCs are manual, thermal magnetic trip, molded case units in 100 A frame size or larger as required.

Motor starters located in MCCs are combination type, consisting of a three pole disconnecting device, a magnetic contactor (or contactors if for reversing service), a three-pole thermal overload relay, a 480-120V control transformer and the necessary control devices for remote manual and automatic operation. MCC contactors, used in heater circuits and other non-motor

circuits requiring remote and/or automatic operation, are also combination type, consisting of the same components as motor starters, however, the thermal overload relays are excluded from the circuit. The disconnecting device is either a thermal-magnetic breaker, a magnetic breaker-current limiting fuses combination or magnetic breaker with adjustable instantaneous trip settings in lieu of current limiting fuses. In some cases, where back-up protection is required (i.e., penetration circuits), or for emergency lighting circuits an additional breaker, thermal-magnetic type, is included in the feeder circuit. Refer to Sections 8.3.1.1.2.11 and 8.3.1.1.2.15 for additional details.

Motor starters and/or heater contactors located outside the MCC, local to the serviced system, are generally provided by the system vendor and are designed to meet the necessary electrical requirements for the system operation and for connection to the ESF electrical distribution system.

Power and control cables for the 480V auxiliary system are either rated 600V, 90C with ethylene-propylene rubber type or cross-linked polyethylene insulation with flame resistant jacketing or they are rated 600V, 3 hour, steel jacketed, fire rated cables. Cables conductors are sized to carry the maximum available short circuit current for the time required for the circuit breaker or fuse to clear a fault.

All power center transformers, power center buses, and MCC buses have adequate capacity to supply the momentary and continuous loads connected to the 480V buses. The ratings of all electrical distribution equipment are listed in Table 8.3.1-1.

The ESF power centers of each division are located within separate switchgear rooms in the Reactor Auxiliary Building which is a Seismic Category I structure and are protected from potential missile hazards. Physical separation and fire walls are provided between redundant components. MCCs are separated from their redundant counterparts by physical separation or fire walls. Electrical and physical separation is detailed in Section 8.3.1.2.

8.3.1.1.1.3 208/120V AC system

Certain loads for which 480V three-phase supply is either impractical or undesirable are supplied from 208/120V distribution panels. In general, these panels are connected to 480-208/120V three-phase transformers. Panels and their transformers are either located in MCCs or wall-mounted. Loads may be supplied at 208V or 120V.

The transformer secondary wye winding has its neutral grounded. The same 600V cable sizing criteria used in the 480V system are also used in the 208/120V AC system. Both 600V power and control cable have an adequate rating for use in 120V AC and 125V DC power or control applications. For 208V AC through 480V AC service, 600V power cable is used. Separation criteria are the same as for the 480V ESF system.

8.3.1.1.1.4 120V Uninterruptible AC system

The 120V ESF uninterruptible AC system consists of four separate rectifier/inverters (Channels I, II, III, & IV) each supplying power to a separate 120V AC power distribution panel. The system configuration is shown on Figure 7.6.1-4. The loads include the four channel safety related Reactor Protection System (RPS) and Nuclear Instrumentation System (NIS) as well as the Post-accident Monitoring System (PAM) and other safety related vital instrumentation and

control loads. Refer to Section 7.5 and 7.6 for additional discussions for these ESF uninterruptible loads. There are no non-safety related loads connected to the 120V ESF uninterruptible AC system.

Each safety 7.5 KVA inverter is nominally rated 118 VAC, 60 Hz, and is normally supplied through its rectifier from a 480V ESF MCC. Should this voltage drop below the required level, the inverter is supplied automatically from a 125V DC ESF battery. Blocking diodes are provided to each input circuit to prevent voltage feedback. Channels I and III are powered from MCC 1A21-SA and MCC 1A31-SA respectively for the main feeds and 125 V DC bus DP 1A-SA for backup. Channels II and IV are powered from MCC 1B21-SB and MCC 1B31-SB respectively for the main feeds and 125V DC bus DP-1B-SB for backup.

Each inverter is also connected to a 120 VAC bypass power source and equipped with a static transfer switch. Channels I and III bypass power sources are from MCC 1A31-SA and MCC 1A21-SA respectively through 480VAC/120VAC voltage regulating transformers. Channels II and IV bypass power sources are from MCC 1B31-SB and MCC 1B21-SB respectively through 480VAC/ 120VAC voltage regulating transformers. The static transfer switch will automatically align the output of the inverter to the bypass power source upon inverter failure, inverter over-current, and inverter low output voltage or manually. The static transfer switch will automatically re-transfer the output from the bypass source to the inverter, once the inverter output has returned to normal operating voltage and current and remained within normal parameters for a predetermined time delay.

In addition, each inverter can be bypassed manually, via a connection to a 120V ESF power panel through a normally open switch at the uninterruptible bus. The alternate power sources are from 120/208 V Power Panel 1A211-SA, 1A311-SA for channels I and III, respectively, and Power Panel 1B211-SB, 1B311-SB for channels II and IV, respectively. There is no automatic transfer to this alternate power source. The system one line representation is shown on Figure 8.1.3-3, which also depicts the non-safety related 120V AC uninterruptible system.

The 120V ESF uninterruptible AC system is arranged so that any single failure or fault will not prevent proper functioning of the safety related system. Low AC and DC input voltage, low AC output voltage, and overcurrent are all alarmed as UPS trouble in the control room. Power and control cable for the 120V AC uninterruptible system is the same type as that used for the 208/120V system. With each Instrument Distribution Panel aligned to its associated UPS output (or to its automatic bypass source), the load supply cables have been sized to ensure adequate voltage is available at the load terminals under all plant conditions per Calculation E-6007.

The non-safety Vital AC Power Supplies are fed from two Static Uninterruptible Power Supplies (SUPS). These are used to power non-safety instrumentation and controls circuits, fire detection and radiation monitoring systems. They are both nominally rated 120 V, 60 Hz, single phase 60 KVA and 7.5 KVA. Both SUPS are designed to provide power to their loads normally from the main feed through the rectifier/inverter. Failure of the main AC feed will cause the 7.5 KVA SUPS to be powered from the non-safety battery. The 7.5 KVA SUPS is also connected to a 120 VAC bypass power source and equipped with a static transfer switch. The static transfer switch will automatically align the output of the inverter to the bypass power source upon inverter failure, inverter over-current or inverter low output voltage. The static transfer switch may also be operated manually. The static transfer switch has an auto re-transfer feature which returns the output to the inverter, once the inverter output has returned to normal operating parameters and remains within normal parameters for a predetermined time delay. The 7.5

KVA SUPS can also be bypassed using the manual bypass switch located on the SUPS cabinet itself or by using the remote maintenance bypass switch. There are no automatic transfer capabilities associated with either of these bypass switches. The 60 KVA SUPS will automatically transfer as discussed below.

Circuitry is provided in the non-safety 60 KVA vital AC SUPS to shut down the inverter portion and transfer to an alternate AC source via a high speed static switch. The static switch will automatically align the output of the inverter to the bypass power source upon: 1) Inverter Failure (loss of square wave resulting from power or control circuit malfunction), 2) Loss of Inverter AC Output Voltage (ferroresonant transformer failure), 3) AC Output Overload (125% current overload). The static switch includes auto-retransfer capability which returns the output from the bypass source to the inverter, once the inverter output has returned to normal operating parameters and remains within normal parameters for a period of 30 seconds. Manual actuation of the static switch is also possible using the bypass source to load switch located on the inverter front panel.

The loss of power to Class IE and Non-Class IE 120 V buses is alarmed in the Main Control Room. The alarms for each bus/panel are grouped into a single annunciator window to provide a system level alarm. The purpose of this alarm is to alert the control room operator to an electrical system problem. Also the Process Instrumentation Control Panels used to power equipment used for control interlock and indication are grouped in a single annunciator window.

The alarm message printouts are:

1) 60 KVA UPS Trouble
2) 7.5 KVA UPS Trouble
3) 125 V DC (NNS) Trouble
4) 125 V DC EMER BUS A/B Trouble
5) CHANNEL I UPS Trouble
6) CHANNEL II UPS Trouble
7) CHANNEL III UPS Trouble
8) CHANNEL IV UPS Trouble
9) PIC 5-6-7-8-11-12-15-16 Power Failure
10) PIC 1,2,3,4,9,10,13,14 Power Failure
11) PIC 17-18 Power Failure
12) PIC 19 Power Failure

Loads connected to the Class 1E and Non-Class 1E 120 V buses which are necessary for the plant to achieve cold shutdown are, the auxiliary relay cabinets, process instrumentation

cabinets, isolation cabinets, ESS cabinets and the solid state protection cabinets. During normal shutdown, several non-safety-related systems or portions of the safety systems with non-safety controls are utilized and therefore lacks redundancy. Examples are the Feedwater System, the Condenser Steam Dump System, the CVCS Letdown System and normal charging path of the CVCS system. A detailed analysis of these systems and the ability to take the plant to shutdown in the event of failure of the instrumentation and control loads are summarized in Table 8.3.1-9. Non-safety inverter failure will prevent the operator from utilizing several of these systems. However an alternate means of achieving cold shutdown is available by utilizing the part redundant system and non-safety systems which are powered from diverse power panels as described in the safe shutdown analysis in case of fire.

8.3.1.1.1.5 Standby AC power supply

The Onsite Power Distribution System can receive power from either the Preferred (offsite) Power System or from the Standby Power Supply which consists of two diesel generators, one for each division. Each diesel generator is rated at 6500 kW, 0.8 power factor, 6.9 kV and is complete with its accessories and fuel storage (day tank) system.

The diesel generator ratings are sufficient to supply reliable power to all safety related loads in its respective division, as well as to those non-safety-related loads which it is desirable to have manually loaded on the diesel generator. Each diesel generator is designed for fast starting and load acceptance, with a high degree of availability and reliability. Each diesel generator is furnished with automatic field flashing equipment for quick voltage buildup during the start-up sequence. The automatic voltage regulators provide steady-state voltage regulation within ± 1.0 percent of set voltage for any load from no load to full load. The Diesel Engine Starting System and the Fuel Oil Storage and Transfer Systems are covered in Sections 9.5.6 and 9.5.4, respectively.

Cooling water to the diesel generator jacket water heat exchangers is supplied from the Emergency Service Water System as described in Section 9.5.5.

The ventilation system provided for each diesel generator room is described in Section 9.4.5. Each diesel generator has its own Combustion Air Intake and Exhaust System as described in Section 9.5.8.

The generators are open, self-ventilated, synchronous revolving field type with solid state excitation systems. The frame is designed and constructed so that windings, collector rings, etc., will be protected against drip, dirt, etc., and accumulation of foreign materials.

Rotor and stator windings are insulated with Class F materials. However, the temperature rise is limited to that specified for Class B insulation systems as measured by the resistance method during the performance of periodic surveillance testing and pre-operational testing. Exceptions to limiting the stator temperature rise to the preferred temperature index of Class B insulation (130 C) shall be during performance of the 24-hour load test as described in RG 1.108, when the diesel generator unit is supplying power to only its emergency bus during plant tests or actual emergency condition. In these cases, the temperature rise shall be limited to the preferred temperature index for Class F insulation systems.

Each diesel generator unit can be started either manually for test or automatically upon receipt of a Loss of Off-site Power, Safety Injection Signal or a simulated accident signal. When a

manual start for testing is performed, the opening of the diesel generator fuel racks is constrained to attain rated speed in 30 (24 to 35 seconds). Diesel generator field flashing is delayed until engine speed reaches 370 rpm. When an automatic start is initiated by either an actual or simulated signal, the diesel generator is not constrained, allowing rated speed and rated voltage to be attained within 10 seconds. If an automatic start signal is initiated subsequent to a manual start, the diesel generator fuel racks are released to allow fast acceleration to rated speed and voltage. Following a manual start for test or simulated automatic start, the diesel generator can be manually synchronized to the plant auxiliary busses and manually loaded. Following an actual automatic start signal and attainment of required speed and voltage, plant safety loads will be automatically applied to the diesel generator in sequence, and later, manually applied loads as shown in Table 8.3.1-2c. Each diesel generator is capable of sequentially starting all required motors and accelerating them to full load operation after receiving the automatic start signal.

There are recognized situations that will require the standby diesel to start and to continue operation in the no-load conditions. These situations are as follows:

a) No-load run-in for overhaul (major maintenance) of cylinders, piston rings, crank shaft bearings in accordance with IEEE-387-1977,

b) Upon receiving a Safety Injection Signal, with offsite power available, the diesel will start and operate unloaded until the Emergency Operating Procedures are used to evaluate the events and a determination is made whether the diesels should be running or secured.

After the no-load situations cited in items a. and b. above, the diesel generators will be demonstrated operable by performing surveillance requirements on the required independent circuits between the off-site transmission network and the on-site Class 1E distribution system. These requirements are covered in a one hour run-time operational surveillance test.

Diesel generator 1A-SA supplies power to 6.9 kV bus 1A-SA and diesel generator 1B-SB supplies power to 6.9 kV bus 1B-SB.

The diesel generator controls are designed for automatic and manual operations and disconnected for "Maintenance Mode" servicing. The selection of a diesel-generator mode - "operational" or "maintenance" is by means of a key locked switch located on the local (diesel generator room) "Engine Control Panel." In the "operational" position all remote and local starting and tripping signals will be operable. In the "maintenance" mode, to be used only when the diesel generator is being maintained, all remote and local starting and tripping controls will be disconnected. The placing of the "mode" control selector switch in "maintenance" mode will be annunciated in the Control Room and indicated on the ESF bypass panel as an inoperable condition.

A key-locked control selector switch, located on the "Generator Control Panel" will determine whether remote (Control Room) or local (Generator Control Panel) mode is operable. Placing of the "mode" control switch in local will be annunciated in the Control Room.

Voltage and speed sensing devices are provided to prevent loading the generator until the diesel engine has accelerated to acceptable speed and voltage levels as determined by the diesel-generator manufacturer.

The neutral of each generator is grounded through a transformer-resistor combination which is mounted in a well-ventilated metal enclosure.

Local control is also established by actuating the appropriate controls on the Transfer Panel; once local control is established, the local control selector switch must be used to return control to the Control Room.

Provision has been made for manually synchronizing the diesel generator with the incoming power source for test purposes and upon return of offsite power during an emergency.

Each diesel generator has been provided with a preheat system which maintains adequate engine temperature to ensure fast starts. The preheat system includes a jacket coolant heater and a lubricating oil heater. Interlocks are provided to de-energize the lube oil and jacket coolant heater upon starting of the respective diesel generators. Control circuits for each diesel generator operate from separate Class 1E 125V DC circuits supplied from the safety battery of the same division.

Each diesel generator is capable of starting and carrying the maximum ESF loads required under postulated accident conditions. After the automatic loading sequence is completed, each diesel generator will have a reserve capacity, which is the difference between the diesel generator rating and the total load shown in Tables 8.3.1-2a and 8.3.1-2b.

Additional loads may be manually started by the operator after the automatic loading sequence is completed. Such additional loading is limited by the rated capacity of the diesel generators. A wattmeter, a varmeter, and an ammeter are provided for continuous indication of diesel generator loading. Administrative control will be exercised to prevent loading the diesel generators over their rated capacities. Single line and logic diagrams for the diesel generators are shown on Figures 8.1.3-1, 8.1.3-2 and 8.3.1-1.

All of the standby power supply system components are designed to meet the seismic requirements for Class 1E electric equipment as described in Section 3.10. All Class 1E components are located within Seismic Category I structures and are protected from potential missile and fire hazards.

Physical separation and isolation have been maintained in the location and installation of equipment for redundant systems. Each diesel generator is housed in a separate concrete room in the Diesel-Generator Building.

Diesel generator training will be given to licensed operators and to operations' supervisory personnel and maintenance supervisors and personnel as discussed in Section 13.2.

Environmental qualification of the standby supply system is described in Section 3.11.

In 1984, the NRC raised concerns regarding the reliability of the TDI standby diesel generator. The NRC required owners of TDI diesel generators to formulate a program to resolve reliability issues stemming from early problems with TDI engines. CP&L, as a member of the group, submitted a plan to the NRC that contained a combination of design review, quality validation, component inspection, and engine tests to provide an in-depth assessment of the adequacy of the TDI standby diesel generator sets. That program plan was submitted to NRC on March 2, 1984. The program reports were submitted to the NRC for review and approval. Subsequently,

a license condition was issued which required the performance of emergency diesel generator component inspections at periodic intervals. The specific conditions, tests and intervals were identified in Attachment 1 to the Operating License. After reviewing the operational data and component inspection results, the TDI Owners Group submitted to the NRC comprehensive reports on November 30, 1992 and December 7, 1993 to justify relief from the license conditions imposed on licensees with TDI diesel generators. Subsequently, SHNPP submitted a license amendment request and supporting documentation for removal of the license condition requirement for SHNPP. That request was granted by NRC on January 12, 1995 in License Amendment No. 53.

8.3.1.1.1.6 Dedicated Shutdown Diesel Generator

The Dedicated Shutdown Diesel Generator (DS DG) is an independent, outdoor, non-safety related diesel generator rated at 400kW, 0.8 power factor, 480VAC, and is complete with its accessories and fuel storage system. It is a standby generator with average power output as 70% of the standby power rating.

The DS DG provides back-up power for 480V MCC 1D23 upon loss of normal source (bus 1D2) via an automatic transfer switch (ATS) and is capable of supplying all loads fed by the MCC. It is designed for fast starting and can accept up to 100% of rated load in one step. It is started by a DC electric starter motor which is supplied by a skid-mounted 24V battery.

A sound attenuated enclosure is provided for the generator set with lockable access doors and an externally mounted emergency stop button. It also has a control panel viewing window so the generator set can be monitored without opening the enclosure.

The generator is a random wound, four pole, synchronous type with permanent magnet excitation. Its enclosure is designed and constructed such that the generator will be protected against accumulation of foreign materials. The windings are insulated with Class H materials.

The diesel generator can be started either manually for test or automatically upon loss of normal source (bus 1D2) at the associated automatic transfer switch. The loss of normal source can also be simulated at the ATS by electing to perform an engine test. Following the initiation of a start signal (either simulated or actual) from the ATS and attainment of required voltage and frequency, the ATS will transfer to utilize the diesel generator as the feed for MCC 1D23 after a time delay with the switch in the "neutral" position for 10 seconds.

The diesel generator controls are designed for automatic and manual operations and no-load operation for servicing. The generator is normally operated in automatic mode but can be manually started by pressing the RUN key on the diesel generator control panel. When the control panel initiates a start command on the diesel engine, the controller checks to make sure there are no shutdown events present or active. Pressing the RUN or STOP keys will disable automatic operation of the generator until the AUTO key is pressed.

The neutral of the generator is grounded through a transformer-resistor combination which is mounted in a well-ventilated metal enclosure.

Since the "source" to the MCC is electrically dead for at least 10 seconds in between transferring either from normal source to emergency or vice versa, no synchronism check between sources is performed before supplying the MCC.

A dedicated load bank is provided for the diesel generator for testing purposes and is available to provide a resistive load to the generator in 50kW increments up to 400kW, selectable at the load bank local control panel. The load bank has an automatic load dump feature that will not allow itself to load the diesel generator if the normal source (bus 1D2) to MCC 1D23 is unavailable at the Automatic Transfer Switch.

The Dedicated Shutdown Diesel Generator will provide remote annunciation in the main control room when it is running as well as of any warning or shutdown conditions that exist.

8.3.1.1.2 Specific features of the onsite power system

8.3.1.1.2.1 Power supply feeders

Power for the onsite power distribution system is powered from either the Preferred (offsite) Power System or the standby power supply which consists of two diesel generators, one for each division. Under normal operating conditions, power is supplied through the unit auxiliary transformers. Under start-up and shutdown conditions, power is supplied through the start-up transformers. Two non-safety-related 6.9kv switchgear buses (1D and 1E) provide the path of power from these transformers to safety buses 1A-SA and 1B-SB, respectively. Buses 1A-SA and 1B-SB supply equipment essential for safe shutdown of the plant. Buses 1A-SA and 1B-SB are connectible to either the offsite power source through buses 1D and 1E or to the Emergency Diesel Generators 1A-SA and 1B-SB. Power from the emergency diesel generators of each division to the appropriate 6.9kv ESF bus is supplied through three 750 kcmil cables per phase.

Outgoing cable feeders serve 6600 volt motors and 6900/480V station service transformers which are throat connected directly to the main incoming breakers in their respective 480V power centers. From the 480V power centers, feeder cables supply power to motors, large 480V heating loads, and motor control centers. All power supplied from the motor control centers is fed through cable to their individual loads.

8.3.1.1.2.2 Busing arrangements

Figures 8.1.3-1, 8.1.3-2, and 8.1.3-3 show the busing arrangements for the onsite AC power system. There are no direct ties between buses of the two divisions. Redundant ESF buses are connected to Division A and Division B power supplies. No ESF buses are connectable to both divisions.

One 480 volt non-safety related power center is powered from a 6.9 kV ESF bus in each division, through an isolation device as discussed in Section 8.3.1.1.2.5. These two power centers in turn feed one non-safety related motor control center each.

8.3.1.1.2.3 Loads supplied from each bus

The Power Distribution and Motor Data Sheets (Drawing CAR-2166-B-041) show each load in the plant, the bus to which it is connected and schematically show the means of connection and circuit protection. The criterion governing the assignment of safety related loads to safety related buses is that redundant loads are assigned to Division A and Division B buses. (There are non-safety related loads connected to safety related buses including the AC emergency lighting loads. The safety related system is protected from unacceptable influences due to connection of these non-safety loads as described in Section 8.3.1.2.14.) Non-safety related

buses powered from the safety related system feed non-safety loads for which it is desirable to have emergency power available (refer to Section 8.3.1.1.2.5). There are no safety related loads connected to the non-safety related buses.

Third service loads are the third component cooling water pump motor (CCWP) and the charging safety injection pump motor (CSIP), which, as noted in Table 8.1.3-1, can be connected to either a Division A or a Division B bus (see Figure 8.3.1-2 and Figure 8.3.1-3). Third service equipment is that equipment which has been provided for back-up, during maintenance, of redundant components, thus providing increased operational flexibility of the plant. The design criterion which pertains to the connection of the third service loads is that of ensuring the availability of one component in each division during periods of maintenance. The connection of the third service loads to either of the Division A or Division B buses is accomplished manually assuring redundancy is maintained between divisions and is described in Section 8.3.1.1.2.4.

The two motor operated valves in the letdown line between the high pressure Reactor Coolant System and the relatively low pressure Residual Heat Removal System are connected in series and provided with a special provision which would enable the Train-A RHR suction valve power supply to be transferred to a Train-B power supply source. This is accomplished by specific operator actions outside the control room from the valve's normal power supply (Class 1E 480 volt Train-A) to its alternate Class 1E power supply (Class 1E 480 volt Train-B). A similar connection is provided such that the Train-B RHR suction valve can be supplied with power from the 480 volt Train-A bus (Figure 8.3.1 5). This design feature ensures that the RHR flow path can be maintained during a long term cooling post-LOCA. A detailed description of the connection is provided in Section 8.3.1.1.2.4.

8.3.1.1.2.4 Manual and Automatic Interconnections Between Buses, Between Buses and Loads, and Between Buses and Supplies

Normal transfer of the 6.9 kV auxiliary buses between the Unit auxiliary and start-up transformers is initiated by the operator from the Control Room, and emergency transfer from the auxiliary transformer to the start-up transformer is initiated automatically by protective relay action. Normal bus transfer from the start-up transformer to unit auxiliary transformer or vice versa utilizes a live bus transfer; i.e., the incoming source feeder breakers are momentarily paralleled (the incoming feeder breaker is closed onto the energized bus), resulting in transfers without power interruption.

The emergency bus transfer, used upon loss of the main generator, is an automatic fast bus transfer, initiated by main generator lockout relays which simultaneously initiate closing of the standby source feeder breaker and tripping of the auxiliary transformer source feeder breaker, resulting in completion of the transfer within a few cycles. If the standby (preferred) power source is not available, as monitored by a switchyard breaker position and transformer lockout relays, then transfer will not occur. The resultant loss of voltage will cause tripping of the breakers at both ends of the bus tie between normal and emergency 6.9 kV buses and cause tripping of the breakers feeding the non-safety related 6900/480V station service transformers, resulting in isolation of the safety related buses from the non-safety related buses. In addition, the loss of voltage will cause the shedding of all ESF loads (except small static loads) from the ESF buses and initiate starting of the emergency diesel generator.

The generator lockout relay trip initiates the transfer of power from the auxiliary to the start-up transformers. Westinghouse flexitest switches have been incorporated into each lockout relay's circuitry to provide the capability for testing the relay during plant operation. The flexitest can be opened for the required trip blocks, and the generator lockout relay can be manually tripped. This action will initiate the automatic fast transfer between the auxiliary and the start-up transformers. The generator lockout relay can then be reset and the flexitest switches closed, after which manual transfer from start-up to auxiliary transformers may be initiated. There is no automatic transfer from the start-up to the auxiliary transformers. For additional information regarding the main auxiliary and startup transformers test summaries, refer to Section 14.2.12.1.2.

An additional source of auxiliary power can be obtained from the high voltage grid, through utilization of CP&L's backfeed capability, after disconnection of the main generator. This manual operation can be completed in less than eight hours, which is sufficient time following a loss of all onsite AC power supplies and the other offsite power circuits, to assure that the specified fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. This backfeed capability is treated as the delayed access source of offsite power in the event that one of the start-up transformers is out of service.

Energization of the non-ESF 480V buses (1A1, 1B1) and non-ESF MCC's (1A24, 1B24) is by manual switching of the 6.9 kV ESF switchgear and 480V bus breakers, respectively. All safety related loads, except those in the manual load block of the diesel generator are switched automatically on occurrence of an event as required. Safety related loads in the diesel generator manual load block, and all non-safety loads connectable to the diesel generator (except emergency lighting) are switched manually, when permitted by the emergency load sequencer (refer to Section 8.3.1.1.2.14).

There are no connections, either manual or automatic, between buses of different divisions. There are also no connections between redundant 120V uninterruptible AC buses, although the power supply inverters for uninterruptible Channels I and III are normally powered from safety related Division A, while Channels II and IV are powered from Division B.

During normal operation only one Charging/Safety Injection pump and one Component Cooling Water pump is connected to each safety bus through a circuit breaker. In order for the spare component cooling water pump "C" to replace either pump "A" or pump "B" and to maintain redundancy in electrical power supply and control, pump "C" has a dual cubicle, single breaker arrangement so that it can be powered and started from the same train as the pump it replaces. These pump "C" cubicles have been designed to accept only one unique breaker specifically used for pump "C". Since only one breaker fits these pump "C" cubicles, pump "C" can be powered from only one bus at a time. This ensures that train separation and single failure criteria is maintained.

The spare Charging/Safety Injection pump "C" can replace either pump "A" or pump "B" by way of a manual transfer switch that is configured to ensure that train separation and single failure criteria are maintained.

Administrative controls and mechanical interlocks are used to prevent concurrent connection of a spare pump "C" breaker and a dedicated pump "A" or "B" breaker on the same bus. The interlock assures that one breaker must be racked out of the connected position before the other breaker can be racked into the connected position. This is accomplished through a dead

bolt type lock and key in which the lock captures the key when unlocked. When locked, the cubicle mounted interlock prevents the breaker from being racked to the connected position. This protects against starting more than one of each pump on a bus during a loss of off-site power event which could overload the emergency power supply. As an additional barrier against this condition, annunciators on the Main Control Board are provided which alarm if both Component Cooling Water pump breakers on a bus or both Charging/Safety Injection pump breakers on a bus are racked to the connected position simultaneously. A system bypass indication is also provided in the control room, when both the dedicated and the spare breakers of either train are in the racked out position. An additional cubicle-mounted lock and key mechanical interlock system is provided for the power circuits from each division supplying the manual transfer switch for the "C" Charging/Safety Injection Pump. Like the key-capture interlock described above, this interlock ensures that one breaker supplying the manual transfer switch must be racked out of the connected position before the other breaker can be racked into the connected position. This ensures that the two (2) power sources (one from each division) to the manual transfer switch are not energized concurrently.

There are no "swing" buses or "AB" buses. As stated in Section 8.3.1.1.2.3, third service loads can be connected to either Division A or B by manual means (see Figure 8.3.1-2 and Figure 8.3.1-3), under the direction of administration controls (refer to Figure 8.3.1-1). The manual reconnection from one division to another will transfer all power, control and instrumentation circuits. In this way, the required independence of redundant divisions is maintained in the installation and operation of the third service loads.

To facilitate the reconnection of the power feeders for component cooling water pump "C", two separate independent feeder circuits, one from each division, are routed to separate locations close to the motor. However, only one feeder circuit breaker is provided for each third service motor. Reconnection from one division to another requires that the breaker be physically removed from one bus and that same breaker be installed in the other bus. To transfer the power cables at the motor terminal box, they are disconnected and pulled back to a point just inside the conduit, which is embedded in concrete, and which is then capped with the cables inside. The other division's feeder cables, which are also installed to the motor in embedded conduit, are then pulled up through a short exposed length of flexible conduit to the motor terminal box and terminated. An electrical pull box is installed in the vicinity of the motor to facilitate the cable pulling operation. For the Division A circuit, the feeder cable is installed in exposed conduit throughout its length from the bus to the pull box, and Division B cable is installed in embedded conduit from the B bus to the pull box. Division A and Division B cables in the pull box are separated by a suitable barrier, and the circuits are installed in separate embedded conduit for the short run from the pull box to the motor. A similar manual reconnection operation is performed for the auxiliary power circuit and instrumentation device circuits at the motor, maintaining the required separation between Divisions A and B. The complete reconnection of each third service load can be performed during a time period which is well within the limits stated in the Technical Specification for plant operation with one inoperable, redundant pump.

To facilitate realignment of the power source to the charging/safety injection pump "C" from one division to the other, the breaker for the in-service circuit must be physically racked-out of the connected position. Once the breaker has been racked out, the cubicle-mounted key interlock is placed in the "locked" position which prevents the breaker from being racked in and also releases the interlock's key from the lock. The shared key is then placed into the lock on the breaker cubicle for the power circuit supplying the charging/safety injection pump from the

opposite division. The key interlock from the other division is then unlocked to allow the breaker to be racked to the "connect" position. The manual transfer switch, which consists of one load interrupter switch from each division, is then realigned to accept power from the other division. (Key interlocks are provided on the transfer switch to permit only one load interrupter switch from being closed at one time). Once the manual transfer switch has been realigned to accept power from the other division, the breaker from the other division can be closed for powering the charging/safety injection "C" pump.

Each RHR inlet line is provided with two motor-operated valves in series which are fed from Train A and Train B power sources. To ensure operation of at least one RHR pump in the event of loss of power on one of the safety trains, provisions similar to those described above are made for a temporary connection of power, control and interlocks to the necessary suction line isolation valve. For the RHR pump fed from Train A, its associated Train B motor-operated valve is provided with an alternate power feeder from its redundant division Motor Control Center (Train A). Similarly for the RHR pump fed from Train B, its associated Train A motor-operated valve is provide with an alternate power feeder from its redundant division MCC (Train B). As illustrated in the power supply arrangement on Figure 8.3.1-5, a separate compartment is provided in each redundant division MCC for the alternate feed. The alternate power feeder and control cables from the MCC compartment are brought into the remote terminal boxes near the outboard side of the penetration via independent conduits. The cables are provided with ring tongue terminal lugs. These cables are coiled inside the separate compartment of the remote terminal boxes. The MCC circuit breaker and starter combination feeding the alternate redundant circuit is maintained in the off position. To transfer the connection at the remote terminal box, the permanent circuit breaker and the starter combination at the MCC and valve position indication power supply breaker are tripped prior to disconnecting the permanent cables from its associated remote terminal blocks. These cables are then coiled inside the separate compartment in the remote terminal boxes. The other division cables are then uncoiled and connected to the same terminal blocks previously used by the permanent cables. Administrative control ensures that both redundant circuit breakers feeding the same valve are not closed at the same time. Reconnection from Train A to Train B (and vice versa) requires that the permanent circuit breakers be opened prior to closing the alternate circuit breaker. Alternate cables from the inboard penetration enclosure boxes to the valves inside containment are routed in dedicated independent conduits. Terminal blocks used for terminating the cables outboard side (associated with the RHR valves) in the same remote terminal boxes are separated from the cables within the same terminal box by means of suitable barriers. This temporary power supply arrangement does not violate physical and electrical separability requirements during normal operation. The control and interlock arrangements are illustrated in Control Wiring Diagrams CAR-2166-B-401 Sheets 336 and 337.

In the event of loss of offsite power following a Safety Injection Actuation Signal the response would be essentially the same as the loss of offsite power event described above. The exceptions are that the diesel generator would have already been started and the non-safety station service transformer fed from the ESF bus would have already been tripped (both by SIS). Concurrently the sequencer will shift to the LOCA with LOOP program. The diesel generator breaker will close upon sensing rated frequency and voltage at the diesel generator and after a time delay for residual voltage to decay has elapsed. The ESF loads will then be sequenced onto the diesel generator.

It is expected that prior to tripping of the breakers the voltage at the Class 1E buses has significantly, if not completely declined (in the event of a short circuit), and subsequently the

motor speed will decline in relation to the reduction in voltage. With respect to overvoltage due to improper phase angle relationship, sufficient time delay is introduced between the load shedding of ESF motors and subsequent energization of the motors which will allow the motor residual voltage to subside to a level where no significant overvoltage can occur.

The first load block of the diesel generator consists mainly of relatively low horsepower motors with the exception of the 900 horsepower Charging Pump motor. The lower horsepower motors, due to their low inertia, have the characteristic of fast decay rate of speed and residual voltage. For the Charging Pump motor, the time delay associated with the undervoltage relays, load sequencer time delay, and control circuits will allow sufficient time for the residual voltage to decay to an acceptable level. Similarly, the subsequent load blocks are influenced by further time delays and overvoltage due to improper phase angle relationships is not of significance.

8.3.1.1.2.5 Interconnections between safety and non-safety-related buses

The interconnections between safety and non-safety related buses are as follows:

a) 6.9 kV Bus Ties - ESF buses 1A-SA and 1B-SB are normally connected to non-safety-related buses 1D and 1E, respectively through bus ties. Each bus tie consists of a non-segregated phase bus duct terminated at a normally closed circuit breaker at each end. The circuit breaker located at the ESF bus together with its associated relaying serves as the isolation device, as described in Section 8.3.1.2.14(1). Upon loss of offsite power, the circuit breakers at both ends of the bus duct ties are automatically tripped. In addition, the bus duct, bus duct supports, non-safety related 6.9 kV switchgear and supports, are designed to maintain structural integrity during and after a design basis earthquake, by the methods discussed in Section 3.10.

b) 6.9 kV ESF Bus Feeder Circuits - One 6.9 kV ESF bus feeder breaker in each division is connected to a non-safety related 6900/480V station transformer (1A1 and 1B1), which in turn feeds a non-safety related 480V power center bus. As in the case of the 6.9 kV bus ties, the 6.9kV circuit breaker together with its associated relaying serves as the isolation device. Upon a loss of offsite power or initiation of an accident signal, this circuit breaker is automatically tripped and prevented from being reclosed until receipt of a permissive signal from the emergency load sequencer. Beginning with the transformer feeder cable emanating from the 6.9 kV ESF switchgear, all equipment and devices connected downstream are non-Class IE and non-safety related. However, to provide further design margin, the feeder cable to the 6900/480V transformer is qualified as Class IE equipment and installed in conduit embedded in the concrete floor. In addition, the non-safety related 6900/480V transformer, 480V power center, supports and all devices installed in the power center are fully qualified as Class IE equipment. The DC control power supply for this power center is from the safety-related DC system through isolation devices as described in Section 8.3.1.2.14(1). The auxiliary AC power supply for the 480V transformer and power center is from the non-safety-related system. Signals from the emergency load sequencer pass through isolation devices prior to entering non-safety-related power distribution equipment.

8.3.1.1.2.6 Redundant bus separation

Separation of redundant 6.9 kV and 480V power centers, the 480V redundant MCCs and 208/120V power panels, the 120V uninterruptible AC buses and inverters and the 125V DC batteries and chargers and distribution panels has been accomplished through spatial separation or provision of fire resistant barriers. The two redundant diesel generators are housed in separate fire resistant rooms in the Diesel-Generator Building which is a Seismic Category I structure.

8.3.1.1.2.7 Electrical equipment capacities

Power requirements for balance-of-plant safety loads are based on conservative design calculations of each safety load, for example: horsepower ratings of safety-related motors are calculated under expected flow and pressure condition and pump runout condition and the maximum of those ratings is utilized. The above considerations are also reflected in Section 8.3.1.1.2.14 and in addition a detailed analysis is given in Section 8.3.1.1.3.

The Westinghouse basis for defining the power requirements of the safety loads is the maximum loading that may be expected for the event. In the case of the Charging/Safety Injection pumps it is the potential pump runout load.

Ratings of all safety related electrical system equipment are shown in Table 8.3.1-1. Equipment capacities have been conservatively selected. The two redundant diesel generators each have adequate capacity to supply all safety related and uninterruptible equipment loads required for safe shutdown of the plant. The continuous rating for the onsite power source is 6500 kW (as indicated in Table 8.3.1-1, Item A) with a short-term rating of 110 percent of the continuous rating for two hours out of every 24 hours. Tables 8.3.1-2a, 8.3.1-2b and 8.3.1-2c list the safety-related loads connected to each of the diesel generators under emergency conditions.

Horsepower ratings listed in the above tables for safety-related motors are based on loads under expected flow and pressure. All safety-related loads are confirmed by preoperational tests.

8.3.1.1.2.8 Automatic tripping and loading of buses

The emergency diesel generators and the emergency load sequencers will be started if an ESF actuation signal is present. However, if offsite power is available, the appropriate safety-related loads will be started sequentially on this preferred (offsite) power source. The safety loads which were running during normal full load operation remain running. The diesel generators will attain rated speed and voltage but will not be connected to the safety-related buses if the preferred power source continues to be available; they may be manually shutdown after a suitable time.

The loads are connected sequentially, through the load sequencer, so as to minimize the effect of excessive voltage drop on the safety buses due to simultaneous large motor starting while all other plant loads remain connected. In addition, the quantity of sequencing relays are minimized by utilizing the same time delay relays to initiate the bus loading whether preferred power is available or unavailable. This prevents duplication of auxiliary and time delay relays which would otherwise be required. Refer to Section 7.3.1.5.1 for a further discussion of the load sequencer.

The 6.9 kV buses 1A-SA and 1B-SB have been provided with undervoltage relays to monitor the voltage condition on these buses. Loss of voltage on either of these buses is sensed by its time-delayed undervoltage relays, all loads connected to the bus are shed and the emergency diesel generator is started automatically. When the diesel generator has attained rated speed and voltage (within 10 seconds after the start signal), the diesel generator circuit breaker to the 6.9 kV ESF bus is closed and the safety-related loads are connected to the bus automatically by the emergency load sequencer in accordance with the loading sequences shown in Table 8.3.1-2c. Once the loading of the diesel generator has begun, operation of the undervoltage relays is blocked.

Loads connected to the safety related switchgear are de-energized when voltage is lost on the 6.9 kV safety related buses, except small safety related static loads and the emergency lighting circuits which remain connected to the safety related buses when voltage is lost. These loads are therefore re-energized independent from the operation of the load sequencer, when voltage is restored to these buses.

Except for emergency lighting and vent stack flow monitoring panels PNL-21AV-3509 and PNL-21AV-3509-1, and the FLEX Spent Fuel Pool Level Indication equipment loads powered from Power Panels PP-1&4A33-SA and Power Panel PP-1&4B33-SB, any non-safety loads connectable to the safety buses, and any safety loads in the diesel generator manual load block, can only be reconnected manually by the operator. In addition, their reconnection is blocked until receipt of a permissive signal from the emergency load sequencer. This permissive signal is provided automatically after the automatic load starting sequence is completed.

Automatic tripping by protective relays, circuit breakers, etc., is discussed in Section 8.3.1.1.2.11.

If a Loss Of Offsite Power (LOOP) occurs without an ESF actuation present, the offsite tie breaker to the ESF bus and the diesel generator output breaker are tripped open by an ESF undervoltage. The load shedding and sequencing process is initiated by the ESF bus undervoltage. Additionally, the tie breaker between the non-safety auxiliary bus and the ESF bus receives a LOOP event trip signal determined by the status of the Unit Auxiliary Transformer (UAT) and Startup Auxiliary Transformer (SUT) breaker positions and the status of the main generator lockouts. A LOOP detection logic uses these non-class 1E inputs to define a LOOP event as either of the following:

a) The SUT and the UAT breakers to the 6.9 kV auxiliary bus are OPEN; or

b) The SUT breaker to the 6.9 kV auxiliary bus is OPEN and either of the main generator lockouts (86/G1A or 86/G1B) are tripped.

When the diesel generator is in the standby (normal) mode, the primary safety related trip for the offsite power tie breaker comes from the detection of an undervoltage condition on the ESF bus.

When a diesel generator is in the test mode (i.e., the diesel generator and the offsite power supply are connected in parallel), additional action to trip open the diesel generator output breaker based on a signal from the LOOP detection logic occurs. This LOOP detection trip of the diesel generator output breaker is a safety function that is necessary to ensure the ESF bus

is deenergized to ensure that an undervoltage condition occurs on the ESF bus. The LOOP detection logic utilizes signal inputs and uninterruptible power supply that are non-class 1E. Operator action is used as a backup to the LOOP detection logic to trip the diesel generator output breaker manually if the LOOP detection logic were to fail. The diesel generator is removed from the test mode by tripping the EDG output breaker.

The diesel generator and its associated control system is designed to initiate automatically the required actions on receipt of emergency signals, as described below:

a) On receipt of a SIS signal with offsite power available:

1) Start DG or it remains running if running on test.

2) Trip the D/G breaker to the ESF bus if D/G on test.

3) The D/G protective trips, other than those described in Section 8.3.1.1.2.11(b) are bypassed.

4) Transfer the governor to "isochronous" mode from "droop" mode, if the D/G is running on test.

5) The offsite breaker remains connected and ESF loads are connected to the bus per design, that is, load breakers if closed remain closed otherwise loads are sequenced to the bus.

b) On receipt of LOOP signal following the SIS signal:

1) The offsite breaker to the ESF bus is tripped.

2) Loads are shed from the ESF bus except for the 6.9kV breaker feeding 480V power center transformers.

3) The D/G remains running due to SIS.

4) Protective trips, other than those described in Section 8.3.1.1.2.11(b) are bypassed.

5) Close D/G breaker upon attaining normal voltage and frequency.

6) Close ESF load breakers as required through the sequencer.

c) On receipt of simultaneous LOSP and SIS signal:

As described in item (b) above except the D/G is started by the SIS signal.

d) On receipt of LOSP signal only:

As described in item (c) above except that the diesel generator will be started by the undervoltage relays at the safety related 6.9kV bus.

e) On receipt of LOSP signal only:

1) Trip the offsite breaker feeding the ESF bus and the D/G breaker, if closed. If the D/G breaker fails to trip, operator action will be required to trip the D/G breaker.

2) The D/G remains running, and governor control transfers to "isochronous" mode from "droop" mode.

3) Load shed all breakers from the ESF buses except the 6.9kV breaker feeding 480V power center 1A2-SA and 1B2-SB.

4) Close D/G breaker, upon attaining normal voltage and frequency.

5) Connect ESF loads as required, in sequence.

8.3.1.1.2.9 Safety related equipment identification

All safety related equipment has been identified by means of nameplates, tags and/or surface printing (i.e., electric cable) which include equipment nomenclature and its respective safety division or channel markings. A further discussion may be found in Section 8.3.1.3.

