8.0 ELECTRIC POWER

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CHAPTER 8.0 - ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 DESCRIPTION OF UTILITY GRID

The Alabama Power Company (APC) is a part of the Southern electric system and, as such, its lines interconnect with the contiguous national utility grid.

[HISTORICAL]

[The interconnections for 1983 are shown on figure 8.1-1.]

The network interconnections between Joseph M. Farley Nuclear Plant (FNP) and the Southern electric transmission system consist of six high-voltage transmission lines and two 500/230-kV autotransformer connections for Units 1 and 2. These lines approach the site on separate rights of way designed and located to minimize the likelihood of their simultaneous failure. The lines also interconnect the FNP with other major sources of generation in the system. Figure 8.2-1 shows the connections of Unit 1, Unit 2, and the transmission lines to the 500-kV and the 230-kV switchyards at the plant. A detailed description of the transmission system is given in subsection 8.2.1.

8.1.2 DESCRIPTION OF ONSITE ELECTRIC SYSTEM

Each unit is provided with at least one unit auxiliary transformer (1A and 1B for Unit 1, 2B for Unit 2) as shown on drawings D-177000 and D-207000. The unit auxiliary transformers are capable of supplying power to 4.16-kV buses A, B, C, D, and E for Unit 1; A, B, and C for Unit 2, as shown on drawings D-177000 and D-207000. Under normal operating conditions, 4.16-kV buses A, B, and C of Units 1 and 2 are powered from unit auxiliary transformer (1B and 2B, respectively). Two startup auxiliary transformers are provided for each unit (1A and 1B for Unit 1, 2A and 2B for Unit 2) as shown on drawings D-177001 and D-207001. The startup auxiliary transformers are capable of supplying power to the nonsafety-related 4.16-kV buses A, B, C, D, and E as well as the safety-related 4.16-kV emergency buses F, G, H, J, K, and L. During normal operations, 4.16-kV buses D and E, along with the 4.16-kV emergency buses F, G, H, J, K, and L of each unit, are powered from the startup auxiliary transformers. Each unit is provided with an adequate number of 600-V load centers and 600-V and 208-V motor-control centers.

The onsite emergency power supply for Units 1 and 2 is obtained from five diesel generators (1-2A, 1B, 2B, 1C, and 2C) feeding the 4.16-kV emergency buses. Of these diesel generators, 1-2A, 1C, 1B, and 2B are dedicated for use during design basis events. Diesel generator 2C is dedicated as the alternate ac (AAC) power source for station blackout (SBO) events. Four diesels (1-2A, 1B, 1C, and 2C) were installed when Unit 1 was constructed and one diesel (2B) was installed when Unit 2 was constructed. Three diesel generators (1-2A, 1C, and 2C) are shared between Units 1 and 2. Diesel generators 1B and 2B are lined up to supply emergency

hpower to Units 1 and 2, respectively. Upon loss of offsite power, the diesel generators supply the engineered safeguard loads.

The ac auxiliary power system is described in detail in subsection 8.3.1.

A 125 V-dc system provides a source of reliable, uninterruptible dc power for all emergency control, instrumentation, and power loads. A few normal loads are also supplied from this system. In addition, four separate dc systems provide power for loads in the turbine building, the switchyard, the service water and the cooling tower areas. Each system consists of one or more batteries, battery chargers, and dc distribution panels. For a detailed description of the dc power systems, refer to subsection 8.3.2.

Each unit is equipped with a 7.5-kVA uninterruptible power system (UPS), uniquely assigned to provide a reliable source of control power, ac and dc, for turbine-driven auxiliary feedwater pump and its associated steam admission valves. For a detailed description of this system, refer to subsection 8.3.3.

8.1.3 IDENTIFICATION OF SAFETY LOADS AND FUNCTIONS

The loads required for the engineered safeguard systems are identified in table 8.1-1, which includes a description of the safety function to be performed by each load and the type of electric power being provided (ac or dc).

8.1.4 DESIGN BASIS

The electrical system is designed to provide reliable power sources for electrical equipment for startup, normal operation, safe shutdown, and emergency situations. The following bases are used in the system and equipment design:

A. Electrical systems and components vital to plant safety, including the emergency diesel generators, are designed as Category I and protected as necessary so that their functional integrity is not impaired by the safe shutdown earthquake (SSE), windstorms, floods, tornado winds, or disturbances on the maximum probable natural phenomena expected at the site, with appropriate margin to account for uncertainties in the data.

B. Seismic design requirements established for all Class IE electrical systems and equipment are contained in section 3.10.

C. Components of the system are sized for operation under normal and emergency conditions.

The design bases, criteria, safety guides, standards, and other documents that are implemented in the design of this system are as follows:

All electrical equipment, such as the generators, motors, transformers, switchgear, control panel equipment, control equipment, and cabling system, is in accord with the standards listed below:

A.	ANSI C37[a]	Switchgear.
B.	ANSI C50.2	Alternating current induction motors, induction machines in general and universal motors.
C.	ANSI C57[a]	Transformers, regulators, and reactors.
D.	IPCEA P-46-426-1962	Power cable ampacities, Volume 1 - Copper Conductors.
E.	NEMA SG3-1965	Low voltage power circuit breakers.
F.	NEMA SG4-1968	AC high voltage circuit breakers.
G.	NEMA SG5-1967	Power switchgear assemblies.
H.	NEMA SG6-1966	Power switching equipment.
I.	NEMA TR1-1968	Transformers, regulators, and reactors.
J.	NEMA MG1-1967	Motors and generators.
K.	NFPA No. 70-1971	National Electrical Code - 1971 edition.
L.	NFPA No. 78-1971	Lightning protection code.
M.	UL Standard 96A-1963	Installation requirements - master-labeled lightning protection system.
N.	IES - 1972	Illuminating Engineering Society Standards.

a. Individual equipment specifications should be consulted for actual standard numbers, descriptions, and applicable revision dates.

The power supply for the reactor protection system and the engineered safety features is in accord with Criteria 17 and 18 of NRC General Design Criteria for Nuclear Power Plant Construction Permits, 10 CFR 50, published in Federal Register, February 1971, and the following Regulatory Guides:

A. NRC Regulatory Guide 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems.

B. NRC Regulatory Guide 1.9 - Selection of Diesel Generator Set Capacity for Standby Power Supplies.

C. NRC Regulatory Guide 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants.

The following standards provide the bases for the design of the electrical auxiliary system, including the selection, protection, and specification of electrical equipment associated with the auxiliary system:

Standard No.	Title	How Implemented
A. IEEE 279-1971	Criteria for Nuclear Power Plant Protection Systems	The engineered safety feature systems are designed so that a failure in one safety-related circuit will not jeopardize the corresponding redundant circuit. This aspect is discussed in paragraphs 8.3.1.1, 8.3.1.4, and subsection 8.3.2 and is supported by elementary diagrams in the FSAR. Discussion in regard to instrumentation is covered in paragraph 7.3.2.1 for IEEE-279 and paragraph 7.3.2.5 for IEEE-338.
IEEE Guide (SC-1)	Application of the Single Failure Criterion to Nuclear Power Generating Station Protection Systems	
IEEE 338-1971	Trial-Use Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems	

Standard No.		Title	How Implemented
B.	IEEE 317-1971	Electrical Penetration Assembly in Containment Structures for Nuclear Fueled Power Generating Stations	Reference was made (in the specifications for Electrical penetration) that the penetration assemblies shall be subjected to production and prototype test requirements for this period.
C.	IEEE 323-1971	General Guide for Qualifying Class I Electrical Equipment for Nuclear Power Generating Stations	Qualification tests and documentation requirements of these standards were stipulated in the specifications for Class IE Motors installed within the containment.
	IEEE 334-1971	Trial-Use Guide for Type Tests of Continuous – Duty Class I Motors Installed Inside the Containment of Nuclear Power Generating Stations	
D.	IEEE 336-1971	Standards Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment during the Construction of Nuclear Power Generating Stations	Refer to discussion in paragraph 8.3.1.3.
E.	IEEE 344-1971	Guide for Seismic Qualification of Class I Electric Equipment for Nuclear Power Stations	Reference was made in the specifications for Class I electrical equipment that the testing procedure shall be in accordance with this standard.
F.	IEEE 387-1972	Trial Use Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations	The specifications for diesel generators included the requirements outlined under Principal Design Criteria of this standard. The criteria are also discussed in paragraph 8.3.1.1.7 and Technical Specifications. Automatic control aspects are shown on logic diagrams for auto start and loading, drawings D-177032, D-207032, D-177033, D-207033, D-177036, D-207036, D-177037, and D-207037.

Standard No.		Title	How Implemented
G.	IEEE 288-1969	Guide for Induction Motor Protection	Provides the bases for designing the protection system for motors as reflected in paragraph 8.3.1.1.9-(A) and in the single-line diagrams, drawings D-177005, D-207005, D-177006, D-207006, D-177018, D-207018, C-177027, D-207027, C-177043, C-177044, D-177007, D-207007, D-177009, D-207009, D-177010, D-207010, D-177011, D-207011, C-177012, D-177014, D-207014, D-177015, D-207015, D-177045, D-207045, D-177046, D-207046, D-177677, and D-177678.
H.	IEEE 308-1971	Criteria for Class 1E Electrical Systems for Nuclear Power Generating Stations	Refer to discussion in paragraph 8.3.1.2-(E).
I.	IEEE Guide (proposed 384)	Criteria for Separation of Class IE Equipment and Circuits	Refer to discussion in paragraph 8.3.1.4.
J.	IEEE 450-1980	Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations	Refer to discussion in paragraph 8.3.2.1.5.
K.	IEEE 485-1983	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substation.	Refer to discussion in paragraph 8.3.2.1.1.

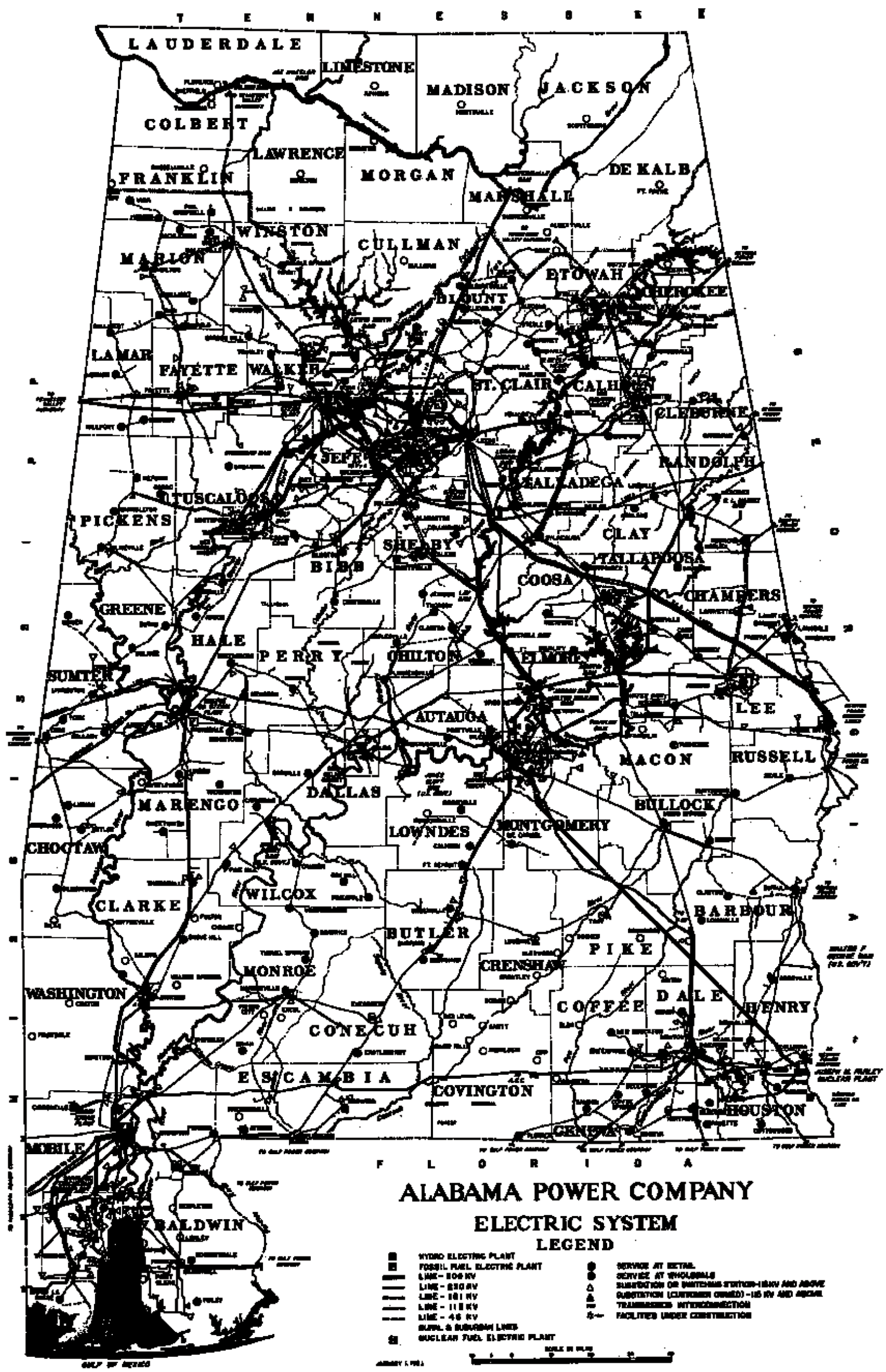
TABLE 8.1-1 (SHEET 1 OF 2)

SAFETY LOADS AND FUNCTIONS

Safety Loads	Safety Function	Power
Residual heat removal/ L.H. safety injection pumps	Emergency core cooling for post-LOCA operation.	ac, dc
Charging/H.H. safety injection pumps	Provide makeup reactor coolant system emergency core cooling for post-LOCA operation.	ac, dc
Auxiliary feedwater pumps (motor driven)	Supply feedwater to steam generators during emergency conditions.	ac, dc, UPS (TDAFW pump only)
Containment spray pumps	Provide cooling spray in containment during LOCA.	ac, dc
Component cooling water pumps	Provide cooling water for safety-related components.	ac, dc
Containment cooler fan	For cooling containment after LOCA.	ac, dc
Spent fuel pool coolant pumps	Cool spent-fuel assemblies in the spent-fuel pool.	ac, dc
Hydrogen recombiners, post-LOCA mixing fans and reactor cavity hydrogen dilution fans	Maintain a safe level of hydrogen in containment vessel after LOCA.	ac, dc
Control room air conditioners and fans	Maintain proper air temperature and habitability of control room.	ac
Battery chargers	Provide dc power for control and power loads.	ac

TABLE 8.1-1 (SHEET 2 OF 2)

Safety Loads	Safety Function	Power
Service water pumps	Satisfy cooling water requirements for: (1) Component cooling water heat exchanger. (2) Containment air coolers. (3) Diesel generator heat exchangers. (4) Various room coolers for rooms containing safety-related equipment (see table 9.2-3 for more information).	ac
Loads off motor control centers A, B, F, G, K, L, N, P, S, T, U, V, CC, and DD	Provide power for M.O.V., small motors, fans, heaters, vital instrument buses, and small pumps associated with safety-related equipment.	ac
Inverters/Constant Voltage Transformers	Supply power to the 120 V-ac vital instrumentation distribution panels.	dc, ac
Safety feature actuation system solenoid valves	Control flow of the NSSS (pneumatic valves with solenoid actuators).	ac, dc
Distribution panel	Supplies power to emergency lighting and protective relay panel.	ac, dc
ESS sequencers	Provide starting signals to safety loads following a safety injection signal.	dc
Reactor trip switchgear	Remove power from the rod cabinets to shut down the reactor.	ac, dc
Emergency diesel generators	Provide power to ESF loads due to a loss of offsite power along with a LOCA.	dc, ac



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JOSEPH M. FARLEY
NUCLEAR PLANT
UNIT 1 AND UNIT 2

ALABAMA POWER COMPANY ELECTRIC SYSTEM – 1983

FIGURE 8.1-1

8.2 OFFSITE POWER SYSTEM

8.2.1 SYSTEM DESCRIPTION

The Southern electric transmission system supplies offsite ac energy for operating the emergency busses as well as startup and shutdown of Units 1 and 2.

[HISTORICAL]

[Either unit will be 9 percent of the total installed capacity of the Alabama Power Company (APC) system in 1983 and about 3 percent of the total installed capacity of the Southern electric system in 1983.]

Unit 1 and Unit 2 are connected by separate generator step-up transformers to the 230-kV and 500-kV switchyards, respectively. Six transmission lines interconnect the 230-kV and 500-kV switchyards to the Southern electric transmission system, as shown by figure 8.2-1. The 230-kV switchyard is connected to the 230-kV system by four 230-kV lines and the 500-kV switchyard is connected to the 500-kV system by two 500-kV lines. The 230-kV and 500-kV switchyards are interconnected at the plant site by two 500/230-kV autotransformers. A spare 500/230-kV autotransformer has been provided that will be physically connected if there is a failure with one of the main Bank #1 or Bank #2 autotransformers. A switchable 230-kV shunt reactor is provided to help control switchyard voltages and improve stability during transmission system light load conditions. A switchable 230-kV 90-MVAR capacitor bank is provided for voltage support during periods of high system load.

Six sources of offsite power are available to the 230-kV switchyard. These sources are the four 230-kV lines (Webb, Sinai Cemetery, South Bainbridge, and Pinckard) and the two 500/230-kV autotransformers which connect to the 500-kV system via the two 500-kV lines (Raccoon Creek and Snowdoun). The 230-kV switchyard is interconnected to the onsite electrical distribution system by four physically-separated, underground, oil-static cables. Each cable supplies power to one of the four startup auxiliary transformers which supply power to the emergency busses for Units 1 and 2. Any of the startup auxiliary transformers may be temporarily connected to the 230-kV switchyard by means of an overhead bus available for that purpose. The requirements of GDC No. 17 and Regulatory Guide 1.32 are met by the offsite power system as details provided in the following paragraphs show.

8.2.1.1 Offsite Power Sources

[HISTORICAL]

[Figure 8.1-1 shows the Alabama Power Company transmission system in 1983.]

Figure 8.2-2 shows the general physical plan of lines from the switchyard structures to the plant property boundaries. Figure 8.2-2 also illustrates the separation of lines within the site

boundaries and the direction taken by the various right-of-ways emanating from the plant site. Figures 8.2-3 and 8.2-4 show the details for the 230-kV and 500-kV transmission line separation in the vicinity of the 230-kV and 500-kV switchyards, respectively. Table 8.2-1 provides a summary of the lines terminating at the plant and their construction features.

These lines are not considered to have unusual features. Crossing of lines of different voltage levels, as listed in table 8.2-1, is a normal design feature.

8.2.1.2 Switchyard

The 230-kV and 500-kV switchyards are located as shown on figure 8.2-2. Figure 8.2-5 shows the physical arrangement of these switchyards. The 230-kV and 500-kV switchyards both employ a breaker-and-a-half arrangement to provide the necessary operating flexibility, and consequently, reliability. This breaker arrangement is redundant in that it incorporates two energized main busses so that either of the main busses can be removed from service without interruption of power flow. In most cases, three breakers service a pair of connections. In some cases, additional reliability is provided for more critical connections by using two breakers to service a single connection. Details on the electrical connections for the switchyards are shown on figure 8.2-1.

The switchyard is equipped with a switchhouse containing two independent batteries, independent primary and secondary relaying, and breaker failure relaying.

Two trip coils are provided in each circuit breaker for independent tripping from the primary and secondary relay systems. Redundant closing coils are not provided in the circuit breakers. The closing coils for the circuit breakers are supplied from one of the two substation batteries so that the loss of either battery will not prevent closing breakers as required to energize at least one startup transformer for each unit.

Each of the 230-kV and 500-kV circuit breakers has independent gas and independent air supplies for the pneumatic mechanism.

Four terminals are provided in the switchyard to supply power to the four transformers referred to in paragraph 8.2.1.3. These four transformers (1A, 1B, 2A, and 2B) are supplied through separate oil-static cables from separate 230-kV terminals. An overhead bus arrangement provides a temporary backup connection to any of the four transformers.

Each of the four underground cable circuits consists of three single-conductor 500-MCM compact round aluminum conductors. Each conductor has 0.760 in. of paper insulation, zinc alloy shielding tape, and a 0.0063-in. x 0.188-in. zinc alloy skid wire. Metalized paper tape is provided adjacent to the conductor and also over the insulating paper tapes. The three single-conductor cables of each circuit are contained in a 6 5/8-in. O.D. x 0.250-in. wall somastic-coated pipe. The oil-static cable system requires no forced cooling and has an ampacity of 341 A. The current rating of the cable system is established by the maximum allowable conductor temperature of 85°C. This conductor temperature ensures that the cable's insulation system operates within its thermal capacity. At each end of the cable circuit, a termination (trifucator)

assembly is used as a transition between the 6 5/8-in. underground pipe and the three above-ground cable terminations. A 90-degree type termination assembly is used at the transformer end of each circuit and an angular, or sloping-type, termination assembly is used at the transmission substation end of each circuit. Each of these assemblies consists of the necessary pipe bend, spreader head assembly, and riser pipes. Each end of each of the three single-conductor cables in each circuit is terminated with 230-kV pothead assembly. The cables are buried with a minimum cover of 3 ft. except where they exit the ground. Separation is provided as indicated on figure 8.2-5 and drawing D-173000, sheet 1. Typical interfaces between underground and overhead transmission are shown on figures 8.2-6 and 8.2-7.

The entire cable containment system, including the 6 5/8-in. diameter pipe, the spreader head assembly, stainless steel riser pipes, and potheads is filled with polybutene oil that is maintained at a static pressure head of approximately 200 psi by an automatic pressure system. The automatic pressure system consists of two indoor, dual unit-type pumping plants, each with a 1000-gal oil storage tank normally maintained at approximately 750 gal. Each of the two pumping plants is connected to pressurize two of the four cable systems. One supplies the cable system for transformer 1A and 2B and the other supplies the cable system for transformer 1B and 2A.

Power supply for the pumping plants is provided by redundant transformers connected to busses 1D and 2E. The pumping plants and transformers are separated by firewalls. Redundant pumps are provided in each pumping plant.

8.2.1.3 Offsite Power Supply to Plant

Each unit is provided with at least one unit auxiliary transformer (1A and 1B for Unit 1 and 2B for Unit 2) as shown on drawing D-173000, sheet 1. The unit auxiliary transformers (1B and 2B) normally supply power to 4.16-kV busses A, B, and C of each unit.

The four startup auxiliary transformers, two for each unit, are connected to the APC transmission system through four separate 230-kV oil-static cables as shown on figure 8.2-5 and drawing D-173000, sheet 1. These transformers provide a source of power for startup, shutdown, and after-shutdown requirements for both units. Under normal operating conditions, these startup transformers supply power to 4.16-kV busses D and E along with 4.16-kV emergency busses F, G, H, J, K, and L for each unit. A spare startup auxiliary transformer, which can be fed by the overhead bus system, is available and can be moved in place in case one of the four startup transformers fails. The startup auxiliary transformers are provided with open phase protection equipment. The impact of open phase conditions (OPCs) on the capability of the 1A, 1B, 2A, and 2B startup auxiliary transformers was evaluated. The conditions analyzed consisted of single (i.e., one of three) and double (i.e., two of three) open phase conductors on the 230-kV high voltage side of the 1A, 1B, 2A, and 2B startup auxiliary transformers. The analysis considered OPCs with and without a ground. Open phase detection (OPD) systems for the transformers were installed in response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," and in accordance with the NEI OPC Initiative. Upon detection of an OPC, local and control room alarm annunciation occur. The open phase protection system is provided with an available option to open the high side breakers of the

impacted start up auxiliary transformer and associated downstream 4.16-kV breakers upon detection of an OPC.

A risk-informed assessment utilizing the Farley specific electrical design configuration was performed in accordance with the guidance in NEI 19-02, "Guidance for Assessing Open Phase Condition Implementation Using Risk Insights." The assessment demonstrated that in the event of an OPC, the risk associated with OPD system that is reliant on manual operator action versus the automatic actuation of an open phase isolation system was below the threshold of what is generally considered a small change in core damage frequency (1.0E-6) and large early release frequency (1.0E-7). Based on the results of the risk-informed assessment, Farley has opted to utilize the OPD system and operator manual actions to address OPCs.

The breaker arrangement (figure 8.2-1) employed by Alabama Power Company provides breaker-and-a-half protection for all four startup transformers (1A, 1B, 2A, and 2B). A single failure of any electrical component employed by this arrangement will preclude a simultaneous trip of both units due to the loss of one offsite power source and loss of all onsite power. This breaker arrangement provides for greater overall system protection and is designed to minimize the simultaneous failure of the circuits under postulated accident and environmental conditions.

Each circuit supplies power to the associated emergency busses under normal operating conditions, with a provision for supplying the other redundant bus if the second circuit is not available. A simultaneous loss of all onsite ac power supplies and loss of one of the offsite power circuits will fail a maximum of one group of emergency busses. The redundant emergency busses continue to supply the safety-related loads and are designed to shut down the unit safely. Power to the failed emergency busses can be restored in a few seconds by closing the normally open breaker on the affected emergency bus. An interlock is provided to prevent simultaneous closing of both the normal and standby supply breakers.

8.2.1.4 Summary

The system of lines, switchyards, and transformer connections are planned around the requirements of GDC No. 17 and Regulatory Guide 1.32 and are considered to meet the requirements of these criteria for the offsite power system.

The redundancy and backup features in the system described are such that most active components (i.e., circuit breakers, relays, meters, batteries, battery chargers, etc.) can be removed from service, maintained, and tested without loss of offsite power. However, those components that can be tested without removal from service will normally be tested in service. In the event that it should become necessary, an oil-static cable and its associated transformer can be removed from service for tests with only temporary loss of offsite power to one of the two trains of safety-related busses. The design of the switchyard and connections to the plant are considered to meet the requirements of GDC No. 18 as applicable to the offsite power system.

8.2.2 ANALYSIS

8.2.2.1 Loss of Either Farley Unit No. 1 or No. 2 or Largest Unit (Gaston No. 5) (Effect on Offsite Power)

Farley Unit 1 and Unit 2 are connected to the 230-kV and 500-kV transmission systems as described in subsection 8.2.1.

Periodic studies simulating peak conditions are made to determine the effect of the loss of either Farley Unit 1 or 2 on the APC transmission system and the system's ability to maintain continuity of service to the loads. These studies have revealed that the transmission system will be adequate to maintain continuity of service to the load areas and the offsite power to the safety-related emergency busses at the Farley plant.

The loss of the largest unit (Gaston No. 5) on the APC system will not result in the loss of the offsite power to the safety-related emergency busses at the Farley plant.

8.2.2.2 Farley Plant Transient Stability

Transient stability studies simulating “worst case” anticipated loading conditions are periodically performed to verify operational capability of off-site preferred power supply to the Class 1E loads at Farley Nuclear Plant. The offsite power system is designed to prevent a complete loss of preferred power (LOSP) due to a single event such as electrical fault, loss of a generator, loss of load, or loss of a transmission line. Stability analyses also verify that grid failure modes do not result in frequency variations exceeding the 5 hertz per second maximum decay rate assumed in the accident analysis for loss of reactor coolant flow.

Under normal expected transmission system operating conditions, the grid will remain stable and safety-related busses will continue to be supplied by the offsite preferred power source for single contingency events and faults. The additional contingency of breaker failure is also considered in conjunction with faults in order to optimize the stable operation and design of the FNP units and the system grid. Grid stability is maintained if, after a disturbance such as a fault, the power system returns to equilibrium without experiencing cascading trips of lines or units that could result in the system or voltage collapse. For the double contingency of fault plus breaker failure, FNP may experience unit trips.

3-Phase faults (230 kV and 500 kV) at FNP which involve the additional contingency of breaker failure include maximum breaker failure clearing times of 8.50 cycles for the 230-kV breakers and 9 cycles for the 500-kV breakers. The 230-kV and 500-kV switchyards are arranged so that only one transmission line will be lost after a 3-phase fault at the Farley plant where breaker failure is involved.

8.2.2.3 Grid Availability

[HISTORICAL]

[Table 8.2-2 is derived from the Alabama Power Company 1983 Transmission Monthly Summaries. It should be noted that the higher voltage lines have better operating records than lower voltage lines.]

The use of 230-kV and 500-kV lines and two 230/500-kV Autobank Transformers for connecting FNP to the grid provides reliable service to the plant. A spare 500/230-kV autotransformer has been provided that will be physically connected if there is a failure with one of the main Bank #1 or Bank #2 autotransformers.

