SEABROOK STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

CHAPTER 8
ELECTRIC POWER

8.1 INTRODUCTION

The electric power system is the source of power for the plant auxiliaries during normal operation, and for the plant protection system and Engineered Safety Features during abnormal and accident conditions. The systems that comprise the electric power system are the utility grid and offsite power system, the onsite AC power system, and the onsite DC power system.

8.1.1 Utility Grid Description

Seabrook Station has three ties to the New England 345-kV transmission grid. These ties are via transmission lines to substations at Scobie Pond in New Hampshire; at Ward Hill and West Amesbury in Massachusetts; and at Newington and Timber Swamp in New Hampshire. Refer to Subsection 8.2.1.1 for additional details on these lines.

The 345 kV grid consists of a major network of inter-connecting lines covering all of New England, with cross-ties at various points, and radial lines feeding the outlying areas. The New England 345-kV transmission grid is shown in Figure 8.1-1, sh.1, and Figure 8.1-1, sh.2. These figures show both existing transmission facilities and additions that are planned or under study for installation.

The 345 kV grid of New England has three external ties to neighboring grid systems. One tie is to Keswick in the New Brunswick System in Canada, and is an extension of the lines to Maine Yankee Atomic Power Station. The other two ties connect New England to the New York Power Pool. One connection is a line from Northfield, Massachusetts to New Scotland, New York in the Niagara Mohawk System. The other tie is a line from Long Mtn., Connecticut to Pleasant Valley, New York in the Consolidated Edison System.

8.1.2 Onsite Power System Description

The onsite power system is comprised of the 4160V Emergency Distribution System, including the standby diesel generators and the 4160-volt connections from the unit and reserve auxiliary transformers, the 480V Emergency Distribution System, the 120V Vital Instrumentation and Control Power System and the 125V DC Distribution System including the batteries and battery chargers. The Supplemental Emergency Power System (SEPS) also provides a non-safety related, diesel generator backed, power supply to the emergency buses during certain non-design basis events.

Under normal operating conditions, the main generator supplies electrical power via isolated phase bus ducts to the utility grid through the generator step-up transformers and to the plant through the unit auxiliary transformers. The main generator is connected to the generator step-up and unit auxiliary transformers through a generator circuit breaker. During startup and shutdown, auxiliary power may be taken from the 345-kV system in one of two ways:

a. Back-fed through the generator step-up transformers and unit auxiliary transformers when the generator circuit breaker is open

b. From the reserve auxiliary transformers.

The one-line diagram of the onsite AC power system is shown in Figure 8.3-1. The principal feature of this system is the two redundant diesel generators which are connected to two groups of redundant emergency buses and loads when a loss of all offsite power sources occurs. Each redundant emergency bus and associated load group has sufficient redundancy, independence and testability to assure that the safety functions are performed. SEPS provides a non-safety related, diesel generator backed, power supply to the emergency buses if there is a loss of all offsite power and the emergency diesel generators fail to start and load.

The onsite AC vital instrumentation and control power system one-line diagram is shown in Figure 8.3 4. This system, consisting of inverters and distribution panels, provides power to safety-related control and instrumentation systems. Sufficient redundancy, independence, and testability are incorporated to assure that the safety functions are performed.

The onsite DC system one-line diagram is also shown in Figure 8.3-37. This system consists of batteries, battery chargers, and distribution panels. The DC system provides power for the normal and standby DC requirements. Sufficient redundancy, independence and testability are incorporated to assure that the safety functions are performed.

8.1.3 System Safety Loads

All electrical equipment required for the Engineered Safety Features Systems is supplied from the AC emergency buses, the AC vital instrumentation and control power supplies, or from the DC buses.

The safety loads are listed in Table 8.1-1 as to load type, function performed, and type of electrical power required (AC or DC).

8.1.4 Design Bases of Safety-Related Electrical Systems

The safety-related electrical systems shall meet their functional requirements under the conditions produced by the design basis event.

8.1.5 Design Criteria

8.1.5.1 General Design Criteria of Appendix A to 10 CFR Part 50

The design of the onsite power system conforms to the NRC General Design Criteria of Appendix A listed below. See Section 3.1 for a discussion on design criteria.

GDC-2	Design Bases For Protection Against Natural Phenomena
GDC-4	Environmental and Missile Design Bases
GDC-5	Sharing of Structures Systems and Components
GDC-17	Electric Power Systems

GDC-18 Inspection and Testing of Electric Power Systems

GDC-50 Containment Design Bases

8.1.5.2 Institute of Electrical and Electronic Engineers (IEEE) Standards

a. The design of the electric power systems is in conformance with the following standards except as noted below:

IEEE Std. 1 - 1969	"General Principles for Temperature Limits in the Rating of Electrical Equipment"
IEEE Std. 80 - 1971	"Guide for Safety in AC Substation Grounding"
IEEE Std. 96 - 1969	"General Principles for Rating Electrical Apparatus for Short-Time, Intermittent, or Varying Duty"
IEEE Std. 142 - 1972	"Recommended Practice for Grounding of Industrial and Commercial Power Systems" (IEEE Green Book)
IEEE Std. 279 - 1971	"Criteria for Protection Systems for Nuclear Power Generating Stations"
IEEE Std. 288 - 1969	"Guide for Induction Motor Protection"
IEEE Std. 308 - 1971	"Standard Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations" The standard provides a listing of Illustrative Periodic Tests in Table 2 for the electric power system. The surveillance activities required for Seabrook are given in the Technical Specifications (T/S). Where differences exist between the T/S and the Standard, the T/S is the governing document.
IEEE Std. 317 - 1972	"Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations"
IEEE Std. 323 - 1974	"Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations". (Refer to Subsection 3.11 for discussion of this standard.)

IEEE Std. 334 - 1971	"Trial-Use Guide for Type Tests of Continuous-Duty Class 1 Motors Installed Inside the Containment of Nuclear Power Generating Stations"
IEEE Std. 336 - 1985	"Installation, Inspection and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities. The 1971 standard was used until April 2007.
IEEE Std. 338 - 1975	"Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems"
IEEE Std. 344 - 1975	"Guide for Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations". Refer to Section 3.10 for discussion of this standard.
IEEE Std. 379 - 1972	"Trial-Use Guide for the Application of the Single Failure Criterion to Nuclear Power Generating Station Protection Systems"
IEEE Std. 380 - 1972	"Definitions of Terms used in IEEE Nuclear Power Generating Station Standards"
IEEE Std. 382 - 1972	"Trial-Use Guide for Type Tests of Class I Electric Valve Operators for Nuclear Power Generating Stations"
IEEE Std. 383 - 1974	"Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations"
IEEE Std. 387 - 1972	"Trial-Use Standard Criteria for Diesel- Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations"

IEEE Std. 450 - 1975	"Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations" Regulatory Guide 1.129 endorses IEEE Std. 450-1975 whereas T/S Bases 3/4.8.2 states that the T/S battery surveillance requirements are based on IEEE Std. 450-1980. A comparison of the 1975 to the 1980 revision concluded that there are no differences of safety significance. UFSAR compliance to IEEE Std. 450 will use the 1980 revision (See Section 8.1.5.2.b).

Documents Applicable to Equipment Purchase Orders - The issue of the documents listed above in effect on the date of the purchase orders are applicable when supplying equipment/services against the purchase order.

b. An evaluation of the Seabrook design has been performed to the standards listed below some of which have more recent issue dates than those listed above. The purpose of the evaluation was to determine if there are any requirements of safety significance that the Seabrook design does not meet and which are included in the standards. The results of the evaluation are outlined below:

<u>IEEE 308-1974</u>: It is our engineering judgment that the Seabrook design meets the requirements of this standard. The standard provides a listing of Illustrative Periodic Tests in Table 2 for the electric power system. The surveillance activities required for Seabrook are given in the Technical Specifications (T/S). On test intervals for batteries and diesel generators, our design (T/S) exceeds the requirements of this standard because the intervals have been specified to meet even more recent industry standards such as IEEE 387 on diesel generators and IEEE 450 on batteries. Where differences exist between the T/S and the Standard, the T/S is the governing document.

<u>IEEE 387-1977</u>: The basic difference between the 1977 version of the standard and the 1972 version is the incorporation of type-testing requirements for diesel generators. Because the UFSAR commits to the type test program of IEEE 387-1977, it is our engineering judgment that the Seabrook design meets this standard.

IEEE 317-1976: All major electrical containment penetrations were manufactured to meet the 1976 version of the standard. Some minor electrical penetrations, ¾" to 1" size which are associated with the personnel air lock, the equipment hatch and the containment recirculation sump isolation valve encapsulation tank, were manufactured to meet the 1972 version. It is our engineering judgment that these minor penetrations meet all the important design requirements necessary to perform their safety function. Requirements that may be lacking are in the areas of QA documentation, Service Classification documentation, and definition of certain production tests.

IEEE 384-1974: The Seabrook design meets the requirements of this standard except as noted. For exception to Subsection 5.1.2 on conduit markings, see UFSAR Subsection 8.3.1.4k. For exception to Subsection 5.1.1.3(c) on cables above the cable tray side rails, see UFSAR Subsection 8.3.1.4e.

The Seabrook cable and raceway separation criteria (see UFSAR Subsection 8.3.1.4) is a combination of the standard criteria given in Attachment C of AEC Letter dated December 14, 1973 (see UFSAR Appendix 8A) and IEEE 384-1974 and criteria established by analysis and testing as permitted by Attachment C and IEEE 384-1974.

IEEE 338-1977: The Seabrook design meets the requirements of this standard.

IEEE 484-1975: The Seabrook design meets the requirements of this standard.

IEEE 450-1980: The Seabrook design meets the requirements of this standard except as follows:

1. The electrolyte level check of all cells (Section 4.3.1[3]) is performed at least once per quarter as outlined in the Technical Specifications.
2. The yearly inspections (Section 4.3.3) and the annual performance tests (Section 5.2[3]) are performed at least once per 18 months as outlined in the Technical Specifications.
3. The intercell resistance measurement acceptance criteria (Section 4.4.1[2]) will be as given in the Technical Specifications.

IEEE 741-1986: Use of standard limited to Subsection 5.4.3 for the protection of non-Class 1E circuits using containment penetration assemblies.

8.1.5.3 Regulatory Guides

a. The design of the electric power system is in conformance with the following Regulatory Guides:

RG 1.6 (Rev. 0, 3/71)	"Independence Between Redundant Standby (Onsite) Power Supplies and Between Their Distribution Systems". (Refer to Subsections 8.3.1.2 and 8.3.2.2.)
RG 1.29 (Rev 3, 9/78)	"Seismic Design Classification" (Refer to Section 3.2.)
RG 1.30 (Rev. 0, 8/72)	"Quality Assurance Requirements for the Installation, Inspection and Testing of Instrumentation and Electric Equipment" (Refer to Section 1.8.)
RG 1.40 (Rev. 0, 3/73)	"Qualification Tests of Continuous Duty Motors installed Inside the Containment of Water Cooled Nuclear Power Plants" (Refer to Section 3.11.)
RG 1.41 (Rev. 0, 3/73)	"Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments"
RG 1.53 (Rev. 0, 6/73)	"Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems" (Refer to Subsection 7.1.2.)
RG 1.62 (Rev. 0, 10/73)	"Manual Initiation of Protection Actions" (Refer to Subsection 7.3.2.)
RG 1.73 (Rev. 0, 1/74)	"Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants" (Refer to Section 3.11.)
RG 1.81 (Rev 1, 1/75)	"Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants"
RG 1.100 (Rev 1, 8/77)	"Seismic Qualification of Electric Equipment for Nuclear Power Plants" (Refer to Section 3.10.)
RG 1.106 (Rev 1, 3/77)	"Thermal Overload Protection for Electric Motors on Motor Operated Valves" (Refer to Subsection 8.3.1.1.)

RG 1.128 (Rev 1, 10/78)	"Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants"
RG 1.131 (Rev. 0, 8/77)	"Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water Cooled Nuclear Power Plants" (Refer to Subsection 8.3.1.4.)
RG 1.155 (Rev. 0, 6/88)	"Station Blackout" (Refer to Section 8.4.)

b. The design of the electric power system is in accordance with the following regulatory guides, with clarifications as noted. Refer to Section 1.8 for additional discussion and references to other sections:

RG 1.9 (Rev 2, 12/79)	"Selection of Diesel Generator Set Capacity for Standby Power Supplies" Position C.14 requires that the engine run at full load for 22 hours following 2 hours at short time rated load. For Seabrook, a "Load Capability Qualification" test was performed per IEEE 387-1977. The engine was run at full load for 22 hours after reaching equilibrium temperature, followed by 2 hours at the short time rated load. The subject matter of this guide is discussed in Section 8.3.1.
RG 1.22 (Rev 0, 2/72)	"Periodic Testing of Protection System Actuation Functions" The design is in accordance with RG 1.22 as supplemented by Regulatory Guide 1.108, Rev. 1, entitled "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants." Refer to Subsection 8.3.1

RG 1.32 (Rev 2, 2/77)

"Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants"

The safety related electric power system design conforms with the recommendations of Regulatory Guide 1.32, Rev. 2, with the following exceptions:

The response to Regulatory Guide 1.75 in this UFSAR Subsection addresses conformance to Regulatory Guide 1.75 which is referenced in Regulatory Guide 1.32 Positions C.1.d and C.1.e.

The Regulatory Guide states in Position C.1.c, "The battery service test described in IEEE Std 450-1975 should be performed in addition to the battery performance discharge test." The Technical Specifications require service tests at least once per 18 months and performance discharge tests at least once per 60 months. However, the Technical Specifications allow the performance discharge test to be performed in lieu of (not in addition to) the service test once per 60 month interval.

The Regulatory Guide also states in Position C.1.c, "The battery service test should be performed during refueling operations or at some other outage, with intervals between tests not to exceed 18 months." The Technical Specifications permit the battery service test to be performed during non-outage periods. The Seabrook Station design incorporates two 100% capacity battery banks per train. Removing one of these battery banks from service for surveillance testing does not reduce the system capabilities. The regulatory guide assumes only one 100% capacity battery bank per train.

The Subject matter of Regulatory Guide 1.32 is further discussed in Subsections 8.1.5.3, 8.3.1, and 8.3.2.

RG 1.47 (Rev. 0, 5/73)	"Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems" With the exception of the Emergency Diesel Generator System, the Electric Power System is not required to have inoperable status indication because it is not expected to be bypassed or deliberately induced inoperable more frequently than once per year. Reference regulatory position C.3(b). Inoperable status indication is provided for the Emergency Diesel Generator System as a result of data provided by the NRC indicating that diesel generator systems have been declared inoperable more frequently than once per year.
RG 1.63 (Rev 2, 7/78)	"Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Plants" The electrical penetration assemblies are designed to withstand, without loss of mechanical integrity, the maximum fault current vs. time conditions that could occur as a result of single random failures of circuit overload devices. In addition to the 15 kV switchgear breakers, the medium voltage 15 kV penetrations are also protected by fuses inserted in the feeders outside containment. These fuses are qualified by experience and seismic testing. The 600 volt system x/R ratio used in specifying the electrical penetrations is 4. Calculations show that this value is conservatively applied because the actual ratio is considerably less than 4. Refer to Subsection 8.3.1.2
RG 1.68 (Rev 2, 8/78)	"Preoperational and Initial Startup Test Program for Water-Cooled Power Reactors" (Refer to Subsection 14.2.7 for exceptions.)

RG 1.75 (Rev 2, 9/78)	"Physical Independence of Electric Systems" The design is consistent with the criteria for physical independence of electric systems established in Attachment C of AEC letter dated December 14, 1973 (See UFSAR Appendix 8A), and is in general conformance with Regulatory Guide 1.75, except as follows:

Battery Room Ventilation. Although the four Class 1E batteries are housed in separate safety class structures, they represent only two redundant load groups (see Subsection 8.3.2). Each load group is served by a separate safety-related ventilation system. There is a cross-tie between the two ventilation systems to allow one system to serve both load groups in case the other system is inoperable. Fire dampers are provided to isolate each battery room.

For additional information on the four batteries and two redundant load groups, see Subsection 8.3.2.1a.

Refer to Subsection 8.3.1.2b.5 for a discussion of the onsite AC power system.

The requirements of position C4, as it relates to cables for the associated circuits, is clarified as follows:

Instrumentation, control and power cables used for the associated circuits will not be covered by the Operational Quality Assurance Program (OQAP). However, programmatic controls will be applied to these items. The actual implementation of these controls will be defined by the program manuals used to control specific activities at Seabrook Station. Implementation of these programmatic controls will be verified by Quality Assurance personnel to the extent necessary to insure proper application. For further details on provisions and considerations for the associated circuits, see UFSAR Chapter 8, Subsection 8.3.1.4b.1(d).

The Seabrook cable and raceway separation criteria (see UFSAR Subsection 8.3.1.4) is a combination of the standard criteria given in Attachment C of AEC Letter dated December 14, 1973 (see UFSAR Appendix 8A) and IEEE 384-1974 and criteria established by analysis and testing as permitted by Attachment C and IEEE 384-1974.

RG 1.89 (Rev. 1, 6/84	"Qualification of Class 1E Equipment for Nuclear Power Plants"

The guidance provided by Regulatory Guide 1.89, which endorses IEEE 323-1974 with certain exceptions, i.e., source terms and the use of IEEE 344-1971, has been followed for the BOP equipment except for those instances discussed below:

a. Qualification of Class 1E electrical, instrumentation and control equipment meets the requirements of IEEE 323-1974, with exceptions. Further discussion regarding qualification is provided in Sections 3.10, 3.11 and Reference 15 in UFSAR Section 1.8.

   Exceptions: Turbine trip-related inputs to the Reactor Trip System consist of the following:

   1. Turbine stop valve position
   2. Turbine Electro-Hydraulic System fluid pressure.
   3. Turbine impulse chamber pressure

   This equipment was tested in accordance with the guidelines of IEEE Standard 323-1974.

b. The total integrated radiation doses to be used in qualification of the Class 1E equipment will be a combination of normal operating environment and post-accident environment, with credit taken for locations, shielding and the time for which the equipment is required to perform its function.

   Values of integrated doses to be used in the qualification of Class 1E equipment are given in Reference 15 in Section 1.8.

   For the safety related equipment located inside the containment and required after a LOCA, the sources used in establishing the integrated dose are consistent with Regulatory Guide 1.89, Rev. 0. Both instantaneous gamma and beta doses have been considered in establishing the integrated doses.

The seismic qualification of electrical, instrumentation and control equipment meets the requirements of IEEE 344-1975.

Conformance of NSSS Class 1E equipment with IEEE

Standard 323-1974 (including IEEE Standard 323A-1975 position statement of July 23, 1975) and Regulatory Guide 1.89 is being demonstrated by an appropriate combination of any or all of the following: type testing, operating experience, qualification by analysis and on-going qualification programs. This commitment is being satisfied by implementation of Reference 9 in UFSAR Section 1.8.

RG 1.93 (Rev. 0, 12/74)

"Availability of Electric Power Sources"

The Technical Specification (T/S) ac and dc power sources allowable out-of-service times (action statements) are based on RG 1.93. Where differences exist between the T/S and RG 1.93, the T/S are the governing document.

RG 1.93 does not allow out-of-service times to be used for preventative maintenance that incapacitates a power source. These activities are to be scheduled for refueling or shutdown periods. This is interpreted to also apply to surveillance activities. Preventative maintenance and surveillance activities are performed on-line when permitted by the T/S and with appropriate consideration of the effects on safety, reliability, and availability.

RG 1.108 (Rev 1, 8/77) (Errata 9/77)

"Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants"

The diesel generator testing is in conformance with the recommendations of Regulatory Guide 1.108 except as noted below:

The requirements of position C.1.c are met with the following exception:

> Temporary jumpers are used on a limited basis during the performance of periodic tests for the emergency diesel generators.

The above exception to Regulatory Guide 1.108 is determined to be acceptable because the NRC has previously accepted the use of temporary jumpers for testing of protection system circuits addressed in UFSAR Section 7.1.2.11.d. This position is further supported by the discussion in SER Section 7.3.2.14. The NRC based its acceptance on the combination of explicit test procedures and administrative controls (independent

second-person verification) which met the guidelines in NRC IE Information Notice No. 84-37, Use of Lifted Leads and Jumpers During Maintenance or Surveillance Testing. These guidelines provide reasonable assurance that the instrumentation will be restored to the correct configuration following testing. The use of jumpers is minimized and is performed only where permanent hardware changes are not practical or cannot be justified.

The requirements of position C.2.a(5) were met for preoperational testing as follows:

> The functional capability at full-load temperature was demonstrated during preoperational testing by performing the test outlined in position C.2.c(1) and (2) immediately following the full-load carrying capability test described in position C.2.a(3). The full-load carrying capability of position C.2.c(2) was demonstrated for greater than or equal to five minutes.

The above testing met the intent of position C.2.a(5) by demonstrating the capability of the diesel generator to start and accept load at full-load temperature.

The requirements of position C.2.a(3) will be met every 18 months as follows:

> Full-load carrying capability will be verified by operating the diesel generator at a load of greater than or equal to 5600 kW and less than or equal to 6100 kW. The 2-hour rating of the diesel generator will be verified by operating the diesel generator at a load of greater than or equal to 6363 kW and less than or equal to 6700 kW.

The above exceptions to Regulatory Guide 1.108 meet the intent of position (3) by demonstrating that the diesel generators are capable of carrying approximate full load for an interval of not less than 24 hours.

The requirements of position C.2.a(5) will be met every 18 months as follows:

> The functional capability at full-load temperature will be demonstrated by verifying that the diesel generator will start from a manual or automatic start signal within

> five minutes of shutdown following the 24-hour surveillance run. The generator voltage and frequency shall be 4160 ± 420 volts and 60 ± 1.2 Hz within 10 seconds after the start signal, and the diesel generator shall be operated for at least five minutes.***

The above exception to Regulatory Guide 1.108 meets the intent of position (5) by demonstrating the capability of the diesel generator to start at normal operating temperature.

The periodic testing requirements of C.2.c(2) will be met as follows:

> Full-load carrying capability will be verified by periodically running the diesel generator at a load of greater than or equal to 5600 kW and less than or equal to 6100 kW for at least 60 minutes.

The above exception to Regulatory Guide 1.108 meets the intent of position (2) by demonstrating that the diesel generators are capable of carrying approximate full load for a period of not less than 60 minutes.

*** If the diesel generator fails to start during this test, then it is not necessary to repeat the preceding 24-hour test. Instead, the diesel generator may be operated at greater than or equal to 5600 kW and less than or equal to 6100 kW for 2 hours or until operating temperature has stabilized. The load range is provided to preclude routine overloading of the diesel generator. Momentary transients outside the load range, due to changing bus conditions, do not invalidate the test.

The periodic testing interval requirements of position C.2.d will be met as follows:

> The periodic testing interval will be no more than 31 days per T/S 4.8.1.1.2.a. The corrective actions for a test failure will be determined by the maintenance rule emergency diesel generator performance criteria.

The above exception to Regulatory Guide 1.108 meets the intent of position C.2.d by maintaining the periodic test interval and ensuring that adequate corrective actions are implemented if a test failure occurs.

The records and reporting requirements of position C.3.b will be met as follows:

> Significant emergency diesel generator failures will be reported in accordance with the provisions of 10CFR50.72 and 50.73. Footnote 3 in position C.3.b references Regulatory Guide 1.16. UFSAR Section 1.8 documents compliance with Regulatory Guide 1.16.

The above exception to Regulatory Guide 1.108 meets the intent of position C.3.b by providing NRC notification of diesel generator failures in accordance with the licensee's reporting requirements.

For further information refer to Subsections 8.3.1.1j and 8.3.1.1(e).

RG 1.118 (Rev 1 & Rev 2)	"Periodic Testing of Electric Power and Protection Systems" Position C.6 (Rev. 2) and Position c.14 (Rev. 1) state that temporary jumpers may be used with portable test equipment where the safety system equipment to be tested is provided with facilities specifically designed for connection of this test equipment. The intention of this position is to ensure that test setups are of a quality that does not degrade the equipment and that makeshift test setups are not used. Temporary jumpers are used on a limited basis during the performance of periodic tests for various electric power and protection systems. Regulatory Guide 1.118 does not provide details on what constitutes facilities specifically designed for connection of test equipment. When temporary jumpers are used during testing, they are connected via devices that are suitable for ensuring a reliable connection to the equipment under test. Certain points of connection may not have been specifically designed for the connection of test equipment, but the points are evaluated for acceptability for each application. This meets the intent of the regulatory position to ensure that makeshift test setups are not used. For additional information on the use of temporary jumpers, refer to the discussion under Regulatory Guide 1.108.

RG 1.129 (Rev. 1, 2/78) "Maintenance, Testing and Replacement of Large Lead Acid Storage Batteries for Nuclear Power Plants" (Refer to Subsection 8.3.2)

The plant design conforms to Regulatory Guide 1.129 except for the following:

The Regulatory Guide states in Position C.1, "The battery service test should be performed in addition to the battery performance discharge test." The Technical Specifications require service tests at least once per 18 months and performance discharge tests at least once per 60 months. However, the Technical Specifications allow the performance discharge test to be performed in lieu of (not in addition to) the service test once per 60 month interval.

The Regulatory Guide states in Position C.1, "The battery service test should be performed during refueling operations or at some other outage, with intervals between tests not to exceed 18 months." The Technical Specifications permit the battery service test to be performed during non-outage periods. The Seabrook Station design incorporates two 100% capacity battery banks per train. Removing one of these battery banks from service for surveillance testing does not reduce the system capabilities. The regulatory guide assumes only one 100% capacity battery bank per train.

Although RG 1.129 endorses IEEE Std. 450-1975, its regulatory positions are worded such that they can also be applied to IEEE Std. 450-1980 revision which is referenced in the Technical Specification Bases.

8.1.5.4 Branch Technical Positions (BTPs)

The electrical power system is in conformance with the following BTPs with clarifications as noted:

BTP PSB 1 "Adequacy of Station Electric Distribution System Voltages

"See Subsection 8.3.1.2(c) for clarifications.

BTP EICSB 2 "Diesel-Generator Reliability Qualification Testing"

The number of allowable failures permitted during diesel generator reliability testing is in accordance with RG 1.9 (Rev. 1) and IEEE 387-1977.

BTP EICSB 6 "Capacity Test Requirements of Station Batteries-Technical Specifications"

The periodic testing of the batteries will comply with the requirements of RG 1.32, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants" as described in Section 8.1.5.3, IEEE 450 as described in Section 8.1.5.2 and the Technical Specifications.