8.3.1.1.2.10 Instrumentation and control systems with assigned power supply

The Reactor Protection System (RPS), and other instrumentation and control systems provided for monitoring and controlling the reactivity, temperature and other vital parameters within the reactor, are supplied with power from the four uninterruptible AC inverters described in Section 8.3.1.1.1.

There are four separate channels in these protective systems, each of which operates from one of the four inverters. Thus, independence of the four channels from each other is maintained. There are two separate channels for the control systems which are powered from two redundant sources.

Each inverter is supplied from a safety related MCC, with automatic transfer to a battery supply on AC failure. The AC and DC supplies for the inverters are taken from the same Division A or B so as to provide full separation between redundant divisions.

Controlled actuators or final devices, such as motor operated valves, receive power from the 480V MCCs or 208/120V power panels, if AC, and from 125V DC batteries if DC. Other instrumentation and control equipment, if AC and not powered from the uninterruptible buses, receive power from the 480V MCCs or 208/120V power panels, as applicable. If DC, such equipment is powered from the 125V DC distribution panels.

Control power for the MCCs is obtained from 480/120V control transformers located in the MCC compartments. For the 480V power centers and 6.9 kV switchgear, control power is supplied from the 125V DC distribution panels.

8.3.1.1.2.11 Electric circuit protection systems

Electrical protection for safety related equipment designed for selective tripping, is as follows:

1) Safety Related 6.9 kV System Protection - Safety related 6.9 kV switchgear are protected against bus faults by differential relays which trip each incoming bus breaker in the event of a fault on the switchgear bus. In addition, inverse time overcurrent relays, one in each phase, provide additional protection against bus faults and backup protection to individual load feeders.

   All outgoing feeders from safety related 6.9 kV switchgear are protected against feeder short circuit by instantaneous relays in each phase.

   Each motor circuit is protected by means of three overcurrent relays with an instantaneous element in all three phases for the short circuit protection. The inverse time elements are set for locked rotor protection on Phases A and C, with Phase B set for overload alarm.

   Feeders to the 6900/480V station service transformers are equipped with one inverse time overcurrent relay and one instantaneous relay in each phase. These relays will trip the breakers under all overload or fault conditions.

   Each outgoing feeder is also equipped with ground fault alarm, as is the incoming feeder from the offsite power supply. The diesel generator neutral grounding equipment has been designed to alarm a ground fault on the generator feed to the 6.9 kV switchgear bus.

2) Diesel Generator Protection - During a Design Basis Accident or a loss of offsite power, the diesel generator sets are automatically shutdown and the generator breaker is tripped during the following conditions:

   a) Engine overspeed

   b) Generator differential relay action

   c) Generator bus fault

   d) Loss of generator potential transformer circuit

   The Diesel Generator Auxiliary Power System is a high resistance grounded system capable of furnishing power to the ESF loads during a phase to ground fault condition. If a phase to phase or three phase fault is present, all power flow to ESF loads is precluded. Without generator bus differential protection the generator could feed the faulted bus indefinitely causing considerable equipment damage.

   The differential relays (Diesel Generator Bus and Generator Zone) operate only during phase to phase or three phase fault conditions, thus no safety functions are impaired or degraded.

   The bus differential scheme utilizes separate single phase relays in conjunction with current transformers for independent monitoring of each phase current. The logic for tripping of the diesel generator breaker during a bus fault requires coincident operation of any two of the three single phase relays, thus satisfying the criteria referenced in Paragraph B-3 of Branch Technical Position EICSB 17.

The bus differential relay system will be tested periodically for proper operation, i.e., to check conformance with settings.

During non-emergency operation of the diesel-generator sets, such as testing, the engine is shutdown and the generator breaker is tripped under the following conditions:

a) Generator differential relay action

b) Generator bus fault

c) Generator loss of excitation

d) Generator negative phase sequence

e) Generator overcurrent

f) Reverse power flow

g) Engine overspeed

h) Low lube oil pressure

i) High jacket water temperature

j) High generator bearing temperature

k) High crankcase pressure

l) High lube oil temperature

m) Low jacket water pressure

n) Low turbocharger oil pressure, left or right

o) Excessive turbocharger vibration or excessive engine vibration

p) High engine bearing temperature

q) Emergency Stop

r) Loss of Generator Potential Transformer Circuit

Protective tripping of the engine and generator are annunciated locally and in the Control Room.

3) Safety Related 480 Volt System Protection - Safety related 480V switchgear and non-safety related 480V switchgear connected to the 6.9 kV ESF buses are protected against bus faults by circuit breakers each provided with direct-acting, series trip having short time and long time trip functions. These breakers also provide back-up protection to the individual

load feeders. The 480V switchgear feeders to MCCs and static loads are each similarly protected by a circuit breaker with short time and long time trip functions.

Feeders to 460V motors from the 480V switchgear buses have been provided with long time and instantaneous trips. Motor protection is arranged to trip on overloads or short circuits. Each 480V switchgear feeder is provided with ground fault alarm, as is the 6900/480V station service transformers. There are no safety related 480V power centers directly feeding containment electrical penetration circuits.

For short circuit protection, the 480V MCC combination motor starters have been provided with a thermal-magnetic, time-delay and instantaneous trip circuit breaker; a magnetic, instantaneous trip circuit breaker/current limiting fuses combination; or magnetic breaker with adjustable instantaneous trip settings in lieu of current limiting fuses. Generally, the magnetic breaker/current limiting fuses combination and magnetic breaker with adjustable instantaneous trip settings in lieu of current limiting fuses have been utilized in circuits feeding small motors where it is desirable to have a lower adjustable trip range than is available on thermal-magnetic breakers, and still maintain the high short circuit current interrupting rating of a thermal-magnetic breaker. The current limiting fuses, one in each phase, are sized according to the manufacturer's recommendation such that the lower limit of their protection range is coordinated with the upper limit of the breaker's protecting capability, so that there is no gap in protection and no nuisance fuse blowing. The current limiting fuses include the manufacturer's circuitry to prevent a blown fuse from causing single phasing. The method of setting magnetic breakers with adjustable instantaneous trip settings (in lieu of current limiting fuses) requires that the margin between the locked rotor current and the magnetic trip set point be adequate to avoid nuisance tripping when the motor is started.

For overload protection of MCC motor circuits, thermal overload devices are provided, one per phase. The overload elements have been set to protect the connected motor and its feeder cable. For all safety related motor operated valves, the thermal overload devices are prevented from opening the circuit by bypassing them when an ESF actuation signal is present. This gives sufficient time for the motor, if overloaded but not stalled, to complete the valve closure (or opening). Refer to Chapter 7 for additional discussion of the by-pass circuitry.

The 480V MCC static loads are fed from thermal magnetic breakers which provide overcurrent and short circuit protection.

4) Safety Related 120 Volt AC System Protection - Each outgoing feeder is provided with overcurrent and short-circuit protection by a thermal magnetic breaker. Single pole breakers are used for 120V single phase circuits and double pole breakers are used on 208V single phase circuits.

Most panel buses are directly connected to the secondary terminals of a three-phase 480V-208/120V transformer, the primary of which is protected by a three pole thermal magnetic breaker. The instantaneous trip setting of this breaker is set high enough to trip only on faults on the feeder cable or within the transformer itself, thus ensuring that faults in the branch circuits will trip only the affected secondary breaker and not the transformer feeder breaker.

5) 120V Uninterruptible AC Power Supply System Protection - The AC incoming feeder breaker (480V, 3 Phase Supply), 125V DC incoming feeder, 120V AC bypass source, 120V AC output, and 120V distribution breakers are of the thermal magnetic type. The inverters contain the necessary undervoltage and overcurrent protection to maintain their uninterruptible service.

6) Ground Fault Protection - High resistance grounding is used on the 6.9 kV and 480V systems. Ground fault currents will be sufficiently low such that tripping of the affected breaker is not required. Thus, these systems are designed to alarm only, on occurrence of ground faults. Ground faults are detected locally and alarmed locally and/or in the Control Room.

   The 208Y/120V and uninterruptible 120V AC systems are solidly grounded, so that ground faults are seen by the breaker as equivalent to phase-to-phase faults and tripping will occur.

7) Circuit Protection Criteria For Safety Systems/Equipment To Avoid Premature Trip Due To Protective Relay Trip Setpoint Drift - The criteria for protection of Class 1E circuits utilizes a coordinated and selective relaying scheme. This allows faulted zone to be restricted and affecting minimum number of Class 1E circuits or equipment. Although it is our experience that the type of relays utilized for the Shearon Harris plant have been successfully operating in various installations for many years without failure of the stated nature, the protective relays will be set with adequate margin over the expected range, so as not to permit spurious tripping. In addition, regular inservice inspection and maintenance during plant operation will ensure that the relay setpoints are maintained at the proper level.

8) The Harris Nuclear Plant electrical distribution system design complies with the following guidelines as recommended in BTP PSB-1:

   A second level of undervoltage protection with time delay is provided to protect Class 1E equipment against exposure to sustained degraded voltage conditions while the emergency power system is connected to the preferred (offsite) power source.

   a. The degraded voltage relay scheme utilizes coincident logic (i.e., 2 out of 3 logic) to preclude spurious trips of the offsite power source.

   b. The selection of undervoltage and time delay setpoints has been determined from an analysis of the voltage requirements of the Class 1E loads at all voltage levels of the emergency power system.

   c. The degraded grid voltage scheme utilizes two distinct time delay relays. Upon expiration of the first time delay (Device 2-1), which is long enough to establish the existence of a sustained degraded voltage condition and to prevent spurious alarms/trips during motor staring transients, an alarm is actuated at the main control board to alert the operator of the degraded condition. However, should a safety injection actuation signal be present after expiration of the first time delay, automatic tripping actions are initiated to separate the emergency power system from the offsite power system. If no safety injection actuation signal is present, a longer time delay (Device 2-2) is allowed before the automatic tripping actions are initiated. This second time delay has been selected to ensure Class 1E loads will not be damaged.

d. The first time delay (Device 2-1) is consistent with the maximum time delay considered in the design basis accident analysis and will prevent spurious tripping due to short time transient conditions. To assure no spurious operation of the undervoltage initiated load shedding scheme while connected to the Main Generator and Unit Auxiliary Transformer, a worst case condition was studied. With the auxiliary system fully loaded and the generator at minimum voltage, the starting of the Normal Service Water Pump (3000 HP) was studied. This pump starts in approximately 10 seconds at 90% voltage and was determined to be the worst case based on studies previously performed.

e. The design and hardware selection is consistent with the requirements of IEEE-279-1971 Criteria for Protection Systems for Nuclear Power Generating Stations. Class 1E equipment is utilized and independent schemes are provided for each division.

f. A trip initiation is provided to disconnect the degraded offsite power source from the emergency power system whenever voltage setpoints and time delay limits exceed the preset values. The signal will also initiate load shedding and start of the Emergency Diesel Generator as described in FSAR 8.3.1.1.2.8. When the diesel generator has attained rated speed and voltage (within 10 seconds of the start signal), the diesel generator breaker to the Class 1E buses is closed and the Class 1E loads are connected to the buses automatically by the Emergency Load Sequencer in accordance with the loading sequence shown in FSAR Table 8.3.1-2c.

The alarm/tripping logic of the degraded grid voltage relaying scheme are disabled while the emergency power system is being supplied by the Emergency Diesel Generator.

If no safety actuation signal is present, a further time delay (Device 2-2) is allowed before the automatic tripping actions are initiated. This second time delay is based on the maximum time for which the most sensitive load can perform its safety function without impairment at the degraded voltage.

8.3.1.1.2.12 Testing of power systems during operation

Operational and periodic tests, including in-service tests, are performed after installation on the power and control circuits and components, including protective relays, meters and instruments. Protective relays, meters and instruments have provisions for inservice testing and calibration. Drawout power circuit breaker operation and operation of their control circuits and protective devices are tested. Testing of each diesel generator is described in Section 8.3.1.1.2.14. Preoperational testing is described in Chapter 14.

8.3.1.1.2.13 Deleted by Amendment No. 15

8.3.1.1.2.14 Design Aspects of the Emergency Diesel Generators

a) Automatic Starting Initiating Circuits - Each diesel generator can be started automatically either by an Engineered Safety Features Actuation Signal (ESFAS) or by the undervoltage relays on the respective 6.9 kV ESF bus. When there is an ESFAS present, the diesel generator is not connected to the ESF bus unless there is also a loss of preferred (offsite) power.

b) Starting Mechanism and System - Each diesel generator is started by compressed air, which is stored in two separate air tanks. Each tank has sufficient air to start the engine five times without recharging. The air starting system is described in Section 9.5.6.

Admission of air to the starting header on the engine is by solenoid valves, which are energized by an engineered safety features actuation signal, an undervoltage signal from the related 6.9 kV bus, or by local or remote control switch operation. Unless the engine has been deliberately shutdown for maintenance, by placing an "operation maintenance" switch in the maintenance position, a condition which is annunciated in the Control Room, the automatic starting signals override all manual controls, irrespective of the position of other switches.

c) Tripping Devices - Diesel generator protection is described in Section 8.3.1.1.2.11(c) which gives the conditions under which automatic shutdown of the unit will occur.

Manual tripping may be done by operator action at any time from the Main Control Board, Auxiliary Control Panel or Diesel Generator (local) Control Panel. If the local selector switch is in the local position, the diesel generator can be tripped locally by simultaneously pressing the "Think" and "Emergency Stop" pushbuttons or the Auxiliary Control Panel by turning an "Emergency Stop" switch. If the local selector switch is in the MCB position, the diesel generator can be tripped from the Main Control Board.

d) Interlocks - Interlocks have been provided in the closing and tripping circuits to prevent closing of a diesel generator breaker under the following conditions:

1) During testing of the diesel generator if a lockout relay is tripped, the breaker closing circuit is deenergized, and the trip is energized.

2) During testing of the diesel generator if the generator is out of synchronism with the bus, synchronism check relays prevent closure of the incoming breaker.

3) Automatic connection of the ESF loads, except for small static loads, without voltage on the associated ESF bus is prevented by a contact of the bus voltage sensing relays in the closing circuits of the individual breakers.

e) Permissives

1) To start the diesel generator:

a) Local Selector Switch in either "local" or "MCB" position.

b) Diesel Generator lockout relay in reset position.

c) "Operational - Maintenance" Switch in "Operational" position.

d) All other manufacturer's permissives satisfied

2) To trip the emergency diesel generator when the unit is on auto operation:

This is covered in Section 8.3.1.1.2.14(c).

3) To close the diesel generator Circuit Breaker:

a) Manual - with live bus (test condition).

1) Diesel generator lockout relay in reset position.

2) Correct voltage and frequency on the diesel generator.

3) Synchronizing switch "on" and synchronizing check relay contact closed.

b) Auto Close (after emergency start)

1) Diesel generator lockout relay in reset position.

2) Near-rated voltage and frequency on the diesel generator.

3) Preferred source breaker open.

f) Load Shedding Circuits - All loads connected to the ESF buses have been arranged to be shed upon loss of normal and preferred sources of power. The ESF 480V power center 1A2-SA(1B2-SB) is energized through its station service transformer concurrently with the closing of the diesel generator breaker. The ESF 480V power center 1A3-SA(1B3-SB) is energized through its station service transformer 0.5 seconds after power center 1A2-SA(1B2-SB) is energized. The loads fed from these power centers are energized in sequence according to Table 8.3.1-2c. Loads in the manual load block can only be reconnected to the ESF buses manually, when a permissive signal is present from the emergency load sequencer (refer to Section 7.3 for a description of emergency load sequencer), which occurs when the automatic sequence is completed.

g) Testing - Each diesel generator is equipped with a means for starting periodically to test for readiness, a means for synchronizing the unit onto the bus without interrupting the service, for loading, and for shutdown after test. Each diesel generator can be manually synchronized to its emergency bus from the Main Control Board or the Diesel Generator (local) Control Panel. Administrative controls ensure that both diesel generator units are not load tested simultaneously.

The following periodic tests will be performed on each diesel generator:

1) starting

2) load acceptance

3) design loading

4) load rejection

5) functional

External fault back-up protection for the diesel generator and safety-related electrical system during periodic testing of the diesel generator is provided by the voltage controlled

overcurrent relay (51V). This relay senses overcurrent due to overloading of the diesel generator in conjunction with a reduction in voltage. The 51V relay is arranged to trip the diesel generator output breaker.

h) Fuel Storage and Transfer System - The Diesel Fuel Storage and Transfer System is described in Section 9.5.4.

i) Diesel Generator Cooling System - The Diesel Generator Cooling Water System is described in Section 9.5.5.

j) Instrumentation and Control for Standby Power Supply - Manual control of the diesel generators is described in Section 8.3.1.1.2.14(e).

Automatic operation of the units, as described in Section 8.3.1.1.2.14(e) is initiated by any signal requiring operation of any of the engineered safety features as well as 6.9 kV bus undervoltage, and supersedes manual control.

The diesel generator controls and monitoring instruments are installed on free standing floor mounted panels separate from the engine skid. Control panels are located in the electrical equipment room whose foundation is isolated from that of the diesel generators. Certain control system components, mostly pneumatic devices, are mounted on the engine. These devices have a history of reliable performance in this type of environment. In addition, control panels complete with all controls and instrumentation and engine mounted components were shake table tested to the short term forces of a seismic event with no damage or malfunction sustained. These forces are many times greater than vibrations caused by diesel generator operation.

Performance of the engine, generator and auxiliaries is monitored locally. Local devices are provided to monitor the following:

1) Fuel oil pressure and day tank level

2) Lube oil pressure, temperature and sump level

3) Jacket water pressure and temperature

4) Starting air pressure (in each header)

5) Combustion air manifold pressures and temperatures

6) Engine speed and operating time

7) Exhaust gas temperatures at each cylinder head

8) Deleted by Amendment No. 48

9) Engine crankcase pressure

10) Generator output (current, frequency, voltage, power, reactive power and energy)

11) Control air pressure

12) Turbocharger oil pressure

13) Combustion air header pressure

14) Lube oil filter differential pressure

15) Standpipe level

16) Fuel oil filter differential pressure

Control Room indication is provided for:

1) Generator output (voltage, power, reactive power, current and frequency)

2) Generator excitation field current

3) Control Voltage (DC)

4) Synchroscope

5) Diesel generator fuel oil day tank level

6) ERFIS computer display of generator load (MW), AC volts and amps, and stator temperature

Local alarms include high or low pressures, temperatures and levels as listed in Sections 9.5.4, 9.5.5, 9.5.6 and 9.5.7, together with engine and generator trip alarms as listed in Section 8.3.1.1.2.11(c). Grouped alarms are transmitted to the Control Room if any alarm condition occurs.

Conditions that render the diesel generator incapable of responding to an automatic emergency start signal are the same whether the condition occurs while the diesel generator is in the standby or test mode. These conditions and corresponding wording of the annunciator windows in the main control room are listed as follows:

Condition	Engine Control Panel Annunciation	Main Control Room Annunciation
Engine overspeed	Overspeed trip	Diesel generator trip
Generator differential operated	Generator differential protection trip	Diesel generator trip
Engine “Operational and Maintenance” switch in maintenance mode	D-G on maintenance mode	D-G control to local or maintenance mode
Emergency bus differential relay operated	Emergency bus differential	Diesel generator trip
Loss of Generator Potential Transformer Circuit	Gen Pot Ckt Loss of Fuse	Diesel generator trip

The main Control Room annunciation for the diesel generator system consists of five individual windows for each train with the following legends:

1) Diesel generator trip
2) Diesel generator trouble
3) Diesel generator start failure
4) Diesel generator day tank hi-hi/lo-lo level
5) Diesel generator control to local or maintenance mode

Annunciator windows (1) and (2) described above are category alarms and are actuated due to the following conditions:

1) Diesel generator trip: This alarm is actuated due to conditions in the diesel generator which will render the diesel-generator incapable to respond to an emergency start signal or otherwise is considered detrimental to the satisfactory operation of the diesel generator. The conditions are as follows:

   – Lube oil high temperature
   – Turbo charger oil low pressure
   – Crankcase high pressure
   – Jacket water high temperature
   – Vibration
   – Loss of generator excitation
   – Generator reverse power
   – Generator overcurrent
   – Bearing high temperature
   – Lube oil low pressure
   – Jacket water low pressure
   – Emergency bus differential
   – Engine overspeed
   – Generator differential
   – Generator negative sequence

– Generator bearing high temperature

– Loss of Generator Potential Transformer Circuit

All of the above conditions are alarmed at the local panel individually.

2) Diesel generator trouble: This alarm is actuated due to conditions at the diesel generator which indicate a malfunction of the diesel generator. The conditions included in this alarm are as follows:

– Lube oil (in) - High temp.

– Lube oil strainer - High Δ P

– Jacket Water low pressure

– Jacket Water (in) - High temp.

– Fuel oil strainer - High Δ P

– Fuel oil filter - High Δ P

– Generator ground

– Auto start & protection bypassed

– Diesel generator closing circuit trouble

– Generator overload

– Lube oil (out) - High temp.

– Jacket Water - Low Level

– Lube oil filter - High Δ P

– Jacket water (out) - High temp.

– Starting air - Low pressure

– Loss of DC power to generator panel

– Loss of DC power to engine panel

– Lube oil standby pump on

– Lube oil (in) - Low temp.

– Turbo charger oil (left) - Low pressure

- Lube oil - Low level
- Jacket water (in) - Low temp.
- Shutdown lockout tripped
- Loss of generator PT's
- Transfer relay failure
- Engine panel - High/low temp.
- Lube oil (out) - Low temp.
- Turbo charger oil (right) - Low pressure
- Lube oil - Low pressure
- Jacket water (out) - Low temp.
- Fuel oil - Low pressure
- Control air - Low pressure
- Barring device engaged
- Annunciator ground
- Generator Control Panel Hi-Temp

All of the above conditions are alarmed at the local panel individually.

There are no conditions that render the diesel generator incapable of responding to an automatic emergency start signal not alarmed in the control room.

k) Qualification Testing Program - Qualification testing of diesel generator for the SHNPP plant consists mainly of the following steps:

1) Factory run-in test.

2) Type qualification test

a) Start and load acceptance qualification

b) Load capability qualification

c) Margin qualification

d) Sequential loading test

e) Starting air capacity test

3) Site test

a) Start and load acceptance test

b) Load capability test

c) Design load test

d) Electrical test

Test steps 1 & 2, performed at the manufacturer's facility, established test conditions similar to what can be expected at the actual site except that the intake and exhaust system and starting air of the test facility is substituted for the actual equipment. During the pre-operational test at the site, test step 3, the actual equipment is utilized. Each of the tests mentioned above demonstrates the capability of the diesel generator as described hereunder:

1) Factory Run-in Test: This step demonstrates the performance of the engine prior to qualification type testing and to obtain the performance data for operation up to 110% of engine rating for reference in subsequent testing steps.

2) Type Qualification Testing -

a) Start and load acceptance testing: This test demonstrates that the diesel generator has the reliability to start and accept load within the period of time specified in the design specification. The specific method utilized to demonstrate this is by conducting a total 300 valid start and loading tests in accordance with the steps established in Section 6.3.2 of IEEE 387-1977. The unit is considered acceptable if the failure rate does not exceed one per hundred starts.

The test data of a 300 start and load test performed by the manufacturer on the same model engine-generator set, built for Middle South Energy, Unit-1, is utilized to establish the acceptability of the Shearon Harris diesel generator. A comparison of the tested diesel generator to the Shearon Harris diesel generator is provided in Table 8.3.1-8.

b) Load Capability Qualification: This test demonstrates the capability of the diesel generator to carry the rated load at rated power factor for the specified period of time and to successfully reject the rated load without exceeding the specified limits of voltage, frequency and recovery time. This test is performed in two steps:

1) Rated load test: Load the diesel generator at 110 percent of its continuous rating (its 2 hour rating) and hold for 2 hours. Subsequently load the diesel generator for 100 percent of its continuous rating and hold for 22 hours.

2) Load rejection test: Establish continuous rated load and operate to establish the temperature equilibrium, and then reject the established load instantaneously. The acceptance criteria is to demonstrate that the

speed increase of the diesel generator does not exceed 75 percent of the difference between nominal speed and over-speed set point or 115 percent of nominal, whichever is lower.

c) Margin Qualification Test: This test demonstrates the capability of the engine-generator to start and carry loads at least 10% greater than the most severe single step load within the specified load sequence without experiencing instability resulting in generator voltage collapse or significant evidence of the inability of the voltage to recover. In addition, this test demonstrates that there is sufficient engine torque available to prevent engine stall and to permit the engine speed to recover when experiencing the most severe load requirement.

d) Sequential Loading Test: This test demonstrates the engine-generator's ability to start and accept sequentially applied load in accordance with the design specification without exceeding the specified limits of voltage, frequency and recovery time.

e) Starting Air Capacity Test: This test demonstrates that the engine-generator can be successfully started a minimum of five times without recharging the air receivers.

f) Factory No-Load Endurance Test: The diesel generators are Transamerica-DeLaval, Inc. Model DSRV-16-4. The design provision of the engine takes into consideration the prolonged period of no-load operation at synchronous speed.

A factory no-load endurance test has been conducted by the manufacturer on the same model machine as the one furnished to the Shearon Harris project to verify that engine model DSRV-16-4 could operate at zero load for at least 7 days (168 hours) without detrimental effects on the engine's performance or its capability to accept a significant step load. The specific procedure utilized for this test is to start and run the engine at no-load, rated speed for 168 hours. At the end of this time, a 1000 KW resistive load is applied, and one-half second later a 3000 KW resistive load is applied (4000 KW total).

The results of this test indicate that the engine-generator set performed without developing abnormal engine responses, noise, or vibration. The exhaust was clear from the start of the unit until the moment the load was applied. After application of the step loads, the exhaust smoke was heavy for about 20 seconds. Within 35 seconds the exhaust was normal indicating that during no-load operation the combustion process was good with no fuel carry-over to the exhaust stack. There was also no indication of lube oil being pumped into the intake or exhaust manifolds.

3) Site Tests -

a) Start and load acceptance test: This test demonstrates the similar objectives as described in type qualification testing with the following exception:

The diesel generator reliability is demonstrated by means of any 69 consecutive valid tests (per plant) with no failures, with a minimum of 23 or 69/n tests

whichever is the larger, per diesel generator unit (where n is equal to the number of diesel generator units of the same design and size).

b) Load capability test: Similar to item 2(b).

c) Design load test: This test demonstrates the capability of carrying the design load for a time required to reach the temperature equilibrium plus 1 hour without exceeding the manufacturer's design limits.

d) Electrical test: This test demonstrates that the electrical properties of the generator, excitation system, voltage regulation system, engine-generator system and control and surveillance systems are acceptable for the required design conditions.

Further discussion of site test methods is provided in FSAR Section 14, Subsection 14.2.12.1.16.

l) Basis for Diesel Generator Sizing - Table 8.3.1-2c lists the ESF and non-ESF loads that are sequenced on to each emergency diesel generator or which may be manually loaded after sequencing has been completed. The total loading on each emergency diesel generator in kW is shown in Tables 8.3.1-2a and 8.3.1-2b. The continuous rating of each diesel generator is based on the total calculated consumption of all loads, ESF and non-ESF, that will have to be powered by the system under design basis accident or safe shutdown conditions. The calculated load on each motor or heater is based on conservative design calculations under expected flow and pressure conditions, pump runout condition or manufacturers' recommendations.

Each diesel generator has the following ratings:

1) 6500 kW - 8760 hours.

2) 7150 kW - two hours in any 24-hour period. (Both the above ratings are for yearly maintenance intervals).

m) Table 8.3.1-2c shows the automatic and manual loading sequence of the emergency power supply system. All essential loads are started automatically by their respective safety features actuation signals in a predetermined step by step loading sequence. Equipment which may require manual start-up will only be started after the initial automatic sequential loading, and only if the generator unit is operating satisfactorily.

8.3.1.1.2.15 Electrical penetrations

Modular type penetrations are used for all electrical conductors passing through the containment wall. Each penetration assembly consists of a stainless steel header plate attached to a carbon steel weld ring which is in turn welded to the pipe sleeve. The header plate accepts either three or six modules depending on the penetration diameter and voltage classification. The modules are sealed by dual pressure seals and held in the header plates by means of retaining clamps. Each module is a hollow cylinder through which the conductors pass. The conductors are hermetically sealed into the module with an epoxy compound.

High voltage penetrations are equipped with bushing type terminations. The low voltage power control modules are provided with pigtails.

Pigtails are terminated on all safety-related circuits inside the Containment by in-line splices (bolted and crimped), utilizing Grayboot cable connectors (refer to Table 3.11.0-3), and coaxial/triaxial cable connectors only. All penetration terminations inside Containment, except high voltage and Grayboot connectors, are covered with qualified heat shrinkable tubing to protect splices from the Containment environment. Terminations using Grayboot connectors provide a qualified environmental seal without a covering of heat shrinkable tubing. High voltage terminations utilize a qualified molded rubber boot connector (quick disconnect type). All pigtails outside the Containment are terminated by coaxial cable connectors, terminal blocks, and multi-pin connectors.

The electrical penetrations are in conformance with IEEE 317-1976.

Coordinated fault-current-versus-time curves showing the relationship of the fault carrying capability between the electrical penetration, the primary overcurrent protective devices, and the backup overcurrent protection device for typical cable types that penetrate primary containment are provided by Figures 8.3.1-6 through 8.3.1-11.

Test reports substantiating the capability of the electrical penetration to withstand the total range of time versus fault current without seal failure for worst case environmental conditions are referenced in Sections 3.10 and 3.11.

Both safety related and non-safety related penetrations are protected against overcurrent. Primary and backup overcurrent protection meets the requirements of IEEE 279-1971 with regard to testing and independence. As part of the plant's normal maintenance procedure, circuit breakers are inspected and tested periodically, based on vendor recommendations and/or industry standards. Testing includes manually operating and/or electrically tripping circuit breakers. In all cases, the penetration circuit protection has been designed so that the primary and back-up disconnecting devices can each limit the maximum I2t at the penetration to a value less than that required for thermal damage to the penetration conductor. Details of the protection scheme are given below, and further discussion can be found in Section 8.3.1.2.11.

a) 6.9kV Circuits - Only three (3) 6.9kV circuits penetrate the containment, one for each of the three (3) Reactor Coolant Pump (RCP) motors. The feeders themselves are not nuclear safety related, but the switchgear breakers and cubicles have been purchased and qualified as Class IE for RPS sensing and tripping purposes. Accordingly, each breaker has independent and redundant trip coils and trip coil power supplies. While the current/overcurrent relaying does not have an RPS function, all equipment in the cubicles were bought to the same quality level.

Overcurrent protection is provided by one set of differential relays and two sets of overcurrent (50/51) relays. The differential relays and one set of overcurrent relays furnish tripping signals to one of the redundant trip coils. The second set of overcurrent relays furnish a tripping signal to the second redundant trip coil. Each of the redundant tripping circuits has a set of breaker failure (50 FD) relays associated with it. These relays initiate timers to trip the line breakers feeding the bus. Control power for the line breakers is from a

different dc power supply. Neither the failure of a single breaker nor the failure of one dc power supply can cause the failure of the protection circuit.

Current vs. time curves for these devices are given in Figure 8.3.1-6.

b) 480V Circuits from Power Centers - The 480V penetration circuits directly fed from 480V power centers are non-safety related and are protected by circuit breakers having long time and instantaneous trip functions (primary device) in series with current limiting fuses, one per phase, servicing as the back-up protection device. The fuses are equipped with an anti-single phase device to ensure that all three phases of the circuit are tripped when a fuse blows. Current versus time curves for these devices are given in Figure 8.3.1-7.

All other 480V penetration circuits are from MCCs or in the case of the pressurizer heaters, from heater control or distribution panels.

c) 480V Circuits from Motor Control Centers - Each 480V penetration circuit fed from an MCC is provided with a back-up thermal-magnetic circuit breaker in series with the primary circuit breaker or circuit breaker/current limiting fuses combination described in Section 8.3.1.1.2.11. The back-up circuit breaker trip characteristic is closely matched to that of the primary device. Current versus time curves for these devices are given in Figure 8.3.1-8.

The only exceptions to the above MCC penetration circuit protection scheme occur in the safety-related containment fan cooler motor feeder circuits. Due to the large penetration conductor size used for these circuits, the MCC feeder breaker located at the 480V power center bus provides sufficient backup protection for these penetration circuits. Current versus time curves for the fan cooler motor feed circuits are given in Figure 8.3.1-8.

Penetration circuits fed from 480V heater distribution panels to the pressurizer heaters are each protected by a thermal-magnetic breaker in series with a fuse in the heater distribution panel, to provide primary and backup overcurrent protection. Current versus time curves for the pressurizer heater feeder circuits are given in Figure 8.3.1-9.

d) 208/120V AC Circuits from Distribution Panels - The penetration circuits are each provided with either two thermal-magnetic circuit breakers connected in series, with similar tripping characteristics, or a thermal-magnetic circuit breaker in series with a fuse, or a fuse in series with a fuse to provide primary and back-up overcurrent protection.

e) 125V DC Circuits - The DC circuits are protected by double pole fuses and the system is ungrounded. Therefore, any overcurrent condition is detected by two devices in series and, if one fails, the other provides the necessary protection.

f) 120V AC Control Circuits - Each one of these low energy circuits is protected by one fuse. The 120V AC control circuits derived from 480V motor control centers do not require backup overcurrent protection. These circuits are supplied via 480/120V control transformers with a maximum rating of 150 VA and an impedance of 3.9 percent. This transformer maximum rating will limit the available short circuit current at the penetration for these circuits to a value less

than the continuous current capability of the penetration conductor used for control circuits. The transformer secondary fuse provides protection to control components and associated cables against a short circuit downstream of the transformer secondary. The fuse is sized based on the twice full load current of the control power transformer. The primary of the transformer is unfused and connected directly to the load feeder breaker. The feeder breaker is sized to trip for a fault at the primary side of the transformer. Any 120V AC control circuits that are derived from distribution panels have backup protection as discussed in (d) above.

g) Instrumentation Circuits - These are circuits in which the possible energy release on a faulted condition is so low as to be less than the maximum that the penetration can withstand. Therefore, no protection is required.

8.3.1.1.2.16 Electric cables and raceway systems

Power and control cable types and ratings used in the onsite AC power system are given in Section 8.3.1.1.1. Cables for the DC system are the same type as those used for 480V AC power and control applications.

Instrumentation cable for the onsite power system consists of copper conductors with ethylene-propylene rubber type or cross-linked polyethylene insulation with hypalon jackets or ETFE Fluoropolymer insulation and jacket, rated 300 or 600 volts for continuous operation at a conductor temperature of 90C.

Cables servicing the onsite power system are safety related. Environmental conditions under which the cables must operate are given in Section 3.11 and the cables have been qualified to meet these conditions.

Cable ampacities are in accordance with ICEA-54-440 and ICEA P-46-426. Except where impractical, all non-safety related cable is flame retardant and has met the flame test requirement of IEEE-383. Lighting branch circuit cable has been assigned to a dedicated raceway system and is not routed with other plant cable.

A raceway system is comprised of channel that is designed and used expressly for supporting or enclosing wires, cables or bus bars. Raceway systems primarily consist of, but are not restricted to, rigid steel conduits for exposed and embedded applications, PVC conduit for safety related power and control cable in underground duct banks, PVC coated steel conduits for safety related instrumentation cable in underground duct banks, plenum rated interlocking armored cable for the installation of nonconductive fiber optic cables, and solid bottom and ladder type steel trays in all indoor plant areas. Conduit raceway encompasses the following: rigid steel, electrical metallic tubing, flexible metal with or without coating, and intermediate metal. Flexible metal conduit is typically used for raceway connections to vibrating equipment.

Steel jacketed fire rated cables are not required to be supported by any of the described raceway systems.

All raceway systems, along with steel jacketed fire rated cables, are supported securely and at intervals governed by the span loading.

The underground raceway system for safety related cables utilizes directly buried ducts, adequately protected by earth cover and/or a concrete slab where required. The specific design criteria for the safety related underground cable system are analyzed in Section 8.3.1.2.37.

8.3.1.1.2.17 Lifted leads and jumpers

Where the use of jumpers or other temporary bypass mechanisms cannot be avoided, this is controlled in approved procedures or by use of a temporary modification. The control of jumpers and lifted leads for trouble shooting purposes will be documented by the associated work ticket and/or a temporary modification. The control of jumpers and lifted leads used to satisfy required testing will be documented in the associated approved procedure. Independent verification will be used to ensure proper restoration. The guidelines used for controlling lifted leads and jumpers are similar to the guidance of INPO Good Practice TS-412.

8.3.1.1.3 Design criteria and bases for safety related electric equipment

Design criteria and bases for specific types of Class IE equipment are discussed below:

a) Motors - Motor size has been determined by the characteristic of the driven equipment so that the motor develops sufficient torque to drive the load under maximum expected flow and pressure.

Class IE motors are designed to start their respective driven equipment with 75 percent of rated motor terminal voltage. The motor starting torque is sufficient to start and accelerate the connected load to normal speed within specified time to permit its safety function for all expected operating conditions. On the basis of these capabilities, CP&L has evaluated that all such motors will operate for one minute at 75 percent of rated voltage without suffering any damage.

Motor insulation systems have been selected based on the particular ambient conditions to which the insulation will be exposed. For Class IE motors, the insulation system has been qualified as described in Section 3.11. All Class IE motors have Class B, or better, rated insulation.

Safety related motors without antifriction type bearings, 100 horsepower and above, are provided with bearing thermocouples for measuring bearing temperature.

Class 1E motor operators for the steam supply valve to the Auxiliary Feedwater Pump turbine, the Safety Injection valves and the Safety Injection Discharge valves have been qualified for a total number of load cycles far in excess of the actual expected service requirement. The availability of these safety systems will not be compromised due to limitations in the duty cycle of the valve operator motors.

b) Ratings of Switchgear Power Centers and Motor Control Centers - The ratings of this equipment are listed in Table 8.3.1-1. The ratings have been selected such that (1) any bus is capable of starting the largest motor with all other equipment in operation while maintaining adequate voltage at the motor terminals, and (2) the circuit breakers can safely interrupt any short circuit that may occur in the system.

c) Electric Circuit Protection - Electric circuit protection has been designed for selective tripping as discussed in Section 8.3.1.1.2.11.

d) Grounding - The 6.9 kV and 480V systems employ high resistance grounding, so that ground fault currents are sufficiently low such that breaker tripping is not required, permitting continued operation in the event of a ground fault.

The 6.9 kV system is grounded through transformer/resistor combinations connected to the secondary neutrals of the start-up and unit auxiliary transformers. The diesel generator is high resistance grounded through a transformer and resistor connected to the generator neutral.

The 480V system is grounded through grounding resistors connected to the secondary neutrals of the station service transformers. Lower voltage AC systems are solidly grounded.

8.3.1.2 Analysis

Class 1E electric components are designed to ensure that any of the design events listed in IEEE Standard 308-1971 do not prevent operation of the minimum number of safety-related loads and protective devices that would be required to mitigate the consequences of an accident and/or safely shutdown the reactor. The requirements to which the offsite power system is designed are listed in Section 8.1.4.1.

The following design aspects illustrate the extent of conformance with respect to Regulatory Guides, IEEE Standards, and General Design Criteria (GDC). The General Design Criteria are covered in detail in Section 3.1.

8.3.1.2.1 GDC Criterion 17

Redundancy of the emergency auxiliary power system has been provided for the operation of redundant safety related electrical load groups divisions A and B. This redundancy extends from the emergency power source, through 6.9 kV buses, station service transformers, 480 volt buses, MCCs, electric cables, 208/120V and 120V distribution panels, inverters, and protective devices.

No redundant essential electrical component is dependent for its emergency power supply upon electrical equipment or devices which are common to the power supply for its redundant counterpart.

Each of the redundant onsite emergency power sources and associated load groups can independently provide for safe shutdown of the plant and/or mitigate the consequences of a design basis accident.

8.3.1.2.2 GDC Criterion 18

The two onsite electrical load groups are redundant; therefore allowing either of the two divisions (A or B) to be tested while the other division performs its function of supplying required power.

8.3.1.2.3 Regulatory Guide 1.6 (Revision 0, March 1971)

The design conforms to the positions of this guide as follows:

a) The electrically powered loads, both AC and DC, have been separated into two redundant divisions such that loss of either division will not prevent the minimum safety functions from being performed.

b) Each AC division has a connection to the preferred (offsite) power source and to a standby (onsite) power source. Each standby power source has no connection to the other redundant load group.

c) Each DC division has a separate battery and battery charging system. No connection has been provided between the battery and charger combination of one group and their redundant counterparts.

d) No means are provided to automatically parallel the standby source associated with Division A with the standby source associated with Division B.

e) No provision exists for automatically connecting one redundant load group to the other or for automatically transferring loads between redundant power sources.

f) Third service loads and RHR inlet valves can be manually connected to either Division A or Division B buses, but never both simultaneously, as discussed in Section 8.3.1.1.2.4.

g) Each standby power source consists of a single generator driven by a single prime mover.

8.3.1.2.4 Regulatory Guide 1.9 (Revision 2, December 1979)

The intent of Regulatory Guide 1.9 is met as follows:

a) The diesel generators are each rated as shown in Table 8.3.1-1. The maximum automatically started load on each diesel generator is within the continuous rating of 6500 kW. The total maximum load, including manually started loads, is also within the continuous rating of the diesel generators.

b) Preoperational tests are discussed in Chapter 14.

c) Preoperational tests will verify the capability of each diesel generator set to start and accelerate to rated speed all of the needed safety related loads in the required sequence.

d) The diesel generator sets will be capable of reaching full speed and voltage within 10 seconds after receiving a signal to start. The engine will be capable of starting, accelerating and supplying the above loads in the sequence shown in Table 8.3.1-2c without exceeding five percent speed drop, maximum, at any time.

A load sequencing test has been performed reflecting the Shearon Harris diesel generator loading condition as per FSAR Table 8.3.1-2a, 8.3.1-2b, and 8.3.1-2c with margin. The test results indicate that at no time during the load sequencing does the frequency and voltage decrease to less than 95 percent of the nominal and 75 percent of the nominal respectively.

The generator will be capable of starting, accelerating, and supplying the above loads in their proper sequence without exceeding 25 percent voltage drop at the generator terminals.

The speed of the diesel generator set will not exceed 111.25 percent of nominal speed (450 rpm) during recovery from transients caused by disconnection of the largest single load. The engine trip setpoint is 517±5 rpm (115 percent nominal) to ensure that the unit will not trip on rejection of the largest single loads.

The recovery of the diesel generator from transients, to within 10 percent of nominal voltage and two percent of nominal frequency, will be within 60 percent of each load sequence time interval. The recovery from transients will be verified during preoperational testing.

Qualification data (as described in Section 3.11) will be submitted and preoperational tests will be performed to confirm the suitability of the diesel generator set.

8.3.1.2.5 Regulatory Guide 1.29 (Revision 3, September 1978)

For a listing of the seismic classification of electrical equipment important to safety, refer to Section 3.2.

8.3.1.2.6 Regulatory Guide 1.30 (Revision 0, August 1972)

The extent of conformance with this guide is described in FSAR Section 1.8.

8.3.1.2.7 Regulatory Guide 1.32 (Revision 2, August 1977)

The design complies with the positions of this guide, except as stated in Section 8.3.2.2. Further discussion of the batteries and their chargers is contained in Section 8.3.2.

8.3.1.2.8 Regulatory Guide 1.40 (Revision 0, March 1973)

The design complies with the positions of this guide. Further discussion on qualification of motors is contained in Sections 3.10 and 3.11.

8.3.1.2.9 Regulatory Guide 1.41 (Revision 0, March 1973)

The design conforms to the positions of this guide. Refer to Section 14.2 for a description of conformance.