8.2.2.4 Offsite Power System Operating Voltage Range

The normal offsite power system operating voltage range for Plant Farley Units 1 and 2 is within 101.6% to 104.5% of 230 kV. System studies have shown that this range can be maintained when at least one Farley unit is on line for system voltage support and will assure reliable unit operation. Offsite power system voltage is not intentionally lowered below the 101.6% voltage level because some nonsafety-related loads are not analyzed for operation below 101.6%. System voltages for worst-case single contingencies are expected to remain at or above 101% of 230 kV. This includes the contingency that assumes one Farley unit is in a LOCA and the other unit is tripped. The value of 101% assures acceptable terminal voltages, with margin, for safe shutdown equipment to perform its safety function. Therefore, continued unit operation is acceptable in the unlikely event that system voltage is found to be < 101.6% but above 101%. Voltages > 104.5% are allowed as long as 4160-V bus voltage levels do not cause equipment maximum voltage ratings to be exceeded.

Periodic transmission system planning studies are performed to help ensure that voltages can be maintained within acceptable limits.

TABLE 8.2-1 (SHEET 1 OF 2)

SUMMARY OF 230-kV AND 500-kV LINE CONSTRUCTION

	Farley Webb	Farley Pinckard	Farley S. Bainbridge	Farley Raccoon Creek	Farley Snowdoun	Farley Sinai Cemetary
Operating voltage	230 kV	230 kV	230 kV	500 kV	500 kV	230 kV
Tower design	Guyed aluminum delta	Guyed aluminum delta	Guyed steel pole H-frame	Self-supported latticed	Self-supported latticed	H-frame
Conductor	2-1351 ACSR	2-1033 ACSR	1-1351 ACSR	3-1113 ACSR	3-1033 ACSR	3-1351 ACSS/A
R/W width	125 ft	125 ft	125 ft	150 ft	200 ft	100 ft
Location of line on R/W	C/L	C/L	C/L	C/L	C/L	C/L
Line length	10 miles	35 miles	46 miles	62 miles	97 miles	47 miles
Terrain	Flat to rolling	Flat to rolling	Flat to rolling	Flat to rolling	Flat to rolling	Flat to rolling
Isokeraunic level	70	70	60-70	60-70	60-70	70-75
Phase/phase clearance	24 ft	24 ft	20 ft	28.5 ft	31 ft	20 ft
Phase/ground clearance at maximum operating condition	30 ft	30 ft	27 ft	33 ft	33 ft	30 ft
Remote line termination	Webb transmission substation	Pinckard T. W.	South Bainbridge Service Station	Raccoon Creek	Snowdoun substation	Sinai Cemetery substation
Unusual operating condition	None	None	None	None	None	None

TABLE 8.2-1 (SHEET 2 OF 2)

	Farley Webb	Farley Pinckard	Farley S. Bainbridge	Farley Raccoon Creek	Farley Snowdoun	Farley Sinai Cemetary
Major transmission line crossing (a)	None	115-kV Webb-Scholtz 115-kV Pinckard-Dothan #2 115-kV Pinckard-Columbia	500-kV Raccoon Creek on plant site 500-kV Snowdoun 115-kV Blakeley Cedar Springs 115-kV East Bainbridge-Donalsonville 115-kV Colquitt-Donalsonville	115-kV Mitchell-Moultrie 230-kV Mitchell-Thomasville 115-kV Blakely-East Bainbridge 230-kV South Bainbridge on plant site 115-kV Blakeley-Cedar Springs	230-kV Montgomery-Pinckard (3 crossings) 115-kV Union Springs-Pinckard 115-kV Troy-Union Springs 230-kV South Bainbridge on plant site 115-kV Pinckard Columbia 115-kV Webb-Eufaula	115-kV Scholtz-Marianna

a. Includes 115 kV and above.

[HISTORICAL]

[TABLE 8.2-2

SUMMARY OF 115-kV THROUGH 500-kV TRANSMISSION LINE FAILURES

Type of Failure	*Number*	*Cause of Failure*	*Number*
Pole/tower	*12*	*Lightning*	*5*
Crossarm	*18*	*High wind*	*12*
Insulator	*4*	*Tree*	*6*
Arrester	*0*	*Cold weather*	*5*
Shield wire	*10*	*Others*[(b)]	*51*
Span	*13*		
Sleeve	*2*		
Jumper	*1*		
Other[(a)]	*19*		
Total Failures	*79*		*79*

Voltage Class	*Structure Miles*[(c)]	*Number of Failures*	*Failures Per 100 Miles of Line*
500 kV	*192.14*	*5*	*2.60*
230 kV	*1,307.70*	*18*	*1.38*
161 kV	*295.08*	*5*	*1.69*
115 kV	*3,712.20*	*51*	*1.37*
Total	*5,507.12*	*79*	*1.43*

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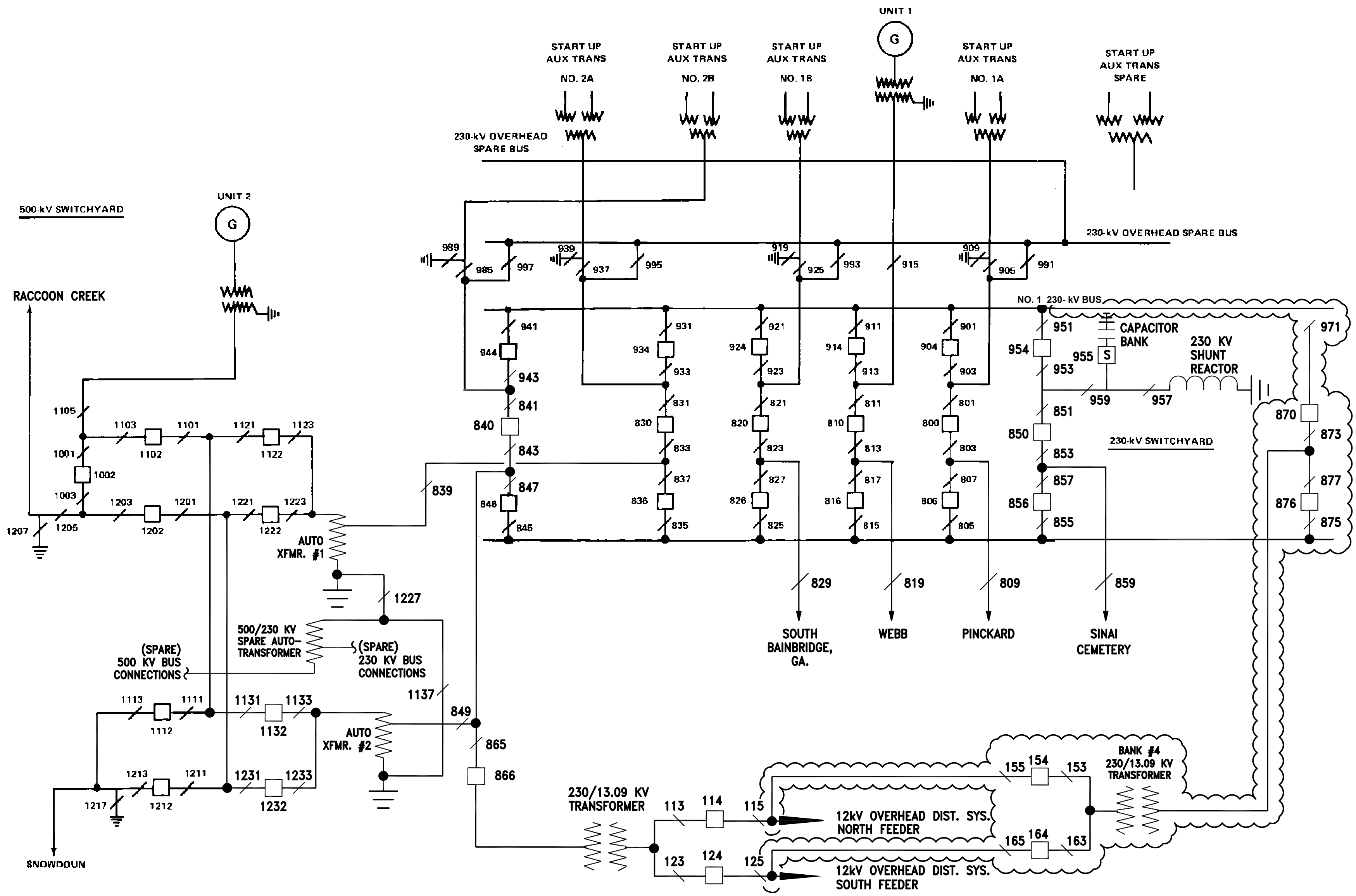
a. Includes conductor shorted together, foreign matter on lines, line switch failures, etc., and unknown causes.

b. Includes vandals, autos, trucks, airplanes, etc., and unknown causes.

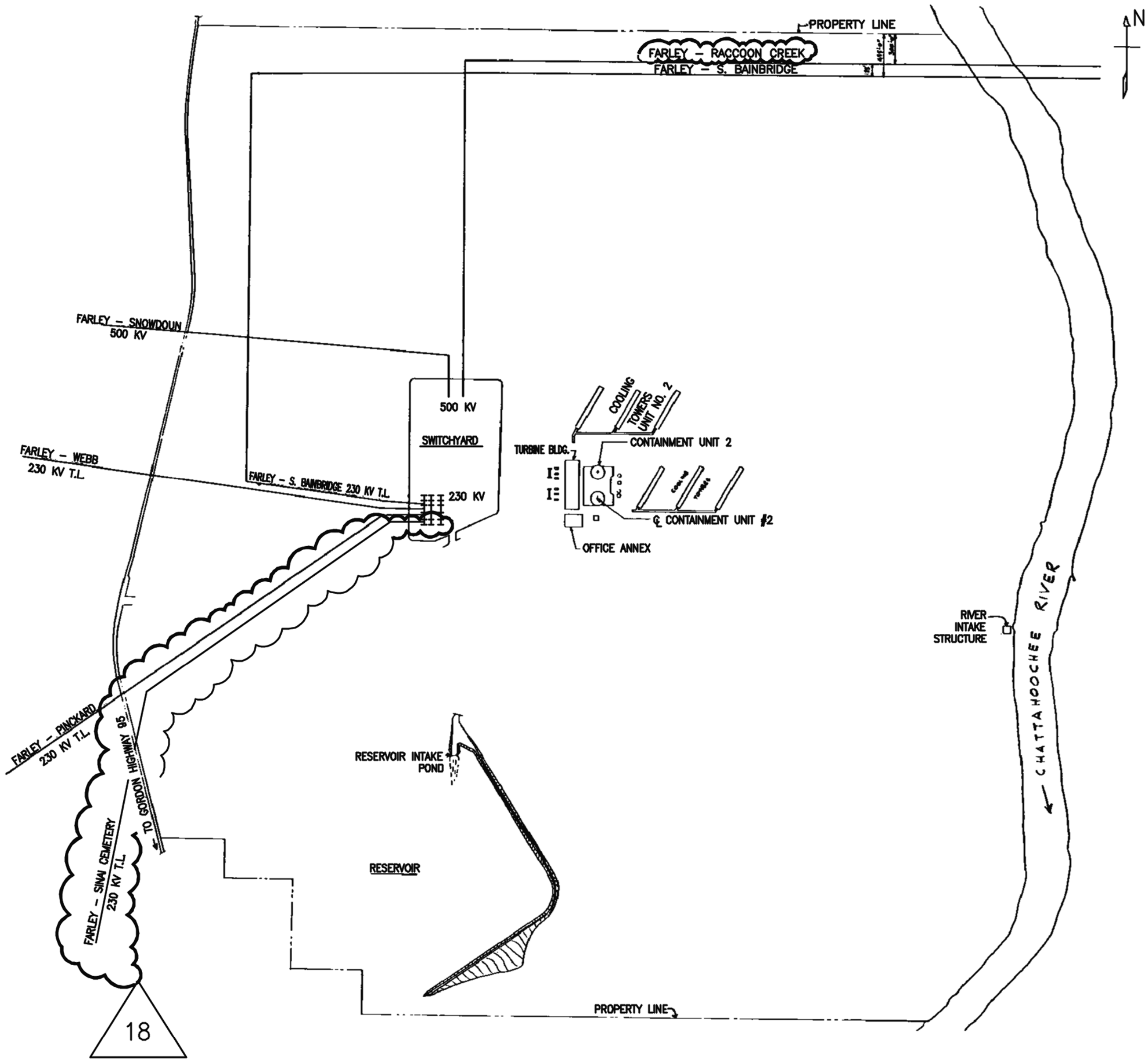
c. Structure miles as of December 31, 1982.]



REV 29 4/20

NOTE:
SWITCH 971 IS NOT CONNECTED TO 230KV BUS NO. 1

SOUTHERN COMPANY *Energy to Serve Your World®*	JOSEPH M. FARLEY NUCLEAR PLANT UNIT 1 AND UNIT 2	SWITCHYARD ARRANGEMENT ONE-LINE DIAGRAM FIGURE 8.2-1



REV 21 5/08

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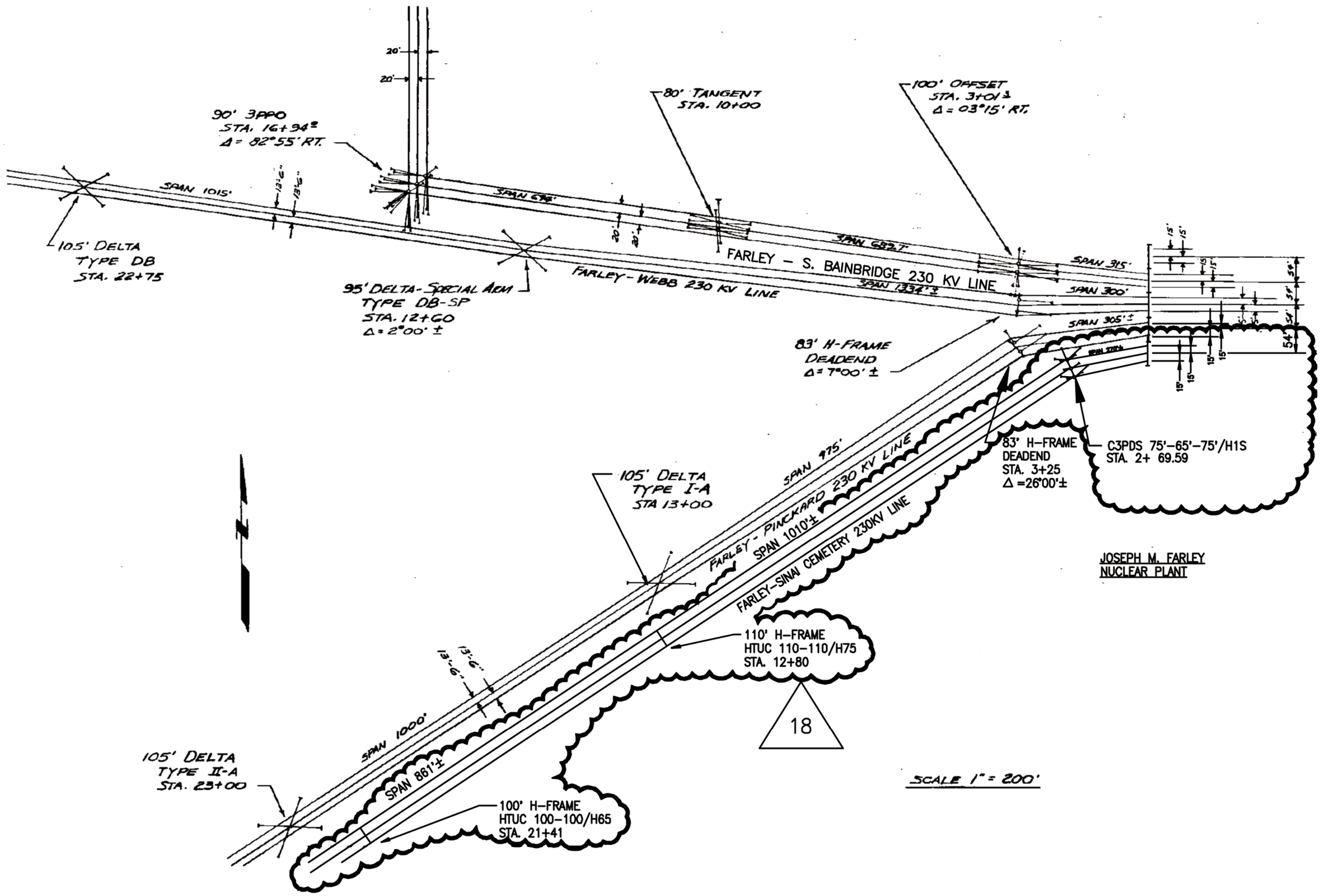
JOSEPH M. FARLEY
NUCLEAR PLANT
UNIT 1 AND UNIT 2

TRANSMISSION LINE SEPARATION

FIGURE 8.2-2



REV 21 5/08

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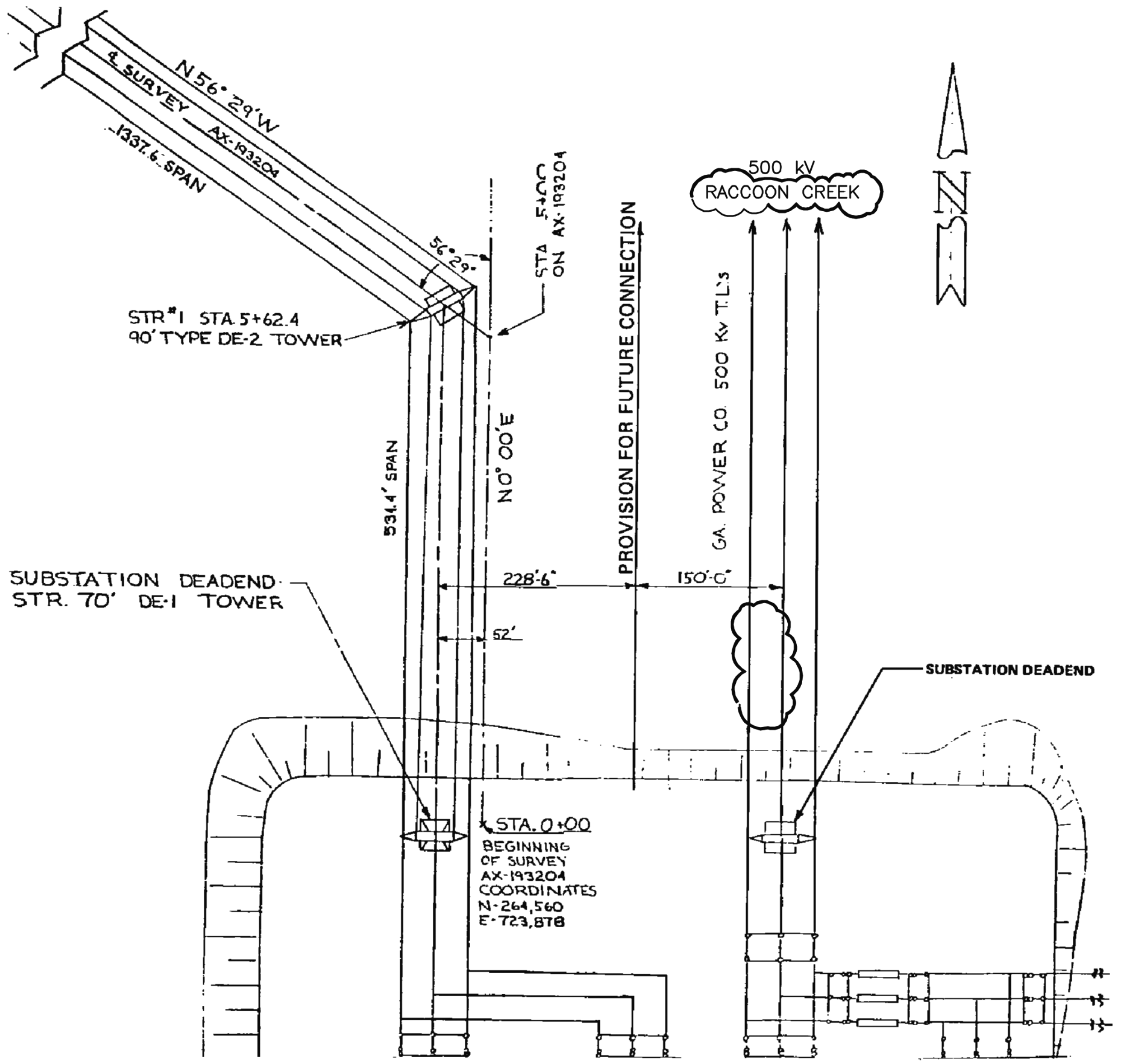
JOSEPH M. FARLEY
NUCLEAR PLANT
UNIT 1 AND UNIT 2

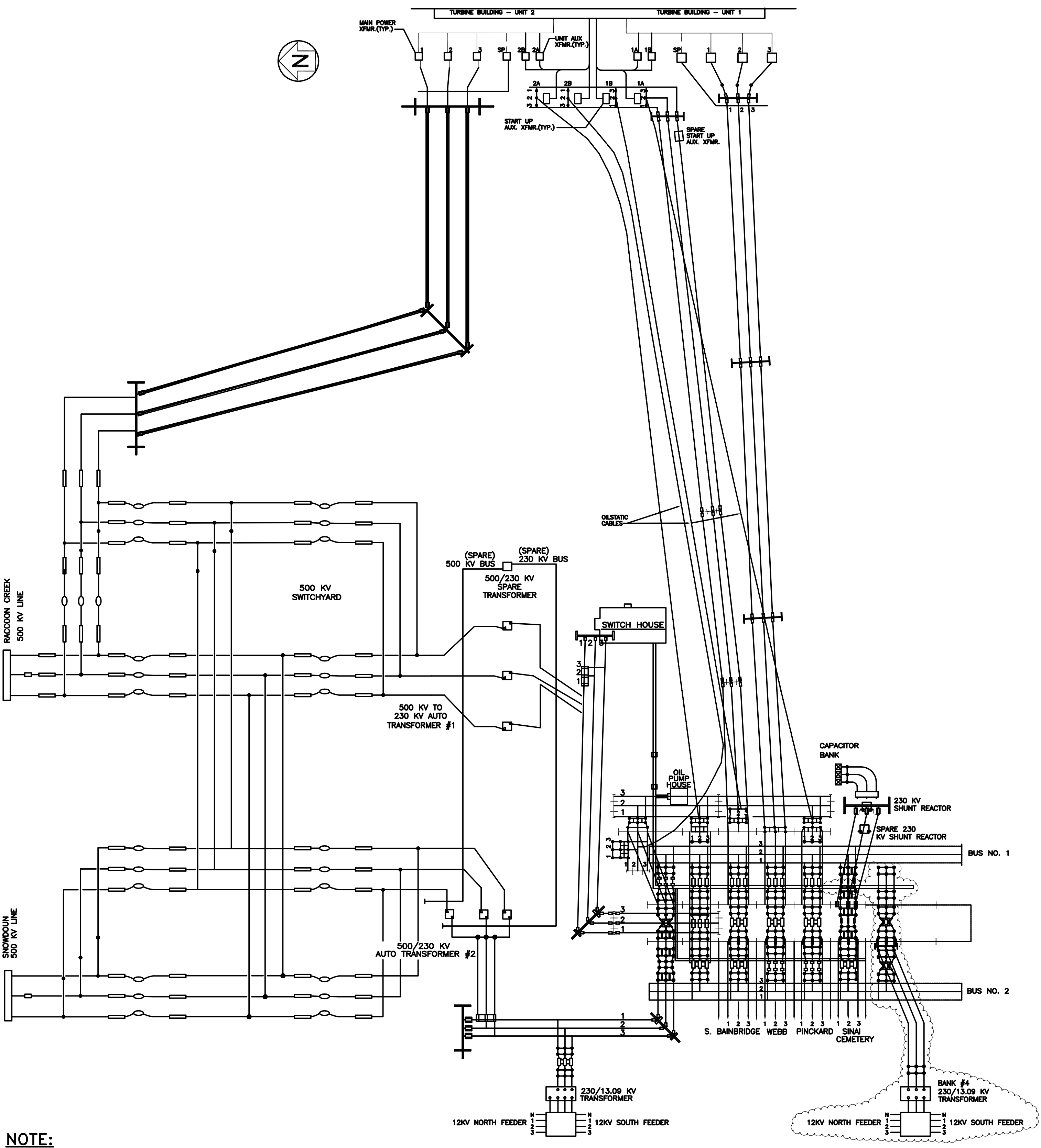
230 kV TRANSMISSION LINE SEPARATION

FIGURE 8.2-3



REV 21 5/08

SOUTHERN COMPANY *Energy to Serve Your World®*	**JOSEPH M. FARLEY NUCLEAR PLANT UNIT 1 AND UNIT 2**	500 kV TRANSMISSION LINE SEPARATION
		FIGURE 8.2-4



NOTE:
THE BANK #4 230 KV TERMINAL
IS NOT CONNECTED TO BUS NO. 1

REV 29 4/20

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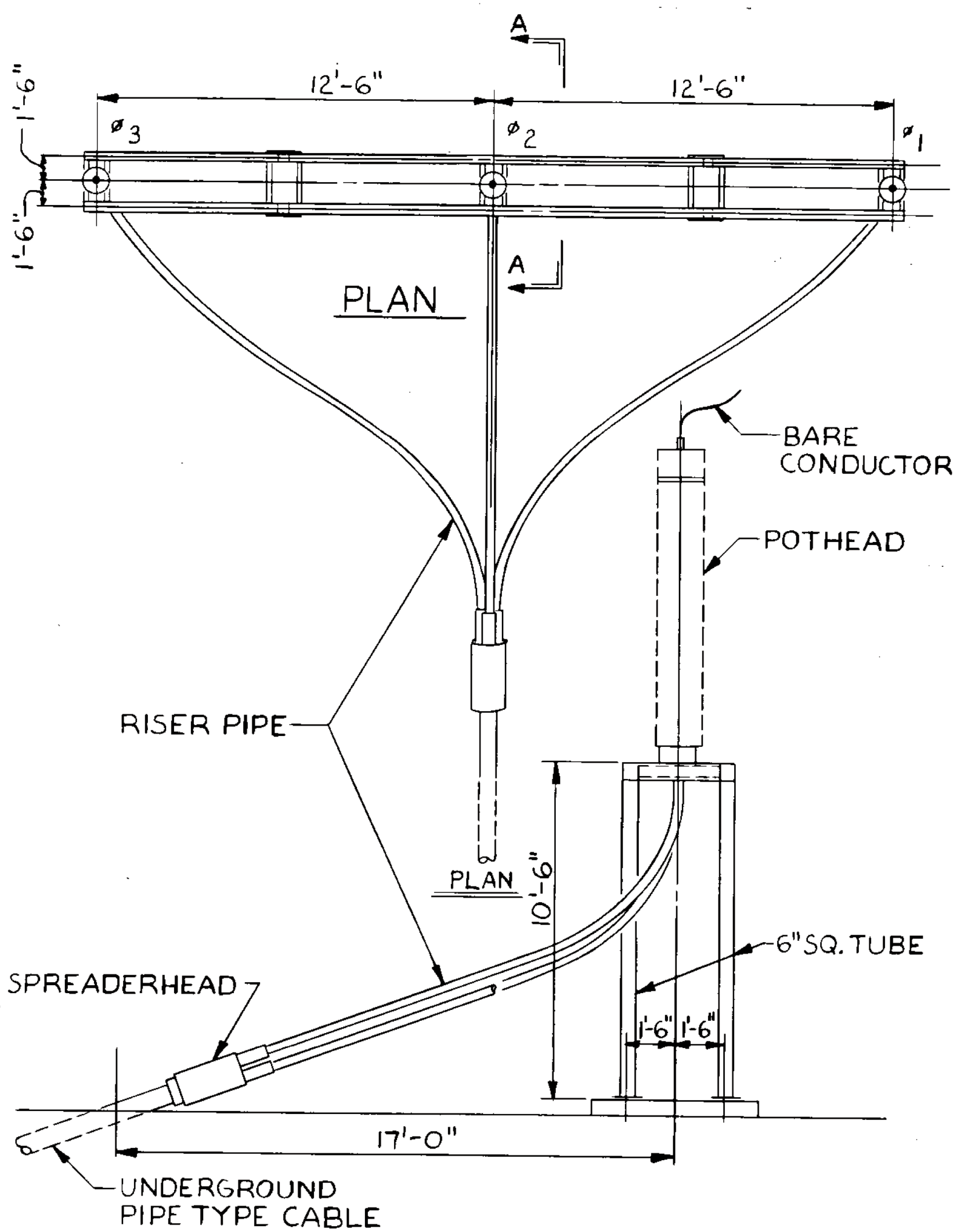
UNIT 1 AND UNIT 2