BTP EICSB 7 "Shared Onsite Emergency Electrical Power Systems for Multi-Unit Generating Stations"

BTP EICSB 8 "Use of Diesel-Generator Sets for Peaking"

BTP EICSB 11 "Stability of Offsite Power Systems"

BTP EICSB 17 "Diesel-Generator Protective Trip Circuit Bypasses"

The design is in compliance with the recommendations of BTP 17. All protective trips except engine overspeed, generator differential, 4160-volt bus fault, and engine low lube oil pressure (which has been provided with the recommended independent measurements and coincident logic) are rendered inoperable by a bypass circuit during an accident condition. Refer to Subsection 8.3.1.1.e.4

BTP EICSB 18 "Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves"

BTP EICSB 21 "Guidance for Application of RG 1.47"

BTP EICSB 27 "Design Criteria for Thermal Overload Protection for Motors of Motor-Operated Valves"

8.1.5.5 Other Standards and Documents

The electric power system is in conformance with the following documents except as noted:

ANSI C34.2 - 1968	"Practice and Requirements for Semi-Conductor Power Rectifiers"
ANSI C37.010 - 1972	"Application Guide for AC High Voltage Breakers"
ANSI C37.4 - 1953 and Suppl. of 1958 and 1970	"Definitions and Rating Structure, AC High Voltage Circuit Breakers Rated on a Total Current Basis"
ANSI C37.13 - 1973	"Low Voltage AC Power Circuit Breakers Used in Enclosure"
ANSI C37.20 - 1972	"Switchgear Assemblies Including Enclosed Bus"
ANSI C37.90 - 1971	"IEEE Standard for Relays and Relay System Associated with Electric Power Apparatus"
ANSI C37.91 - 1967	"Guide for Protective Relay Applications to Power Transformers"
ANSI C57.12.00 - 1973	"General Requirements for Distribution, Power and Regulating Transformers" Circuit protection for dry-type unit substation transformers is evaluated using the through-fault protection curves provided in IEEE Standard C57.12.59-1989, "IEEE Guide for Dry-Type Transformer Through-Fault Current Duration," versus using the ANSI withstand point methodology provided in ANSI C57.12.00-1973. The through-fault protection curves contained in IEEE C57.12.59-1989 represent an improved methodology that is based on current industry information.
ICEA No. S-19-81 - 1969	"Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy"
ICEA No. P-46-426-1962	"Power Cable Ampacities"

ICEA No. P-54-440 - 1972	"Ampacities - Cable in Open-top Cable Trays"
ICEA No. S-66-525 - 1971	"Cross-Linked Thermosetting Polyethylene Insulation for Power Cable Rated 601-15,000 Volts"
NEMA MG-1 - 1972	"Motors and Generators"

Attachment C of AEC letter dated December 14, 1973, entitled "Physical Independence of Electric Systems" (see UFSAR Appendix 8A). For exception to Subsection 5.1.2 of Attachment C on conduit markings, see UFSAR Subsection 8.3.1.4k.

The Seabrook cable and raceway separation criteria (see UFSAR Subsection 8.3.1.4) is a combination of the standard criteria given in Attachment C of AEC Letter dated December 14, 1973 (see UFSAR Appendix 8A) and IEEE 384-1974 and criteria established by analysis and testing as permitted by Attachment C and IEEE 384-1974.

<u>Documents Applicable to Equipment Purchase Orders</u> - The issue of the documents listed above in effect on the date of the purchase orders are applicable when supplying equipment/services against the purchase order.

8.2 OFFSITE POWER SYSTEM

8.2.1 Description

The transmission grid connections that provide offsite power to Seabrook Station consist of three 345-kV transmission lines, as shown in Figure 8.2-1, Figure 8.2-2, and Figure 8.2-3. These lines are designed and built to provide the electrical and structural independence necessary to insure continuity of offsite electrical power to the station.

At Seabrook Station, the three lines terminate at separate terminating structures. From the terminating structures each circuit is routed in metal-enclosed, SF_6 gas-insulated bus to a common switching station, as shown in Figure 8.2-7 and Figure 8.2-8.

8.2.1.1 Transmission Lines

The topography of the 345-kV transmission line rights-of-way is reasonably flat areas or low rolling hills. The Newington/Timber Swamp line runs in a northerly direction for approximately 4.5 miles and terminates at Timber Swamp Substation in Hampton Falls, New Hampshire. The 345 kV Transmission Line System continues approximately 13.5 miles to the Newington Generating Station in Newington, New Hampshire. The Ward Hill/West Amesbury line runs in a westerly direction for approximately 5 miles and then veers southerly for approximately 20 miles, terminating at Ward Hill Substation in Ward Hill, Massachusetts. A tap in the line to Ward Hill terminates at the West Amesbury Substation in Amesbury, Massachusetts. The Scobie Pond line runs in a westerly direction for approximately 30 miles and terminates at Scobie Pond Substation in Derry, New Hampshire.

The 345-kV lines from Seabrook to Scobie Pond and from Seabrook to Ward Hill/West Amesbury are on separate towers but share the same right-of-way for approximately 5 miles as shown in Figure 8.2-1. The balance of the Ward Hill/West Amesbury line is shown in Figure 8.2-2.

Both the Scobie Pond and the Ward Hill/West Amesbury transmission lines use wood or steel H-frame type structures, with two steel H-frame structures in parallel on the common portion of their rights-of-way. See details B and E of Figure 8.2-4 for typical parallel 345-kV H-frame structures. The steel angle structures necessary for those portions of the lines are similar to that shown in detail C of Figure 8.2-4. As noted on Figure 8.2-1, the spacing of the structures on the parallel lines is 85 feet center-to-center except for the beginning distance of about 1 mile at Seabrook Station where the spacing is 75 feet center-to-center as shown in detail E of Figure 8.2-4. The combination of 75- or 85-foot separation and the safety factors in the design of the steel structures ensures complete electrical and physical separation of the two transmission lines along the 5-mile section of common right-of-way.

The Newington/Timber Swamp line is on an entirely separate right-of-way, as shown in Figure 8.2-3. The transmission line from Seabrook to Timber Swamp Substation and Newington Station uses single pole steel structures similar to that in detail A of Figure 8.2-4 and single circuit H-frame steel structures similar to those shown in detail B of Figure 8.2-4.

a. Structural Design

The structural design of the transmission structures and lines is based on design criteria which meet or exceed the Grade B requirements for heavy-loading districts of the National Electrical Safety Code (NESC) (Reference 4). The portion of the 345-kV transmission line to Ward Hill/West Amesbury that is within the Massachusetts boundary also meets the requirements of the Commonwealth of Massachusetts "Code for the Installation and Maintenance of Electrical Transmission Lines" (Reference 5). Other conditions considered in design of transmission towers used in New Hampshire were: (1) 1½" radial ice vertical loading, no wind; and (2) 100 mph wind with safety factor of 1.2.

The transmission line structures are wood or steel, with heights above ground which vary from about 70 feet to about 103 feet. Safety factors of wood H-frames are 4 to 1 under NESC heavy-loading conditions.

Full-scale tests of the steel H-frame structures have been performed and prove that under maximum design transverse loads, including applicable safety factors, the structures will remain intact and will not affect the parallel line. Design of wood H-frame structures is based on results of destructive testing of similar structures.

The angle structures (See detail C of Figure 8.2-4) used in conjunction with H-frame structures are steel poles maintaining the flat conductor configuration of the H-frame tangent design. The steel angle structures used in New Hampshire are designed to meet or exceed the NESC Grade B code requirements for heavy-loading districts. Steel angle structures used for the Massachusetts portion of the Ward Hill/West Amesbury line are also designed to meet or exceed the NESC Grade B code requirements for heavy-loading districts. No problems are anticipated due to shock loading of an angle structure by the near conductor on the inside corner of the adjoining line in the event of an insulator string assembly failure.

The transmission line terminating structures at Seabrook, shown in detail D of Figure 8.2-4, are designed with the same safety factors as the steel angle structures.

b. General Design Information

Conductors are 2-1113 kcmil ACSR per phase on the line to Newington/Timber Swamp; 2-2156 kcmil ACSR per phase on the line to Ward Hill/West Amesbury, changing to 2-1590 kcmil ACSR per phase at Boxford Junction (Figure 8.2-2, sh.1); and 2-2156 kcmil ACSR per phase on the line to Scobie Pond.

The maximum tension of the conductors is limited to reduce the possibility of aeolian vibration. In addition, armor grip suspension clamps are used to help protect the conductor, should any vibration develop. The relatively low tension line design reduces the probability of galloping conductors.

The isokeraunic level of the areas where the transmission lines are located varies between 18 and 24 thunderstorm-days per year based on ten-year local weather history. Forty thunderstorm-days per year is the national average. The transmission lines are designed to have no more than one outage per 100 miles per year due to lightning.

Each of the 345-kV transmission lines from Seabrook crosses over lower voltage transmission (115 or 230 kV) and subtransmission (23 or 33 kV) lines enroute to its remote substation. In all cases, the 345-kV lines from Seabrook cross above the lower voltage lines with crossing clearances designed to meet or exceed the requirements of the National Electrical Safety Code (Reference 4) and (in Massachusetts) the Commonwealth of Massachusetts "Code for Installation and Maintenance of Electrical Transmission Lines" (Reference 5).

8.2.1.2 Transmission Interconnections

The New England 345-kV transmission grid described in Subsection 8.1.1 is made up of transmission facilities owned and operated by the various electrical utilities in the New England region. The transmission grid is designed to conform to the NPCC (Northeast Power Coordinating Council) "Basic Criteria for the Design and Operation of Interconnected Power Systems" (Reference 2) and to the "Reliability Standards for the New England Power Pool" (Reference 3). The basis for these criteria is the proposition that "an interconnected power system should be designed and operated with a level of reliability such that the loss of a major portion of the system would not result from reasonably foreseeable contingencies."

Day-by-day maintenance of grid configuration is a pool level as well as an individual company responsibility. Independent System Operator – New England (ISO-NE) coordinates all New England grid operations including generation dispatching, and coordinates New England operations with those of New York and New Brunswick. Generation dispatching is the responsibility of the (ISO-NE) Dispatch Center in Holyoke, Massachusetts, and actual grid operation is the responsibility of the (ISO-NE) satellites, in this case the Electric System Control Center (ESCC) of Public Service Company of New Hampshire. For system operating purposes, the station operators and ESCC operators have at least two independent voice communication links with each other. For communicating generation dispatch directives, the station operators and (ISO-NE) generation dispatchers have at least two independent voice communication links with each other.

Operating procedures are established as required to control system frequency and voltage within limits set by the several pool members, individually; on a pool level through the NEPOOL (New England Power Pool) Planning Committee; and on an interpool level through the NPCC (Northeast Power Coordinating Council).

Through the transmission line connections to Scobie Pond Substation, Timber Swamp Substation, and Newington Station in the Public Service Company of New Hampshire territory and to Ward Hill and West Amesbury Substations in the National Grid USA territory, Seabrook Station is interconnected with generation sources throughout the New England region and beyond. The adequacy of this interconnected transmission grid under normal and faulted conditions is verified by load flow and transient stability studies, as reported in Subsection 8.2.2.

8.2.1.3 Switching Station, Generator and Auxiliaries

a. Switching Station Description

1. Physical

The 345-kV switching station is located adjacent to the north side of the Administration and Service Building, as shown in Figure 8.2-7.

The switching station consists of metal-enclosed, gas-insulated components (circuit breakers, disconnect switches, buses, surge arresters, potential devices, etc.) connected by an integral bus system. Pressurized sulphur hexafluoride (SF_6), a nonflammable, nontoxic gas, is used as the insulating and arc-quenching medium.

The SF_6-insulated bus system consists of tubular conductor at line potential concentrically located within a tubular metal enclosure at ground potential. Spacer insulators located at intervals within the enclosure keep the conductor centered, and SF_6 gas under pressure provides insulation between the conductor and enclosure. Clearances are designed so that the bus system will withstand rated voltage even if the gas pressure drops to 0 psig.

Gas monitoring systems are provided to monitor the condition of the SF_6 gas in the bus system, connected components, and in the circuit breakers. The gas monitor systems for the original design switchyard equipment and replacement equipment are slightly different.

All gas monitoring systems monitor SF_6 gas density through the use of temperature compensated pressure switches located on each gas zone. Some of the original design monitoring equipment also included local temperature and moisture content indication. Replacement equipment does not incorporate local temperature or moisture indicators. Since the pressure switches are temperature compensated, temperature indication is unnecessary. Moisture monitoring is more accurately provided by routine sampling of the gas in accordance with station procedures.

The switching station is divided into many individual gas zones for monitoring purposes. Groups of these gas zones comprise the various 345-kV buses and breakers within the switchyard. If a problem is detected within a gas zone, the affected gas zone can be removed from service for maintenance by manual switching of circuit elements.

For the original switchyard equipment, each circuit breaker and each bus section of the 345-kV switching station forms a separate gas-insulated system that is individually monitored as a 3-phase system. Each 3-phase circuit breaker is supplied with its own self-contained SF_6 gas system. There is no interconnection between the circuit breaker SF_6 gas systems and the switching station gas systems. The bus section gas systems include the 3-phase bus connections between two circuit breakers, extending to the point of connection to a transformer or to an overhead line.

For replacement switchyard equipment, each circuit breaker and each bus section are comprised of individual gas zones that are monitored separately for each phase of the 3-phase system. There exist some locations where original and replacement equipment interface. Bypass valves that connect adjacent gas zones are only used with the replacement equipment where it is necessary to interface with original equipment that is already connected with bypass valves. Similar to the original equipment, there is no interconnection between the circuit breaker SF_6 gas systems and the switching station gas systems.

Refer to Figure 8.2-11 for a schematic of the switching station gas systems.

There are no gas interconnections between the bus gas zones on one side of a circuit breaker and the bus gas zones on the other side. Therefore, a gas leak in any one SF_6 gas zone only affects the insulation level of one bus. The affected circuit can be electrically isolated without affecting the availability of any other bus.

Each of the original equipment switching station SF_6 gas systems is subdivided by gas barrier insulators provided with normally open bypass valves. These gas-tight barriers (located at disconnect switches and other natural division points) permit optimum installation, maintenance, and leak-detection procedures. In addition, valves and manifolds provide gas interconnections between the three phases of individual circuit sections to maximize the volume of each SF_6 gas system and thus minimize the sensitivity to small leaks. The interconnecting valves can be closed to permit evacuation of a single-phase section.

Replacement equipment switching station SF_6 gas systems are also subdivided by gas barrier insulators, but do not use normally open bypass valves. Each separate gas zone is monitored with its own gas pressure (density) monitor. This design eliminates the effect of leakage in one gas zone from impacting adjacent gas zones. Also, smaller individual gas zones allow for more efficient maintenance and leak detection.

Rupture disks are installed in various gas zones to protect the bus duct and connected equipment from overpressurization as a result of a severe fault. Not all gas zones are provided with rupture disks, rupture disks are only provided for those gas zones where the manufacturer has determined that there is a potential for overpressurization due to fault conditions.

The independence requirements of GDC 17 are satisfied by ensuring that a loss of insulating gas in one bus section or in one circuit breaker of the 345-kV switching station does not affect the availability of other circuit paths through the switching station. Sufficient independence exists to assure performance of the required safety function assuming a single failure.

Metal-enclosed, SF_6-insulated buses connect the 345-kV switching station directly to the high voltage bushings of the generator step-up transformers (GSUs) and the reserve auxiliary transformers (RATs), as shown in Figure 8.2-7. The three 345-kV transmission lines are connected to the switching station by metal-enclosed, SF_6-insulated buses running between the line terminating yard and the switching station, as shown on Figure 8.2-7 and Figure 8.2-8.

Protection to the SF_6 buswork from vehicles on the controlled access bridges and on the roads adjacent to the bus runs is provided by guardrails and bollards along the plant access road and by guardrails on all bridges which pass over bus runs except the South side of Bridge B. Protection of the buswork adjacent to the South side of Bridge B is provided by the Vehicle Barrier System, installed to meet the requirements of NRC Regulatory Guide 5.68. In addition, the use of Bridge B is strictly controlled or limited to essential maintenance activities. The guardrails on the bridges are designed in accordance with AASHO requirements (American Association of State Highway Officials). The rail is 2'-8¾" total overall height above the road surface and it is made of 5" extra-strong pipe. Each horizontal guardrail at the supporting structures will accept a horizontal load of 5,000 pounds, a total of 10,000 pounds at each impact point. The bridges themselves are conservatively designed for the largest loads required during construction or operation of the plant. The possibility of a vehicle causing damage to the SF_6-insulated bus runs is further minimized by the fact that roadways adjacent to the SF_6 bus runs are on plant property, access to the bridge outside the fenced area is controlled, and vehicles are subject to strict plant-regulated speed limits.

Structures such as lighting poles, adjacent to the SF_6 bus runs, are located so that their failure will not jeopardize the availability of the offsite power circuits outlined in GDC 17.

In addition, in the area between the north and south bridges where a light pole is in close proximity to the SF_6 bus runs located below grade level, a galvanized steel grating is installed over the SF_6 bus runs for additional protection of the buses from a falling light pole. The grating is designed for a dead load of 35 psf and live load of 100 psf, and will withstand the impact of the adjacent light pole falling on it.

An Equipment Enclosure and Overhead Crane Structure (EEOCS) is located at the East end of the 345-kV Switchyard for housing SF_6 circuit breakers and accessories. The design and analysis of the EEOCS was performed in accordance with SD-66, "System Description for Structural Design Criteria for Public Service Company of New Hampshire Seabrook Station," and the International Building Code, IBC 2006, as documented (Reference 25). This analysis considered the potential effects of a 'single failure' per GDC 17 criterion including structural members, foundations, and roof rafters. It also evaluated the impact of the potential failure of the 5 ton under hung bridge crane, as well as the potential impact of a fire event. The evaluation concluded that the EEOCS contains sufficient margin and design integrity to ensure the failure of a single member or connection will not result in the loss of more than one offsite power source.

The totally enclosed switching station provides maximum protection to the electrical equipment from adverse environmental effects; safety for plant personnel; reliability; and resistance to vandalism or sabotage. The compactness of the gas-insulated system minimizes the visual impact of the switching station.

2. Electrical

The electrical configuration of the 345-kV switching station is a breaker-and-half arrangement (as shown on Figure 8.2-5) consisting of:

(a) Ten circuit breakers.

(b) Six line positions for connection of three incoming lines, the GSU transformers, the RAT transformers, and provision for an additional future connection.

(c) One bus position provided for a future connection.

b. Generator

The generator is rated 1373.1 MVA, 25 kV, 60 Hz, 0.94 power factor, 3 phase, 1,800 rpm, and is hydrogen-cooled with a water-cooled stator. Forced air cooled, isolated phase bus ducts are used to connect the generator to its associated generator step-up and unit auxiliary transformer. Turbine-generator details are given in Section 10.2.

Three single-phase potential power transformers (PPTs) are tapped off the isolated phase bus duct connecting the generator to the generator breaker. These PPTs provide the supply for the generator excitation system.

c. Generator Step-up Transformers (GSUs)

The generator is connected to the 345-kV switching station through three single-phase generator step-up transformers (GSUs). These transformers are single-phase, outdoor-type, oil-filled, rated at 410 MVA at 55°C and 460 MVA at 65°C, FOA. They are located adjacent to the Turbine Building, as shown in Figure 8.2-6. They are delta-connected on the primary (low voltage) side and wye-connected on the secondary (high voltage) side. Connections from the 345-kV side of the GSUs to the switching station are made by means of SF_6-insulated bus.

The GSUs form part of the immediate access circuit from the preferred (offsite) power supply to the onsite distribution system when the generator circuit breaker is tripped.

d. Unit Auxiliary Transformers (UATs)

Two unit auxiliary transformers (UATs) are tapped off the isolated phase bus duct connecting the generator to the GSU transformers. Each unit auxiliary transformer is a three-phase, three winding, outdoor-type, oil-filled, Class OA/FA/(FOA Future) transformer with delta-connected 24.5-kV primary winding rated 27/36/(45 Future) MVA at 55°C and 30.24/40.32/(50.4 Future) MVA at 65°C, wye-connected 13.8-kV secondary winding rated 18/24/(30 Future) MVA at 55°C and 20.16/26.88/(33.6 Future) MVA at 65°C, and delta-connected 4300-volt tertiary winding rated 12/16/(20 Future) MVA at 55°C and 13.44/17.92/(22.4 Future) MVA at 65°C. Each transformer has the capacity to supply the power requirements of the connected load under all plant conditions. The UATs are located on the north side of the Turbine Building, as shown in Figure 8.2-6.

The secondary winding of each unit auxiliary transformer is connected to a 13.8-kV switchgear bus and the tertiary winding is connected to one train of 4160-volt emergency switchgear and to one 4160-volt nonessential switchgear lineup. By this arrangement, a separate UAT feeds each emergency bus. The connections to the 13.8-kV switchgear and to the 4160-volt switchgear are made with three-phase nonsegregated phase bus ducts as shown in Figure 8.2-6.

The UATs and GSUs provide an immediate access circuit from the preferred power supply (offsite source) to the onsite distribution system, providing power for all loads including all the engineered safety features loads of the unit, when the generator circuit breaker is tripped. The UATs are also the normal source of power to the onsite distribution system when the generator is on line.

e. Generator Circuit Breaker

1. General

A generator circuit breaker, rated at 25 kV, 35-kA rated continuous current, 160-kA rated short circuit current, is provided between the main generator and the connections to the generator step-up and unit auxiliary transformers. This circuit breaker consists of three single pole units mounted in line with and forming part of the isolated phase bus duct. The circuit breaker is located on a platform inside the north wall of the Turbine Generator Building.

When the generator circuit breaker is tripped, the UATs remain energized from the 345-kV switching station via the GSUs, thus providing an immediate access circuit from the preferred power supply (offsite source) to the onsite distribution system, providing power for all loads including all the engineered safety features loads.

Operational control of the generator circuit breaker is from the main control room. When the unit is offline, breaker testing can be performed locally from the three-pole control cabinet located adjacent to the breakers. Key interlocks are provided to prevent inadvertent operation.

The high current-carrying capacity generator circuit breaker is an air blast type using high pressure air to operate the breaker, as an arc-extinguishing medium, and as a cooling medium. The generator circuit breaker is an adaptation of an extra-high voltage air blast circuit breaker design modified for installation in isolated phase bus duct. The use of forced air cooling of the conductors provides the required current-carrying capability.

For the reliability of performance, a Compressed Air System with two high-pressure compressors and air receivers is provided. The air receivers have sufficient storage capacity for five close-open operations. A forced air cooling system is provided for each circuit breaker pole consisting of an air-to-air heat exchanger with redundant fans and circulators mounted on top of the main interruption chamber.

2. Qualification Testing

The capability of the generator circuit breaker to perform its required operational functions has been demonstrated by qualification testing of prototype circuit breaker poles. The qualification testing program for the Seabrook generator circuit breaker is equivalent to the test program adopted for the similar design generator circuit breakers of the Catawba Nuclear Generating Station of the Duke Power Company. The Duke Power qualification test program was reviewed by the Nuclear Regulatory Commission and found acceptable.

The tests specified in the Seabrook qualification test program, the test reports, and the analyses demonstrating acceptability of the test reports furnished by the manufacturer, are contained in Reference 12. A tabulation of the tests performed is given in Table 8.2-1.

3. Generator Circuit Breaker Tripping

The following design criteria apply to the generator circuit breaker tripping:

(a) Each pole of the generator circuit breaker is equipped with dual trip coils. Breaker tripping is initiated through two independent protective schemes, each activating one of the two generator breaker trip coils.

(b) Control power for the dual trip coils is provided by separate 125-volt DC circuits; one from battery ED-B-2A and the other from battery ED-B-2B. These batteries are located in the Turbine Building. These control power sources are separate and independent of the control power sources for the 345-kV system breakers.

(c) Reactor trip conditions, through two redundant trains, actuate turbine tripping (see Section 7.2). Under turbine trip conditions, trip signals from the Turbine Digital Electro-Hydraulic Control (DEHC) System initiate turbine shutdown. Following turbine shutdown, one of the redundant generator breaker trip coils is normally actuated by the sequential trip circuit in the generator primary protection scheme. The sequential trip circuit uses all steam valve paths closed position logic and a reverse power relay to ensure that main sources of steam to the turbine have been closed off and the generator begins to motor for a set time delay before initiating a breaker trip. A bypass of the reverse power relay is provided whenever both of the 345 kV breakers that connect the GSU to the grid are open. This bypasses the reverse power interlock for the most likely scenario where a reverse power condition could not occur. This scheme reduces the risk of dangerous turbine generator overspeed during non-electrical turbine trips. Should the primary protection scheme fail to trip the generator breaker, a reverse power relay in the generator backup protection scheme will sense the motoring condition and, after a selected time delay, the redundant generator breaker trip coil would be actuated. Hence, either a reactor trip or a turbine trip initiates a generator circuit breaker trip, transferring unit auxiliary load (fed via the UATs) to the preferred (offsite) supply (via the GSUs) without any distribution bus breaker action.

(d) Electrical disturbances (such as generator, isolated phase bus duct or transformer short circuit; loss of excitation; over-excitation; loss of a PPT; and reverse power flow) operate protective relays which will trip the generator circuit breaker. Relays operating for faults on the 345-kV bus positions to which the generator step-up transformers are connected will trip the generator circuit breaker, as well as the adjacent 345-kV circuit breakers. Failure of the associated 345-kV circuit breakers to operate for faults on adjacent 345-kV bus sections will also result in a trip signal to the generator circuit breaker.

4. Periodic Testing

The generator circuit breaker is considered an integral part of the isolated phase bus duct which connects the output of the generator to the generator step-up transformer. Online testing of the transfer scheme for immediate access to the offsite power source through the UATs (by tripping of the generator circuit breaker) cannot be accomplished without interruption of generation. However, each time the plant is shut down, the generator circuit breaker is tripped to disconnect the generator and to effect the transfer to the offsite power source. This operation of the generator circuit breaker constitutes a periodic test of the ability of the breaker to trip.

Online testing of the transfer scheme can be accomplished by proving the integrity of the generator breaker trip actuation circuitry. Since the generator breaker is equipped with two sets of trip coils, each individual actuating device on a trip coil circuit can be independently tested, after being disconnected from the trip bus, without affecting the operation of the redundant trip coil circuit. Test devices are provided to allow disconnecting individual trip actuating devices from a trip bus.

The integrity of each individual trip coil circuit is continuously monitored by indicating lights on the main control board and by relays in each trip coil circuit that provide an alarm in the control room if trip circuit continuity is lost.

f. Reserve Auxiliary Transformers (RATs)

Two reserve auxiliary transformers (RATs) for each unit provide a second immediate access circuit from the preferred power supply (offsite source) to the onsite distribution system, providing power for all loads including all the engineered safety features loads. The transformers are three-phase, three-winding, outdoor-type, oil-filled, Class OA/FA/(FOA Future) transformers with wye-connected 345-kV primary rated 27/36/(45 Future) MVA at 55°C and 30.24/40.32/(50.4 Future) MVA at 65°C; wye-connected 13.8-kV secondary winding rated 18/24/(30 Future) MVA at 55°C and 20.16/26.88/(33.6 Future) MVA at 65°C, and delta-connected 4300-volt tertiary rated 12/16/(20 Future) MVA at 55°C and 13.44/17.92/(22.4 Future) MVA at 65°C. Each transformer has the capacity to supply the power requirements of the connected load under all plant conditions.