8.3.1.2.10 Regulatory Guides 1.47 (Revision 0, May 1973) and 1.53 (Revision O, June 1973)

The extent of conformance with these guides is described in Chapter 7.

8.3.1.2.11 Regulatory Guide 1.63 (Revision 2, July 1978)

The intent of this guide is met as follows:

1) Electric containment penetrations are in accordance with IEEE 317-1976.

2) The penetrations are designed to withstand without loss of mechanical integrity, the maximum short circuit current that could occur due to a through fault, for a period of time sufficiently long enough to allow back-up circuit protection to operate, assuming a failure of the primary protection device. Only through faults are considered, since in the case of power penetrations, it would be impossible to dissipate the energy caused by an internal fault without loss of pressure retaining integrity. Refer to Section 8.3.1.1.2.15 for a description of primary and back-up protection used for electric penetration circuits.

3) The Class 1E and non-Class 1E penetration circuits have overload protection systems which conform to the criteria of IEEE-279-1971, except that requirements regarding equipment qualification have not been equally applied to non-Class 1E penetration protection circuits, since to do so would require upgrading of the non-Class 1E circuits and protection systems. Also, in the case of low voltage circuit protection, it is difficult to meet the testability requirements of IEEE-279-1971. It has not been considered realistic to treat all penetrations equally, since there is a large difference in energy to be dissipated within the penetration assembly under short circuit conditions, depending on the voltage level. The 6.9 kV penetration circuits have been provided with redundant overcurrent and tripping circuits that meet the intent of IEEE-279-1971, as well as redundant breaker failure protection (refer to Section 8.3.1.1.2.15a).

   Low voltage penetration circuit protection is testable consistent with the type of components available that have been successfully demonstrated to provide the required overcurrent protection (e.g. solid state trip breakers, thermal-magnetic breakers and current limiting fuses). Refer to section 8.3.1.1.2.15 for discussion of each representative circuit type.

8.3.1.2.12 Regulatory Guide 1.68 (Revision 2, August 1978)

The extent of conformance with this guide is described in Chapter 14.

8.3.1.2.13 Regulatory Guide 1.73 (Revision O, January 1974)

The extent of conformance with this guide is described in Sections 3.10 and 3.11.

8.3.1.2.14 Regulatory Guide 1.75 (Revision I, January 1975)

The intent of this guide is met as follows:

1) Position C1: Non-Class 1E AC power distribution equipment and the non-Class 1E loads powered from this equipment have been connected to the Class 1E AC system through isolation devices at the 6.9 kV switchgear (except for (1) Emergency Lighting, (2) Vent Stack Flow Monitoring Panels PNL-21AV-3509 and PNL-21AV-3509-1, (3) FLEX Spent Fuel Pool Level Indicators as discussed below). The isolation device is the 6.9 kV circuit breaker which, in addition to its normal overcurrent protection (refer to Section 8.3.1.1.2.11) is tripped either on a loss of bus voltage, or on initiation of an accident signal. The only

exceptions to the above are the AC emergency lighting circuits and vent stack flow monitoring panels. Isolation of the AC emergency lighting system has been considered contrary to the intent of Standard Review Plan Section 9.5.3. However, two circuit breakers connected in series have been provided for each Class 1E MCC circuit feeding a lighting transformer and lighting panel, such that under a faulted condition other sections of the circuit and other circuits are protected against unacceptable influences. In addition, this scheme can withstand a single failure of the primary breaker through tripping of the back-up breaker. These circuits are considered non-Class 1E beyond the Class 1E MCC. The 120 VAC safety-related feed to plant vent stack panel 21AV-3509-1 is isolated from the panel by the installation of double fuses, in series, for both line and neutral wires. The 480 VAC safety-related feed to the plant vent stack pump motor in panel 21AV-3509 is isolated from the panel by a local, 3-pole circuit breaker installed in series with a 3-pole, fused disconnect switch. These schemes can withstand a single failure due to the redundancy of the isolation devices. The FLEX Spent Fuel Pool Level Indicator power supply system has been designed in accordance with the requirements of IEEE Std. 384-1992 as endorsed and modified by Regulatory Guide 1.75 Revision 3. To ensure positive electrical isolation between the plant Class 1E power supply and the non-safety related instrumentation, two series fuses in each power supply conductor (i.e. two for line and two for neutral) have been provided as permitted by IEEE 384-1992 and Regulatory Guide 1.75 Revision 3. These fuses are sized and coordinated to prevent any fault from the non-safety related level instrumentation from adversely impacting the plant safety related bus, and no single failure will prevent these isolation devices from performing their protection function. Lighting and other non-Class 1E circuits connected to the Class 1E System are routed in non-Class 1E raceways and separated from Class 1E raceways in accordance with Section 8.3.1.2.30, for the entire section of the circuit that has been considered non-Class 1E (i.e., beyond the isolation device or, for lighting circuits beyond the Class 1E MCC).

The Class 1E DC system supplies 125V DC control power to the non-Class 1E 480V power centers which provide power to the back-up pressurizer heater groups and are connectible to the emergency diesel generators. This Class 1E DC power is isolated from the non-Class 1E circuit by a circuit breaker and a fuse connected in series and located in the Class 1E DC distribution panel of the appropriate safety division. Refer to Section 8.3.2 for further discussion of DC Power System.

The Reactor Coolant Pump (RCP) motors are fed from non-safety related 6.9kV Switchgear 1A, 1B and 1C. The feeders themselves are not nuclear safety related. The switchgear breakers and cubicles, however, are required for RPS sensing and tripping purposes. The specific cubicles have been purchased and qualified as Class 1E. Each RCP breaker has dual trip coils, SA and SB respectively. Each coil (and related control circuit) is supplied with Class 1E dc control power from its respective Class 1E dc system. Non-safety related control sensing functions (e.g., current) are isolated from the safety related control functions through the respective relay contacts. SA, SB and non-safety related wiring are spatially separated, or separated by barriers or flexible conduit.

2) Position C2: Based upon industry practice at the time, an exception was taken to the inclusion of interlocked armor cable under the definition of "Raceway" in Section 3 of IEEE Std. 384-1974. Regulatory Position C2 was resolved under Revision 3 of Regulatory Guide 1.75, based on a modified definition of "Raceway" in IEEE Std. 284-1992. Per updated provisions of NFPA 70: National Electric Code 2011 Edition (i.e., Article 770 - Optical Fiber Cables and Raceways), the use of Plenum Rated Interlocking Armored Cable is considered

an approved raceway for the installation of nonconductive fiber optic cables (i.e., OFCP), and as a raceway, possesses the highest fire resistance level available (i.e., suitable for use in ducts, plenums and other spaces used for the supply /return of environmental air).

3) Position C3: The separation of circuits and equipment has been achieved by safety class structures, distance, barriers or combinations thereof. In general, locating redundant circuits and equipment in separate safety class structures affords a greater degree of assurance that a single event will not affect redundant systems. Therefore, this method of separation has been used whenever practicable and its use does not conflict with other safety objectives.

4) Position C4: Associated circuits are used in only limited situations. Current design has a single use of associated circuits related to the Hydrogen Monitoring System. Due to a safety classification change from safety-related to non-safety-related for the Hydrogen monitoring system, the system cables are designated and identified as associated in accordance with Reg Guide 1.75, position C-4. No other use of associated circuits has been implemented.

   Non-Class 1E circuits are separated from Class 1E circuits. If connected to the Class 1E system through isolation devices, non-Class 1E circuits are separated from the Class 1E System beyond the isolation device.

   Separation between 1E and non-1E field cabling in the logic bay of each Solid State Protection System cabinet is maintained to the best extent possible. The separation which is maintained and the isolators used have been shown by test to be acceptable by the vendor per Section 5.6.2 of IEEE 384-1974 (see Section 7.1.2.2.1).

5) Position C5: The offsite power system meets the requirements of GDC 17 (refer to Section 3.1).

6) Position C6: The analyses identified in this regulatory position correspond to those contained in Section 8.3.1.2.30, Paragraph b.

7) Position C7: Associated circuits are not utilized. Non-Class 1E instrumentation and control circuits are routed in separate raceways from Class 1E circuits. Separation of instrumentation and control circuits is discussed further in Chapter 7. Certain motor and diesel generator terminal boxes house both Non-Class 1E thermocouple cables and Class 1E space heater cables. The low energy thermocouple cables and the space heater cables are properly identified and, other than in these common terminal boxes, are separately routed to meet the provisions of Section 8.3.1.3. No credible failure of the thermocouple cable can degrade Class 1E space heater circuits.

8) Position C8: Cable tunnels are not utilized.

9) Position C9: Cable splices have not been designed into the cable systems. Cable splices required to be made during or after cable installation are not permitted to be made in cable trays. All such splices are made in suitable conduits, metallic electrical boxes or manholes with the exception of non-Class 1E medium voltage cables that are not subject to reduced separation and low voltage cables that are installed in locations where reduced separation criteria has not been implemented. These cables will be evaluated on a case by case basis

and may be spliced in cable trays. Thermocouple extension wire connecting to thermocouples for monitoring thermal stratification (in accordance to Bulletin 88-08) are not run in raceways

10) Position C10: Cables installed in exposed Class 1E raceways are color coded with painted bands or tape extending entirely around the outside jacket of the cable. The bands are approximately 2 inches in width and are located at intervals of approximately 3 feet along the entire length of the cable, in a manner of sufficient durability to ensure initial verification that the installation is in conformance with the separation criteria. The cable markings are generally applied prior to or during installation. When markings are applied after installation, the 3 foot interval is waived for that part of the cable in conduit. In this case, the cable is marked at the entry and exit points of the conduit(s) as well as at 3 foot intervals throughout the remainder of the run.

11) Position C11: The above color coding method readily distinguishes between redundant Class 1E Systems, and between Class 1E and non-Class 1E Systems, based on knowledge of the colors involved and that a color coded tray must contain only cables bearing that same color code or codes.

12) Position C12: The cable spreading area and Control Room do not contain high energy equipment such as switchgear, transformers above 480 volts, rotating equipment or potential sources of missiles or pipe whip, and are not used for storing flammable materials. Circuits in the cable spreading area are limited to control and instrument functions and those power supply circuits serving the Control Room. Such circuits with operating voltage above 120 volts AC or 125 volts DC (i.e., power circuits) are limited to control room lighting panel feeders and are routed in enclosed raceways.

    A minimum amount of circuits (120V AC or 125V DC and below only} pass through the cable spreading rooms only where unavoidable.

    Cable spreading rooms A and B are separated from each other by three hour fire barriers. Automatic sprinklers are also provided in the cable spreading rooms. Separation is further discussed in Section 8.3.1.2.30.

13) Position C13: There are no different separation requirements utilized for different tray widths.

14) Position C14: Redundant Class 1E standby generating units are placed in separate rooms of the Diesel-Generator Building, a Seismic Category I structure, and have independent air supplies.

15) Position C15: Redundant Class 1E batteries are placed in separate rooms of the Reactor Auxiliary Building, a Seismic Category I structure, and are served by independent ventilation systems.

16) Position C16: The separation requirements of IEEE-384-74, Section 5.6, apply to instrumentation racks. In addition, redundant Class 1E instruments are located on separate racks or compartments of a cabinet.

Where redundant Class 1E instruments are located in separate compartments of a single cabinet, attention is given to routing of external cables to instruments to assure that cable separation is retained.

In locating Class 1E instrument cabinets, attention is given to the effects of all pertinent design basis events.

8.3.1.2.15 Regulatory Guide 1.81 (Revision 1, January 1975)

Regulatory Guide 1.81 is not applicable to the SHNPP.

8.3.1.2.16 Regulatory Guide 1.89 (Revision O, November 1974)

The extent of conformance with this guide is described in Sections 1.8, 3.10, and 3.11.

8.3.1.2.17 Deleted by Amendment No. 11

8.3.1.2.17a Regulatory Guide 1.100 (Revision 1, August 1977)

The extent of conformance with this guide is described in Section 1.8.

8.3.1.2.18 Regulatory Guide 1.106 (Revision 1, November 1977)

The intent of this guide has been met by incorporation of circuits which bypass the thermal overload protection devices of all safety related motor operated valve motors under accident conditions. Some safety-related MOVs may be required to be repositioned following the rest of the Thermal Overload Bypass signal. Re-setting the Thermal Overload Bypass signal disables the thermal overload relay bypass feature. In the event that the thermal overload relay actuates during stroking of these MOVs, the bypass feature can be “re-instated” via a Control Switch located on the Main Control Board. The bypass initiation circuitry is periodically tested and conforms to the applicable sections of IEEE-279-1971, referenced in the guide. Further discussion of this bypass circuitry can be found in Chapter 7 in Table 7.1.0-1.

8.3.1.2.19 Regulatory Guide 1.108 (Revision 1, August 1977)

The extent of conformance with this guide is described in Sections 1.8, 8.3.1.1.2.14 and 14.2.12,1.16.

8.3.1.2.20 Regulatory Guide 1.118 (Revision 2, June 1978)

The extent of conformance with this guide is described in Section 1.8.

8.3.1.2.21 Regulatory Guide 1.155 (August 1988)

Carolina Power & Light Company complies with the Station Blackout (SBO) rule, the guidance of Regulatory Guide 1.155, Nuclear Management and Resources Council (NUMARC) 87 00, and NUMARC 87-00 Supplemental Question/Answers and Major Assumptions, dated December 27, 1989. This discussion will follow the structure of NUMARC 87-00.

1) The general criteria and baseline assumptions contained in NUMARC 87-00 are applicable to the evaluation of SBO at HNP. There are no unique situations or plant conditions that conflict with the criteria and assumptions underlying the NUMARC guidelines.

2) CP&L Analysis I.D. SBO-CALC-001; Station Blackout Coping Duration Requirements For Shearon Harris Nuclear Power Plant was prepared to determine the coping duration for HNP to comply with 10 CFR 50.63, Loss of All Alternating Current Power. The minimum acceptable station blackout duration capability is based on the following factors:

   a) Redundancy of the on-site emergency power system

   b) Reliability of each of the on-site emergency AC power sources

   c) Expected frequency of loss of off-site power

   d) Probable time needed to restore off-site power

   Analysis SBO-CALC-001 was performed in accordance with NUMARC 87 00, Revision 0, Section 3, "Required Coping Duration Category" as accepted by Reg. Guide 1.155. Based on the results of the calculations and studies by CP&L, HNP is subject to a minimum station blackout coping capability of four hours. Additionally, HNP will be subject to maintaining an EDG target reliability of 0.95.

3) Station Blackout Response Procedures include emergency and normal operating procedures, procedures for restoring AC power and severe weather procedures, that are to be utilized by the operators for coping with SBO. The procedures provide the necessary detailed procedural steps to:

   a) Recognize a station blackout

   b) Cope with the SBO

   c) Restore offsite power

   d) Restore power to the station's emergency buses

   e) Allow station recovery from the effects of the SBO

4) The design and operational testing of the emergency diesel generators ensure that they are operated and tested in a manner that improves their reliability and availability and ensure that the target reliability of 0.95 can be maintained.

5) HNP submits quarterly reports of data to INPO as a participant in the Plant Performance Indicator Program. Surveillance testing and the maintenance program for the emergency diesel generators ensure that the target reliability is achieved.

   HNP implemented an EDG reliability program utilizing the guidance of Appendix D of NUMARC 87-00.

HNP complies with NUMARC Initiative 4 by participation in the INPO Plant Performance Indicator Program.

6) The Station Blackout (SBO) Coping Capability is independent of an alternate AC power source for the SBO coping duration of 4 hours and recovery therefrom. The characteristics of the following plant systems and components were reviewed to assure that the systems have the availability, adequacy, and capability to achieve and maintain a safe shutdown and to recover from an SBO for a 4-hour coping duration.

    a) Condensate Inventory for Decay Heat Removal

    b) Class 1E Battery Capacity

    c) Compressed Air

    d) Effects of Loss of Ventilation

    e) Containment Isolation

    f) Reactor Coolant Inventory

8.3.1.2.22 IEEE Standard 279-1971

The provisions of this standard relate mainly to the Instrumentation System and are discussed in Chapter 7. The electrical system supplying power to the Reactor Protection System has been designed to ensure that failures in the supply system would result in consequences no more limiting than failures in the Reactor Protection System, as follows:

1) Power supply to the protection systems is from four (one for each channel) power supply inverters as described in Section 8.3.1.1.1. No random single failure in any one inverter will degrade the performance of the other three. With one measurement channel bypassed for testing, failure of a second channel inverter will still leave two channels functional, thus providing protection without unnecessary tripping (refer to Section 7.2 for a discussion of the RPS logic).

2) Any one of the four power supply units can be isolated for maintenance at the same time as the remaining protective channel equipment is being maintained operable and in service.

3) Loss of either the AC or DC source of power for the Class 1E inverters is annunciated in the Control Room.

4) Each power supply unit is so constructed as to facilitate repair by replacement of defective components or modules, to ensure a minimum of downtime.

IEEE Standard 279-1971 has also been used as a guide in the design of all safety related power systems. In particular, the power systems have been designed to meet the single failure criterion; electrical equipment may be tested for functional integrity when the loads it supplies are tested, and all bypasses in safety related circuits (i.e., thermal overload relays in valve operating motor starters) are provided with indication.

8.3.1.2.23 IEEE Standard 308-1971

The Class IE electric systems comply with the requirements of this standard, as modified by Regulatory Guide 1.32 as follows:

1) Principal Design Criteria

   a) Conditions of operation, due to design basis events, both natural and postulated, have been defined in Sections 3.10 and 3.11; Class IE electric systems design was developed, and equipment purchased, such that their safety related functions can be performed, in the respective operating environment, under normal and design basis event conditions.

   b) The quality of the Class IE electric system output is such that all electrical loads are able to function in their intended manner, without damage or significant performance degradation.

   c) Control and indicating devices, required to switch between the preferred and standby power supplies and to control the standby power supply system, are provided inside and outside the Control Room.

   d) All Class IE electric system components are identified, along with the proper channel (safety division) assignment.

   e) Class IE electric equipment is physically located in Seismic Category I structures, except as discussed in 8.3.1.2.30.b.8, and separated from its redundant counterpart to prevent the occurrence of common mode failures.

   f) Equipment qualification by analysis, tests, successful use under similar conditions, or a justifiable combination of the foregoing, ensures that the performance of safety related functions under normal and design basis event conditions was demonstrated. (Refer to Sections 3.10 and 3.11).

   g) Tables 8.3.1-3 through 8.3.1-7 and 8.3.2-5 depict the single failure analysis and the failure mode analysis for the Class IE electric systems.

2) AC Power Systems

   a) Alternating current power systems include power supplies, a distribution system and load groups arranged to provide AC electric power to Class IE loads. Sufficient physical separation, electrical isolation and redundancy have been provided to prevent the occurrence of common failure modes in the Class IE systems.

   b) The electric loads have been separated into redundant groups.

   c) The safety actions by each group of loads are redundant and independent of the safety actions provided by the redundant counterparts.

   d) Each of the load groups has access to both a preferred and a standby power supply.

e) The preferred and the standby power supplies do not have a common failure mode between them. This has been ensured by means of administrative controls that will allow only one diesel generator to be load tested at any time. Also, protective relaying has been included to isolate the standby sources from the preferred power sources in order to preserve the availability of the standby sources.

3) Distribution System

a) All distribution circuitry is capable of starting and sustaining required loads under normal and design basis event conditions.

b) Physical isolation between redundant counterparts ensures independence.

c) Local and/or remote control and indicating components monitor distribution circuits at all times.

d) Auxiliary devices that are required to operate dependent equipment are supplied from a related bus section to prevent loss of electric power in one load group from causing the loss of equipment in another load group.

e) All Class IE electrical power circuits have provision for isolation from non-Class IE circuits through, as a minimum, circuit breakers or fuses located in seismically qualified structures.

4) Preferred Power Supply

a) The preferred power supply derives power from two separate sources.

b) Energy in sufficient quantities is available for normal, standby, and emergency shutdown conditions of the plant.

c) Offsite power is available to start and sustain all required loads.

d) Surveillance of the availability and status of the preferred power supply is maintained to ensure readiness when required.

5) Standby Power Supply:

a) The standby power supply consists of two diesel generators, each connected to one of the safety related 6.9 kV AC buses. Each diesel generator represents a complete, independent source of standby power.

b) The redundant standby power supplies provide energy for the safety related systems when the preferred power supply is not available.

c) Independence of the two standby power systems ensures that a failure of either standby power source will not jeopardize the capability of the remaining standby power source to start and run the required ESF loads.

d) Each diesel generator is available for service within the time specified upon loss of the preferred power supply.

e) Status indicators, local and in the Control Room, provide monitoring and alarm for the surveillance of all vital functions for each diesel generator with respect to standby and operating modes (see Section 9.5).

f) Sufficient fuel is provided at the site to sustain the operation of both standby diesel generators continuously for seven days. Offsite supplies of fuel are available for transportation to the site within this time.

g) Automatic and manual controls are provided for the selection, disconnection, and starting of appropriate loads supplied by the standby power sources.

h) Automatic devices disconnect and isolate failed equipment and indication to this effect is provided.

i) Test starting and loading can be accomplished during normal station operation.

6) For the analysis of the DC Power System, see Section 8.3.2.2.1.

8.3.1.2.24 IEEE Standard 317-1976

Electrical containment penetrations are designed in accordance with this standard. For a description of the penetration design, and for discussion on protection, refer to Sections 8.3.1.1.2.15 and 8.3.1.2.11.

Seismic and environmental qualifications are discussed in Sections 3.10 and 3.11, respectively.

8.3.1.2.25 IEEE Standards 323-1971 and 1974, 334-1974, 344-1975 and 382 1972

For discussion of compliance with these standards, refer to Sections 3.10 and 3.11.

8.3.1.2.26 IEEE Standard 336-1971

For discussion of compliance with this standard, refer to Section 1.8 and Chapter 14.

8.3.1.2.27 IEEE Standard 338-1975

Because of the separation of all safety related electrical equipment into two redundant groups, it is possible to test the power equipment while testing the signal and control systems (also refer to Table 7.1.0-1). Compliance with this standard is further discussed in Sections 13.5.1.3.e and 1.8 (Regulatory Guide 1.118).

8.3.1.2.28 IEEE Standard 379-1977

The single failure criterion has been applied to all Class IE systems. Refer to Tables 8.3.1-3 through 8.3.1-7 and 8.3.2-5 for single failure analyses as described in Section 3.11.

8.3.1.2.29 IEEE Standard 383-1974

Class IE cables and connector assemblies have been qualified in accordance with this standard for normal operating and design basis event conditions, except where the adequacy of the installation has been achieved through other design features such as cables within dedicated conduits or enclosed boxes where the cable will not be exposed to harsh environments or flame propagation, or have been 3 hour fire rated and tested in accordance with NRC Generic Letter 86-10 Supplement 1. The fire testing requirements of NRC Generic Letter 86-10 Supplement 1 exceed the flame test requirements of IEEE Standard 383-1974.

The flame tests covered by Section 2.5 of this standard have been performed with the ribbon-type gas burner, rated 70,000 Btu/hr for its total width. It has been recognized that the objective of the flame test is to provide guidance for the selection of fire-resistant cables rather than to establish the adequacy of the installation of the cables. The adequacy of the installation has been achieved through other factors such as the separation criteria and fire protection measures (reference Sections 8.3.1.2.30 and 8.3.3). In addition, most non-Class IE cables have been type tested for fire resistance by the methods of IEEE-383-1974.

8.3.1.2.30 IEEE Standard 384-1974

Prompted as a direct result of the increased use of digital technologies in plant control and instrumentation systems, IEEE Standard 384-2008 formally addresses the application of physical separation and isolation criteria associated with the use of fiber optic cables in the nuclear power industry. Prior to the issuance of the 2008 Revision, IEEE Std. 384 dealt strictly with the independence requirements of circuits and equipment interconnected with current-carrying cables constructed with metal or metal alloy conductors. The general criteria for Non-Class 1E circuits have been updated to state: "Non-Class 1E fiber optic circuits are not required to be physically separated from Class 1E and associated circuits. Electrical isolation is an inherent characteristic of the fiber optic circuits. Since fiber optic circuits have no potential to degrade Class 1E circuits, they can be considered non-Class 1E circuits verses associated circuits." The general criteria for Class 1E circuits have been updated to state: "No separation distance is required between Class 1E fiber optic circuits of one division and Class 1E fiber optic circuits of a redundant division." In addition, specific separation criteria are provided to address interactions between Class 1E fiber optic circuits as target cables in relationship to current-carrying circuits as source cables (i.e., a faulted Class 1E or non-Class 1E current-carrying source cable can create an ignition source and/or a credible hazard to a neighboring Class 1E fiber optic target cable). The above separation methodologies are based on both cable and associated raceway being qualified as flame retardant, meeting or exceeding the flame test requirement of IEEE Std. 383-1974.

The installation of `non-Class 1E fiber optic cabling' and `Class 1E fiber optic cables of one division in proximity to Class 1E fiber optic circuits of a redundant division' shall be in compliance with the separation criteria set forth in IEEE Standard 384-2008. The installation of Class 1E fiber optic circuits as target cables in proximity to current-carrying circuits as source cables shall be evaluated on a case-by-case basis with consideration given to available test data for the cables involved, along with the criteria presented in IEEE Standard 384-2008.

The extent to which this standard has been followed is described below. (Refer to Section 8.3.1.2.14 for a discussion of the related provisions of Regulatory Guide 1.75).

a) General Separation Criteria and Methods - Separation is provided to maintain independence of electrical circuits and equipment so that the protective functions required during any design basis event can be accomplished. The degree and method of separation varies with the potential hazards in a particular area.

Equipment and circuits requiring separation are identified on drawings and in the field in a distinctive manner as described in Section 8.3.1.3. Separation of equipment and circuits is achieved by separate safety class structures (i.e., rooms), distance, barriers or any combination thereof. In addition, in fire hazard areas, protection is provided in the form of fire suppression systems, fire retardant coatings or both (refer to fire hazards analysis in Section 9.5.1). Electrical equipment, circuits and raceways are separated into redundant Class IE safety related divisions and non-Class IE systems as described below:

1) Class IE safety related: equipment, circuits, or raceways that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment.
   Redundant safety related equipment, circuits, and raceways are separated by the above methods.

2) Non-Class IE circuits and equipment: Equipment and raceways that do not perform any safety operation within the plant.

   a) Non-Class IE circuits are routed in separate raceway systems from Class IE circuits. These raceway systems are separated from Class IE raceway systems by the above methods, and as specified in Section 8.3.1.2.30(b). Non-Class IE circuits connected to the Class IE system are considered Class IE up to and including an isolation device. That part of each circuit considered Class IE has been subject to all requirements placed on Class IE equipment, such as seismic and environmental qualification, separation of redundant divisions, etc.

      Isolation devices are devices in a circuit which prevent malfunctions in one section of a circuit from causing unacceptable influences in other sections of the circuit or other circuits.

      Separation by isolation of non-Class 1E control circuits from Class 1E control circuits is accomplished through Isolation Devices located in the Isolation Cabinets. These Isolation Devices consist of electro-mechanical plug-in type relays, 120V AC and/or 125V DC. Relays provide an electrical isolation of 4KV rms between the input and output sides. A mechanical isolation barrier separates the wiring of the coil and the output contacts of the relay. Independent power supplies are provided for safety sections and non-safety sections. Isolation devices are specifically designed to meet the following criteria:

      1) Single failure criterion in accordance with IEEE-279 to the extent that any random single failure can be accommodated without precluding the initiation of the safety features when true initiating conditions exist.

      2) Electrical isolation to be maintained to prevent any malfunction in the non-Class 1E circuits from adversely affecting the Class 1E circuits.

3) Physical and Electrical independence to be maintained between redundant portion of Class 1E and non-Class 1E circuits.

For a further description of isolation devices, refer to Section 7.3.2.2.6 and 7.7.2.1.

b) Non-Class IE equipment is physically separated from Class IE equipment by the above mentioned methods (i.e., separated safety class structures, distance, suitable barriers, or any combination thereof).

c) Specific Separation Criteria

1) Separation Criteria for Cables and Raceways

a) General Plant Areas: General plant areas are considered to be those areas in which the Class IE raceways are not subject to pipe whip or other hazards as described in Paragraph (b) below, and with the exception of the cable spreading rooms. The minimum separation distances utilized in general plant areas are 3 ft. for trays separated horizontally and 5 ft. for trays separated vertically.

In October 1985, an Electrical Separation Verification Test Program was completed (as described below), and the minimum separation distances reduced as detailed in Table 8.3.1-10. Subsequently, SHNPP design documentation was revised to reflect these distances for raceway/cable installation purposes.

The above given separation distances are based on the following:

1) Cable splices in cable trays are prohibited, with the exception of non-Class 1E medium voltage cables which are not subject to reduced separation and low voltage cables that are installed in locations where reduced separation criteria has not been implemented.

2) Cable and raceways are flame retardant.

3) Cable trays are generally not filled above the side rails. This is accomplished by implementing design limitations on tray fill percentage which is monitored during the design of a cable route. However, presently there are 17 Class 1E control trays and 2 Class 1E low level trays (excluding risers) where the cable installation techniques (bedding, crossovers (tees), etc.) cause several cables to rise above the side rails.

For each installation where cables rise above the side rails and which rework cannot eliminate the condition, the governing plant-specific fill and weight criteria will assure that cable ampacity and tray support weight limitations are not jeopardized. To assure conservatism, each tray section will be documented and the acceptability of the cable ampacity and tray loading verified.

To ensure the requirements of IEEE-384, each tray section with cables above the side rails will be evaluated, case by case, and through the use of spatial separation and/or flame retardant wrap, circuit independence maintained.

4) Hazards are limited to failures or faults internal to the electric equipment or cables.

Horizontal separation is measured from the side rail of one tray to the side rail of the adjacent tray. Vertical separation is measured from the bottom of the top tray to the top of the side rail of the bottom tray. Conduit separation is measured from the perimeter of the conduit. Cable separation is measured from the perimeter of the cable.

Where the above separation distance could not be maintained, the lesser separation distances have been established and justified by (1) test, (2) analysis or (3) the installation of suitable fire barriers/or approved protective coatings.

1) Test - CP&L has contracted Wyle Laboratories to perform testing in accordance with Section 5.1.1.2 of IEEE-384-1974 to justify lesser separation distances. The test methodology, conditions and results are documented in Wyle Test Report No. 47879-02 and are briefly described in the sections below.

    a) Test Methodology/Sequence

        1) CP&L evaluation of SHNPP electrical auxiliary system design and breaker schemes, cable tray fill, etc. as input to development of the test conditions.

        2) CP&L/Wyle evaluation of field as-built installations and development of test configurations.

        3) CP&L/Wyle development of test procedure No. 47879-01 Rev. A.

        4) Screening Tests - to determine the cable(s) with ignition potential and the worst damage potential.

        5) Configuration Tests - verify acceptability of tested configurations and separation distances without interposing barriers. Configuration tests were only necessary for that voltage class where the capability of ignition was demonstrated (i.e., power class).

    b) Test Conditions

    The following conditions/assumptions are bases of the test program:

        1) A cable in the SHNPP raceway system experiences a fault current in excess of the cables allowable energy let-through (I2t) due to failure of the circuits primary overcurrent protective device.

        2) The test current is that current just below the long-time trip setting of the circuits secondary overcurrent protective device,

and is maintained at a constant value until conductor open-circuit or steady-state is reached.

3) No credit has been taken for operator initiated action to clear the fault.

4) The current was conservatively maintained at a constant level as the circuit impedance increases due to conductor heating.

c) Test Results

The test results are detailed in Wyle Test Report No. 47879-02. The minimum separation distances based on the test results are detailed in Table 8.3.1-10.

Where conduit separation distances are detailed in Table 8.3.1-10, it applies to any enclosed raceway (i.e., conduit, box, equipment enclosure, condulet, fitting, etc.).

2) Analysis - Where the damage potential is contained within a conduit, and the Class 1E cable(s) are in tray or are free air drop out cable, an analysis has been performed in accordance with the recommendations of Section 5.1.1.2 of IEEE-384-1974 to justify a minimum separation distance of one inch. The results of the analysis indicate that provided one inch separation is maintained, any damage potential associated with the conduit will have no adverse effects on the Class 1E circuits.

3) Installation of Barriers - Where the separation distances could not be justified by test or analysis suitable barriers/or approved protective coatings have been utilized, or cables have been installed in enclosed raceways which are suitable for protecting the cables. The minimum separation distance between enclosed raceways or between barriers and the raceway/cable(s) is one inch. The following are suitable barriers to meet the intent of IEEE-384:

a) Steel Tray Covers - Tray covers are utilized to protect any raceway/cable which converges within the separation window of the tray. A top cover is used to protect above the tray and/or a bottom cover is used to protect below the tray.

b) Thermal Barrier Wrap System - A cable is wrapped to protect any raceway/cable which converges within the separation window of the cable.

c) One-Hour and Three-Hour Firewrap Systems - One hour and three hour firewrap are installed to meet the requirements of Section 9.5.1. These firewraps are acceptable barriers.

d) Steel Jacketed Fire Rated Cable - One-hour and three-hour, steel jacketed, fire rated cables are installed to meet the requirements of

Section 9.5.1. The cable itself includes an acceptable barrier as part of the cable construction.

Also, 1 inch of firewrap is also equivalent to 1 inch of air. Since one hour and three hour wrap systems are greater than 1 inch thick, separation is not required between these wraps and protected raceways.

b) Cable and Raceway Hazard Areas - Analyses of the effects of pipe whip, jet impingement, missiles, fire, and flooding demonstrate that safety related electrical circuits, raceways, and equipment are not degraded beyond an acceptable level.

The analyses are referenced as follows:

High Pressure Piping (Section 3.6)

Missiles (Section 3.5)

Flammable Material (Section 9.5.1)

Flooding (Section 2.4)

In fire hazard areas outside the cable spreading rooms, where redundant safety related trays or safety related and non-safety related trays are exposed to the same fire hazard, protection has been provided by spatial separation, fire suppression systems, fire retardant coatings, fire barriers, or combination thereof.

c) Cable Spreading Area and Control Room

The cable spreading area is the space below the Control Room where the instrumentation and control cables converge prior to entering the control, termination, or instrumentation panels. Refer to Section 8.3.1.2.14 for further discussion of the circuits in these areas.

Cable spreading rooms A and B are separated from each other by three hour fire barriers. Automatic sprinklers are also provided in the cable spreading rooms. Non-safety related cables are run in separate raceways from safety related cables with a separation distance of 1 ft. for trays separated horizontally and 3 ft. for trays separated vertically. In October 1985, an Electrical Separation Verification Test Program was completed (as described below), and the minimum separation distances reduced as detailed in Table 8.3.1-10. Subsequently, SHNPP design documentation was revised to reflect these distances for raceway/cable installation purposes. Where the above separation distance could not be maintained, the lesser separation distances were justified by (1) test, (2) analysis, or (3) the installation of suitable fire barriers/or approved protective coatings (see Section 8.3.1.2.30.b.1.a).

The above separation methods are based on the following:

1) Cable splices in cable trays are prohibited.

2) Cable and raceways are flame retardant.

3) Cable trays are generally not filled above the side rails. This is accomplished by implementing design limitations on tray fill percentage which is monitored during the design of a cable route. However, presently there are 17 Class 1E control trays and 2 Class 1E low-level trays (excluding risers) where the cable installation techniques (bedding, crossovers (tees), etc.) cause several cables to rise above the side rails.

For each installation where cables rise above the side rails and which rework cannot eliminate the condition, the governing plant-specific fill and weight criteria will assure that cable ampacity and tray support weight limitations are not jeopardized. To assure conservatism, each tray section will be documented and the acceptability of the cable ampacity and tray loading verified.

To ensure the requirements of IEEE-384, each tray section with cables above the side rails will be evaluated, case by case, and through the use of spatial separation and/or flame retardant wrap, circuit independence maintained.

4) Hazards are limited to failures or faults internal to the electric equipment or cables.

Identification - For identification of cable and raceways, refer to Section 8.3.1.3.

2) Separation Criteria for the Emergency AC Power Supply

a) Emergency Diesel Generators: Redundant Class 1E emergency diesel generators are located in separate safety class structures and have independent air supplies. The wall separating diesel generator sets is floodtight and fire resistant, and protects the redundant sets against internally generated missiles. Missile protection is described in Section 3.5.

3) Separation Criteria for the DC Power Supplies

a) Batteries: Redundant Class 1E batteries are installed in separate rooms in the Reactor Auxiliary Building.

b) Battery Chargers: Battery chargers for redundant Class 1E batteries are physically separated by the methods described in Section 8.3.1.2.30(a).

c) Distribution Panels: Redundant Class 1E DC distribution panels are physically separated by the methods described in Section 8.3.1.2.30(a).

4) Separation Criteria for the Distribution System

a) Redundant Class 1E 6.9 kV switchgear and 480V power centers are located in separate electrical equipment rooms.

b) Redundant Class 1E 480V motor control centers, 208/120V distribution panels and 120V uninterruptible power supplies are separated by the methods described in Section 8.3.1.2.30(a).

5) Separation Criteria for Containment Electrical Penetrations - Redundant Class 1E containment electrical penetrations are separated by the methods described in Section 8.3.1.2.30(a). In addition, the following criteria have been applied:

a) Electrical penetrations are located in two areas which are separated from each other by a minimum distance of approximately 40 ft. between their boundaries. These areas are also separated by structural walls.

b) When two channel redundancy is involved (i.e., divisions A and B), redundant cables are routed through penetrations in each of the two penetration areas. When three or four channel redundancy is involved (i.e., reactor protection system), pairs of channels share the same penetration areas; however, each channel of the pair is separated by a minimum distance of ten ft. Safety related instrumentation channel pairs are routed through the same penetration area as their respective redundant division (A or B).

c) All penetrations, Class 1E and non-Class 1E, are separated from each other by a minimum center-to-center distance of approximately four ft. horizontally and four ft. vertically. The minimum distance between conductors of adjacent penetrations is approximately 28 in.

6) Separation Criteria for Class 1E Instrument Cabinets, Sensors, and Sensor-to-Process Connections.

Discussion of these separation criteria and methods is given in Chapter 7.

7) Separation Criteria for Actuated Equipment - Locations of Class 1E actuated equipment, such as pump drive motors and valve operating motors are normally dictated by the locations of the driven equipment. The resultant locations of this equipment are reviewed to ensure that separation of redundant Class 1E actuated equipment is acceptable.

8) Cables and conduits routed in non-Category I structures associated with safety related functions or anticipatory trips (i.e., turbine trip on reactor trip, reactor trip on turbine trip, loss of feedwater) are designed to meet IEEE-Standard 279-1971 including redundancy, separation, and single failure criteria (see detailed description in Section 7.2.1.1.2). These circuits are designated as safety related and identified similar to the reactor protection system channels as described in Section 8.3.1.3. Separation of these circuits is maintained from other reactor trip circuits by routing each of these circuits independently in a separate conduit from the actuating device to the Reactor Protection System cabinet.

9) Certain motor and diesel generator terminal boxes house both Non-Class 1E thermocouple cables and Class 1E space heater cables. The low energy thermocouple cables and the space heater cables are properly identified and, other than in these common terminal boxes, are separately routed to meet the provisions of Section 8.3.1.3. No credible failure of the thermocouple cable can degrade Class 1E space heater circuits.

10) Separation of Class 1E and Non-Class 1E 6.9 KV circuits is accomplished by isolation as described in Section 8.3.1.1.2.15a.

c) Main Control Boards and auxiliary equipment panel have maintained the separation criteria by use of metal enclosures for Class 1E circuits within the board. Class 1E devices are mounted in metal enclosures (module cans), and wirings from these devices are enclosed in flexible metallic conduits and/or enclosed sheet metal wireways which are train dedicated inside the boards. Non-Class 1E circuits are separated from Class 1E circuits by the use of internal wiring runs and exit points which are physically separated from those for Class 1E circuits.

8.3.1.2.31 IEEE Standard 387-1977

The diesel generator sets are designed, constructed, and installed in accordance with this standard. They are provided with surveillance systems to indicate occurrence of abnormal, pretrip or trip conditions. Periodic tests will be performed on the power and control circuits and components including protective relays, meters, and instruments to demonstrate that the emergency power supply equipment and other components that are not exercised during normal operation of the station are operable. The operational tests will be performed at scheduled intervals to test the ability to start the system and run under load for a period of time long enough to establish that the system can meet its performance specifications.

8.3.1.2.32 IEEE Standard 415-1976

Compliance with this standard is discussed in Chapter 14.

8.3.1.2.33 IEEE Standard 420-1973

Compliance with this standard is discussed in Chapter 7.

8.3.1.2.34 IEEE Standards 450-1975 and 484-1975

Compliance with these standards is discussed in Section 8.3.2.

8.3.1.2.35 Compliance with NUREG - 0737 "Clarification of TMI Action Plan Requirements."

a) Emergency Power Supply to Pressurizer Heaters

The SHNPP pressurizer heaters are normally powered from the main generator via the unit auxiliary or, during startup or shutdown, from the preferred (offsite) power supply via the startup transformers. Following a loss of the preferred (offsite) power supply, two groups (Group A 431 kW, Group B 377 kW) of pressurizer heaters may be manually connected to the standby power

supply to aid in establishing and maintaining natural circulation at the hot shutdown condition (See Table 8.3.1-2c).

The number of heaters that can be powered from each emergency bus is based on a Westinghouse requirement which indicates that a minimum of 250 kW (two groups each with a minimum of 125 kW) of pressurizer heaters is required to maintain natural circulation in hot shutdown. Each group of pressurizer heaters is composed of eight 54 kW banks, which is an adequate capacity to maintain the natural circulation condition. Therefore, redundant heater capability is provided. Procedures and training which make the operator aware of when and how the pressurizer heaters are to be connected to the emergency buses have been established. The procedures and training do not address the shedding of loads from the emergency buses as each standby diesel generator has the capacity required to power the pressurizer heaters concurrent with the loads required for a LOCA. However, since the heaters are non-Class IE, they will be automatically shed from the emergency buses should a safety injection actuation signal occur, thus preventing an overload of the diesel generators during the starting of the engineered safeguards system.

The emergency procedure for a loss of offsite power requires that one group of pressurizer heaters be energized by an emergency source of power within 60 minutes of loss of normal offsite power. The 60 minute time limit is based on a Westinghouse recommendation which indicates that power should be restored to the pressurizer heaters within one hour.

The pressurizer heater Groups A and B are connected to nonsafety 480 volt buses 1A1 and 1B1, respectively, which are in turn powered from the 6.9 kV emergency buses 1A-SA and 1B-SB respectively. (See drawing CAR-2166-B-041 sheets 125 and 130) The control power required to close the pressurizer heaters 480 volt and 6.9 kV circuit breakers is obtained from redundant safety grade 125 VDC emergency buses. The power and control interfaces with emergency buses are accomplished through devices that have been qualified in accordance with safety-grade requirements. For a further description of these interconnections, refer to Section 8.3.1.1.2.5.b. The SHNPP design is consistent with the requirements of GDC 10, 14, 15, 17, and 20 of Appendix A to 10CFR50 for a loss of offsite power.

Following the loss of offsite power, the 6.9 kV breaker which supplies power to the non-ESF 480 volt buses (1A1, 1B1) will open on undervoltage. The pressurizer heaters are connected to the emergency buses by closing the 6.9 kV breakers between the 6.9 kV emergency buses and the nonemergency 480 volt buses, and by closing the 480 volt breakers feeding the heater groups. This evolution is performed manually in the Control Room. For further detail description, refer to Section 8.3.1.1.2.4 and 8.3.1.1.2.5.