SWITCHYARD ARRANGEMENT

FIGURE 8.2–5



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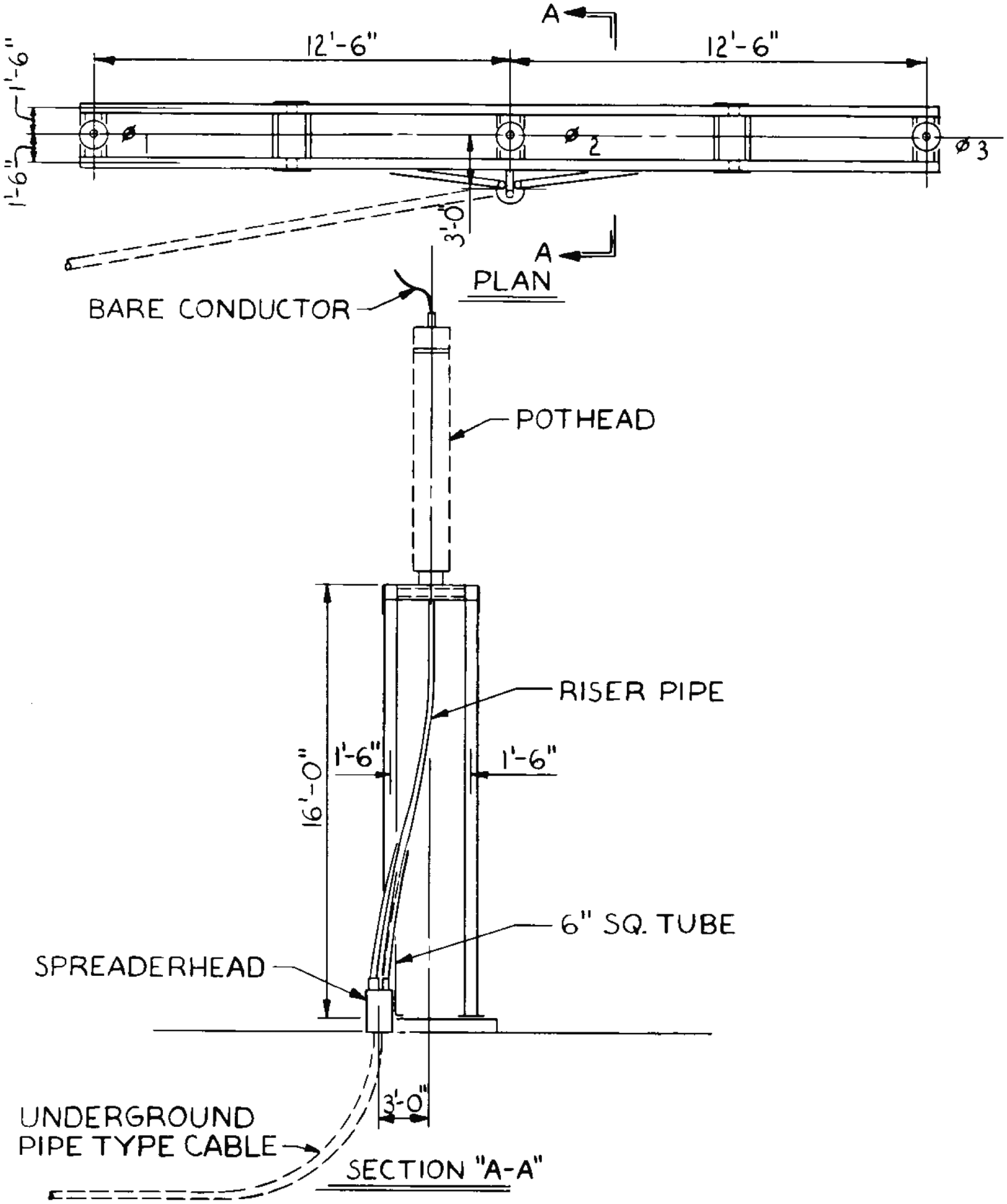
NUCLEAR PLANT
UNIT 1 AND UNIT 2

TYPICAL INTERFACE BETWEEN UNDERGROUND AND OVERHEAD TRANSMISSION AT SUBSTATION

FIGURE 8.2-6



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NUCLEAR PLANT
UNIT 1 AND UNIT 2

TYPICAL INTERFACE BETWEEN UNDERGROUND AND OVERHEAD TRANSMISSION AT TRANSFORMER

FIGURE 8.2-7

8.3 ONSITE POWER SYSTEMS

8.3.1 AC POWER SYSTEMS

The ac auxiliary system for each unit consists of the 4.16-kV, 600-V, 480-V, 208-V, and 120-V subsystems, each designed to provide reliable electrical power during all modes of plant operation and shutdown conditions. The system for each unit is designed with a sufficient number of power sources and redundant buses to accomplish this. Engineered safeguard circuits are arranged so that the loss of a single bus section results in only single losses of engineered safeguards. A redundant engineered safeguard circuit is available to perform the same function.

The auxiliary system for each unit is capable of starting the largest required drive with the remainder of the connected motor load in service. Each unit is provided with a fast, dead-bus transfer feature which transfers the 4.16-kV buses A, B, and C from the unit auxiliary transformers to the startup auxiliary transformers following a turbine generator trip or reactor trip.

Protective relaying is arranged for selective tripping of circuit breakers after occurrence of an electrical fault. The electrical one-line diagrams for Unit 1 are shown on drawings D-177000 and D-177001, and for Unit 2 on drawings D-207000 and D-207001.

8.3.1.1 Description

8.3.1.1.1 Auxiliary System (4.16-kV)

A. Safety-Related Systems

The 4.16-kV emergency buses, which supply equipment essential for the safe shutdown of the plant, are comprised of six buses F, G, H, J, K, and L for each unit and are supplied from two startup transformers connected to the offsite source during normal and emergency operating conditions. Buses H and J also supply power to the river water system nonsafety-related loads. The preferred and the normal power supplies being the same, no transfer to a preferred source is required to be made in the event of an emergency. All components are designed to conform with Class 1E Electrical System Design Criteria as defined in IEEE Standard 308. In the unlikely event of a failure of one startup auxiliary transformer, three emergency buses are deenergized and their loss annunciated in the main control room.

The remaining emergency buses of the affected unit are capable of supplying the minimum required engineered safeguards independently as indicated in table 8.3-1. Manual action is required to reenergize the bus from the other startup auxiliary transformer.

No single failure of an active component will remove two startup auxiliary transformers in redundant circuits at one time. The capacity of the transformers and circuit breakers is sufficient to permit full-plant operation with one transformer out of service.

Each 4.16-kV emergency bus, except K and L (which are considered extensions of buses F and G) is equipped with a set of undervoltage relays which provide protection against a loss of voltage condition. Upon recognition of a loss of voltage on a 4.16-kV emergency bus, these relays, configured in a two-out-of-three coincidence logic, initiate a signal to effect the following:

A. Load shedding.

B. Diesel generator starting (except diesel 2C).

C. Tripping of 4.16-kV preferred offsite power supply breakers.

The undervoltage relays employed for loss of voltage protection are induction disc-type relays with an inverse time trip characteristic set at 3255 V, approximately 78.24 percent of the nominal (4160-V) bus voltage and with the time dial selected in such a way as to avoid nuisance tripping during normal operating conditions.

In addition, each of the 4.16-kV emergency buses F and G is equipped with a degraded grid alarm and a second set of undervoltage relays to provide protection against a sustained degraded grid voltage condition. Upon recognition of a sustained degraded grid voltage condition at or below the alarm setpoint, the alarm will alert operators so that actions can be taken to restore voltages to normal levels. For continued voltage degradation that leads to sustained degraded voltage levels at or below the relay setpoint, the degraded grid undervoltage relays, configured in a two-out-of three coincidence logic, initiate a signal to trip the 4.16-kV preferred power supply breakers.

The degraded grid alarms are set at 3850 V, approximately 92.55 percent of the nominal (4160-V) bus voltage to minimize nuisance alarms during normal operating conditions. The undervoltage relays employed for sustained degraded voltage protection have voltage and time delay settings (tabulated in TS 3.3.5) which are calculated to minimize nuisance tripping during normal operating conditions without exceeding the maximum time delay assumed in the accident analyses. The degraded grid alarm setpoint and the degraded grid relay voltage and time settings were also selected to ensure that voltage requirements of the safety-related loads at all onsite system distribution levels are met.

The voltage levels at safety-related buses are optimized for the expected load conditions throughout the anticipated range of voltage of the offsite system by adjustment of transformer taps. The analysis has been verified to be accurate by testing.

The onsite emergency ac power supply for Units 1 and 2 consists of five diesel generator units which supply standby power for 4.16-kV emergency service buses F, G, H, J, K, and L of each unit. For a detailed description of the operation of the diesel generators, refer to paragraph 8.3.1.1.7. A schematic arrangement of the diesel generators and the safeguard buses is shown in figure 8.3-1.

The engineered safety feature loads are divided between the emergency buses of each unit in a balanced, redundant load grouping so that the failure of one emergency diesel generator or one emergency bus in each unit will not prevent the safe shutdown of both reactors.

Drawings C-177119, C-177120, and C-177121 show the interlocking scheme for 4-kV pump motors which can be aligned either to bus F or bus G. Elementary diagrams for the operation of the startup transformer incoming feeders are covered in drawings D-177155, D-207155, D-177161, D-207161, D-177168, and D-177169. Drawings D-177185, D-207185, D-177187, and D-207187 show the controls for the swing component cooling pump B. This design is typical for the high head safety injection pump B and service water pump C.

B. Nonsafety-Related System

The 4.16-kV auxiliary system for the nonsafety-related loads is comprised of five buses: A, B, C, D, and E. Nonsafety-related river water system loads are supplied from safety-related buses H and J. During normal operations, the unit auxiliary transformers supply power for buses A, B, and C of each unit while buses D and E for each unit are powered from the unit startup transformers.

Condensate Pump A, the reactor coolant pumps, and the circulating water pumps are supplied from buses A, B, and C. Provision has been made on these buses for a fast, dead-bus transfer to the startup transformer source in the event of failure of the normal supply from the unit auxiliary transformers. For a fault that is nonelectrical and restricted to the turbine system, the tripping of the generator and, consequently, the initiation of a fast transfer is delayed by 30 s to permit continued operation of the reactor coolant pumps. For reasons of safety and optimum utilization of the flywheel energy in the reactor coolant pump, the latter is electrically disconnected from the 4.16-kV system upon the occurrence of an undervoltage or an underfrequency condition.

8.3.1.1.2 600-V, 480-V, and 208-V Auxiliary Systems

Twenty 600-V load centers are provided for Unit 1 and another 20 for Unit 2. In addition, seven load centers are being shared between the two units. Two more 600-V load centers, powered from Unit 1, are provided for the Visitors Center. Each load center, except 1, 2, and 3, derives its power supply from the 4.16-kV auxiliary system through individual 4160/600-V station service transformers rated at either 1000 kVA or 300 kVA. Load centers 1, 2, and 3 derive their power

from the 12-kV overhead distribution system through individual station service transformers rated 1250 kVA.

Load center F, with a separate 1000-kVA transformer, is a spare and provides a standby source of power supply to load centers A, B, C, D, E, G, M, N, P, and Q. Each load center receiving power from load center F has a key interlock to ensure that it is supplied from only one source at a time (dead bus transfer), with the exception of maintenance performed under plant maintenance procedures that allow for the simultaneous connection of any of these load centers to both the primary and standby source during the transfer between power sources (hot bus transfer). A typical interlock schematic is shown in drawing D-177122. The capacity of the spare transformer located in load center F and the arrangement of the 600-V load center tie breakers permit plant operation with one transformer out of service. For operation of load center F, key interlocks are provided between the 4.16-kV supply breakers, the associated disconnects, and the 600-V feeder breaker to ensure correct alignment to one of the two 4160-V engineered safeguard buses F or G. Details of the interlocking scheme are shown on drawing C-177118.

600/208-V, 600-V, and 208-V motor control centers (MCCs) are provided to supply power to equipment within their related areas. Most of these MCCs are dedicated to either Unit 1 or Unit 2, but several supply shared equipment and/or are located in shared structures. Each MCC is fed from a 600-V load center or the 120/208-V switchgear.

In addition, two 480-V MCCs 1Q and 1R supply power to loads in the service building. These MCCs are in turn supplied from 4160-V bus 1E through 4160-V, 750-kVA transformers.

A. Safety-Related System

All components are designed to conform with Class 1E electrical system design criteria as defined in IEEE Standard 308.

600-V load centers D, E, K, L, R, and S supply power for engineered safety features equipment. Load centers K, L, R, and S are shared between the two units. Load centers A and C have one bus section allocated for supplying safety-related loads (see drawings D-177007, D-207007, D-177009, and D-207009). In addition, spare load center F is provided to supply standby power to load centers D and E under the conditions previously outlined in this section.

Under normal operating conditions, load centers A and C are operated as continuous sections. In the event of loss-of-offsite-power (LOSP), the emergency part of load centers 1C and 2C can be manually disconnected from the normal side and supplied from load centers 1E and 2E, respectively, through electrically interlocked breakers. In the event of a LOSP, the emergency part of the load center A is automatically disconnected from the normal side and supplied from load center D through electrically interlocked breakers. With A and C transferred to D and E, the total load on load centers D and E is within the rated capacity of the individual station service transformer of each bus.

The loss of one 600-V emergency bus or the failure of any redundant component of the emergency system deprives the unit of only part of the equipment associated with that particular function. The remaining operational equipment is adequate for the shutdown of the unit under normal or accident conditions.

Safety-related 600/208-V MCCs are provided to supply power for safety-related equipment within their related areas. Each safety-related MCC is fed from a safety-related 600-V load center.

Some nonsafety-related loads are fed from safety-related load centers or MCCs. Primary protection of the safety-related load centers and MCCs has been selected such that a fault at the terminals of nonsafety-related equipment powered from a safety-related load center or MCC will not result in a loss of the associated load center or MCC bus.

B. Nonsafety-Related System

600-V load centers A, B, C, G, H, I, J, M, N, P, Q, U, V, W, X, Y, Z, 1, 2, and 3 supply power for nonsafety-related equipment. Load centers H, J, and N are shared between the two units. 600-V load centers 1O and 1T provide power to the Visitors Center. In addition, spare load center F is provided to supply standby power to load centers A, B, C, G, M, N, P, and Q under the conditions previously outlined in this section.

600/208-V, 600-V, 480-V, and 208-V MCCs are provided to supply power to nonsafety-related equipment within their related areas.

8.3.1.1.3 Equipment Rating

A. Transformer

Drawings D-177000, D-177001, D-207000, and D-207001 show the unit auxiliary transformers and startup transformers electrical arrangement. The unit auxiliary transformers are capable of supplying power to 4.16-kV buses A, B, C, D, and E for Unit 1 and A, B, and C for Unit 2. The startup transformers are also capable of supplying power to 4.16-kV buses A, B, C, D, and E, along with 4.16-kV emergency buses F, G, H, J, K, and L of each unit. The ratings of the transformer are as follows:

1. Unit auxiliary transformer 1A

Winding	55°C Rise	65°C Rise
22-kV	20/26.67/33.33 MVA	22.4/29.87/37.33 MVA
4.16-kV	10/13.33/16.67 MVA	11.2/14.93/18.67 MVA
4.16-kV	10/13.33/16.67 MVA	11.2/14.93/18.67 MVA

Three-phase, 60 hertz, class OA/FA/FOA, 10.4% (1A) impedance at 10-MVA base.

2. Unit auxiliary transformer 1B

Winding	65°C Rise
22-kV	28/37.33/46.66 MVA
4.16-kV	14/18.66/23.33 MVA
4.16-kV	14/18.65/23.33 MVA

Three-phase, 60 hertz, class ONAN/ONAF/ONAF, design impedance 12.4% ±10% at 14-MVA base.

3. Unit auxiliary transformer 2B

Winding	55°C Rise	65°C Rise
22-kV	25/33.3/41.67 MVA	28/37.33/46.7 MVA
4.16-kV	12.5/16.67/20.83 MVA	14/18.67/23.33 MVA
4.16-kV	12.5/16.67/20.83 MVA	14/18.67/23.33 MVA

Three-phase, 60 hertz, class OA/FA/FOA, 11.1% (2B) impedance at 12.5-MVA base.

4. Startup auxiliary transformers A and B

Winding	55°C Rise	65°C Rise
230-kV	26/34.6/43.2 MVA	29.1/38.75/48.38 MVA
4.16-kV	13/17.3/21.6 MVA	14.56/19.38/24.19 MVA
4.16-kV	13/17.3/21.6 MVA	14.56/19.38/24.19 MVA

Three phase, 60 hertz, class OA/FOA/FOA, 13.89% (1A & 1B), 13.8% (2A), or 13.9% (2B) impedance at 13-MVA base.

B. 4160-Volt Switchgear

The general arrangement of buses F, G, H, J, K, and L, including the description of loads supplied, is indicated in the single-line diagrams of drawings D-177005, D-207005, D-177006, D-207006, D-177018, D-207018, C-177027, D-207027, C-177043, and C-177044. The switchgear is of metal-clad construction and is equipped with three-pole, drawout-type, electrically and remotely controlled circuit breakers. The ratings of the switchgear are as follows:

1. Rated short-circuit current = 41-kA rms (sym) at 4.76-kV.

2. Rated current of breakers:

   - 1200 amperes
   - 2000 amperes
   - 3000 amperes

3. Rated current of main bus bars:

   - 1200 amperes
   - 2000 amperes
   - 3000 amperes

C. 600-Volt Load Center

Drawings D-177007, D-207007, D-177009, D-207009, D-177010, D-207010, D-177011, D-207011, C-177012, D-177014, D-207014, D-177015, D-207015, D-177045, D-207045, D-177046, D-207046, D-177677, and D-177678 show the bus and feeder arrangement of load centers A, C, D, E, F, H, J, K, L, R, and S. The main bus bars, rated at 1600 amperes and 600 volts, are braced for a fault duty of 22,000 amperes ac. The load centers are of metal-enclosed construction and are equipped with three-pole, drawout-type, electrically and remotely controlled air circuit breakers, except load center F, which is equipped with a manually operated

breaker. All breakers are rated to interrupt a fault current of 22,000 amperes at 600 volts. The continuous current ratings and trip sensor rating for the breakers are given in the relevant single-line diagrams. The breaker trip settings for each breaker can be found on its associated relay setting sheet (see drawings A-177048 or A-207048).

D. 600-Volt and 208-Volt MCCs

The MCCs are equipped with combination across-the-line starter and molded-case circuit breakers and have the following ratings:

	600-V MCC	208-V MCC
Breaker interrupting current rms (sym)	18,000 A	18,000 A
Starter size, minimum	No. 1	No. 1
Bus rating	600 A	150 A

The 208-V MCCs obtain their power supply from the associated 600-V MCC through 30-kVA, 45-kVA, or 75-kVA 600- to 208/120-V dry-type transformers. The 600-V and the 208-V MCC form a single lineup. The 600-208/120-V transformer in each MCC is protected on the 600-V side by a molded-case circuit breaker or a disconnect switch and fuses.

8.3.1.1.4 120-Volt Vital Instrument Power System

Four redundant channelized 120 V-ac vital instrumentation distribution panels are provided for each unit to supply power for essential instrumentation and control loads under all operating conditions (see drawings D-177024, D-207024, D-177025, and D-207025). Each distribution panel is supplied separately from a static inverter.

The normal power source for each static inverter is the associated Class 1E battery charger via the 125 V-dc switchgear. Loss of the battery charger will not render the normal power source inoperable, as the inverter will automatically begin to draw power from the associated Class 1E battery via the same 125 V-dc switchgear without interruption. In case of inverter failure, overload, or branch fault resulting in inverter output voltage outside the specified limits, the static transfer switch (STS), which is part of the inverter unit, transfers the 120-V vital ac distribution panel to an alternate source: Class 1E CVT. Retransfer of the inverter back to its normal power source can only be achieved manually. Each inverter is also equipped with a manual bypass switch (MBS) to be used when the inverter is to be taken out of service for maintenance purposes.

Each of the four redundant channels of nuclear instrumentation, as described in chapter 7, is supplied from a separate channelized distribution panel. Also, each of the four independent and redundant channels of the reactor protection system and engineered safeguards system is

supplied from a separate channelized distribution panel. The system is arranged so that any type of single failure within the system will involve only one channel and will not prevent the reactor protection system or the engineered safeguards system from performing its safety function.

Two redundant train oriented 120 V-ac vital instrumentation distribution panels are provided for each unit to supply power to nonchannelized essential instrumentation and control loads under all operating conditions (see drawings D-177024, D-207024, D-177025, and D-207025). Each train oriented distribution panel is supplied in a manner similar to the channelized instrumentation distribution panels.

8.3.1.1.5 120 Volt-ac Regulated Instrument Power System

The system provides power for nonessential instrumentation, control, and loads requiring regulated 120 V-ac power. It consists of distribution panels and regulating transformers fed from MCCs as shown in drawings D-177024, D-207024, D-177025, and D-207025.

8.3.1.1.6 208/120 Volt-ac Power System

The distribution cabinets that make up the 208/120 V-ac, 3-phase, 4-wire, unregulated power system derive their supply from a 208-V MCC or the 120/208-V switchgear located in the turbine building. The system provides power for nonessential instrumentation, small motors (3-hp and less), and other miscellaneous 208- or 120-V loads.

The 208/120 V-ac distribution panels have a main bus which shall be compatible with the maximum design load assigned to the panel and can withstand the short circuit current calculated for the actual location of the panel. The branch circuit breakers are of molded case design and provide overload and short circuit protection for the panels and are capable of interrupting fault current.

Safety-related loads are supplied from distribution panels fed from safety-related MCCs. The distribution system is arranged to provide adequate independence and redundancy so that a single failure will not prevent the ESF system from performing its required function. Some nonsafety-related loads are fed from safety-related distribution cabinets. These nonsafety-related loads will not affect the integrity of the safety-related loads.

All other nonsafety-related loads are supplied from distribution panels fed from nonsafety-related MCCs and various other distribution cabinets fed from the 120/208-V switchgear.

8.3.1.1.7 Onsite Emergency Power Systems

8.3.1.1.7.1 <u>General</u>. The onsite emergency ac power supply for Units 1 and 2 consists of five diesel generators which supply standby power for 4160-V emergency buses F, G, H, J, K, and L

of each unit when offsite power is unavailable. These buses provide power to the emergency loads. As documented in Section 8.3.3 of NUREG 0117, Supplement 5 to NUREG-75/034 dated March 1981, the NRC acceptance criteria associated with the design of the diesel generators and their auxiliary systems is contained in GDC 17, 18, 21, and NUREG/CR-0660.

The LOSP loads are the emergency loads required to function during the shutdown process of a nonaccident unit when that unit experiences the loss of its offsite power sources.

The engineered safeguard system loads are the emergency loads required to function during the shutdown process of an accident unit.

The emergency loads are divided between the emergency buses of each unit in two balanced, redundant load groups so that the failure of a redundant group does not prevent the safe shutdown of either reactor.

The 4160-V emergency buses F, H, and K of each unit and their associated emergency loads are designated as the redundant load group train A.

The 4160-V emergency buses G, J, and L of each unit and their associated emergency loads are designated as the redundant load group train B.

Diesel generators 1-2A and 1C are assigned to the redundant load group train A, while diesel generators 1B, 2B, and 2C are assigned to the redundant load group train B (as discussed below, diesel generator 2C is dedicated to SBO events).

The five diesel generators are of two different sizes, as follows: three 4075-kW diesel generators 1-2A, 1B, and 2B and two 2850-kW diesel generators, 1C and 2C.

The capacity of each of these diesel generators ensures that sufficient power will be available at its respective emergency bus to provide for the operation of its required emergency loads during design basis events or an SBO event as applicable.

The design of the onsite emergency power system is such that the plant meets its licensing basis for all design basis events using only four of the diesel generators, namely 1-2A, 1C, 1B, and 2B.

Therefore, these four diesel generators are dedicated for use during the design basis events as discussed in paragraph 8.3.1.1.7.2.

Diesel generator 2C is dedicated as the alternate ac (AAC) power source for use during station blackout (SBO) events as discussed later in paragraph 8.3.1.1.7.3.

Diesel generator 2C, being the AAC for SBO events, is not considered a candidate for the design basis single failure. However, diesel generator 2C meets all applicable safety-related criteria and thus, it is available for use on B-train during design basis events.

Each generator is supplied with a high-speed voltage regulator designed to return generator voltage to its rated value within an acceptable delay after starting of the largest motor.

Voltage and frequency relays connected to potential transformers on the diesel generator output circuit at the local control panel detect generator voltage and frequency conditions. When voltage and frequency conditions are acceptable, they provide a permissive interlock for closing of the respective generator output circuit breaker.

Interlocks are provided to prevent closing of a diesel generator breaker to a faulty bus.

Synchronizing by the plant operator is performed per plant procedures when paralleling the diesel generator with the startup auxiliary transformers.

Each diesel generator is equipped with means for periodic starting to test for readiness and loading, and means for synchronizing the unit onto the bus without interrupting the service.

The diesel generators 1-2A, 1B, 1C, 2B, and 2C starting circuit includes a start to idle feature which allows the operator to perform a modified start for maintenance or surveillance testing in order to reduce stress and wear on the diesel engine. With the idle start mode selected, a manual diesel generator start brings the diesel generator up to idle speed with the field flash circuit blocked. Following engine warmup at idle speed, the operator can raise the engine speed to rated and manually flash the field by placing the RATED/IDLE selector switch in the RATED position. For diesel generator 2C, if either Unit 1 or 2 experiences a station blackout while the diesel generator is in the idle mode, depressing the SBO start pushbutton automatically places the circuit in the rated mode and the diesel generator responds normally. For diesel generators 1-2A, 1B, 1C, and 2B, either a safety injection signal or undervoltage signal received while the diesel generator is in the idle mode automatically places the circuit in the rated mode and the diesel generator responds normally.

Diesel fuel oil storage tanks and day tanks provide sufficient fuel oil to support required diesel generator operation. The diesel generator fuel oil system is described in subsection 9.5.4.

The quality of fuel oil in long term storage is monitored by periodic sampling of the fuel oil in the storage tanks and sampling of new fuel in accordance with plant procedures. If the fuel oil in the storage tanks does not meet the required specifications identified in the plant procedures, corrective actions are initiated to return the fuel oil within the acceptable limits. These corrective actions may range from chemical additions to complete replacement of the fuel oil.

The diesel generators are housed in reinforced concrete, Category I seismic structures. Each unit is completely enclosed in its own concrete cell and isolated from the other units. Each diesel generator has an electrically powered standby warming system which will automatically maintain the engine, cooling water, and lubricating oil temperature at a satisfactory level to allow fast starting of the diesel generator sets. Local annunciation and local indication of malfunctions are provided so that, in the event of a failure, an operator may immediately determine the cause. Two complete and independent starting-air-supply systems with receivers, valves, and fittings are supplied with each diesel. The starting air receivers for each of the starting systems have enough capacity for a minimum of five consecutive starts.

Each diesel generator is cooled through a closed loop series of three heat exchangers. For diesels 1-2A, 1B, and 2B, service water enters the intercooler heat exchanger through an engine-driven cooling water pump, passes through the jacket water heat exchanger, and finally through the lubricating oil heat exchanger before returning to the service water system. For diesels 1C and 2C, service water enters the intercooler heat exchanger through an engine driven cooling water pump, passes through the lubricating oil heat exchanger, and finally through the jacket water heat exchanger before returning to the service water system.

The cooling medium flowing through the tube side is part of the service water system. Each diesel engine heat exchanger can be supplied from two service water headers. The cooling water system for the diesels is discussed in subsection 9.5.5.

Typically, emergency diesel generator engines for this service operate for approximately 3 min at full load without cooling water supply. This provides time, in the event of a dead bus, for the initiation of flow in the service water system.

The dc power required for emergency buses and diesel generators for Units 1 and 2 is provided as shown on drawings D-177082, D-177083, D-207082, and D-207083. Diesel generators 1-2A, 1C, and 2C can receive dc power from either Unit 1 or Unit 2 batteries. Automatic transfer switches, mechanically held, are provided. The transfer is initiated when the selected source is deenergized.

Loss of dc control power for each diesel generator is annunciated locally and in the control room. The alarm local to the diesel generators indicates “control circuit failure” upon loss of dc control power. The control room alarm is located on the EPB and alerts the operators to “diesel generator trouble.” At the same time the EPB annunciator sounds, the diesel generator “ready for automatic start” lamp goes out. The lamp is also located on the EPB.

During emergency power operation only a limited number of protective devices will lead to a trip of the unit. These will include the following:

- Engine overspeed.
- Lubrication oil pressure low.[a]
- Generator differential.

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a. Two lube-oil pressure switches will be installed and wired in series so that two-out-of-two signals will be necessary to trip.

During periodic testing operation, the conditions causing a trip are as follows:

- Engine overspeed.
- Generator differential.
- Lubrication oil pressure low.
- High jacket water temperature.
- High lubrication temperature.
- Generator under frequency.
- Reverse power flow.
- Loss of excitation.
- Jacket water pressure low.
- Crankcase pressure high.
- Generator overcurrent.