The RATs are located on the north side of the Turbine Building heater bay, as shown in Figure 8.2-6. The pair of transformers is connected to the 345-kV switching station by SF_6 gas-insulated bus.

The secondary winding of each reserve auxiliary transformer is connected to a 13.8-kV switchgear bus, and the tertiary winding is connected to one train of 4160-volt emergency switchgear and to one 4160-volt nonessential switchgear lineup. By this arrangement, a separate RAT feeds each emergency bus. Connections to both the 13.8-kV and the 4160-volt switchgear are made with three-phase nonsegregated phase bus ducts as shown in Figure 8.2-6. Subsection 8.3.1.1.b.9 describes a contingency alignment where emergency diesel generator EDG-1A may be aligned to provide power to the RAT-3A tertiary winding.

8.2.1.4 Switching Station - System Control and Protection

The protective relaying philosophy follows that generally employed for bulk power systems, and is designed in accordance with guidelines and requirements of the Northeast Power Coordinating Council's "Bulk Power System Protection Criteria" (Reference 1). This design is based on the local backup philosophy of clearing all faults at the station which would normally clear that fault. In the design of local backup systems, consideration is included for failure of relays, current or potential transformers, DC-power supplies, wiring, and the circuit breaker itself.

a. Local Backup Protection

Local backup protection falls into two categories: relay backup and breaker backup.

1. Relay Backup Protection

Relay backup protection is provided for each transmission line and bus position by two independent protective relay systems, System No. 1 and System No. 2. Each relay system is connected to isolated current, potential and DC supplies with separate wiring and cable connections. The independence of System No. 1 and System No. 2 components and power supplies ensures that at least one system will function in the event of any single failure.

(a) Transmission Line Protection

The protection for each of the three 345-kV transmission lines is provided by two electrically independent, microprocessor based high-speed relaying systems: System No. 1 and System No. 2. Each system uses an independent communication channel to provide high-speed clearing of all faults within the relay system zones of protection.

In the event of a failure of both communication channels, Relay System No. 1 and System No. 2 are provided with facilities for local fault clearing.

(1) Transmission Line Relaying - System No. 1

This system is a microprocessor based directional comparison carrier-blocking system that uses the power line as a communication channel. Microprocessor based impedance relays are included to provide protection against all phase and ground faults.

(2) Transmission Line Relaying - System No. 2

This system is a microprocessor based directional comparison permissive-overreaching transfer trip assembly that uses a fiber-optic system as a communication channel. Microprocessor based impedance relays provide complete phase and ground fault protection for the transmission line. In addition, two zones of backup protection are built into this system to provide backup protection in the event of failure of the System No. 1 and System No. 2 communication channels.

(b) Bus Protection

Each 345-kV bus section is protected by two high-speed voltage-type bus differential relaying systems (System 1 and System 2). Each of these relay systems is connected to its own dedicated current transformers, to an independent DC power supply, and to high-speed tripping and lockout relays. Each system is separated both physically and electrically in the same manner as the line relaying systems.

2. <u>Breaker Backup Protection</u>

Breaker backup protection is provided for each 345-kV circuit breaker. The function of this protection is to clear line sections adjacent to a 345-kV circuit breaker that has failed to trip when called upon to do so by the protective relays or by manual control devices.

Breaker backup protection is provided by the application of breaker failure relays. Two independent solid-state and/or microprocessor based breaker failure systems (System No. 1 and System No. 2) are provided for each breaker. Each system is separated both physically and electrically in the same manner as the line relaying systems, and is initiated by the relay system or control system that operates the breaker. Each of these systems includes a current level detector, a timing device, and tripping outputs to clear all adjacent line positions.

In addition to the System No. 1 and System No. 2 breaker-failure relay schemes initiated by the protective relay systems, a nonfault breaker-failure protection system is provided which is initiated by low SF_6 gas pressure in the circuit breaker gas system and by pole-disagreement circuitry.

3. Direct Transfer Trip Protection

A dual-channel, bi-directional, direct-transfer trip system is provided for each transmission line. This system uses dual high-speed channel audio-tone transmitters, and receivers which interface with the fiber-optic communications system. This system is used primarily for protection of the 345-kV SF_6 bus runs to the line terminating towers and for tripping remote terminals in the event of a failure of a 345-kV breaker associated with one of the three 345-kV line positions.

b. Separation Philosophy for the Protective Relaying Systems

1. Physical Separation

Physical separation of the independent System No. 1 and System No. 2 wiring is achieved within the switching station by use of two separate and independent duct and manhole systems along with solid bottom covered cable trays (primary and backup) starting at the line terminating towers, extending through the switching station and continuing on to the relay room, where the final cable terminations for all switching station to plant connections are made. The independent wiring systems are arranged so that System No. 1 is installed in one set of duct banks (primary) and System No. 2 is installed in the other set of duct banks (backup) (see Figure 8.2-9). Each relay system is housed in a separate cabinet arranged within the relay room so that all of the System No. 1 relay enclosures are in one lineup of cabinets and all of the System No. 2 enclosures are in another lineup. This provides the desired physical separation of the System No. 1 and System No. 2 protective relays. Additionally, within each system, the relays for each line or function are grouped together on a panel separate from the relays for any other line or function.

2. <u>Electrical Separation</u>

   Electrical separation of Relay Systems No. 1 and No. 2 is achieved by the use of separate and dedicated current transformers, potential supplies that originate on isolated secondary windings of either inductive voltage transformers or capacitor-coupled voltage transformers, and separately fused and monitored DC power supplies that originate on separate distribution systems supplied by two independent 125V DC control batteries. The outputs of Relay Systems No. 1 and No. 2 are connected to separate trip coils on each 345-kV circuit breaker, so that electrical separation is maintained from the relay systems in the relay room to the 345-kV circuit breaker trip coils in the switching station.

c. <u>Power Supply Systems - 125V DC</u>

Dedicated DC power supplies for the 345-kV switching station protective relay and control systems are provided by two independent 125V lead calcium batteries and two battery chargers. Each battery with its associated charger furnishes the DC supply requirements of one of the two electrically separate protective relay systems. In addition, each of these batteries is sized to handle the total switching station load in the event of a failure of the other battery. A manual switching arrangement is provided to connect the total switching station load to either battery when necessary. The two battery systems are enclosed in separate rooms within the relay room.

d. <u>Switching Station Controls</u>

Control and position indication for the 345-kV circuit breakers and the 345-kV motor-operated disconnect switches (MODS) are provided at the main control board and in the relay room as described below. Control over the 345-kV circuit breakers and other 345-kV devices is normally accomplished at the main control board. For specific 345-kV circuit breaker and MOD control locations, position indication locations, and equipment identification numbers, refer to Figure 8.2-5 and Figure 8.2-10.

Specific control locations and limitations on operation of the 345-kV circuit breakers and MODs are as follows:

Main Control Room and Relay Room

Control and position indication (in a mimic configuration) is provided for all 345-kV circuit breakers and MODs on the main control board with the exception of MOD T-1006 for a future switching station connection for which only local position indication is provided, MOD G-206 for a future switching station connection for which no position indication is provided, and MOD T-5006 for the RAT bus connection and MODs (ground switches and disconnects) that are provided for maintenance activities for which only local control and indication are provided. MODs for future switching station connections are maintained in the locked open position and do not require position indication until the future connection is established. These controls can be transferred on an individual basis from the main control board to the relay room by transfer switches located in the relay room.

e. Electrical Systems Control Center - ESCC

As described in Subsections 8.1.1 and 8.2.1.2, Seabrook Station has three major ties to the New England 345-kV transmission grid. As with every major transmission grid, maintenance of grid configuration is a pool level as well as an individual company responsibility.

Independent System Operator – New England (ISO-NE) coordinates all New England grid operations. Generation dispatching is the responsibility of the ISO-NE Dispatch Center in Holyoke, Massachusetts and actual grid operations is the responsibility of the ISO-NE satellites. For the Public Service Company of New Hampshire, this satellite is located in Manchester, New Hampshire and is called ESCC (Electrical System Control Center). A backup ESCC location required by NERC Standard EOP-008-0, Plans for Loss of Control Center Functionality, is located in Derry, NH and communicates with Seabrook Station via a computer interface in Windsor, Connecticut. Because of this overall responsibility, position indication and control of the 345-kV breakers is provided at the ESCC.

This control availability at ESCC can be defeated by transfer switches located at the relay room at Seabrook Station. Operation of the switches also transfers the control capability of the 345-kV breakers from the main control room to the relay room.

Any switching operation of the 345-kV breakers by the station operators is always cleared with the ESCC, and conversely any operation by the ESCC is coordinated with the station operators. At least two independent voice communication links are provided between ESCC and Seabrook Station.

Control and position indication at ESCC for all 345-kV circuit breakers and for the three transmission line MODs (3J-94, 3J-63, and 3J-69) is provided.

Control interlock limitations are placed on the 345-kV circuit breakers associated with the generator bus position. For example, ESCC control of Circuit Breaker 11 or 12 is restricted to times when MOD G-106 is open; or to when the other of the two circuit breakers is closed. Similar control interlocks apply for the future connection bus position circuit breakers (22 and 294).

The 345-kV generator MOD G-106 and the reserve auxiliary transformer MOD T-5006 and MODs for future bus connections (G-206 and T-1006) are provided with position indication facilities at the ESCC. These MODs cannot be controlled from the ESCC.

f. Offsite Power System Monitoring

The status of offsite power availability is monitored by the position indicating lights, provided on the main control board and on the control panels in the relay room for the 345-kV switching station circuit breakers and motor-operated disconnect switches. Motor-operated disconnects provided for maintenance activities are provided with only local control and indication as noted in Section 8.2.1.4.d.

Status information for the three transmission lines that comprise the offsite power systems is provided by wattmeters, varmeters, ammeters and voltmeters on the main control board and by wattmeters and varmeters on control panels in the relay room.

g. Relay Room Locations and Equipment

The relay room is located at Elevation 21'-6" in the northern end of the heater bay which is located between the turbine room and the Administration and Service Building.

The following equipment is installed in the relay room:

1. 345-kV Switching Station Relay Panels
2. Protective Relay Panels
3. Digital Metering Panels
4. 345-kV Switching Station and Unit 1 Annunciators
5. Event Recorder - Switching Station
6. Digital Fault Recorder - Switching Station
7. 125V DC Switching Station Batteries and Chargers
8. 125V DC Distribution Panels and Throwover Switches
9. 480V AC Power Panel and Transfer Switches

10. 120/240V AC Power Panel and Transfer Switches
11. 48V DC Battery and Charger
12. 48V DC Distribution Panel
13. Eye Wash Stations
14. Supervisory Control Equipment associated with the ESCC
15. Partial Discharge Monitoring System Panel
16. Remote Communication Cabinet

h. Out-of-Step Protection

Generator protection against system instability and loss of excitation is provided by an out-of-step relay in the relay room. The out-of-step relay trips 345 kV circuit breakers 11 and 12. Tripping of these circuit breakers will result in a turbine trip and then a sequential trip of the generator breakers on sudden loss of generator load (100% load rejection). The control system which responds to a sudden loss of generator load is described in Subsection 10.2.2.4.c. Opening of circuit breakers 11 and 12 causes loss of offsite power to the in-station buses. The buses are not transferred to the RATs because of a concern with possible equipment damage due to the quality of power, if available, in the switchyard during system instability. Power to the emergency buses for plant shutdown is supplied by the emergency diesel generators. Restoration of offsite power to the plant buses would be coordinated with the system dispatchers at the Electrical System Control Center (ESCC).

8.2.1.5 Compliance with General Design Criterion 17 and NRC Regulatory Guide 1.32

The offsite electric power system complies with General Design Criterion 17.

General Design Criterion 17 requires two physically independent circuits to supply electric power from the transmission network to the onsite electric distribution system, designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions.

One of the required, independent, offsite circuits is connected to the onsite distribution system, including all of the emergency buses, through the unit auxiliary transformers, as shown in Figure 8.3-1. The supply to the unit auxiliary transformers can be traced from the transformers through the generator isolated phase bus, the generator step-up transformers, the gas-insulated isolated phase bus of the 345-kV switching station, and then to an offsite transmission line. The second required, independent, offsite circuit is connected to the onsite distribution system, including all of the emergency buses, through the reserve auxiliary transformers, also indicated on Figure 8.3-1. This circuit can be traced from the reserve auxiliary transformers through a different portion of the gas-insulated isolated phase bus of the 345-kV switching station, and then to another offsite transmission line. This description of the Seabrook design includes two unit auxiliary transformers (UAT) and two reserve auxiliary transformers (RAT) with one UAT and one RAT connected to each emergency bus. The minimum requirements of GDC 17 and Reg Guide 1.32 can be met with one UAT and one RAT inoperable if the operable UAT and RAT are connected to opposite emergency buses. This connection is acceptable since there are still two independent circuits (one UAT and one RAT) from the transmission network to the onsite distribution system.

The connections from the transformers to the onsite distribution system of these two circuits are made with separate nonsegregated phase bus ducts which provide the necessary separation to minimize the likelihood of simultaneous failure of these circuits to the extent practical.

Both of these circuits are designed for immediate access to the onsite distribution system, thus meeting the preferred design of Regulatory Guide 1.32.

Redundant protective relaying systems and utilization of a breaker-and-a-half switching station, together minimize the likelihood of any single failure causing the loss of more than a single circuit. The transmission lines have also been designed to minimize simultaneous failures. The northerly line is on a separate right-of-way from the two westerly lines. The two westerly lines are also on separate rights-of-way, except for the 5 miles near the plant site. Within this 5 miles of common right-of-way, the circuits are on separate towers and are conservatively designed and located so that the failure of one line will not affect the other.

8.2.1.6 Compliance with General Design Criterion 18

The offsite electric power system complies with General Design Criterion 18.

Inspection and testing of the transmission line protective relaying and the 345-kV circuit breakers can be performed without disrupting the operation of the plant or the availability of the two offsite circuits. Furthermore, the electrical power system is designed to permit testing of the operability and functional performance of the transfer scheme which performs the transfer of auxiliary power from the nuclear power unit to the offsite preferred power supplies. The various automatic and manual transfer schemes for each bus from one source to the other, are detailed in Subsection 8.3.1.1b.3. The transfer schemes as described can be tested during plant normal operation. A program of routine inspection and preventive maintenance is used to detect any deterioration of components or circuits which could lead to the loss of offsite power supplies.

The requirements of GDC 18 are met, because the electric power systems are designed with the capability to test the transfer of power between the nuclear power unit, the offsite power system, and the onsite power system.

Additional information on this subject is provided in Subsection 8.3.1.2a.2.

8.2.1.7 Compliance with General Design Criterion 5

Seabrook Station is a single unit plant; therefore, no portion of the offsite power is shared with another unit.

8.2.2 Analysis

8.2.2.1 Switching Station

The breaker-and-a-half arrangement of the Seabrook switching station provides flexibility and reliability during maintenance and operational conditions since any circuit or bus can be switched under normal or fault conditions without affecting any other circuit and any circuit breaker can be isolated for maintenance without interrupting any circuit. The transmission lines, the generator step-up transformers, and the reserve auxiliary transformers are so arranged in the switching station that protective tripping of any bus or circuit accompanied by failure of one circuit breaker will not cause the loss of more than one of the two immediate access offsite power connections to the unit.

If some event or series of events in the protective relaying systems for the 345-kV switching station and transmission lines resulted in any or all of the eleven 345-kV breakers being tripped, re-establishment of offsite power connections to the Class 1E power systems would be accomplished through the coordinated action of the station operators and the transmission system dispatchers at the Electrical System Control Center (ESCC).

Initially, a station operator would be sent to the relay room to determine which relays had operated. Step-by-step restoration of the offsite circuit connections would be performed as a coordinated effort of the station operators and the system dispatchers in accordance with a written procedure for responding to protective relay operations at Seabrook. Relays would be reset in the relay room. Manual disconnect switch operation (if required) would be performed in the switching station. The 345-kV circuit breakers would be closed using any one of the following: control switches in the control room, in the relay room, at the ESCC, or at the device (or local control cabinet) in the switching station. Communications would be maintained between the station operators and the system dispatchers throughout this process.

If the above occurred simultaneously with loss of the onsite power (both emergency diesels have failed), the procedure described above for the restoration of the offsite power connections will not be affected. The control and indication of the 345-kV breakers are on DC power which is available. The gas system which is used for closing and tripping operations of each original equipment breaker is designed to store enough high-pressure gas for a minimum of three close/open operations at full rating without the need to operate the air compressors. Replacement breakers do not rely on a compressed air system for operation. They are spring operated and rely on DC power which is available to recharge the springs for subsequent operations. The breaker close springs are recharged immediately following a breaker close operation by the close spring charging motors. The trip springs are mechanically recharged by the breaker closing operation and do not rely on DC power. Therefore, the replacement breakers have enough stored energy for one and a half operations (trip/close/trip). If DC power is unavailable, replacement breakers also have the capability to manually recharge the close springs to allow subsequent manual breaker operation.

A single-failure analysis of the switching station shows that:

a. Failure on a transmission line followed by breaker failure backup operation in the 345-kV switching station will not further degrade the availability of the remaining transmission lines.

b. Failure in either 345-kV bus 1 or 345-kV bus 2 will not cause the loss of any of the three 345-kV transmission lines.

c. Failure in either 345-kV bus 1 or 345-kV bus 2 followed by breaker failure backup operation in the 345-kV switching station will not cause loss of more than one transmission line.

d. Failure in 345-kV bus 6 and tripping of the 345-kV circuit breakers associated with a generator step-up transformer followed by breaker failure backup operation will not cause the loss of any transmission line and will not cause the loss of the other immediate access offsite power circuit to the plant.

e. Failure in 345-kV bus 5 and tripping of the 345-kV circuit breakers associated with the reserve auxiliary transformers followed by breaker failure backup operation will not cause the loss of more than one transmission line and will not cause the loss of the other immediate access offsite power circuit to the plant.

8.2.2.2 Transmission Grid Availability

There has been no instance of total 345-kV transmission grid unavailability (as of 2000). Transmission lines making up the grid are subject to occasional forced outages due to lightning, relay misoperations, or clearance problems (i.e., outage due to trees or other grounded objects coming too close to or in contact with a transmission line).

Forced outages of lines are minimized by proper design and operating practices. Outages due to lightning are minimized by design to be no more than one per 100 circuit miles per year. Clearance problems are minimized by transmission line design, right-of-way design, and control of tree growth within the right-of-way. Relay problems are minimized by testing and maintenance.

Forced outages of 345-kV transmission lines with at least one terminal under PSNH control were analyzed to determine the actual forced-outage rate. Based on operating history from December 1972 through September 1990 (5466.8 circuit mile years) the total forced-outage rate was 1.97 outages per 100 circuit miles per year.

Outage rates by causes were:

Lightning and unknown	.49/100mi/yr.
Relay-related problems	.55/100mi/yr.
Clearance problems	.33/100mi/yr.
All other problems	.60/100mi/yr.

The four-hour duration for a Station Blackout event was based, in part, on offsite power design characteristics including the expected frequency of grid-related loss of offsite power, the estimated frequency of loss of offsite power from severe and extremely severe weather, the number of switchyards and the type of bus transfers (see Section 8.4.2). Site-specific weather data were used to evaluate the reliability of offsite power relative to weather-caused outages.

8.2.2.3 Power Flow and Stability Studies

Power flow and transient stability studies (see Subsection 8.2.3; references 6, 7, 13, 21 and 22) demonstrate that Seabrook Station and the Seabrook – Scobie Pond, Seabrook – Newington/Timber Swamp, and Seabrook – Ward Hill/West Amesbury 345-kV lines meet the NEPOOL "Reliability Standards For the New England Power Pool" and the NPCC "Basic Criteria for the Design and Operation of Interconnected Power Systems." By meeting these standards and criteria, the studies affirm that adherence to proper system operating procedures will result in stable operation of the interconnected power system. This in turn will result in a reliable source of offsite power for Seabrook Station, which satisfies the requirements of GDC 17.

In support of the Power Uprate Project, additional studies (Ref. 21) were performed. The overall conclusion of Reference 21 is that the thermal, voltage, short circuit and stability performance of the power uprate is satisfactory and requires no mitigating measures. The power uprate has no significant adverse impact on the thermal, voltage, short circuit and stability performance of the NEPOOL System.

As system configuration warrants and on a periodic basis, NEPOOL will review the performance of the New England Bulk Power Supply System. These operational and planning reviews will be performed in accordance with both NEPOOL standards and NPCC criteria. These review processes assure that operating procedures are kept current and Seabrook Station continues to have a reliable source of offsite power.

8.2.3 Results and Conclusions

The 1985 studies (see Subsection 8.2.4, Reference 13) demonstrated that Seabrook Station connected to the transmission system by two 345-kV lines (Seabrook - Scobie Pond and Seabrook - Newington) can meet the NEPOOL "Reliability Standards for the New England Power Pool" and the NPCC "Basic Criteria for Design and Operation of Interconnected Power Systems." Since then, a third 345-kV line has been built (Seabrook - Tewksbury). This line provides additional flexibility which results in improved reliability.

As a result of configuration changes to the 345-kV transmission system, the Newington line has been renamed the Newington/Timber Swamp line, and the Tewksbury line has been renamed the Ward Hill/West Amesbury line.

The load-flow studies demonstrate the power system can be operated such that all voltages and line loadings can be within required limits, for the loss of the Seabrook to Scobie Pond line, the Seabrook to Newington/Timber Swamp line, the Seabrook to Ward Hill/West Amesbury line or for any other representative line contingency.

Frequency decay rates (initiated by a sudden generation/load imbalance) are predicted to be less than the maximum credible frequency decay rates used by Westinghouse to determine loss of flow transients caused by frequency decay events. This conclusion is based on analysis and experience in the NPCC system (of which the New England 345-kV grid is part). Although it is not possible to predict with certainty the boundaries of electrical islands, should they occur, computer studies for the NPCC system (References 11 and 19), have shown that the frequency decay does not exceed 4 Hz/second. These studies took into account the NPCC underfrequency load shedding program.

In support of the Power Uprate Project, additional studies (Ref. 22) were performed. Reference 22 determined that increasing the gross electrical megawatt output of Seabrook Station by 23 MWe to 1318 MWe will not have a significant effect upon the reliability or operating characteristics of the NEPOOL System, subject to conditions that are addressed through the use of appropriate Seabrook procedures and design processes.

The transient stability and power flow studies show that with proper system operating procedures, stable operation of the interconnected power system can be maintained and availability of offsite power supplies to Seabrook Station will not be impaired. In so doing, base case voltages, line loadings, and equipment loadings on the 345-kV transmission system will be within normal limits at both heavy- and light-load levels, and will be within the applicable emergency limits for contingency conditions.

In support of the Seabrook Substation Reliability Upgrade Project, additional studies and evaluations (Ref. 26 through 28) were performed. An evaluation performed by ISO New England, Reference 26, concluded that the project will not have a significant adverse effect on the stability, reliability, and operating characteristics of any transmission facilities or the system of a Market Participant. A transient analysis study, Reference 27, concluded that the replacement switchyard breakers did not require pre-insertion resistors to mitigate transient voltages during switching activities and there were no transient voltage issues associated with the revised switchyard design configuration. A single failure analysis, Reference 28, concluded that the revised switchyard configuration resulted in a more reliable configuration.

A system impact study (SIS), Reference 29, was performed to determine the effect on the New England grid stability from enabling the Seabrook Station main generator excitation system power system stabilizer (PSS). The stability analysis was conducted to study the PSS impact on the transient stability performance based on contingencies in the vicinity of Seabrook Station. Stability analyses were evaluated at 2012 and 2014 light and peak load levels. Under all lines in conditions, all normal contingencies (NC) and extreme contingencies (EC) stability simulations passed the acceptability criteria. In addition dynamic control system testing analysis was performed on the PSS model which determines the PSS as a Type III control system. Removing the dynamic control system (the Power System Stabilizer) in the Seabrook model did not cause a violation of acceptability criteria. This classified the system as Type III, based on results that indicate no significant adverse impact outside the local area. Based on the stability assessment of the transmission system, the Project causes no significant adverse impact upon the reliability, stability or operating characteristics on the transmission system of Public Service of New Hampshire, the transmission facilities of another Transmission Owner, or the system of a Market Participant.

8.2.4 References

1. "Bulk Power System Protection Criteria," Northeast Power Coordinating Council.
2. "Basic Criteria for the Design and Operation of Interconnected Power Systems," Northeast Power Coordinating Council.
3. "Reliability Standards for the New England Power Pool," New England Power Pool.
4. ANSI C2, "National Electrical Safety Code."
5. "Code for the Installation and Maintenance of Electrical Transmission Lines," Commonwealth of Massachusetts (applies within Massachusetts only).
6. Public Service Company of New Hampshire, Seabrook Station, Unit No. 1 and Unit No. 2 Transient Stability Study, January 1980.
7. Public Service Company of New Hampshire, Seabrook Station, Unit No. 1 and Unit No. 2 Power Flow Study, January 1980.
8. NPCC Report: "Analysis of the NPCC 1985 Transmission System," June 1976; NPCC Working Group No. 17.
9. NPCC Report: "Analysis of the NPCC 1983 Summer and 1983/4 Winter Transmission System," July 1979; NPCC Working Group No. 27.

10. NPCC Report: "Study of the Use of Pumped Storage Units for Load Shedding by NPCC Task Force on Systems Studies," April 1974; NPCC Working Group No. 16.

11. NPCC II Joint Working Group Report, September 1970.

12. Seabrook Generator Circuit Breaker Qualification Test Reports and Analyses.

13. Public Service Company of New Hampshire, Seabrook Station, Unit No. 1 Load Flow and Transient Stability Study, December 1985 (analysis before completion of Seabrook to Tewksbury transmission line).

14. Public Service Company of New Hampshire, Seabrook Station, Units No. 1 and No. 2 Stability Study, November 5, 1974.

15. Public Service Company of New Hampshire, Seabrook Station, Units No. 1 and No. 2 Loadflow Study, December 26, 1974.

16. Public Service Company of New Hampshire, An Assessment of the Adequacy of the Northern New England to Southern New England Interface after Commercial Operation of Unit No. 1 at Seabrook Station under First Contingency Conditions, February 1980.

17. NEPEX, "All Lines In" Analysis NEPOOL Thermal Operations with Seabrook and Hydro Quebec Phase II in Service Early 1990s - Summer Periods, November 3, 1989.

18. NEPLAN, "Northern New England 'All Lines In' Stability Transfer Limits Early 1990s Report," May 17, 1990.

19. NPCC Joint Working Group Report, Review of Adequacy of Procedures for Protection Against Off-Nominal Frequency Operation, Dated December 1991.