Reloading of the pressurizer heaters onto the emergency buses is blocked automatically until their circuit breakers receive a permissive signal from the emergency load sequencer. This permissive signal is provided upon completion of the automatic load starting sequence. Resetting of the SLAS signal is not required to permit loading of the heaters. For detail connection, refer to drawing CAR-2166-B-401 sheets 152 and 153.

b) Power Supply for Pressurizer Relief and Block Valve and Pressurizer Level Indicators

Control power for the power operated relief valves (PORV's) is supplied from the 125 volt DC buses. Two of the valves are safety related with one on train A and one on train B. The power

for these valves is supplied from 125V DC Panels DP 1A SA and DP-1B-SB respectively. Power for the remaining non-safety PORV is supplied from 125V DC Panel DP-1A-1. These buses are normally powered by the station batteries which can be charged by a standby diesel generator or offsite power.

The PORVs are pneumatically operated valves. Should the supply of nitrogen from the accumulators and instrument air be removed, the valves will fail closed as designed.

The motive power for the PORVs is nitrogen which upon failure is backed by the instrument air system. If necessary, the instrument air system can be powered from the standby diesel generators or offsite power.

Power to the 1A-NNS and 1B-NNS air compressors is provided from the same 480 volt buses, 1A1 and 1B1, that power the pressurizer heaters.

Operator action is required to start the compressors after a loss of electrical power. The 6.9 kV breaker to the 480 volt bus, is prevented from closing by the sequencer until the last (manual) load block. The back-up instrument air supply for PORVs is isolated on Phase A Containment Isolation Signal (CIS).

The motive and control power for the PORV block (isolation) valves is obtained from MCCs 1A24 and 1B24 which are capable of being supplied from either offsite power or the standby diesel generators through 480 V buses 1A1 and 1B1 respectively. The motive and control power for a particular block valve is from a different source than the block valve's respective PORV.

The motive and control power connections to the emergency buses are through devices which have been qualified in accordance with safety grade requirements, as discussed in Section 8.3.1.

The pressurizer level indication instrument channels are powered from the emergency vital instrument buses and as such can be powered from onsite or offsite sources of power. The SHNPP design is consistent with the requirements of GDC 10, 14, 15, 17 & 20 of Appendix A to 10 CFR 50 for loss of offsite power.

The prevalent consideration with respect to the PORV/blocking valves is to close the valves and shut off the relief path when conditions allow. This is reinforced in the system design by use of a fail-safe PORV in series with a motor operated blocking (isolation) valve. Should the PORV fail to shut, the condition would be recognized by a valve position indicator and the motor operated blocking valve could be shut thus eliminating the relief path.

Although the system has been designed to close the PORV/blocking valves the ability to open at least one of these valves is maintained through use of independent emergency power supplies as described above.

8.3.1.2.36 Service environment

For a description of the service environment for safety related equipment located inside and outside the Containment, and a discussion of how such equipment was qualified for the environmental conditions listed, refer to Section 3.11.

8.3.1.2.37 Underground raceway design

The Class IE underground system is in conformance with applicable industry standards and has been designed in accordance with 10CFR50 General Design Criteria 1, 2, 3, 4, 17, and IEEE 308-71 Section 5.2.1.

The specified design criteria are addressed as follows for the Class IE underground cable system.

a) General Design Criteria 1 - Quality Standards and Records

1) Cable - The Class IE cables are environmentally qualified as discussed in Section 3.11. In addition, the cables are purchased in accordance with applicable industry standards, appropriately specified in purchase specification for underground and above ground installation in wet or dry locations. Vendor documentation for cable material, cable environmental qualification, testing and shipment is retrievable.

2) Duct - The Class IE underground power and control cables are installed in non-encased plastic (PVC Schedule 40) ducts and the Class IE underground instrumentation cables are installed in non-encased plastic (PVC) coated steel conduit. The PVC coated steel conduits are used to provide a corrosion protected, magnetically shielded raceway in the underground, non-encased duct banks. The ducts are UL rated and listed, and in compliance with applicable industry standards (NEMA and Federal). Vendor documentation showing location of fabrication and vendor's certificate of compliance with the above standards has been obtained.

b) General Design Criteria 2 - Design Bases for Protection Against Natural Phenomena

1) Cable - All cables have been specified and purchased for underground or aboveground installation in wet or dry areas and are suitable for use where there is periodic flooding of the underground duct system. Long term testing of similar cable under water at elevated temperature has been performed by various vendors with the results demonstrating that the installed cable is suitable for the intended wet/dry duct services. Other natural phenomena (earthquakes, tornadoes, etc.) are addressed by demonstrating the adequacy of the duct systems and thereby precluding adverse effects on the Class IE cable.

2) Duct - Protection of the ducts from tornado missiles is described in Item d (GDC 4 below). Seismic design of the duct system has been accomplished by using a flexible (unencased) design. The flexible design has been verified for seismic loadings by analysis. The analysis considers soil strains induced by seismic waves to determine the shear and moment acting on a particular buried element. Newmark's method has been adopted for this calculation (refer to Section 3.8.4).

   Where seismic design is considered, the seismic effects of the soil on the ducts is a relevant consideration. Ideally, the ducts should move with the soil. This condition is approached in the SHNPP design by utilizing a conduit system with sufficient flexibility in soil and by separation of the manhole from other structures. The unencased ducts are backfilled after the duct bank is completed.

Flexibility has been achieved by not encasing the duct runs in concrete; the moment of inertia and modulus of elasticity of an unencased duct bank is considerably less than that of an encased duct run. Structural separation of the duct runs from other structures has been achieved by using flexible isolation joints, permitting three dimensional movement between the structures and the manholes.

Protection from construction damage, normally achieved by concrete encasement, has been obtained by the installation of reinforced concrete slab over the Class IE duct runs where required. Slab thickness and reinforcing has been based on the loading analysis. When two redundant underground ducts cross each other they are separated by an intermediate reinforced concrete slab.

c) General Design Criteria 3 - Fire Protection: A redundant and independent Class IE underground cable system is utilized for each safety system. Therefore, any fire in the Class IE underground cable system of one redundant safety system will have no effect on the other redundant safety system. Adjacent manholes have a concrete wall (1 foot thick) as their common side. The isolated duct systems SA and SB have a minimum separation of two ft.

Underground cable ampacity ratings for SHNPP are based upon industry accepted calculation methods as outlined in ICEA Publication P-46-426. An earth ambient temperature of 20 C has been used in the calculations for the cables.

The ampacities tabulated in ICEA Publication P-46-426 are calculated by use of the Neher McGrath method of calculation. The method was outlined in an AIEE paper published in 1957. It has been accepted for universal use in the United States and in other countries. This calculation method has been checked by field tests and found to be conservative.

With confidence in the method and the conservative factors used in the calculations, allowable cable insulation temperatures will not be exceeded in normal operation or in any conceivable emergency situation.

d) General Design Criteria 4 - Environmental and Dynamic Effects Design Bases

1) Cable - The Class IE cables installed in the underground cable system are protected by the duct system against environmental and missile conditions, except water. As stated above for GDC 1 and 2, all cables are designed to accommodate water.
2) Duct - Protection for the Class IE cable system ducts installed under roadways or other areas where heavy equipment may be moved over them, and protection against a tornado missile, is provided by means of earth cover and/or reinforced concrete slabs (see Figure 8.3.1-4). The inherent capability of this protection is within the bases of the spectrum of tornado missiles and loading applicable for the SHNPP.

   The ducts are protected from the direct effects of the winds associated with the design basis natural phenomena by virtue of being below grade. The ducts will be located below the frost line.

   The manholes are designed and constructed to minimize the infiltration of water. Any water that would enter is collected in a sump at the base of the manhole. An embedded pipe is installed between the exposed surface of the manhole and the sump. Pumps are

utilized to remove accumulated water, as necessary. (Reference Section 3.4.1 for flood analysis.)

During severe hurricanes, or excessive rain storms, flooding of the areas surrounding the plant island could result in backup of the storm water system which in turn could result in a wetting of underground cables. As stated previously, no adverse effect would result from this condition.

The strength of the PVC Schedule 40 and PVC coated steel ducts has been analyzed as flexible buried pipes. Applicable analysis methods have been used to determine the magnitude of loading transmitted from the surface to the buried ducts, and the resulting deflection and stressing of the duct. The resultant roadway surface loading at the top of the duct bank has been calculated and the stresses in the ducts are sufficiently less than those which the ducts can accommodate.

The results of the analysis demonstrate that the ducts can withstand the maximum surface loading with ample margins of safety against crushing or overstressing (refer to Section 3.8.4).

e) General Design Criteria 17 - Electric Power Systems - GDC 17 states in part, "the onsite electrical power sources, including the batteries and the onsite electrical distribution system, shall have sufficient independence, redundancy and testability to perform their safety function assuming a single failure".

The Class IE underground cable system is composed of two (A and B) systems (i.e., redundancy) which are separated from each other (i.e., independence) via separate manholes and duct banks. As stated above, redundant duct bank systems are separated either by distance, reinforced concrete, or both.

Periodic testing of the Class 1E underground cable system (i.e., testability) will be as follows:

In-Service, medium voltage, Class 1E power cables will be tested periodically to demonstrate that the insulation dielectric integrity is maintained throughout the life of the cables.

f) IEEE-308-1971 - Section 5.2.1 - IEEE-308 - Section 5.2.1(5) states, "Common Failure Modes: The preferred and the standby power supply shall not have a common failure mode. In addition, the generating sources of the standby power supply shall not have a common failure mode for any design basis event."

IEEE-308 - Section 5.2.1, Table 1 defines design basis events as (1) Natural Phenomena: (a) Earthquake (b) Wind (c) Hurricane (d) Tornado (e) Rain (f) Ice (g) Snow (h) Floods (i) Lightning and (j) Temperature and (2) Postulated Phenomena: (a) Post-Accident Environment (b) Fire (c) Accident-Generated Missiles (d) Fire Protection System Operation (e) Accident-Generated Flooding, Sprays or Jets (f) Postulated Loss of the preferred power supply combined with any of the above (g) Single Equipment Malfunction (h) Single Act, event, component failure or circuit fault that can cause multiple equipment malfunction, and (i) Single equipment maintenance outage.

For the Class 1E underground cable system only (1) a, b, c, d, e, h, j, and 2b above are applicable. These have been covered previously by GDC 2, 3, and 4, as discussed above.

8.3.1.2.38 Manually-controlled, electrically operated valves to which power is removed per BTP-ICSB 18(PSB)

The manually-controlled, electrically-operated valves, which are provided with means to lock-out power in order to prevent an inadvertent valve position change during normal operation are listed below with the valves divided into "active" and "passive" categories. Refer to Section 6.3.1 for discussion of ECCS equipment.

Valve	Tag Number	Valve Position	Category
a) Hi Head SI to RCS Hot Legs	8884 (2SI-V500-SA)	Closed	Active
b) Hi Head SI to RCS Hot Legs	8886 (2SI-V501-SB)	Closed	Active
c) Hi Head SI to RCS Cold Legs	8885 (2SI-V502-SA)	Closed	Active
d) Low Head SI to RCS Cold Legs	8888A (2SI-V579-SA)	Open	Active
e) Low Head SI to RCS Cold Legs	8888B (2SI-V578-SB)	Open	Active
f) Low Head SI to RCS Hot Legs	8889 (2SI-V587-SA)	Closed	Active
g) Accumulator A Discharge	8808A (2SI-V537-SA)	Open	Passive
h) Accumulator B Discharge	8808B (2SI-V536-SB)	Open	Passive
i) Accumulator C Discharge	8808 (2SI-V535-SA)	Open	Passive

The "active" valves have their power locked-out by means of two manually operated switches for each valve, located in the control room, thus preventing a change in valve position as a result of single failure. One maintained contact "On-Off" switch acts as a permissive interlock, which will disconnect control power to the starter coils. The other maintained contact switch will also disconnect control power to the starter coils from a separate module in the control room. The intent is that the operator must activate two separate switches in order to change the valve from its locked-out position, thus preventing spurious activation.

The "active" valves are provided with diverse Class 1E valve position indication in the control room. The lights are powered from diverse power sources and are activated by separate sets of limit switches from each valve. Each valve is equipped with one set of rotary type limit switches mounted on the valve actuator and one set of limit switches mounted on the valve stem. Valve positions are indicated at the control module, which is powered from the 120V AC control power that originates from the starter and at the permissive module, which is powered from the safety 125V DC source. In addition, a white monitor light is provided for each valve to indicate when the valve is not fully closed or not fully open. For a description of these monitor lights refer to Section 7.5.1.10.3.

The "passive" valves (accumulators discharge) have their power lockout in open position by padlocking the breaker at the starters. These valves are provided with redundant valve position indicating lights, as described in Section 6.3.5.5.1.

8.3.1.3 Physical Identification of Safety Related Electrical Equipment

All cables, except lighting and communications cables are tagged at their terminations with a unique identifying number. Electrical safety related equipment (switchgear, motor control centers, junction boxes, cables, cable trays, and conduits excluding conduits in yard duct runs) are identified by color coded tags, nameplates, printing, paint, or tape according to the following color identification scheme:

Division/ Channel Code	Description	Separation Color Code
SA	Nuclear Safety Division A	Orange
SAB	Nuclear Safety Division A or B	Orange & Green
SPM1	Post-Accident Monitoring System 1	Orange
SB	Nuclear Safety Division B	Green
SPM2	Post-Accident Monitoring System 2	Green
S1	Nuclear Instrumentation System Channel I	Red
S2	Nuclear Instrumentation System Channel II	White
S3	Nuclear Instrumentation System Channel III	Blue
S4	Nuclear Instrumentation System Channel IV	Yellow
SR1	Reactor Protection Set I	Red Cables/Red-Orange Raceways
SR2	Reactor Protection Set II	White Cables/White-Green Raceways
SR3	Reactor Protection Set III	Blue
SR4	Reactor Protection Set IV	Yellow
-	Non-Safety Systems	Black

Color coded tray numbers are either stenciled, engraved or have color coded markers on both sides of cable trays at 15 ft. intervals and at points of entry to and exiting from enclosed areas except where it is impractical or inaccessible. However, at least one side of the tray must be identified at the most visible location possible. Additional tray designations are placed at elbows, room entrances and other areas of possible confusion. All safety related conduits excluding duct runs are identified by means of color at intervals of 15 ft. Safety related conduits in yard duct runs are identified by embossed stainless steel markers, without color coding. The manhole I.D. will be stenciled inside and outside the manhole in accordance with the above color identification scheme. All safety related cables are painted with the appropriate color at maximum intervals of five feet and have color coded termination tags. All non-safety related cables have no color code, thus enabling the redundant cables to be distinguished from each other and from non-safety related cables in a readily identifiable manner.

The cables associated with each of the safety systems and divisions designated are further subdivided, for routing purposes, into discrete groupings by function and cable types, identified as power, control and instrumentation. Each of the three cable classes is routed through a network of raceways that is totally independent of the other two classes. Prudent engineering practices will however allow mixing of power and control class cables in a common raceway. Instrument class cables are routed with cables of the same class only. Therefore, separation between the three classes of cables is maintained only to the extent that cables of one class cannot be intermixed with or physically routed through the same raceway as the other two classes, except as previously noted. No distinction is made among the three classes of cables

in addressing the minimum separation between redundant systems. The minimum separation required between cables and raceway of redundant systems is addressed in section 8.3.1.2.30 of the FSAR.

The ICEA Publication P-54-440 (third edition) is used as a basis for selecting the proper cable ampacity and applicable derating factors for the cables installed in the tray. Cable trays containing power circuits are filled to a maximum of 30 percent of the trays usable (4" depth) cross sectional area. This conforms to a calculated cable depth of 1.5 inches, which is the basis of the ICEA data. Trays with a fill over 30% are analyzed on a case by case basis.

For discussions of power, control, and instrumentation insulation and ratings, refer to FSAR sections 8.3.1.1.1.1, 8.3.1.1.1.2, 8.3.1.1.1.3 and 8.3.1.1.2.16.

The following is a summary of the general assumptions and considerations used to arrive at the maximum ampacity in tray for the cable types used on Shearon Harris from the values given in the ICEA Publication:

a. 15KV & 600V Class Cables

	Derating Factor	Derating Factor
Ambient/Allowance for tray stacking	50°C/5°C	40°C/5°C
Conductor Temperature (85°C)	0.95	0.95
Overall Derating Factor	0.8075	0.9025

b. Ampacity of each cable type

(Ampacity) = (Total derating factor) x (Actual Cable 0.D)

÷ (Cable 0.D given in ICEA P-54-440)

X (Ampacity from ICEA Tables)

8.3.1.4 Independence of Redundant Systems

The redundant systems are designed to be physically independent of each other so that failure of any part or the whole of one train, channel, or division will not prevent safe shutdown of the plant.

The Class 1E electric systems are designed to ensure that a design basis event will not prevent operation of the minimum amount of safety related equipment required to safely shutdown the reactor and to maintain a safe shutdown condition.

The Class 1E power system is designed to meet the requirements of IEEE 279-1971, IEEE 308-1971, 10 CFR 50 including Appendices A and B, and Regulatory Guide 1.6. Safety related loads are separated into two completely redundant load groups (divisions). Each division has adequate capacity to start and operate a sufficient number of safety related loads to safely shutdown the plant, without exceeding fuel design limits or reactor coolant pressure boundary limits during normal operation or a design basis event. As required by IEEE-308 and 10 CFR 50 (General Design Criterion 17) each redundant safety related load can be powered by both onsite and offsite power supplies. Two diesel generators, one per each safety related

division, will furnish the required emergency safety related AC power supply requirements. Consistent with Regulatory Guide 1.6, no provision exists for automatically transferring loads between the redundant power sources. Furthermore, the redundant load groups cannot be automatically connected to each other, nor can the two emergency power sources be paralleled automatically. Separation and independence have been maintained between all redundant systems, including the raceways, so that any component failure in one safety related division will not disable the other safety related division.

A discussion of the independence of redundant Class 1E electric systems including electrical and physical separation of power and control cables, cable tray fill, sharing and derating, tray marking, and fire protection is contained in Section 8.3.1.1 and 8.3.1.2. The administrative controls used to assure compliance with these criteria are a part of the quality assurance program as described in the Engineering and Construction Quality Assurance program approved by the NRC during the Construction Permit review.

8.3.2 DC POWER SYSTEM

8.3.2.1 Description

The DC Power System is shown on Figure 8.1.3-3. The DC Power System is designed to provide a source of reliable continuous power for the plant protection system, control and instrumentation and other loads for start-up, operation, and shutdown modes of plant operation.

The DC Power System consists of three 60 cell, 125V batteries and one 120 cell, 250V battery, each with its own battery chargers, and DC load center.

The two banks of 125V batteries, designated 1A-SA and 1B-SB, and their associated load centers and distribution panels have been arranged to feed the safety-related DC loads associated with divisions A and B respectively. The third 125V battery, designated 1A, has been provided to feed the non-safety- related switchgear, emergency control room lighting and other 125V DC non-safety loads. The 250V station battery has been provided to feed non-safety-related 250V loads.

In addition to the above-mentioned station batteries there are two 60 cell, 125V non-safety-related batteries at the 230kV switchyard. These non-safety batteries do not interact with the safety-related DC Power System.

8.3.2.1.1 Batteries

The safety-related redundant 125V batteries, 1A SA and 1B-SB, consist of 60 cells assembled in heat and shock resistant, transparent plastic, vented jars. They are of the lead-acid type with lead-calcium grid construction. Each battery is rated 1170 Ah for a four-hour rate of discharge to 1.75V per cell at 25 C.

A load profile enveloping the required loading requirements of both safety-related batteries is shown in Table 8.3.2-1. The major 125 DC safety-related loads for both safety related batteries are shown in Table 8.3.2-1. The ampere-hour capacity and short time rating of the safety-related batteries are in accordance with IEEE-308-1971. Each battery is capable of supplying all DC power which is required to safely shutdown the station and/or limit the consequences of a

design basis accident. In addition, further detailed schematic diagrams showing the DC power system loads are included in Drawing CAR-2166-B-041.

The safety related battery room ambient temperature range is 70 to 85F. The design temperature for the battery is selected to be 77F. Batteries are selected based on the above temperature with appropriate temperature derating considerations.

The safety related battery racks and batteries meet the Seismic Category I requirements stated in Section 3.10.

Both non-safety-related batteries and their racks are not seismically qualified.

The safety related loads fed through the inverter are considered for 2 hours in the battery duty cycle, based on the following considerations:

1. During normal operation, the steady state loads on the 125V DC bus (except for the inverters) are supplied by the battery charger which receives its normal power from a Class 1E motor control center.

2. During normal operation, the inverter input power is derived from a Class 1E motor control center with the DC source (i.e. Class 1E battery) assuming the load upon loss of AC voltage.

3. On loss of AC power, the batteries can supply the inverter up to 2 hours, or until the restoration of AC power. The battery chargers and the inverters are connected to the first load block of the diesel generator. MCC 1D23 provides back-up power to the safety-related battery chargers and is normally fed by bus 1D2 with a back-up source of the Dedicated Shutdown Diesel Generator. A separate feed is provided for each train's chargers.

4. Each Class 1E 125V DC system is provided with two battery chargers, so that malfunction of one battery charger will not restrict the power supplies to the inverter.

8.3.2.1.2 Battery chargers

Four safety-related battery chargers (1A-SA, 1B-SA, 1A-SB and 1B-SB) are provided; two for each safety-related battery (1A-SA and 1B-SB). Each battery charger is rated 150A continuous capacity. Each individual safety-related charger is capable of maintaining the connected battery in a fully charged condition by supplying a float charge at 133.5V or an equalizing charge at 138.6V, and has the capability to restore sufficient battery capacity to successfully perform the design basis duty cycle in 24 hours after an emergency discharge while supplying 100 percent of the continuous load on the D.C. bus. This configuration is used to enhance the reliability and availability of each safety DC division. In the event of malfunction of one charger, the redundant charger is capable of maintaining the DC system in a fully operable condition. The battery charger typically maintains a regulated float voltage of 2.20 to 2.25 volts per cell so that no recharging/equalizing charge is required under normal plant operation.

Each safety-related battery charger is fed from a separate safety-related 480V, three phase, 60 Hz MCC and can maintain its adjusted output voltage within 1.0 percent for any load from zero to full rated current, with input variations of ±10 percent in voltage and ±2.5 percent in

frequency. MCC 1D23 provides back-up power to the safety-related battery chargers and is normally fed by bus 1D2 with a back-up source of the Dedicated Shutdown Diesel Generator. A separate feed is provided for each train's chargers.

Two non-safety-related battery chargers feed the non-safety 125V DC load center, each rated 150A continuous capacity. Two non-safety-related battery chargers feed the non-safety 250V DC load center, each rated 100A continuous capacity. The non-safety chargers are equipped for parallel operation.

All battery chargers are provided with the means to detect a DC ground, and are also provided with a voltmeter and an ammeter. See Section 8.3.2.2.1.4 for additional details.

To assure equipment protection in the DC Power System from damaging overvoltages from the battery chargers that may occur due to faulty regulation or operator error, each battery charger is supplied with built-in overvoltage shutdown protection circuitry which senses output voltages over a pre-adjusted level and shuts down the battery charger after an adjustable time delay. In addition, relaying is provided on each battery charger which annunciates a charger malfunction locally and in the Control Room. Based on the vendor information for the voltage range of connected Class 1E equipment, all loads can withstand 140 V DC during equalization.

The design is such that there are no disconnecting means between the battery terminal and the DC distribution bus which will preclude any occurrence of leaving the battery circuit inadvertently open from the bus after maintenance periods.

8.3.2.1.3 DC load centers

Each battery is connected directly to a fully insulated bus in a metal-enclosed load center. Furthermore, the DC distribution bus is also being monitored against an undervoltage condition due to any malfunction in the charger circuit. A DC bus undervoltage alarm will be actuated in the event bus voltage falls below a certain preset value. DC bus undervoltage alarms are provided at the control room annunciator system. Each of the two related chargers is connected to the bus through a circuit breaker.

The safety-related load centers, 1A-SA and 1B-SB, either utilize molded case circuit breakers or fused switches to protect feeder circuits. The safety-related DC buses are insulated for 600V and braced for 50kA short circuit current. The feeders are sized for 20kA short circuit current which exceeds the battery short circuit rating.

The fused switches provided in the safety related load centers and distribution panels consist of dual element current limiting fuses in conjunction with the DC manual interrupting, load break disconnecting devices. The disconnecting switch is rated to withstand 20kA DC interrupting current. Fuses are selected based on a coordination study for selective tripping of branch circuit protective devices under short circuit and overcurrent conditions. Time vs. current characteristic curves for each type of fuse are utilized to ensure that the branch circuit fuse isolates the faulted zone and reduces the amount of energy to the fault. This avoids unnecessary clearing of unfaulted portions of the system. Fuse melting time and clearing time have been coordinated to provide protection for the connected device as well as associated cables. The cable sizing criteria are addressed in Section 8.3.2.1.4.

Each load center is provided with a ground detector relay, a ground voltmeter, a bus voltmeter, an ammeter (with shunt) and an undervoltage relay. The safety related load centers include provisions for monitoring the safety related DC bus voltage at the main control board and auxiliary control panel.

8.3.2.1.4 System operation

The DC Power System operates ungrounded but will continue to function with a ground on one polarity. Ground fault detectors are provided to detect and locally annunciate a single polarity ground condition that would otherwise go unnoticed.

One undervoltage relay is provided for each DC bus section to initiate an alarm if voltage on the bus drops below a preset value. An AC power failure alarm relay, provided on each charger, detects and annunciates, in the control room, a failure in AC power input. A load of DC power alarm relay, provided on each charger, detects and annunciates a failure in DC power output.

Cables for the DC power and control systems ace rated 600V, 90 C with ethylene-propylene rubber or cross-linked polyethylene type insulation, flame resistant jacket, and copper conductors. DC power cables are sized to carry the maximum available short circuit current for the time required for the circuit breaker or fuse to clear the fault. DC power cables are sized based on the current carrying requirements of the load and to ensure adequate voltage is available. DC control cables are sized to ensure adequate voltage is available at the load.

Raceways for the DC Power System are described in Section 8.3.1.1.2.16.

8.3.2.1.5 Equipment separation and redundancy

The safety related DC loads have been grouped into two redundant load groups such that loss of either group will not prevent the required safety functions from being performed.

The 125V safety related DC Power System is designed to meet the Seismic Category I requirements stated in Section 3.10. The two redundant safety batteries and their related accessories are located in separate rooms in the Reactor Auxiliary Building which is a Seismic Category I structure. The 125V non-safety battery is located in a third room in the same building. The 250V non-safety battery is located in a room in the Turbine Building.

Complete separation and independence are maintained between components and circuits of the two safety related 125V DC systems, including raceways. For raceway separation, see Section 8.3.1.2.31. Because of physical and electrical separation provided for the batteries, chargers, distribution equipment and wiring of the safety related 125V DC systems, a single failure at any point in either system will not disable both systems. The single failure analysis for the safety related 125V DC system is given in Table 8.3.2-5.

Additionally, a non-safety related back-up feed from MCC 1D23 can be selected to supply one battery charger on each train, which can be selected via a manual transfer switch provided for each division. This non-safety-related supply is double-isolated from safety-related battery chargers by both circuit breakers provided at MCC 1D23 in addition to fuses provided at the manual transfer switches on the non-safety-related feeds only. This separation is in compliance with IEEE Standard 384-2008. Separate routing is utilized for the train A and B back-up feeds, which will minimize the likelihood of a single fire damaging both feeds. Since the alternate

supply is not safety-related, the charger(s) are not considered operable while being fed by the alternate source.

8.3.2.1.6 Connection between safety and non-safety related DC system

The Class 1E DC System supplies 125 V DC control power to the non-Class 1E 480V power centers, which provide power to the back-up pressurizer heater groups and are connectable to the emergency diesel generators. This Class 1E DC power is isolated from the non-Class 1E circuit by a Class 1E circuit breaker in series with Class 1E fuse which are located in the Class 1E DC distribution panels of the appropriate safety division.

8.3.2.1.7 Ventilation

Each battery is located in a separate ventilated room. For additional discussion of the Battery Room Ventilation see Section 9.4.5.2.

8.3.2.1.8 Identification of safety related loads and their duration

Table 8.3.2-1 identifies the major safety related DC loads and the length of time they will operate in the event of loss of all AC power.

8.3.2.1.9 Inspection, servicing, testing, installation, and qualification

The facilities for the station batteries are designed to meet the intent of IEEE Standards: 450-1975, 450-1980 (as noted), 450-2010, and 484-1975.

The station batteries and their associated equipment are easily accessible for inspection, servicing, and testing. Service and testing will be performed on a routine basis in accordance with the manufacturer's recommendations and the Technical Specifications. Typical inspection includes visual inspection for leaks, corrosion, or other deterioration, and checking cells for voltage, specific gravity, level of electrolyte, and temperature. Rated discharge acceptance tests are made to verify that the battery capacity meets the manufacturer's rating.

The safety related 125V DC redundant system was purchased and installed under a strict quality assurance program which was approved by the NRC during the Construction Permit review of SHNPP.

A battery capacity test, to meet the intent of Section 6.2 of IEEE 308-1971, was performed according to Section 5 of IEEE 450-1975.

A performance discharge test, as listed in Table 2 of IEEE Std. 308-1971, was initially performed according to Sections 4.2 and 5.4 of IEEE Std. 450-1975. Subsequent tests will be performed according to Sections 5.2 and 6.4 of IEEE Std. 450-1980 (prior to 2012), or 6.2, 6.3, 6.5, and 7.5 of IEEE Std 450-2010 (2012 and beyond) except that the required frequency will be as stated in the Technical Specifications.

A battery service test, to meet the intent of Section 4.3 of IEEE STD 450-1975 and Section 7.3 of IEEE Std 308-1980 was performed upon initial installation according to Sections 4 and 5 of IEEE Std. 450-1975. In case of any significant DC Power System design changes, the battery service test will be repeated to satisfy the intent of Section 5.3 of IEEE Std. 450-1980.

8.3.2.2 Analysis

The Class 1E 125V DC Power System is designed to meet the requirements of IEEE 279-1971, IEEE 308-1971, General Design Criteria 17 and 18, and Regulatory Guides 1.6 and 1.32 (with exception as noted in Section 8.3.2.2.1.3). This system also meets the requirements for Design Basis Accidents described and evaluated in Chapter 15.

8.3.2.2.1 Compliance with general design criteria, regulatory guides, and IEEE standards

The following analyses of the Class 1E DC Power System demonstrates compliance with General Design Criteria 17 and 18, Regulatory Guides 1.6 and 1.32 (with exception as noted), IEEE 308-1971, IEEE 450-1975, and IEEE 450-1980.

8.3.2.2.1.1 Redundancy

In accordance with General Design Criteria 17, IEEE 308, and Regulatory Guide 1.6, redundancy, electrical independence, and physical separation of power sources and distribution equipment is provided such that no single failure can result in loss of the minimum required safety related DC power. The system has sufficient capacity to supply at least the minimum DC power requirements of the redundant load groups following loss of normal power to the plant auxiliary power system coincident with a design basis accident. This redundancy extends from the station batteries and battery chargers through distribution panels, cabling, and protective devices.

The battery capacity is more than adequate since power will be restored to the battery chargers from the standby diesel generators within a minute after the loss of normal AC power.

There are no direct electrical connections or any automatic/manual transfer of DC loads between divisions A and B. The elimination of ties between DC systems prevents a single fault from affecting redundant load groups.

8.3.2.2.1.2 Inspection, Testing, and Installation

In accordance with GDC 18, the Class 1E DC Power System is designed to permit appropriate periodic inspection, testing, and installation as described in Section 8.3.2.1.9.

8.3.2.2.1.3 Regulatory Guide 1.32-1977

The Shearon Harris battery charger size is determined based on the largest combined demand of the various steady state loads plus the charging capacity to restore the battery from the design minimum charge to the fully charged state regardless of the status of the plant during which demand occurs.

8.3.2.2.1.4 IEEE Standard 308-1971

For the analysis per principal design criteria of IEEE 308-1971, see Section 8.3.1.1.3. The following presents an analysis per supplementary design criteria as applicable to the Class 1E DC Power System.

The Class 1E DC Power System provides DC electric power to Class 1E DC loads and for control and switching operation of Class 1E systems. Physical separation, electrical isolation, and redundancy have been provided to prevent the occurrence of common failure modes. The design of the Class 1E DC Power System includes the following features:

a) The system is separated into redundant systems.

b) The safety actions by each group of loads are independent of the safety actions provided by its redundant counterpart.

c) Each redundant system includes power supplies that consist of one battery and two battery chargers.

d) Redundant batteries cannot be interconnected.

e) The batteries are arranged to prevent a common mode failure.

Each distribution circuit is capable of transmitting sufficient energy to start and operate all required loads in that circuit. Distribution circuits to redundant equipment are independent of each other. The distribution system is monitored to the extent that it is shown to be ready to perform its intended function. The DC auxiliary devices required to operate equipment of a specific AC load group are supplied from the same load group (A or B).

Each battery supply is continuously available during normal operation, and following a loss of power from the AC Power System, to start and operate all required loads.

Instrumentation is provided at the DC panels in the vicinity of the Battery Room(s) to monitor the status of the battery supply as follows:

a) DC bus undervoltage alarm;

b) Battery current indication;

c) DC voltage indication;

d) DC ground indication at DC panels.

At the main control board, indicating meters for monitoring items b) and c) are provided. A summary alarm for each train indicates a DC system malfunction for DC bus undervoltage, DC bus ground, or battery charger malfunctions (items 2 through 6 below). A separate alarm indicates DC bus ground or DC bus undervoltage. One alarm is provided for each train. Items b) and c) supply inputs to the plant computer. For further description of DC system instrumentation, refer to Section 7.5.1.

The battery chargers of the two redundant systems are electrically and physically independent. Instrumentation has been provided at the battery charger to monitor the status of each battery charger as follows:

1) Output current and voltage at charger

2) Input AC available at charger

3) High or low DC voltage indication at charger

4) No charge indication at charger

5) Phase failure/loss of input AC indication at charger

6) Ground indication at charger

7) Ground test (positive and negative) at charger

Each Class 1E battery charger has an input AC breaker and output DC circuit breaker for isolation of the charger. Each battery charger has been designed to prevent the AC supply from becoming a load on the battery due to a power feedback as the result of the loss of AC power to the charger.

Manual transfer switches allow MCC 1D23 to provide back-up power to each redundant battery charger system.

Dependable power supplies have been provided for the Reactor Protection System. Two independent DC and four independent AC power supplies have been provided for control and instrumentation of this system. The independent DC supplies are provided by distribution circuits from each of two redundant DC distribution systems. Independent AC supplies are provided by the four inverters and associated 120V vital AC buses. Refer to Sections 8.3.1.1.1.4, 7.6.1.9, and 7.6.2.3 for further description of these 120V uninterruptible AC power supplies.

Since each inverter is normally powered from an AC supply with DC back-up, the failure of a battery or battery charger will not in any way affect the normal operation of the required AC loads from the inverter, unless there is a simultaneous failure of the AC feeder. Upon a failure of the normal AC power system, the DC back-up supply automatically assumes the inverter load without the aid of a transfer switch. If a failure of the DC back-up should occur at this time, the redundant inverters will be able to perform the required safety functions.

8.3.2.2.1.5 IEEE standard 450-1975 and 450-1980

The initial battery acceptance test and capacity test were performed according to IEEE 450 1975.

Operational Procedures for normal maintenance and replacement comply with IEEE Standard 450-1980 with the exception of Section 4.4.4 and IEEE 450-2010 (Performance Test Only). According to the Battery manufacturer, when the batteries are operated in accordance with the instruction manual, periodic equalizing charges are not normally required. Required tests are made in accordance with the Standard. The batteries will be tested, serviced, and inspected at regular intervals, as outlined in the Technical Specifications which were developed from IEEE 450 1980 (IEEE 450-2010 does not change testing intervals), to ensure that batteries and associated equipment are maintained in a satisfactory condition.

Batteries will be replaced in accordance with the requirements of Section 7 of IEEE 450-1980 or section 8 of IEEE 450-2010. Records will be maintained in accordance with the recommendations in the Standard.

8.3.3 FIRE PROTECTION FOR CABLE SYSTEMS

The measures employed for the prevention of and protection against fires in electrical cables are described in Section 9.5.1. Cable derating and cable tray fill, and fire barriers and separation between redundant trays are described in Section 8.3.1.

TABLE 8.1.3-1 SAFETY RELATED EQUIPMENT IDENTIFICATION

	Rating		No. Connected		
Description of Load	AC Volts	HP (kW)	Div A	Div B	Function
Emergency Diesel Generator	6900	(6500)	1	1	Supply emergency AC power to safety related loads
Metal Clad Switchgear	6900	(1200a)	1	1	Supply power to 6900 V safety related loads
Component Cooling Water Pump	6600	800	1*	1*	Refer to Section 9.2
Auxiliary Feedwater Pump	6600	500	1	1	Refer to Section 10.4
Charging Safety Injection Pump	6600	900	1*	1*	Refer to Section 9.3
Emergency Service Water Pump	6600	1300	1	1	Refer to Section 9.2
Essential Chilled Water Chiller WC-2	6600	840	1	1	Refer to Section 9.2
Station Service Transformers	6900-480	(2000kVA)	2	2	Supply power to 480V safety related buses
Metal Enclosed Switchgear	480	(3200a)	2	2	Supply power to safety related loads incl. MCC's
Motor Control Centers	480	(600a)	9	9	Supply power to safety related loads incl. power panels
Containment Spray Pump	460	350	1	1	Refer to Section 6.3
Chilled Water Recirculation Pump	460	100	1	1	Refer to Section 9.2
Service Water Booster Pump	460	200	1	1	Refer to Section 9.2
Residual Heat Removal Pump	460	300	1	1	Refer to Section 5.4
Chiller Condenser Water Pump	460	20	1	1	Refer to Section 9.2
Boric Acid Tank Transfer Pump	460	10 (15.5)	1	1	Refer to Section 9.3
Motor Operated Valves	460	(**)	1 Lot	1 Lot	Valving for safety related systems
Motor Operated Dampers	120/460	(**)	1 Lot	1 Lot	Dampers for safety related systems
D/G Fuel Oil Transfer Pump	460	7.5	1	1	Diesel Generator Fuel Handling
Emergency Intake Screen Wash Pump Motor	460	15	1	1	Refer to Section 9.2
Emergency Intake Travelling Screen (Main Reservoir)	460	5/1.25	1	1	Refer to Section 9.2
Emergency Intake Travelling Screen (Auxiliary Reservoir)	460	2/0.5	1	1	Refer to Section 9.2
125V DC Battery Charger	480	(35)	2	2	Supply power to safety related 125V DC battery
Inverter	480	7.5 kVA	2	2	ESF UPS
Appendix R Transformer	480	7.5 kVA	1	1	Safe Shutdown
125V Battery	(DC)	--	1	1	Refer to Section 8.3
208V/120V Power Panel	208	101.25 per lot	7 per lot	7 per lot	Supply 208V and 120V AC powr to small safety loads
Deleted in Amendment 62					
Air Handling Units:					
AH-1 (Containment Fan Cooler)	460	125/62.5	-	2	Containment Building Cooling
AH-2 (Containment Fan Cooler)	460	125/62.5	2	-	Containment Building Cooling
AH-3 (Containment Fan Cooler)	460	125/62.5	2	-	Containment Building Cooling

TABLE 8.1.3-1 SAFETY RELATED EQUIPMENT IDENTIFICATION

	Rating		No. Connected		
Description of Load	AC Volts	HP (kW)	Div A	Div B	Function
AH-4 (Containment Fan Cooler)	460	125/62.5	-	2	Containment Building Cooling
AH-5	460	7.5	1	1	RHR and Cont. Spray Pump Area Cooling EL. 190.0', RAB
AH-6	460	10	1	1	Component Cooling Water Pumps and Heat Exchanger and Auxiliary Feedwater Pump Area Cooling EL. 236.0', RAB
AH-7	460	10	1	1	Component Cooling Water Pumps and Heat Exchanger and Auxiliary Feedwater Pump Area Cooling EL. 236.0', RAB
AH-9	460	7.5	1	1	Charging Pumps SA, SB Areas Cooling, EL. 236.0', RAB
AH-10	460	10	1	1	Charging Pump 1C-SAB Area Cooling, EL. 236.0', RAB
AH-11	460	10	1	1	Mechanical Penetration Area Cooling EL. 236.0', RAB
AH-12	460	75	2	-	Switchgear "A" & Cont. Fan Cooler Starter Area Cooling EL. 286' RAB
AH-13	460	75	-	2	Switchgear "B" & Cont. Fan Cooler Starter Area Cooling EL. 286' RAB
AH-15	460	20	1	1	Control Room Air Conditioning EL. 305' RAB
AH-16	460	30	1	1	Protection & Repair Shop Spaces, Air Conditioning EL. 305' RAB
AH-19	460	7.5	1	1	HVAC Chiller, Pump Aux. Feedwater Piping & Valve Area Cooling EL. 261' RAB
AH-20	460	7.5	1	1	HVAC Chiller, Pump Aux. Feedwater Piping & Valve Area Cooling EL. 261' RAB
AH-23	460	2	1	-	Mech. & Elec. Penet. & Cont. Fan Cool. Starter (1A22-SA for AH-2) Area Cooling EL. 236.0' RAB
AH-24	460	3	1	-	Elect. Penet. Area SA & MCC 1A-24 (Misc. Loads Manually Diesel Loaded) Area Cooling EL. 261.0' RAB
AH-25	460	3	-	1	Elect. Penet. Area SB & MCC-B-24 (Misc. Loads Manually Diesel Loaded) Area Cooling EL. 261.0' RAB
AH-26	460	3	1	1	RAB H&V Equip. SA, SB Area Cooling EL. 261.0'
AH-28	460	5	1	1	Cont. Spray Tank, Boron Injection Tank & Pump Instrument Racks and Rad. Monitors Area Cooling EL. 216.0' RAB
AH-29	460	2	-	1	Cont. Fan Cool. Starter (1B-22-SB for AH-1) Area Cooling EL. 236.0' WTA
AH-85	460	15	2	2	Diesel Generator Building Electrical Equip. Room Cooling

TABLE 8.1.3-1 SAFETY RELATED EQUIPMENT IDENTIFICATION

	Rating		No. Connected		
Description of Load	AC Volts	HP (kW)	Div A	Div B	Function
AH-86	460	10	1	1	Emergency Serv. Water Intake Structure MCC Room Cooling
AH-92	460	5	1	1	RAB MCC 1A-35 SA & MCC 1B-35SB Area Cooling EL 261.0' RAB
AH-93	460	5	1	-	Rod Control Cabinet RM Area Cooling EL. 305' RAB
Supply Air Systems:					
S-2	460	40	1	1	RC Primary Shield Cooling
S-4	460	50	1	1	Reactor Support Cooling
S-64	460	30	1	-	RAB Main Steam Pipe Tunnel Ventilation
S-65	460	30	-	1	RAB Main Steam Pipe Tunnel Ventilation
S-68	460	3	1	-	RAB Instrument Rack Cooling
Return Air Systems:					
R-2	460	25	1	1	Control Room Emergency Filtration Fan
Exhaust Fans:					
E-6	460	30	1	1	RAB Emergency Exhaust
E-10	460	1	1	1	RAB Protection Area Exhaust
E-28	460	3	2	-	RAB Battery Room SA Exhaust
E-29	460	3	-	2	RAB Battery Room SB Exhaust
E-85	460	3	2	2	Fuel Oil Transfer Pump House Exhaust
E-86	460	50	2	2	Diesel Generator Building
E-88	460	15	1	1	Emergency Serv. Water Intake Structure Pump Room Ventilation
E-61	460	5	2	2	Diesel Generator Building Exhaust
Electric Heating Coils:					
EHC-24	460	(56)	1	-	Control Room Air Heating (serving AH-15 Div A)
EHC-26	460	(56)	-	1	Control Room Air Heating (serving AH-15 Div B)
EHC-30	460	(40)	1	1	RAB Emergency Exhaust Filtration Humidity Control
EHC-72	460	(14)	1	1	Control Room Emergency Filtration Unit Humidity Control
Fuel Handling Building Loads:					
Local Cooling Unit AH-17	460	20	1	1	Spent Fuel Pools Pumps & Heat Exch. Space Cooling EL. 236' FHB
Electric Heating Coil EHC-17	460	(40)	1	-	FHB Emergency Exhaust Filtration Humidity Control
Emergency Heating Coil EHC-18	460	(40)	-	1	FHB Emergency Exhaust Filtration Humidity Control
Emergency Exhaust Fan E-12	460	30	1	-	FHB Operating Floor Emergency Exhaust

TABLE 8.1.3-1 SAFETY RELATED EQUIPMENT IDENTIFICATION

Description of Load	Rating		No. Connected		Function
	AC Volts	HP (kW)	Div A	Div B	
Emergency Exhaust Fan E-13	460	30	-	1	FHB Operating Floor Emergency Exhaust
Fuel Pool Cooling Pump Motor Operated Valves	460	150	2	2	Spent Fuel Pool Cooling Emergency Exhaust System
	460	(**)	1		Valving
Motor Control Centers	480	(600A)	1	1	Supply 480V AC power to safety related FHB loads
208Y/120V Power Panels	208	(30kVA)	1	1	Supply 208V and 120V AC power to small safety FHB loads

NOTES:

* A third pump can be connected to either Div A or Div B.