Should a diesel fail to achieve sufficient speed to clear its starting interlocks within 7 s, its starter air supply and the fuel are cut off and an alarm is sounded.

8.3.1.1.7.2 **Response to Design Basis Events.** During normal plant operation the four design basis diesels 1-2A, 1C, 1B, and 2B are set for emergency operation, each with its mode selector switch (MSS) in Mode 1 position. With this setting, the starting, alignment, and loading of these four diesel generators are entirely automatic in all design basis events, with no need for any manual operator action.

These four diesel generators are each uniquely assigned to a redundant train of safe shutdown equipment for one unit in each design basis event.

A safety injection (SI) signal from either unit will start shared diesel generators 1-2A and 1C. Diesel generators 1B and 2B will also start on an SI signal if their corresponding unit is experiencing an accident.

An undervoltage (LOSP) signal on the 4-kV ac train A buses of either unit will start the associated shared diesel generator (diesel generator 1-2A associated with buses 1F and 2F, diesel generator 1C associated with buses 1H and 2H). Diesel generators 1B and 2B will also start upon receipt of an undervoltage (LOSP) signal from their assigned 4-kV ac train B buses (diesel generator 1B assigned to bus 1G and diesel generator 2B assigned to bus 2G).

Diesel generators 1B and 2B are uniquely dedicated to train B of Unit 1 and Unit 2, respectively. Diesel generators 1-2A and 1C are shared between both units and are directly connectable to the units through dedicated breakers, not through bus interties. Diesel generators 1-2A and 1C are dedicated to train A, but there are no design basis events in which diesel generator 1-2A or 1C supplies power to safety loads of both units simultaneously. In all events, diesel generators 1-2A and 1C are assigned to only one of the two units, depending on the event. The Unit 1 and Unit 2 breakers for each of these two diesels are interlocked so as to prevent the diesels from being connected to both units at the same time; therefore, diesel generators 1-2A and 1C are characterized as "shared" only from the point of view of their capability to align to either Unit 1 or Unit 2.

The capacity of the diesel generators and their unit alignment must ensure adequate power for the safe shutdown loads during the worst case loading scenario (LOSP on both units concurrent with a loss-of-coolant accident (LOCA) on one unit). Diesel generators 1-2A, 1B, and 2B each have a continuous rating of 4075 kW (4353 kW for the 2000-h rating), which is sufficient to ensure adequate power for one complete train of normal (LOSP) or accident shutdown loads in one unit. Diesel generator 1C has a continuous rating of 2850 kW (3100 kW for the 2000-h rating), which is sufficient to ensure adequate power for one complete train of normal (LOSP) shutdown loads in one unit.

Consequently, the alignment of train B diesel generators 1B and 2B, which remains the same during all design basis events, ensures adequate power for a complete train B of LOSP or accident shutdown loads in each unit.

Of the two train A diesel generators, 1-2A and 1C, diesel generator 1C has sufficient capacity to only provide power to a complete train of shutdown loads of a nonaccident unit (LOSP only). Since a LOCA is assumed to occur on only one unit, the alignment logic of these two train A diesel generators is designed to ensure that in events involving a LOCA, diesel generator 1-2A aligns to the accident unit and diesel generator 1C aligns to the nonaccident unit. The alignment chosen for these train A diesels in scenarios involving LOSP only is arbitrary (1-2A is aligned to Unit 1 and 1C is aligned to Unit 2 for a dual unit LOSP event), since both diesel generators 1-2A and 1C have sufficient capacity to energize the required loads in these events. Therefore, the alignment logic of the two train A diesel generators, 1-2A and 1C, ensures adequate power for a complete train of required shutdown loads in each unit.

When offsite power is not available from the startup auxiliary transformer, the emergency buses are isolated from those sources and all main-load feeder breakers off these buses are tripped.

The emergency loads required for design basis events are automatically energized by the diesel generators in a predetermined sequence with time intervals sufficient to allow the inrush current of large motors to decay and the diesel generator to recover from one load step prior to the application of the next load step. Drawings D-177645, D-177646, D-177647, D-177648, D-177649, D-177650, D-177653, and D-177654 show the loading sequence for diesel generators 1-2A, 1B, and 1C for Unit 1. Similar circuits determine the loading for diesel generators 1-2A, 2B, and 1C for Unit 2.

The loading requirements of the emergency buses, as a function of time for the design basis accident and for the shutdown conditions, are shown in table 8.3-1. The main loads in the loading tables are conservatively based on a detailed analysis of the manufacturer’s data (nameplate ratings, horsepower curves) and the field preoperational test results. The miscellaneous loads are determined by the nameplate ratings along with application of an appropriate diversity factor.

The alignment and maximum estimated loading of each design basis diesel generator during all design basis and SBO events are shown in tables 8.3-2 and 8.3-2A, respectively.

The diesel generator ratings in table 8.3-3 are compared to the maximum calculated automatic sequenced loading for design basis and SBO events. This table, in conjunction with tables 8.3-1, 8.3-2, and 8.3-2A demonstrates that each of the diesel generators and its respective alignment to the emergency buses are adequate to supply their required loads during design basis events.

Due to the full redundancy provided by the four diesel generators and the existing full redundancy of the safe shutdown loads, the failure of a complete train in one unit will not prevent the safe shutdown of that unit.

It should be noted that if an emergency situation occurs while a diesel generator is being prepared for test with its MSS in Mode 2 position (remote manual), the automatic signals generated by the emergency situation (SI and/or LOSP) will override the test mode and, therefore, the diesel generator will automatically start and align for the event.

8.3.1.1.7.3 <u>Response to Station Blackout (SBO)</u>. FNP is capable of withstanding and recovering from a total loss of both offsite and onsite emergency ac power sources (called "station blackout") as required by 10 CFR 50.63 for a specified duration. For Farley, this duration was determined to be 4 h. This ability to cope with an SBO is consistent with the guidance contained in Regulatory Guide 1.155 and NUMARC 87-00, including supplement, and therefore meets the NRC acceptance criteria contained in 10 CFR 50.63.

The initiating event is assumed to be a LOSP at a plant site. At a multiunit site such as Farley, the LOSP is assumed to affect all units, while the SBO is assumed to occur in only one unit.

SBO is not a design basis accident (DBA). Therefore, single failures of equipment and other assumptions normally considered for DBAs and analysis need not be considered. The unaffected unit must be able to achieve safe shutdown with a single failure; a DBA need not be considered.

FNP selected the AAC approach for coping with an SBO event and dedicated Class 1E diesel generator 2C as the AAC power source to cope with an SBO event in either unit for the required duration (4 h).

Given this selected approach and the assumptions that must be made (LOSP on both units concurrent with the simultaneous failures of any three of the four diesel generators: 1-2A, 1C, 1B, and 2B), an SBO event at FNP falls into one of the following four configurations:

1. SBO in Unit 1 (LOSP and failure of diesel generators 1-2A and 1B) concurrent with the Unit 2 LOSP and failure of diesel generator 1C.

2. SBO in Unit 1 (LOSP and failure of diesel generators 1-2A and 1B) concurrent with the Unit 2 LOSP and failure of diesel generator 2B.

3. SBO in Unit 2 (LOSP and failure of diesel generators 1C and 2B) concurrent with the Unit 1 LOSP and failure of diesel generator 1-2A.

4. SBO in Unit 2 (LOSP and failure of diesel generators 1C and 2B) concurrent with the Unit 1 LOSP and failure of diesel generator 1B.

In all four of the above configurations, diesel generator 2C will be manually aligned and started from the control room and automatically loaded. The remaining design basis event diesel in the non-SBO unit will be aligned, started, and loaded automatically utilizing its respective logic. The SBO configurations are shown in table 8.3-2A.

An SBO in Unit 1 assumes LOSP on both units concurrent with the failure of both redundant diesel generators 1-2A and 1B in Unit 1. At least one of the two redundant Unit 2 diesel generators, 1C and 2B, will be available to power a complete train of safe shutdown loads of Unit 2. Bus 1J is required to support operation of diesel generator 2C in the event of a Unit 1 SBO.

A complete train B of safe shutdown loads of Unit 1 will be powered by diesel generator 2C as the dedicated AAC source for this event. The starting and unit selection are performed manually by operator actions from the EPB in the control room. The closing of diesel generator 2C Unit 1 breaker DJ06, as well as the loading of diesel generator 2C with Unit 1 train B safe shutdown loads are automatic. The Unit 1 train B large LOSP shutdown loads are sequenced onto diesel generator 2C by the Unit 1 train B LOSP sequencer. This is identical to the loading of diesel generator 1B with Unit 1 train B large LOSP shutdown loads during a LOSP event in Unit 1.

An SBO in Unit 2 assumes LOSP on both units concurrent with the failure of both redundant diesel generators 1C and 2B in Unit 2. At least one of the two redundant Unit 1 diesel generators 1-2A and 1B will be available to power a complete train of safe shutdown loads of Unit 1. Bus 2J is required to support operation of diesel generator 2C in the event of a Unit 2 SBO.

A complete train B of safe shutdown loads of Unit 2 will be powered by diesel generator 2C as the dedicated AAC source for this event. The starting and unit selection are performed manually by operator actions from the EPB in the control room. The closing of diesel generator 2C Unit 2 breaker DJ06, as well as the loading of diesel generator 2C with Unit 2 train B safe shutdown loads are automatic. The Unit 2 train B large LOSP shutdown loads are sequenced onto diesel generator 2C by the Unit 2 train B LOSP sequencer. This is identical to the loading of diesel generator 2B with Unit 2 train B large LOSP shutdown loads during a LOSP event in Unit 2.

A comparison of the maximum loading of diesel generator 2C to its rating during an SBO event is shown in table 8.3-3.

The above evaluation demonstrates that diesel generator 2C can be characterized as a fully capable AAC power source since it has the capacity to power a complete safety train (train B) of LOSP shutdown loads for one unit, and therefore is able to safely shut down either unit in the event of an SBO in that unit.

Although diesel generator 2C is dedicated the AAC power source, it still may be used during design basis events if diesel generator 1B or 2B fails. Diesel generator 2C does not have the capacity to carry a complete train of ESS loads in one unit in the event of a LOSP and LOCA but it can be used to power partial train B loads.

8.3.1.1.8 Tests and Inspections

Class 1E electric power systems are designed to permit periodic testing of the following aspects of the electric power system:

A. The operability and functional performance of the components of Class 1E electric power systems (diesel generators, emergency buses, dc system, and 120-V vital instrument power system).

B. The operability of these electric power systems as a whole, and under conditions as close to design as practical, including the full operational sequence that brings these systems into operation.

The 230-kV and 500-kV circuit breakers will be inspected, maintained, and tested on a routine basis. This can be accomplished without removing the generators, transformers, and transmission lines from service.

Transmission line protective relaying will be tested on a routine basis. This can be accomplished without removing the transmission lines from service. Generator, unit auxiliary transformer, and startup auxiliary transformer relaying will be tested when the generator is offline. Protective relaying associated with the 4160-V and the 600-V systems has provisions for inservice testing and calibration.

The 4160-V and 600-V circuit breakers and associated equipment can be tested when the individual equipment controlled by the breaker is shut down. The circuit breakers may be placed in the "test" position and tested functionally. Circuit breakers and contactors for redundant or duplicated circuits can be tested one at a time without interfering with the operation of the plant.

Preventive maintenance, inspection, and testing intervals for Unit 2 circuit breakers required to be operable as containment penetration conductor overcurrent protective devices are specified in the Technical Requirements Manual.

Channel calibration intervals for safety-related motor-operated valves thermal overload protection devices which are not permanently bypassed are specified in the Technical Requirements Manual.

[HISTORICAL]

[*Following final assembly and preliminary startup testing, each diesel generator unit has been tested at the site, prior to reactor fuel loading, to demonstrate the capability of the unit to perform up to the limits of design. The following tests have been performed on the diesel generator units to certify the adequacy of the unit for the intended service:*

A. Starting tests have demonstrated the capability to attain frequency and voltage within the rated limits and time.

B. Load acceptance tests have demonstrated the capability to accept the desired loads in the desired sequence and time duration.

C. Operation tests have demonstrated the capability of carrying the required loads without exceeding the manufacturer's design limits, in accordance with drawings D-177033, D-177032, D-177036, and D-177037.

D. Load rejection tests have demonstrated the capability of rejecting the largest single load without exceeding speeds or voltages which will cause tripping, mechanical damage, or harmful overstresses.]

The diesel generator units are tested/inspected periodically, in accordance with the Technical Specifications or the Technical Requirements Manual, as applicable, to demonstrate the continued capability of the unit to perform to the limits of the qualified design. The diesel generator surveillance test frequency is generally based on Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," Revision 1, August 1977, with adjustments made in accordance with Generic Letters and adjustments made to preclude overtesting which has been verified by the manufacturer to be detrimental to diesel generator reliability. In addition, Farley has an NRC approved Surveillance Frequency Control Program which allows adjusting certain surveillance test frequencies per the provision of the Technical Specification 5.5.19. Refer to the Surveillance Test Internal List Bases for a further discussion of diesel generator surveillance test frequency conformance to Regulatory Guide 1.108.

4.16-kV emergency bus loss of voltage relays, degraded grid voltage relays, and degraded grid voltage alarms are periodically tested in accordance with the Technical Specifications.

8.3.1.1.9 Design Criteria

The criteria used for initial design and procurement of electrical equipment associated with safety-related systems are provided below. Evaluations performed to ensure the components and associated systems meet the design intent are based on information specific to the application.

A. Motors

Motor Size:

The horsepower rating of the motors is based on continuous operation of the driven equipment load without exceeding the NEMA standard temperature rise above the stated ambient temperature.

Motor Starting Torque:

Motors are capable of accelerating the load in accordance with the load-speed torque curves with 75-percent rated motor-nameplate voltage at the motor terminals.

Motors rated 250 hp and above have minimum torque values in percent-of-full-load torque as follows:

Locked rotor torque............ 100 percent

Pull-up torque .... 75 percent
Breakdown torque.............. 200 percent

The starting current does not exceed 6.5-times full-load current at rated voltage and frequency.

Motors rated 200 hp and below have torque characteristics as established in NEMA Standards for Designs B and C, without the starting current exceeding 6.5-times full-load current at rated voltage and frequency.

Insulation:

The motor insulation system is designed for the special environmental conditions described in table 3.11-1. The insulation system is a combination of materials and processes which provide high resistance to moisture, radiation, and other contaminants experienced by the motors in specified service conditions.

B. Interrupting Capacity of Breakers

The interrupting capacities of breakers associated with 4160-V switchgear, 600-V load centers, 600-V and 208-V MCCs, and distribution panels are adequate to interrupt the maximum calculated fault current experienced on the associated circuit. Paragraph 8.3.1.1.3 gives the interrupting capacities for 4160-V switchgear, 600-V load centers, and 600-V and 208-V MCCs. Paragraph 8.3.1.1.6 gives the interrupting capacities for 208/120 V-ac distribution panels. Paragraph 8.3.2.1.4 gives the interrupting capacities for the dc distribution panels.

Relay settings are established to provide coordinated tripping of related feeders and are shown on relay setting sheets. These sheets are controlled design documents similar to engineering drawings and are handled and stored in the same manner.

C. Grounding Requirements

All electrical equipment and building steel, such as motor frames, load centers, lighting cabinets, contactors, conduits, cable trays, transformer tanks, stairs, handrails, etc., are effectively and permanently grounded by direct connection to the building ground bus.

Each floor has its own ground bus which is connected by a number of vertical conductors to the main ground bus on the grade level.

8.3.1.2 Analysis

The following analysis demonstrates compliance with NRC General Design Criteria 17 and 18; NRC Regulatory Guides 1.6, 1.9, and 1.155; and IEEE Standard 308.

A. Compliance with Criterion 17

The ESF system is designed with sufficient capacity, independence, and redundancy to ensure that core cooling, containment integrity, and other vital functions are maintained in the event of postulated accidents, assuming a single failure.

The engineered safety features ac power system of each unit is divided into two separate and redundant subsystems. Each subsystem is comprised of 4160-V switchgear buses, 600-V load centers, 600-V/208-V MCCs, and 120-V vital instrument power system buses (refer to subsection 8.3.1 for the ac power system details). The ac power system has adequate capacity and capability to start and supply the engineered safety feature load necessary to safely shut down the reactor, without exceeding fuel design limits or reactor coolant pressure boundary limits, defined in the Technical Specifications, during normal operation or any design basis event. Each diesel generator unit is capable of supplying, without exceeding its design rating, the loads of its associated ac power subsystem that are required for operation during design basis events and hot shutdown conditions. See paragraph 8.3.1.1.7 and tables 8.3-1 and 8.3-2 for details.

In the event of a loss of all onsite power and the failure of an offsite circuit, power for the redundant ESF load group is available through the other offsite circuit. No switching of circuits is necessary to achieve this.

Supply to the ESF buses from the onsite power source during any design basis event is established automatically only if the supply from the network is disconnected. This ensures that any failure or fault in the network will not affect the ESF distribution system.

Complete separation and independence has been maintained between the two train systems so that any single failure in one train will not prevent the other train from performing its required safety function.

As shown in drawing D-177001, the ESF buses for each unit are connected to the 230-kV switchyard by two physically independent circuits through startup auxiliary transformers. The switchyard is connected to the network by four 230-kV and two 500-kV high voltage transmission lines. See section 8.2 for a detailed description of the offsite power system. A fault on any component of the two offsite circuits will result only in the loss of power to the associated ESF buses aligned to the faulted circuit. Power can be restored to the affected buses from the other startup auxiliary transformer by manual switching.

B. Compliance with Criterion 18

The auxiliary electrical system is designed to permit inspection and testing of all important areas and features, especially those that have a standby function and

whose operation is not normally demonstrated. Details of the testing program for the ESF equipment including diesel generators are discussed in paragraph 8.3.1.1.8.

Testing of the integrity of safeguard action initiating relays with the unit in service is discussed in paragraph 7.2.2.2.1.F.

C. Compliance with Regulatory Guide 1.6

The standby ac power system for both units consists of five diesel generator sets, feeding two independent and redundant safety load groups.

Each load group has the capability to provide the minimum safety functions necessary to shut down the unit and maintain it in the safe shutdown condition. Each diesel can be aligned only to load groups within its own redundant system. Diesel 1-2A automatically aligns itself with the accident unit.

Except for the following, no provision has been made in the design to permit a load or a bus to swing between redundant power sources:

- Component Cooling Water Pump B
- Safety Injection Pump B
- Service Water Pump C
- Auxiliary Building Battery Charger C
- 600-V Load Center F.

In each of the above cases, a breaker and a disconnect switch separate the two trains so that a failure of either one will not affect the redundant train.

Key interlocking (see drawings C-177118, C-177119, C-177120, C-177121, and C-177133 for Unit 1 and D-207118, D-207119, D-207120, D-207121, and D-207133 for Unit 2) ensures alignment to one train only.

The design of the ESF system meets the requirements of the guide and particularly the following:

1. No provisions exist for automatically paralleling two diesel generators from redundant load groups. There are also no provisions for automatically paralleling two diesel generators within the same load group to the same ac buses within one unit. Although it it possible to parallel two diesels of the same load group manually to the same unit during testing, operating procedures specifically call for testing one diesel at a time. As stated above, the parallel operation of diesel generators from redundant load groups is not feasible.

2. No provisions exist for automatically transferring loads between redundant power sources.

D. Compliance with Regulatory Guide 1.9

The selection of diesel generators 1-2A, 1B, 1C, 2B, and 2C conforms with the purpose of this guide to provide an adequate power source for meeting the starting and continuous power requirements of the safety-related loads. The ratings are discussed in paragraph 8.3.1.1.7.

The sequencing of large loads at 5-s intervals allows large motors to accelerate before the succeeding loads are applied. Dynamic simulations (based on verification testing) are used to model the response of critical components (generators, buses, and loads). The results are evaluated to verify satisfactory performance of the required loads. Engineering evaluations verify that the MCC contactors and other relay type components can function as required during the first load step. After the first load step, the decreases in frequency and the MCC voltages are limited to 95 and 60 percent of nominal, respectively. This ensures that the succeeding voltage dips will not affect the continued operation of the MCC contactors and other relay type components.

Prototype qualification tests on 4075-kW diesels and actual tests conducted on 2850-kW units indicate that the diesel generators are capable of starting and accelerating the required ESF loads to rated speed in accordance with the sequence shown in tables 8.3-1 and 8.3-2.

E. Compliance with IEEE 308

All components of the Class 1E electric system (discussed in paragraph 8.3.1.1) are designed to meet their functional requirements under conditions produced by the design basis events.

The Class 1E electric system has been designed to voltage and frequency limits for proper functional requirements of the ESF equipment.

All incoming circuits to ESF buses are monitored in the control room through breaker position indication lights and/or by analog indicators. Abnormal conditions of these circuits are annunciated in the control room. Separate status indication lights are provided for monitoring each diesel generator and its associated equipment.

Complete separation and independence has been maintained between all redundant systems so that any component failure in one ESF load group will not disable any component in the other ESF load group. See paragraph 8.3.1.4 for a detailed analysis of Independence of redundant systems.

[HISTORICAL]
[*The Class 1E electric equipment was purchased and installed under a strict quality assurance program described in subsection 17.1.2. Certified records of quality assurance inspections and tests performed during production were obtained from the manufacturer.*

The ESF 4160-V switchgear, 600-V load centers, and 600-V motor control centers have been qualified by both tests and successful application under similar operating conditions. Current-carrying capability and fault interrupting tests have been successfully performed on prototypes in accordance with applicable ANSI standards listed in subsection 8.1.4. Standard production tests were performed on the above equipment assemblies in accordance with the same ANSI standards.

*Class 1E equipment has been qualified to meet seismic requirements by either tests or analyses, or by a combination of both. This is discussed at length in section 3.10.****]***

Each component of the Class 1E electric system in one train has a redundant component in the other train. A single failure within a train, therefore, will not prevent satisfactory performance of the minimum ESF loads required for safe shutdown and for maintaining the plant in a hot shutdown condition.

The Class 1E electric systems are designed to preclude a common mode failure for two or more diesel generator units under conditions of a design basis event.

Provision has been made to disconnect the non-Class 1 equipment from the Class 1E systems by Class 1 breakers.

Following a loss of offsite power, the onsite power sources can accept full loads within a time compatible with the ESF loading requirements.

Automatic and manual controls are provided to permit the following:

1. Selecting of the most suitable power source for the Class 1E electric system.

2. Disconnecting the appropriate loads when offsite power is not available.

3. Starting and loading the onsite power supply.

Protection systems are provided and designed to isolate failed equipment and to identify the equipment that has failed. For the protection system related to the ESFs and essential functions, complete redundancy, independence, and inservice testability have been provided.

Essential instrumentation, control, and power requirements are supplied by reliable, independent, and redundant sources designed to ensure that no single failure will result in loss of power to redundant safety-related equipment.
Table 3.2-1 identifies the safety-related equipment required to operate in a hostile environment. A discussion of the qualification tests and design bases for this equipment is given in section 3.11.

F. Compliance With Regulatory Guide 1.155, "Station Blackout"

FNP selected the AAC approach for coping with an SBO event and dedicated Class 1E emergency diesel generator 2C as the AAC power source to cope with an SBO event in either unit for the required duration (4 h). The remaining four diesel generators -- 1-2A, 1B, 1C, and 2B -- ensure that the plant meets its licensing commitments for all design basis events.

The Farley approach to SBO meets the basic requirements for an "AAC" as stated in RG 1.155, section 3.3.5 and as summarized below:

1. It is connectable to but not normally connected to the offsite or onsite emergency ac power systems.

2. It has minimum potential for common mode failure with offsite or onsite emergency ac power sources.

3. It is available in a timely manner after the onset of an SBO. The time required for making this equipment available should not be more than 1 h; therefore, plants using the AAC approach must assess their ability to cope for 1 h. However, if an AAC power source can be shown by test to be available within 10 min of the onset of SBO, then no coping assessment is required.

   The 10-min requirement is meant to cover the period between the time when the operator realizes that an SBO has occurred and the time when the AAC source is ready for loading the shutdown loads. When actions from the control room are unsuccessful in restoring offsite or onsite emergency ac power, the onset of SBO has been verified. If the AAC source can be started and ready for loading within the next 10 min, taking all actions from within the control room, the 10-min criterion is met.

4. It has sufficient capacity and reliability to operate the systems necessary for coping with an SBO for the time required to bring the plant to and maintain it in safe shutdown. Therefore, the AAC source must power all the shutdown loads, which would normally be powered by the onsite emergency ac source(s) in the event of an LOSP.

   An AAC power source serving a multiunit site where onsite emergency ac sources are not shared between units should have, as a minimum, the capacity and capability for coping with SBO in any of the units. If the onsite

emergency ac sources are shared between units, the AAC power source(s) should have the capacity and capability to ensure that all units can be brought to and maintained in safe shutdown.
At multiunit sites, where the combination of onsite emergency ac sources exceeds the minimum redundancy requirements for normal safe shutdown (non DBA) of all units, one of the existing onsite emergency ac sources may be used as an AAC power source provided it meets the applicable criteria for an AAC source. Also, an existing onsite emergency ac source could qualify as an AAC source on the basis of excess capacity provided specific modifications to enhance connectability are made.

If an existing Class 1E emergency diesel generator is used as an AAC power source, this existing Class 1E diesel generator must continue to meet all applicable safety-related criteria.

Paragraph 8.3.1.1.7.3 demonstrates Farley compliance with the above regulatory requirements.

8.3.1.3 *[HISTORICAL] [Conformance With Appropriate Quality Assurance Standards*

To ensure conformance with requirements of appropriate quality assurance standards and criteria such as IEEE Standards and NRC Criteria B-10 CFR 50, a field quality control program is being enforced by use of written field quality control procedures, checklists, and planned periodic audits.

A. Receipt

The installation prerequisites of the above standards, and criteria for electrical materials and equipment in both the ac and dc power systems, are being complied with by field receiving, inspection, and documentation procedures to verify conformance with specifications and drawings on receipt of equipment at the jobsite.

B. Storage

To preserve their integrity and prevent physical, mechanical, and/or electrical damage while in storage, an inspection and maintenance program is enforced by written procedures and manufacturer's recommendations.

C. Installation

An inspection program is also being enforced to ensure that the equipment is being located, installed, assembled and/or connected in strict accordance with latest approved-for-construction drawings, installation specifications and field quality control procedures.

The field quality control inspection program for equipment and material installation consists of checking for the required separation of redundant engineered safeguards, reactor protection, and the balance of Class 1E electrical system cables and components, and for proper termination and marking of these cables.

D. *Testing*

A test program to verify the quality and performance of Class 1 and 1E instrumentation and electrical equipment is being planned and implemented. Procedures and instructions are being prepared to ensure that tests are performed in accordance with the latest specifications and requirements. A system will be established whereby construction testing procedures and instructions are prepared and approved by qualified test personnel. Test results will be documented and evaluated by the construction testing department to ensure that all components comply with specified design criteria. Nonconforming equipment will be identified and procedures to eliminate the nonconforming situation will be initiated.

Tests during construction will include, as appropriate, electrical continuity and resistance, phase rotation, proper circuit functioning, pressure tests, and other tests as necessary to assure equipment quality.

A procedure to ensure that test equipment meets required standards of accuracy will be enforced. Test instruments will undergo a periodic calibration and will be marked to indicate the date of the next required calibration. Test control will be established so that any construction or other work affecting the tests will be completed prior to the conduct of the test. Final construction verification will be conducted to ensure that all temporary connections have been removed, all deficiencies have been resolved, installation is in accordance with specifications, deterioration has not reduced quality, and equipment and system functions are in accordance with design.]

8.3.1.4 Independence of Redundant Systems

8.3.1.4.1 Design Basis

The design criteria for cable, electrical penetrations, and circuit routing have been established to prevent a failure in electrical cable and penetration systems from initiating a fire and to minimize and localize the effect of a fire should one occur. These criteria are met by the following provisions:

A. Cable derating and cable tray fill.

B. Cable routing.

C. Cable routing in cable spreading room.

D. Sharing of cable trays with nonsafety-related cables.

E. Fire detection and protection.

F. Cable and cable tray marking.

G. Spacing of wiring and components on control board and relay racks.

H. Fire barriers and separation between redundant trays.

I. Electrical penetrations.

8.3.1.4.2 Cable Derating and Cable Tray Fill

Ampacity rating of cables is established in accordance with IPCEA P-46-426 and manufacturer's standards. To this basic rating, a grouping derating factor, also in accordance with IPCEA P-46-426, is applied. Wherever applicable, a load diversity factor is taken into consideration. As a minimum, all power cables are selected utilizing a 100-percent load factor and continuously rated at 125 percent of the full-load current.