20. Report, "Seabrook Uprate System Impact Study, Phase 1, Final Report," January 22, 2004.

21. ISO-New England Study, "Seabrook Uprate System Impact Study, Phase 2, Final Report", Rev. 5, dated August 16, 2004.

22. ISO-New England to FPL Energy Letter, FPLE-04-G02, dated September 3, 2004.

23. Siemens Report #R7-05, "Proposed Plan Stability Analysis for the National Grid North Shore Updates", July 13, 2005 Siemens PTI Project Number 110064. (Ref. FP 35583)

24. EPRO Study Report, "Timber Swamp Project Proposed Plan Application Analyses Stability & Short-Circuit Final Report, July 2006." (Ref. FP35693)

25. R. T. Patterson Structural Calculation, "Seabrook Equipment Enclosure and Overhead Crane Structure Analysis, 345 kV Switchyard Station" (Ref. FP 100435)

26. ISO New England correspondence, Seabrook Substation Reliability Improvement Project – FPLC-08-T01, dated 11/20/08. (Ref. EC 12735, 09DCR002)

27. FP36141-00, Seabrook 345kV Gas Insulated Substation (GIS) Transients Analysis

28. FP36255-01, Seabrook Switchyard Availability and Loss of Offsite Power Analysis

29. FP36534-00, System Impact Study Seabrook Nuclear Plant Power System Stabilizer Project PPA Analysis

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

8.3.1.1 Description

The onsite AC power systems include the 13,800V Distribution System, including the connections from the unit auxiliary transformers (UAT) and reserve auxiliary transformers (RAT); the 4160V Distribution System, including the standby diesel generators, the Supplemental Emergency Power System and connections from the UATs and RATs; the 480V Distribution System; and the 120V Vital Instrumentation and Control Power System. The onsite AC power system one-line diagram is shown in Figure 8.3-1. The 120V Vital Instrumentation and Control Power System is shown in Figure 8.3-2 and Figure 8.3-4.

Qualification of the Class 1E electrical equipment used in the onsite AC power system is discussed in Section 3.11.

Post accident monitoring of the onsite AC power system is discussed in Section 7.5.

a. 13,800V Distribution System

The 13,800V Distribution System is nonsafety-related, and is shown in Figure 8.3-1, Figure 8.3-5 and Figure 8.3-6. Each of the two 13.8-kV buses is normally fed from a UAT. A reserve source is available to each bus through a RAT.

1. Automatic and Manual Transfers

The automatic and manual transfers of power from one source to the other are as follows:

(a) An automatic transfer from the main generator supply to the offsite source through the generator step-up transformers (GSUs) is accomplished by the opening of the main generator breaker; no bus breaker action is required.

(b) A manually initiated live bus transfer is provided for transferring the 13.8-kV buses from the offsite source through the GSU transformers to the main generator source and vice versa, by the operation of the main generator breaker. The transfer from offsite to main generator source is contingent upon the two sources being in synchronism.

(c) The opening of the UAT incoming line breaker, either manually or automatically, initiates an automatic transfer from UAT to RAT source, provided that the RAT is energized, no fault exists on the bus, and the bus voltage is in synchronism with the RAT voltage at the time of transfer initiation, or has decayed to an acceptable value.

A high-speed static synchronism check relay will allow the RAT incoming line breaker to close, if both the bus voltage and phase angle between bus and RAT source are within limits. If the transfer is not completed 20 cycles after initiation, the reactor coolant pump motors are tripped to reduce inrush on the RAT when the bus is re-energized. If the transfer continues to be blocked due to lack of synchronism, the RAT breaker will be automatically closed when the residual bus voltage decays to an acceptable value.

(d) A manually initiated, synchronism check relay-supervised live bus transfer is provided for transferring a 13.8-kV bus from the UAT source to the RAT source, and vice versa, provided that the source to which the bus is being transferred is energized, and the two sources are in synchronism.

2. Switchgear

The 13,800V Distribution System is comprised of two metal-clad indoor switchgear assemblies containing 15 kV, 500 MVA nominal interrupting rating air circuit breakers. The incoming line breakers and the switchgear buses are rated 2000-amperes continuous current. Motor and unit substation feeder breakers are rated 1200-amperes continuous current. The 13.8-kV switchgear is non-Class 1E, and is located in the noncategory I, nonessential switchgear room adjacent to the north wall of the Control Building. Connections to the auxiliary transformers are made by means of 15-kV nonsegregated phase bus duct. This duct is routed through the Turbine Building.

3. Grounding and Ground Detection

The 13,800V System is a low-resistance grounded system. Grounding resistors for limiting the ground fault current to 600 amperes are located at the UAT and RAT transformers. Occurrence of a line to ground fault will cause the faulted portion of the system to be isolated by tripping appropriate circuit breakers. Inspection of the ground fault detector relays at the switchgear indicates the location of the fault.

4. Protection of 13.8 kV Containment Electrical Penetrations

Fuses mounted in Class 1E metal-clad fuse enclosures are provided in the feeders to the reactor coolant pump motors. These fuses are located in a seismic Category I building and are part of the protection for the containment electrical penetrations as required by Regulatory Guide 1.63. In addition, a measure of backup protection is provided by the reactor coolant pump circuit breaker and the 13.8-kV bus incoming line circuit breaker. DC control power from separate battery sources is provided for these breakers to preclude the loss of a single DC source from preventing the tripping of both the RCP and the incoming line breaker. Although these breakers are not Class 1E, the construction of the 13.8-kV switchgear is similar to the construction of the Class 1E 4-kV switchgear. Periodic testing of these breakers according to the Technical Requirements further verifies their reliability.

A fault on one of the RCP motors assuming failure of its switchgear will be isolated by the fuses provided. Backup protection is provided by the incoming feeder to the switchgear; credit is taken for the 13.8-kV breakers mentioned above to provide backup protection because if it is assumed that the seismic event damages the nonseismic qualified 13.8-kV switchgear, then it will have to be assumed that the nonseismic qualified power sources will also be damaged by the same event; thus, the circuit will be de-energized. For the penetration protection coordination curve, see Figure 8.3-47.

5. Contingency Power Source

During an extended loss of off-site power (LOP) event, emergency diesel generator EDG-1A may be aligned to provide power to 13.8 kV Buses 1 & 2 (see Figure 8.3-1). This contingency alignment is described in Subsection 8.3.1.1.b.9.

b. 4160V Distribution System

1. Arrangement

The 4160V Distribution System is shown in Figure 8.3-1, Figure 8.3-7, Figure 8.3-8 and Figure 8.3-9. The system consists of four buses, two of which are the redundant Class 1E emergency buses supplying the redundant engineered safety features loads. These safety loads are divided into two separate and independent Trains A and B, as shown on Figure 8.3-8 and Figure 8.3-9. The preferred power supply to each 4160-volt bus is from a UAT. An alternate source is available to each bus through a RAT. A standby power supply, consisting of a diesel generator, is available to each emergency bus. A non-safety related supplemental emergency power system (SEPS) is available as a backup power source to either Bus E5 or E6 when one or both emergency diesel generators fail to start and load. This alignment is described in Subsection 8.3.1.1.b.9. Buses E5 and E6 are the equipment designations of the redundant Class 1E buses.

Redundant Class 1E Buses E5 and E6 are located in completely separate, but adjacent rooms in the seismic Category I Control Building, as shown on Figure 8.3-27. Buses E5 and E6 are connected to the auxiliary transformers via non-Class 1E nonsegregated phase bus duct.

The bus duct is supported by seismically qualified supports in the Control Building. Taps in the bus duct provide the power to nonsafety-related Buses 3 and 4 from the bus duct runs to Buses E5 and E6, respectively. The tie between the nonsafety-related bus ducts and the Class 1E switchgear is through Class 1E air circuit breakers.

2. Switchgear

All Class 1E switchgear has identical electrical ratings:

(a) Buses - 2000-ampere continuous rating, braced for 80,000 amperes momentary.

(b) Incoming line breakers - 2000-ampere continuous rating, 350-MVA nominal interrupting capacity. SEPS incoming breaker – 1200-amperes continuous rating, 350 MVA nominal interrupting capacity.

(c) Feeder breakers - 1200-ampere continuous rating, 350-MVA nominal interrupting capacity.

The switchgear is selected in accordance with the criteria of ANSI C37.010 and C37.4.

3. Automatic and Manual Transfers

The automatic and manual transfers of power to each bus from one source to the other are as follows:

(a) An automatic transfer from the main generator supply to the offsite source through the GSUs is accomplished by the opening of the main generator breaker; no bus breaker action is required.

(b) A manually initiated live bus transfer is provided for transferring the 4.16-kV buses from the offsite source through the GSUs to the main generator source, and vice versa, by the operation of the main generator breaker. The transfer from offsite to main generator source is contingent upon the two sources being in synchronism.

(c) The opening of the UAT incoming line breaker, either manually or automatically, initiates an automatic transfer from UAT to RAT source, provided that the RAT transformer is energized, no fault exists on the bus, and the bus voltage is in synchronism with the RAT voltage at the time of transfer initiation or has decayed to an acceptable value.

A high-speed static synchronism check relay will allow the RAT incoming line breaker to close, thus completing the transfer, if both the voltage and phase angle between bus and RAT source are within limits. If the transfer is blocked due to lack of synchronism, the RAT breaker will be automatically closed when the residual bus voltage decays to an acceptable value. On the emergency buses, if the RAT breaker has not closed 1.2 seconds after transfer initiation, then the motors on the bus are tripped and the automatic transfer circuitry is disabled to prevent inadvertent RAT breaker closure.

(d) A manually initiated, synchronism check relay-supervised, live bus transfer is provided for transferring a 4.16-kV bus from the UAT source to the RAT source, and vice versa, provided that the source to which the bus is being transferred is energized, and the two sources are in synchronism. Synchronism is checked at the main control board (MCB), prior to manual initiation, by energizing the appropriate synchronism check relays.

After synchronism is verified by the synch scope, the transfer is initiated by manually closing (by means of the MCB-mounted control switch) the desired source breaker, which automatically trips the other source breaker.

4. Undervoltage and Load Shedding

(a) First Level Undervoltage Protection

Upon loss of voltage on a 4.16-kV emergency bus, 1.2 seconds are allowed for the automatic transfer described in Subsection 8.3.1.1b.3(c) above to be completed. If undervoltage persists after this time, the first level of undervoltage protection will be activated. Channel response time includes consideration of the bus voltage decay time due to generated Electro-Motive Force (EMF) from motors connected to the bus as the motors coast down. The following actions occur simultaneously:

(1) Bus loads are tripped as required

(2) UAT and RAT breakers are tripped to isolate the bus

(3) Automatic transfer schemes are disabled

(4) Standby power supply (diesel generator) is started and subsequently connected to the emergency bus as described in Subsection 8.3.1.1e.

On an emergency bus, if the UAT incoming line breaker trips open and the RAT source is unavailable, the transfer schemes are not initiated. The standby power supply (diesel generator) is immediately started and connected to the emergency bus as described in Subsection 8.3.1.1e.

(b) Second Level Undervoltage Protection

If the voltage on a 4.16-kV emergency bus is below that required to ensure the continued operation of safety- related equipment, the second level undervoltage protection scheme is activated. If the activation occurs coincidentally with an accident signal, then the UAT and RAT incoming line breakers are automatically tripped after a time delay to prevent spurious operation due to transients such as starting of large motors. This will result in total loss of voltage to the bus with ensuing actions described in Subsection 8.3.1.1b.4(a) above.

If the second level undervoltage protection scheme is activated without the coincident presence of an accident signal, then only an alarm is received. Established plant procedures require the operator to take specific steps to assess the magnitude and expected duration of the disturbance causing the undervoltage. If he is not assured that the disturbance is transitory, and that recovery is imminent, he may choose to manually trip the offsite power circuit breakers after ensuring that further deterioration of safety will not result from his proposed action.

Systems and equipment used for safe shutdown as listed in Section 7.4 will be available in the event of a degraded grid voltage because of one or more of the following reasons:

(1) Not powered by the degraded power source

(2) Does not rely on electric power

(3) In standby and, therefore, not connected to the degraded source

(4) Equipment will continue to run unimpeded under degraded voltage conditions because of margin between equipment rating and duty

(5) Not sensitive to degraded voltage (resistive load)

(6) Time is available for corrective action.

This equipment will not be exposed to or rendered inoperative by degraded voltage and, therefore, would be available to place the plant in a safe shutdown status under nonaccident conditions.

5. <u>480-Volt Substation Feeders</u>

Feeders from the 4.16-kV emergency buses are taken to 480-volt unit substations to supply the engineered safety feature loads requiring 480 volt supply. The 4.16-kV breakers feeding load centers are normally closed during the plant operation, and control is provided at the 4.16-kV switchgear. Breaker position indication is provided on the main control board.

6. Bus Ties

A non-safety related 4160 volt transfer switch (SEPS-CP-1) for the Supplemental Emergency Power System is located on elevation 21'-6" of the Train B switchgear room for the purpose of selecting a connection to 4.16 kV bus E5 or E6. The transfer switch consists of three cubicles; an incoming termination section and two switching sections. The termination cubicle is the center section which contains the connections for the incoming cables and bus bar which connects to the line side of the two disconnect switches located in the outer cubicles. A mechanical interlock is used that allows operation of only one switch closure at a time. These switches are manual assisted and do not have any automatic controls for operation. A 4.16 kV safety related circuit breaker on bus E5 and E6 is used to connect the SEPS output to the selected bus. A Kirk key interlock is provided to prevent both breakers from being racked in at the same time. One of these breakers is normally racked in. These design features prevent connection between the two safety-related buses.

7. Grounding, Ground Detection and Protective Relaying

The 4.16-kV system is a high resistance grounded system. In addition, the diesel generator neutral is grounded through a single-phase grounding transformer. The SEPS diesel generators neutrals are grounded through a single phase grounding resistor. In order to detect grounds, ground sensors have been provided on each motor circuit and load center feeder and each incoming line, including the diesel generator. Inputs from ground sensors and ground detection circuits are furnished to the station computer. The computer is programmed to recognize various combinations of inputs and to provide an alarm to alert the operator of the ground fault and its location. The grounding scheme used allows single ground faults to be alarmed only, and the equipment to continue operation.

The 4.16-kV motor and load center feeders are protected by overcurrent relays with long-time characteristics and instantaneous elements. The buses and incoming feeders are protected by inverse-time overcurrent relays.

8. Control Power Supplies

DC power supplies, as shown on Figures 8.3-3 and 8.3-37, are used to provide power for the operation of breakers and control circuitry associated with each of the redundant 4.16-kV emergency buses.

9. Contingency Connections

(a) Startup Feedpump

The startup feedwater pump (SUFP) P-113 can be supplied from either Bus 4 or Bus E5. Through Bus E5, the SUFP can be supplied power from emergency diesel generator EDG-1A under contingency conditions (see Subsections 6.8 and 10.4.12). Connection of the SUFP to Bus E5 is through a Class 1E circuit breaker. These connections are shown in Figures 8.3-7 and 8.3-8.

Paralleling of the Class 1E and non-Class 1E buses will be positively prevented by an interlocking system. A two-position (Bus E5 - Bus 4) key-locked switch must be operated to be able to close the breaker on Bus E5 or Bus 4. In addition to this interlock, when the switch is placed in position "Bus E5" it will send a trip signal to the circuitry of the SUFP on Bus 4 and vice versa. Kirk Key interlocks assure that only one breaker can be racked in at anytime. During transfer from one bus to the other, the "from" bus circuit breaker will have to be racked out before the "to" circuit breaker can be racked in preventing paralleling the buses. Transferring the SUFP power supply between Buses 4 and E5 will be manual actions controlled by procedure.

(b) Extended Loss of Offsite Power

An extended loss of offsite power (LOP) in the winter months such as could occur during a severe winter storm or from a Y2K grid disturbance results in concern with equipment freezing in the non-safety related balance-of-plant (BOP) areas. Heating in these areas is not supplied by an emergency power supply. An LOP at 100% power would cause a plant trip with both safety related EDGs automatically starting to supply safe shutdown loads.

As a contingency action, emergency diesel generator EDG-1A can be aligned to supply the BOP loads (e.g., heating and lighting) on the non-safety related electrical buses (see Figure 8.3-1). This alignment is administered under procedural control and can be used only after EDG-1B is verified stable and supplying the loads required to maintain the plant in a safe shutdown condition. EDG-1A is still available to supply safety-related loads if problems are encountered with operation of EDG-1B.

EDG-1A can be connected to the non-safety related electrical buses using both reserve auxiliary transformers (RAT) or only using RAT-3A and the unit substation (US) cross tie circuit breakers to supply the Bus 2 US from the Bus 1 US. A study and analysis has been performed to demonstrate the capability of EDG-1A and RAT(s) to supply the BOP loads. EDG-1A loading will be maintained within its continuous rating while supplying the BOP loads. Because this contingency connection is not a normal system lineup, various control circuit features, some of which are discussed in Subsection 8.3.1.1.b.3(c) & (d); 8.3.1.1.b.4(a) & 8.3.1.1.e.6, must be bypassed (jumper, lifted lead, etc.) to permit EDG-1A to supply the RAT(s). Installation of the circuit bypasses will be a controlled evolution according to an approved procedure. These circuit bypasses do not degrade the electrical protection (e.g., overcurrent, differential, etc.) for EDG-1A, the electrical buses and RAT(s). The same degree of electrical protection is provided for EDG-1A, the electrical buses and RAT(s) for this contingency lineup as is available when EDG-1A is paralleled with offsite for routine surveillance testing.

Control room bypass/inop status indication per Regulatory Guide 1.47 is not required for these circuit bypasses because the LOP condition is not expected to occur more frequently than once per year. Also, EDG-1A is not required to be operable since EDG-1B is operable/operating to supply the safety-related equipment required to cope with the LOP.

After offsite power is restored and verified stable and reliable, normal offsite power connections to the plant buses can be restored. EDG-1A would be synchronized with offsite power, its circuit breaker opened and EDG-1A shut down.

Subsection 8.3.1.4.a indicates that protective devices for non-Class 1E loads connected to Class 1E buses are coordinated such that failure of all of the non-Class 1E loads will not result in tripping the incoming breaker to the Class 1E bus. The RAT, Buses 1 & 2 and their connected loads are non-safety related so the Bus E5 RAT circuit breaker potentially falls under this requirement. However, since EDG-1A and Bus E5 are considered inoperable for this contingency alignment, there is no need for coordination or testing of the protective device since trip of this circuit breaker to Bus E5 would not affect loads performing a safety related function.

(c) Supplemental Emergency Power System (SEPS)

The non-safety related supplemental emergency power system (SEPS) is designed as a backup power source to either Bus E5 or E6 when the EDGs fail to start and load. SEPS is capable of providing the required safety related loads in the event of a loss of offsite power (LOP) coincident with the loss of both emergency diesel generators. During these events it is assumed that there is no seismic event or an event that requires safeguards actuation (SI, CBS, CVI, CI, etc.). This is considered a non design basis event. Although SEPS may be used during a station blackout, it will not be credited as a station blackout power source. Seabrook Station will continue to be an AC independent plant (See UFSAR Section 8.4)

Subsection 8.3.1.4a indicates that protective devices for non-Class 1E loads connected to Class 1E buses are coordinated such that failure of all of the non-Class 1E loads will not result in tripping the incoming breaker to the Class 1E bus. Non-safety related SEPS is connected to bus E5 or E6 when the offsite power sources and both EDGs fail to start and load so the SEPS circuit breakers potentially fall under this requirement. However, since EDG-1A, EDG-1B, and Buses E5 and E6 are not operable during this contingency alignment, there is no need for coordination or testing of the protective devices since trip of these breakers would not effect loads performing a safety related function.

The SEPS supply connects to a transfer switch for the purpose of selecting a connection to 4.16 kV Bus E5 or E6. Mechanical interlocks prevent closing both switches at any one time. A 4.16 kV safety-related circuit breaker on buses E5 and E6 is used to connect the SEPS system output to their respective buses. Connection to both E5 and E6 will be positively prevented by mechanical interlock. The mechanical interlock assures that only one breaker can be racked in at anytime.

c. 480V Distribution System

1. Arrangement

The 480V Distribution System comprises unit substations, 460-volt motor control centers, and distribution panels. The unit substations consist of a transformer and adjacent 480-volt switchgear.

The 480V Engineered Safety Features Distribution System consists of two separate and independent Trains A and B, to supply redundant engineered safety features load groups, consistent with the separation of the 4160V Engineered Safety Features Distribution System. The system configuration, shown on Figure 8.3-1, Figure 8.3-11, Figure 8.3-12, Figure 8.3-13, Figure 8.3-14, and Figure 8.3-15, shows the motor loads and motor control centers fed from the unit substations. The loads supplied from the motor control centers are shown on Figure 8.3-16, Figure 8.3-17, Figure 8.3-18, Figure 8.3-19, Figure 8.3-20, Figure 8.3-21, Figure 8.3-22, Figure 8.3-23, Figure 8.3-24, Figure 8.3-25, Figure 8.3-26, Figure 8.3-52, Figure 8.3-53, and Figure 8.3-54.

2. Unit Substation Transformers

Transformers for 480-volt emergency buses are supplied from the 4160 volt emergency buses. The transformers are rated 1000/1333 kVA (AA/FA) and are air insulated, dry type. The transformer impedance is selected to limit the maximum short-circuit current at the 480-volt load center bus to the motor control center (MCC) breaker rating of 25,000 amperes rms symmetrical (except as noted in Section 8.3.1.1.c.3), and to maintain voltage at the motors of 414 volts (90 percent of 460) under normal operating conditions and 368 volts (80 percent of 460) during starting of motors except for unit substation E64. A lower transformer impedance is selected for unit substation E64 to maintain voltage at the motors of 414 volts (90 percent of 460) under normal operating conditions and 368 volts (80 percent of 460) during starting of motors. The maximum short-circuit current at the 480-volt unit substation bus is limited to the motor control center breaker rating of 25,000 amperes rms symmetrical by limiting the load on unit substation E64 to 600 kVA.

3. Unit Substation Switchgear

The 480-volt safety-related switchgear is of metal-clad indoor design and has three-pole, metal frame, low-voltage power circuit breakers. Electrically operated breakers receive control power from one of the redundant DC power supplies, as shown in Figure 8.3-3. The switchgear is selected in accordance with ANSI C37.13, where applicable, and has ratings compatible with the normal current and expected fault duty as follows:

	Frame Size Amperes	RMS Sym. Amps. with Inst. Trip	RMS Sym. Amps. without Inst. Trip
Transf. secondary bkr.	2000	65,000	55,000
Feeder breaker	600	30,000	22,000*
Feeder breaker	1600	50,000	50,000

* Design calculations confirm that the actual available fault current is less than 22,000 A where 600 A frame breakers without instantaneous trip devices are used since their interrupting rating is less than the 25,000 A available short circuit current given in Section 8.3.1.1.c.2.

The 460-volt motors connected to the load centers are protected by tripping devices having a combination of long time delay and instantaneous elements. Feeder breakers to MCCs are equipped with the long-time and short-time tripping devices.

4. <u>460 Volt Motor Control Centers</u>

460 volt motor control centers are of metal-enclosed indoor design, and are provided with molded-case circuit breakers with magnetic or thermal-magnetic tripping devices. Combination motor starters, consisting of a magnetic-only breaker and a starter having one thermal overload element per phase, are provided for motors located outside the containment. (For motors located inside the containment, see Subsection 8.3.1.1c.7 on special 480-volt circuits.) Thermal magnetic breakers, with a contactor as required, are provided for all other loads.

The motor control center buses are braced to withstand 42,000 amperes rms symmetrical. The combination starter units and feeder breaker units are rated to withstand a three-phase fault at the load terminals, with a fault current contribution of 25,000 amperes rms symmetrical at the line terminal. Contactors and starters are rated to withstand voltage dips to 70 percent of 460 volts without dropping out.

Distribution panels are standard metal-enclosed panelboards with molded case breakers protecting the branch circuits. Breakers are rated to withstand a three-phase fault at the load terminals, with the maximum available system fault current contribution at the line terminals.

5. Classification

The 480-volt load centers, 460-volt motor control centers and distribution panels which supply power to Engineered Safety Features or reactor protection systems are all Class 1E and are located in seismic Category I structures.

Certain other motor control centers (MCC 111 and MCC 231) and distribution panels (RC-PP-6A, 6B, 6C, 6D and 6E) are qualified to meet Class 1E requirements and are located in Category I structures specifically because they are used to feed loads inside the containment as described in paragraph 7(a) below.

6. Bus Ties

No bus ties exist between redundant buses. Manual bus tie breakers provide the capability to interconnect load center buses within a single train.

Bus tie breakers provide manual interconnection capability between unit substations E51, E52 and E53, all of Train A. Similarly, interconnection capability exists between unit substations E61, E62 and E63, all of Train B.

Bus ties may be used when any unit substation transformer is out of service for maintenance or repair. Bus ties are provided only for operational flexibility. The unit substations are not designed to supply the total load of both buses when bus ties are used. When a bus tie breaker is used, loading on each unit substation will be administratively controlled to be within the FA rating of the unit substation transformer.

7. Special 480-Volt Criteria

(a) Protection of Containment Electrical Penetrations

The Class 1E and non-Class 1E 480-volt unit substations, 460-volt motor control centers and the distribution panels which feed loads inside the containment are all qualified to meet Class 1E requirements and are located in seismic Category I structures. 460-volt loads inside the containment are fed from distribution equipment with special provisions to satisfy the requirements of Regulatory Guide 1.63 for containment electrical penetration protection. These provisions are outlined below.

460-volt loads inside containment which are fed from unit substations, motor control centers or distribution panels are provided with one of the following special arrangements to insure that the penetration integrity is maintained:

(1) Circuits of motors 5 hp and less are provided with two identical combination starters. Both units are located in the same compartment of the MCC. See Figure 8.3-50 for typical coordination curves. The thermal overload relays identified in the figure by numbers (2) and (4) are utilized to protect the penetration from a fault whose magnitude is insufficient to trip the magnetic part of the protective device.

(2) Circuits of motors greater than 5 hp are provided with a thermal magnetic breaker in series with a combination starter. Both the breaker and the combination starter are located in the same compartment of the MCC. See Figure 8.3-49 for typical coordination curves.

(3) Feeder circuits, except for the pressurizer heater circuits, are provided with two identical thermal magnetic breakers. Both breakers are located in the same compartment of the MCC or panel.

(4) Feeder circuits for the pressurizer heater Groups A and B circuits are provided with fuses in series with an air circuit breaker. Feeder circuits for the pressurizer heater Groups C, D, and E are provided with dual fuses. The fuses are located in panels and the air circuit breakers are located in unit substations.

The motor control centers and unit substations containing these special protective devices are located in the Control Building switchgear area, with one exception. The panels for the pressurizer heater circuits are located in the electrical penetration area outside the containment. Both the primary and the backup protective devices are qualified 1E devices.

There are no high or moderate energy lines in the above areas; therefore, only faults within the electrical devices could conceivably damage these protective devices. If a protective device fails catastrophically while clearing a short circuit, the second protective device may possibly be affected because of its proximity. However, in this instance, no penetration damage can occur because all short-circuit current flow will be diverted to the new fault located at the protective device. Therefore, there is no conceivable electrical failure that could prevent both the protective devices from operating and at the same time allow the fault current to flow through the penetration.

460-volt loads inside the containment, which are fed directly from the 480-volt unit substation, satisfy the requirements of Regulatory Guide 1.63 by utilizing the load breaker as primary protection and the unit substation incoming feeder breaker as backup protection. See Figure 8.3-48 for typical coordination curves.