** Intermittent Load.

TABLE 8.2.1-1

TRANSMISSION LINES CONNECTING
SHNPP TO CP&L TRANSMISSION SYSTEM

Termination	Nominal Voltage (kV)	Rated MVA	Approximate Length
Cape Fear (North LIne)	230 kV	797 MVA	7 miles
Cape Fear (South Line)	230 kV	797 MVA	6 miles
Siler City	230 kV	797 MVA	32 miles
Ft. Bragg Woodruff St.	230 kV	1084 MVA	36 miles
Erwin	230 kV	797 MVA	30 miles
Apex US #1	230 kV	797 MVA	4 miles
Wake	230 kV	637 MVA	38 miles
RTP	230 kV	1195 MVA	21 miles

TABLE 8.3.1-1

RATINGS OF CLASS IE ELECTRICAL DISTRIBUTION EQUIPMENT

A)	Diesel Generators	1A-SA & 1B-SB	
	Starting time to rated speed and voltage	Sec.	10
	Output, continuous	kW	6500
	Power factor, lagging		0.8
	Frequency	Hz	60
	Voltage	kV	6.9
	Overload capacity (Two hours in any 24 hours)	%	10
	Largest motor to be started	Hp	1300
	Cooling water:		
	Max. temperature	F	95
	Supply pressure	psig	150
	Inlet air temperature:		
	Maximum	F	105
	Maximum	F	-2
B)	6900V Switchgear	1A-SA & 1B-SB	
	Nominal voltage rating	kV	6.9
	Nominal interrupting capacity	MVA	500
	Rated bus continuous current	a	1200
	Rated short circuit current: (rms sym at nominal voltage)	kA	39.45
	Closing and latching capability: (rms asym)	kA	66
	Control voltage, DC	V	125

TABLE 8.3.1-1 (Continued)

C) 480V Power Centers and Transformers

Power Center Buses:		1A1, 1B1	1A2-SA, 1A3-SA B2-SB, 1B3-SB	
Voltage Rating	V	480	480	480
Cont. Current				
- incoming side of bus reactor	a	2500	3200	3200
- outgoing side of bus reactor	a	N/A	N/A	1600
Short Circuit Current, RMS Sym.				
- incoming side of bus reactor	kA	50	50	50
- outgoing side of bus reactor	kA	N/A	N/A	22
Transformers:				
Output	kVA	1500	2000	2000
Type		AA	AA	AA
Temperature rise	C	150	150	150
HV Winding:				
Rated voltage	kV	6.9	6.9	6.9
Connection		Delta	Delta	Delta
BIL rating	kV	45	45	45
LV Winding:				
Rating voltage	V	480	480	480
Connection		Wye	Wye	Wye
BIL rating	kV	10	10	10
Taps no load full capacity:				
Above rated voltage	%	(2) 2 1/2 ea	(2) 2 1/2 ea	(2) 2 1/2 ea
Below rated voltage	%	(2) 2 1/2 ea	(2) 2 1/2 ea	(2) 2 1/2 ea
Impedance	%	(1A1) 5.59	(1A2-SA) 5.84	(1A3-SA) 5.87
		(1B1) 5.68	(1B2-SB) 5.86	(1B3-SB) 6.97

C) 480V Power Centers and Transformers (Continued)

Circuit breakers		1A1, 1B1, 1A2-SA, 1B2-SB 1A3-SA, 1B3-SB
Voltage rating	V	480
Control voltage dc	V	125

Frame Size (max rated cont. current) AMPS	Interrupting rating RMS Sym. at 480 V w/Inst. Trip AMPS	w/Delayed Trip AMPS
800	30,000	30,000
1600	50,000/65,000	50,000
2500	N/A	85,000
3200	N/A	65,000/85,000

TABLE 8.3.1-1 (Continued)

Switchgear Bus Current Limiting Reactors:

		(Installed in Buses 1A3-SA & 1B3-SB)
Voltage rating	V	480
Continuous current	a	1600
Reactance	ohm/phase	0.01
Temp. rise	C	80

D) Motor Control Centers

		1A22-SA, 1B22-SB 1A34-SA, 1B34-SB	All Others
Buses:			
Voltage rating	V	600	600
Short circuit current RMS symmetrical	kA	30	22
Main bus cont. current	a	600	600
Vert. bus cont. current	a	300	300
Circuit Breakers:			
Voltage rating	V	600	600

Frame size (cont. current) AMPS	Type	Interrupting rating, RMS symmetrical AMPS at 480V
100	Magnetic with current limiting fuses	100K
	or	
150	Magnetic with adjustable instantaneous trip settings in lieu of current limiting fuses	65K
100	Thermal Magnetic	25K
	or	
150	Thermal Magnetic	65K
225	Thermal Magnetic	30K
250	Thermal Magnetic with adjustable magnetic settings	65K
	or	
300	Thermal Magnetic	30K
600	Drawout, Manually Operated with time delay trip	30K

TABLE 8.3.1-1 (Continued)

Magnetic Starters:		(All MCC's)
Voltage rating	V	480
Control circuit voltage	V	120 ac
Control transformers:		Single Phase
Voltage ratio	V	480/120[1]
Output rating:		
Size 1	Va	100 or 150
Size 2	Va	150
Size 3	Va	250
Size 4	Va	350 or 500
Size 5	Va	500 or 1000

Note 1 - Control power transformer voltage ratio does not include “compensation”. Secondary voltage may be higher in unloaded condition.

1-208Y/120V Transformers and Power Panels		1A212-SA, 1B212-SB 1A211-SA, 1B211-SB 1A311-SA, 1B311-SB	1&4A33-SA 1&4B33-SA	1A231-SA 1B231-SB 1A321-SA 1B321-SA
Transformers				
Voltage	V	480-208Y/120	480-208Y/120	480-208Y/120
Output	kVA	45	30	15
Temp. rise	C	115	115	115
Impedance	%	4	4	4
Power Panel Buses				
Voltage	V	208Y/120	208Y/120	208Y/120
Cont. current	a	225	225	225
Short circuit current, RMS Sym. Amps	kA	10	10	10
Circuit Breakers				
Voltage	V	120 (1 pole) 240 (2 pole)	120 (1 pole) 240 (2 pole)	120 (1 pole) 240 (2 pole)
Cont. current	a	100	100	100
Interrupting current, RMS Sym. Amps	kA	10	10	10

TABLE 8.3.1-1 (Continued)

2-120V Voltage Regulated Transformers and Power Panels		1A312-SA, 1B312-SB
Transformers		
Output Rating:		
Output (at load power factor)	kVA	7.5
Load Power Factor		0.8
Output Voltage	V	118
Output Frequency	Hz	60
Output Circuit		1 ph, 2 wire solidly grounded
Input Rating:		
Normal input (AC, 3 phase):		
Normal Voltage	V	460
Low Voltage	V	414
High Voltage	V	506
Available Fault Current (rms Sym)		
Emergency Input	kA	10
Normal Voltage		N/A
Power Panel Buses		
Voltage	V	120
Cont. Current	a	225
Short Circuit Current, RMS Sym. Amps	kA	10
Circuit Breakers		
Voltage	V	120 (1 pole) 240 (2 pole)
Cont. Current	a	100
Interrupting current, RMS Sym. Amps	kA	10

F) Battery Chargers

Battery Chargers		1A-SA, 1B-SA, 1A-SB, 1B-SB
Input (AC 3 phase):		
Voltage	V	480
Frequency	Hz	60
Current	a	41
Output (DC)		
Floating voltage	V	133.5 ± 1.5
Equalizing charge	V	138.6 ± 1.2
Continuous battery load	A	65.48 SA 72.59 (SB)
Voltage regulation	%	±1
Output current	A	150
Rated short circuit current	kA	S/c at output current limiting to approx.. 150% of DC output rating

TABLE 8.3.1-1 (Continued)

G) Batteries		1A-SA & 1B-SB	
Capacity (4 hr. rate)	Ah	1170	
Or (5 hr. rate Modified Performance Test Only)	Ah	1248.35	
Nominal Voltage	V	125	
Cells per battery		60	
Voltage		Per Cell	Avg Battery
During Equalization	V	2.29-2.33	138.6 ± 1.2
Normal Floating	V	2.20-2.25	133.5 ± 1.5
Final (4 hr. & 5 hr. rate)	V	1.75	105.00

H) 125 Volt DC Buses		1A-SA & 1B-SB 1A1-SA & 1B1-SB	1B2-SB 1A2-SA
Circuit breakers and fusible switches:			
Voltage rating	V	125	125
Frame size	A	100, 225	100, 225
Poles		2	2
Minimum Interrupting Rating (at 125V DC)	kA	20	20
Buses:			
Short circuit current	kA	50	50
Continuous rating	A	400	600

I) Uninterruptible Power Supplies		1A-SA/1B-SB Channel I, III/Channel II, IV
Output rating:		
Output (at load power factor)	kVA	7.5
Load power factor		0.8
Output voltage	V	118
Output frequency	Hz	60
Output circuit		1ph, 2 wire solidly grounded
Input rating:		
Normal input (AC, 3 phase):		
Normal voltage	V	460
Low voltage	V	414
High voltage	V	506
Frequency	Hz	60
Available fault current (rms Sym)	kA	10
Emergency input (DC):		
Normal voltage	V	125
Low voltage	V	105
High voltage	V	140
Available fault current	kA	20
Frequency regulation:	Hz	1/2
Voltage regulation:	%	+5,-2.5
Total Harmonic Distortion (rms):	%	5

TABLE 8.3.1-2a EMERGENCY DIESEL GENERATOR 1A-SA CONTINUOUS LOADING (LOCA/LOOP & LOOP)

	EDG STEADY-STATE KW LOADING AT END OF EACH LOAD BLOCK (NOTE 2)									FINAL KW LOADING (NOTE 4)
Sequencer Loading Block----------------→	1 (10 SEC)	2 (15 SEC)	3 (20 SEC)	4 (25 SEC)	5 (30 SEC)	6 (35 SEC)	7 (45 SEC)	8 (55 SEC)	9 (MANUAL)	
Calculation E-6000 Computer Case--→	401-LA	402-LA	403-LA	404-LA	405-LA	406-LA	407-LA	408-LA	409-LA	
6.9 KV BUS 1A-SA										
BUS 1A-SA MOTORS	692	696	1687	2283	2686	2691	2689	3346	3355	3355
480 V BUS 1A1 (NON-SAFETY/LB 9)										
MCC 1A24	0	0	0	0	0	0	0	0	163	163
PANEL PHPP-1A	0	0	0	0	0	0	0	0	427	427
BUS 1A1 MOTORS (note 2)	0	0	0	0	0	0	0	0	153	153
480 V BUS 1A2-SA										
BUS 1A2-SA MOTORS	0	279	279	279	677	677	677	677	677	677
480 V BUS 1A3-SA										
MCC 1A21-SA	133	132	113	113	113	163	165	165	164	164
MCC 1A22-SA	0	91	91	91	91	91	91	91	91	91
MCC 1A23-SA	78	78	78	78	78	90	90	90	72	72
MCC 1A31-SA	16	24	24	31	31	107	114	129	136	136
MCC 1A32-SA	1	1	2	2	2	2	17	17	28	28
MCC 1A34-SA	0	91	91	91	91	91	91	91	91	91
MCC 1A35-SA	14	14	14	20	20	86	88	89	110	110
MCC 1A36-SA	2	2	2	2	2	119	119	119	118	118
MCC 1&4A33-SA	24	24	24	24	24	23	23	23	209	209
Misc Cable & Transformer Losses	2	1	2	2	2	2	4	4	4	4
E-6000, R9 EDG 1A-SA KW LOADING	962	1433	2407	3016	3817	4142	4168	4841	5798	5798
MARGIN RESERVED FOR FUTURE LOAD ADDITIONS (KW)										702
EDG 1A-SA MAXIMUM KW LOADING CONSIDERING RESERVED MARGIN FOR FUTURE LOAD ADDITIONS										6500
EMERGENCY DIESEL GENERATOR 1A-SA CONTINUOUS RATING IN KW (SEE NOTES 1 & 2)										6500

Table 8.3.1-2A (Continued)

NOTES TO TABLES 8.3.1-2a

1. The continuous ratings of the emergency diesel generators are as follows:

   Continuous Rating 6500 kW at 0.8 power factor
   Overload Rating7150 kW at 0.8 power factor for 2 hrs in any 24 hr period

2. Emergency Diesel Generator 1A-SA and 1B-SB loading in kW (kilowatts) is shown in Tables 8.3.1-2a and 8.3.1-2b, respectively. The bases for the loading data presented in these tables is Calculation E-6000, Rev. 11, Tab A, Tables A10 & A11 and supporting computer analyses from the E-6000, Tab Z computer cases indicated in the header for each load block. The loading shown is conservative since it is a combination of both LOCA/LOOP and LOOP scenarios. (Loads common to both scenarios are shown as well as loads that are only applicable to either LOCA/LOOP or to LOOP). A listing of "sequenced on" loads is shown in Table 8.3.1-2c. Also see Note 3 below. The total loading shown in Tables 8.3.1-2a and 8.3.1-2b for each individual load block is the summation of continuous load for running motors and static loads and assumes all motors have completed acceleration. In other words, the kW shown would be the final steady-state kW if the sequencer "stopped" at the end of the load block. Emergency Diesel Generator terminal voltage during sequencing is calculated in Calculation 0017-EP and verified by test (OST-1823 & OST-1824) every outage.
3. It is recognized that there are outstanding change documents posted in the PassPort Controlled Document Module against Calculation E-6000. Some of the loading changes reflected in these documents (ECs, etc.) have actually been installed in the plant while others are pending. It is intended that Tables 8.3.1-2a and 8.3.1-2b will not be revised until such time that E-6000 has been revised and/or the loading margin identified as "Reserved for Future Loads" is being approached by the accumulation of load changes due to outstanding change documents. Due to this approach, it is possible that some of the individual power supply loadings shown will not exactly match the plant "as-built" condition. As stated in Note 2, the purpose of Table 8.3.1-2c is to show the "sequenced on" loads. Minor changes in the details of this table due to revisions to Calculation E-6000 may not be reflected. See Calculation E-6000, Tab D for more detail.
4. Sequencing times shown are seconds after receipt of SIS signal (assumes 10 seconds from SIS signal until closure of the EDG breaker).
5. Load Block 9 loads (those manually added) are blocked from starting until either confirmation that the essential chilled water chiller (Load Block 8) has started or 150 seconds have passed since initiation of load sequencing.
6. The loading shown for 480 V Substation 1A1 (1B1) is for non-safety related loads which are "blocked" from starting until Load Block 9.
7. Containment spray pumps get a start permissive signal at Load Block 2, but are blocked from starting in Load Block 3. They can therefore start in Load Blocks 2, 4, 5, 6, 7, 8 or 9 upon receipt of a containment spray actuation signal or can be running in any load block after Load Block 1.
8. In Table 8.3.1-2c, "S" indicates motor is starting. "R" indicates motor is running (or load is "on" for non-motor loads). Multiple "S's" indicate that the motor has a long acceleration time that spans more than one load block.

TABLE 8.3.1-2b

EMERGENCY DIESEL GENERATOR 1B-SB CONTINUOUS LOADING
(LOCA/LOOP & LOOP)

	EDG STEADY-STATE KW LOADING AT END OF EACH LOAD BLOCK (NOTE 2)									FINAL KW LOADING (NOTE 4)
Sequencer Loading Block----------------→	1 (10 SEC)	2 (15 SEC)	3 (20 SEC)	4 (25 SEC)	5 (30 SEC)	6 (35 SEC)	7 (45 SEC)	8 (55 SEC)	9 (MANUAL)	
Calculation E-6000 Computer Case--→	401-LB	402-LB	403-LB	404-LB	405-LB	406-LB	407-LB	408-LB	409-LB	
6.9 KV BUS 1B-SB										
BUS 1B-SB MOTORS	693	696	1688	2283	2686	2689	2689	3346	3355	3355
480 V BUS 1B1 (NON-SAFETY/LB 9)										
MCC 1B24	0	0	0	0	0	0	0	0	181	181
PANEL PHPP-1B	0	0	0	0	0	0	0	0	426	426
BUS 1B1 MOTORS (note 2)	0	0	0	0	0	0	0	0	154	154
480 V BUS 1B2-SB										
BUS 1B2-SB MOTORS	0	280	280	280	679	679	679	679	679	679
480 V BUS 1B3-SB										
MCC 1B21-SB	126	125	106	106	106	157	159	158	157	157
MCC 1B22-SB	0	91	91	91	91	91	91	91	91	91
MCC 1B23-SB	78	78	78	78	78	90	90	90	72	72
MCC 1B31-SB	27	32	32	32	32	102	109	109	113	113
MCC 1B32-SB	1	1	2	2	2	2	17	17	27	27
MCC 1B34-SB	0	91	91	91	91	91	91	91	91	91
MCC 1B35-SB	2	6	6	19	22	86	88	105	125	125
MCC 1B36-SB	0	0	0	0	0	118	117	117	117	117
MCC 1&4B33-SB	8	18	18	18	18	18	18	18	204	204
Misc Cable & Transformer Losses	1	0	1	1	0	2	3	3	5	5
E-6000, R9 EDG 1B-SB KW LOADING	946	1418	2393	3001	3805	4125	4151	4824	5797	5797
MARGIN RESERVED FOR FUTURE LOAD ADDITIONS (KW)										703
EDG 1B-SB MAXIMUM KW LOADING CONSIDERING RESERVED MARGIN FOR FUTURE LOAD ADDITIONS										6500
EMERGENCY DIESEL GENERATOR 1B-SB CONTINUOUS RATING IN KW (SEE NOTES 1 & 2)										6500

Table 8.3.1-2b (Continued)

NOTES TO TABLES 8.3.1-2b

1. The continuous ratings of the emergency diesel generators are as follows:

   Continuous Rating 6500 kW at 0.8 power factor
   Overload Rating7150 kW at 0.8 power factor for 2 hrs in any 24 hr period

2. Emergency Diesel Generator 1A-SA and 1B-SB loading in kW (kilowatts) is shown in Tables 8.3.1-2a and 8.3.1-2b, respectively. The bases for the loading data presented in these tables is Calculation E-6000, Rev. 11, Tab A, Tables A10 & A11 and supporting computer analyses from the E-6000, Tab Z computer cases indicated in the header for each load block. The loading shown is conservative since it is a combination of both LOCA/LOOP and LOOP scenarios. (Loads common to both scenarios are shown as well as loads that are only applicable to either LOCA/LOOP or to LOOP). A listing of "sequenced on" loads is shown in Table 8.3.1-2c. Also see Note 3 below. The total loading shown in Tables 8.3.1-2a and 8.3.1-2b for each individual load block is the summation of continuous load for running motors and static loads and assumes all motors have completed acceleration. In other words, the kW shown would be the final steady-state kW if the sequencer "stopped" at the end of the load block. Emergency Diesel Generator terminal voltage during sequencing is calculated in Calculation 0017-EP and verified by test (OST-1823 & OST-1824) every outage.
3. It is recognized that there are outstanding change documents posted in the PassPort Controlled Document Module against Calculation E-6000. Some of the loading changes reflected in these documents (ECs, etc.) have actually been installed in the plant while others are pending. It is intended that Tables 8.3.1-2a and 8.3.1-2b will not be revised until such time that E-6000 has been revised and/or the loading margin identified as "Reserved for Future Loads" is being approached by the accumulation of load changes due to outstanding change documents. Due to this approach, it is possible that some of the individual power supply loadings shown will not exactly match the plant "as-built" condition. As stated in Note 2, the purpose of Table 8.3.1-2c is to show the "sequenced on" loads. Minor changes in the details of this table due to revisions to Calculation E-6000 may not be reflected. See Calculation E-6000, Tab D for more detail.
4. Sequencing times shown are seconds after receipt of SIS signal (assumes 10 seconds from SIS signal until closure of the EDG breaker).
5. Load Block 9 loads (those manually added) are blocked from starting until either confirmation that the essential chilled water chiller (Load Block 8) has started or 150 seconds have passed since initiation of load sequencing.
6. The loading shown for 480 V Substation 1A1 (1B1) is for non-safety related loads which are "blocked" from starting until Load Block 9.
7. Containment spray pumps get a start permissive signal at Load Block 2, but are blocked from starting in Load Block 3. They can therefore start in Load Blocks 2, 4, 5, 6, 7, 8 or 9 upon receipt of a containment spray actuation signal or can be running in any load block after Load Block 1.
8. In Table 8.3.1-2c, "S" indicates motor is starting. "R" indicates motor is running (or load is "on" for non-motor loads). Multiple "S's" indicate that the motor has a long acceleration time that spans more than one load block.

TABLE 8.3.1-2c EMERGENCY DIESEL GENERATOR LOAD SEQUENCING

LOAD BLOCK---→		1	2	3	4	5	6	7	8	9
LOAD	BUS									
LP-502	1&4A33-SA	R	R	R	R	R	R	R	R	R
LP-507	1&4A33-SA	R	R	R	R	R	R	R	R	R
LP-512	1&4A33-SA	R	R	R	R	R	R	R	R	R
AH-17 (1-4A-SA)	1&4A33-SA	0	0	0	0	0	0	0	0	R
EHC-17 (1-4X-SA)	1&4A33-SA	0	0	0	0	0	0	0	0	R
E12 (1-4X-SA)	1&4A33-SA	0	0	0	0	0	0	0	0	R
SFPCP 1&4A-SA	1&4A33-SA	0	0	0	0	0	0	0	0	R
1&4A33-SA	1&4A33-SA	R	R	R	R	R	R	R	R	R
LP-504	1&4B33-SB	R	R	R	R	R	R	R	R	R
LP-510	1&4B33-SB	R	R	R	R	R	R	R	R	R
LP-514	1&4B33-SB	R	R	R	R	R	R	R	R	R
AH-17 (1-4B-SB)	1&4B33-SB	0	0	0	0	0	0	0	0	R
EHC-18 (1-4X-SB)	1&4B33-SB	0	0	0	0	0	0	0	0	R
E13 (1--4X-SB)	1&4B33-SB	0	0	0	0	0	0	0	0	R
SFPCP 1&4B-SB	1&4B33-SB	0	0	0	0	0	0	0	0	R
1&4B33-SB	1&4B33-SB	R	R	R	R	R	R	R	R	R
AC 1A-NNS	1A1	0	0	0	0	0	0	0	0	R
PHPP-1A	1A1	0	0	0	0	0	0	0	0	R
AH-24 (1X-SA)	1A21-SA	0	0	0	0	0	0	S	R	R
S-2 Pri Shield Fan	1A21-SA	0	0	0	0	0	S	R	R	R
S-4 Rx Support Fan	1A21-SA	0	0	0	0	0	S	R	R	R
LP-112	1A21-SA	R	R	R	R	R	R	R	R	R
LP-114	1A21-SA	R	R	R	R	R	R	R	R	R
LP-118	1A21-SA	R	R	R	R	R	R	R	R	R
LP-128	1A21-SA	R	R	R	R	R	R	R	R	R
LP-134	1A21-SA	R	R	R	R	R	R	R	R	R
LP-533	1A21-SA	R	R	R	R	R	R	R	R	R
IDP-I	1A21-SA	R	R	R	R	R	R	R	R	R
1A212-SA	1A21-SA	R	R	R	R	R	R	R	R	R
1A211-SA	1A21-SA	R	R	R	R	R	R	R	R	R
Batt Chgr 1A-SA	1A21-SA	R	R	R	R	R	R	R	R	R
AH-2 (1A-SA) CFC	1A22-SA	0	S	S	R	R	R	R	R	R
LP-563	1A23-SA	R	R	R	R	R	R	R	R	R
AH-85 (1A-SA)	1A23-SA	0	0	0	0	0	S	R	R	R
E61 (1A-SA)	1A23-SA	0	0	0	0	0	S	R	R	R
DG1A STRT AIR 1A	1A23-SA	S	R	R	R	R	R	R	R	0
DG1A STRT AIR 1B	1A23-SA	S	R	R	R	R	R	R	R	0
E86 (1A-SA)	1A23-SA	S	R	R	R	R	R	R	R	R
E86 (1B-SA)	1A23-SA	0	0	0	0	0	0	0	0	R
1A231-SA	1A23-SA	R	R	R	R	R	R	R	R	R
HYDR / AMMON PUMP	1A24	0	0	0	0	0	0	0	0	R
E80 (1A-NNS)	1A24	0	0	0	0	0	0	0	0	R
AIR DRYER 1A-NNS	1A24	0	0	0	0	0	0	0	0	R
PASS CHILLER	1A24	0	0	0	0	0	0	0	0	R
RX WTR MAKEUP 1A	1A24	0	0	0	0	0	0	0	0	S
TG BEARING OIL PUMP	1A24	0	0	0	0	0	0	0	0	S
PASS CONTROL PNL	1A24	0	0	0	0	0	0	0	0	R
Batt Chgr 1A-125v	1A24	0	0	0	0	0	0	0	0	R
Cont Spray Pump 1A-SA	1A2-SA	0	0	0	0	S	S	R	R	R
Chilled Water P4 (1A2-SA)	1A2-SA	0	S	R	R	R	R	R	R	R
RHR Pump 1A-SA	1A2-SA	0	S	R	R	R	R	R	R	R

TABLE 8.3.1-2c EMERGENCY DIESEL GENERATOR LOAD SEQUENCING

LOAD BLOCK--→		1	2	3	4	5	6	7	8	9
LOAD	BUS									
SWB Pump 1A-SA	1A2-SA	0	0	0	0	S	R	R	R	R
AH-5 (1A-SA)	1A31-SA	0	S	R	R	R	R	R	R	R
AH-11 (1A-SA)	1A31-SA	0	0	0	0	0	0	S	R	R
AH-12 (1A-SA)	1A31-SA	0	0	0	0	0	S	R	R	R
AH-28 (1A-SA)	1A31-SA	0	0	0	0	0	S	R	R	R
AH-93 (1X-SA)	1A31-SA	0	0	0	0	0	S	R	R	R
E28 (1A-SA)	1A31-SA	0	0	0	0	0	0	0	0	R
S-64 (1X-SA)	1A31-SA	0	0	0	0	0	S	R	R	R
S-68 (1X-SA)	1A31-SA	0	0	0	0	0	0	0	0	R
Hydrogen Analyzer 1A	1A31-SA	0	0	0	0	0	0	0	0	R
Chiller P-7 (1A-SA)	1A31-SA	0	0	0	0	0	0	0	S	R
IDP-III	1A31-SA	R	R	R	R	R	R	R	R	R
AH-6 (1A-SA)	1A31-SA	0	0	0	S	R	R	R	R	R
AH-19 (1A-SA)	1A31-SA	0	S	R	R	R	R	R	R	R
1A311-SA	1A31-SA	R	R	R	R	R	R	R	R	R
Apdx R Trans 1A	1A31-SA	R	R	R	R	R	R	R	R	R
AH-86 (1A-SA)	1A32-SA	0	0	0	0	0	0	0	0	R
E88 (1A-SA)	1A32-SA	0	0	0	0	0	0	0	0	R
3SW-S21-SA Disch Str	1A32-SA	0	0	S	R	R	R	R	R	R
Screen Wash Pp 1A-SA	1A32-SA	0	0	0	0	0	0	S	R	R
ESW Main Res Scn	1A32-SA	0	0	0	0	0	0	S	R	R
1A321-SA	1A32-SA	R	R	R	R	R	R	R	R	R
AH-3 (1A-SA) CFC	1A34-SA	0	S	S	R	R	R	R	R	R
AH-10 (1A-SA)	1A35-SA	S	R	R	R	R	R	R	R	R
AH-20 (1A-SA)	1A35-SA	0	0	0	0	0	S	R	R	R
AH-92 (1A-SA)	1A35-SA	0	0	0	0	0	S	R	R	R
AH-9 (1A-SA)	1A35-SA	S	R	R	R	R	R	R	R	R
AH-7 (1A-SA)	1A35-SA	0	0	0	S	R	R	R	R	R
E6 (1A-SA)	1A35-SA	0	0	0	0	0	S	R	R	R
AH-26 (1A-SA)	1A35-SA	0	0	0	0	0	0	S	R	R
E85 (1A-SA)	1A35-SA	S	R	R	R	R	R	R	R	R
Boric Acid Xfr Pp 1A	1A35-SA	0	0	0	0	0	0	0	0	R
AH-23 (1X-SA)	1A35-SA	0	0	0	0	0	S	R	R	R
EH-30 (1A-SA)	1A35-SA	0	0	0	0	0	R	R	R	R
EDG.F.O.Xfr Pp 1A	1A35-SA	0	0	0	0	0	0	0	0	R
WC-2 Chiller Oil Pp 1A	1A35-SA	0	0	0	0	0	0	0	S	R
EHC-24 (1X-SA)	1A36-SA	0	0	0	0	0	R	R	R	R
AH-16 (1A-SA)	1A36-SA	0	0	0	0	0	S	R	R	R
Flo Cntr Pnl 21AV-3509	1A36-SA	R	R	R	R	R	R	R	R	R
AH-15 (1A-SA)	1A36-SA	0	0	0	0	0	S	R	R	R
EHC-72 (1A-SA)	1A36-SA	R	R	R	R	R	R	R	R	R
R-2 (1A-SA)	1A36-SA	S	R	R	R	R	S	R	R	R
WC-2 Chiller 1A-SA	1A-SA	0	0	0	0	0	0	0	S	R
AFW Pump 1A-SA	1A-SA	0	0	0	0	S	R	R	R	R
ESW Pump 1A-SA	1A-SA	0	0	S	R	R	R	R	R	R
Comp Cool Pump 1A-SA	1A-SA	0	0	0	S	R	R	R	R	R
Charging/SI Pump 1A-SA	1A-SA	S	R	R	R	R	R	R	R	R
AC 1B-NNS	1B1	0	0	0	0	0	0	0	0	R
PHPP-1B	1B1	0	0	0	0	0	0	0	0	R
S-2 Pri Shield Fan	1B21-SB	0	0	0	0	0	S	R	R	R
S-4 Rx Support Fan	1B21-SB	0	0	0	0	0	S	R	R	R
LP-113	1B21-SB	R	R	R	R	R	R	R	R	R

TABLE 8.3.1-2c EMERGENCY DIESEL GENERATOR LOAD SEQUENCING

LOAD BLOCK---→		1	2	3	4	5	6	7	8	9
LOAD	BUS									
LP-115	1B21-SB	R	R	R	R	R	R	R	R	R
LP-119	1B21-SB	R	R	R	R	R	R	R	R	R
LP-127	1B21-SB	R	R	R	R	R	R	R	R	R
LP-135	1B21-SB	R	R	R	R	R	R	R	R	R
LP-534	1B21-SB	R	R	R	R	R	R	R	R	R
IDP-II	1B21-SB	R	R	R	R	R	R	R	R	R
AH-29 (1X-SB)	1B21-SB	0	0	0	0	0	S	R	R	R
AH-25 (1X-SB)	1B21-SB	0	0	0	0	0	0	S	R	R
1B212-SB	1B21-SB	R	R	R	R	R	R	R	R	R
1B211-SB	1B21-SB	R	R	R	R	R	R	R	R	R
Batt Chgr 1A-SB	1B21-SB	R	R	R	R	R	R	R	R	R
AH-1 (1A-SB) CFC	1B22-SB	0	S	S	R	R	R	R	R	R
LP-564	1B23-SB	R	R	R	R	R	R	R	R	R
AH-85 (1C-SB)	1B23-SB	0	0	0	0	0	S	R	R	R
E61 (1C-SB)	1B23-SB	0	0	0	0	0	S	R	R	R
DG1B STRT AIR 1C	1B23-SB	S	R	R	R	R	R	R	R	0
DG1B STRT AIR 1D	1B23-SB	S	R	R	R	R	R	R	R	0
E86 (1C-SB)	1B23-SB	S	R	R	R	R	R	R	R	R
E86 (1D-SB)	1B23-SB	0	0	0	0	0	0	0	0	R
1B231-SB	1B23-SB	R	R	R	R	R	R	R	R	R
AUX BEARING LIFT OIL	1B24	0	0	0	0	0	0	0	0	R
E80 (1B-NNS)	1B24	0	0	0	0	0	0	0	0	R
AIR DRYER 1B-NNS	1B24	0	0	0	0	0	0	0	0	R
RX WTR MAKEUP 1B	1B24	0	0	0	0	0	0	0	0	S
TG BEARING LIFT OIL Pp	1B24	0	0	0	0	0	0	0	0	S
TG TURNING GEAR	1B24	0	0	0	0	0	0	0	0	R
EHC-1 (1X-NNS)	1B24	0	0	0	0	0	0	0	0	R
E4 (1X-NNS)	1B24	0	0	0	0	0	0	0	0	R
Batt Chgr 1A-250v	1B24	0	0	0	0	0	0	0	0	R
Cont Spray Pump 1B-SB	1B2-SB	0	0	0	0	S	S	R	R	R
Chilled Water P4 (1B-SB)	1B2-SB	0	S	R	R	R	R	R	R	R
RHR Pump 1B-SB	1B2-SB	0	S	R	R	R	R	R	R	R
SWB Pump 1B-SB	1B2-SB	0	0	0	0	S	R	R	R	R
AH-5 (1B-SB)	1B31-SB	0	S	R	R	R	R	R	R	R
AH-10 (1B-SB)	1B31-SB	S	R	R	R	R	R	R	R	R
AH-11 (1B-SB)	1B31-SB	0	0	0	0	0	0	S	R	R
AH-28 (1B-SB)	1B31-SB	0	0	0	0	0	S	R	R	R
E29	1B31-SB	0	0	0	0	0	0	0	0	R
S-65 (1X-SB)	1B31-SB	0	0	0	0	0	S	R	R	R
Hydrogen Analyzer 1B	1B31-SB	0	0	0	0	0	0	0	0	R
AH-13 (1A-SB)	1B31-SB	0	0	0	0	0	S	R	R	R
IDP-IV	1B31-SB	R	R	R	R	R	R	R	R	R
AH-9 (1B-SB)	1B31-SB	S	R	R	R	R	R	R	R	R
1B311-SB	1B31-SB	R	R	R	R	R	R	R	R	R
Apdx R Trans 1B	1B31-SB	R	R	R	R	R	R	R	R	R
AH-86 (1B-SB)	1B32-SB	0	0	0	0	0	0	0	0	R
E88 (1B-SB)	1B32-SB	0	0	0	0	0	0	0	0	R
3SW-S22-SB Disch Str	1B32-SB	0	0	S	R	R	R	R	R	R
Screen Wash Pp 1B-SB	1B32-SB	0	0	0	0	0	0	S	R	R
ESW Main Res Scn	1B32-SB	0	0	0	0	0	0	S	R	R
1B321-SB	1B32-SB	R	R	R	R	R	R	R	R	R
AH-4 (1A-SB) CFC	1B34-SB	0	S	S	R	R	R	R	R	R
Chiller P-7 (1B-SB)	1B35-SB	0	0	0	0	0	0	0	S	R

TABLE 8.3.1-2c EMERGENCY DIESEL GENERATOR LOAD SEQUENCING

LOAD BLOCK---→		1	2	3	4	5	6	7	8	9
LOAD	BUS									
AH-20 (1B-SB)	1B35-SB	0	0	0	0	0	S	R	R	R
AH-26 (1B-SB)	1B35-SB	0	0	0	0	0	0	S	R	R
AH-8 (1X-SB)	1B35-SB	0	0	0	0	S	R	R	R	R
AH-92 (1B-SB)	1B35-SB	0	0	0	0	0	S	R	R	R
AH-6 (1B-SB)	1B35-SB	0	0	0	S	R	R	R	R	R
AH-7 (1B-SB)	1B35-SB	0	0	0	S	R	R	R	R	R
AH-19 (1B-SB)	1B35-SB	0	S	R	R	R	R	R	R	R
E6 (1B-SB)	1B35-SB	0	0	0	0	0	S	R	R	R
E85 (1A-SB)	1B35-SB	S	R	R	R	R	R	R	R	R
Boric Acid Xfr Pp 1B	1B35-SB	0	0	0	0	0	0	0	0	R
EHC-30 (1B-SB)	1B35-SB	0	0	0	0	0	R	R	R	R
EDG F.O. Xfr Pp 1B	1B35-SB	0	0	0	0	0	0	0	0	R
WC-2 Chiller Oil Pp 1B	1B35-SB	0	0	0	0	0	0	0	S	R
EHC-26 (1X-SB)	1B36-SB	0	0	0	0	0	R	R	R	R
AH-16 (1B-SB)	1B36-SB	0	0	0	0	0	S	R	R	R
AH-15 (1B-SB)	1B36-SB	0	0	0	0	0	S	R	R	R
EHC-72 (1B-SB)	1B36-SB	R	R	R	R	R	R	R	R	R
R-2 (1B-SB)	1B36-SB	S	R	R	R	R	S	R	R	R
WC-2 Chiller 1B-SB	1B-SB	0	0	0	0	0	0	0	S	R
AFW Pump 1B-SB	1B-SB	0	0	0	0	S	R	R	R	R
ESW Pump 1B-SB	1B-SB	0	0	S	R	R	R	R	R	R
Comp Cool Pump 1B-SB	1B-SB	0	0	0	S	R	R	R	R	R
Charging/SI Pump 1B-SB	1B-SB	S	R	R	R	R	R	R	R	R

NOTES

Loads shown in "white" background are motor loads / loads shown in "gray" background are static (non-motor) loads. This table has been reproduced from Calculation E-6000, Tab D, Table D3 (only starting and running loads shown).

NOTES TO TABLES 8.3.1-2c

1. The continuous ratings of the emergency diesel generators are as follows:

   Continuous Rating 6500 kW at 0.8 power factor
   Overload Rating7150 kW at 0.8 power factor for 2 hrs in any 24 hr period

2. Emergency Diesel Generator 1A-SA and 1B-SB loading in kW (kilowatts) is shown in Tables 8.3.1-2a and 8.3.1-2b, respectively. The bases for the loading data presented in these tables is Calculation E-6000, Rev. 11, Tab A, Tables A10 & A11 and supporting computer analyses from the E-6000, Tab Z computer cases indicated in the header for each load block. The loading shown is conservative since it is a combination of both LOCA/LOOP and LOOP scenarios. (Loads common to both scenarios are shown as well as loads that are only applicable to either LOCA/LOOP or to LOOP). A listing of "sequenced on" loads is shown in Table 8.3.1-2c. Also see Note 3 below. The total loading shown in Tables 8.3.1-2a and 8.3.1-2b for each individual load block is the summation of continuous load for running motors and static loads and assumes all motors have completed acceleration. In other words, the kW shown would be the final steady-state kW if the sequencer "stopped" at the end of the load block. Emergency Diesel Generator terminal voltage during sequencing is calculated in Calculation 0017-EP and verified by test (OST-1823 & OST-1824) every outage.

3. It is recognized that there are outstanding change documents posted in the PassPort Controlled Document Module against Calculation E-6000. Some of the loading changes reflected in these documents (ECs, etc.) have

actually been installed in the plant while others are pending. It is intended that Tables 8.3.1-2a and 8.3.1-2b will not be revised until such time that E-6000 has been revised and/or the loading margin identified as "Reserved for Future Loads" is being approached by the accumulation of load changes due to outstanding change documents. Due to this approach, it is possible that some of the individual power supply loadings shown will not exactly match the plant "as-built" condition. As stated in Note 2, the purpose of Table 8.3.1-2c is to show the "sequenced on" loads. Minor changes in the details of this table due to revisions to Calculation E-6000 may not be reflected. See Calculation E-6000, Tab D for more detail.

4. Sequencing times shown are seconds after receipt of SIS signal (assumes 10 seconds from SIS signal until closure of the EDG breaker).

5. Load Block 9 loads (those manually added) are blocked from starting until either confirmation that the essential chilled water chiller (Load Block 8) has started or 150 seconds have passed since initiation of load sequencing.

6. The loading shown for 480 V Substation 1A1 (1B1) is for non-safety related loads which are "blocked" from starting until Load Block 9.

7. Containment spray pumps get a start permissive signal at Load Block 2, but are blocked from starting in Load Block 3. They can therefore start in Load Blocks 2, 4, 5, 6, 7, 8 or 9 upon receipt of a containment spray actuation signal or can be running in any load block after Load Block 1.

8. In Table 8.3.1-2c, "S" indicates motor is starting. "R" indicates motor is running (or load is "on" for non-motor loads). Multiple "S's" indicate that the motor has a long acceleration time that spans more than one load block.

TABLE 8.3.1-3

6.9 kV SAFETY RELATED SYSTEM SINGLE FAILURE ANALYSIS

FAILURE	CAUSE	CONSEQUENCES AND COMMENTS
1. 6.9 kV power to bus 1A-SA or 1B-SB (assuming coincident loss of preferred power).	a. Failure of the associated DG (diesel generator) to start.	a. Failure of the DG to start will result in the loss of one complete ESF actuation division. The redundant DG will start and supply the redundant ESF loads. The reliability of the DG to start has been enhanced considerably by the following design features: Starting Signal: Engineered Safety Features Actuation Signal or undervoltage relays on 6.9 kV bus. Starting System: Two air starting systems for each DG.
	b. Failure of the DG to develop voltage.	b. The consequences will be identical to Item a.
	c. Failure of DG ACB to autoclose	c. Consequences will be identical to Item a.
	d. Bus fault on Bus 1A SA or 1B-SB.	d. A bus fault will prevent loading of the bus. The redundant bus will provide the power to the redundant ESF loads.
	e. Loss of associated dc control power source	e. DC control power to the two redundant 6.9 kV ESF systems is supplied from two redundant batteries. Loss of control power to any one system will not prevent the redundant system from performing the safety function.
	f. Failure of a feeder breaker to trip on feeder fault.	f. A fault on a feeder cable, if not cleared by the feeder breaker, will lead to tripping of the bus. Under this condition, the redundant 6.9 kV bus will supply the redundant ESF loads. The ESF System is designed to operate without isolating any component on a single ground fault. As multiphase faults are relatively few in number, reliability of complete safety functions is greatly increased.
2. 6.9 kV load (power center, motor, etc.)	a. Failure of power center feeder circuit breaker to close.	a. .Any of the events a, b or c will result in loss of the affected actuated component. The redundant load on the redundant bus will perform the safety function.
	b. Stalled motor.	
	c. Feeder cable fault.	