As a minimum requirement,[a] cable trays carrying low voltage power cables are limited to 40-percent fill by cross-section and 60-percent fill for trays carrying control cables. In addition, all 4-kV and larger 600-V cables will have, as a minimum, one cable diameter spacing between all cables in the same tray.

8.3.1.4.3 Cable Routing

Normal and emergency power and control cables are routed in a manner which meets the physical separation criteria presented in the following paragraphs. Cable and raceway installation throughout the plant is designed to satisfy the single-failure criteria and ensures an optimum level of circuit integrity and operating reliability.

Cables associated with redundant equipment are classified by safety train and are routed in redundant conduits, cable trays, ducts, penetrations, etc. (i.e., raceways), which are also classified by safety train. Cables are also classified and segregated by voltage level.

a. Cable trays may exceed the above fill limits if an engineering evaluation indicates that the included cables will satisfactorily perform their intended functions and there are no adverse seismic effects from the additional weight of the cables.

The first character after the facility (examples of facility identifiers are 1V for the auxiliary building, 1T for the containment building) in all cable and raceway numbers classifies the cable or raceway by safety train. A list of the characters used to identify the safety train classification of circuits and raceways is shown in table 8.3-5. The next character in all raceway numbers after the safety train classification identifies the voltage level of the circuits routed through the raceway. See table 8.3-4 for a list of the characters used to identify the raceway voltage level. Each cable is routed in the appropriate raceways based on the cable's safety train, voltage level, and usage.

Cable trays are arranged with the highest voltage at the top, the next higher voltage at the next level, etc., with instrumentation at the lowest level whenever feasible.

Power and control cables are installed in ladder-type trays and conduits. Low-level instrumentation cables are installed either in solid, nonventilated-type trays with solid covers or in rigid conduits.

Arrangement of electrical equipment and cabling will be such that fire in one redundant system will not propagate to the other system. In the absence of confirming analysis to support less stringent requirements, the following general rules are followed:

A. Routing of cables for instrumentation, control, or power through rooms or spaces where there is potential for accumulation of large quantities of oil or other combustible fluids through leakage or rupture of lube-oil or cooling systems is avoided. Where such routing is practically unavoidable, only one redundant system of cables is allowed in any such space, and the cables are protected from dripping oil by conduits or covered trays.

B. In any room or compartment in which the only source of fire is of an electrical nature, cable trays of redundant systems have a minimum horizontal separation of 3 ft if no physical barrier exists between trays.

   In the limited number of areas where separation of 3 ft is unattainable, a fire barrier(a) is installed extending at least 1 ft above (or to the ceiling), and 1 ft below (or to the floor). The separation provided when conduits are used for cable routing is described in appendix 3A. Refer to paragraph 8.3.1.4.4 for additional requirements in the cable spreading room.

C. For cable trays of redundant systems in any area in which the only source of fire is of an electrical nature, there is a minimum vertical separation of 5 ft between open-top trays stacked vertically one above the other, if no physical barrier is installed between trays. Vertical stacking of redundant trays is avoided wherever possible. In the limited number of areas where a vertical separation of 5 ft is unattainable, a fire barrier is placed between the two redundant systems. The barrier extends 1 ft on each side of the tray system. Refer to paragraph 8.3.1.4.4 for additional requirements in the cable spreading room.

D. In the case of crossover of one tray over another carrying redundant systems in any area in which the only source of fire is of an electrical nature, there is a minimum vertical separation of 15 in. (clear space between trays) with a fire barrier extending 1 ft from each side of each tray and 5 ft along each tray from the crossover.

E. Any openings in fire-rated-area floors for vertical runs of cables are sealed with fire resistant material.

F. Any openings in fire walls for horizontal runs of cables are sealed with fire resistant material.

Arrangement and/or protective barriers are such that no locally generated force or missile can destroy redundant systems. In the absence of confirming analysis to support less stringent requirements, the following rules are given:

A. In rooms or compartments having rotating heavy machinery, such as the reactor coolant pumps, or in rooms containing high pressure feedwater piping or high pressure steam lines, such as those existing between the containment and the turbine building, a minimum separation of 20 ft or a 6-in.-thick reinforced concrete wall is maintained between trays containing cables of redundant systems, unless it can be shown by analysis that lesser separation distances in the vicinity of specific hazards cannot prevent the raceways and their included cables from performing their protective functions.

B. Any switchgear associated with redundant systems is separated by a protective wall, ceiling, or floor equivalent to a 6-in.-thick reinforced concrete wall.

Supports for cable trays carrying Class 1E and non-1E circuits in safety-related structures are designed to meet Category I seismic requirements. Cable trays at FNP are designated as nonsafety-related equipment. However, their design provides assurance that the function of the Class 1E circuits contained in these trays will not be affected and the trays will not pose a II/I concern during a seismic event at Farley Nuclear Power Plant.

All cables entering the cable spreading room and control room areas, and interconnecting cables between these two rooms, follow the foregoing wiring separation criteria. The penetrations associated with these cables are sealed where they penetrate the room boundary to ensure the integrity of each area.

Figures 8.3-2 through 8.3-5 show the routing of cables that is typical for the Farley plant. These figures, while representing actual Farley plant drawings, are examples and will not be updated for subsequent design changes.

8.3.1.4.4 Design Criteria for Cables in Cable Spreading Room

Cables in the cable spreading room associated with the reactor protection system and the engineered safeguards system are arranged so that redundant circuits for each of the individual systems are isolated by physical separation or by fire barriers where physical separation cannot be maintained to completely prevent the spread of fire in any one tray or conduit system to other redundant circuits of the same system.

The minimum horizontal and vertical separation requirements in the cable spreading room are in accordance with paragraph 8.3.1.4.3. However, additional specific requirements are as follows:

A. Where it is necessary that cables or cable trays of redundant systems approach the same or adjacent control panels with less than 1-ft horizontal spacing, a fire barrier is installed and extends from 1 ft below to 1 ft above the trays; or the cables of each system are installed in rigid conduits from the floor penetrations back to a point where the 1-ft spacing exists. Where it is not possible to install fire barriers, solid aluminum covers are provided on the tops and bottoms of redundant trays.

B. Vertical stacking of trays is avoided wherever possible for trays containing cables of different separation divisions. However, where unavoidable, cables of redundant systems may be stacked one above the other with less than 3-ft vertical spacing if a fire barrier is installed between the trays and extends 1 ft to each side of the tray system. In addition, a solid aluminum standard tray cover is installed on the lower tray where less than 3-ft vertical separation exists. Where it is not possible to install fire barriers, solid aluminum covers are provided on the lower tray and also on the bottom of the top redundant tray. An acceptable alternate is for the cables of each redundant system to be installed in rigid conduits where less than 3-ft vertical separation exists. The separation provided when conduits are used for cable routing is described in appendix 3A.

The cable spreading room cable tray layout is shown on drawing D-177754.

No ducts or pipes, except those required to recirculate or exhaust air from the cable spreading room and piping for the fire protection system, are located in the cable spreading room. There are no 4160-V and 600-V power cables in the cable spreading room.

In addition to the utilization of physical separation and fire barriers, an automatic sprinkler system and a manually-initiated CO_2 fire protection system are installed, complete with fire detectors and alarms.

8.3.1.4.5 Sharing of Cable Trays with Nonsafety-Related Cables

Nonsafeguard cables may be intermixed with ESF cables of the same voltage level, but the specific nonsafeguard cable is not intermixed with both channels of redundant systems. All cables have adequate overload and short circuit protective features to ensure that nonsafeguard cables do not jeopardize the integrity of the vital cables.

The nonsafeguard cables, when routed in 'A' train raceways, are assigned an 'X' train scheme cable number in accordance with table 8.3-5. Routing procedures ensure that these 'X' cables are not run in 'B' train raceways.

8.3.1.4.6 Fire Detection and Protection

Adequate fire detection and protection measures have been taken where cables and safety-related equipment are installed. Appendix 9B has the necessary details.

8.3.1.4.7 Cable and Cable Tray Marking

All cables and raceways have their scheme cable or raceway code number permanently affixed at both ends. This is more completely described in paragraph 8.3.1.5.

8.3.1.4.8 Spacing of Wiring and Components

8.3.1.4.8.1 <u>Control Board and Relay Racks</u>. In the control board panel wiring separation, control board switches and associated lights are furnished in modules. Modules provide a degree of physical separation between associated lights and wiring of redundant trains.

The control board layout is based on making it easy for the operator to relate the control board devices to the physical plant and to determine the status of related equipment at a glance. This is referred to as providing a functional layout. Within the boundaries of a functional layout, modules are arranged in vertical columns. Control functions associated with the trains for reactor protection and engineered safeguards systems which require physical separation are grouped in columns by train. Teflon wire is used within the module and between the module and the first termination point.

Mutually redundant safety train wiring is routed to maintain a minimum of 6 in. of air separation between wires associated with different trains. Where such air separation is not available, barriers are provided in lieu of air space.

When a device such as braided sheath material (known as shielding and bonding cable) is used to provide a barrier in lieu of the 6-in. dimension, the braided sheath is not in physical contact with the redundant circuit. An example of this sheath material is Belden Braid. When this

sheath material is used to provide a barrier, it is sized and secured to the wire bundle and provides a minimum of 90-percent surface coverage.

Mutually redundant safety train wiring is not terminated on single devices.

The interface between the control board wiring and field wiring is made in terminal board cabinets at el 139 ft. Teflon-covered cables with connectors provide the interconnection between control board and terminal board cabinets. This precludes any self-generated fire in the control board as a potential loss of separation. These cables are supported on metal supports to ensure separation of the cables consistent with the separation criteria discussed above.

Rack and panel separation for the protection of engineered safeguards actuation systems and physical separation of redundant wiring is maintained by use of separate metal enclosed cabinets and separate wireways. For other systems where separation is required between redundant wiring, either separate panels or metal barriers are used to maintain the required physical separation.

Separation of redundant channels running between the electrical penetration rooms and the cable spreading room is achieved by the use of four duct banks. Each duct bank consists of 3-in. and 4-in. rigid steel conduits embedded in concrete with a minimum of 2 in. of spacing between conduits, each carrying the control and instrumentation cables associated with one of the redundant channels of the reactor protection system and the engineered safeguards system.

Vertical runs of cable trays have solid covers up to a minimum height of 7 ft above the floor.

Wherever an open wireway passes through a floor or a wall, a fire stop is provided to prevent the spread of fire through the wall or floor.

Solid tray covers are used where cables may be subject to falling debris or hot weld material. Particular care is exercised during construction to ensure that the cables are not damaged. Also, solid tray covers are used on trays directly under gratings or other areas subject to dirt and oil drippings. Temperature monitoring of cables is not provided.

The cable installation associated with the reactor protection and ESF systems is subject to quality assurance procedures to ensure that the design criteria are met through all stages of design, procurement, and installation.

Circuit and raceway schedules are prepared and cables are routed in the engineering design office to provide a permanent record of the designation, routing, and terminations of cables and the designations of raceways. Circuit coding provides identification of the associated system either directly, by means of total plant numbering system equipment numbers used as circuit location numbers, or indirectly by means of coded switchgear cell numbers or abbreviated total plant equipment numbers.

8.3.1.4.8.2 <u>Emergency Power Board (EPB)</u>. Because of the plastic wireways inside the emergency power board (EPB), the two 4-in. conduits are shielded from potential fire sources in an opposite train board section. Each conduit is enclosed in a 14-gauge metal shroud along its entire length of exposure to an opposite train compartment. The shroud is insulated with 2 in. of Cera-Form thermal insulation (rated to withstand continuous exposure to a full 2100°F) on the top and rear surfaces. Conservative calculations indicate that, from the start of a fire, in excess of 3 h is required for the cables included in the subject conduits to reach their rated ambient temperature of 90°C, and in excess of 14 h for the assemblies to reach a maximum steady-state temperature of 118°C. However, from the assessment of the amount of flammable material in the EPB, it has been determined that there is not enough material to support a fire for 3 h of such magnitude that safe temperatures (90°C) would be exceeded within the conduit.

8.3.1.4.9 Fire Barriers and Separation Between Redundant Trays

Paragraphs 8.3.1.4.3 and 8.3.1.4.4 discuss separation between redundant cable trays.

8.3.1.4.10 Electrical Penetrations

The power, control, and instrument cables pass through the containment wall in electrical penetrations which are described in chapter 6.0.

Three penetration rooms, separated from each other by concrete walls, provide the necessary physical separation for redundant systems.

The criteria for the separation of electrical penetrations are as follows:

A. Separate penetrations are provided for 4160-V and 600-V power, control, and instrumentation cables.

B. Redundant circuits of a two-out-of-three logic matrix associated with the reactor protection system and the engineered safeguards system are run through different penetration rooms as shown in figure 8.3-2. (Figure 8.3-2 is not updated for design changes. See paragraph 8.3.1.4.3.) Redundant circuits of a two-out-of-four logic matrix associated with the reactor protection system and the engineered safeguards system are run through the three penetration rooms as follows:

   1. Channels 2 and 3 - through one room. A minimum separation of 6 ft is provided between channels 2 and 3.

   2. Channel 1 - through the second room.

   3. Channel 4 - through the third room.

   Conductors inside the penetration are applied with consideration to the aforementioned application criteria, the number of circuits, the load factor, and the

ambient temperature within the penetration. Test data have been obtained to determine the offgassing properties of the conductor insulation. The method of applying cables and the test performed on insulation ensure that offgassing within the penetration does not occur. Tests performed ensure that all connections for wiring have been made properly.

8.3.1.5 Physical Identification of Equipment and Associated Cables

All equipment and associated cables are allocated a color scheme to identify each type of equipment or cable as follows:

Equipment Train Designation	Cable Train Designation	Color Identification
A	A - Safety-related	Red
B	B - Safety-related	Blue
C	C - Safeguard cable that may be Train A at one time or Train B at other times	Red/Blue
N	N - Nontrain-oriented Nonsafety-related	Black (or unpainted or natural color)
	X - N cables in A raceways	Pink
	Y - N cables in B raceways	Violet
	Z - N cables run separately from all other trains	Pink/ Violet

ESF equipment is divided into safety channels with a color scheme as follows:

Safeguard Channel I............. Yellow
Safeguard Channel II............ Green
Safeguard Channel III........... Orange
Safeguard Channel IV .... Silver

No other train cables may be run in engineered safety channel raceways.

Cable trays are marked with a marker which presents a color mark of the color scheme shown above, as well as the last six digits of the raceway number.

These markers are applied at both ends and at approximately 20-ft intervals on the trays.

The conduits and 4-in. channels are marked at both ends with a marker which presents a color mark of the color scheme shown above, as well as the last six digits of the raceway number. In addition, the conduits and 4-in. channels have a color mark of the color scheme shown above applied at 20-ft intervals along their length (where visible) and at each side of the wall and floor penetrations. These markers are applied at a position most accessible to view.

Cables are marked at both ends with marker tags which have a color dot of approximately 1/8-in. diameter, of the proper scheme color. A color marking of the proper scheme color is also provided at intervals of from 10 to 15 ft along the cable.

Switchgear, control panels, control boxes, rectifiers, battery chargers, and other similar pieces of equipment are marked with a descriptive nameplate which has white or black letters and a background of the proper scheme color.

Concrete pullboxes have markers on the ends of conduits run into them.

8.3.2 DC POWER SYSTEMS

8.3.2.1 Description

The direct current systems which provide a reliable source of continuous power for control, instrumentation, and emergency lighting consist of independent and redundant subsystems, used primarily for safety-related loads, and separate subsystems for the other direct current loads required for power generation, as described in the following:

A. Safety-Related Systems

1. A 125 V-dc system in the auxiliary building provides a source of reliable dc power for control, instrumentation, and power loads required for operation under normal conditions and during design basis accidents. This system and the bus arrangement are shown in drawings D-177082 and D-177083 for Unit 1 and in drawings D-207082 and D-207083 for Unit 2.

   The system for each unit consists of two 125 V-dc switchgear assemblies, three 125 V-dc battery chargers, two 125 V-dc batteries, and six dc distribution cabinets. Each 125 V-dc bus is supplied from one of the battery chargers with one battery floating on the bus. The 125 V-dc system is ungrounded and is equipped with ground detectors installed in each switchgear for continuous monitoring.

2. The separate 125 V-dc system for the service water area consists of two independent and redundant subsystems. Each subsystem consists of two battery/charger sets and two dc distribution panels. Either battery/charger set is capable of providing 100-percent power to both dc distribution panels while recharging its batteries. One battery/charger set provides power to the dc distribution panels while the other is on standby. The active battery/charger set is selected by means of a manual selector switch. The two dc distribution panels feed Unit 1, Unit 2, and shared loads. The majority of these loads are switchgear control supply.

Several loads that are not safety related are also supplied from these systems. These nonsafety-related loads will not affect the integrity of the safety-related systems. All components are designed to conform with Class 1E power system design criteria as defined in IEEE Standard 308.

B. Nonsafety-Related System (Power Generation)

The dc system for the nonsafety-related loads is comprised of three separate subsystems. Each of these subsystems is independent of and separated from the safety-related dc system.

1. The dc system serving the cooling tower area consists of one 125-V battery, two battery chargers, and one dc distribution panel.

2. The turbine building dc system is comprised of two 125-V batteries, three battery chargers (including one standby), and four dc distribution panels. Two of these distribution panels are located in the auxiliary building and supply dc control power to the nonsafety-related 4160-V switchgear buses 1A, 1B, and 1C and 600-V load centers 1B, 1I, 1M, and 1N. The two 125-V batteries are connected in series to provide a 250-V source for the emergency dc seal-oil pump and other normal loads.

3. Two 125-V battery chargers and two independent 60-cell batteries located in the high voltage switchyard supply separate dc distribution cabinets to provide power for tripping through primary and secondary relay systems for protection and control of 230-kV and 500-kV circuits associated with the 230-kV and 500-kV systems.

8.3.2.1.1 Safety-Related Batteries

The safety-related battery systems consist of two batteries for the auxiliary building and four batteries for the service water building (two batteries per train). Each battery contains 60 lead-calcium cells electrically connected in series to establish a nominal 125-V power supply. Each cell is of a sealed type, assembled in a shock-absorbing, clear plastic container with covers bonded in place to form a leakproof seal. The batteries are mounted on corrosion-resistant racks. The batteries are floated at 2.20 V per cell. The auxiliary building and service water building battery systems are discussed separately in the paragraphs which follow.

8.3.2.1.1.1 Auxiliary Building Battery System. The auxiliary building station batteries are sized in accordance with the methodology contained in section 6 of IEEE 485-1983. The 1A, 1B, 2A, and 2B batteries have a rated capacity of 1300 A-h based on a 2-h discharge rate at 77ºF to 1.75 V per cell average. Under both normal and accident conditions the batteries are designed such that they will provide the voltage required for operation of safety-related components, considering an aging factor of 25 percent and electrolyte temperature within the range of 60°F to 110°F.

8.3.2.1.1.1.1 Normal Operating Conditions. The capacity requirement for the batteries during normal operation is to carry the loads necessary to support plant operation for 2 h. The 2-h duration is based on the time required for the operators to connect the spare battery charger to the system if the connected battery charger fails on either train. During this 2-h period, the redundant train of the dc system with operable battery charger is available for accident mitigation, if required.

The normal load on the batteries during the 2-h period will not exceed 250 A for batteries 1A, 2A, and 2B and 300 A for battery 1B.

8.3.2.1.1.1.2 Design Basis Accident Conditions. The capacity requirement for the batteries during the design basis accident (LOSP or LOSP+LOCA) is to carry the dc loads necessary to support accident mitigation for the time period from the initiation of the LOSP until the battery chargers are reenergized from the emergency diesel generators. After battery charger reenergization, the battery chargers provide the necessary support for the dc loads. The battery chargers are sequenced back onto the emergency diesel generators during the last load sequencing step. Therefore, the batteries are required to provide adequate voltage to all safety-related components without battery charger support for less than 40 s (37 s from LOSP initiation to the last load sequencer step plus or minus the timer tolerance). The design calculations for verifying the adequacy of dc system voltage have been conservatively performed based upon a 1-min voltage. Any failure of the battery charger to be sequenced onto the emergency diesel generators is considered a single failure and the redundant train will be available for safe shutdown. There is no design basis accident scenario where the auxiliary building batteries will be required to supply LOSP or LOSP+LOCA loads for a period greater than 1 min without charger support.

The design basis accident load profile for the auxiliary building batteries is shown below. The load consists primarily of emergency lighting, vital bus inverters, and dc-operated controls and instruments as detailed in table 8.3-6.

Accident Conditions

Time Period (min)	Current (A)
0 to 1	500

Although not a requirement for mitigation of the design basis accidents, the batteries are capable of supplying adequate voltage to all safety-related components for an extended period without battery charger support under the following scenario:

After initiation of a LOSP or LOSP+LOCA, the batteries will have sufficient capacity to support automatic diesel generator starting and load sequencing. The batteries are sized to support control room operation of all required safety-related dc loads for 2 h, assuming a battery charger failure occurs after initiation of the LOSP or LOSP+LOCA event. Diesel generator automatic start or load sequencing failures with multiple attempts for diesel generator restart and

automatic sequencing are not assumed during the event. The load profile for this scenario is shown below.

Time	Load
0 to 1 min	500 A
1 to 120 min	350 A

The service test for the batteries will be performed using the load profile above and test voltages below which envelope both the normal and design basis accident load profiles.

To assure the minimum voltage requirement for each of the connected emergency loads is satisfied, the battery terminal voltage at the end of each load profile test interval shall be greater than or equal to the following:

Battery	1st Minute	120th Minute
1A	113.4 V	111 V
1B	113.4 V	111 V
2A	113.4 V	110 V
2B	113.4 V	110 V

Test voltage limits listed above are greater than the minimum required design voltage to provide acceptable margin to support future design load additions or variations. In the event post-test terminal voltages are lower, comparison of actual values to minimum acceptable design voltages is required to determine whether the battery is capable of satisfactorily supplying design loads. In addition, all individual cell voltages (ICVs) at the end of the test should be $\geq$ 1.75 V. While overall battery terminal voltage may be acceptable, single (or multiple) ICVs of $<$ 1.75 V are indicative of degraded cell(s) that must be evaluated for corrective action or potential replacement.

8.3.2.1.1.2 **Service Water Building.** The service water building safety-related station batteries are sized in accordance with Section 6 of IEEE-485-1983 for operation at a minimum electrolyte temperature of 35°F and including an aging factor of 25 percent. The batteries have a capacity of 75 A-h based on an 8-h discharge rate to 1.75 V per cell. The battery load primarily includes switchgear controls and indication. Each battery has adequate storage capacity to carry its load without charger support for a period of at least 2 h.

Battery terminal voltage shall remain greater than or equal to 105 V and ICVs should remain greater than or equal to 1.75 V when the batteries are subjected to a service test with the load profile below which envelops the load requirements under all conditions.

Time	Load
0 to 1 min	47 Amps
1 to 120 min	3 Amps

Test voltage limits listed above are greater than the minimum required design voltage and provide acceptable margin to support future design load additions or variations. In the event post-test terminal voltages are lower, comparison of actual values to minimum acceptable design voltages is required to determine whether the battery is capable of satisfactorily supplying design loads. In addition, all Individual Cell Voltages (ICVs) at the end of the test should be greater than or equal to 1.75 V. While overall battery terminal voltage may be acceptable, single (or multiple) ICVs of less than 1.75 V are indicative of degraded cell(s) that must be evaluated for corrective action or potential replacement.

8.3.2.1.2 Safety-Related Battery Chargers

Each 125 V-dc bus is supplied from one of the battery chargers with one battery floating on the bus. The chargers are adjusted to give an output voltage of 132 V for floating the batteries. The supply to each of the normally-operating battery chargers is from a separate ac emergency bus. Each battery charger can recharge a discharged battery and simultaneously supply the steady-state normal or emergency loads. Each charger is housed in a separate metal enclosed cabinet. Battery charger ratings are given as follows:

A. Rated output current:

Auxiliary building - 600 A (660 A maximum)	Service water building - 12 A (13.8 A maximum)

B. Voltage and frequency variation: maintain ± 0.5 percent of rated dc volts from 0- to 100-percent capacity with a ± 10 percent ac line voltage variation and ± 5 percent frequency variation.

C. Maximum ambient temperature for continuous operation at rated current and voltage: 104°F.

For the auxiliary building, one spare battery charger is provided between the two batteries as backup for the normally operating chargers. The spare battery charger can be supplied from either of the redundant ac emergency buses. Mechanically interlocked breakers and inline disconnects prevent inadvertent paralleling of the two redundant ac emergency buses or the two redundant dc buses. Drawing C-177133 gives details of the interlocking scheme.

For the service water building, each of the four batteries has its own dedicated charger. Two of the charger/battery sets (one operating and one in standby) are fed from one ac bus while the other two are fed from the redundant ac bus.

8.3.2.1.3 DC Switchgear

The bus and feeder arrangement of each switchgear, including the description of loads being supplied, is indicated in the single-line diagrams (drawings D-177082 and D-207082 for 125 V-dc bus A and drawings D-177083 and D-207083 for 125 V-dc bus B). The main bus bars, rated at 1000 A, 250 V, are braced for a fault duty of 25,000 A-dc.

The switchgear is of metal-clad construction and is equipped with two-pole, drawout-type, electrically- and remotely-controlled air circuit breakers having an interrupting duty of 25,000 A-dc at 125 V-dc. The continuous current ratings and trip settings for the breakers are given in the single-line diagrams.

8.3.2.1.4 DC Distribution Panel

Three dc distribution panels connected to each dc switchgear bus supply safety-related loads as indicated in the single-line diagrams. Each dc panel has a 125-V, 400-A main bus braced for 10,000 A. The branch breakers are of molded case design capable of interrupting a fault current of 10,000 A.

8.3.2.1.5 Testing

The dc switchgear, batteries, and battery chargers will be inspected and tested on a periodic basis in accordance with manufacturer's recommendations. The inspection and testing include, but are not limited to, the following:

A. Checking the specific gravity of the electrolyte, voltage, and temperature of the battery cells.

B. Opening and closing functions of breakers.

C. Checking battery charger float voltage and current.

The procedure for battery acceptance, performance, and service tests is in accordance with IEEE Standard 450-1980. The modified performance discharge test is in accordance with the guidance of IEEE 450-1995. A service (load profile) test will be performed at intervals as required by the Technical Specifications. The service test will be based on the load profiles listed in paragraph 8.3.2.1.1.1.2. A performance discharge test or a modified performance discharge test is also required by the Technical Specifications. A performance test is also required to be performed by the battery vendor prior to shipment. Testing of batteries and chargers is in accordance with the Technical Specifications.

8.3.2.1.6 Separation and Redundancy Requirements

The equipment design and layout arrangement for the auxiliary building and service water building provides two completely independent and redundant dc systems. The batteries are installed in rooms separated by walls and doors with a Class A fire rating to prevent simultaneous damage to both batteries. Each battery room is ventilated with exhaust fans as described in section 9.4. Fire dampers are provided in the HVAC penetrations of each battery room to limit the effects of a fire to one fire area. For the auxiliary building the dc switchgear, together with the associated battery charger, are located in separate rooms outside the individual battery rooms. The spare charger is located in a room that adjoins, but is separated from, the two other rooms. At the service water building, the battery chargers are located in separate rooms outside the individual battery rooms.

The design basis for routing cables, trays, and conduit described in paragraph 8.3.1.4 are applicable to the dc system.

8.3.2.2 <u>Analysis</u>

The 125 V-dc Class 1E electric systems are designed to meet the requirements of IEEE-308-1971, 10 CFR General Design Criteria 17 and 18, and NRC Regulatory Guide 1.6. The safety design bases for each of the 125-V batteries is to provide adequate capacity to supply vital loads required to safely shut down the reactor without charger support until ac power is restored.

The battery chargers are automatically sequenced to the diesel generators. The auxiliary building battery chargers are in operation within 40 s after LOSP initiation. The service water intake structure battery chargers are in operation within 12 s after LOSP initiation (i.e., as soon as the MCCs providing power to the chargers are energized from the diesels). In case a battery charger fails to energize, the operator will be notified by a failure alarm in the main control room. In the unlikely event that a battery charger fails, the spare battery charger will be manually placed in service. During the period of changeover to the spare charger, the battery will carry the normal loads.

The basis for design for each battery charger is to provide adequate capacity to restore its battery to full charge after the battery has been discharged while carrying steady-state normal or emergency loads. The time required to recharge the battery to full charge is compatible with the recommendation of the battery manufacturer.

Each dc system is equipped with the following indications in the control room to provide a continuous monitoring of dc power source condition:

- dc undervoltage alarm.

- Battery current indication.