Feeders for 460-volt distribution panels (lighting panels), located inside containment are provided with two thermal magnetic molded-case breakers in series to satisfy the requirements of Regulatory Guide 1.63.

460-volt loads inside the containment which are normally used only during shutdown (e.g., cranes, refueling machines, welding receptacles, etc.) are not provided with redundant protection because their circuits are de-energized and padlocked at the unit substation or motor control center during normal plant operation. Verification of the circuits being de-energized is part of the Technical Specifications. Though some of these circuits may be required for brief durations during plant operation, such as prior to or after refueling outages, lack of redundant protection is justified because of the very limited usage in this mode and the fact that such usage will be under Technical Specification requirements.

Control circuits powered from 120V AC or 125V DC distribution panels have dual protective devices (circuit breakers and/or fuses) to provide penetration protection in accordance with Regulatory Guide 1.63. The protective devices are located in seismically qualified buildings.

The CRDM circuits (lift coil, stationary and movable gripper) which are powered from the CRDM power distribution system have dual non-Class 1E protective devices (fuses) to provide penetration protection in accordance with IEEE Standard 741-1986, Subsection 5.4.3. These fuses are part of the CRDM Power Distribution System.

The manufacturer of the penetrations has furnished damage curves which establish the duration and magnitude of overcurrents that the penetrations can sustain. Typical coordination curves are shown on Figure 8.3-47, Figure 8.3-48, Figure 8.3-49 and Figure 8.3-50. Except for Figure 8.3-47 which shows the coordination curves for the RCP electrical penetrations, the sizes, setpoints, and response curves of the protective devices in the figures do not correspond to any specific load applications. Those figures are intended to be representative of how various types of protective devices are used to coordinate with the electrical penetration damage curves. The specific sizes, setpoints, and response cures are controlled by design calculations and drawings.

It can also be seen in these figures, that the curves of the protective devices are, in all cases, to the left of the penetration damage curves. Thus, the protection provided will assure that long or short duration overcurrents that are capable of damaging the penetration will be interrupted before they cause damage.

Low energy circuits, i.e., control circuits powered from limited-capacity power sources such as control power transformers (maximum capacity 300 VA) and instrumentation circuits, do not require dual protection because the short circuit versus time capacity of their power sources is within the penetration capabilities.

(b) Protection Against Single Failure of Manually Controlled Electrically Operated Valves (BTP ICSB 18)

Separate, normally de-energized motor control centers (E522-Train A, E622-Train B) are provided for motor- operated valves in the Safety Injection and Residual Heat Removal Systems whose spurious movement due to random single failures is deemed unacceptable. These valves are normally aligned to their safe positions. Following an accident, the operator can energize these MCCs from the control room to accomplish any necessary valve repositioning. Redundant valve position indication is provided on the main control board for each valve. One set of indicating lights is powered from a 120V AC uninterruptible power supply; the redundant set of lights is powered from a 120V AC power panel in a safety-related MCC other than E522 or E622.

In addition to the above circuits, another special circuit is used to support BTP ICSB-18. Valve SI-V93, in the common miniflow return line from the SI pumps SI-P6A and P6B to the RWST is provided with a contactor controlled by a key-operated switch in addition to the normal combination motor starter. For details see Figure 8.3-45. With this arrangement, a single failure will not cause a valve movement and, furthermore, the operator is required to perform two distinct operations to change the valve position. The circuit for SI-V93 is powered from MCC E621.

(c) Special Provisions in Response to NUREG-0737

The design complies with the guidelines of NUREG-0737 and the "clarifications" to NUREG-0737.

(1) Item II.E.3.1, Pressurizer Heaters

A description of the pressurizer heaters is provided in Section 5.4.

One pressurizer heater bank can be supplied from the Train A diesel generator and one bank can be supplied from the Train B diesel generator during loss of offsite power. Each bank can establish and maintain natural circulation at hot standby conditions. Each bank can be supplied from either offsite power or from one diesel generator.

As demonstrated in Table 8.3-1, the standby power supply has the capacity to supply the pressurizer heaters without load shedding.

Changeover of the pressurizer heaters from normal offsite power to emergency onsite power can be accomplished manually in the control room.

Motive and control power connections to the Class 1E buses from the pressurizer heaters are through Class 1E devices.

The pressurizer heaters are not automatically shed from the emergency buses upon the occurrence of a safety injection actuation signal. However, they are load shed on loss of offsite power.

(2) Item II.G.1, PORV and PORV Block Valve Power and Control

Motive and control components of the PORVs and the PORV block valves can be supplied from the offsite power source or the onsite power source.

Motive and control power connections to the Class 1E buses for the PORVs and block valves are through Class 1E devices.

The pressurizer level indication instrument channels are powered from the vital instrument buses. The vital buses can be powered from the offsite power source or onsite power sources.

The design of the PORV block valves provides the capability to close the valves and retains to the extent practical the capability to open the valves. These capabilities are maintained by providing two redundant motor-operated PORV block valves located in parallel flow paths. One PORV valve is supplied power by the Train A emergency bus and the other PORV block valve is supplied power by the Train B emergency bus.

The motive and control power for the block valves is supplied from a different emergency bus than the source supplying the PORVs. See Figure 8.3-57.

Changeover of power to the PORV and block valves from offsite power to onsite power can be accomplished from the control room.

8. Undervoltage and Load Shedding

Selected loads on 480-volt safety-related load centers are tripped upon detection of sustained undervoltage on the 4160-volt emergency bus. Automatic reclosing of the unit substation motor feeder breakers is described in Subsection 8.3.1.1.e.6.

Upon loss of voltage on a 460-volt MCC bus, all starters will drop out automatically. Combination starters having maintained start circuits with an over-riding trip will reclose upon restoration of voltage. However, other combination starter units will require start signals for reclosing. Refer to Subsection 8.3.1.1.e.6 for automatic reclosing on the standby power supply.

9. Grounding and Ground Detection

The 480V system is a high-resistance grounded system. The grounding equipment is located at the 480-volt unit substations. This grounding configuration allows the system to operate effectively as an ungrounded system, i.e., service is not interrupted in case of a single ground fault, but an alarm is initiated.

d. 120V Vital Instrumentation and Control Power System

The 120V Vital Instrumentation and Control Power System comprises the uninterruptible power supply (UPS) units and the 120-volt distribution panels, as shown in Figure 8.3-4. The vital instrument panels and the vital UPS units are Class 1E and are located in the seismic Category I Control Building at elevation 21'-6". The physical arrangement of these UPS units and panels is shown in Figure 8.3-27. These UPS units feed six electrically independent 120-volt AC vital instrument panels which serve as instrument and control power supplies.

Four of the vital UPS units provide separate and independent power supplies to the four NSSS instrumentation channels (designated as channels I, II, III and IV). These four UPS units are powered either from the 480V system or 125 volt DC system (station batteries/chargers) depending on the available 480V bus voltage. The two additional vital UPS units provide redundant power supplies to the balance of plant Train A and Train B vital instrument panels. These two UPS units are normally powered from the 480V system and can also convert 125 volt DC power from station batteries to 120V AC Power. Each vital UPS unit has adequate capacity to carry the associated load continuously. Loads supplied from each UPS unit are as shown in Figure 8.3-28, Figure 8.3-29, Figure 8.3-30, Figure 8.3-31, Figure 8.3-32, Figure 8.3-33, Figure 8.3-34 and Figure 8.3-35.

One of the NSSS channel-associated UPS units and one of the balance-of-plant UPS units also feed separate panels for nonvital instrumentation and controls. The nonsafety-related panels are supplied from Class 1E panels through Class 1E circuit breakers. Manually operated maintenance feeds are provided to each of the four vital instrument panels associated with the NSSS instrumentation channels from 480/120-volt AC transformers connected to nonsafety-related MCCs. Each of the two balance-of-plant vital instrument panels are provided with a static transfer switch for automatic and fast transfer of these buses to a maintenance supply from a 480/120-volt AC transformer connected to a nonsafety-related MCC in the event of unavailability of the associated UPS. In addition to the automatic transfer switch, the manual transfer capability to maintenance supply is also provided to bypass and isolate the static transfer switch for maintenance. On each UPS, instrumentation is provided to monitor AC and DC input currents, as well as output current and voltage. Alarms are provided on the station computer for loss of AC voltage on the vital instrument panels. The 120V AC Vital System is a two-wire ungrounded system with a ground detection scheme. Each branch circuit at the distribution panel is protected by a thermal magnetic breaker.

In addition to the six vital UPS units, there are three nonsafety-related UPS units feeding the station computer and miscellaneous auxiliary loads which require a reliable AC source. These units are also normally powered from the 480V AC system and can also convert 125-volt DC power from station batteries to 120-volt AC power. Two additional non-safety UPS units (with associated batteries for 30 minutes of operation) feed secondary control systems and miscellaneous related loads requiring reliable regulated AC power with short term battery backup. These units are normally powered from the 480V AC system and can also convert 125-volt DC power from their associated batteries to 120-volt AC power.

e. Standby Power Supply (Diesel Generator Units)

1. Diesel Generator Ratings and Capabilities

The standby power supply is provided by two redundant diesel engine generator systems of identical design and characteristics which supply onsite power of sufficient capacity and capability to reliably shut down the reactor. The load rating of each diesel generator is as follows:

8760 hours per year (continuous)	6083 kW
Short time	6697 kW

The generator itself is rated 8375 kVA at 0.8 pf lagging continuous, with a 2-hour short time rating of 9213 kVA at 0.8 pf.

The basis for sizing the diesel generator is consistent with the regulatory position of Regulatory Guide 1.9, the application criteria set forth in IEEE 387, and the "single generator driven by a single prime mover" philosophy that conforms to the regulatory position of Regulatory Guide 1.6.

The capacity of each diesel generator is adequate to support operation of engineered safety feature loads within the short time rating, and is determined on the basis that the sum of the predicted loads needed to be powered at any one time does not exceed the short time rating.

Each diesel generator is connected to a 4160-volt emergency bus as shown in Figure 8.3-1 and Figure 8.3-10. The capacity of each diesel generator is sufficient to meet the safety features demand caused by a loss of offsite power with or without a coincident loss-of-coolant accident. The diesel generator safety features loading sequence is shown in Table 8.3-1 and Table 8.3-2.

The diesel generator control circuits provide the capability for both fast and slow starts. A fast start is where rated voltage and frequency is attained within a maximum of 10 seconds after receipt of a start signal. A slow start involves starting to idle speed, operation at idle speed for a predetermined time period, and then automatic speed increase to rated speed at a predetermined rate. Slow start capability is provided to reduce engine wear and tear during periodic surveillance testing. Emergency start signals (manual, safety injection or loss of bus power) are always fast starts. Emergency starts always override a slow start signal.

2. <u>Diesel Generator Auxiliaries</u>

Each diesel generator system comprises the auxiliaries necessary for fast start operation, connection to the 4160-volt emergency bus, and connections to the required services. No auxiliaries are shared between the diesel generator systems. External power sources, other than DC control power from the unit's station batteries and AC power from vital uninterruptible power supply (UPS) units, are not required for starting or subsequent operation.

To ensure availability of starting air, each diesel engine is supplied with air starting systems, as described in Subsection 9.5.6. Elapsed time from receipt of start signal to a condition of rated voltage and frequency is a maximum of 10 seconds.

The diesel engines are cooled by a closed-jacket water system which in turn is cooled by water from the Service Water System. Each diesel is provided with a thermostatically controlled electric heater for the jacket water. Lubricating oil is continuously circulated through the engine and receives heat from an electric heater. This procedure provides maximum assurance of starting with minimum engine wear. The diesel is capable of operating without cooling water flow through the heat exchanger during loss of offsite power for a period of time in excess of that required to start the service water pumps (minimum of 52 seconds) from the emergency bus. A further description of the Diesel Cooling Water System is presented in Subsection 9.5.5.

Each diesel generator system is provided with a seven-day fuel oil storage tank and a day tank of capacity sufficient for a minimum of three hours of engine operation at continuous full load. The day tank is equipped with level switches to provide automatic actuation (starting and stopping) of the associated fuel oil transfer pump, and low level and high level alarms. Overflow recirculation piping is provided from the day tank to the fuel oil storage tank. The fuel oil storage tanks have a capacity suitable for operating one emergency generator at post-accident load for at least seven days. Fuel oil is transferred from each oil storage tank to its respective day tank by a pump powered from the associated emergency bus. Valving is provided to permit either transfer pump to supply one or both day tanks from either storage tank.

Procedural controls and scheduled periodic testing are established to maintain the integrity of the system, and to confirm that the tanks have an adequate fuel supply when the diesel generators are in the standby condition. A further description of the Diesel Engine Fuel Oil System is presented in Subsection 9.5.4.

Each diesel generator unit and its auxiliaries are located in a separate and independent enclosure within a seismic Category I building. The reinforced concrete enclosure wall between diesel generators has a three-hour fire rating and is designed to withstand explosions and stop postulated missiles from the adjoining diesel generator and its auxiliaries, such as a crank-case door created by a crank-case explosion, or rupture of one of the air receiver vessels. The diesel generator and its auxiliaries which are essential for the operation are designed in accordance with Category I seismic requirements.

Separate and independent heating and ventilating equipment is provided for each diesel generator system to supply adequate air for control of the ambient temperature. The heating and ventilation system for the diesel generator system is described in Subsection 9.4.8.

Electrical components associated with the starting of the diesel generators (e.g. auxiliary relay contacts, control switches, etc.) are located within NEMA 12 control cabinets which minimize the accumulation of dust and dirt on electrical contacts. The cabinet doors are gasketed and, where louvers are provided, the openings are covered by filters which will prevent passage of particulate matter including products of combustion which could degrade engine starting or operation.

3. Arrangement

The power connection between the diesel generator and the 4160-volt emergency bus is made with Class 1E nonsegregated phase bus duct. The bus duct and power and control cables for each diesel unit are routed to maintain physical separation of the diesel generator systems, and to prevent a single event from disabling both of the redundant systems. The arrangement of the diesel generator systems, demonstrating physical separation and isolation, is shown in Figure 8.3-36.

4. Protective Devices

Diesel generator protective trips are in compliance with the requirements of Branch Technical Position ICSB 17. They consist of low lube oil pressure, high lube oil temperature, high jacket coolant temperature, generator overcurrent, reverse power, generator differential current, loss of field and mechanical overspeed.

The generator overcurrent, reverse power, loss of field, high lube oil temperature, and high jacket coolant temperature protective devices are automatically bypassed when the diesel generator is started to mitigate the effects of an accident from a safety injection signal (DG Backup Protection Bypass). The protective device for high lube oil temperature and high jacket coolant temperature are also automatically bypassed by a separate circuit (High Temperature Protection Bypass) on a manual emergency start, emergency safety injection start or loss of power emergency start of the diesel generator by the emergency power sequencer. The generator overspeed, generator differential and low lube-oil pressure protective devices are not bypassed in any mode of operation. To preclude the possibility of a spurious trip from low lube-oil pressure, three independent low-pressure signals are conditioned by a two-out-of-three coincidence logic.

The operability of the bypass circuits can be tested during diesel generator routine testing. When the diesel generator is running and connected to the emergency bus, a signal is simulated to activate the bypass circuit being tested and then the protective signals are simulated. Failure of the engine to shut down and the diesel generator breaker to trip is evidence of the proper functioning of the bypass circuitry. Each bypass circuit is tested separately and overlap testing is used to ensure proper operation of the complete bypass circuitry.

During an accident (safety injection) or loss of offsite power event the bypassed protective devices provide annuniciation. Other monitoring devices provide annunciation in any mode of operation. Mechanical and electrical surveillance devices are located at the local panel and in the control room so operators can observe conditions and take appropriate action.

Because the diesel generator cannot supply power to a faulted bus, it should be disconnected in the event of a bus fault to avoid possible damage or fire to the 4.16-kV switchgear. For this reason, an additional protective relay has been provided to trip the diesel generator circuit breaker on a 4.16-kV bus fault. This bus fault relay is not bypassed in any mode of operation. The relay does not trip the diesel generator but only trips the generator circuit breaker. The diesel engine continues to run and can be reconnected manually to the bus if no fault exists. The bus fault relay is set to actuate at a fault current sufficiently high to avoid spurious trips of the diesel generator breaker.

An additional trip (operational) when the diesel generator is connected to the bus during testing with UAT or RAT supply connected, assures isolation of the diesel generator on receipt of an accident signal.

Status monitoring lights are provided on the main control board to indicate diesel generator operating mode, availability, and bypassed conditions during all modes of plant operation.

Alarms are provided in the control room to indicate the availability of diesel generator auxiliaries.

Conditions that can render the diesel generator unable to respond to an emergency start signal have been evaluated. These conditions and the resulting alarms and monitoring lights presented to the control room operator have been summarized in Table 8.3-8.

Other conditions that can make emergency power unavailable, but do not necessarily render the diesel generator unable to respond to an automatic start signal, and the resulting alarms are presented in Table 8.3-9.

Table 8.3-8 and Table 8.3-9 list specific alarms actuated by disabling conditions as well as common alarms that use logic to provide one alarm from multiple inputs. The alarms listed in the tables are those which are actuated by disabling conditions. Each common alarm clearly indicates the status of the emergency diesel generator and Emergency Power System. All disabling conditions are clearly distinguishable from conditions that are abnormal but not disabling. All conditions that render the diesel generator incapable of responding to an automatic emergency start signal are alarmed in the control room.

5. Reliability and Testing

Prior to shipment of the diesel generator sets, a type qualification testing program meeting the requirements of IEEE 387-1977 was performed on one diesel generator unit. The type qualification testing program consisted of load capability qualification, start and load acceptance qualification, and margin qualification. The test results are summarized below.

Load capability qualification was demonstrated by performing the following tests:

(a) No Load Test

Acceptance Criteria: The diesel generator unit must be operated for 6 hours at "ready to accept load" status, then operated for a period of 1 hour at 100% load with no abnormalities encountered.

Conclusion: Performance of the diesel generator unit met the acceptance criteria.

(b) 100% Load Test

Acceptance Criteria: The unit must operate at 100% load for 22 hours (8414 bhp - 6083 kW) at equilibrium temperatures without exceeding 180°F jacket water temperature out of the engine and 145°F lube oil to the engine.

Conclusion: Seven hourly load readings were noted that were below the 100% load rating. The worst being 98.9 percent or 6066 kW which was 17 kW below rated load. Despite this discrepancy, it is felt that the performance of the diesel generator has met the intent of the acceptance criteria.

(c) 110% Load Test

Acceptance Criteria: Immediately following the 100% load test, the unit must operate at 110% load (9264 bhp - 6697 kW) for a period of two hours without exceeding 180°F jacket water temperature out of the engine and 145°F lube oil to the engine.

Conclusion: Performance of the diesel generator met the acceptance criteria.

(d) 100% Load Rejection Test

Acceptance Criteria: The unit, when operating at 100% load (8414 bhp - 6083 kW) must remove the load instantaneously in one step without exceeding 560 rpm.

Conclusion: The diesel generator met the acceptance criteria.

Start and load acceptance qualification was demonstrated by performing the following test:

(a) 300 Start and Load Acceptance Qualification Test

Acceptance Criteria: A total of 300 valid start and loading tests shall be performed with no more than 3 failures allowed. A valid start and load test is defined as a start with loading to at least 50 percent of the continuous rating within the required time interval, and continued operation until temperature equilibrium is attained. The starts were made from both keep-warm temperature conditions as well as when it was at its normal operating temperatures.

Conclusion: The diesel generator unit successfully passed the 300 start and load acceptance qualification test.

Margin qualification was demonstrated in conjunction with the load acceptance tests.

Acceptance Criteria: Start the diesel generator and apply an initial load 10 percent greater than the initial design load and then, when the diesel is at approximately 75 percent of its rated load, apply an additional load 10 percent greater than the worst design step load:

(1) The voltage shall not drop to less than 80 percent of normal and frequency not less than 95 percent of normal

(2) The time to recover from 80 percent rated volts to 90 percent rated volts and from 95 percent frequency to 98 percent frequency after each load step shall not be more than 3 seconds.

Conclusion: The diesel generator successfully met the stated criteria during the load test.

In addition to the above and the manufacturer's standard tests, the following tests were performed at the factory on each unit prior to acceptance.

Load acceptance test - to demonstrate the capability to accept the loads that make up the design load, in the sequence and time indicated in Table 8.3-1, and to maintain voltage, speed, and frequency within limits specified in Subsection 8.3.1.2b.2. For this factory test, motor loads and resistive loads were connected to the diesel generator in a combination which exceeded the requirements of the actual loading sequence.

Rated load test - to demonstrate the capability to carry the continuous rated load for a time required to reach temperature equilibrium plus one hour, and to carry the 2000-hour rating, 6503 kW, for two hours.

Load rejection test - to demonstrate the capability to reject the largest single load without exceeding the speed limits specified in Subsection 8.3.1.2b.2.

Overload test - to demonstrate the capability to carry the short time rating for two hours.

Each diesel generator has been tested at the site as part of the preoperational tests to demonstrate that it is capable of performing its intended function. Site tests have been performed in accordance with IEEE Standard No. 387 and Regulatory Guide 1.108, with clarification as explained in Subsection 8.1.5.3.

Since the diesel generator has been placed in service, periodic testing is being performed as described in Subsection 8.3.1.1j. This periodic testing also provides input to the Maintenance Rule EDG performance criteria which support the target reliability levels required for the Station Blackout analysis (see Section 8.4.2).

6. Loading Description

Loads important to safety are connected to emergency buses and are arranged so that they are capable of being powered by the diesel generators in the event of failure of the offsite power sources. The operation of either diesel generator provides the minimum Engineered Safety Features required for abnormal and accident conditions.

If undervoltage is experienced on a 4160-volt emergency bus, a 1.2 second time delay is allowed for the transfer scheme to function. If the transfer is unsuccessful, the diesel generator is started. If undervoltage is experienced and offsite power is not available, the diesel generators are started immediately.

Independent manual starting and control devices are provided in the control room and at the local control panel near each unit to allow the generator to be synchronized to the bus for load testing without interrupting normal power to the bus. The capability exists in the control room and at the local control panel to synchronize the diesel generator to the offsite power supply and to close the offsite source breaker.

In the event of loss of offsite power, emergency buses are automatically cleared of all incoming power feeders and selected loads prior to the closing of the diesel generator circuit breaker. The feeder breakers from the 4160-volt emergency bus to the 480-volt load centers are not tripped, and thus these loads become energized when the diesel generator is connected to the 4160-volt bus. Following the automatic closing of the diesel generator circuit breaker, loads are connected to the emergency buses in a predetermined sequence dictated by plant conditions. Protective relays block the connection of a diesel generator to a faulted bus.

The automatic connection of the predetermined loads to the emergency bus is accomplished by emergency power sequencers (EPS). The emergency power sequencers function only upon loss of offsite power to sequence loads on the diesel generator. See Figure 8.3-46 for EPS logic. An EPS is furnished for each safety load group and is located in the Control Building Train A or B switchgear room. The EPS monitors critical emergency bus parameters such as voltage and incoming line circuit breaker positions (open or closed). Depending upon whether an accident condition (SI) is also present, the EPS provides appropriate contact outputs to the various safety-related loads to start them in a programmed time sequence. Momentary signals are provided to circuit breakers and starters of loads which are required to start at a specific time ("definite start loads"; see Table 8.3-1 and Table 8.3-2). Maintained permissive contacts are provided for loads whose starting is also dependent upon the presence of a process signal ("indefinite start loads," see Table 8.3-1 and Table 8.3-2).

The indefinite start loads assigned to the first load step at the 12-second time sequence point are not interlocked with a sequence timer contact and may, therefore, be loaded on the diesel generator at any time. By assigning these loads to the first load step in Table 8.3-1 and Table 8.3-2, they are assumed to start at that time or anytime thereafter throughout the loading sequence. This first step is the most heavily loaded step and, therefore, is the limiting step. If these loads start randomly at any other time, other than at the first step, they will have less impact on the diesel generator loading capability. Indefinite start loads assigned to steps other than the first load step are interlocked with sequencer timing contacts to prevent these loads from starting prior to their assigned sequence point. As in the first step, these loads may start at any time after their assigned step.

Indicating lights for the sequencing steps are provided on the main control board to assist operation. Loading is started when the diesel generator reaches rated speed and voltage and the generator circuit breaker closes (approximately 10 seconds after the diesel start signal).

Table 8.3-1 shows the order and time at which the loads are automatically and sequentially applied to the diesel generator during a combined loss of offsite power and accident condition.

During the diesel generator load sequence testing, which is performed at least every 18 months, the design accident load will be tested by simulating a loss of offsite power with a safety injection signal. In this way, the test will simulate the load of Table 8.3-1 as close as practical.

Table 8.3-2 shows the order and time at which loads are automatically and sequentially applied to the diesel generator during a loss of offsite power.

Whenever a tower actuation (TA) signal is received, the cooling tower pumps receive an automatic start signal and the service water pumps are automatically tripped and blocked from starting until the TA signal is reset.

As noted on Table 8.3-1 and Table 8.3-2, either the cooling tower pump or the service water pump, but not both, will be loaded on the diesel generator. Upon loss of offsite power, all service water pumps and cooling tower pumps receive a trip signal. At sequence interval 52 seconds (step 8), both the cooling tower pump and the service water pump receive a start permissive from the EPS. If a TA signal is also present, the cooling tower pump will start; otherwise the service water pump will start.

The diesel generator has been tested and/or analyzed to demonstrate its ability to successfully start a load larger than the 800-hp cooling tower pump at the 52-second loading sequence interval.

During the diesel generator loading process, 4160 and 480-volt emergency bus undervoltage tripping circuits are disabled to prevent inadvertent tripping due to momentary voltage dips caused by application of large motor loads. During the SEPS DGs loading process the under voltage tripping circuits are also disabled. If for any reason the diesel generator breaker trips open during or subsequent to the loading process, undervoltage tripping is restored and the bus is cleared, as in the original loss of offsite power. Upon reclosing of the diesel generator breaker, the loading process is re-initiated and proceeds as before.

The diesel generator is also capable of starting and powering the startup feed pump (SUFP) P-113 when carrying the maximum Train A load listed in Table 8.3-1. In addition, procedures for operating the SUFP on the diesel generator (refer to Subsection 8.3.1.1b.9) will require that the operator verify diesel generator loading to ensure that adequate margin is available for running this pump. There is also an emergency power sequencer interlock to permit SUFP operation on the diesel generator only after load sequencing has been completed. Subsection 8.3.1.1.b.9 also describes a contingency alignment where emergency diesel generator EDG-1A may be aligned to provide power to the non-safety related electrical buses.

In the event of a safety injection signal, the diesel generators are automatically started and operated at idle. Should the offsite power supply subsequently fail, the diesel generators are automatically connected to the emergency buses and the loading sequence as described in Table 8.3-1 is initiated.