TABLE 8.3.1-4

480V SAFETY RELATED SYSTEM SINGLE FAILURE ANALYSIS

FAILURE	CAUSE	CONSEQUENCES AND COMMENTS
1. 480V power to bus: 1A2-SA, 1B2-SB, 1A3-SA or 1B3-SB	a. Failure of associated power center transformer	Any of the five events a, b, c, d or e will cause the loss of 480 V ESF loads on one channel. The redundant 480V load center bus will supply the redundant ESF loads.
	b. 6.9 kV cable fault.	
	c. Power center bus fault.	
	d. Failure of any load breaker to clear a fault	
	e. Loss of dc control power source	e. The redundant 480V ESF load centers are supplied from redundant batteries. A single failure will not result in the loss of control power to both redundant systems.
2. 480V MCC feeders	a. Feeder cable fault	Any of the events a, b, or c will result in the loss of 480V power to the ESF loads connected to the affected MCC. The redundant loads connected to the redundant MCC will perform the safety function.
	b. MCC bus fault	
	c. Failure of any MCC load feeder breaker to clear a fault	
3. 480V loads	a. Feeder cable fault	The result will be the loss of the affected actuated component. The redundant component on the other division will perform the safety function.
	b. Stalled motor	

TABLE 8.3.1-5

208/120V AC SAFETY RELATED SYSTEM SINGLE FAILURE ANALYSIS

FAILURE	CAUSE	CONSEQUENCES AND COMMENTS
1. Power to bus	a. Failure of associated transformer	a, b, c, d: Any of these events will result in the loss of power to the 208 or 120V loads of one division. The unaffected bus will supply the redundant ESF loads.
	b. Cable fault	
	c. Failure of any load breaker to clear a fault	
	d. Bus fault	
2. Any distribution feeder	a. Cable fault	a. This result in loss of power to the connected loads. The redundant loads on the unaffected division are adequate to insure safety.

TABLE 8.3.1-6

120V UNINTERRUPTIBLE VITAL AC SYSTEM SINGLE FAILURE ANALYSIS

FAILURE	CAUSE	CONSEQUENCES AND COMMENTS
1. 120V AC power to bus: 1A-SI, 1A-SIII 1B-SII or 1B-SIV	a. Bus fault b. Cable fault c. Failure of a distribution breaker to clear a fault d. Failure in SUPS	a, b, c, d. The result will be the loss of 120V uninterruptible ac power supply to one of the four channels of the protection system. As a two out of four criterion is used in all logic circuits, the remaining three channels allow safe, but not false, shutdown.
2. Any distribution feeder	a. Cable fault	a. This will result in the loss of power to the connected loads. The redundant loads in the remaining three channel are adequate to ensure safety.
3. Loss of 480V AC power to SUPS	a. MCC bus fault b. Cable fault	a,b. The SUPS will be supplied by the battery without interruption of output power.

TABLE 8.3.1-7

SINGLE FAILURE ANALYSIS OF TRANSFER
TO PREFERRED POWER SOURCE UPON UNIT TRIP

FAILURE	CAUSE	CONSEQUENCES AND COMMENTS
1. Loss of DC power supply to one generator lockout relay	a. Loss of DC feeder from distribution panel	a. No effect. The duplicate set of lockout relays powered from its associated DC distribution panel will perform all emergency functions and ensure transfer of one division to the preferred power source. (Battery 1A supplies the non-safety related controls, including generator protection and bus transfer circuits, through two separate distribution panels). If the preferred power source is not available, the undervoltage relays of the 6.9 kV ESF buses will start the diesel generators (DG) automatically to meet the load requirements.
2. 2.Loss of DC power to both generator lockout relays	a. Earthquake or foreign objects falling on the non-class IE raceways	a,b. This is the worst case failure. Complete destruction of all non-Class IE cables or loss of DC bus will disable control circuits of unit auxiliary and preferred source switchgear. Hence, tripping of unit auxiliary transformer breakers or transfer to the preferred source cannot occur. Undervoltage relays on the 6.9 kV ESF buses will isolate the DG buses by tripping the incoming feeder breakers which are controlled from Division A or B batteries. Consequently, the functioning of the safety related loads will not be affected.
	b. Loss of DC distribution panel bus	
3. Unit auxiliary transformer breaker	a. Mechanical failure to trip on trip signal	a. This will lead to the loss of one of the bus sections ID or IE. The remaining bus section will be transferred to the preferred source, while the lost bus will cause the DG to restart because of undervoltage, as in Failure 2a above.

TABLE 8.3.1-8

COMPARISON OF MIDDLE SOUTH ENERGY UNIT 1 TO SHEARON HARRIS DIESEL

Parameter	Middle South Energy-Grand Gulf Nuclear Station Unit 1	Shearon Harris
Model	DSRV-16-4	DSRV-16-4
Power Rating	7000KW, Continuous	6500KW continuous
Supplementary Power Rating	7700KW for 2 hrs in any 24 hrs	7150KW for 2 hrs in any 24 hrs
Voltage	4160V	6900V
RPM	450	450
KW^2	322,340 $lb\text{-}ft^2$	350, 545 $lb\text{-}ft^2$
Phase, frequency	3 Phase, 60Hz	3 Phase, 60Hz

TABLE 8.3.1-9

BUS FAILURE ANALYSIS

SYSTEM	COMPONENT	EFFECT OF FAILURE	ALTERNATE INDICATION/EQUIPMENT AVAILABLE
Protection System	Demultiplexer Power Supply	Loss of all indication on status panel pertaining to status trip logic	Back up information on ERFIS computer
	Turbine Pressure PS-446B	Loss of Power to PIC-C8	Back up Supply PP-1E212
Pressurizer System	PIC-C6 TE 450, 454, 453	Loss of Power to PIC-C6 and PREZR temp indication	Back up Supply PP-1E212
Chemical and Volume Control System	Charging Flow Control FCV 122	Valve fails open	Back up Supply PP-1E212
Main Steam	Condenser Steam dump valves PCV 408A, 408B, 408C	Valves fail closed	Atmos. Relief valves PCV 308A, 308B, 308C can be used
Residual Heat Removal System	RHR HX Out VLV HCV 603A	Loss of Power to PIC-C5 No effect on System	Back up power panel UPP-1B
	RHR HX Out VLV FCV 605B	Loss of Power to PIC-C19 No effect on System	Back up power panel UPP-1B
	RHR Pump temp TE 604B	Loss of Power to PIC-C8 No effect on system	Back up power panel PP 1E212

Note: The air compressors will trip upon loss of power. However, the emergency power buses are manually loaded on to the Emergency Diesel Generators after the automatic load sequencer reaches load block 9, following the automatic loading cycles. When an emergency bus is re-energized, its respective air compressor feeder breaker will close.

TABLE 8.3.1-9 (Continued)

SYSTEM	COMPONENT	EFFECT OF FAILURE	ALTERNATE INDICATION/EQUIPMENT AVAILABLE
Protection System	Trip & Bypass status TSLB-1, BPLB	Loss of trip and bypass status indication on the MCB	Back up information on ERFIS computer and MCB annunciator
	MCB & AEP Annunicator system	Loss of Annunicator information	Switch to DC power DP-1A-1 and DP-1A-2
Chemical and Volume Control System	Demin. Valve HCV 387	Fails to boration position No effect on system	None, valve fails safe position

TABLE 8.3.1-9 (Continued)

SYSTEM	COMPONENT	EFFECT OF FAILURE	ALTERNATE INDICATION/EQUIPMENT AVAILABLE
Protection System	Differential amplifier NM 45A, 45B, and recorder TR 408	Loss of recorder information	Back up information on ERFIS computer
Reactor Coolant System	Reactor makeup control circuit	Loss of pump control alarm of MCB.	Manual start of pump from MCB
Safety Injection	Accumulator vent valve HCV 936	Valve fails closed, no effect.	Not required for safe shutdown
Residual Heat Removal System	RHR HX out Vlv FCV 605A	Loss of Power to PIC-C7 No effect on system	Back up Supply PP-1D212
	RHR Pump Temp TE 604A	Loss of Power to PIC-C7	Back up Supply PP-1D212
	RHR HX out valve HCV 603A	Loss of Power to PIC-C5 No effect on system	Back up Supply PP-1D212

TABLE 8.3.1-9 (Continued)

SYSTEM	COMPONENT	EFFECT OF FAILURE	ALTERNATE INDICATION/EQUIPMENT AVAILABLE
Chemical and Volume Control System	BA Flow valves FCV113A, 114A, 114B	Normal flow path closed.	Emergency flow path thru valve 1-8104 to charging pumps.
	Letdown valve to volume control tank LCV-115A	No flow to hold up tank. Flow to VCT.	MCB VCT level indication
	Letdown valve to volume control tank TCV-143	No flow to mix bed Demineralizers. Direct flow VCT Indication on MCB.	MCB VCT level indication
	Letdown valve to volume control tank TCV-381A	Valve fails closed, loss of BTRS control temp in Boron Mode.	Back up Supply PP-1E212
	RCP seal leakoff valves 1-8141A, 8141B, 8141C	Valves fail open, no effect on system. Indication on MCB.	Not required for safe shutdown.
Reactor Coolant System	Reactor Leakoff Isol. VLV 1-8032	Valve normally open, loss of indication only.	MCB temperature indication
Safety Injection	Annumulator fill line Valves fail closed, no Isolation valve 8878A effect (normally closed. B. C.		Not required for safe shutdown.

SYSTEM	COMPONENT	EFFECT OF FAILURE	ALTERNATE INDICATION/EQUIPMENT AVAILABLE
Rod Control System	DC Power to MG Set	Loss of power no effect on shutdown, loss of IND on local panel and tripping of Generator Breaker.	Reactor Trip Breaker

TABLE 8.3.1-10

MINIMUM SEPARATION DISTANCES

	Separation Configuration (From/To) Notes 1 & 2	Minimum Sep. Distances
1.	Low Level or Control F/A Cable or Tray to Class 1E Raceway or Cable	1" H, 3" V
2.	LV Power Tray to Class 1E F/A Tray or Flex Conduit	12" H, 36" V
3.	LV Power Tray (H) to Class 1E Conduit	4" H, 12"V
4.	LV Power F/A Cable to Class 1E F/A Tray or Flex Conduit	12" H, 36" V
5.	LV Power F/A Cable or Tray (R) to Class 1E Conduit	12" H, 12" V
6.	Medium Voltage Conduit to Class 1E Tray or F/A Cable	1"
7.	LV Power, Control or Low Level Conduit to Class 1E Tray, F/A Cable or Parallel Conduit	1/4"
8.	LV Power, Control or Low Level Conduit to Class 1E Perpendicular (Crossing) Conduit	0"

F/A - Free Air

H - Horizontal Tray

LV - Low Voltage

R - Riser Tray

Note 1: Separation distances shown only apply when considering the "From" as the damage source and the "To" as the protected raceway.

Note 2: Configurations 1 thru 5, 7 and 8 are justified by (1) test, and Configuration 6 is justified by (2) analysis as defined in Section 8.3.1.2.30.

TABLE 8.3.2-1

125 V DC BATTERY LOAD PROFILE FOR LOSS OF NORMAL POWER AND SIMULTANEOUS LOSS OF COOLANT ACCIDENT AND LOAD INFORMATION

TIME	AMPERES
0-1 min	450 A
1-120 min	200 A
120-239 min	100 A
239-240 min	150 A

LOAD	LOAD DURATION
6.9 KV & 480 V Switchgear Trip and Close	typically <30 seconds
Inverters	0-2 hours
Diesel Generator Field Flashing	1 minute
Solid State Protection	0-4 hours
Reactor Trip Switchgear	0-4 hours
Instrument and Control Loads	0-4 hours
Motor Operated Valves	typically <30 seconds
Motor Indication & Status Light Boxes	0-4 hours

NOTE: The safety related batteries are required to provide DC power for two hours following this design basis event. However, the batteries were conservatively sized for a four-hour duty cycle even though power will be restored to the battery chargers from the standby diesel generators within a minute after a loss of normal AC power. The load profile and load descriptions, in the above tables, envelope both safety related batteries for the LOCA/LOOP design basis event. The electrical calculations for sizing the Class 1E batteries should be consulted for actual loading information.

TABLE 8.3.2-5

125 V DC SAFETY RELATED SYSTEM SINGLE FAILURE ANALYSIS

FAILURE	CAUSE	CONSEQUENCES AND COMMENTS
1. 125V DC power to bus 1A-SA or 1B-SB	a. Bus fault b. Battery fault c. Failure of load breaker to clear fault.	a, b, c. In the event of the loss of one DC bus, the redundant bus will supply control power to the ESF loads of the redundant division
2. Battery charger	a. Charger fault b. Loss of feeder	a, b. Second charger supplies DC load and maintains battery in fully charged state
	c. Loss of MCC supplying a charger	c. One charger and battery (if necessary) can supply the resultant normal DC load plus the 120V AC inverter loads normally carried by the failed MCC. MCC 1D23 can supply back-up power to the impacted battery charger using a manual transfer switch.
3. Loss of any DC load breaker	a. Cable fault	a. A cable fault will trip the feeder breaker and will result in loss of control power to the connected safety related loads. The redundant loads connected to the redundant DC system will ensure safe shutdown.
	b. Distribution feeder fault not cleared by associated breaker.	b. An uncleared fault will result in loss of all DC on the bus concerned. The redundant loads will ensure safe shutdown as in (a).

FIGURE 8.1.1-1

CP&L TRANSMISSION SYSTEM – SHNPP UNIT 1 IN-SERVICE

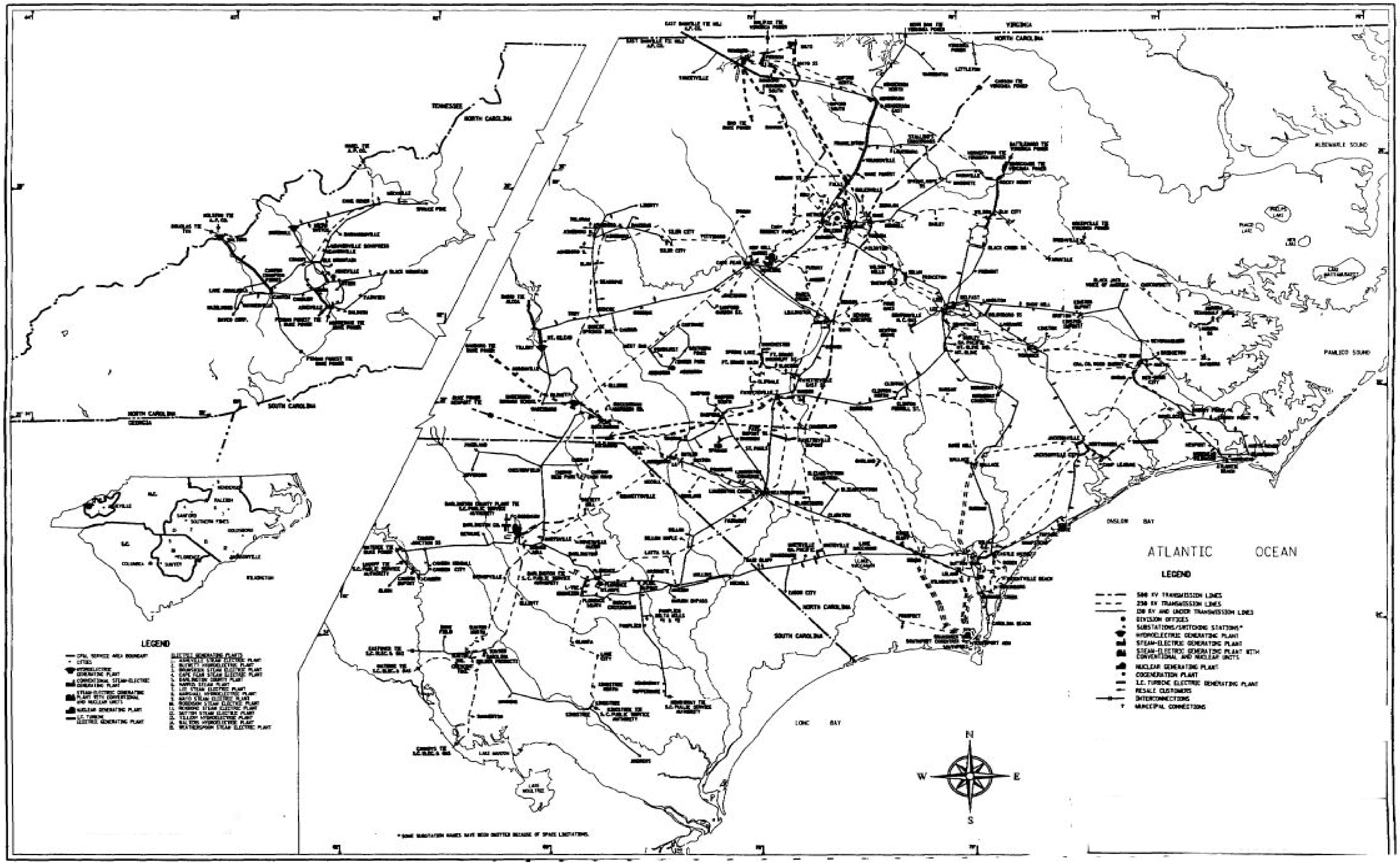


FIGURE 8.1.3-1

MAIN ONE-LINE DIAGRAM

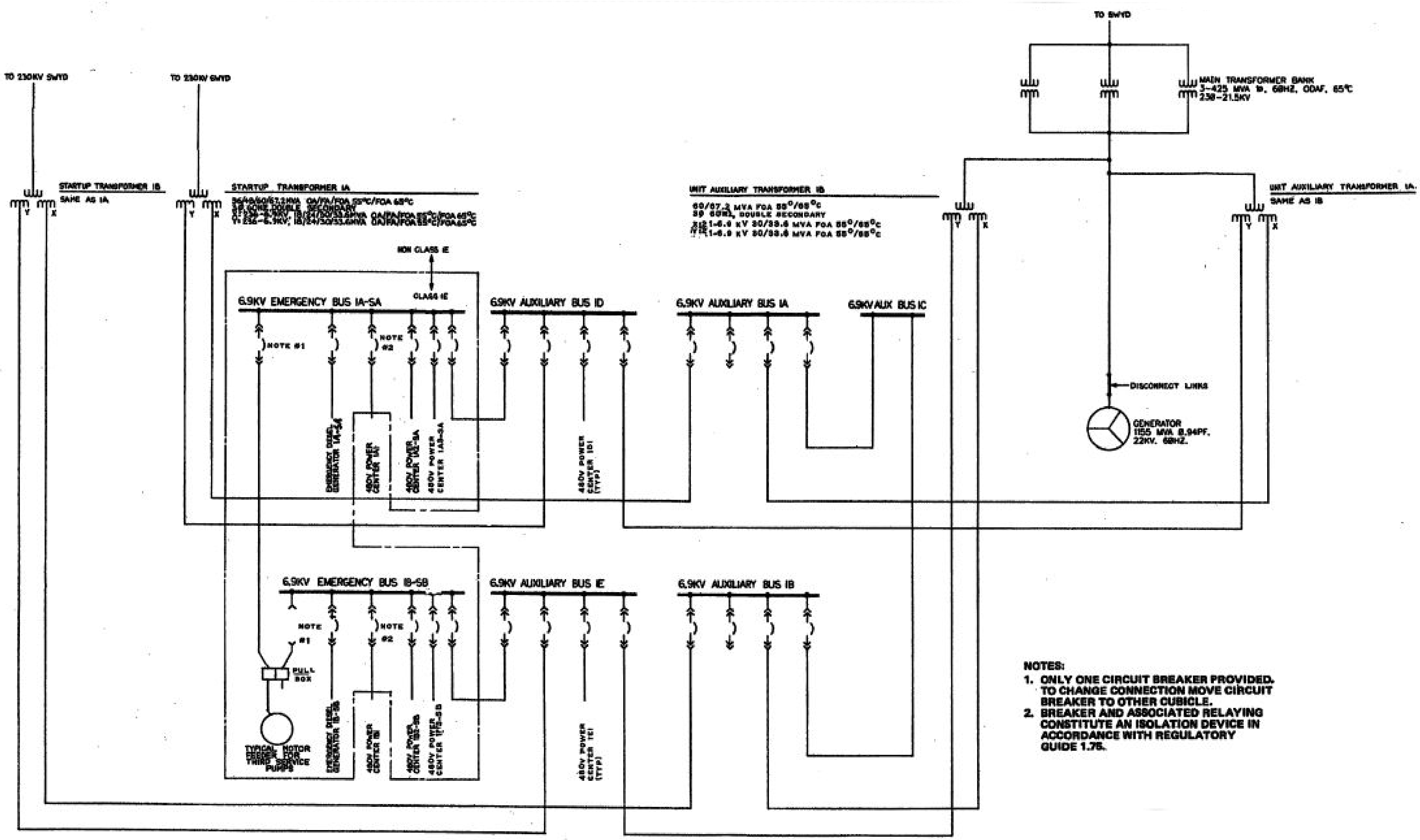


FIGURE 8.1.3-2

AUXILIARY ONE-LINE DIAGRAM

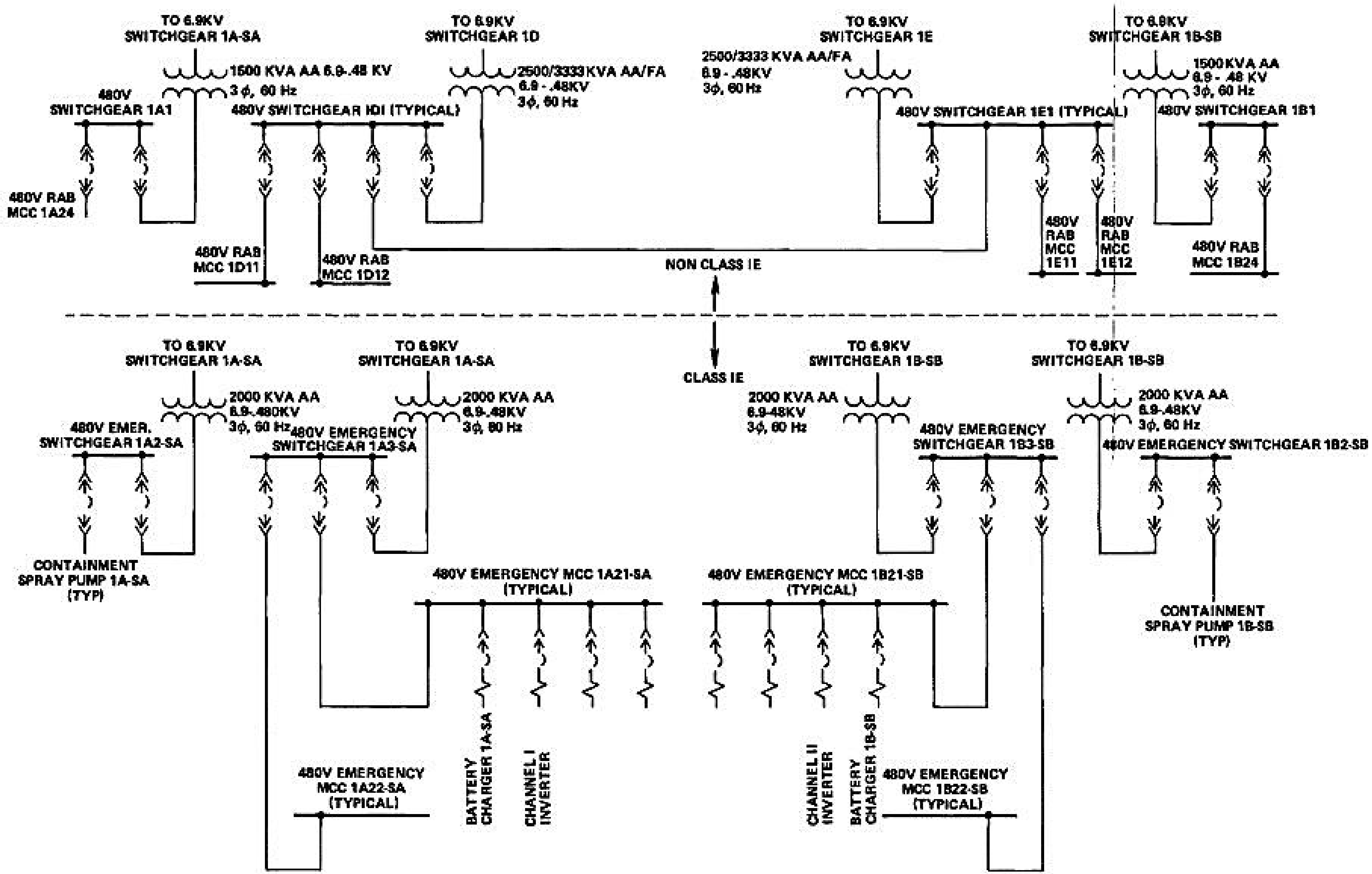


FIGURE 8.1.3-3

125 VOLT D-C, 250 VOLT D-C, AND 120 VOLT A-C ONE-LINE DIAGRAM

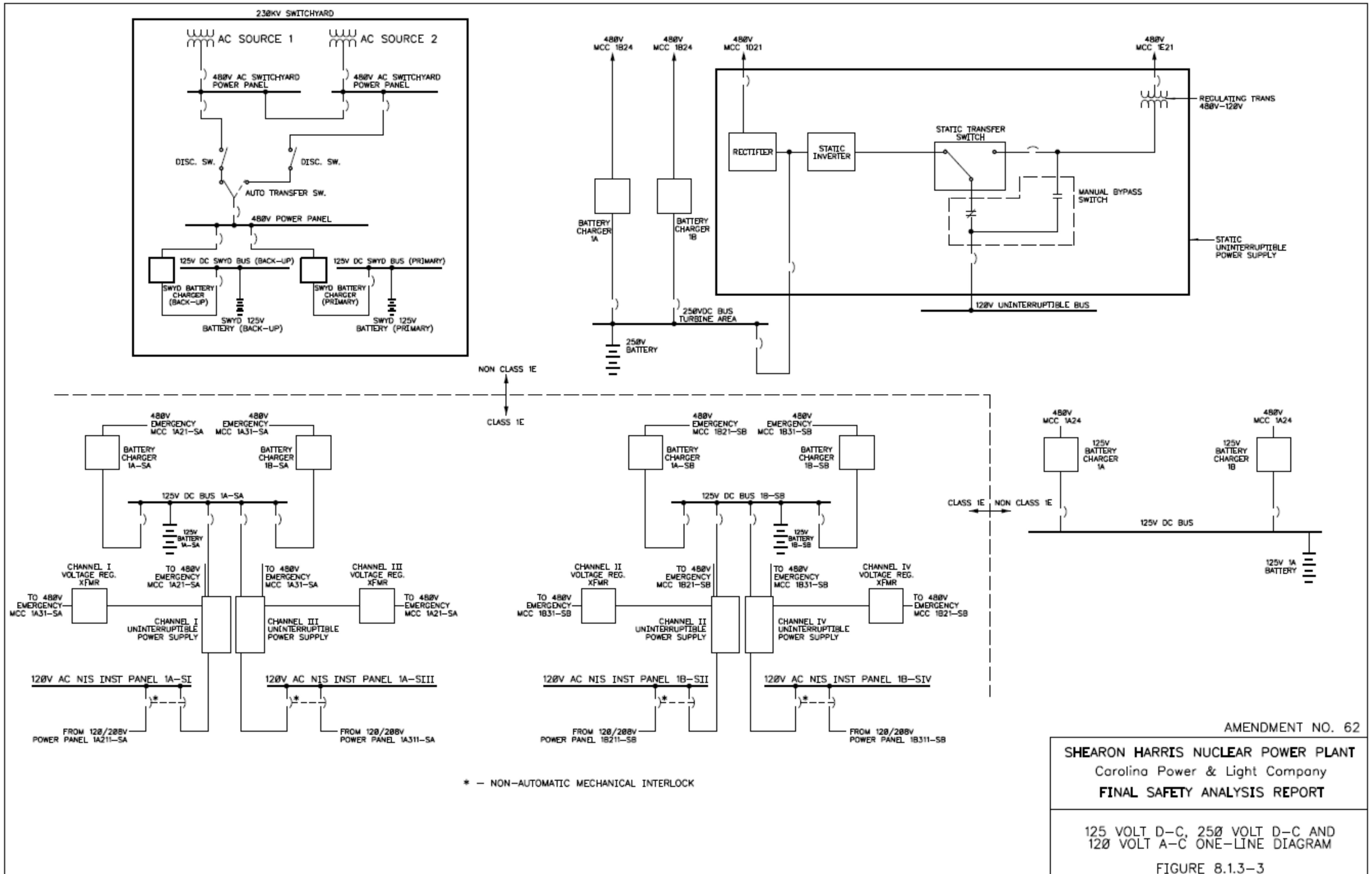
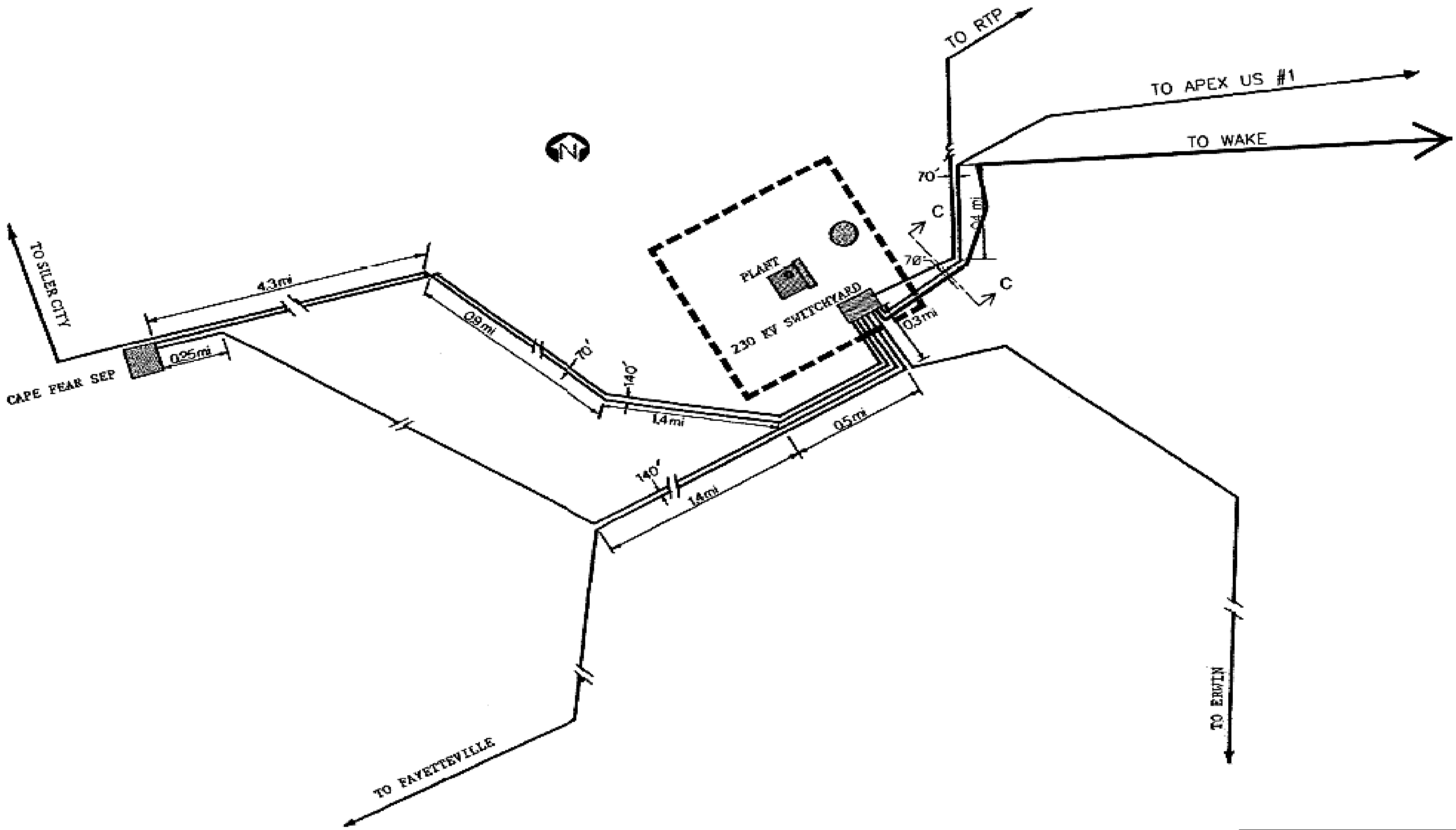


FIGURE 8.2.1-1

TRANSMISSION LINE ROUTING AT THE SHEARON HARRIS NUCLEAR POWER PLANT



AMENDMENT NO. 60

SHEARON HARRIS NUCLEAR POWER PLANT
DUKE ENERGY
FINAL SAFETY ANALYSIS REPORT

TRANSMISSION LINE ROUTING AT THE SHEARON HARRIS NUCLEAR POWER PLANT

FIGURE 8.2.1-1

FIGURE 8.2.1-2

OVERVIEW OF SHEARON HARRIS TRANSMISSION LINES

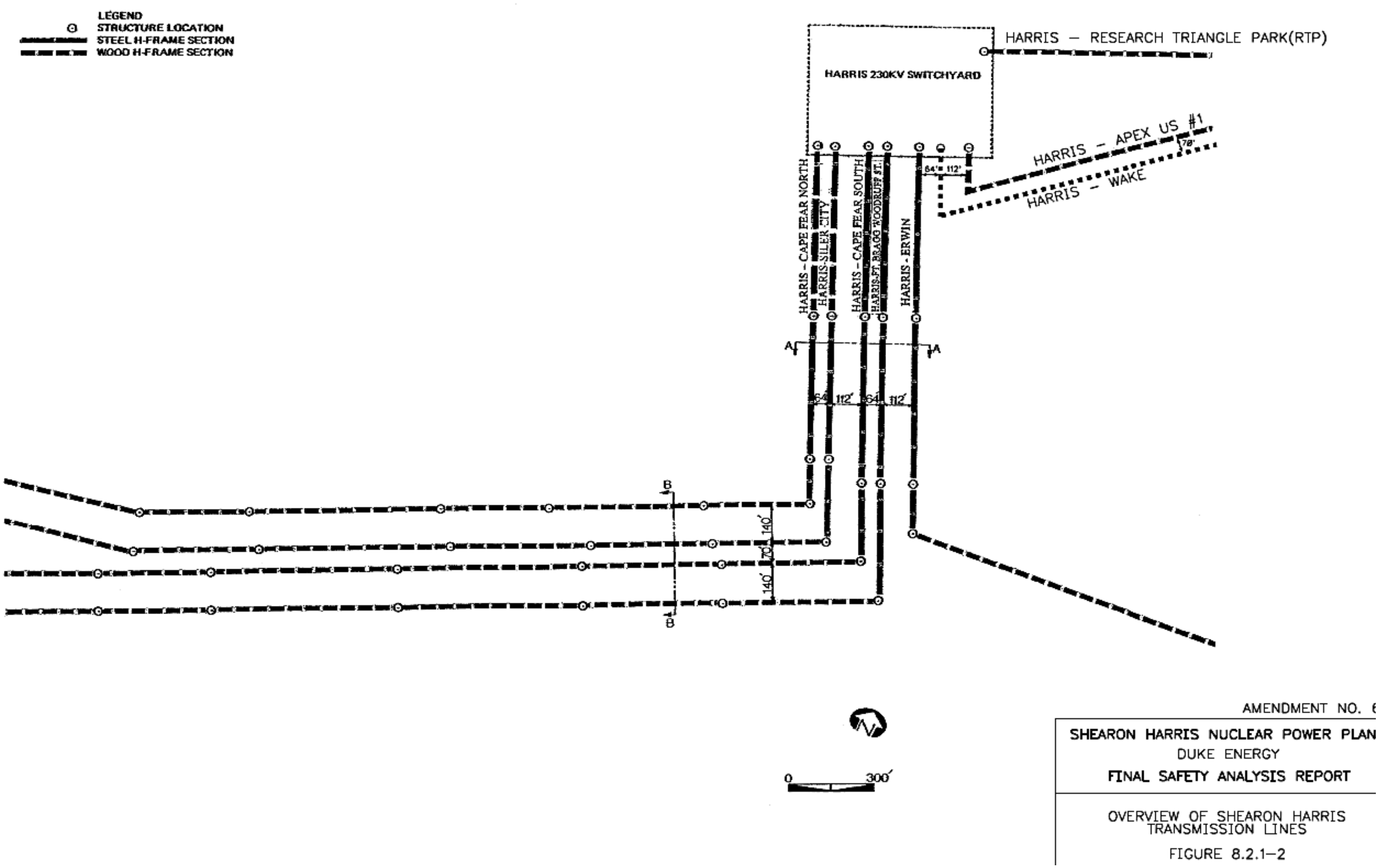


FIGURE 8.2.1-3

SECTION A – A

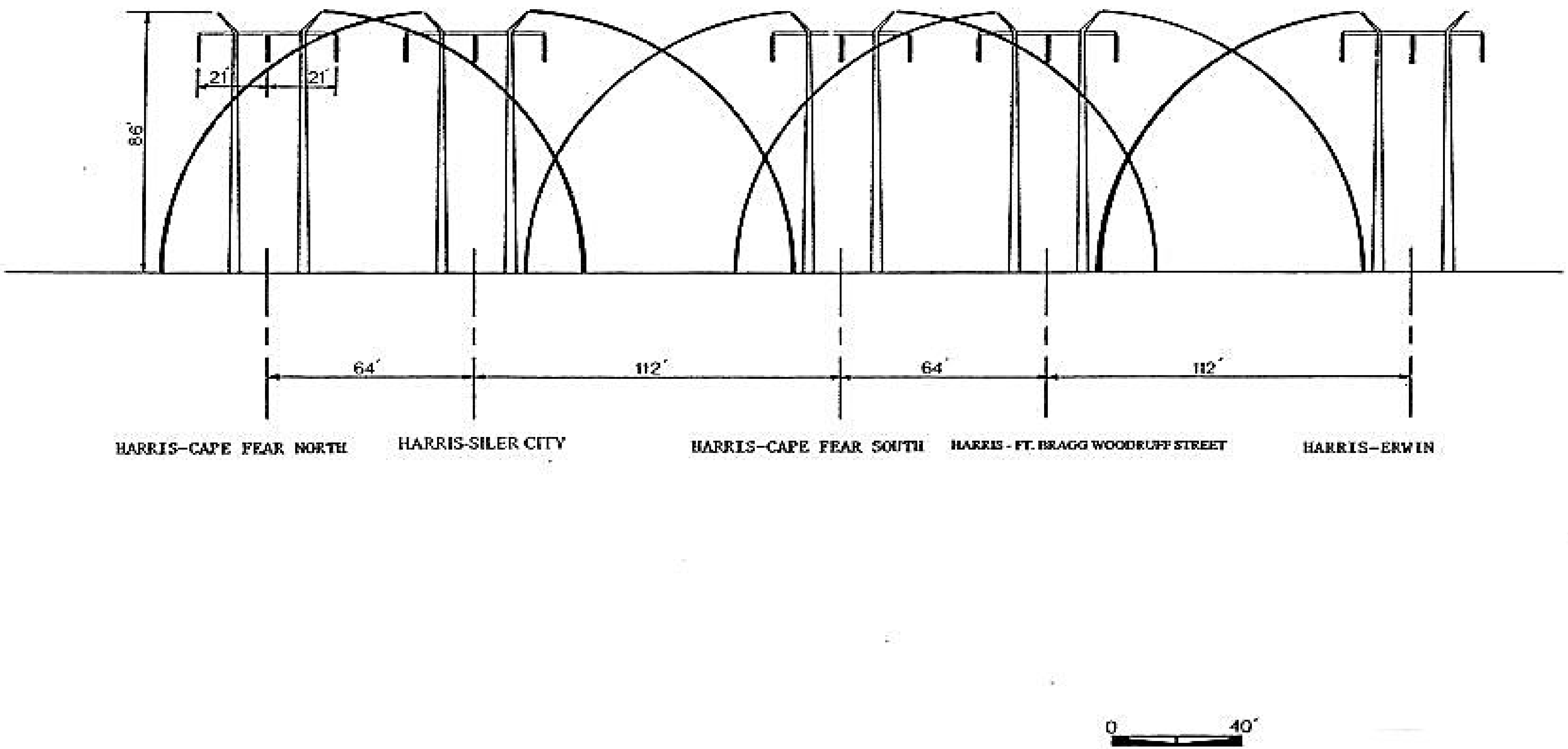


FIGURE 8.2.1-4

SECTION B – B

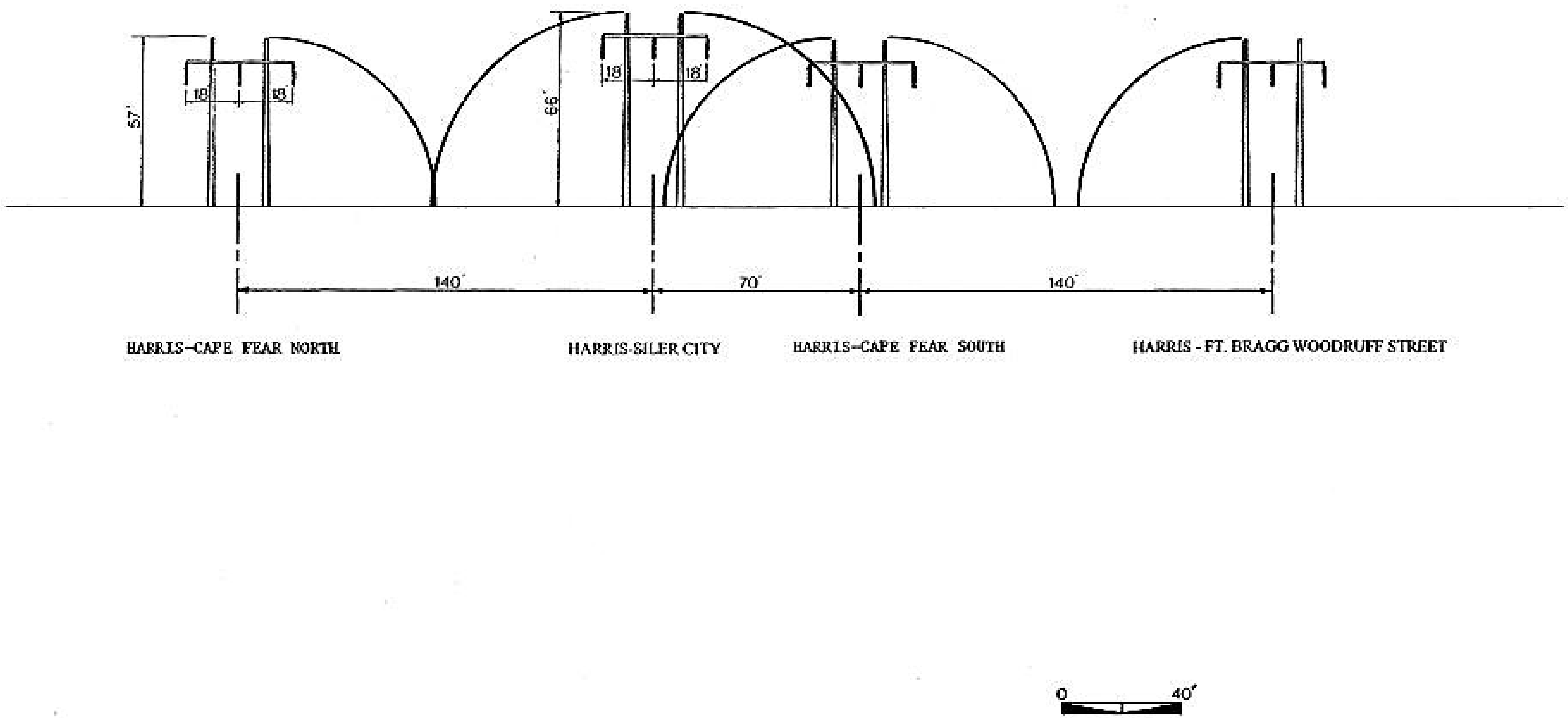


FIGURE 8.2.1-5

SECTION C-C

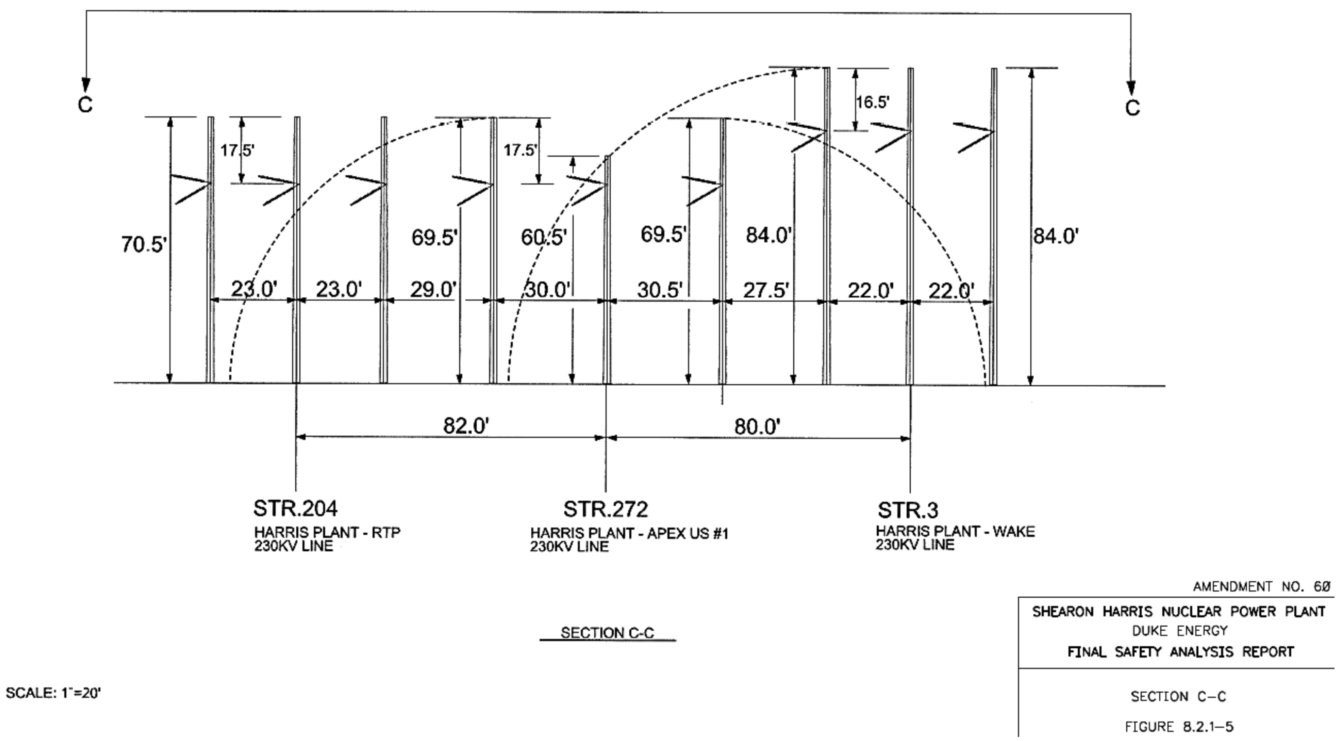


FIGURE 8.2.1-6

230 KV SWITCHYARD INTERCONNECTION DIAGRAM

(FULL DEVELOPMENT)