- Charger current indication.
- Charger input ac failure alarm.
- dc voltage indication.
- dc ground alarm.
- Tripping of battery breaker (applies only to the auxiliary building batteries).
- Each Unit 1 auxiliary building battery charger has a common trouble window in the control room which is activated by any of the following charger alarm conditions: input ac failure, dc output failure, dc output undervoltage, dc output overvoltage, dc output breaker open, fan failure, overtemperature, ac input breaker open.
- The alarms for service water intake structure (SWIS) battery chargers 2 and 4 have trouble windows on the emergency power board (EPB) in the control room. Any of the following charger alarm conditions for chargers 2 and 4 will activate its respective trouble window: ac input failure, dc failure (loss of dc output/loss of charging current), dc undervoltage, dc overvoltage, ac input breaker open, and dc output breaker open.

The undervoltage relay features an extra-high dropout characteristic and is designed specifically to monitor the charging supply for a station battery and sound an alarm if this supply fails. The anticipated setting of the relay is above 125 V.

In order to maintain the required capacity of the dc systems, one battery charger per train is kept energized and maintains a constant voltage to supply the batteries with sufficient current to keep them fully charged and to maintain the steady-state load of dc instruments, control circuits, and inverters. In case of loss of auxiliary system power, the batteries will continue to supply the required dc and vital ac equipment. When ac power is regained from the diesel generators, the battery chargers will be reenergized and resume normal operation. The batteries are sized to supply the anticipated dc and vital ac load, without support from battery chargers, for a period of 2 h under normal operating conditions. The service water building batteries are sized to supply the anticipated load requirement for 2 h, without battery charger support, for both normal and design basis accident conditions.

The battery chargers are designed to prevent the ac source from becoming a load on the battery because of a power feedback as a result of loss of ac power to the chargers.

In the event of failure of a battery charger, the battery will continue to supply the normal operating dc load without interruption for a minimum of 2 h. This gives the operator sufficient time to manually line up the backup battery charger.

The entire auxiliary building dc system for each unit consists of two independent and redundant subsystems. The service water dc system consists of two independent and redundant

subsystems. Each subsystem supplies the Unit 1, Unit 2, and shared loads of one of the two redundant safety-related dc systems at the building. Necessary and sufficient separation has been maintained between components of each subsystem so that a single fault within a subsystem does not prevent the reactor protection system from performing all safety functions. Also, within each subsystem, the component design is based on the premise that the probability of failure is kept to the practical minimum. The separation and redundancy requirements are covered in paragraph 8.3.2.1.6.

No provision has been made for automatically connecting either 125 V-dc system to its redundant dc load group. Also, as explained in paragraph 8.3.2.1.2, adequate interlocks are provided to prevent paralleling of the redundant dc systems. An outline of the inspection and tests that will be performed on the dc systems is provided in paragraph 8.3.2.1.5.

8.3.3 AC AND DC UNINTERRUPTIBLE POWER SUPPLY FOR THE TURBINE-DRIVEN AUXILIARY FEEDWATER PUMP

8.3.3.1 <u>Design Basis</u>

Each plant unit is equipped with a 7.5-kVA uninterruptible power system (UPS), uniquely assigned to provide a reliable source of control power, ac and dc, for the turbine-driven auxiliary feedwater pump and its associated steam admission and discharge valves.

The NRC acceptance criteria for the design of the UPS are as follows.

The UPS and its associated circuits are physically separated from the two train (A and B)-oriented ac and dc systems and their associated circuits, so that in the event of a feedwater pipe break with the loss of all offsite power sources and a single failure which would result in the loss of electrical train A (which provides the ac source of control power to the turbine-driven auxiliary feedwater pump), the turbine-driven auxiliary feedwater pump (in conjunction with the train B motor-driven auxiliary feedwater pump) will be able to start and deliver feedwater to the steam generators. A single failure of electrical train B will not affect the operation of the turbine-driven auxiliary feedwater pump; therefore, the pump (in conjunction with the train A motor-driven auxiliary feedwater pump) will be able to start and deliver feedwater to steam generators. Additionally, the power supply meets the requirements of General Design Criterion 44.

The UPS supplies control power to the following loads:

A. 125 V-dc to the turbine-driven auxiliary feedwater pump control panel.

B. 125 V-dc to the turbine-driven auxiliary feedwater steam admission valves HV-3235A, HV-3235B, and HV-3226.

C. 120 V-ac for the turbine-driven auxiliary feedwater pump speed control.

8.3.3.2 System Description

The UPS is rated 7.5-kVA "continuous service," powered from an emergency ac source 575-V, 3-phase, 60 Hz, and consists of the following components (see drawings D-177944, sh. 1 and D-207944):

A. One battery charger, rated to continuously supply the inverter operating load while completely recharging the battery within 12 h after a 2-h outage. The charger is equipped with an automatic battery recharge/equalize function.

   The input voltage is 575-V, 3-phase, 60 Hz, taken from an emergency train A MCC. The output voltage is 125 V-dc. A dc ammeter and a dc voltmeter measure the output amperage and voltage, respectively. The charger is complete with input and output circuit breaker protection. The following fault conditions are locally identified by individual indicating lights:

   1. High dc voltage.

   2. Charger failure.

   3. AC input failure.

   4. Positive ground.

   5. Negative ground.

   These conditions are remotely alarmed (visual and audible) in the common annunciator window provided in the control room for UPS faults.

B. One inverter, rated to continuously supply 7.5-kVA, 120 V-ac, 1-phase, 60 Hz with an input supply voltage of 125 V-dc. The inverter is complete with input and output circuit breaker protection and is provided with an automatic transfer contactor which will transfer the load to the bypass ac supply in the event of an inverter failure. The inverter output amperage and voltage are measured by an ac ammeter and an ac voltmeter, respectively. The following fault conditions are locally identified by individual indicating lights:

   1. Inverter failure.

   2. Low dc voltage.

   3. Low ac output voltage.

   4. High ac output voltage.

   5. Fan failure.

6. Overtemperature.

7. Static switch transfer.

These conditions are remotely alarmed in the common annunciator window provided in the control room for UPS faults.

C. One rectifier to operate from the inverter output or from the bypass ac supply in the event of an inverter failure. The rectifier provides 125-V, 12-A, fully regulated dc. A dc ammeter and a dc voltmeter measure the output amperage and voltage, respectively. The rectifier is complete with input and output circuit breaker protection. The following fault conditions are remotely alarmed in the common annunciator window provided in the control room for UPS faults:

1. DC failure.

2. High dc voltage.

3. Low dc voltage.

Fuses are provided externally for the dc load circuits.

D. One stepdown transformer, 575/124-V, 1-phase, 60-Hz in the bypass ac supply provides the ac power for the external load (HSP panel F) and the rectifier, so that the dc loads also will be supplied in the event of an inverter failure. The load transfer from the failed inverter to the stepdown transformer is automatic. The input power supply to the stepdown transformer is provided internally by connecting the transformer primary to the same train A MCC supply which feeds the battery charger. The stepdown transformer input is equipped with a disconnect switch.

E. A 125-V nominal battery containing 60 calcium-lead-acid cells, electrically connected in series, and rated to supply the inverter at full load for 2 h. The battery is complete with explosion protecting vents, deadtop construction, and with an earthquake protected, 2-step and/or single-tier, single-row battery rack and necessary interunit connector and accessories.

Each UPS system is provided with additional component redundancy to enhance the reliability of the UPS system. This redundancy includes an alternate (backup) UPS system (battery charger, inverter, rectifier).

The analysis of paragraph 8.3.3.3 remains valid since it applies to a single UPS system.

The battery charger and inverter are in a compact arrangement inside a freestanding cabinet located in the auxiliary building, room 190 (2190 for Unit 2) at el 100 ft. This unit is furnished to

the plant completely preassembled and internally wired and factory tested to full performance parameters.

The rectifier is located in an auxiliary cabinet in the same room as the UPS cabinet.

The battery is located in the auxiliary building, room 194 (2194 for Unit 2). Ventilation is provided through the access hatch next to room 194.

All UPS components are designed to conform with Class 1E Electrical System Design Criteria and, as such, capable of withstanding the maximum seismic forces predicted for the specific location.

The quality assurance procedure described in paragraph 8.3.1.3 is applicable to the UPS and ensures adherence to the design criteria.

8.3.3.3 Analysis

As long as ac power is available from offsite sources or diesel generators, ac as well as dc required for the turbine-driven auxiliary feedwater pump and its associated steam admission valves will be available through the UPS without using the stored energy from the battery. When loss of ac power is experienced at the MCC which powers the UPS, ac and dc will still be obtained directly from the UPS, using the stored energy from the battery.

In the event of an inverter failure, ac and dc will be obtained from the UPS by automatically transferring the loads from the failed inverter to the stepdown transformer in the bypass ac supply.

The automatic transfer of the UPS from the inverter to the stepdown transformer in the bypass ac supply also occurs when the inverter is taken out of service manually.

The "continuous service" feature of the UPS provides increased reliability, since the load sees a closely regulated supply free from all transients of outside supply, and no switching is necessary when the outside supply fails.

TABLE 8.3-1 (SHEET 1 OF 4)

4160-V EMERGENCY BUSES ESTIMATE OFMINIMUM LOADING REQUIREMENTS

Seq. Step	Loads	Motor Rating (hp)	Max. Motor Demand (hp)	0 to 1 hour No. of Pumps Run'g	0 to 1 hour Demand hp	0 to 1 hour Demand kW	1 hour to 8 hours No. of Pumps Run'g	1 hour to 8 hours Demand hp	1 hour to 8 hours Demand kW	Beyond 8 hours No. of Pumps Run'g	Beyond 8 hours Demand hp	Beyond 8 hours Demand kW	Remarks
A.	LOSP LOADS 4-kV Buses 1F & 1K, 2F & 2K, 1G & 1L, or 2G & 2L												
1	Charging pump	900	840	1	600	473	1	600	473	1	600	473	
2	Service water pump	600	600 (583)	1	600 (583)	487 (462)	1	600 (583)	487 (462)	1	600 (583)	487 (462)	Values in parentheses apply to Unit 2 buses.
2	CRDM cooler fan	100	84.5	1	100	78	1	100	78	1	100	78	
3	Service water pump	600	600 (583)	1	600 (583)	487 (462)	1	600 (583)	487 (462)	1	600 (583)	487 (462)	Values in parentheses apply to Unit 2 buses.
4	CCW pump	400	350	1	350	282	1	350	282	1	350	282	
4	Ctmt. coolers-low speed	125	79	1	54	43	1	54	43	1	54	43	
5	Aux. feedwater pump	450	450	1	450	361	1	450	361	1	450	361	
6	Battery charger	120 kVA	-	1	-	60	-	-	60	-	-	60	
6	Station air compressor 1C/2C	200	200	1	200	160	1	200	160	1	200	160	Values apply to 4-kV buses 1F and 1K and 2F and 2K only.
6	Ltg. xfmr.1B	225 kVA	-	-	-	70	-	-	70	-	-	70	Applies to 4-kV buses 1F and 1K only. Load connected when 600V L/C 1A energized.
6	Ltg. xfmr.2B	225 kVA	-	-	-	65	-	-	65	-	-	65	Applies to 4-kV buses 2F and 2K only. Load connected when 600V L/C 2A energized.
(a)	Spent-fuel pool pump	100	100	1	100	81	1	100	81	1	100	81	Manually loaded.

TABLE 8.3-1 (SHEET 2 OF 4)

				0 to 1 hour			1 hour to 8 hours			Beyond 8 hours			
Seq. Step	Loads	Motor Rating (hp)	Max. Motor Demand (hp)	No. of Pumps Run'g	Demand hp	Demand kW	No. of Pumps Run'g	Demand hp	Demand kW	No. of Pumps Run'g	Demand hp	Demand kW	Remarks
(a)	Emergency ac lighting	-	-	-	-	40	-	-	40	-	-	40	Manually loaded.
(a)	Pressurizer heaters	270 kW	-	-	-	-	-	-	270	-	-	270	Manually loaded.
(b)	Auto sequenced load total excluding miscellaneous loads-kW					2507			2507			2507	Values apply to 4-kV buses 1F and 1K only.
						2277			2277			2277	Values apply to 4-kV buses 1G and 1L only.
						2452			2452			2452	Values apply to 4-kV buses 2F and 2K only.
						2227			2227			2227	Values apply to 4-kV buses 2G and 2L only.
B.	ESS LOADS 4-kV Buses 1F & 1K, 2F & 2K, 1G & 1L, or 2G & 2L												
1	Charging pump	900	840	1	900	709	1	900	709	1	900	709	
2	RHR pump	400	400	1	400	324	1	400	324	1	400	324	400 hp envelopes Units 1 and 2 RHR pump loads.
2	Ctmt. spray pump	400	450	1	450	359	1	450	359	1	450	359	
3	Service water pump	600	600 (583)	2	1200 (1166)	974 (924)	2	1200 (1166)	974 (924)	2	1200 (1166)	974 (924)	Values in parentheses apply to Unit 2 buses.
4	CCW pump	400	350	1	350	282	1	350	282	1	350	282	
4	Ctmt. coolers-low speed	125	79	2 [1]	250 [125]	202 [101]	2 [1]	250 [125]	202 [101]	2 [1]	250 [125]	202 [101]	Values in brackets apply to LOSP/SI events only.
5	Aux. feedwater pump	450	450	1	450	361	-	-	-	-	-	-	

TABLE 8.3-1 (SHEET 3 OF 4)

				0 to 1 hour			1 hour to 8 hours			Beyond 8 hours			
Seq. Step	Loads	Motor Rating (hp)	Max. Motor Demand (hp)	No. of Pumps Run'g	Demand hp	Demand kW	No. of Pumps Run'g	Demand hp	Demand kW	No. of Pumps Run'g	Demand hp	Demand kW	Remarks
5	Reac. cav. H2 dil. fan	25	25	1	25	22	1	25	22	1	25	22	Load included as a misc load in Unit 2.
6	Battery charger	120 kVA	-	1	-	60	1	-	60	1	-	60	
6	Station air compressor 1C/2C	200	200	1	200	160	1	200	160	1	200	160	Values apply to 4-kV buses 1F and 1K and 2F and 2K LOSP/SI events only.
6	Ltg. xfmr. 1B	225 kVA	-	-	-	70	-	-	70	-	-	70	Applies to 4-kV buses 1F and 1K LOSP/SI events only. Load connected when 600V L/C 1A energized.
6	Ltg. xfmr. 2B	225 kVA	-	-	-	65	-	-	65	-	-	65	Applies to 4-kV buses 2F and 2K LOSP/SI events only. Load connected when 600V L/C 2A energized.
(a)	Spent-fuel pool pump	100	100	1	100	81	1	100	81	1	100	81	Manually loaded.
(a)	Emergency ac lighting	-	-	-	-	40	-	-	40	-	-	40	Manually loaded.
(a)	H2 recombiner	75 kW	-	-	-	75	-	-	75	-	-	75	Manually loaded.
(b)	Auto sequenced load total excluding miscellaneous loads-kW					3293			2932			2932	Values apply to Unit 1 buses only.
						(3221)			(2860)			(2860)	Values in parentheses apply to Unit 2 buses.
						3403			3042			3042	Values apply to LOSP/SI events for 4-kV buses 1F and 1K only.
						3173			2812			2812	Valves apply to LOSP/SI events for 4-kV buses 1G and 1L only.

TABLE 8.3-1 (SHEET 4 OF 4)

					0 to 1 hour			1 hour to 8 hours			Beyond 8 hours		
Seq. Step	Loads	Motor Rating (hp)	Max. Motor Demand (hp)	No. of Pumps Run'g	Demand hp	Demand kW	No. of Pumps Run'g	Demand hp	Demand kW	No. of Pumps Run'g	Demand hp	Demand kW	Remarks
						3345			2984			2984	Values apply to LOSP/SI events for 4-kV buses 2F and 2K.
						3120			2759			2759	Values apply to LOSP/SI events for 4-kV buses 2G and 2L only.
C.	Emergency LOADS 4-kV Buses 1H, 2H, IJ, or 2J.												
(a)	Station air comp.	125	125	1	125	104	1	125	104	1	125	104	Manually loaded for 4-kV buses 1J and 2J only.
(a)	Water treatment plant	-	-	-	-	-	-	-	-	-	410	340	Manually loaded (90% eff. assumed).
(a)	600-V load (turb. aux.)	-	-	-	200	166	-	200	166	-	200	166	Manually loaded (90% eff. assumed).
(b)	Miscellaneous loads												

a. Prior to any manual loading, the operator must check the available capacity of the diesel generators.

b. Miscellaneous loads that are not shed are shown on table 8.3-2.

TABLE 8.3-2 (SHEET 1 OF 7)

DIESEL GENERATOR ALIGNMENTS FOR DESIGN BASIS EVENTS

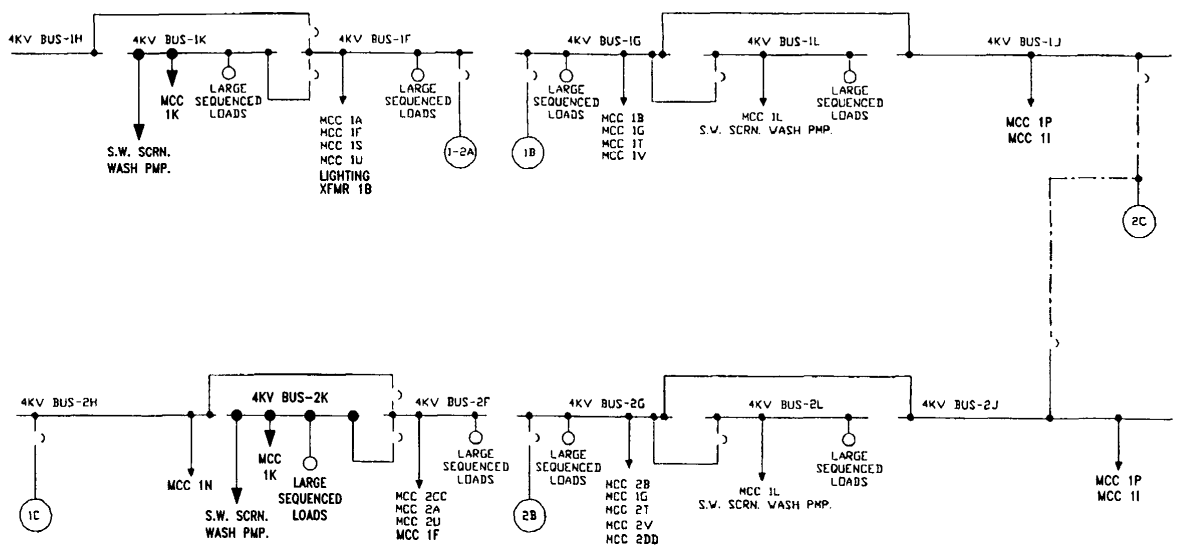
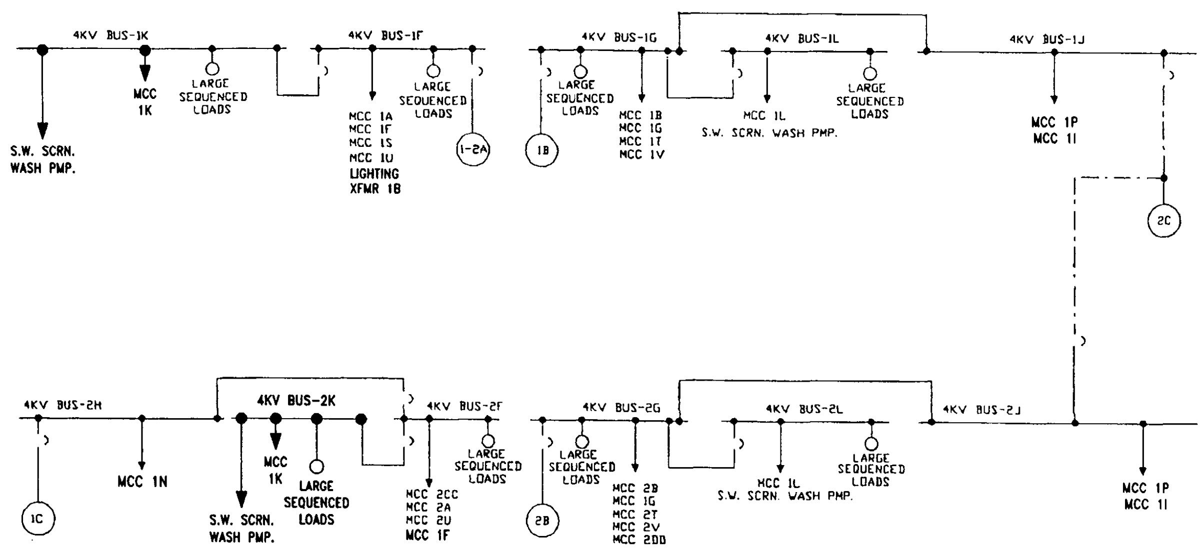
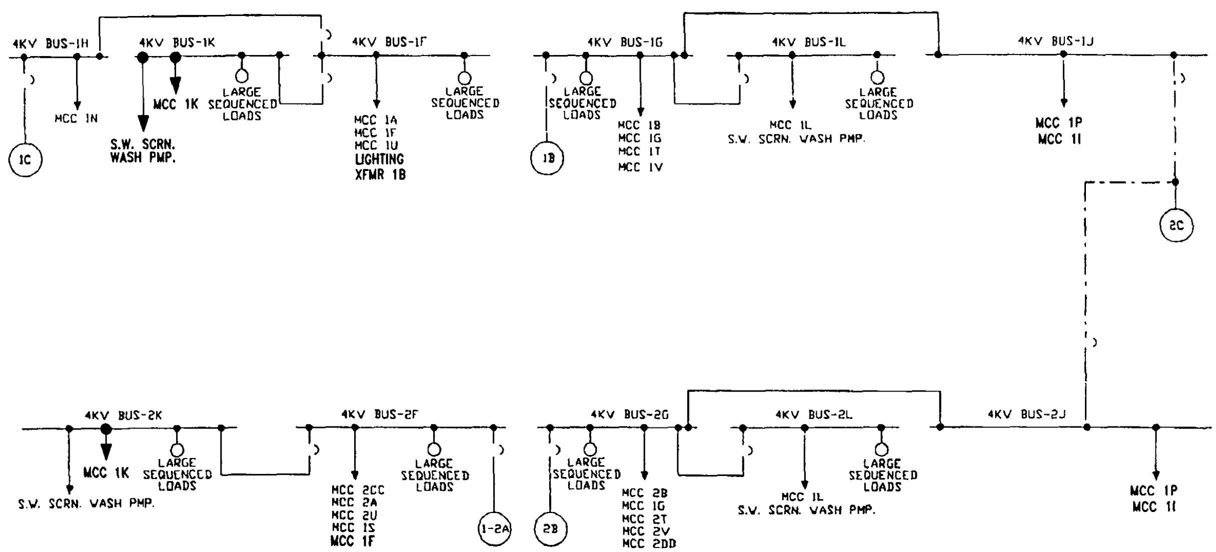
UNIT(S) IN OPERATION	POSTULATED EVENT	SCHEMATIC ARRANGEMENT DIESEL GENERATORS & 4KV EMERGENCY BUSES (TRAIN 'A' / TRAIN 'B')
1. UNIT #1 AND UNIT #2	1. LOSP ON BOTH UNITS	 NOTES (APPLICABLE TO ALL SHEETS OF THIS TABLE): 1. '— — — —' INDICATES THE DIESELS 1B, 2B AND 1-2A ALIGNMENT IN THE EVENT THAT DIESELS 1C AND/OR 2C FAILS, AS APPLICABLE. 2. '—·—·—' DIESEL 2C IS DEDICATED TO SBO EVENT. HOWEVER, IN THE EVENT DIESEL 1B OR 2B FAILS DURING A DESIGN BASIS EVENT, DIESEL 2C MAY BE MANUALLY ALIGNED TO UNIT 1 OR 2 AS SHOWN.

TABLE 8.3-2 (SHEET 2 OF 7)

UNIT(S) IN OPERATION	POSTULATED EVENT	SCHEMATIC ARRANGEMENT DIESEL GENERATORS & 4KV EMERGENCY BUSES (TRAIN 'A' / TRAIN 'B')
1. UNIT #1 AND UNIT #2	2. LOSP ON BOTH UNITS & LOCA ON UNIT #1	

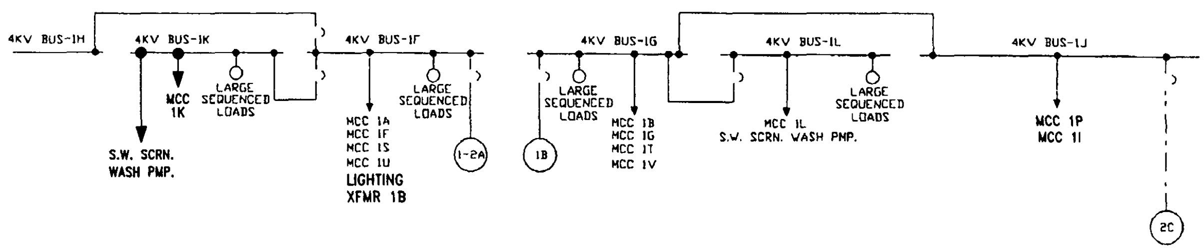
SEE SHEET 1 OF THIS TABLE FOR NOTES.

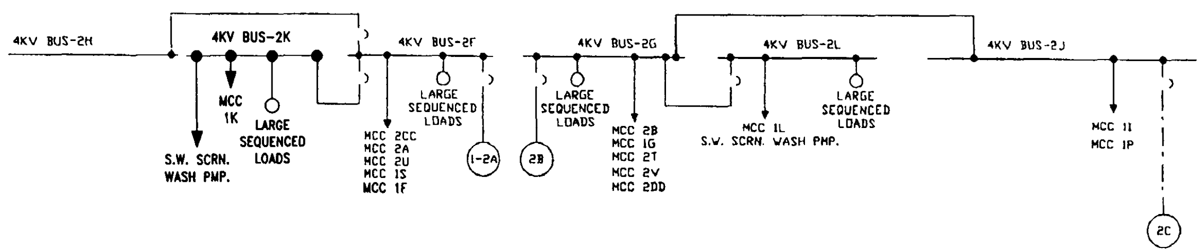
TABLE 8.3-2 (SHEET 3 OF 7)

UNIT(S) IN OPERATION	POSTULATED EVENT	SCHEMATIC ARRANGEMENT DIESEL GENERATORS & 4KV EMERGENCY BUSES (TRAIN "A" / TRAIN "B")
I. UNIT #1 AND UNIT #2	3. LOSP ON BOTH UNITS & LOCA ON UNIT #2	

SEE SHEET 1 OF THIS TABLE FOR NOTES.