Upon receipt of an automatic diesel start signal (LOP or SI) during load testing, the diesel generator breaker is automatically tripped, and the diesel generator continues to run. The diesel generator controls, including voltage regulator control, are automatically returned to the automatic control mode. Should this be accompanied by a loss of offsite power, relays sense the loss of voltage on the emergency bus and respond by initiating the loading sequence described in Table 8.3-1.

If a safety injection signal is received during or after a loss of offsite power load sequencing, the sequencer will reset and resequence all the required engineered safety loads.

The diesel generator is equipped with an auto-tracking manual voltage regulator. As the automatic voltage regulator responds to load variations, the manual voltage level is automatically adjusted to the same level so that in the event of loss of the automatic voltage regulator, voltage transients will be minimized upon switching to manual.

f. Separation of Control Power Sources

The control systems for the Train A Engineered Safety Features are separate and independent from control systems for Train B Engineered Safety Features, as shown in Figure 8.3-3. Control power for the Train A control systems is provided by the Train A 125-volt DC Bus 11A and 120-volt AC vital instrument panel 1A. For Train B, control power is supplied from the 125-volt DC Bus 11B and 120-volt AC vital instrument panel 1B. A detailed description of instrumentation and controls for Engineered Safety Features Systems is included in the description of the respective system.

g. Circuit Protection System

All protective devices and relays are selected on the basis of compatibility with the type of equipment to be protected (motor, transformer, bus) and the equipment characteristics (motor locked rotor current, starting time, etc.). These protective devices are coordinated with the protective devices in adjacent zones to provide selective tripping of breakers.

Relaying schemes for each zone of protection are designed to provide overlap between the zones. This assures that no electrical feeder or equipment is outside a protective relay zone.

Protective relays are specified in accordance with ANSI C37.90 - 1971, "IEEE Standard for Relays and Relay Systems Associated with Electrical Power Apparatus." The following standards are used in developing relaying schemes:

1. ANSI - C37.91 - Guide for Protective Relay Applications to Power Transformers (IEEE 273)

2. IEEE 288 - Guide for Induction Motor Protection

   The Following paragraphs contain general design criteria for the sizing of circuit protective devices. Any exceptions to the specified criteria are evaluated within the applicable design calculations.

   Safety-related 4000-volt motor long-time overcurrent protection is set at a minimum of 125 percent of the full load current to the extent practical. Motor instantaneous overcurrent protection is set at a minimum of 1.75 times the locked rotor current. When locked rotor current is not available, instantaneous protection is set at a minimum of 12 times full load current.

   The design criteria for the selection of thermal overloads is that all motors will be equipped with thermal overload protection, which will be selected so as to protect the motor against failure in the event of an overload condition. Ambient compensated thermal overload relays are used to protect both continuous and short-time rated motors that are connected to motor control centers. These ambient compensated thermal overload relays are responsive to current and their time-current characteristics are, for practical purposes, unaffected by temperature variations.

   The unit substation breakers which feed motor control centers have overloads set at the bus rating of the MCCs (600 amps) except for MCC E511 that has its overload set at 480A and MCCs E522 and E622 that have their overloads set at 240A for coordination purposes. For safety-related motors fed from unit substations, the feeder breaker overload setting is a minimum of 125 percent of the full load current times the equipment service factor. For non-safety related motors fed from unit substation motors, the overload setting is a minimum of 125 percent of full load current.

   The trip point setting criteria for engineered safety features motors connected to motor control centers is as follows:

   1. For motors rated for continuous duty, the trip setpoint of the thermal overload relay is selected so that it is unresponsive to currents below 125 percent of the nameplate full load current times the service factor.

2. For short-time rated motors such as motor-operated valves (MOVs), the trip setpoint is determined by establishing the values for motor nameplate full load and locked rotor current, thermal time limit for carrying locked rotor current, and the actual stroking time of the MOV. The motor trip set point is then determined so that:

   (a) When carrying a current equal to nameplate full-load current times the service factor, the motor will not trip in a time period less than three times the MOV stroking time.

   (b) When carrying locked rotor current, the thermal overload relay should actuate in a time within the motor's limiting time for carrying locked rotor current.

If it is not possible to achieve both (a) and (b) due to relay characteristics, then condition (b) will be relaxed. Condition (a) will not be compromised in any circumstances.

During preoperational testing, the tripping times and currents were measured to verify the accuracy and repeatability of a representative sample of thermal overload relays as follows:

1. The motor was operated to verify that the actual current does not exceed the nameplate full-load current which was used in determining the trip setpoint. Should the actual current exceed the nameplate current, the higher current was evaluated and, if acceptable, the trip setpoint was recalculated based on the actual current measured during dynamic testing.

2. Preselected values of currents were applied to the thermal overload relay. If the relay operating time was in accordance with the criteria established and the relay curve, the relay was considered satisfactory.

Since the plant began operation and at intervals specified in the Technical Specifications, a representative sample of at least 25 percent of the thermal overload relays used on the motor-operated valves listed in the Technical Requirements Manual (TR-14) will be selected for testing and calibration in accordance with the requirements of technical specification subsection 3/4.8.4.3. The selected relays will undergo a testing program at the maintenance shop or other designated location prior to the 18-month test interval. A preselected value of current will be applied and it will be observed that the relay operates (it opens the circuit) in accordance with the criteria established and the relay curve. These pretested relays will then be installed in the selected circuits (see Technical Specification Subsection 3/4.8.4.3) whose thermal overload relays have been removed. The functional operation of the circuit will then be tested (i.e., valve closed or open) with the new relay in place. These test procedures comply with Position C2 of Regulatory Guide 1.106 (Rev. 1).

Because of the nature of application of the continuous duty motors such as pumps, fans, etc., misoperation or misapplication of thermal overload relays will be detected in time by either alarm or other process signals and corrective action will be taken. Therefore, there will be no specific surveillance procedures for periodically testing the thermal overload relays used with the continuous duty motors located outside the containment. These relays will be inspected as part of the plant's regular maintenance program under ANSI N18.7-1976. In addition, redundant motors that are in a standby status will be periodically rotated so that any abnormal condition will be detected.

The thermal overload protection for continuous duty motors located inside containment is part of the design provided to satisfy the requirements of Regulatory Guide 1.63 for containment electrical penetrations. These thermal relays will be periodically tested as defined by Technical Specification 4.8.4.2.

h. Equipment Grounding

Copper, copperweld cable and copper bus provide low resistance ground paths wherever electrical equipment is located. All electric equipment and nonelectrical conductive material such as structures, enclosures, tanks, and raceways are grounded in conformance with IEEE Standard 142-1972 and IEEE Standard 80-1971. The building grounding system is provided with adequately sized ground cables for peripheral connections to the station ground grid.

The method of system grounding utilized at the various voltage levels is discussed in the applicable sections.

i. Safety-Related System Motor Selection

All motors are sized for continuous operation of the running load and operate successfully at 90 percent of rated motor voltage. Motors are capable of starting their rated loads with 80 percent voltage and 95 percent frequency at the motor terminals. The system design and diesel generator specification assures that this voltage will be present at the motor terminals when needed. The calculated continuous brake horsepower is not greater than 95 percent of the horsepower rating of the motor. The starting torque for the motor is based on the inertia and speed-torque characteristics of the driven equipment. Exceptions to the above criteria are evaluated on a case-by-case basis to show that there are adequate voltage and horsepower to start and operate the load.

The motor-torque curve, at its closest approach to the load-torque curve, and at the required starting voltage, is greater than the torque required by the load at that speed. This permits the motor to develop a margin of torque over that required by the load to ensure successful starting and acceleration. The insulation system for motors is NEMA Class B, as a minimum, with the actual insulation class selected on the basis of environment and service conditions in which the motor is required to operate. The factors taken into consideration in selection of the insulation system are resistance to radiation, resistance to moisture, resistance to chemicals, ambient temperature and pressure. The motor enclosure is selected to protect against adverse environmental conditions. Winding temperature detectors and bearing thermocouples are provided on large motors to alarm high temperature conditions.

The motor suppliers are required to verify that actual test data confirm that the torque margin is equal to or greater than that of the calculated data. If this requirement is not met, as an alternate, the vendor is required to furnish an analysis showing that margin between motor torque and load torque is adequate to accelerate the load within an acceptable time period. A further check of motor capability was the preoperational testing conducted at the site under plant light-load conditions to simulate the maximum voltage practically obtainable, and under plant heavy-load conditions to simulate the minimum voltage practically obtainable (reference Subsection 14.2.7, exceptions to Regulatory Guide 1.68).

j. Provisions for Periodic Testing and Maintenance

The onsite AC distribution system for engineered safety features loads is designed and installed to permit periodic inspection and testing in accordance with General Design Criterion 18, IEEE Standard 308, Regulatory Guide 1.118, and IEEE 338 (except as noted in Subsections 8.1.5.2 and 8.1.5.3) to ensure:

1. The operability and functional performance of the components of the system, and
2. The operability of the system as a whole under design conditions.

Switchgear and accessories for the Auxiliary Power System are easily accessible for inspection and testing.

The 13.8-kV, 4160-volt and 480-volt switchgear circuit breakers may be tested when the individual equipment is de-energized. The breakers can be placed in the test position and tested functionally.

The first and second level undervoltage schemes (see Subsection 8.3.1.1b.4) are designed to permit periodic testing during normal plant operation.

Breakers for engineered safety features auxiliaries are exercised on a schedule similar to that for the auxiliaries controlled by the breakers. Transfer schemes can be exercised during normal operation, or by simulation of the necessary conditions. Timing checks can be performed on transfer schemes. Protective relays are provided with test plugs or test switches to permit testing and calibrating the devices.

Containment penetration conductors overcurrent-protective devices are periodically tested according to the requirements of the Technical Requirements.

The control circuits of the emergency diesel generators are designed to permit testing during operation of the plant as well as while the plant is shut down. Periodic tests are performed to demonstrate the availability and capability of the unit to perform its intended function. These tests are performed in accordance with Regulatory Guide 1.108, with clarification as explained in Subsection 8.1.5.3.

This periodic testing also provides input to the Maintenance Rule EDG performance criteria which support the target reliability levels required for the Station Blackout analysis (see Section 8.4.2).

Station procedures require fully loaded operation during routine diesel surveillance testing. This guards against the accumulation of incomplete combustion product buildup in the engine and exhaust systems.

During extended no-load or light-load operation (less than 20% load), the diesel will be loaded to a minimum of 50% load for one hour following each six hours of continuous no-load or light-load operation.

During troubleshooting, no-load operation will be minimized. If the troubleshooting operation takes place over an extended period of time (i.e., greater than four hours), the engine will be loaded to a minimum of 25% load for at least 30 minutes.

The Emergency Power Sequencer (EPS) is designed to permit periodic testing of the sequencer logic during operation of the plant. During the EPS test, combinations of EPS inputs are simulated and the corresponding EPS outputs are verified. During this testing, the continuity of the actual EPS output relay coils is verified and the accuracy of the interval between each sequence step is determined. If a bona fide EPS input is received during EPS testing, testing ceases and the EPS automatically performs its design function.

Every 18 months the actual input and output relays of the EPS are tested as part of the diesel generator load testing program.

k. Lightning Protection

Adequate lightning protection for all structures is provided by a system of air terminals, coursing and down conductors which are connected to the Plant Grounding System.

Lightning protection for the onsite AC distribution system is provided by a combination of metal-enclosed bus design and careful placement of lightning arrestors in the critical areas.

From the point where the 345-kV transmission lines drop down to make the transition to gas-insulated metal-enclosed bus, all outdoor power buses at 345 kV, 25 kV, 13.8 kV and 4.16 kV are of metal enclosed design. These metal enclosures are solidly connected to the plant ground system.

Lightning protection for the 345 kV overhead transmission lines is provided by static wires on top of the transmission line poles. Lightning protection for equipment in the air termination yard, including the air bushings for the gas-insulated metal-enclosed bus, is provided by poles with air terminals mounted in the yard.

In addition, lightning arrestors are provided in the following locations:

1. 25-kV isolated phase bus duct
2. At the transition structures where the overhead 345-kV lines end and the gas insulated bus begins, and at the end of the gas-insulated bus before its connection point to the switching station (line side of the motor-operated disconnect switch)
3. On the primaries of all 480-volt unit substation transformers

These lightning arrestors, together with the protection of medium and high voltage conductors afforded by the grounded metal enclosures, minimize the likelihood of a lightning strike which could jeopardize the onsite power system.

8.3.1.2 Safety Analysis of the Onsite AC Power System

a. Compliance with Applicable General Design Criteria

1. Criterion 17 - Electric Power Systems

The onsite AC power system is designed to permit the functioning of structures, systems, and components important to safety under all normal and accident conditions. The system provides sufficient capacity and capability to assure that specified fuel design limits and design conditions of the reactor pressure boundary are not exceeded as a result of anticipated operational occurrences, and that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

The onsite AC system has sufficient independence, redundancy, and testability to perform its safety functions assuming a single failure. Independence is provided by physical separation of components and cables to minimize vulnerability of redundant engineered safety features systems to single credible accidents. Systems and components which comprise the onsite AC distribution system have been designed to afford maximum in-service testability. Where in-service testability cannot be provided due to adverse impact on plant operation, systems and components are tested during plant shutdown.

The onsite AC source of electrical power consists of two diesel generators, one connected to each of the redundant emergency buses. One diesel generator is capable of supplying sufficient power for the operation of the minimum safety features required during a postulated loss-of-coolant accident and/or loss of offsite power.

During a postulated loss-of-coolant accident, each diesel generator starts automatically on a safety injection signal and, if offsite power is not available, it is connected to its associated emergency bus. The safety feature equipment is then sequentially started.

The Supplemental Emergency Power Supply is a defense-in-depth power source that is beyond the requirements of GDC-17.

There are no ties between redundant engineered safety features load groups. See Section 8.3.1.1.b.6 for a discussion of the SEPS system connections to the emergency buses.

A failure mode and effect analysis of the onsite AC power system is presented in Table 8.3-3.

2. Criterion 18 - Inspection and Testing of Electrical Power Systems

Class 1E electric equipment is designed and located to permit appropriate periodic inspection and testing to assure availability of systems and condition of components, in line with the provisions for testing and maintenance listed in Subsection 8.3.1.1j.

These tests will assure the operability and functional performance of the components, and the operation of the system as a whole.

During plant shutdown, and under conditions as close to normal operation as practical, the full operational sequence that brings the system into operation including portions of the protection system and transfer of power among various offsite and onsite power supplies will be tested.

During reactor operation, the capability to transfer power from the unit auxiliary transformer source to the reserve auxiliary transformer source is continuously monitored. Alarms are provided in the main control room to alert the operator if synchronism is lost between the switchgear and the reserve source or if control power is lost to the reserve source circuit breaker.

Transfer of power from the unit auxiliary transformer source to the reserve auxiliary transformer source is not periodically tested at power because such transfers may introduce unwarranted challenges to the electric power system that may result in a plant trip.

For a discussion of transfer of power initiated by operation of the generator breaker, see Subsection 8.2.1.3.e.1.

3. Criterion 5 - Sharing of Systems or Components Between Units

Seabrook Station is a single unit plant; therefore, electrical structures, systems and components important to safety in the onsite power system are not shared.

4. Criteria 33, 34, 35, 38, 40, 41, 44

   Onsite electric power interconnection and transfers are designed so that the safety functions of the Reactor Coolant Makeup System, the Residual Heat Removal System, the Emergency Core Cooling System, the Containment Heat Removal System, the Containment Atmosphere Cleanup System and the Cooling Water System can be accomplished, assuming a single failure. Two independent power trains at each distribution voltage level supply redundant load groups with power during normal, abnormal and post-accident conditions. These load groups comprise engineered safety features and protection systems in such a way that loss of one group does not prevent the minimum safety function from being performed.

5. Criterion 2 - Design Basis for Protection Against Natural Phenomena

   (a) The components of the onsite AC power system are located in seismic Category I structures which provide protection from the effects of tornadoes and external floods, and other natural phenomena.

   (b) These components are Class 1E.

   (c) These components have been designed to be fully qualified for the seismic and natural environmental conditions appropriate to their location (see Section 3.11).

6. Criterion 4 - Environmental and Missile Design Bases

   (a) The components of the onsite AC power system are located in seismic Category I structures which provide protection from the effects of tornado missiles, turbine missiles and other events and conditions which may occur outside the nuclear power unit.

   (b) These components are Class 1E.

   (c) These components are designed to accommodate the effects of, and to be compatible with or are protected against, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents including loss-of-coolant accidents. Criteria are presented in Chapter 3. Environmental conditions are presented in Chapters 3 and 6.

   (d) These components are protected, as appropriate, against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures (postulated accidents).

b. Compliance with Applicable Regulatory Guides

1. Regulatory Guide 1.6 - Independence Between Redundant Standby Power Sources

Two diesel generators constitute the AC standby power sources. Each diesel generator serves as the standby power supply for a redundant load group. In addition, each redundant load group is connected to the preferred (offsite) power supply through different UATs or RATs. The design is based on the concept of independent, redundant groups of engineered safety feature loads and, as such, one redundant load group or power source is never automatically connected to the other redundant load group or power source. (See Figure 8.3-1 and Figure 8.3-3.)

The Supplemental Emergency Power System (SEPS) uses a transfer switch that has the capability of connecting the non-safety related SEPS DGs to a safety related circuit breaker on either redundant load group. The switch consists of three cubicles, an incoming termination section and two switching sections. The termination cubicle is the center section which contains the connections for the incoming cables and bus bar which connects to the line side of the two disconnect switches located in the outer cubicles. A mechanical interlock is used that allows operation of only one switch closure at a time. Unless in service to supply an emergency bus, the redundant load group circuit breakers which connect to the SEPS system are open. The Train B breaker is normally racked in and the Train A breaker is normally racked out. A Kirk key interlock is provided to prevent both breakers from being racked in at the same time. The racked out breaker and Kirk key interlock provides the Regulatory Guide 1.6 required interlock to prevent connecting redundant load groups together.

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

Each diesel generator set has been selected on the basis that the total running load at any time will not exceed the short time rating of the diesel generator.

During preoperational testing, the maximum continuous load demand has been verified by tests.

Each diesel generator is capable of starting and accelerating all Class 1E loads to rated speed, in the required sequence.

The excitation and governor controls furnished for the diesel generators are designed so that, during and after sequential loading of Class 1E loads, the voltage and frequency decrease to no less than 80 percent and 95 percent of nominal values, respectively.

The voltage may dip to less than 80 percent of nominal value when the diesel generator breaker closes and energizes the 1000/1333 kVA, 4160/480V unit substation transformers. The diesel generators are designed to recover from this dip (due to transformer magnetizing inrush current) to at least 80 percent of nominal value in about 6 cycles, causing a negligible delay to the acceleration of the first load group.

Voltage and frequency are restored to within 10 percent and 2 percent of nominal values in less than 60 percent of each load sequence time interval.

During recovery from transients caused by step-load increases, or resulting from the disconnection of the largest single load, the increase in speed of the diesel generator set will not exceed 75 percent of the difference between nominal speed and the overspeed trip set point, which is set at 110.7 percent of nominal speed.

Diesel generator protective trips, other than engine overspeed, generator differential current, 4.16-kV bus fault and low lube oil pressure, are bypassed during accident conditions. For more information on design and testing of the bypass circuitry, refer to Subsection 8.3.1.1e. Generator overcurrent and reverse power have a common alarm in the main control room. Loss of field, high lube oil temperature, and high jacket coolant temperature each have a separate alarm in the control room. The station computer provides information as to which protective trip is activated first.

Periodic testing of the diesel generator is in accordance with Regulatory Guide 1.108, with clarification as explained in Subsection 8.1.5.3.

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

Two immediate access circuits are available from the transmission network to the Class 1E Emergency Distribution System.

4. Regulatory Guide 1.63 - Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Plants

The electric penetration assemblies are designed to withstand, without loss of mechanical integrity, the maximum fault current vs. time conditions that could occur as a result of single random failures of circuit overload devices. The 600-volt system X/R ratio used in specifying the electrical penetrations is 4. Calculations show that this value is conservatively applied because the actual ratio is considerably less than 4.

To preclude damage to electric penetrations due to single failures of circuit overload protection devices, each penetration circuit, with the exception of CRDM, 15-kV RCP, instrumentation and low energy circuits, is provided with dual Class 1E overload protective devices. Seismically qualified Class 1E fuses protect 15-kV RCP penetrations. Additional protection is provided by two non-Class 1E breakers in series. These breakers are coordinated and derive their control power from different batteries. For more details refer to Subsections 8.3.1.1a and 8.3.1.1c.

5. Regulatory Guide 1.75 - Physical Independence of Electric Systems

The design is consistent with the criteria for physical independence of electric systems established in Attachment C of AEC (NRC) letter dated December 14, 1973. Attachment C which is incorporated as Appendix 8A, is in general conformance with Regulatory Guide 1.75.

For clarification of position C4 as it relates to associated circuits, refer to UFSAR Subsection 8.1.5.3b.

The Seabrook cable and raceway separation criteria (see UFSAR Subsection 8.3.1.4) is a combination of the standard criteria given in Attachment C of AEC Letter dated December 14, 1973 (see UFSAR Appendix 8A) and IEEE 384-1974 and criteria established by analysis and testing as permitted by Attachment C and IEEE 384-1974.

Physical separation and identification of circuits are described in detail in Subsections 8.3.1.3 and 8.3.1.4, respectively.

c. Compliance to Branch Technical Position PSB-1 - Adequacy of Station Electric Distribution System Voltages

1. Position B1

An acceptable alternative to the second level undervoltage protection system described in Position 1 is provided. This alternative system is described in Subsection 8.3.1.1b.4(b).

2. Position B2

The Seabrook Station design meets Position 2 of Branch Technical Position PSB-1 except as noted below. The bypass of the load shedding feature during sequencing, and its restoration in the event of a subsequent diesel generator breaker trip, is discussed in UFSAR Subsection 8.3.1.1e.6. In addition, the load shed feature is reinstated after load sequencer action when the operator resets the sequencer override pushbutton. This action permits the operator to reassume control of diesel generator loading.

Position 2 specifies that the Technical Specifications must include a test requirement to demonstrate the operability of the automatic bypass and reinstatement features at least once per 18 months during shutdown. During development of Seabrook Station's Technical Specifications, the NRC deleted this test requirement.

3. Position B3

The voltage regulation study was performed to meet the requirements of Position 3. The voltage levels at the safety-and nonsafety-related buses are optimized for full load and minimum load conditions that are expected throughout the anticipated range of voltage variations of the offsite power source by appropriate adjustment of the voltage tap settings of the station transformers.

4. Position B4

The analytical techniques and assumptions used in the voltage analysis cited in item 3 (Position B3) above have been verified by actual measurement as part of the pre-operational test program. The guidelines of Position 4 of Branch Technical Position PSB-1 have been followed and good correlation between the analytical results and the test results have been demonstrated.

Seabrook Station's commitment to perform this testing is also described in Subsection 14.2.7, which describes Seabrook Station's interpretation of Regulatory Guide 1.68, Appendix A, Section 1.g.

d. Environmental Effects on Electric Equipment

All equipment that must operate in a hostile environment during and/or subsequent to a design-basis event are identified with their ambient environmental conditions, and their qualifications are discussed in Section 3.11.

e. Effects of Submergence on Electrical Equipment

Analysis has been performed to determine the effects of submergence as a result of a LOCA on electrical equipment. The results of this study indicate no detrimental effect upon the Class 1E electrical power sources as a result of submergence of electrical equipment following a LOCA.

8.3.1.3 Physical Identification of Safety-Related Equipment

All cables, raceways and safety-related equipment are assigned to a particular channel or train. There are two redundant trains of power and controls, and four redundant channels of instrumentation. Each channel or train is assigned a particular color, as shown below:

Separation Group		Equipment Nameplate	Raceway Tag	Cable Color
A.	Channel I and Train A	Red	Red	Red
	Train A Associated	Black		Black w/Red Tracer
B.	Channel II and Train B	White	White	White
	Train B Associated	Black		Black w/White Tracer
C.	Channel III	Blue	Blue	Blue
D.	Channel IV	Yellow	Yellow	Yellow

The equipment nameplate colors described above represent the color assigned to identify each separation group. In the original nameplate design, the nameplate background color was used to identify the separation group. As a result of labeling improvements, including the addition of bar codes, a redesign of the background color was required. Newer nameplates may use different methods, such as black letters on a white background with a border color that identifies the separation group. In this way, the same basic separation group color is maintained for different nameplate styles.

Each piece of electrical equipment is marked with the node number indicated on the design drawings, in the particular color corresponding to the channel or train to which that equipment is assigned. Similarly, trays and exposed conduits are marked with color-coded markers. The cable jacket color code serves as its identification. The operator or maintenance craftsman needs only to observe the color of the nameplate of any piece of equipment or the cable jacket color to determine which channel or train it serves. For exceptions to the above cable and raceway identification criteria, see Subsection 8.3.1.4k. For additional information on physical identification of safety-related equipment, see Subsection 7.1.2.3.

8.3.1.4 Independence of Redundant Systems

a. General

Seabrook Station complies with the requirements of UFSAR Appendix 8A, IEEE 384-1974 and Regulatory Guide 1.75, Rev. 2. These documents describe acceptable methods of complying with IEEE 279-1971 and Criteria 3, 17 and 21 of Appendix A to 10 CFR Part 50 with respect to the physical independence of the circuits and electrical equipment comprising or associated with the Class 1E power system, the protection system, systems actuated or controlled by the protection system, and auxiliary or supporting systems that must be operable for the protection system and the systems it actuates to perform their safety-related functions. Preservation of independence of redundant systems within the control boards and all other field-mounted racks is discussed in Subsection 7.1.2.2.

In accordance with the provisions of Section 4.5a and Subsection 4.6.2 of UFSAR Appendix 8A, Section 4.5(1) and Subsection 4.6.1 of IEEE 384-1974, and Position C4 of Regulatory Guide 1.75, Revision 2, we have elected to associate all of the non-Class 1E circuits with Class 1E circuits. This application of associated circuits allows the plant to be designed with one less separation group; that is, instead of having five separation groups consisting of four safety-related separation groups and one nonsafety-related separation group, Seabrook Station has only four separation groups. The major advantages of this approach are the ability to provide greater separation distances between the groups, as well as to reduce the raceway system's exposure to fire.

As a result of this design, all plant circuits are specifically assigned to one of the following four separation groups as noted in Figure 8.3-55:

Group A - Train A, Channel I and Train A Associated Circuits

Group B - Train B, Channel II and Train B Associated Circuits

Group C - Channel III

Group D - Channel IV

The great majority of associated circuits are with Group A, a very limited number are with Group B, and none are with Groups C and D.

The circuits that are associated with Train A consist of:

1. Non-Class 1E power, control, instrument circuits contained within the Nuclear Island

2. Non-Class 1E power, control, and instrumentation circuits that traverse the Nuclear Island boundary

3. Non-Class 1E power, control, and instrument circuits outside the Nuclear Island.

The circuits that are associated with Train B consist of:

1. Non-Class 1E power, control, and instrument circuits contained within the Nuclear Island
2. Non-Class 1E power, control, and instrumentation circuits that traverse the Nuclear Island boundary.
3. Non-Class 1E power, control and instrumentation circuits outside the Nuclear Island.