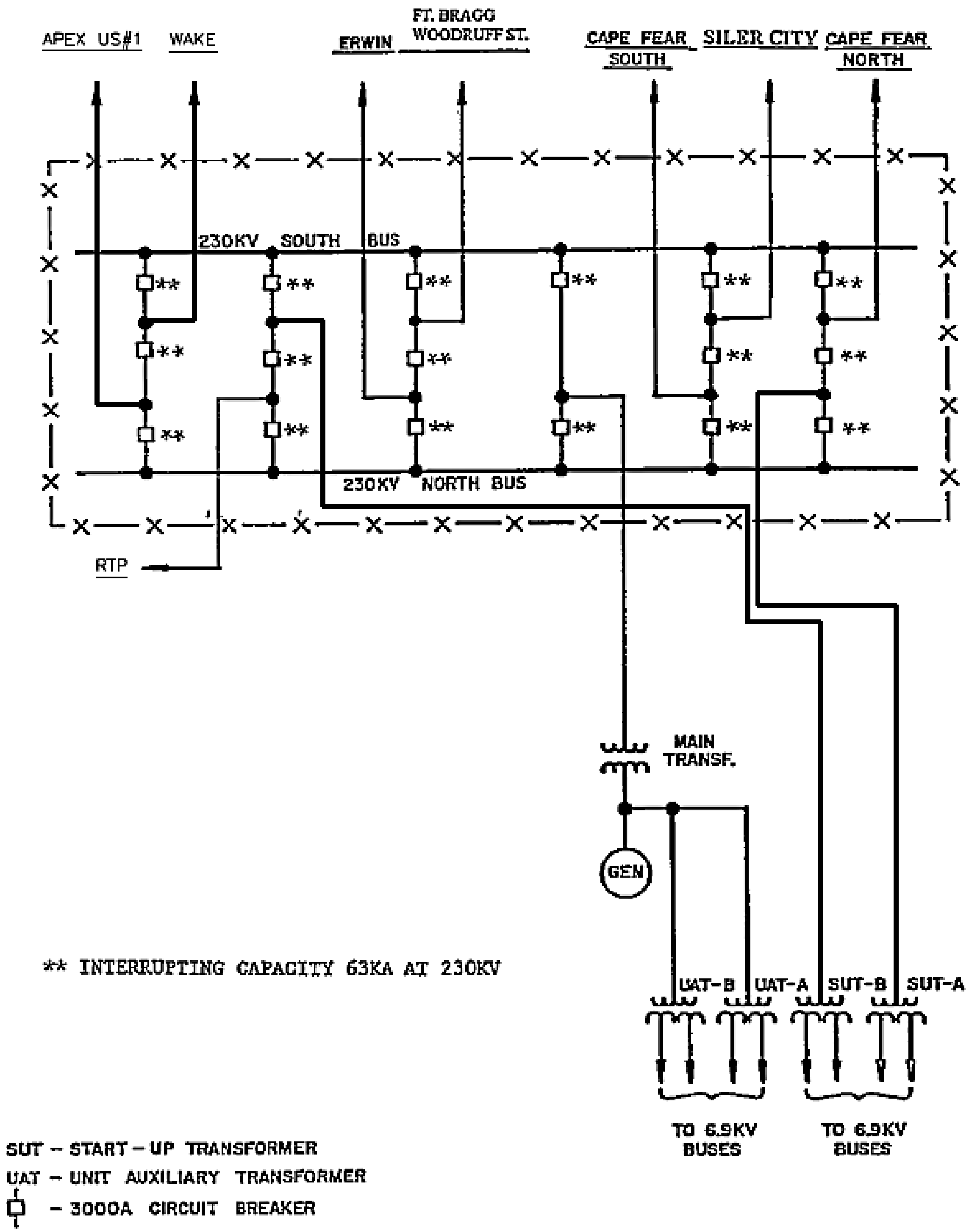


FIGURE 8.2.1-9

AUXILIARY LOADS BACKFEED CAPABILITY DIAGRAM (TYPICAL)

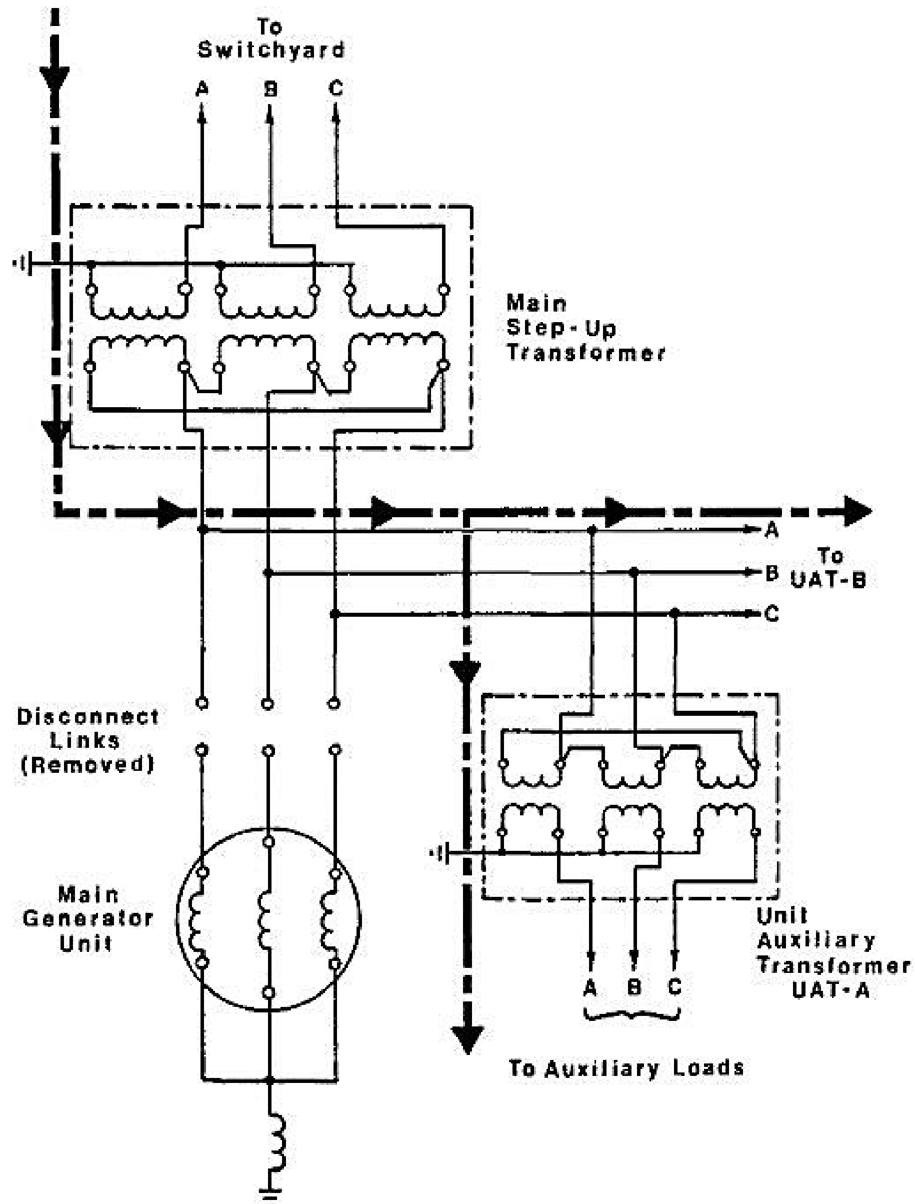


FIGURE 8.2.2-1

NORMAL POWER FLOW DIAGRAM

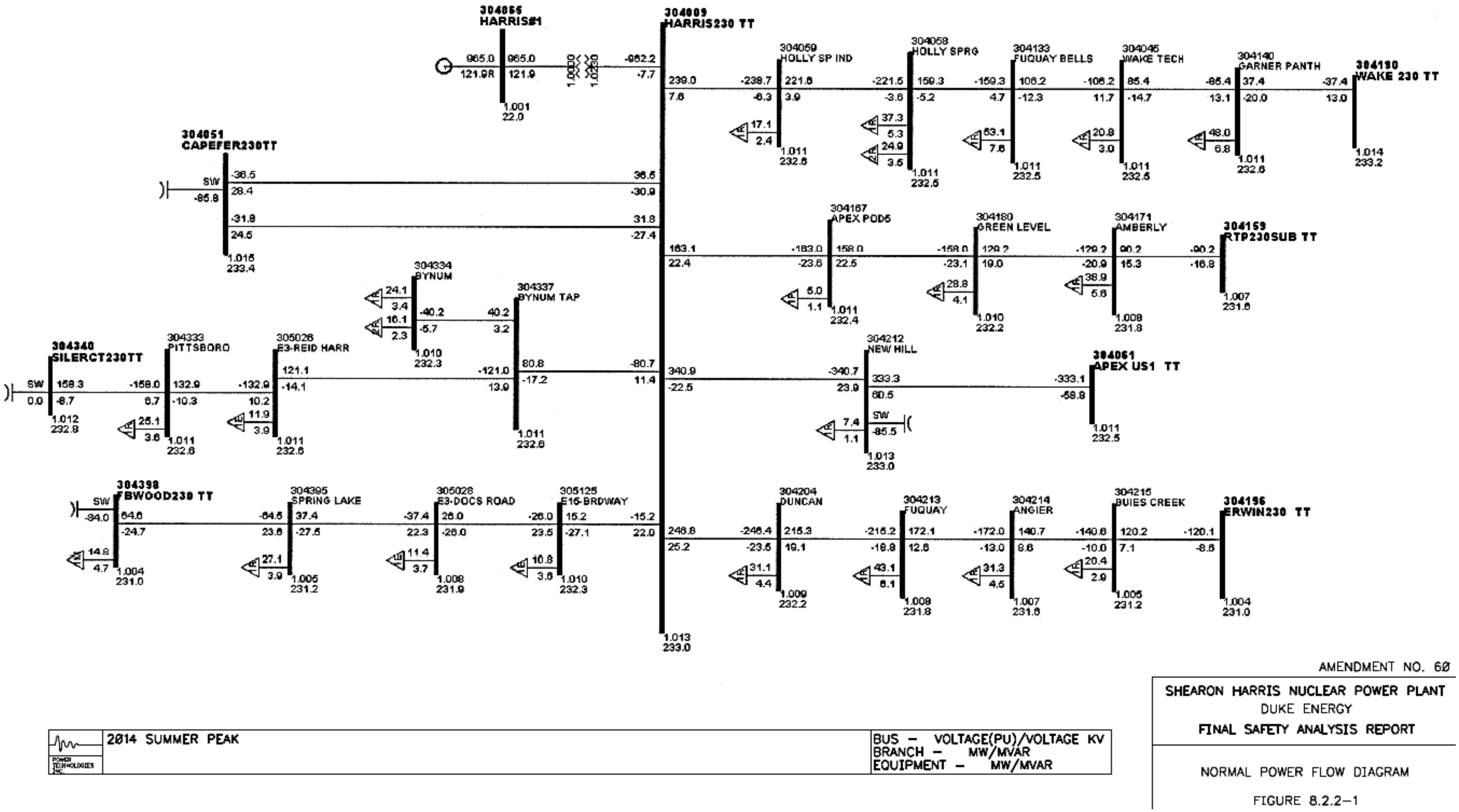
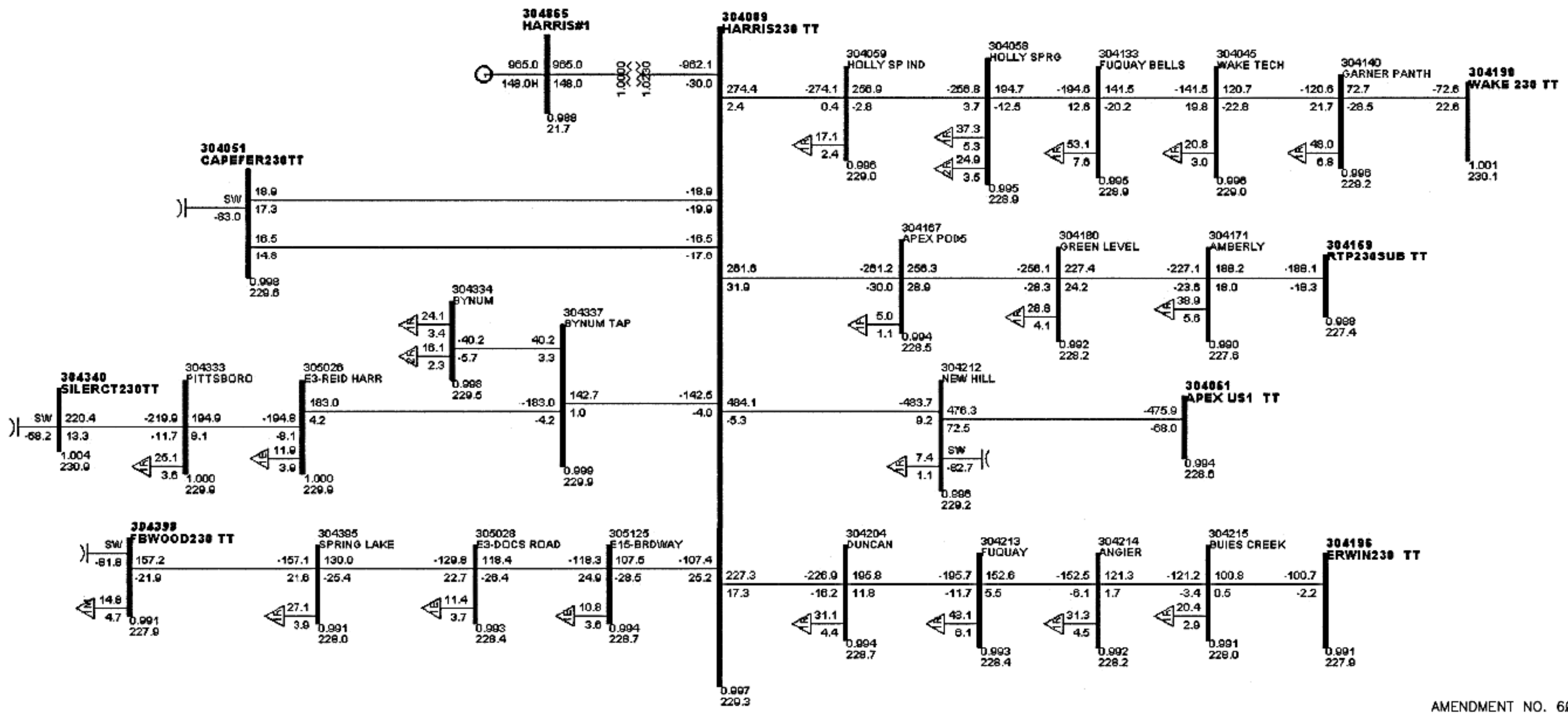


FIGURE 8.2.2-2

POWER FLOW DIAGRAM

LOSS OF ROXBORO S.E.P. GENERATION



AMENDMENT NO. 62

SHEARON HARRIS NUCLEAR POWER PLANT
DUKE ENERGY
FINAL SAFETY ANALYSIS REPORT

POWER FLOW DIAGRAM
LOSS OF ROXBORO S.E.P. GENERATION

FIGURE 8.2.2-2

2014 SUMMER PEAK

BUS – VOLTAGE(PU)/VOLTAGE KV
BRANCH – MW/MVAR
EQUIPMENT – MW/MVAR

FIGURE 8.2.2-3

PHASE ANGLE SWING DIAGRAM

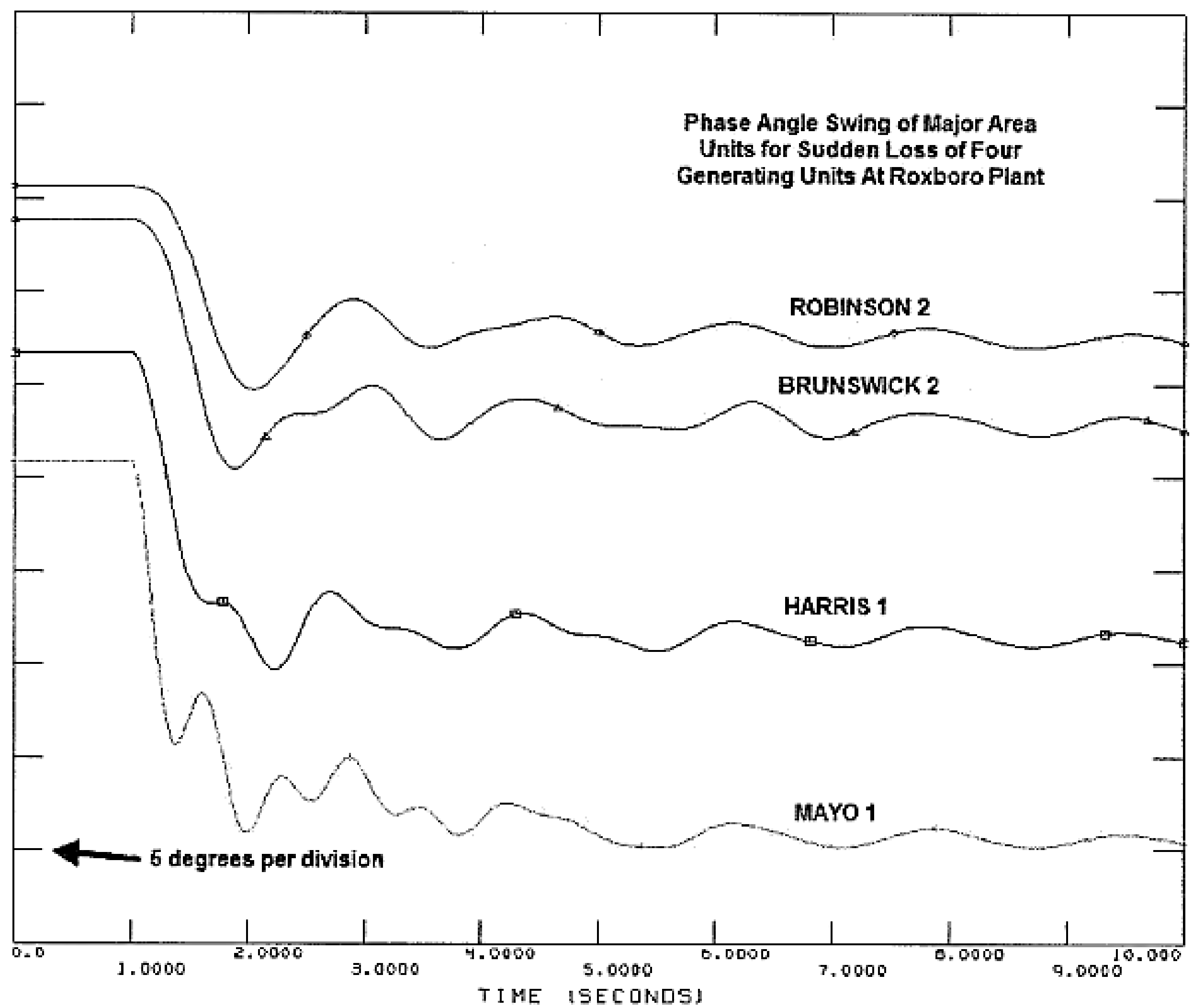
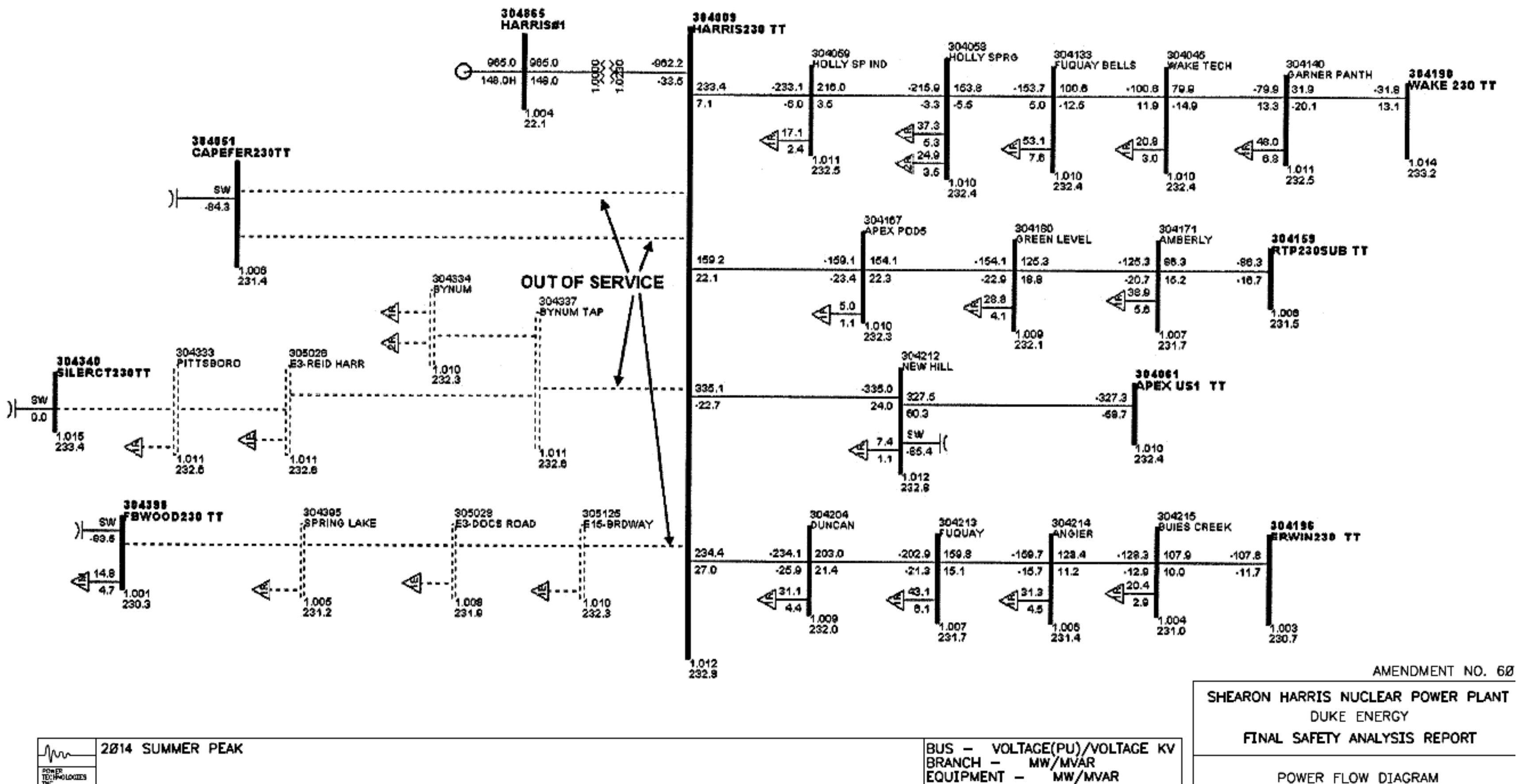

Phase Angle Swing of Major Area
Units for Sudden Loss of Four
Generating Units At Roxboro Plant
ROBINSON 2
BRUNSWICK 2
HARRIS 1
MAYO 1
5 degrees per division
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)

FIGURE 8.2.2-4

POWER FLOW DIAGRAM

OUTAGE OF 4 - 230KV LINES



SHEARON HARRIS NUCLEAR POWER PLANT
DUKE ENERGY
FINAL SAFETY ANALYSIS REPORT

POWER FLOW DIAGRAM
OUTAGE OF 4–230 KV LINES

FIGURE 8.2.2–4

FIGURE 8.2.2-5

PHASE ANGLE SWING DIAGRAM

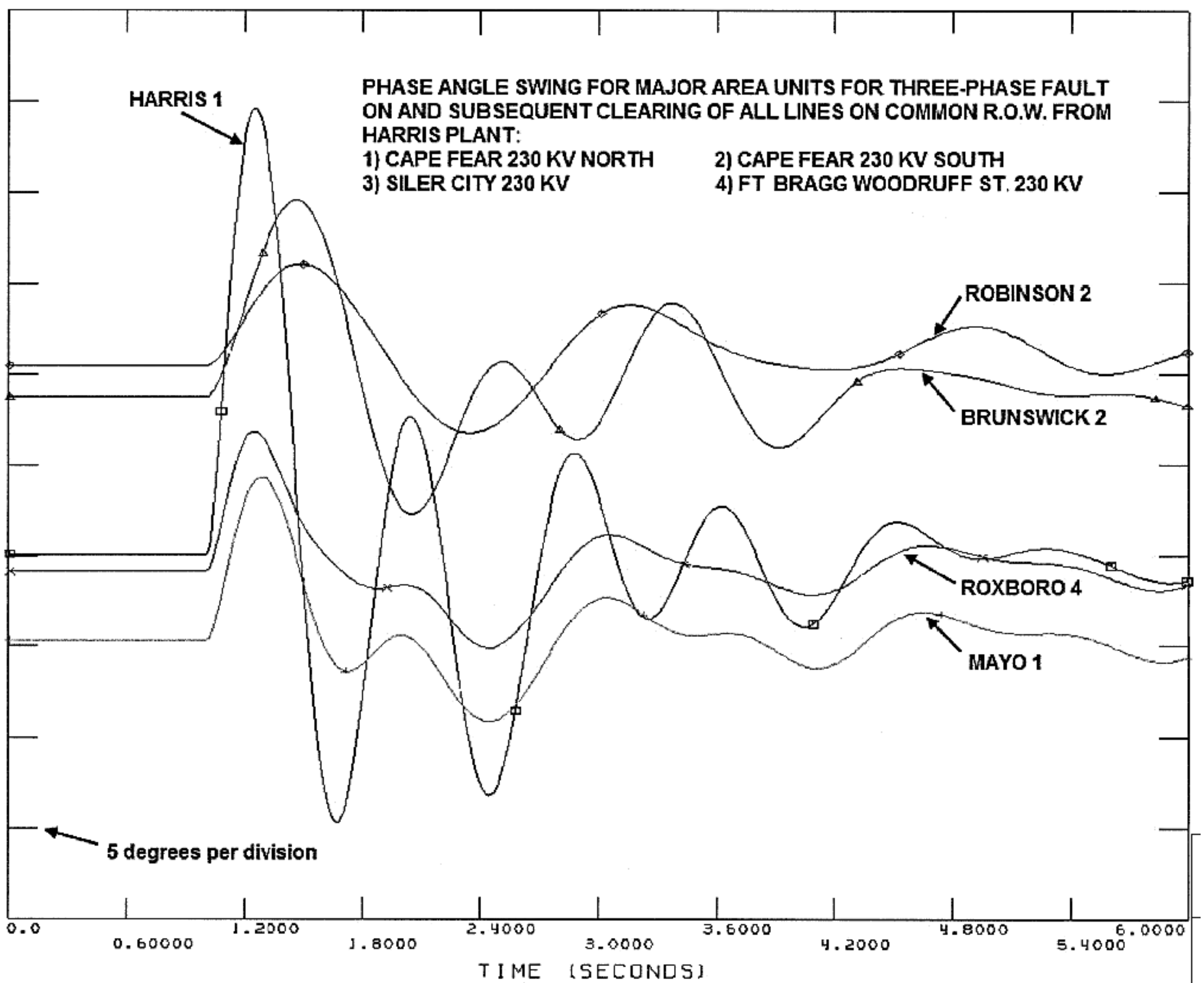


FIGURE 8.2.2-6

POWER FLOW DIAGRAM

STUCK BREAKER OUTAGE

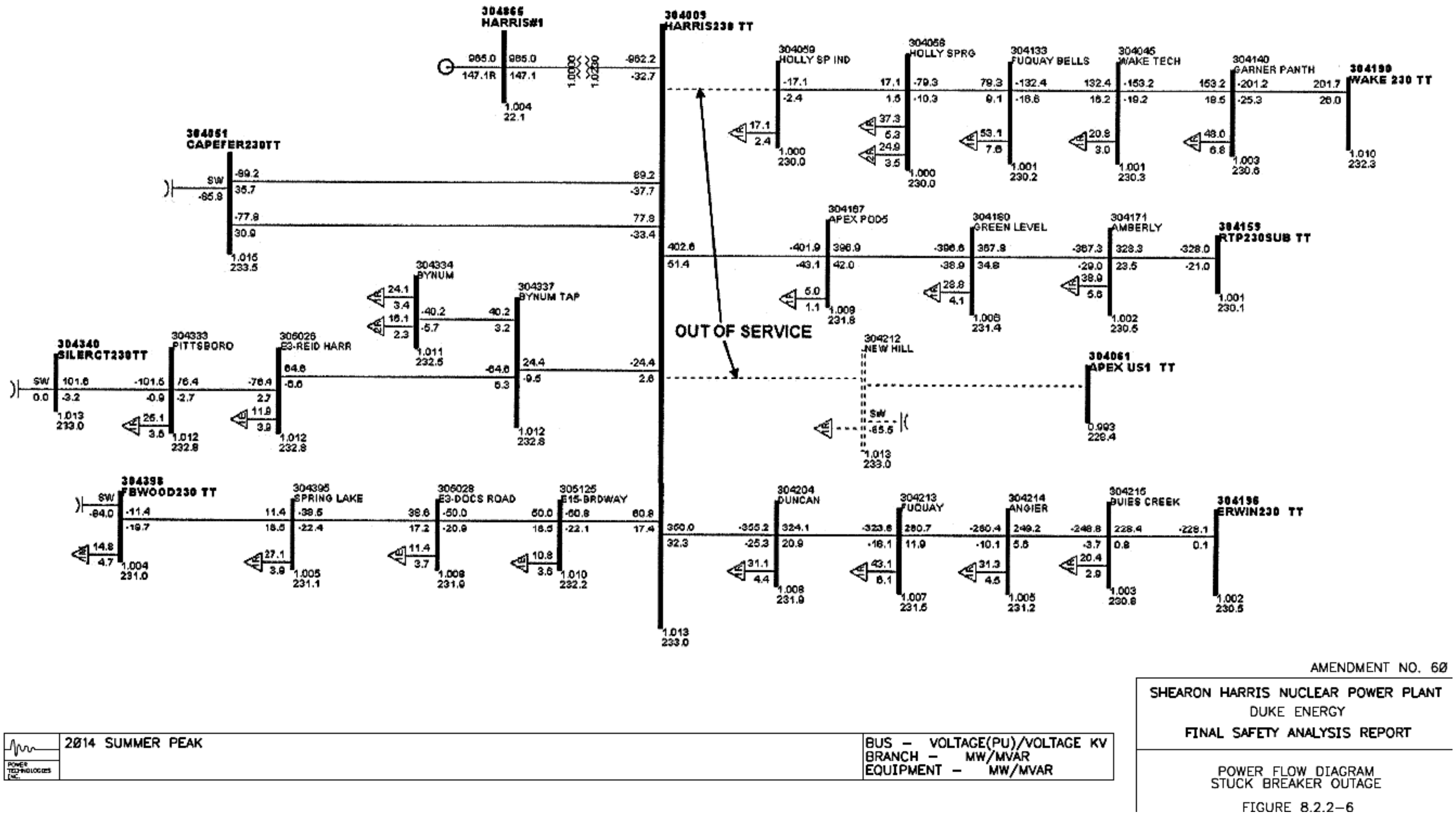


FIGURE 8.2.2-7

PHASE ANGLE SWING DIAGRAM

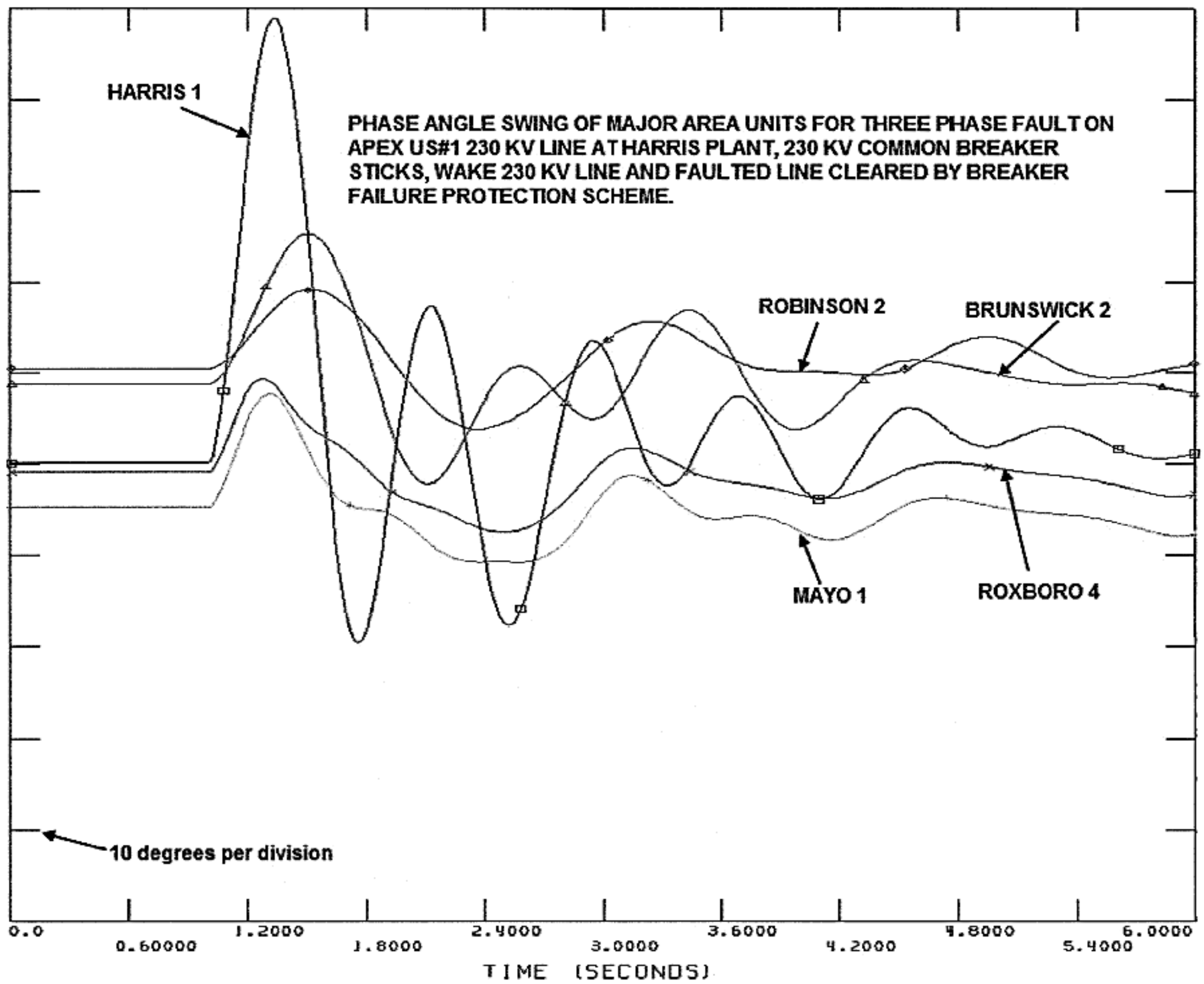
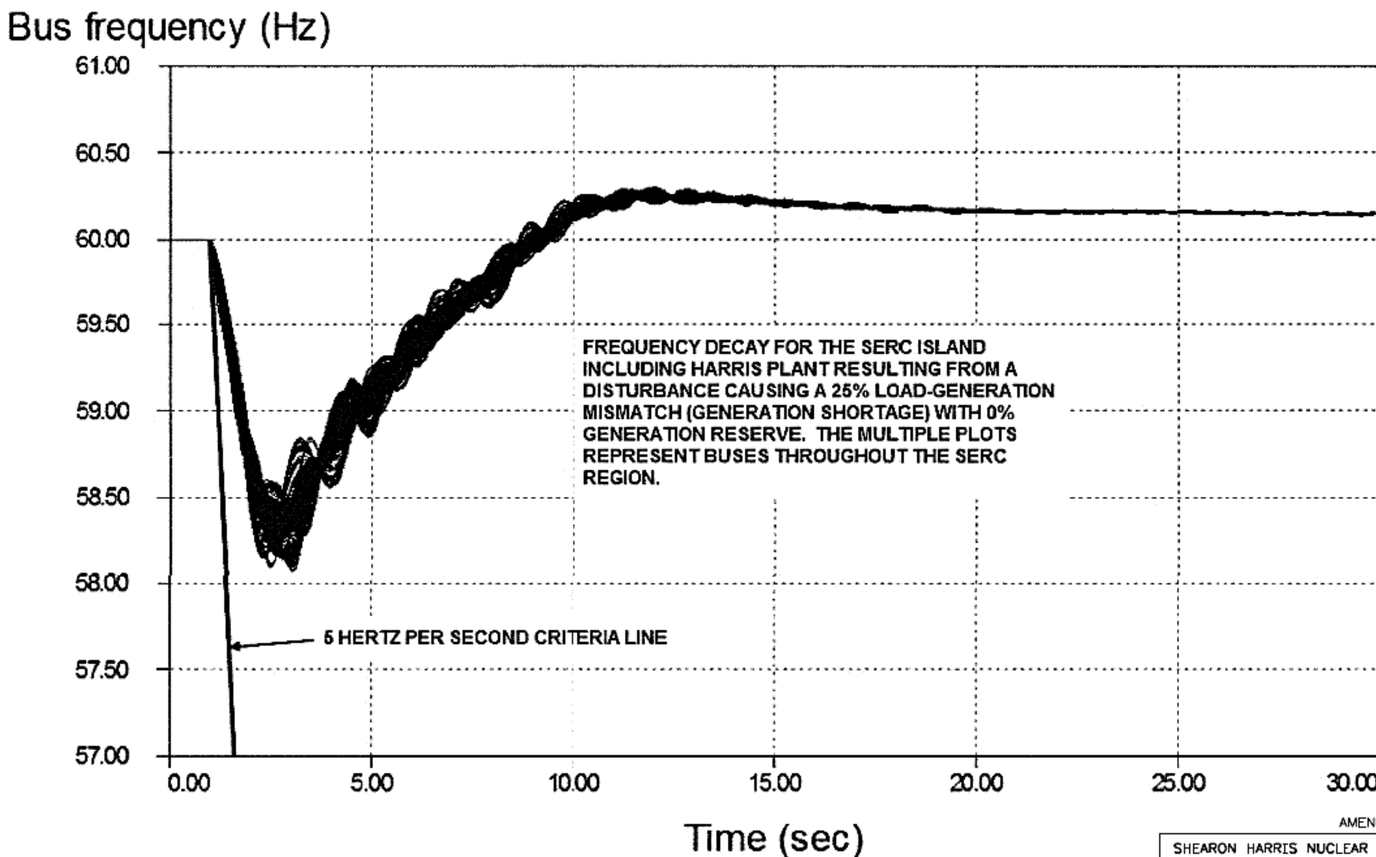