TABLE 8.3-2 (SHEET 4 OF 7)

<table>
<tr><th>UNIT(S) IN OPERATION</th><th>POSTULATED EVENT</th><th>SCHEMATIC ARRANGEMENT
DIESEL GENERATORS & 4KV EMERGENCY BUSES
TRAIN 'A' TRAIN 'B'</th></tr>
<tr><td>1. UNIT #1 AND UNIT #2</td><td>4. LOSP ON UNIT #1</td><td>


</td></tr>
<tr><td></td><td>5. LOSP ON UNIT #2</td><td>


SEE SHEET 1 OF THIS TABLE FOR NOTES.
</td></tr>
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TABLE 8.3-2 (SHEET 5 OF 7)

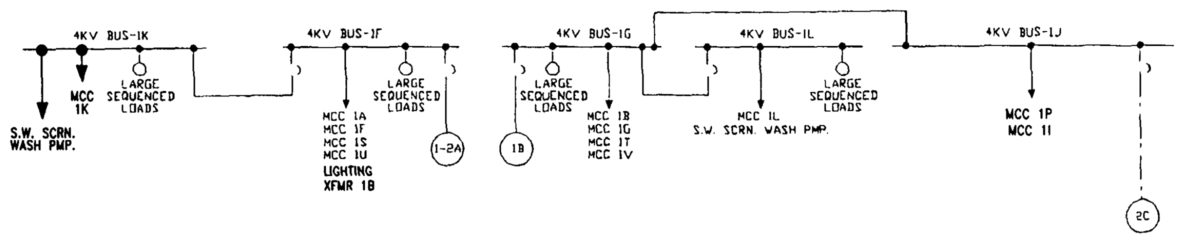
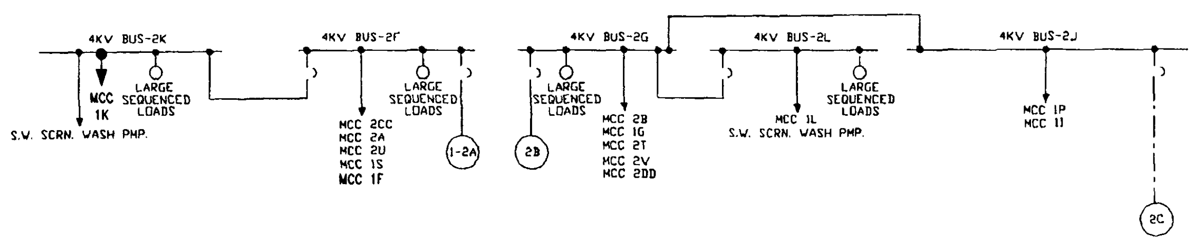
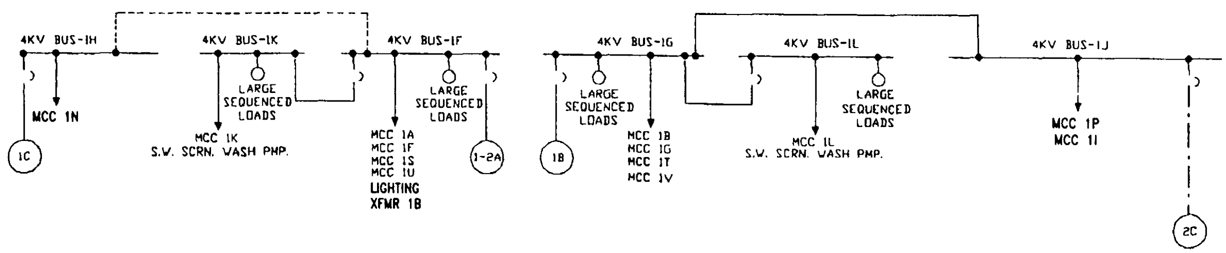
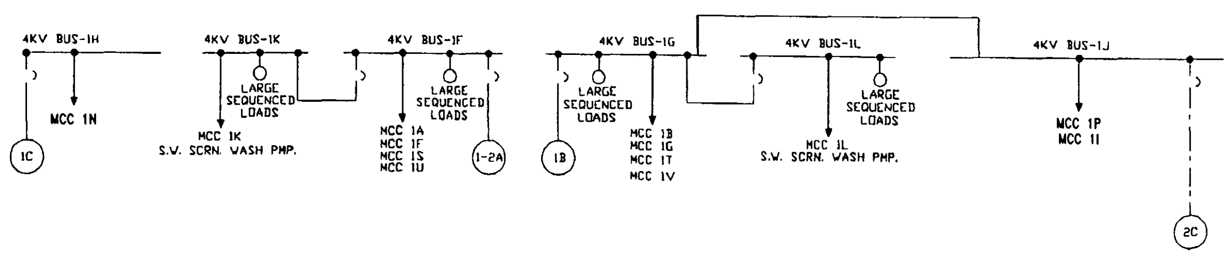
UNIT(S) IN OPERATION	POSTULATED EVENT	SCHEMATIC ARRANGEMENT DIESEL GENERATORS & 4KV EMERGENCY BUSES TRAIN 'A' TRAIN 'B'
1. UNIT #1 AND UNIT #2	6. LOSP & LOCA ON UNIT #1	
	7. LOSP & LOCA ON UNIT #2	 SEE SHEET 1 OF THIS TABLE FOR NOTES.

TABLE 8.3-2 (SHEET 6 OF 7)

<table>
<tr><th>UNIT(S) IN OPERATION</th><th>POSTULATED EVENT</th><th>SCHEMATIC ARRANGEMENT
DIESEL GENERATORS & 4KV EMERGENCY BUSES
TRAIN "A" TRAIN "B"</th></tr>
<tr><td>II. UNIT #1</td><td>1. LOSP</td><td>
</td></tr>
<tr><td></td><td>2. LOSP AND LOCA</td><td>

SEE SHEET 1 OF THIS TABLE FOR NOTES.</td></tr>
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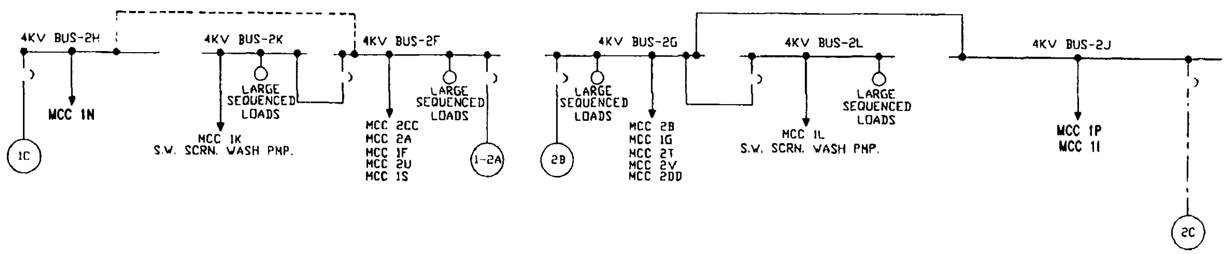
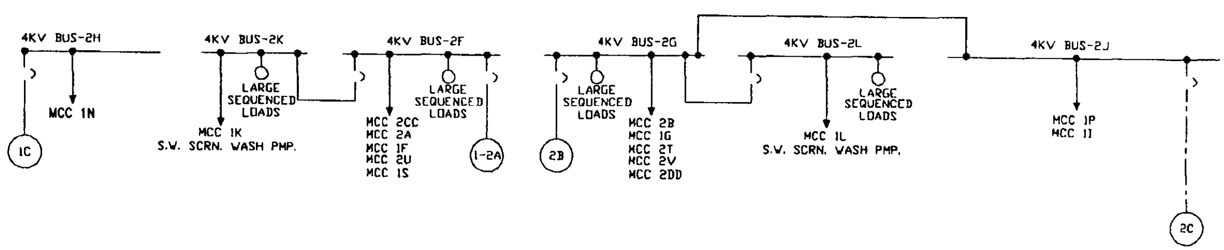
TABLE 8.3-2 (SHEET 7 OF 7)

<table>
<tr><th>UNIT(S) IN OPERATION</th><th>POSTULATED EVENT</th><th>SCHEMATIC ARRANGEMENT
DIESEL GENERATORS & 4KV EMERGENCY BUSES
TRAIN 'A' TRAIN 'B'</th></tr>
<tr><td>III. UNIT #2</td><td>1. LOSP</td><td>



</td></tr>
<tr><td></td><td>2. LOSP AND LOCA</td><td>



SEE SHEET 1 OF THIS TABLE FOR NOTES.

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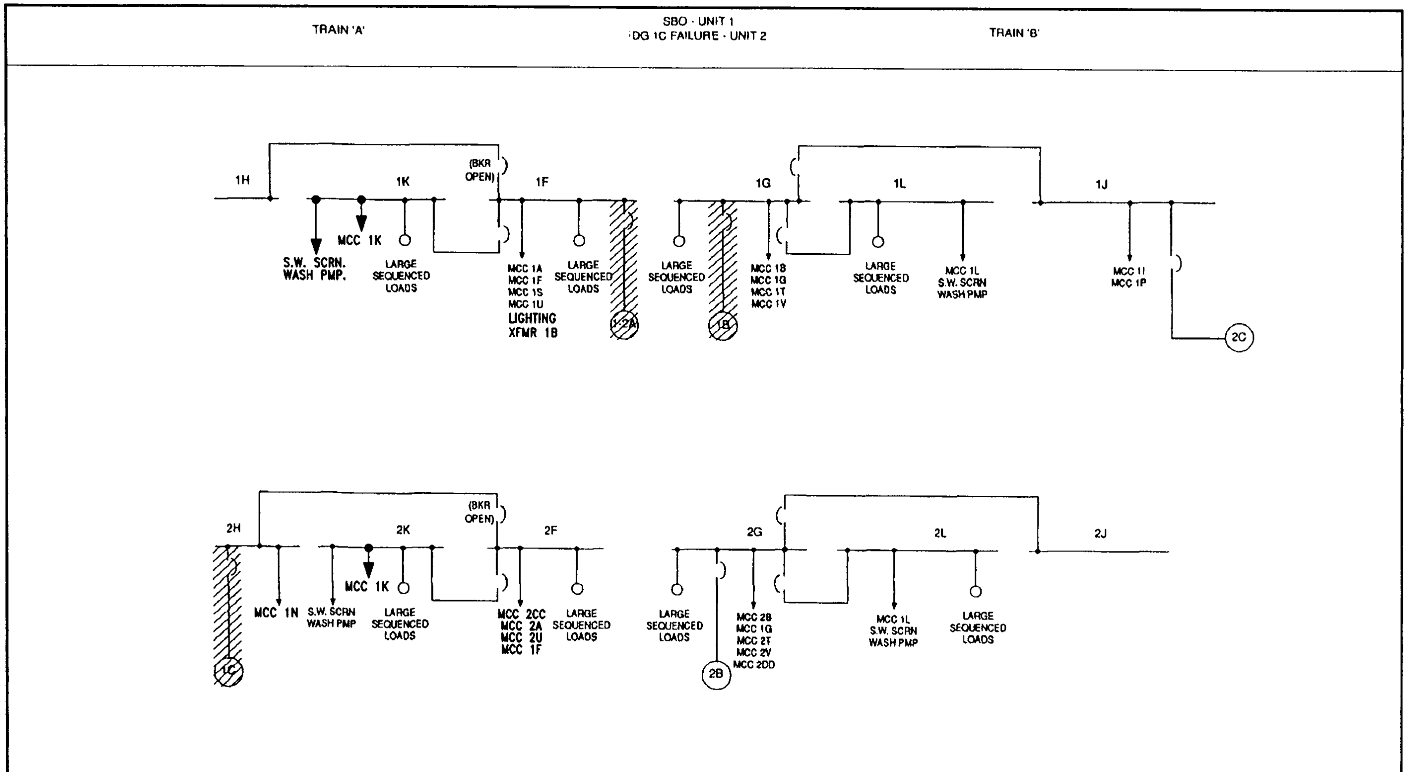
TABLE 8.3-2A (SHEET 1 OF 4)

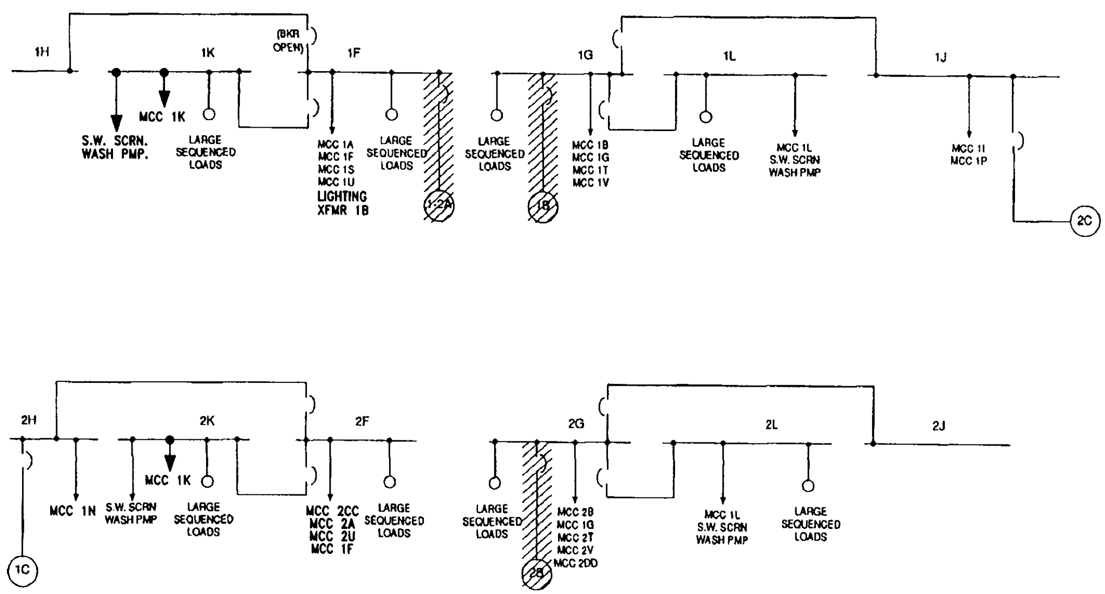
DIESEL GENERATOR BUILDING ALIGNMENTS FOR STATION BLACKOUT



NOTES:
1. EDG 2C DEDICATED TO SBO.
2. SBO IS DEFINED AS A LOSP IN BOTH UNITS CONCURRENT WITH THE FAILURE OF 3 EDGs

TABLE 8.3-2A (SHEET 2 OF 4)

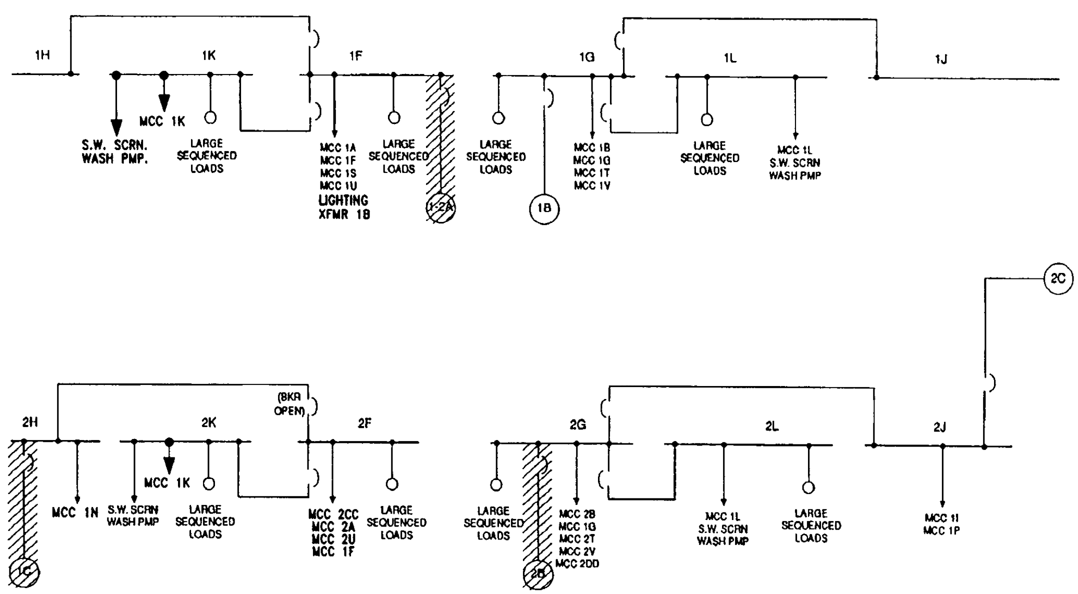
TRAIN 'A' | SBO - UNIT 1
DG 2B FAILURE - UNIT 2 | TRAIN 'B'



NOTES:
1. EDG 2C DEDICATED TO SBO.
2. SBO IS DEFINED AS A LOSP IN BOTH UNITS CONCURRENT WITH THE FAILURE OF 3 EDGs

TABLE 8.3-2A (SHEET 3 OF 4)

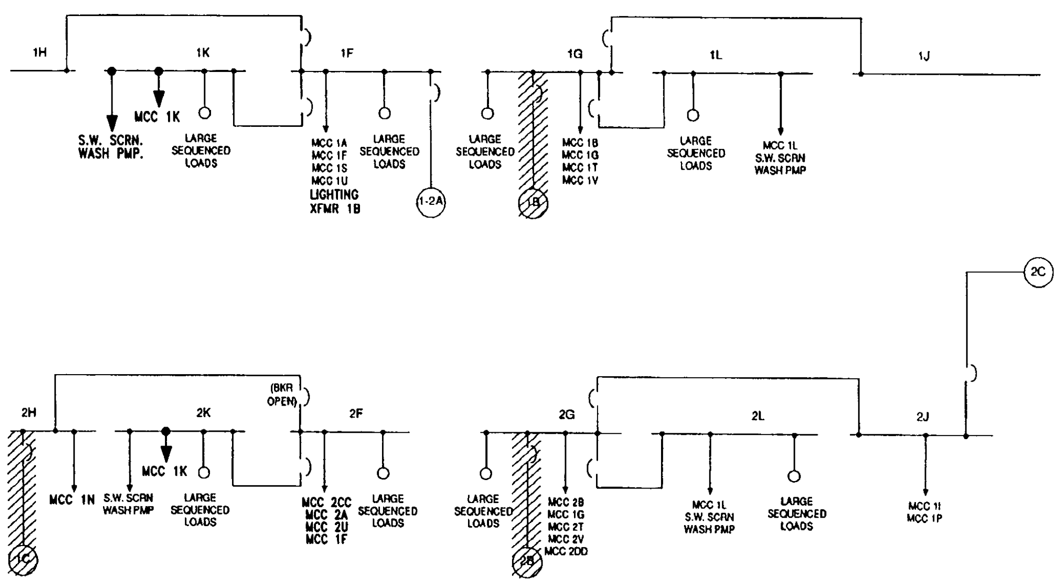
TRAIN 'A' | SBO - UNIT 2 DG 1-2A FAILURE - UNIT 1 | TRAIN 'B'



NOTES:
1. EDG 2C DEDICATED TO SBO.
2. SBO IS DEFINED AS A LOSP IN BOTH UNITS CONCURRENT WITH THE FAILURE OF 3 EDGs

TABLE 8.3-2A (SHEET 4 OF 4)

TRAIN 'A'	SBO - UNIT 2 DG 1B FAILURE - UNIT 1	TRAIN 'B'



NOTES:
1. EDG 2C DEDICATED TO SBO.
2. SBO IS DEFINED AS A LOSP IN BOTH UNITS CONCURRENT WITH THE FAILURE OF 3 EDGs

TABLE 8.3-3

DIESEL GENERATOR RATINGS AND MAXIMUM CALCULATED LOAD

	Ratings-kW					
Diesel Generators	Continuous Rating	2000 h per Year[e]	300 h per Year	30 min in 24-h Period	Maximum Calculated Automatic-Sequence Loads-kW[a]	
1-2A,1B, and 2B	4075	4353	4474	4881	1-2A	<4075[b]
					1B	<4075[b]
					2B	<4075[b]
1C and 2C	2850	3100	3250	3500	1C	>2850[c]
					2C	>2850[d]

a. Maximum diesel generator steady state loading for design basis and SBO is maintained by Calculation E-42.

b. Diesel generators 1-2A, 1B and 2B steady state loading for design basis and SBO events is calculated to be below the continuous ratings.

c. Diesel generator 1C steady state loading in some design basis scenarios and in SBO events is calculated to be above the continuous rating by less than 5% but below the 2000-hour rating.

d. Diesel generator 2C is the dedicated SBO diesel and its steady state loading in SBO events is calculated to be above the continuous rating by less than 5% but below the 2000-hour rating.

e. The diesel generators are subject to more than normal mechanical wear and tear when the intercooler water temperature exceeds 120°F without altering the electrical output at a specific electrical load rating. Operating the diesels above the intercooler temperature limit of 120°F may cause a major inspection/overhaul to be prematurely required. In order to keep the intercooler temperatures within limitations, the allowable kW output of the diesel should be manually reduced for a specific load rating (i.e., the diesel should be manually derated). Manual derating of the diesels for post-accident required automatic sequenced loads is not necessary. However, operations may desire to manually add load to cope with certain post accident scenarios. At service water temperature conditions above 97.3°F, the allowable kW for diesel generators 1-2A, 1B and 2B should be 4279 kW and the allowable kW for diesel generators 1C and 2C, the small OP diesels, should be 3044 kW for their respective 2000-hour ratings.

TABLE 8.3-4

CLASSIFICATION OF RACEWAYS BY VOLTAGE

D	4160-V power cables.
E	600-V heavy power cables requiring maintained spacing (1/0 AWG and larger).
	480-V heavy power cables requiring maintained spacing (1/0 AWG and larger).
	277-V heavy power cables requiring maintained spacing (1/0 AWG and larger).
	125 V-dc heavy power cables requiring maintained spacing (1/0 AWG and larger).
F[a]	600-V low power cables not requiring maintained spacing (No. 2 AWG and smaller).
	480-V low power cables not requiring maintained spacing (No. 2 AWG and smaller).
	277-V low power cables not requiring maintained spacing (No. 2 AWG and smaller).
	125 V-dc low power cables not requiring maintained spacing (No. 2 AWG and smaller).
G & H	208-V power.
	120 V-ac control.
	250 V-dc power.
	125 V-dc control.
	High-level instrumentation.
I	Low-level instrumentation.
P	Plate, penetration, conduit, etc., in main control room floor (access device only, not voltage related).

a. Letter F is used for cable trays only. Level F cable trays carry low power cables that do not require maintained spacing. Conduits containing low power cables use voltage letter E. All voltage level letters except F can apply to any type of raceway (i.e., conduits, cable trays, channels).

TABLE 8.3-5

CLASSIFICATION OF CABLES AND RACEWAYS BY SAFETY TRAINS

N	Nonsafeguard or normal.	
A	Train A	1 train of the ESS or RPS 2-train redundant systems.
B	Train B	Mutually redundant train to Train A.
C	Train AB	Train assigned to those cables capable of being operated in either Train A or Train B at different times.
1 -	Channel 1	Channels 1, 2, 3 and 4, respectively, of the ESS, RPS, and NIS 3- and 4-channel systems.
2 -	Channel 2	
3 -	Channel 3	
4 -	Channel 4	
X -	Nonsafeguard cable associated with (routed through) A train system.	
Y -	Nonsafeguard cable associated with (routed through) B train system.	
Z -	Nonsafeguard cable routed separate from all other trains.	

TABLE 8.3-6 (SHEET 1 OF 2)

UNIT 1 SAFETY-RELATED dc LOAD

A. Loads supplied from 125 V-dc switchgear bus 1A:

1. Inverters 1A, 1B, and 1F.
2. Diesel control panels 1-2A and 1C.
3. Emergency lighting in the control room.
4. Auxiliary relay rack A associated with reactor protection system and engineered safety features system.
5. Annunciator system.
6. Supply to safety feature actuation system solenoid valves.
7. 4160-V switchgear buses 1F and 1H.
8. 600-V load center buses 1A, 1D, and 1R.
9. Reactor trip switchgear.
10. Emergency lighting.

B. Loads supplied from 125 V-dc switchgear bus 1B:

1. Inverters 1C, 1D, and 1G.
2. Diesel control panel 1B and 2C.
3. Emergency lighting in control room.
4. Auxiliary relay rack B associated with reactor protection system and engineered safety features system.
5. Annunciator system.
6. Supply to safety feature actuation system solenoid valves.
7. 4160-V switchgear buses 1G and 1J.
8. 600-V lead center buses 1C, 1E, and 1S.
9. Reactor trip switchgear.
10. Emergency lighting.

TABLE 8.3-6 (SHEET 2 OF 2)

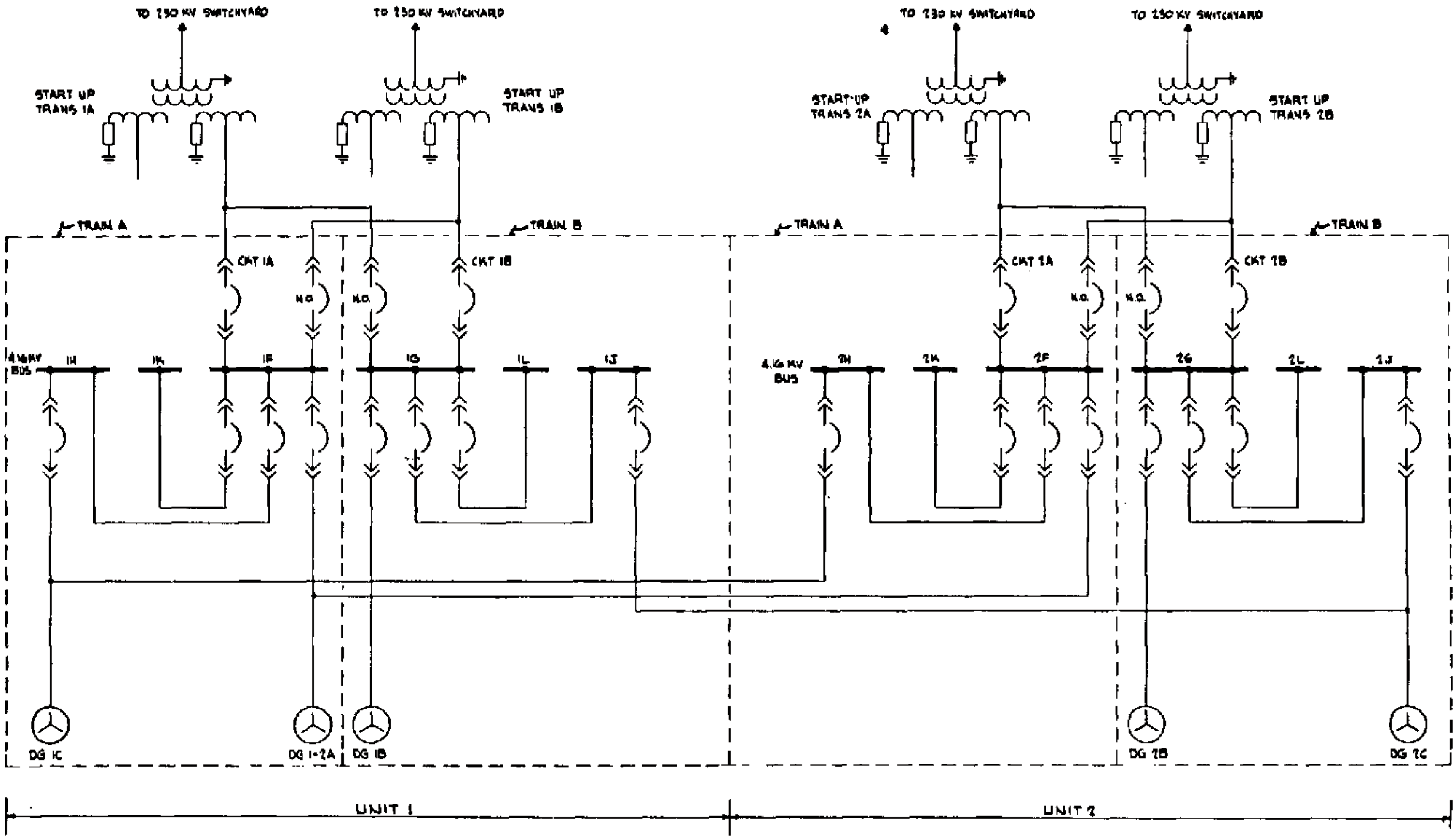
UNIT 2 SAFETY-RELATED dc LOAD

A. Loads supplied from 125 V-dc switchgear bus 2A:

1. Inverters 2A, 2B, and 2F.
2. Diesel control panels 1-2A and 1C.
3. Emergency lighting in the control room.
4. Auxiliary relay rack A associated with reactor protection system and engineered safety features system.
5. Annunciator system.
6. Supply to safety feature actuation system solenoid valves.
7. 4160-V switchgear buses 2F and 2H.
8. 600-V load center buses 2A, 2D, and 2R.
9. Reactor trip switchgear.
10. Emergency lighting.

B. Loads supplied from 125 V-dc switchgear bus 2B:

1. Inverters 2C, 2D, and 2G.
2. Diesel control panel 2B and 2C.
3. Emergency lighting in control room.
4. Auxiliary relay rack B associated with reactor protection system and engineered safety features system.
5. Annunciator system.
6. Supply to safety feature actuation system solenoid valves.
7. 4160-V switchgear buses 2G and 2J.
8. 600-V lead center buses 2C, 2E, and 1S.
9. Reactor trip switchgear.
10. Emergency lighting.