   The Nuclear Island boundary is shown in Figure 8.3-56. This figure denotes the buildings, structures, duct banks, etc., which are part of the Nuclear Island. All other buildings, structures, etc., are considered to be outside the Nuclear Island.

The four separation groups are routed through four separate raceway systems per the separation criteria given in Table 8.3-10. These separation criteria are based on a combination of the following:

1. Standard separation criteria given in Subsections 5.1.3, 5.1.4, and Section 5.6 of UFSAR Appendix 8A and IEEE 384-1974
2. Separation criteria established by analysis and testing as permitted by Subsection 5.1.1.2 and Section 5.6 of UFSAR Appendix 8A and IEEE 384-1974. This analysis and testing are documented in References 1 through 5 (see UFSAR Subsection 8.3.4).

   Cable, raceway and internal wiring installations which do not meet the separation criteria given in Table 8.3-10 are analyzed based on the analyses and testing documented in References 1 through 6 to show that the lesser separation distances do not compromise the ability to achieve a safe plant shutdown under design basis event (DBE) conditions. These analyses are documented in the appropriate design basis documents.

   Separation criteria for temporary cables have also been developed based on the analysis and testing documented in References 1 through 5. These temporary cable separation criteria are contained in the appropriate design and operating documents.

The following analysis examines the design features and modes of failure of associated circuits of each separation group to determine any interaction and challenges with other separation groups. The overall objective is to assure that the ability to achieve a safe plant shutdown under design basis event (DBE) conditions is not compromised.

There are two (2) classifications of associated circuits, those that directly interface with a Class 1E circuit and those that do not directly interface with a Class 1E circuit. An associated circuit has a direct interface with a Class 1E circuit if it shares power supplies, enclosures or raceways, or if it does not meet the minimum separation criteria. Only associated circuits that directly interface with Class 1E circuits have the potential to degrade a Class 1E circuit. This type of associated circuit is provided with at least one protective device to prevent degradation of the Class 1E circuit unless it can be shown by analysis that failure of the associated circuit will not degrade the Class 1E circuit. These protective devices are required to perform their current interrupting function to prevent failure of the associated circuit, which has a direct interface with a Class 1E circuit, from degrading that Class 1E circuit. The special design, procurement and testing requirements imposed on these protective devices are described below.

Devices such as control power transformers and instrument power supplies which limit the current available to a circuit to less than a cable's ampacity are considered low energy sources. Because of this current limitation, protective devices are not required for circuits supplied by low energy sources since there is no potential to degrade Class 1E circuits.

Cables for both Class 1E circuits and associated circuits are procured to the same requirements including applicable environmental qualification. Exceptions to the cable procurement practices are described in Subsection 8.3.1.4f.

When Class 1E power supplies are used for an associated circuit, failure of a non-Class 1E motor, load, or device connected to this power supply will be promptly isolated by operation of Class 1E protective devices. The Class 1E protective devices protecting these non-Class 1E loads are coordinated so that failure of all nonqualified, non-Class 1E loads, with proper operation of their own breakers, will not result in tripping of the incoming breaker to the Class 1E bus.

When non-Class 1E power supplies are used for an associated circuit that directly interfaces with a Class 1E circuit, non-Class 1E protective devices perform a current interrupting function. These non-Class 1E protective devices are of a similar design as their Class 1E counterparts. While these protective devices are not procured as environmentally or seismically qualified, sufficient controls are imposed in the procurement process to ensure that these protective devices will be capable of performing their current interrupting function. These non-Class 1E protective devices will be tested to ensure operability of their current interrupting function when such testing is nondestructive in nature. Periodic testing of the current interrupting function for non-Class 1E protective devices with associated circuit requirements will be performed on a ten-year frequency in accordance with Station procedures. Protective devices, such as fuses, which cannot be nondestructively tested will have their current interrupting function verified on a sampling basis during the procurement process prior to installation in the plant.

Since Class 1E and non-Class 1E protective devices are similar, any generic degradation such as setpoint drift, manufacturing deficiencies, and material defects will be detected and corrected as a result of the Station's procurement, maintenance and trending programs for the Class 1E protective devices and the non-Class 1E protective devices with associated circuit requirements.

Based on the above analysis, the protective devices for directly interfacing associated circuits can be assumed to function properly under design basis conditions. The following provides additional specific analysis for associated circuits contained within the Nuclear Island, traversing the Nuclear Island and those completely outside the Nuclear Island.

The SEPS equipment is associated with Train B because SEPS is normally aligned to Train B and plant design criteria requires that all equipment non-safety related be associated to either train. However, SEPS output can be connected to either Train A or Train B depending on the distribution alignment. When SEPS output is aligned to either Train A or B, the SEPS design is such that the output circuit is completely isolated from the other train and a single failure will not adversely impact the opposite train. A single train alignment is accomplished through strict administrative controls and use of key interlocks during SEPS output feeder alignment. Based on the system design, the SEPS output feeders can be aligned to Train A even though the SEPS is associated with Train B. Also, since the event for which SEPS is used to provide power to an emergency bus is considered a beyond design event, the loads supplied by the emergency bus would not be performing a safety related function and the emergency bus would not be considered operable when powered from SEPS.

b. Train A Associated Circuit Analysis

1. Associated Circuits Contained within the Nuclear Island that Have Direct Interface with Class 1E Circuits

Non-Class 1E circuits that remain within the Nuclear Island are permitted to share the same raceway as Train A Class 1E circuits. These circuits are classified as Train A Associated Circuits and are designed and installed to meet all the requirements placed on associated circuits as required by the compliance documents listed earlier.

Challenges to Class 1E circuits, because of failure in an associated circuit, have been examined and determined to have no detrimental effect because of the following:

(a) Mounting of non-Class 1E power supplies (such as switchgear, motor control centers and distribution panels) within the Nuclear Island is similar to the mounting of their Class 1E counterparts; therefore, credit can be taken for this equipment to perform its current interrupting function under DBE conditions. Mounting of fuses as part of vendor packages may not be similar to the mounting of similar Class 1E fuses. However, there is no credible failure mechanism which could prevent these fuses from performing their current interrupting function under DBE conditions.

(b) The probability of an ensuing fire is minimized because all cables used for associated circuits that have direct interface with Class 1E circuits are specified, designed, manufactured, and installed to the same criteria as Class 1E cables. Factors that have been taken into consideration include flame retardancy, nonpropagating and self-extinguishing properties, splicing restrictions, appropriate limitations on raceway fill, cable pulling and termination requirements, appropriate cable derating, and environmental qualifications. The above provisions and considerations used for the associated circuits during the construction phase of the plant are also used during the operations phase.

(c) Degradation of an associated circuit because of a raceway failure during a DBE, has been eliminated because all electrical raceway systems within the Nuclear Island are seismically analyzed.

(d) Other design considerations that contribute to the integrity of these associated circuits are as follows:

(1) Cables associated with one train are never routed in raceways containing Class 1E or associated cable of another train or channel.

(2) All cables for instrumentation circuits use shielded construction which minimizes any unacceptable interaction between Class 1E and associated circuits.

(3) All circuits entering the reactor containment are provided with protective devices complying with Regulatory Guide 1.63. For exceptions see Subsection 8.3.1.1c.7(a).

Based on the above design features and analysis, we do not consider these associated circuits to pose any challenges to any Class 1E circuits. Therefore, the ability for safe plant shutdown under DBE conditions has not been jeopardized.

2. <u>Train A Associated Circuits that Traverse the Nuclear Island Boundary and Have Direct Interface with Class 1E Circuits</u>

For analysis purposes, the associated circuits that traverse the Nuclear Island boundary can be further subdivided into two basic types: (a) those that have their protective device located in the Nuclear Island, and (b) those that have their protective device outside the Nuclear Island. It should be noted that there are a limited number of power cables in these categories.

(a) Associated Circuits that Have Protective Devices Located in the Nuclear Island and that Have Direct Interface with Class 1E Circuits

These circuits are also designed and installed to meet all the requirements as outlined above. Though the raceway system outside the Nuclear Island is not seismically analyzed, this is of no concern because the circuit protective devices inside the Nuclear Island are assumed to perform their protective function. Concerns that design-basis events such as a seismic event may cause high voltage cables that are not in seismically analyzed raceways and not located in Category I buildings to interact with lower voltage cables are analyzed below.

Seismic tests, performed on raceways representing typical installations on SEP plants, proved that the raceways can withstand seismic events with no significant failures. Since the typical nonseismic installation at Seabrook is superior to the tested SEP installations, it can be assumed that they will survive a seismic event. Failures of raceways resulting from collapse of the nonseismically designed buildings can be dismissed because the conservative criteria and UBC seismic loading used in the construction of the building will ensure little likelihood of collapse.

Not withstanding the preceding, any event involving the raceway system that can cause a higher voltage cable to come in contact with another lower voltage cable will first cause the higher voltage cable to be grounded. Contributing factors to this are: (1) the cables are in grounded metallic trays or enclosures, (2) the 13.8-kV and 4.16-kV power cables are of armored construction, and (3) as indicated in Figure 8.3-55, separate raceways are designated for the different voltage levels.

A ground fault in the low resistance grounded 13.8-kV system will cause protective circuit breakers to open and isolate the fault. In the high resistance grounded 4-kV and 480V system, although a single ground fault will not cause circuit breaker operation, it is highly probable that under such a failure, the faults will be such to cause breaker operation.

In view of the above design considerations and analysis, any possible interaction between cables of different voltage levels is deemed nonexistent.

It is, therefore, concluded that the ability for safe plant shutdown under DBE conditions will not be jeopardized by these associated circuits.

(b) Associated Circuits that Have Protective Devices Outside the Nuclear Island and that Have Direct Interface with Class 1E Circuits

Protective devices outside the Nuclear Island which are not located in a LOCA environment are similar in design to Class 1E devices except for seismic requirements. Other design basis events such as pipe break, fire, flood, etc., will not cause failure of the protective device located outside the Nuclear Island simultaneously with the failure of load which is located in the Nuclear Island. Hence, credit can be taken for their proper operation.

Although the protective devices might not be in Category I buildings, they are similar in design to the Class 1E devices and, based on operating experience of protective devices that have been subject to actual and simulated seismic conditions, it is highly probable that the protective devices will maintain their structural integrity and perform their function.

However, if one postulates their misoperation under a seismic event, such an event is likely to disable the power source itself which is also not seismically qualified.

Analysis of concerns on interaction between cables of different voltage levels is shown in 8.3.1.4b.2(a) above.

We conclude, therefore, that these circuits will not degrade Class 1E circuits, since the non-Class 1E power supply will be lost and all non-Class 1E equipment will become de-energized.

For the above reasons, the ability for the safe plant shutdown under DBE conditions will not be jeopardized by these circuits.

3. Train A Associated Circuits Completely Outside the Nuclear Island that Have Direct Interface with Class 1E Circuits

   There are no Train A associated circuits completely outside the Nuclear Island that have a direct interface with a Class 1E circuit. Therefore, there are no special requirements related to separation for the protective devices for these associated circuits. As described in UFSAR Section 7.2.1.1, there are some Class 1E circuits with a portion of their route in the Turbine Building, which is outside the Nuclear Island. The associated circuits completely within the Turbine Building are not directly interfacing circuits because they meet the minimum separation criteria to these Class 1E circuits. Inherent in application of the separation criteria is the use of flame retardant cable. Therefore, the cables for the associated circuits within the Turbine Building must be flame retardant unless it can be shown by analysis that the lack of such flame retardancy will not degrade Class 1E circuits.

c. Train B Associated Circuit Analysis

1. Associated Circuits Contained Within the Nuclear Island that Have Direct Interface with Class 1E Circuits

   Non-Class 1E circuits that remain within the Nuclear Island are permitted to share the same raceways as Train B Class 1E circuits. These circuits are classified as Train B associated circuits and are designed and installed to meet all the requirements placed on associated circuits as required by the compliance documents listed earlier in Subsection 8.3.1.4a. Therefore, using the analysis performed for Train A associated circuits, we conclude that the ability for the safe plant shutdown under DBE conditions will not be jeopardized by these circuits.

2. Associated Circuits that Traverse the Nuclear Island Boundary and Have Direct Interface with Class 1E Circuits

   For analysis purposes, the associated circuits that traverse the Nuclear Island boundary can be further subdivided into two basic types: (a) those that have the protective devices located in the Nuclear Island and (b) those that have their protective devices outside the Nuclear Island.

(a) Associated Circuits that have Protective Devices Located in the Nuclear Island and Have Direct Interface with Class 1E Circuits

There are very few Train B associated circuits that traverse the Nuclear Island boundary. These circuits are unavoidable either because of plant design constraints, such as the need for interlocks and permissives for the preferred power supply circuits to Train B emergency buses, or because of features provided to improve plant reliability, such as power supply and control for the station service air compressors fed from Train B buses. The portion of these circuits which are outside the Nuclear Island are routed in dedicated embedded or exposed conduits; therefore, the potential or harmful interactions with other associated circuits or other voltage level cables is minimized. For applicable details on the interaction between cables of different voltage levels, see analysis under Subsection 8.3.1.4b.2(a).

The design features described in Subsection 8.3.1.4c.1 for associated circuits contained within the Nuclear Island are also applicable to these circuits. Though the conduit system outside the Nuclear Island is not seismically analyzed, this is of no concern because the circuit protective devices located in the Nuclear Island are assumed to perform their protective function.

Based on the above, we conclude that the ability for the safe plant shutdown under DBE conditions will not be jeopardized by these few circuits.

(b) Associated Circuits that have Protective Devices Outside the Nuclear Island and Have Direct Interface with Class 1E Circuits

The only circuits under this category are the 15-kV cables to the reactor coolant pumps for motor feeders and potential transformers. These interlocked armor cables are routed in embedded conduit outside the Nuclear Island and are in dedicated seismically analyzed raceway systems in the Nuclear Island. Furthermore, the portion of the circuit entering the containment is protected by qualified fuses located in the electrical penetration area which would open the circuit in the event of a catastrophic failure of a reactor coolant pump.

The 15-kV cables used on these circuits meet all the construction and material requirements placed on the 5-kV Class 1E cables, i.e., flame retardancy, etc., but do not have documented LOCA/MSLB qualifications.

Based on the above design features and additional engineering analyses, we conclude that these circuits do not pose any challenges to Class 1E circuits and, therefore, the reactor coolant pump 13.8kV circuit breakers are excluded from having special associated circuits requirements.

3. Train B Associated Circuits Completely Outside the Nuclear Island that have Direct Interface with Class 1E Circuits

There are no Train B associated circuits completely outside the Nuclear Island that have a direct interface with a Class 1E circuit. Therefore, there are no special requirements related to separation for the protective devices for these associated circuits.

d. Groups C and D Circuits

Separation Groups C and D, which are comprised of circuits for Channels III and IV, do not have any associated circuits. Since these channels meet all requirements as defined in the compliance documents listed in Subsection 8.3.1.4a, these channels are not susceptible to any challenges from any associated circuits; therefore, the ability for the safe plant shutdown under a DBE cannot be jeopardized.

e. Cables

Medium voltage (5 kV and 15 kV) power cables are installed in raceways separate from those used for low voltage power and control cables, low level signal cables, and nuclear instrumentation cables. Medium voltage power cables for different voltage levels are installed in separate raceways. In vertically stacked trays, the highest voltage cables are in the highest position in the tray stack.

Low voltage (480 volts AC and some 120 volts AC, and 125 volts DC) power cables in vertically stacked trays are located below the medium voltage power cables, and are separated from control, low level signal and nuclear instrumentation cables.

Low voltage power cables associated with the control rod drive mechanism (CRDM) are routed in raceways separated from control and instrument raceways.

Control cables in vertically stacked trays are located below the low voltage power cables. Control cables are separated from low level signal and nuclear instrumentation cables, as well as from medium and low voltage power cables.

Low level signal cables are run in raceways separate from all other cables except in the 345 kV switchyard raceways where instrumentation cables can be run in the same raceway as control cables. In vertically stacked trays, the low level signal tray is generally at the lowest level in the stack.

In general, the above order of cable trays in a vertical stack is maintained with very few exceptions except where physical interferences within the plant necessitate alteration of the above order.

Nuclear instrumentation cables are routed in steel conduits for their entire distance.

The two redundant trains (Train A and B) and the four redundant channels (Channels I, II, III and IV) are routed through four physically separated raceway systems, called separation groups, as shown in Table 8.3-4. Physical separation of the four groups is maintained by means of one or more of the following:

1. Separate exposed rigid metal conduits, flex conduits, and wireways
2. Separate concrete-encased plastic or metal ducts in the same duct bank
3. Cable trays separated by a wall, a floor, or an equivalent barrier with a three-hour fire rating
4. Separate cable trays in the same room where a minimum of three feet horizontal or five feet vertical separation exists between trays or redundant systems
5. Separate cable trays in the cable spreading room (as defined in Appendix 8A, Subsection 5.1.3) where a minimum of two inches horizontal or six inches vertical separation exists between trays of redundant systems.

Exceptions to the above separation distances are discussed in Section 8.3.1.4.a.

Subsection 5.1.1.3(c) of Appendix 8A specifies that cables shall not fill a cable tray above the side rails. Note 1 under Subsections 5.1.3 and 5.1.4 indicates that tray separation should be measured from the top of the tray side rail, i.e., the side rail is zero reference point for measuring separation. Various conditions in the raceway system, for example, fire stops and cable crossing at tray fittings, result in cables being above the tray side rail. For these cases, the zero reference point for separation will be the top of the cables, not the tray side rails. Since separation will be maintained, this exception to Appendix 8A is considered acceptable.

f. Selection of Cable Insulation

Insulation systems for cables comprise materials or combinations of materials for primary insulation, jackets, shielding, tapes, fillers and armoring. The factors considered in selecting a cable insulation system include stability and length of life, dielectric properties, resistance to ionization and corona, resistance to high temperatures, resistance to moisture, resistance to chemicals, resistance to radiation, mechanical strength, flexibility, self-extinguishing and nonpropagating fire characteristics, and general environmental considerations.

Cables for both Class 1E circuits and associated circuits are purchased to exactly the same requirements, including applicable environmental qualification, except as follows: the 15-kV and 5-kV SEPS power cables meet all the construction and material requirements placed on the 5-kV Class 1E cables, i.e., flame retardancy, etc., but do not have documented LOCA/MSLB qualifications. The 15-kV and 5-kV SEPS power cables are routed in dedicated raceways. 300V instrument cables constructed with Tefzel insulation and jackets have been evaluated to meet all requirements except, due to a low insulation resistance when exposed to peak temperature conditions, they may pose an adverse effect on instrument uncertainty. Consequently, this instrument cable construction is restricted to non-harsh environments. Other exceptions such as certain cables in the Administration Building have been analyzed to show that they cannot challenge Class 1E circuits. In addition, other cables, for example General Electric cables for the turbine EHC System and certain Westinghouse supplied cables which may not have exactly the same qualifications as the Class 1E cables, are routed in dedicated raceways.

The basis for selecting insulation is to obtain insulation systems that are appropriate for each application and are compatible with their individual operating environments.

Cables installed inside the reactor containment which are required to be functional prior to, during, and/or after an accident are suitably selected and qualified to operate in the expected environment.

Cables are typically constructed with the following insulation and jackets:

1. Power cables: Ethylene propylene rubber (EPR) insulation and chlorosulforated polyethylene (CSPE) (Hypalon) on conductors with an overall Hypalon jacket.

2. Control cable: Ethylene propylene rubber insulation with an overall chlorinated polyethylene jacket.

3. Instrumentation cables: Cross-linked polyethylene (XLP) insulation with an overall Hypalon jacket. Tefzel insulation and jacket has been evaluated and approved for applications restricted to non-harsh environments.

4. Control rod drive power cables: Ethylene propylene rubber insulation with Hypalon jacket overall up to the reactor head area where they change to Tefzel insulation with a stainless steel braid jacket overall.

5. Pressurizer heater power cables in the pressurizer area: Ozone and radiation-resistant silicone rubber insulation and a glass braid jacket.

6. Coaxial and triaxial transmission cables: Cross-linked polyethylene insulation and a flame retardant cross-linked polyolefin jacket.

g. Sizing of Conductors

All cables are sized to operate within their normal rating and temperature rise with respect to current carrying capacities and insulation properties.

Ampacity reduction factors using ICEA recommendations are utilized based on the cable arrangement and spacing in tray. Where a cable is routed through several types of raceways and in various arrangement of conductors, the cable size is based on the most restrictive situation. The effect of fire stops and fire barriers is also considered when determining the cable ampacity.

Considering the above and the effects of short circuit current heating, voltage regulation, and voltage drop, the power cables to motors are sized to carry continuously a minimum of 125 percent of the nameplate load current. Feeder cables to load groups are sized for a minimum of 125 percent of the calculated circuit load current.

The basis for correct sizing of cable conductors is to ensure that the connected equipment and the cable operate within their permissible ratings.

h. Cable Routing

A computer-generated conduit and cable schedule is the basic cable drawing. All cables are included in this schedule with various exceptions, e.g., vendor-supplied specialty cable for the Radiation Monitoring System and portions of various other systems (for example, telephone system, lighting [see Subsection 9.5.3], temporary cables and fire protection/detection). This program is designed to maintain records of the power, control and instrumentation circuits through both cables and raceways and to accumulate, sort, collate and print out the information. The computer performs the following functions, all in accord with the limits established in the input data:

1. Calculates the shortest route and length for each cable, given a network of raceways and the origin and destination of the cable
2. Maintains the predetermined maximum fill percentage for each raceway type and size
3. Properly routes the circuits assigned to the four separation groups (see Table 8.3-4), to maintain the required physical independence
4. Properly routes various circuit types (heavy power, medium/light power, control, instrumentation, and signal levels) to the designated raceways
5. Reduces the need for installers to refer to drawings in order to pull cables.
6. Gives the plant maintenance personnel useful information for startup, operation and identification.

As part of the conduit and cable input, the network of raceways is developed connecting the various items of electrical equipment. The bulk of this raceway system is cable trays as listed above. This network is governed by the following:

1. Requirements for the power, control and instrumentation systems
2. Requirements for physical separation of redundant circuits
3. Physical loading requirements
4. Avoidance of hazardous areas where possible
5. Protection from missiles, fire and irradiation
6. Simplicity of layout for ease in installation and access.

Cable routing is governed by the same criteria listed above for raceways.

i. Raceways

Raceways consist of exposed rigid or flexible steel conduit, electrical metallic tubing, concrete encased plastic or metal duct, steel cable trays and wireways. Cable trays are ladder type, except for those containing low-level instrumentation, which are solid bottom trays with covers, except in limited areas of the plant where it has been determined that the noise interaction should not be a problem and that the elimination of the covers will not degrade the installation or violate any separation criteria if applicable. Solid bottom steel cable trays with solid covers are used for the Supplemental Emergency Power System (SEPS) power cables within the plant and control and power trays in the 345 kV switchyard. Raceways are laid out throughout the plant between electrical equipment to support and protect the cables that traverse these locations.

The factors that are considered when selecting a raceway for an application include mechanical strength to support and protect the cables, resistance to chemicals, resistance to moisture, resistance to high temperature, length of life, flexibility, internally generated heating, vulnerability to fire, and general environmental considerations.

The criteria for thermal and physical loading of raceways are based on IEEE/ICEA recommendations or test results for cables installed in different raceways. In cable trays, the percentage fill requirements are as follows:

1. For all 15-kV and 5-kV power cables and 480 volt heavy power cables (4/0 and larger in size) - one layer with a nominal one-quarter diameter air spacing [Note 2].
2. For 480-volt medium and small size power cables (2/0 AWG and smaller in size) - 40 percent [Note 1] of usable tray volume fill
3. For control and instrumentation cables and control rod drive power cables - 40 percent (see [Note 1]) of usable tray volume fill.

In the Nuclear Island, raceways that carry nuclear safety-related circuit cables are embedded in Category I walls, floors, and duct banks or supported by steel members which are qualified by means of seismic analysis.

Note 1 Forty percent fill is based on nominal cable diameters. Actual fill percentage might vary because of manufacturing tolerances in cable construction. Cable ampacity reduction factors remain unaffected by decreased or increased fill percentages. Percent fill greater than 40% is allowable in limited cases where engineering analysis verifies the criteria for thermal and physical loading are maintained.

Note 2 It is understood that there will be occasional crossing and touching (point contact) of cables installed in ladder type trays. This has no appreciable effect on cable ampacity and therefore is acceptable.

The bases for selecting, laying out, and loading raceways are to minimize the loss of function of cables in the raceway due to adverse conditions external or internal to the raceway.

j. Electrical Penetrations

The electrical penetration assemblies provide the means to allow passage of power, control and instrument circuits through the containment pressure barrier while maintaining the integrity of the pressure barrier. The criteria for physical separation of electrical penetrations is the same as for raceways as described above.

Penetrations for 600-volt service and below are modular type with a header plate welded to the outside of a 12-inch containment sleeve. Because of the concern regarding leakage currents of terminal blocks during accident conditions, low level instrumentation circuit conductors inside containment are connected to the penetration conductors with qualified splices. Safety-related 480-volt power, 120-volt AC and 125-volt DC control circuit conductors inside containment required to function for LOCA and main steam line break conditions are also connected to the penetration conductors with qualified splices. The balance of medium power 480-volt conductors, and control and instrumentation conductors are terminated on terminal blocks inside terminal boxes both inside and outside containment. 480-volt heavy power conductors are terminated with lugs on special termination plates inside terminal boxes both inside and outside containment. Nuclear instrumentation detector circuits are terminated with connectors inside terminal boxes both inside and outside containment. Penetrations for medium voltage have header plates welded to the outside of an 18-inch containment sleeve. Each penetration consists of three 1000-MCM conductors terminated with premolded stress cones inside terminal boxes both inside and outside containment.

The capability of the electrical penetrations to withstand the total range of time versus fault current without loss of containment integrity under worst-case environmental conditions was demonstrated by test. These test results substantiate the capability of the electrical penetration to withstand the total range of time versus fault current without seal failure.

The penetrations are arranged in two levels, with one power train and two channels entering above the intermediate floor of the Containment Building, and the redundant train and two channels entering below the intermediate floor. Once inside the containment, this floor provides the necessary physical separation and protection between the redundant trains; outside the containment, this separation is continued by separate tunnels connecting the penetration area to the switchgear and cable spreading areas of the Control Building.

Penetration conductors are sized using ICEA guidelines with an additional restriction of a 65°C nozzle-concrete interface temperature.

The design, construction, and installation of the penetration assemblies are in accordance with IEEE 317 and Regulatory Guide 1.63. (See Subsections 8.1.5.3, 8.3.1.1, and 8.3.1.2 for further details on compliance to Regulatory Guide 1.63.)

k. Cable and Raceway Identification

The computerized conduit and cable schedule provides a permanent record of the routing and termination of cables. Circuit level coding identifies the individual channel or train assigned to each raceway and cable. These data are entered into the conduit and cable program, which in turn produces reports designating the unique number with origin, destination, channel or train, and specific path for every cable. Every cable is identified by a tag affixed at each end, bearing the unique cable number.