FIGURE 8.2.2-8

FREQUENCY DECAY DIAGRAM



AMENDMENT NO. 60

SHEARON HARRIS NUCLEAR POWER PLANT
DUKE ENERGY
FINAL SAFETY ANALYSIS REPORT

FREQUENCY DECAY DIAGRAM
FIGURE 8.2.2-8

FIGURE 8.3.1-2

POWER SUPPLY ARRANGEMENT TO COMPONENT COOLING WATER PUMP 1C MOTOR

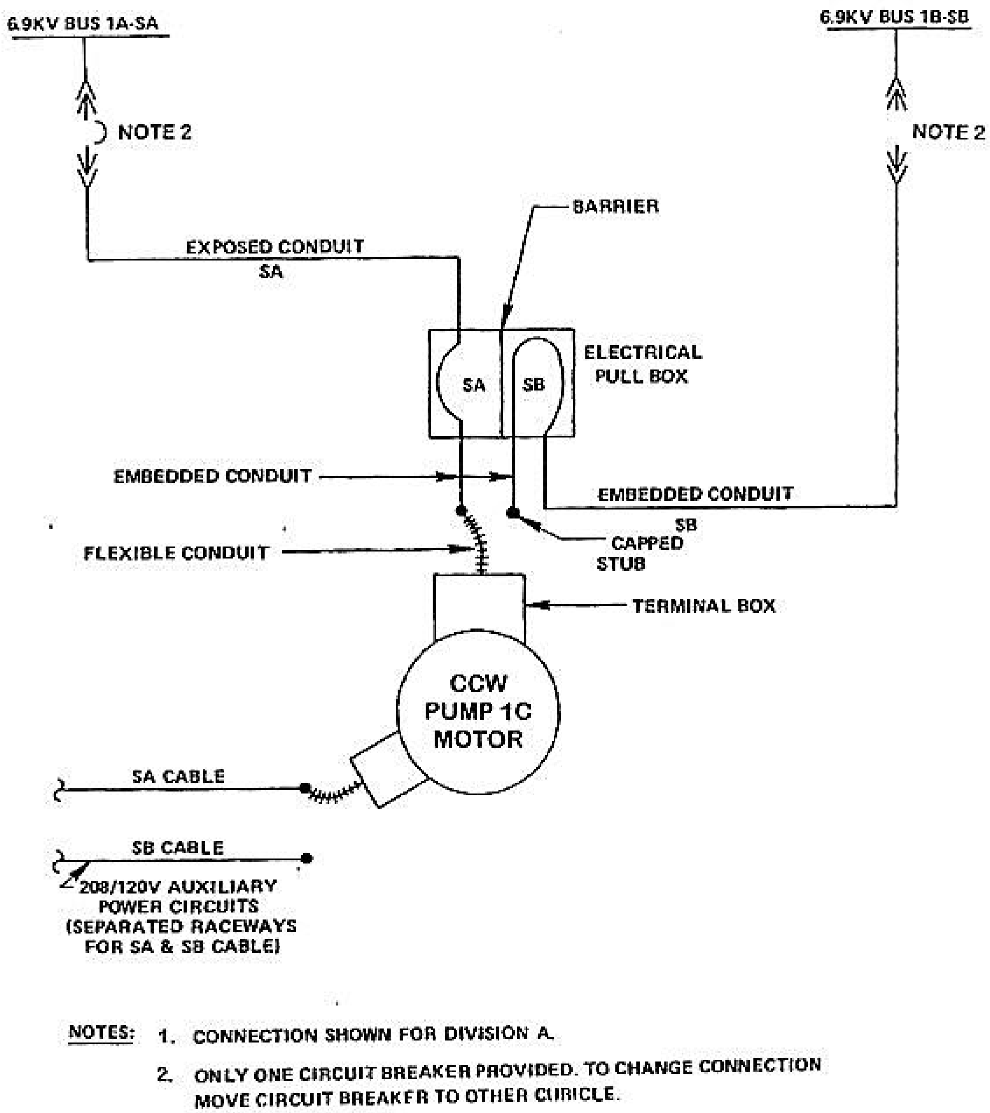


FIGURE 8.3.1-3

POWER SUPPLY ARRANGEMENT TO CHARGING SAFETY INJECTION PUMP 1C MOTOR

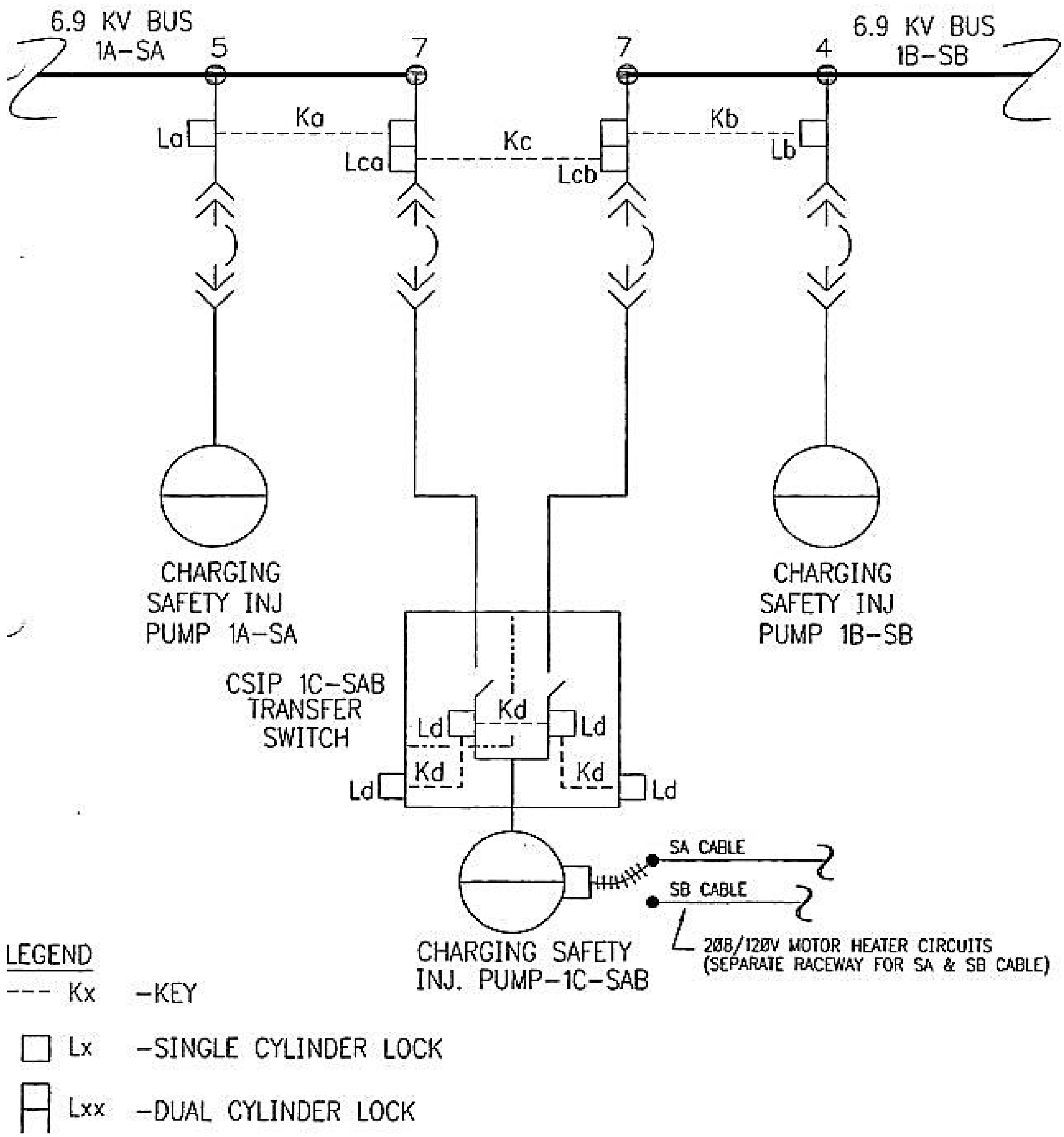
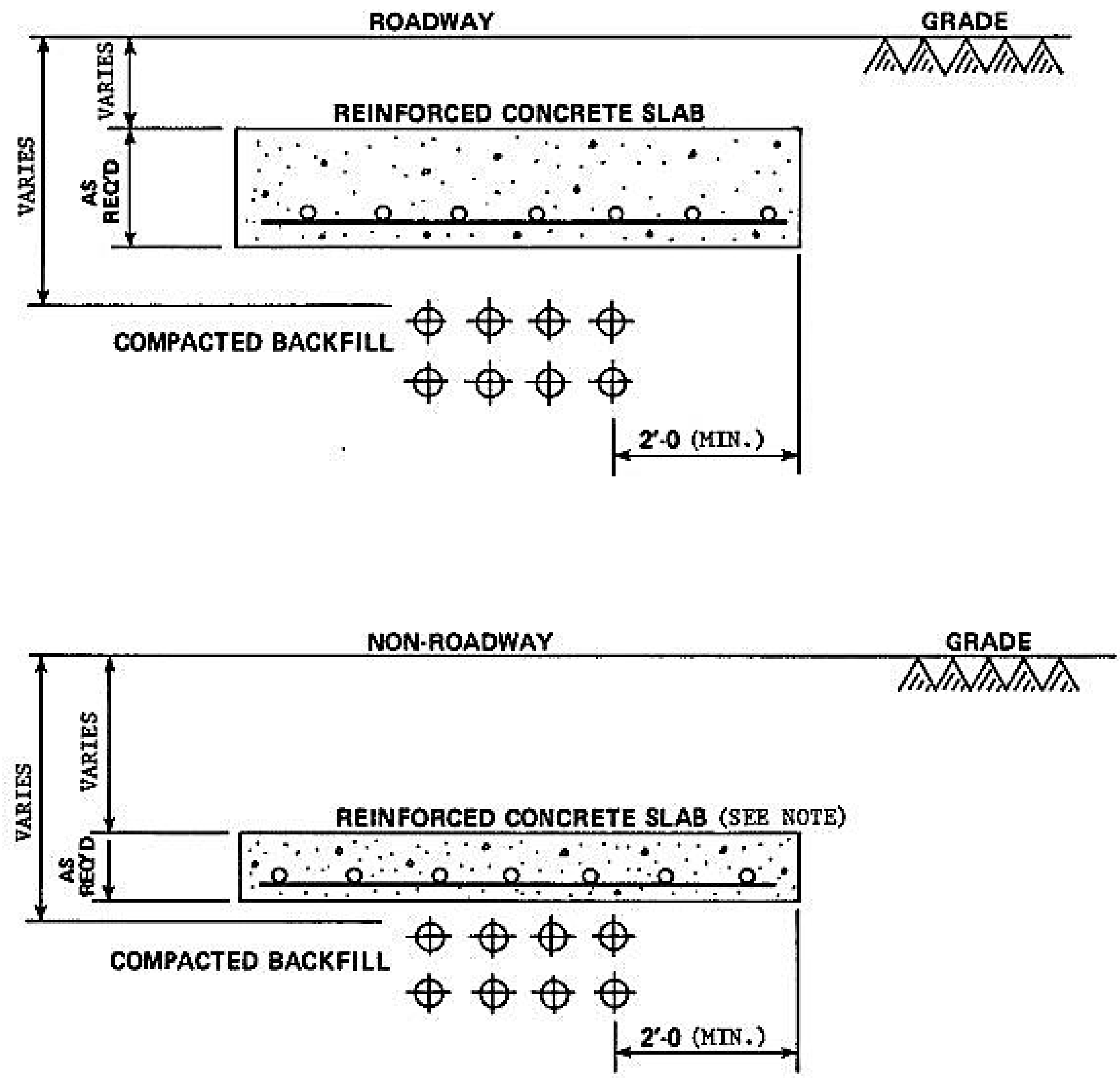


FIGURE 8.3.1-4

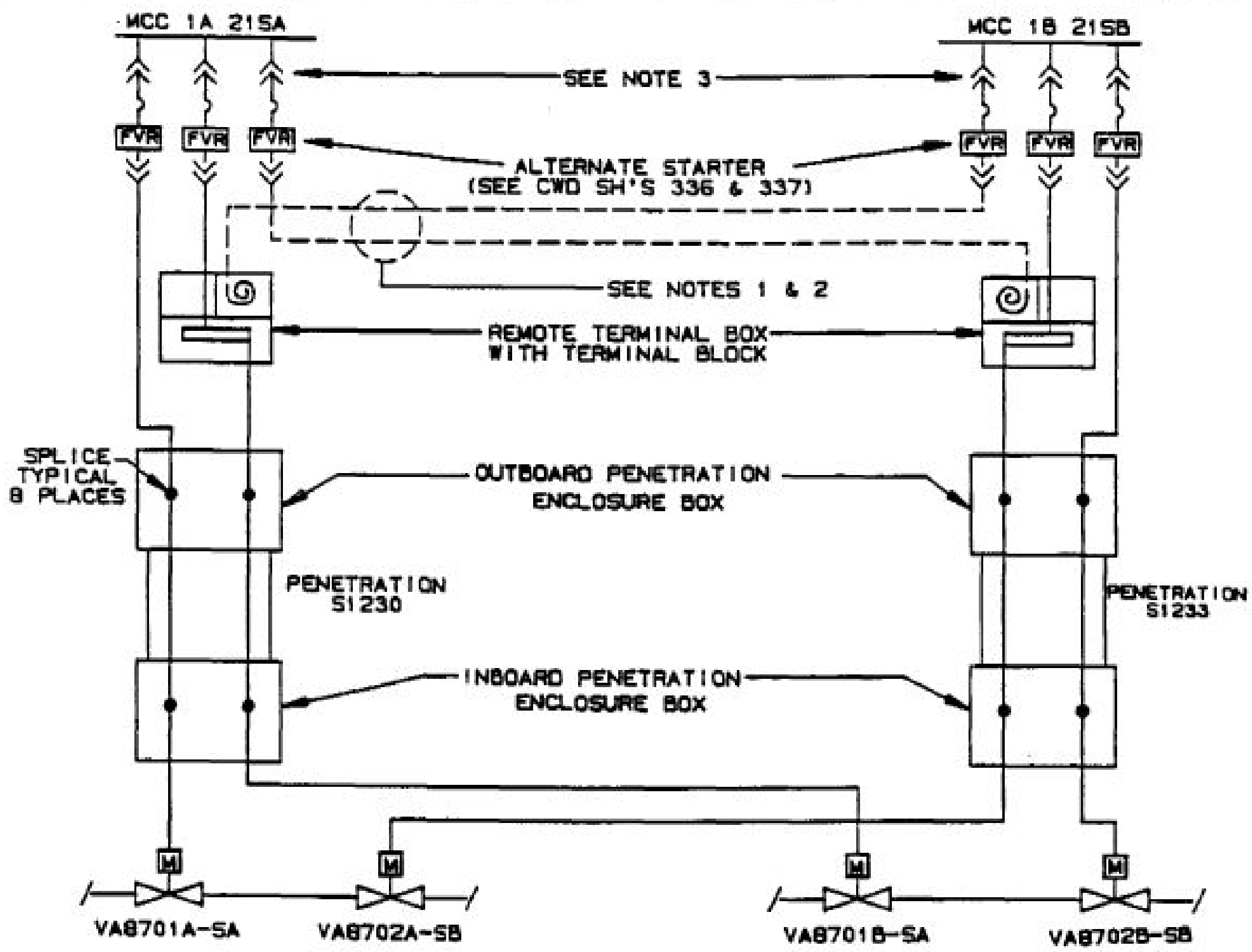
UNDERGROUND DUCT BANK FOR CLASS IE CABLE SYSTEM – TYPICAL CROSS-SECTION



NOTE: NO REINFORCED CONCRETE SLAB IS REQUIRED WHERE BACKFILL COVER ON TOP OF CONDUIT IS MORE THAN 6' - 0".

FIGURE 8.3.1-5

CONNECTION DIAGRAM FOR RHR SUCTION VALVE ALTERNATE POWER SUPPLY

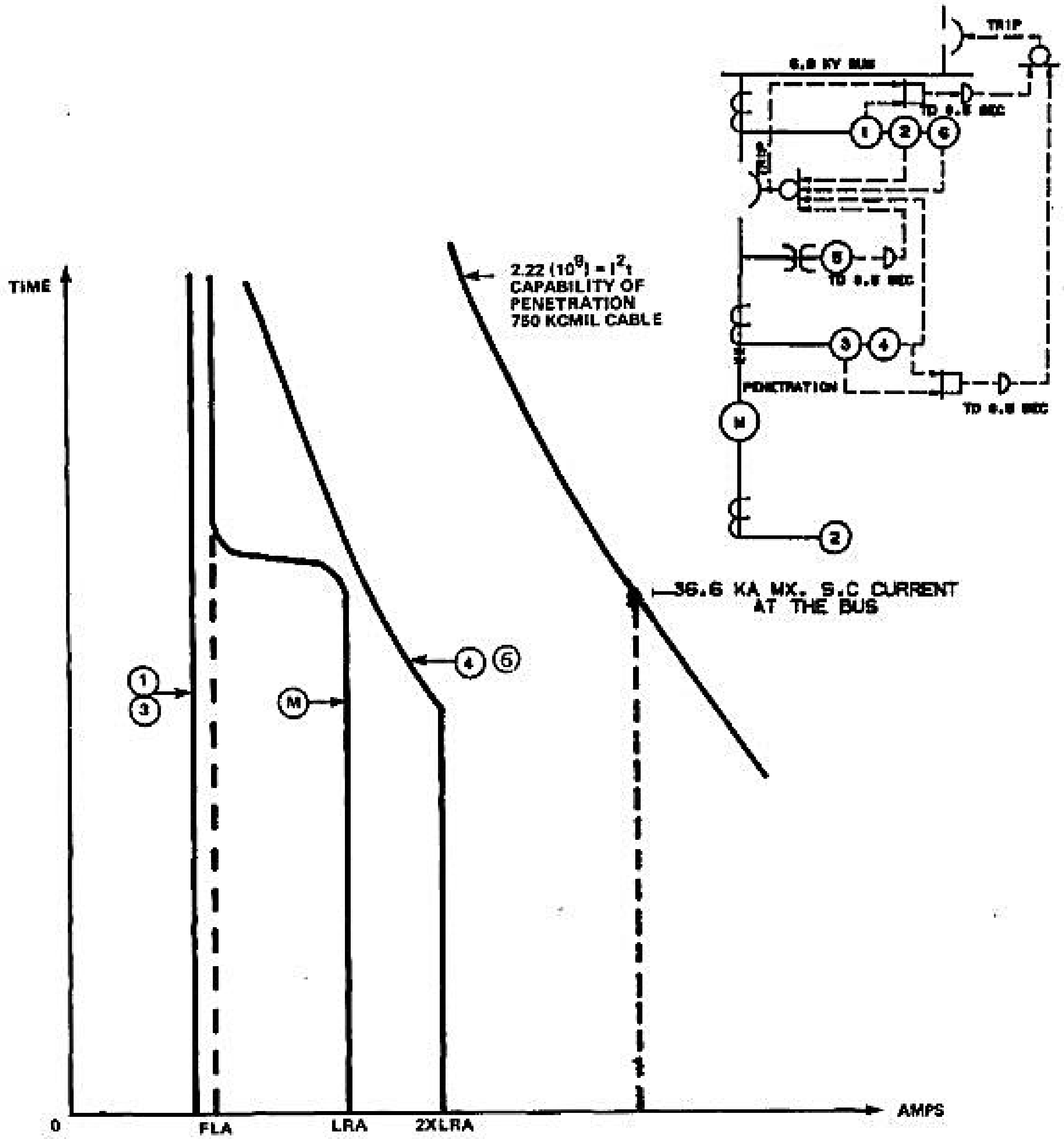


NOTE:

1. CABLES TO BE ROUTED TO REMOTE TERMINAL BOX AND PROVIDED WITH RING TONGUE TERMINAL LUGS. HOWEVER, THEY ARE NOT TO BE TERMINATED ON TERMINAL BLOCKS CABLES TO BE COILED INSIDE THE SEPARATE COMPARTMENT OF THE TERMINAL BOX.
2. UPON FAILURE OF SA POWER REMOVE CABLE TERMINATIONS FOR CABLE RUN FROM MCC1A-21SA TO PENETRATION S1230 AT THE REMOTE TERMINAL BOX. TERMINATE THE CABLE RUN FROM MCC1B-21SB AT THE REMOTE TERMINAL BOX. SIMILAR FOR FAILURE OF SB POWER.
3. WHEN ALTERNATE FEED TO VA8702A-SB OR VA-8701B-SA IS REQUIRED DUE TO POWER FAILURE ON ONE OF THE SAFETY BUSES, THE RECONNECTIONS MUST PROCEED IN THE FOLLOWING ORDER:
   A. MCC COMBINATION STARTER FOR THE AFFECTED CIRCUIT MUST BE PADLOCKED IN "OPEN" POSITION AND POSITION INDICATION POWER MUST BE "OPEN".
   B. RECONNECT CABLE FOR CONTROL AT THE MCC AND FOR POWER CABLE AT THE REMOTE TERMINAL BOX.
   C. CLOSE BREAKER FOR ALTERNATE VALVE POSITION INDICATION POWER AND CLOSE BREAKER AT THE ALTERNATE MCC STARTER (NORMALLY STARTER IS PADLOCKED IN "OPEN" POSITION) AND OPEN VALVE BY THE SWITCH LOCATED IN THE CONTROL ROOM.

FIGURE 8.3.1-6

ELECTRICAL PENETRATION PRIMARY/BACK-UP PROTECTION, 750 KCMIL CABLE REACTOR COOLANT PUMPS



NOTES

M=MOTOR; FLA=FULL LOAD AMPS; LRA=LOCKED ROTOR AMP
1=RELAY 50F-1, TYPE SSC-T (W)
2=RELAY 87M/RCP, TYPE SA-1 (W)
3=RELAY 50F-2 TYPE SSC-T (W)
4=RELAY 50/51-2 TYPE IFC 66 (GE)
5=RELAY 81-1/RCP, TYPE KF-1 (W)
6=RELAY 50/51-1 TYPE IFC 66 (G.E.)

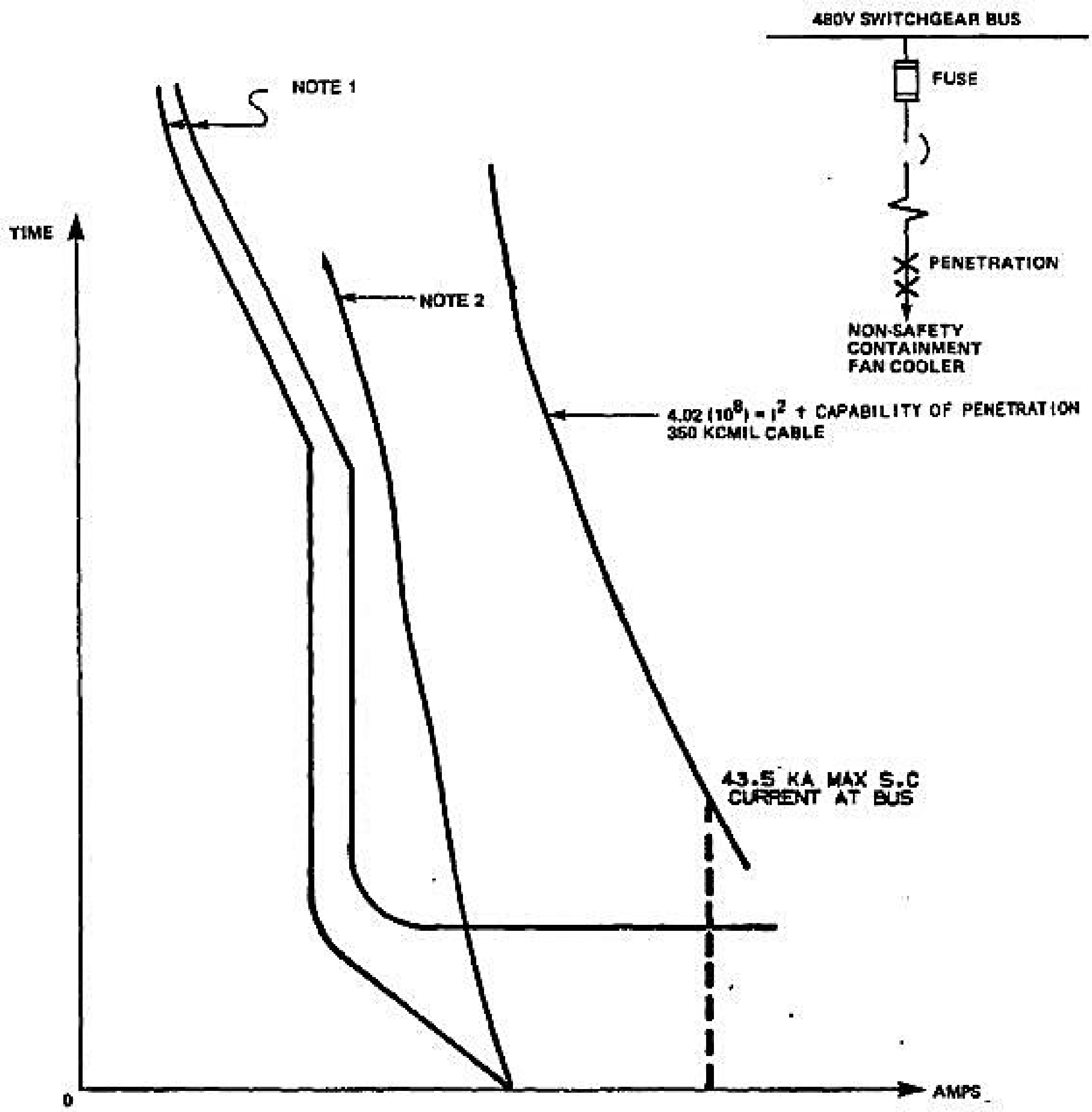
SYMBOLS

OR LOGIC
AND LOGIC
TIME DELAY RELAY

A

FIGURE 8.3.1-7

ELECTRICAL PENETRATION PRIMARY/BACK-UP PROTECTION
350 KCMIL CABLE NON-SAFETY CONTAINMENT FAN COOLERS

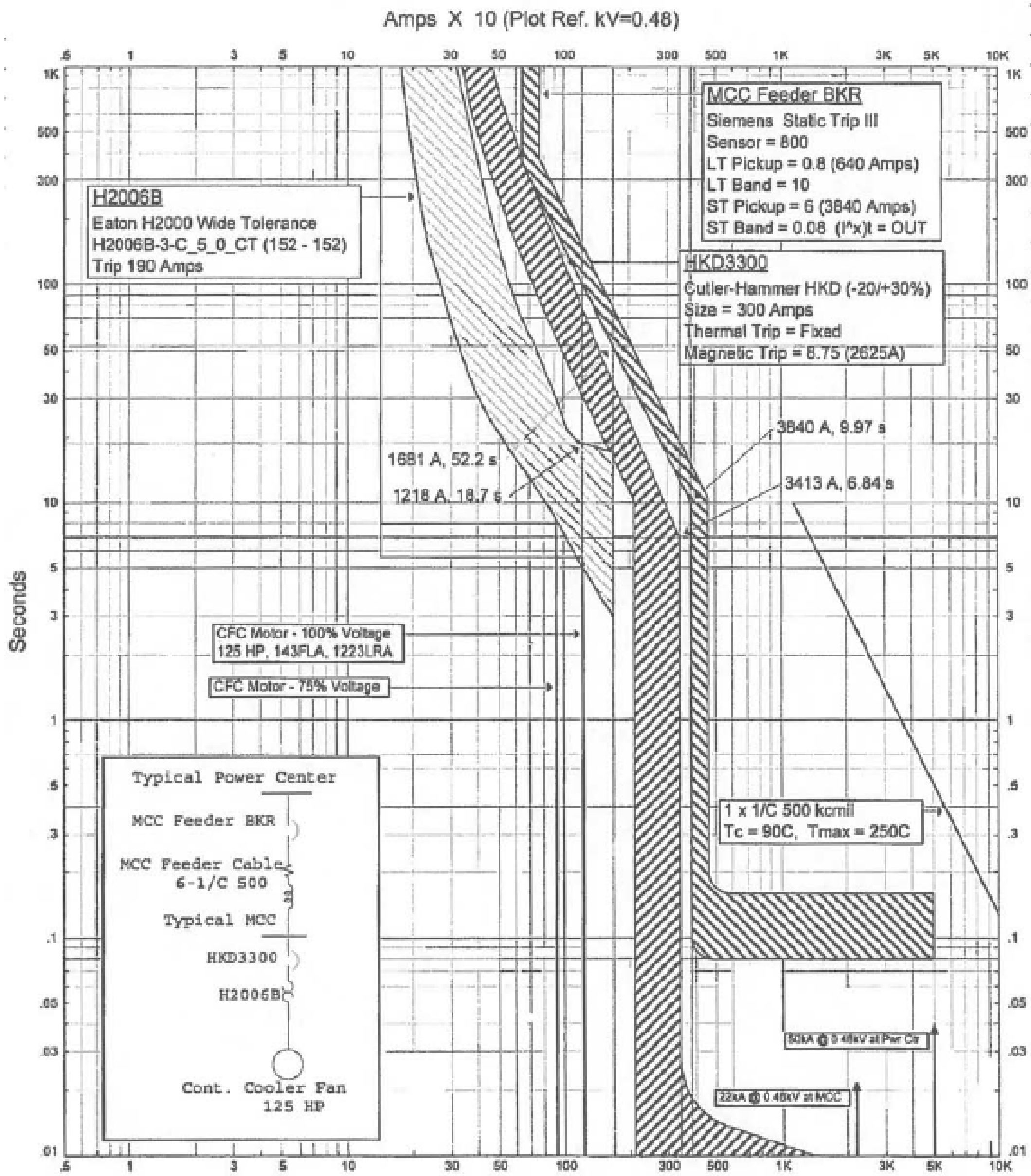


NOTES:

1. PRIMARY PROTECTION IS BY 480V SWITCHGEAR BREAKER WITH SOLID STATE ADJUSTABLE SENSOR.
2. BACK-UP PROTECTION IS BY 400 AMP FUSE.

FIGURE 8.3.1-8

ELECTRICAL PENETRATION PRIMARY/BACK-UP PROTECTION
350 KCMIL CABLE, 480VAC CONTAINMENT FAN COOLERS

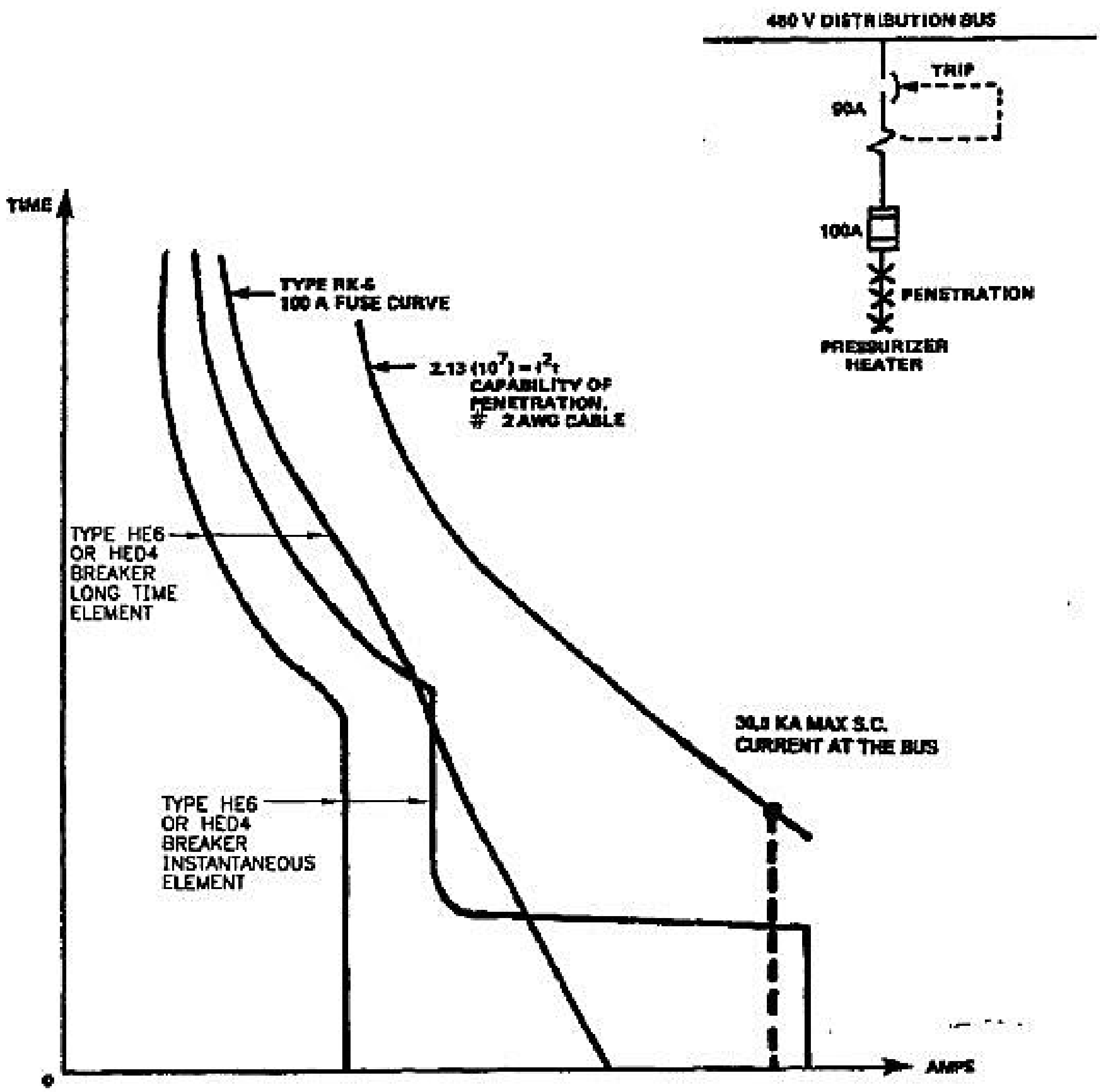


Notes:

1. Deleted
2. BACK-UP PROTECTION IS PROVIDED BY 480 VOLT SWITCHGEAR BREAKER WITH SOLID-STATE ADJUSTABLE SENSOR.
3. ADDITIONAL PROTECTION PROVIDED BY STARTER (CURVES NOT SHOWN).

FIGURE 8.3.1-9

ELECTRICAL PENETRATION PRIMARY/BACK-UP PROTECTION
#2 CABLE, 480 VAC PRESSURIZER HEATERS

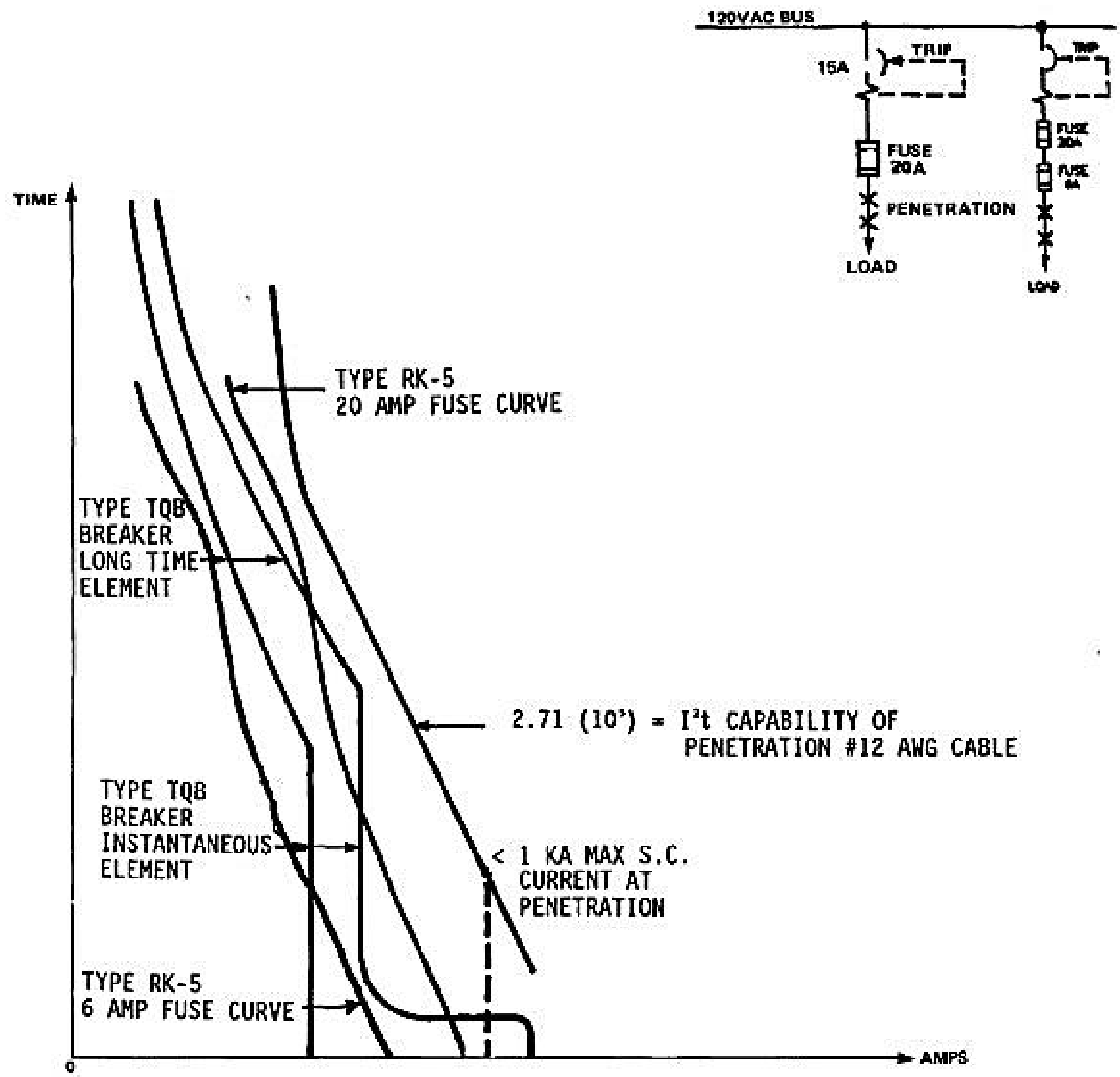


NOTES

1. PRIMARY PROTECTION IS BY GOULD, TYPE HE6 OR SIEMENS HED4, 90 AMP CIRCUIT BREAKER.
2. BACK-UP PROTECTION IS BY 100 AMP CHASE SHAWMUT FUSE, TYPE RK-5.
3. ADDITIONAL 480V CIRCUITS FROM MCC'S ARE PROTECTED WITH TWO BREAKERS IN SERIES FOR PRIMARY/BACK-UP. BREAKERS HAVE IDENTICAL RATINGS
4. CURVES ARE REPRESENTATIVE OF THE PROTECTION FOR ALL CABLE SIZES USED IN THESE CIRCUITS.

FIGURE 8.3.1-10

ELECTRICAL PENETRATION PRIMARY/BACK-UP PROTECTION
#12 CABLE – 120 VAC CIRCUITS FROM DISTRIBUTION PANELS



NOTES:

1. PRIMARY PROTECTION PROVIDED BY:
   A) 15 AMP, TQB CIRCUIT BREAKER OR
   B) TYPE RK-5 6 AMP FUSE

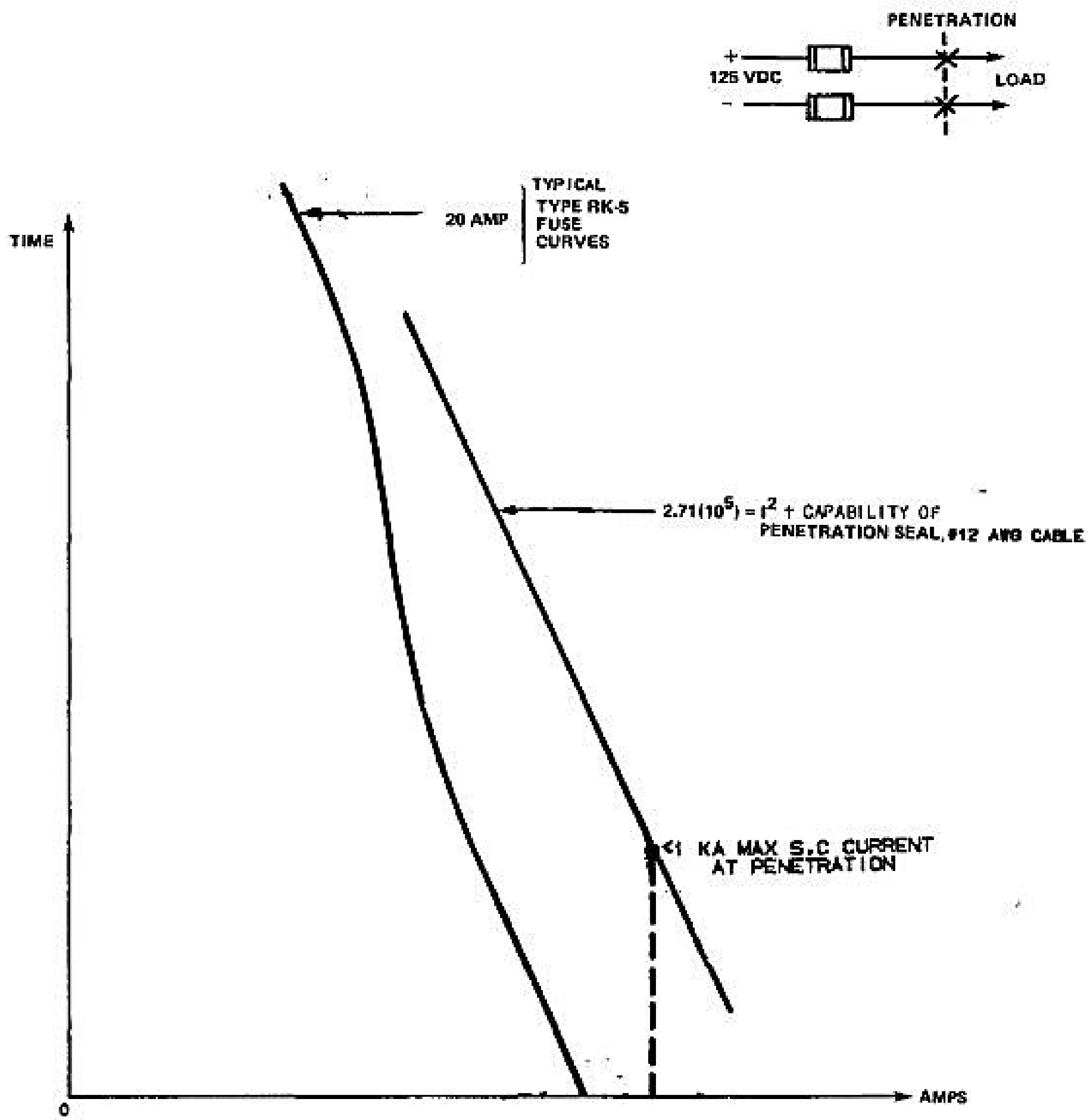
2. BACK-UP PROTECTION IS PROVIDED BY:
   A) CHASE SHAWMUT RK-5, 20 AMP FUSE OR
   B) TYPE RK-5 20 AMP FUSE

3. ADDITIONAL CIRCUITS ARE PROTECTED WITH REDUNDANT TQB BREAKERS RATHER THAN BREAKER/FUSE COMBINATIONS. BREAKERS HAVE IDENTICAL RATINGS.

4. CURVES ARE REPRESENTATIVE OF THE PROTECTION FOR ALL CABLE SIZES USED FOR THESE 120 VAC CIRCUITS.

FIGURE 8.3.1-11

ELECTRICAL PENETRATION PRIMARY/BACK-UP PROTECTION
#12 AND #10 AWG CABLE 125 V DC CIRCUITS



NOTES

1. PRIMARY AND BACK-UP PROTECTION IS PROVIDED BY TWO CHASE SHAWMUT, RK-5 FUSES OF IDENTICAL RATING

FIGURE 8.3.1-12

DIESEL GENERATOR LOADING PROFILE 1A – SA

TOTAL LOADING FOR EACH LOAD BLOCK IS SHOWN IN TABLE 8.3.1-2A

FIGURE 8.3.1-13

DIESEL GENERATOR LOADING PROFILE 1B – SB

TOTAL LOADING FOR EACH LOAD BLOCK IS SHOWN IN TABLE 8.3.1-2B