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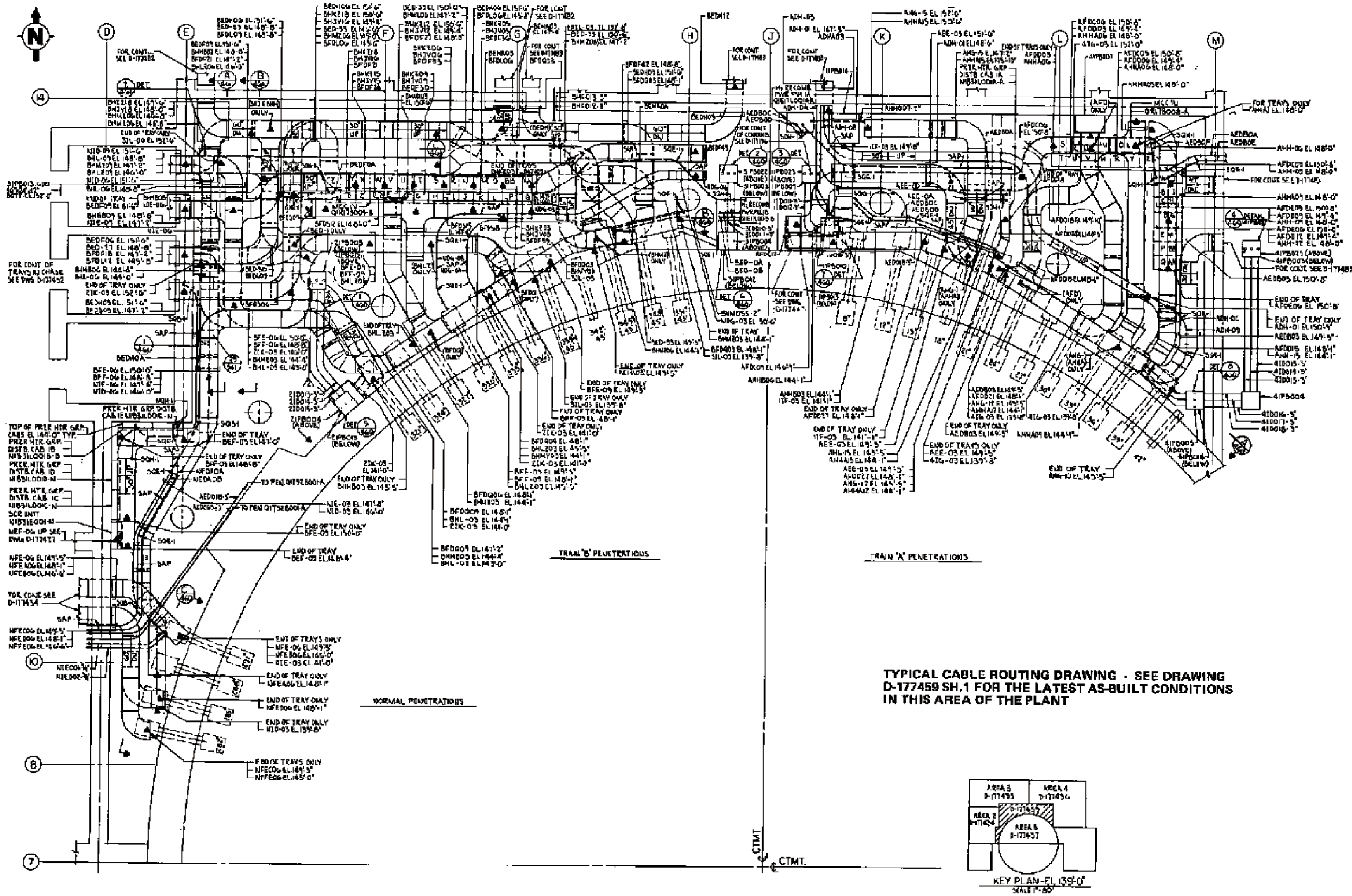
UNIT 1 AND UNIT 2

SCHEMATIC ARRANGEMENT DIESEL GENERATORS AND 4160-V EMERGENCY

FIGURE 8.3-1



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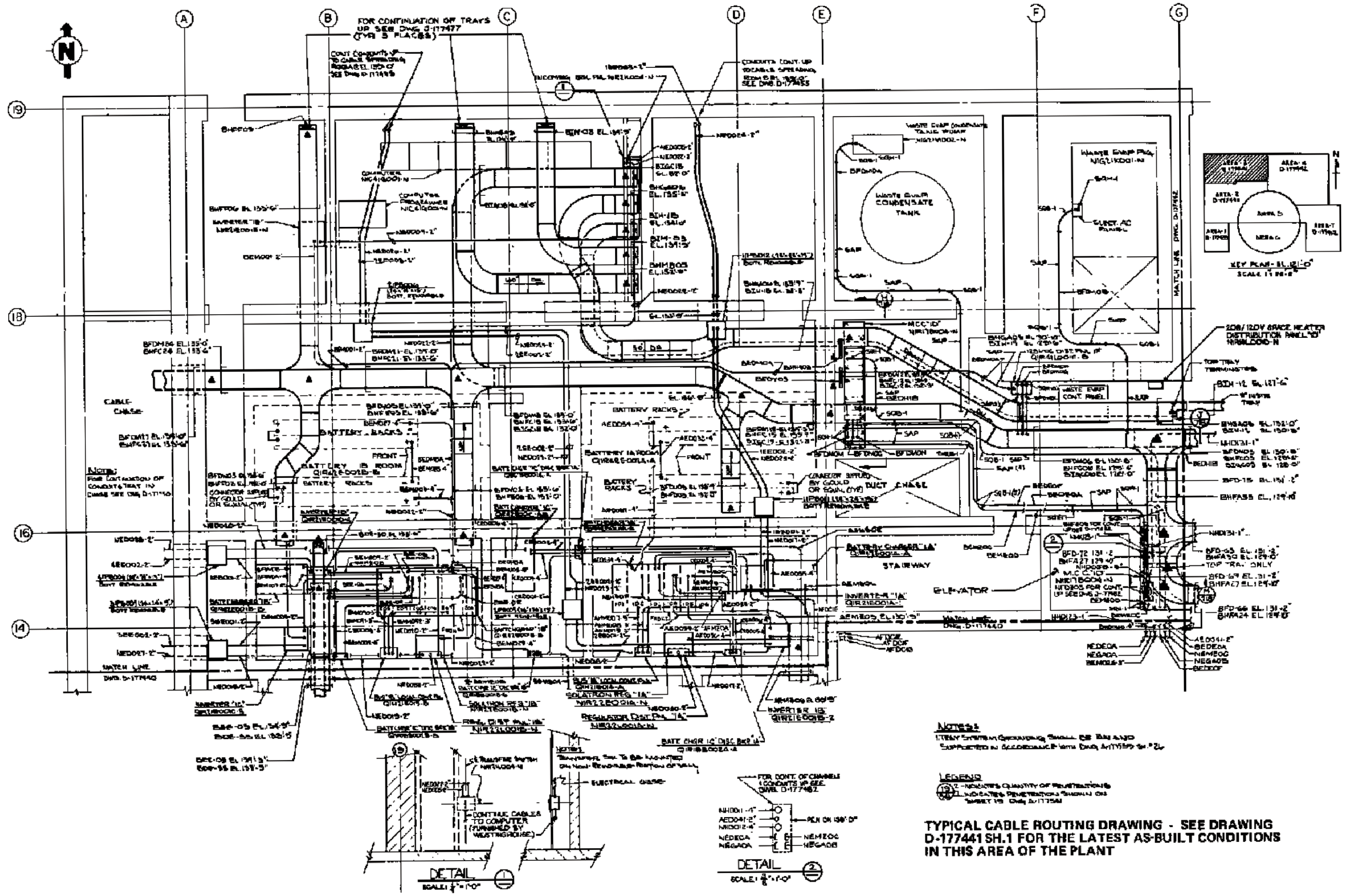
TRAY AND CONDUIT LAYOUT ELECTRICAL PENETRATION ROOM ABOVE el 139

FIGURE 8.3-2



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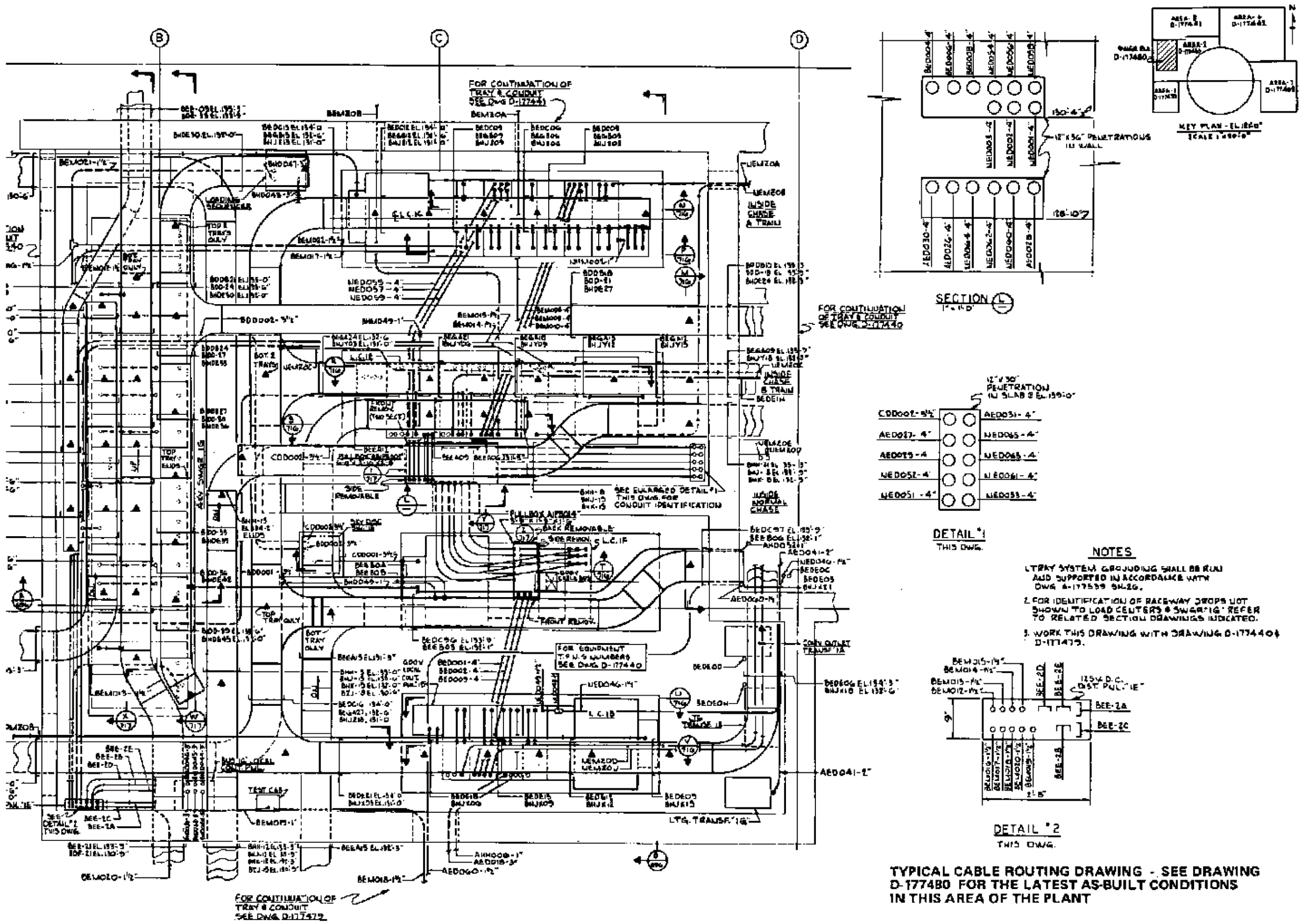
TRAY AND CONDUIT LAYOUT AUXILIARY BUILDING el 121

FIGURE 8.3-3



TYPICAL CABLE ROUTING DRAWING - SEE DRAWING D-177480 FOR THE LATEST AS-BUILT CONDITIONS IN THIS AREA OF THE PLANT

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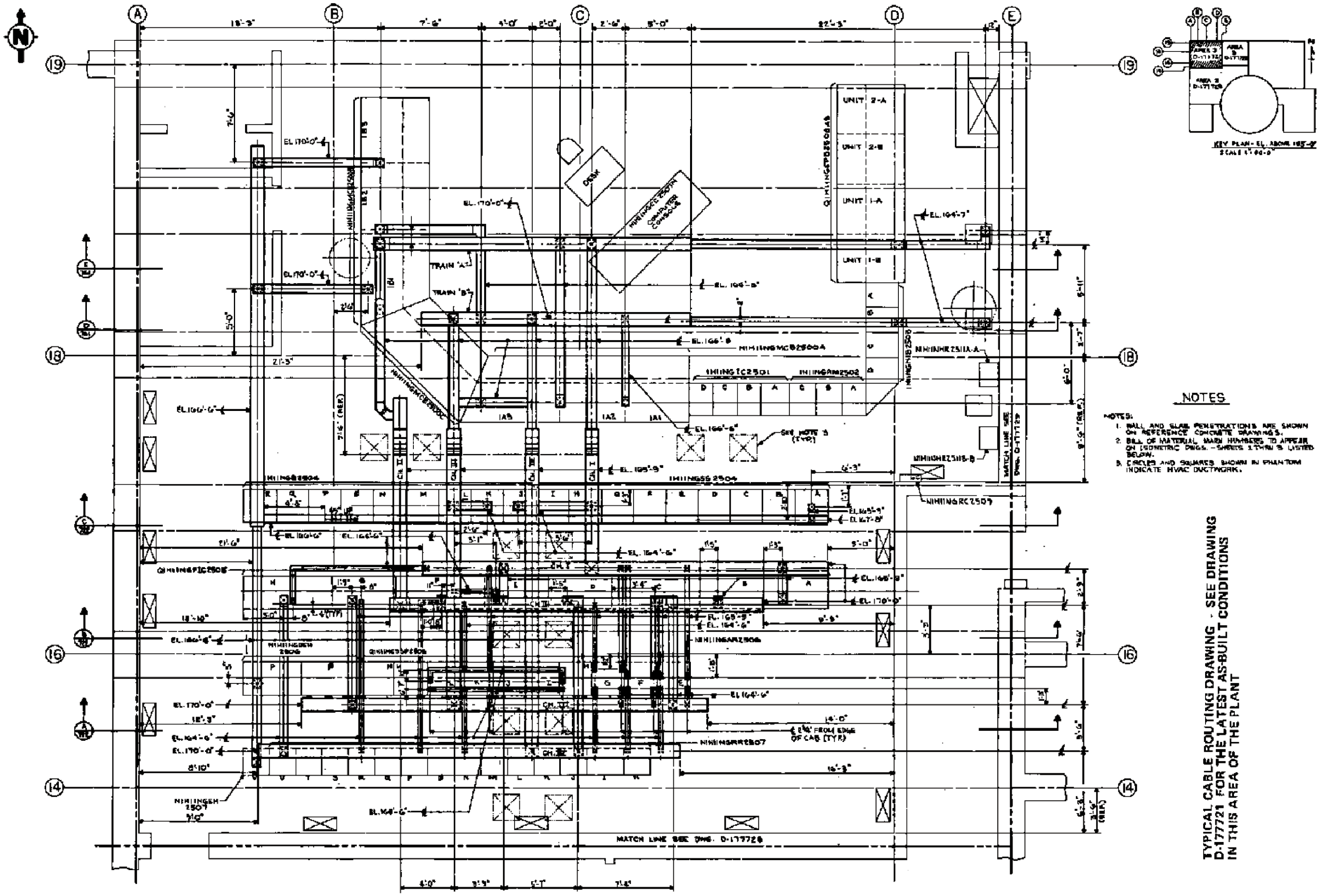
TRAY AND CONDUIT LAYOUT AUXILIARY BUILDING
ABOVE el 121 SWGR ROOM

FIGURE 8.3-4



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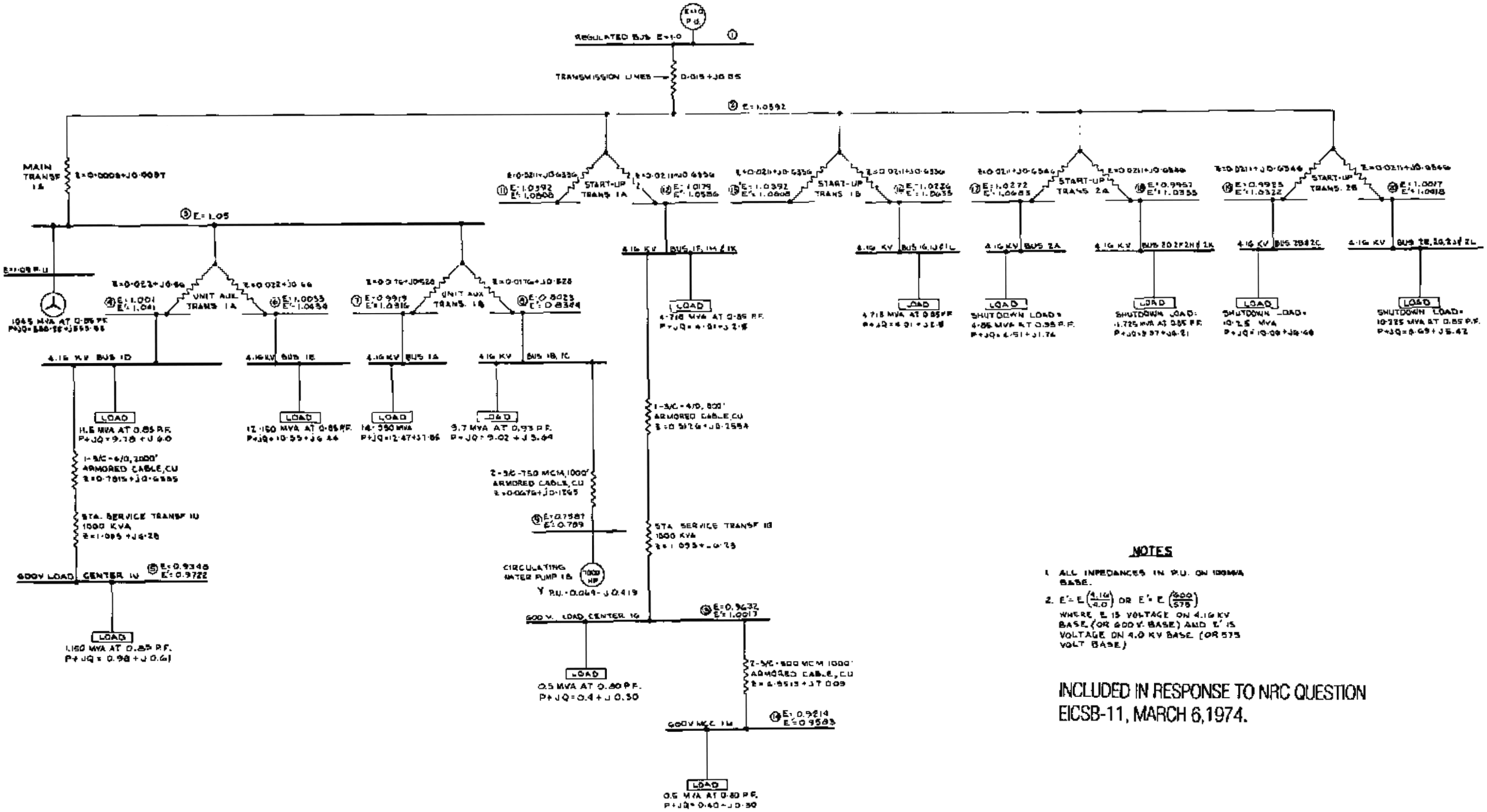
WIREWAY INSTALLATION LAYOUT AUXILIARY BUILDING
ABOVE el 155 CONTROL ROOM

FIGURE 8.3-5



NOTES

1. ALL IMPEDANCES IN P.U. ON 100MVA BASE.
2. $E' = E\left(\frac{4.16}{4.0}\right)$ OR $E' = E\left(\frac{600}{575}\right)$ WHERE E IS VOLTAGE ON 4.16 KV BASE (OR 600 V. BASE) AND E' IS VOLTAGE ON 4.0 KV BASE (OR 575 VOLT BASE)

INCLUDED IN RESPONSE TO NRC QUESTION EICSB-11, MARCH 6,1974.

CASE 7: STARTING 7000 H.P. CIRCULATING WATER PUMP MOTOR ON 4.16 KV BUS 1B.
UNIT 1 IS OPERATING WITH ALL LOADS REQUIRED FOR 100 PERCENT POWER GENERATION ON UNIT AUXILIARYS AND START-UP TRANSFORMERS, AND UNIT 2 WITH SHUTDOWN LOADS ON START-UP TRANSFORMERS.

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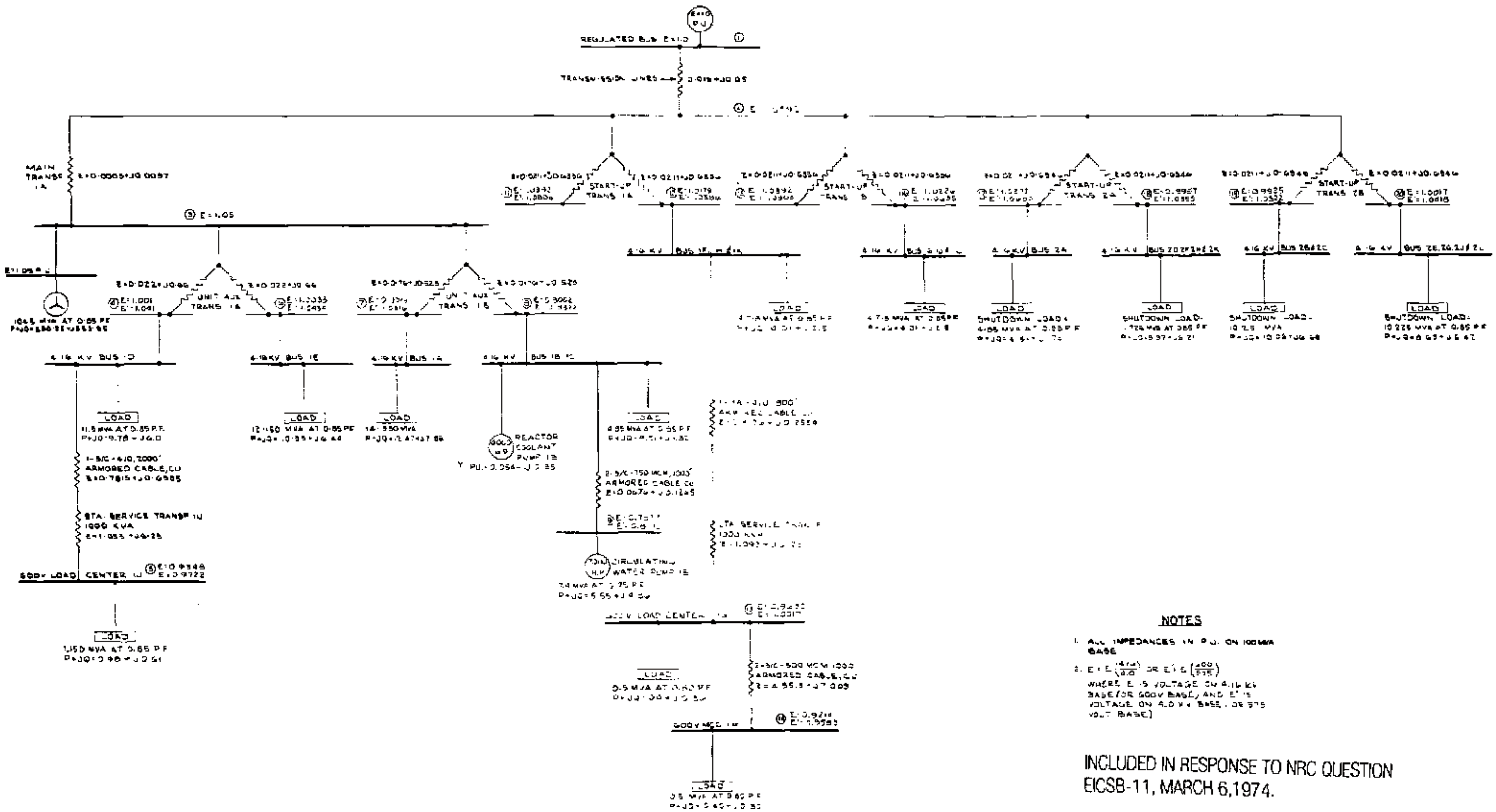
VOLTAGE DROP CALCULATIONS USING COMPUTER

FIGURE 8.3-6



NOTES

1. ALL IMPEDANCES IN P.U. ON 100MVA BASE
2. $E = E'\left(\frac{4.16}{4.0}\right)$ OR $E' = E\left(\frac{600}{575}\right)$ WHERE E IS VOLTAGE ON 4.16 KV BASE (OR 600V BASE) AND E' IS VOLTAGE ON 4.0 KV BASE (OR 575 VOLT BASE)

INCLUDED IN RESPONSE TO NRC QUESTION EICSB-11, MARCH 6,1974.

CASE 8 - STARTING 9000 H.P. REACTOR COOLANT PUMP MOTOR ON 4.16 KV BUS 1B.

UNIT 1 IS OPERATING WITH ALL LOADS REQUIRED FOR 100 PERCENT POWER GENERATION ON UNIT AUXILIARYS AND START-UP TRANSFORMERS, AND UNIT 2 WITH SHUTDOWN LOADS ON START UP TRANSFORMERS.

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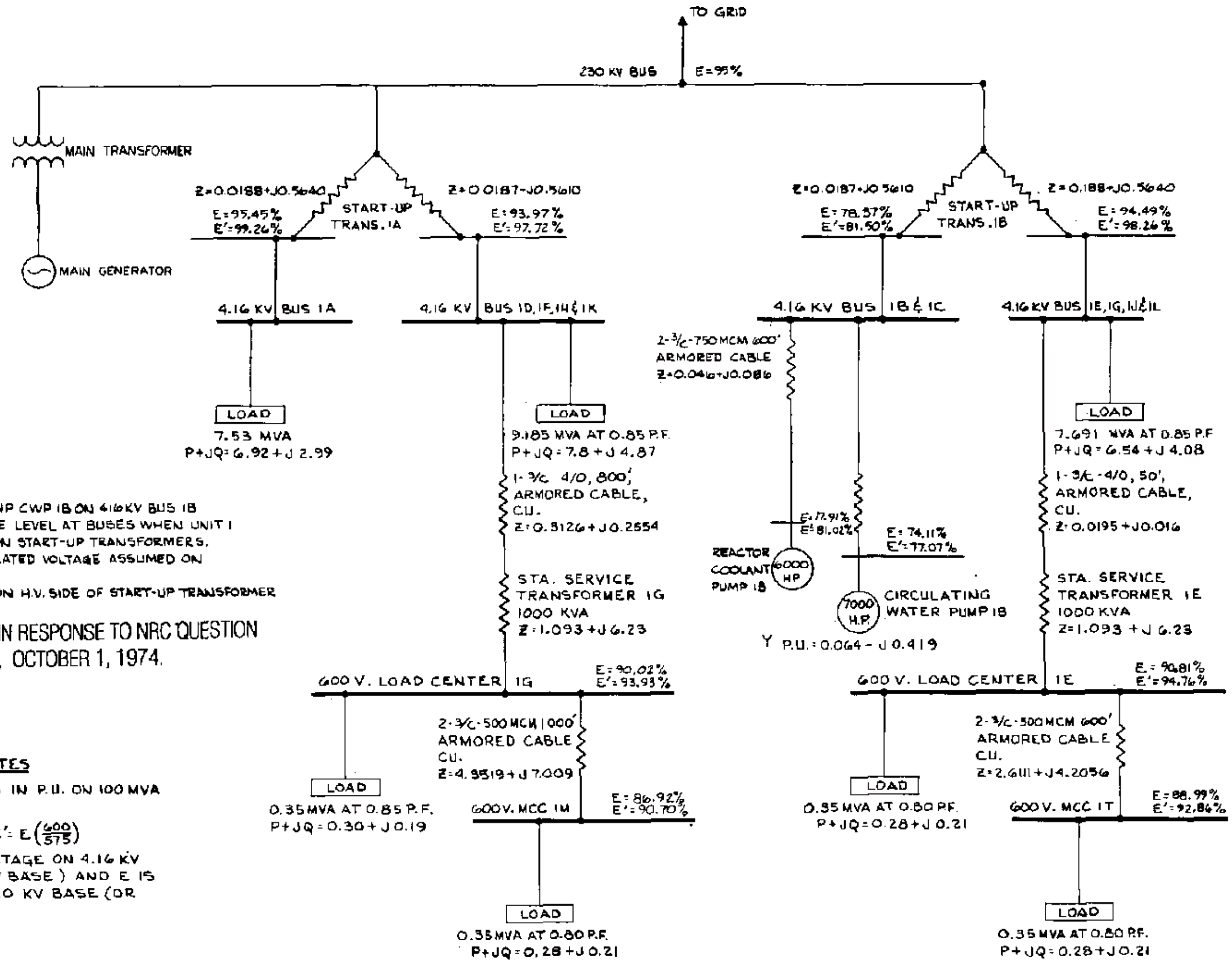
VOLTAGE DROP CALCULATIONS USING COMPUTER

FIGURE 8.3-7



CASE 2: STARTING 7000 HP CWP 1B ON 4.16 KV BUS 1B TO FIND VOLTAGE LEVEL AT BUSES WHEN UNIT 1 IS STARTING UP ON START-UP TRANSFORMERS.

DATA: 1) 0.95 REGULATED VOLTAGE ASSUMED ON 230 KV BUS

2) - 2 1/2 % TAP ON H.V. SIDE OF START-UP TRANSFORMER

INCLUDED IN RESPONSE TO NRC QUESTION EICSB-11A, OCTOBER 1, 1974.

NOTES

1. ALL IMPEDANCES IN P.U. ON 100 MVA BASE.
2. $E' = E\left(\frac{4.16}{4.0}\right)$ OR $E' = E\left(\frac{600}{575}\right)$

   WHERE E IS VOLTAGE ON 4.16 KV BASE (OR 600 V BASE) AND E IS VOLTAGE ON 4.0 KV BASE (OR 575 V BASE)

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FIGURE 8.3-8