Each channel or train is assigned a particular color, as described in Subsection 8.3.1.3.

All safety-related cables have jackets of the color assigned to the particular channel and train so there is no difficulty in distinguishing between cables of redundant channels. Nonsafety-related cables are associated with either Train A or B and have black jackets with a red trace for cables associated with Train A and a white trace for cables associated with Train B. It is immediately evident to the operator or maintenance man, by observing the color of the cable jacket, that a given cable is safety-related and that it is a particular channel or train. This system also prevents placing a cable of one channel or train with cables of another, by the obvious dissimilarity of jacket color. For SF-P10C, which can be powered from either the A or B train emergency bus, an exception has been taken to the general color code convention. The color code of the common cable is selected as Train A.

Per UFSAR Appendix 8A Section 5.1.2, cables were color coded to facilitate initial verification that the installation was in conformance with the separation criteria. Per cable specifications, cable color was only guaranteed for 10 years. In the event that certain cable colors change with age, example: white cables may yellow with age, the separation group can still be identified by the cable code that is printed on the jacket, or by the permanent identification tag at both ends of every cable.

Alternate methods of color coding cable have been made necessary by government regulations restricting the use of paints due to environmental concerns. New installations of safety-related cables may have black jackets stamped with their assigned color at intervals along their length. These cables will be further identified by the application of colored tape at both ends.

Occasionally installations may justify use of a different train cable code. At a minimum, the outer jacket of these cables will be taped with the appropriate color tape at each end along with a tag indicating the intended cable code. Such installations will be evaluated on a case by case basis and will include specific identification details for the application.

Each cable is further identified by a footage and cable code on the jacket of the cable at intervals of approximately five feet. Reference to pulling records reveals the cable number, routing, separation, circuit type, and use of any cable at any accessible point in the raceway system where the footage marker and cable code can be identified.

Exceptions to the above cable identification criteria exist for vendor-supplied specialty cables for the Radiation Monitoring System and portions of various other systems (for example telephone system, lighting, temporary cables and fire protection/detection). For these exceptions, the necessary information to ensure adequate control of separation, installation, inspection, etc., is provided in the construction documents.

Raceways which are part of the computerized cable and conduit schedule are marked to identify their number and circuit level. Conduit raceways are identified at each end where conduit terminates and at both sides of walls, floors and in-line boxes. Tray raceway markers are spaced at 15-foot or less intervals. These markings are in the same colors assigned to the channels and trains. For example, a raceway with a red section marking is utilized only by cables with red (or black with red tracer) jackets. Hence, it is readily apparent that a given cable is routed with its respective channel.

Tray raceway markers are color coded with the same colors assigned to the channels and trains. The markers have a white background with a border color that corresponds to the separation group color code. For example, a raceway section with a marker with a red border is used only by cables with red (or black with red tracer) jackets. It is noted that for Train B/Channel II raceway markers there is no demarcation between the white border and the white background.

Cable tray and raceway systems inside containment were initially identified as described in Section 8.3.1.3. The cable tray identification adhesive labels are removed to meet miscellaneous debris requirements for NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors. The identification numbers are transferred to the cable tray or raceway using an ink marker. The color-coding is maintained by a color stripe applied to the cable tray.

Raceways which are not part of the computerized conduit and cable schedule may not be marked with a unique identification number, but their function is obvious by tracing the raceway to its end device. These raceways may be used to carry vendor-supplied specialty cables for the Radiation Monitoring System and portions of various other systems such as telephone system, lighting and fire protection/detection. For these raceways, the necessary information to ensure adequate controls of separation, installation, inspection, etc., is provided in the construction documents.

Since Seabrook Station is a single unit plant there is no portion of the wiring or its components that is shared; therefore it is in compliance with GDC-5.

l. <u>Administrative Responsibility and Control</u>

Administrative responsibility for assuring compliance with applicable design criteria and bases relative to independence of redundant systems during the initial construction phase rested with the A/E's Project Electrical Engineer. He was responsible for coordination with the A/E's field electrical supervisor to verify that the independence, separation and availability of Class 1E equipment was preserved during installation of the electric power system.

The following control procedures were established by the A/E's Project Electrical Engineer to ensure compliance of the electric power system with the design criteria and bases:

1. Periodic design reviews with the cognizant engineer, the design supervisor, and the reviewing engineer to ensure the criteria are being interpreted and followed

2. Issuance of periodic administrative and design directives covering procedures

3. Periodic field reviews at the job site by the Project Electrical Engineer and/or the cognizant engineer to check field installation procedures, to provide interpretation of design drawings and guidance for solution of field installation problems, and to verify compliance with criteria.

The design of the conduit and raceway system is guided by the recommendations of applicable IEEE, ICEA and NEC standards. For instance, the limiting percentages of fill of internal area of the various size conduits or cable trays are fixed in one of the input forms of the computer conduit and cable schedule and these limits are automatically applied to all conduits and cable trays by the computer. If the conduit or cable tray is one which the computer is free to size, it designates the size which accommodates the cables to be enclosed. If the conduit or cable tray size is designer-designated and the fill exceeds the limiting percentage, the computer indicates an error message so that either the conduit can be made a larger size, or the cables routed by another path. By these methods, all raceways are assured of being of adequate capacity.

Correct installation practice assured that the design criteria by which the equipment was selected were not violated during construction. Installation bases were prescribed, where necessary, by the A/E's Project Electrical Engineer or the field electrical supervisor, and guidelines were established to ensure compliance with the above. For example, maximum pulling tensions for cables are limited, dependent on the method of pulling. In designing the duct runs, anticipated tensions were calculated using industry standard formulae to verify that they are below permissible maximum tensions for the cable being installed. Minimum bending radii were established for the cables being used. These indicate the minimum bend to which a given cable may be bent for safe electrical operation without physically damaging the insulation or coverings. Larger radii were normally implemented whenever installation conditions permit. Precautionary measures to prevent nicks, cuts, abrasion and damage to cables during installation were established.

Inspections were made by the A/E's Project Electrical Engineer and the A/E's field electrical supervisor to verify that cables were being located and routed in accordance with the design criteria.

The design control program and the work control program provide the necessary controls to ensure that the original design bases of the plant are maintained during the operational phases.

8.3.2 DC Power System

8.3.2.1 Description

The station DC power system is comprised of the battery chargers, station batteries and 125V Distribution System. It provides the sources of power for direct current load groups, vital control and instrumentation systems, and control and operation of Class 1E and non-Class 1E electrical equipment. It is a two-wire ungrounded system.

The battery chargers (rectifiers) provide the normal steady-state DC power; the station batteries provide for normal transient loads and also act as the reserve source upon failure of the rectifier or the AC supply to it. Figure 8.3-2, Figure 8.3-37 and Figure 8.3-38 present the one-line diagrams for the station DC electric power system, and show the connections to the AC Vital Instrumentation and Control Power System.

The safety-related portion of the station DC power system shown on Figure 8.3-37 consists of four 125-volt batteries, chargers and DC buses. The loads supplied from the buses include inverters for redundant vital instrument buses, distribution panels for power to the Class 1E direct current loads, power for control and operation of the Class 1E systems for Engineered Safety Features, and power for selected non-Class 1E loads.

Each DC bus consists of metal-enclosed 125-volt DC switchgear consisting of vertical sections housing buses, circuit breakers, instruments and accessory equipment. The breakers are low voltage manual power circuit breakers. Figure 8.3-37 shows that the safety-related DC system incorporates mechanically interlocked manual circuit breakers which will permit the connection of two DC supply buses within the same train to a single battery, but prevents paralleling the two batteries in the train.

The nonsafety-related portion of the station DC systems shown on Figure 8.3-38 consists of two 125-volt batteries, chargers and DC buses. The loads supplied from the buses include inverters for the computer and auxiliary power panels feeding nonvital equipment requiring constant supply and control power feeders to nonvital equipment (13.8-kV switchgear, turbine generator emergency oil pump, etc.).

a. System Separation, Ventilation and Redundancy

Four safety-related 125-volt batteries are supplied. Each battery is housed in an individual room in the seismic Category I Control Building. Separate ventilating systems are provided for the battery rooms of each train (see Subsection 9.4.10). The batteries are seismically qualified and are mounted on seismic Category I racks. The safety-related battery chargers and DC buses are also seismically qualified.

Each battery has its own charger and DC bus. The battery chargers and DC buses of each train are located in an area adjacent to their associated battery rooms and are physically separated from the chargers and buses associated with the redundant train (see Figure 8.3-27 and Figure 8.3-36).

Four DC supplies are provided for the four NSSS inverters for vital instrument buses and the power and control requirements of the two engineered safety features trains (see Subsection 8.3.1.1d). Equipment is located and cables are routed in a manner to assure continued independence and separation so that the loss of DC supply to either train does not prevent the minimum safety function of the other train from being performed.

One nonsafety-related inverter for the station computer is powered from the Train A DC system through a Class 1E breaker on Bus 11C. One nonsafety-related DC power panel is powered from the Train B DC system through a subfeed from safety-related DC power panel PP-111B. All remaining nonsafety-related loads (DC motors, other nonsafety-related inverters, nonvital control panels) are connected to the nonsafety-related batteries (Figure 8.3-38).

b. <u>Station Battery Capacity</u>

The safety-related station batteries are lead-calcium, power station type. Each battery consists of 59 cells, and has a nominal 8-hour rating of 2280-ampere hours.

Each safety-related battery is sized to supply its safety-related and nonsafety-related loads for the durations indicated in Table 8.3-5. Battery B-1C is capable of providing power to the nonvital computer inverter, I-2A, for 15 minutes while supplying its safety-related loads; the inverter load is automatically disconnected from the DC system after the 15-minute period. This disconnection is accomplished by a safety-related trip circuit on the Class 1E breaker feeding inverter I-2A. This circuit, which monitors the time the inverter draws power from the battery, is testable.

In addition, each safety-related battery is sized to have sufficient capacity to serve as the source, for the duration indicated in Table 8.3-5, for two load groups of the same train during the period when one battery is out of service (see Figure 8.3-37). Figure 8.3-51 shows the separate and combined load profiles for the safety-related batteries.

The safety-related station batteries also have sufficient capacity for the four-hour Station Blackout coping duration. The Station Blackout battery sizing evaluation includes the one battery/two bus configuration (see Section 8.4.4.2).

There are two nonsafety-related batteries (B-2A and B-2B) provided in the Turbine Building. The nonsafety-related station batteries are lead calcium, power station type, consisting of 59 cells. Battery B-2A supplies various DC motors for the turbine auxiliaries, various control panels and the Turbine Building DC lighting. Battery B-2B supplies the computer inverter I-2B, the nonvital instrument inverter I-4, Control Building DC lighting and various control panels.

Each Class 1E battery was sized in accordance with the recommended practices in IEEE Standard 485-1978. These practices were applied as follows:

1. The system maximum voltage (140 volts) and maximum equalizing cell voltage (2.33V per cell) were selected. This resulted in a selection of 59 cells which include margin between the equalizing voltage (137.5V), and the system's maximum voltage.

2. A duty cycle diagram was developed, based upon the combined known and anticipated loads for both DC buses of the same train (see Figure 8.3-51).

3. The battery capacity data were selected from the manufacturer's data, based upon the minimum cell voltage (1.78V per cell permitted by the system minimum voltage of 105V).

4. The calculated minimum required cell size was increased by 25 percent for end-of-life compensation.

5. Temperature correction factors were applied to the calculated minimum required cell size, to allow for operation at the minimum design temperature (65°F for batteries B-1A and B-1C, and 60°F for batteries B-1B and B-1D). These temperatures also apply to Station Blackout.

6. Sizing calculations were performed using methods similar to Figure 3 of IEEE 485-1978 to determine the minimum required cell size.

7. A minimum design margin of 15 percent was included in the original battery purchase specification calculated cell size to allow capacity for future loads.

c. Battery Charging

Power for each DC distribution bus is normally supplied through a battery charger dedicated to that bus. Each safety-related battery charger is rated for 150 amps and has been sized to charge its associated battery from the design discharged state (i.e. the state of a battery following a service discharge test) back to the charged state while carrying the largest combined demand of the steady-state loads under all plant operating conditions. If the battery has reached the design minimum charge state (i.e., the state of a battery following a performance discharge test), the charger will restore the battery back to the fully charged state while carrying the largest combined demand of the steady-state loads under all plant operating conditions. Transient emergency peak loads are adequately carried with assistance from the battery if these loads exceed the charger full load output capability.

Each cell is maintained on a float-charge of 2.23 volts. The battery manufacturer's data indicate that when this type cell is float-charged above 2.20 volts per cell it requires little or no equalizing charge. If equalizing is required, the cell voltage will be raised to 2.33 volts per cell (137.5 volts total). Equalized charging of each battery can be provided by the dedicated battery charger with the battery connected to the bus. All DC equipment has been specified and purchased with a maximum operating voltage of 140 volts DC.

Each charger is fed from a separate 460-volt emergency motor control center. On loss of the normal and preferred power supplies, the chargers are energized by standby power. See standby power supply loading sequence charts, Table 8.3-1 and Table 8.3-2.

During the period when a charger requires maintenance, a portable spare charger can be used to replace the normal charger. The spare charger can be positioned adjacent to the charger it is replacing. 460V AC power is supplied to the portable battery charger by means of a plug and receptable connection. The portable charger is connected to the same power train as the fixed charger it is replacing. Alarms from this unit replace the alarms from the fixed charger.

In addition to being used as a one-for-one replacement for a normal charger that is taken out of service, the portable chargers can also be used during the performance of safety-related charger surveillance tests or to recharge the station safety-related batteries following on-line battery maintenance and testing. During this mode of operation, the portable chargers are operated coincident with the normal chargers. Maintenance and test activities on the nonsafety-related chargers and batteries do not require that the portable chargers be operated coincident with the normal chargers. When a portable charger is used for an application other than the replacement of a normal charger, only the local alarms on the portable charger are functional.

d. DC Power System Loading

The safety-related portions of the DC loads are divided into redundant load groups, as listed in Table 8.3-5 and detailed on Figure 8.3-37, Figure 8.3-39, Figure 8.3-40, Figure 8.3-41, Figure 8.3-42, Figure 8.3-58, Figure 8.3-59, Figure 8.3-60 and Figure 8.3-61. The batteries are sized to accommodate both the safety and nonsafety loads, as noted in Subsection 8.3.2.1b. The operator may manually load shed selected loads to extend the discharge time, if required. Load shedding is not required to meet the four-hour Station Blackout duration (see Section 8.4.4.2). Two low voltage alarms, a battery ammeter and a DC bus voltmeter are available in the control room for each DC bus to aid the operator in this decision.

e. DC Power System Testing

The batteries and other equipment associated with the DC system are easily accessible for periodic testing and inspection. Surveillance and testing are performed in accordance with the plant Technical Specifications in compliance with the guidelines of IEEE Standard 338, 450, Regulatory Guides 1.118 and 1.129 except as described in Subsections 8.1.5.2 and 8.1.5.3.

The preoperational testing of the safety-related portion of the DC system has been performed in accordance with Regulatory Guides 1.68 and 1.41.

f. Surveillance and Monitoring

The DC power system (batteries, distribution systems and chargers) is monitored continuously to show that it will be ready to perform its intended function when called upon. Table 8.3-6 summarizes the surveillance and monitoring provisions for the DC power system. The following indications and/or alarms are present locally or in the control room:

1. Battery current (ammeter-charge/discharge) - an ammeter is located in the control room and at the DC switchgear to indicate battery charge and discharge. A local digital ammeter is also provided with sufficient resolution to read normal float charging current.

2. Battery charger output current (ammeter) - an ammeter is located at the charger. The loss-of-charger input AC voltage computer alarm and the battery discharge computer alarm, provide sufficient indication to show when the battery charger is capable of performing its intended function.

3. DC bus voltage (voltmeter) - a voltmeter is located in the control room and at the DC switchgear to indicate the bus voltage. In addition, there is a voltmeter at the charger showing the charger DC output voltage.

4. Battery discharge alarm - a control room alarm is provided to indicate battery discharge. This alarm is derived from the local digital ammeter (see Item 1). This alarm is part of the loss of charging current alarm described in Item 7.

5. DC bus undervoltage and overvoltage alarms - two undervoltage computer alarms are provided for the DC buses; one alarms low voltage as a result of battery discharge. A second alarms on low voltage as a result of a bus fault; this also trips the charger feeder breaker to prevent the charger from feeding a fault. An overvoltage computer alarm is provided by an overvoltage relay at the charger (Device No. 59/62); the charger being the most probable cause of an overvoltage condition. There is also an undervoltage alarm for the battery charger output.

6. DC bus ground alarm (for ungrounded system) - for ground detection, a computer alarm and meters are provided in the control room with additional meters mounted locally in the DC switchgear.

7. Battery breaker(s) or fuse(s) open alarm - the battery supply breaker to the bus has a computer alarm for the breaker open position. A control room alarm is provided to indicate loss of battery charging current. This loss could be caused by an opening in the battery circuit (blown fuses, cut cable, etc.) or by loss-of-charger output. This alarm is part of the battery discharge alarm discussed in Item 4.

8. Battery charger output breaker(s) or fuse(s) open alarm - the battery charger supply breaker to the bus has a computer alarm for the open position. The charger output breaker (integral to the charger) does not have an open alarm; however, it is nonautomatic and would therefore not open on a fault, and if inadvertently left open, it would be alarmed by the battery discharge alarm since the charger could not feed the bus (see 4. above).

9. Battery charger trouble alarm (one alarm for a number of abnormal conditions which are usually indicated locally) - the battery charger trouble alarms (high DC output voltage, low DC output voltage, and loss of AC input voltage), all have separate computer and local alarms.

8.3.2.2 Analysis

The DC System Failure Mode and Effect Analysis are found in Table 8.3-7.

a. Compliance with General Design Criteria

1. Criterion 2 - Design Basis for Protection Against Natural Phenomena

(a) The components of the onsite DC power system are located in seismic Category I structures which provide protection from the effects of tornadoes and external floods, and other natural phenomena.

(b) These components are Class 1E.

(c) These components have been designed to be fully qualified for the seismic and natural environmental conditions appropriate to their location (see Section 3.11).

2. Criterion 4 - Environmental and Missile Design Bases

(a) The components of the onsite DC power system are located in seismic Category I structures which provide protection from the effects of tornado missiles, turbine missiles and other events and conditions which may occur outside the nuclear power unit.

(b) These components are Class 1E.

(c) These components are designed to accommodate the effects of, and to be compatible with or are protected against, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents including loss-of-coolant accidents. Criteria are presented in Chapter 3. Environmental conditions are presented in Chapters 3 and 6.

(d) These components are protected, as appropriate, against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures (postulated accidents).

3. Criterion 5 - Sharing of Systems and Components

Seabrook Station is a single unit plant; therefore, no portion of the station DC system or its components important to safety is shared.

4. Criterion 17 - Electric Power Systems

Compliance with the requirements of the DC portion of the electric power supplies criterion and the associated independence, redundancy and testability are covered by Subsections 8.3.2.1a through 8.3.2.1e.

The station safety-related DC power system provides separate and independent DC power supplies and channels for redundant load groups during abnormal and accident conditions. These redundant load groups comprise engineered safety features and plant protection systems, grouped in such a way that loss of one group does not prevent the minimum safety functions of redundant groups from being performed. In the event of loss of DC power from the chargers, the batteries pick up the load on the DC buses.

5. Criterion 18 - Inspection and Testing of Electric Power Systems

The Class 1E DC electric equipment is designed and located to permit appropriate periodic inspection and testing in line with the provisions for testing listed in Subsection 8.3.2.1e.

These tests assure the operability and functional performance of the DC components, and the operation of the DC system as a whole. During unit shutdown, and under conditions as close to normal operation as practical, the full operational sequence that brings the system into operation, including portions of the protection system, is tested.

b. Compliance with Regulatory Guides

1. Regulatory Guide 1.6 - Independence Between Redundant Standby Power Sources and Between their Distribution Systems

   The safety-related portion of the station DC system includes four batteries. The redundant safety-related load groups are each fed by a separate battery and battery charger. There is no provision for automatically connecting one battery-charger combination to any other redundant load group, nor is there any provision for interconnecting batteries either manually or automatically. To further enhance safety and reliability, two DC supply buses of the same train may be connected together manually, but circuit breaker interlocks prevent an operator error which would parallel two batteries. (See Figure 8.3-37).

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

   The design is consistent with the requirements of this regulatory guide. For details, refer to Subsections 8.3.2.1c and 8.3.2.1e except as noted in Subsection 8.1.5.3.b.

3. Regulatory Guide 1.75 - Physical Independence of Electric Systems

   The design is consistent with the criteria for physical independence of electric systems established in Attachment C of AEC letter dated December 14, 1973. Attachment C is incorporated as UFSAR Appendix 8A and is considered similar to Regulatory Guide 1.75.

   For clarification of position C4 as it relates to associated circuits, refer to UFSAR Subsection 8.1.5.3b.

   The Seabrook cable and raceway separation criteria (see UFSAR Subsection 8.3.1.4) is a combination of the standard criteria given in Attachment C of AEC Letter dated December 14, 1973 (see UFSAR Appendix 8A) and IEEE 384-1974 and criteria established by analysis and testing as permitted by Attachment C and IEEE 384-1974.

4. Regulatory Guide 1.129 - Maintenance, Testing and Replacement of Large Lead Acid Storage Batteries for Nuclear Power Plants

   For compliance to this regulatory guide, refer to Subsection 8.3.2.1e.

5. Regulatory Guide 1.155 - Station Blackout

   The design is consistent with the requirements of this Regulatory Guide. The safety-related station batteries have sufficient capacity for the four-hour Station Blackout coping duration.

c. Compliance with IEEE 308, Class 1E Electric Systems

The station DC system conforms to the requirements of IEEE 308 except as noted in Subsection 8.1.5.2. The power supplies, distribution system, and load groups (see Subsection 8.3.2.1) are arranged to provide direct current electric power to the Class 1E direct current electric loads, and for the control and operation of the Class 1E systems. Sufficient physical separation, electrical isolation, and redundancy are provided to prevent the occurrence of common failure modes in the Class 1E systems.

d. Conformance with Appropriate Quality Assurance Standards

The equipment of the DC system conforms to the controls for electrical equipment listed in Chapter 17.

e. Independence of Redundant Systems

The criteria and bases of minimum requirements to preserve the independence of redundant Class 1E electric systems are those outlined in the General Design Criteria and IEEE 308. Safety loads are divided into redundant groups and equipment is physically separated from its redundant counterpart to prevent the occurrence of a common failure mode.

Batteries are in individual rooms, and chargers and distribution equipment are separated by physical barriers, as indicated on Figure 8.3-27.

The criteria and bases for the installation of raceways and electrical cable for this system are the same as those listed for the AC power system in Subsection 8.3.1.4. Train separation throughout the safety-related portions of the plant is indicated on Figure 8.3-36, Figure 8.3-43 and Figure 8.3-44, which shows electrical arrangements at the three critical elevations.

f. Physical Identification of Safety-Related Equipment

The methods used to physically identify the DC safety-related equipment to assure its appropriate treatment are the same as that for the AC safety-related equipment listed in Subsection 8.3.1.3.

Identification systems distinguish between redundant separation groups; it is clearly evident to the operator or maintenance craftsman which equipment is safety-related and, if safety-related, which separation group is involved.

8.3.3 Fire Protection for Cable Systems

The fire prevention and protection system for cables is part of the integrated fire detection and protection system for the entire plant, and is described in Subsection 9.5.1.

Design aspects used in the prevention of fires in cable systems include separation between redundant trains and voltage levels, cable material selection and cable sizing. This is described in Subsections 8.3.1 and 8.3.2.

8.3.4 References

1. "Analysis of Separation Criteria for Seabrook Station" dated March 24, 1986.
2. Wyle Test Report No. 47966-02 dated January 24, 1986.
3. Wyle Test Report No. 48361-02, dated November 11, 1986.
4. Wyle Test Report No. 48361-03, dated November 11, 1986.
5. Letter No. SBN-1107, Electrical Separation Criteria; Additional Information, J. DeVincentis to V. S. Noonan - NRC, dated June 13, 1986.
6. Foreign Print 34957, Electrical Isolation Test Report

8.4 COMPLIANCE WITH 10 CFR 50.63, LOSS OF ALL ALTERNATING CURRENT POWER (STATION BLACKOUT)

8.4.1 Basic Requirements

This section describes Seabrook's compliance with 10 CFR 50.63 which requires that each light-water-cooled nuclear power plant be able to withstand and recover from a loss of all alternating current power or station blackout (loss of both offsite power and onsite emergency power). Regulatory Guide 1.155 (RG 1.155), "Station Blackout," provided a method for complying with 10 CFR 50.63. RG 1.155 stated that NUMARC 87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," also provided acceptable guidance for meeting the requirements of 10 CFR 50.63. Seabrook followed NUMARC 87-00 except where the Regulatory Guide took precedence.

Station Blackout is considered a non-design basis accident. No other active or passive failures or design basis events are required to be considered during Station Blackout. Safe shutdown for Station Blackout (see 10 CFR 50.2 and NUMARC 87-00) means bringing the plant to a hot shutdown or hot standby condition. The Seabrook analysis and procedures proceed with plant cooldown until secondary side pressure is reduced to about 250 psig and the plant is in a hot standby condition.

Seabrook responds to Station Blackout as an AC Independent plant relying only on the station batteries as a source of electrical power for the coping duration specified in Section 8.4.2. When the Station Blackout analysis was initially performed there were no alternate AC power sources to support response as an Alternate AC (AAC) plant. The Supplemental Emergency Power System (SEPS) was subsequently installed and may be used as a source of power during a station blackout event but will not be credited as an alternate AC power source.

8.4.2 Station Blackout Duration

Seabrook Station's Blackout coping duration is four hours. This is based on evaluation of the offsite power design characteristics, emergency AC power system configuration and emergency diesel generator (EDG) reliability. The offsite power design characteristics included the expected frequency of grid-related loss of offsite power, the estimated frequency of loss of offsite power from severe and extremely severe weather, the number of switchyards and the type of bus transfers. Site-specific weather data were used to evaluate the reliability of offsite power relative to weather-caused outages. One out of two emergency diesel generators is required to operate safe shutdown equipment following a loss of offsite power. A target EDG reliability of 0.975 will be maintained by implementation of the Maintenance Rule EDG performance criteria.

8.4.3 Procedures

Station procedures address the action necessary to cope with a Station Blackout (loss of all AC power) including actions such as opening cabinet doors. Also, as required by RG 1.155, procedures address AC power restoration and severe weather conditions.

8.4.4 Coping Assessment

8.4.4.1 Condensate Inventory for Decay Heat Removal

Decay heat removal for the four-hour Station Blackout coping duration requires 137,000 gallons of water which is less than the Condensate Storage Tank (CST) 194,000 gallon dedicated EFW supply. The 194,000 gallons is the usable volume from the 212,000 gallon Technical Specification limit. The 137,000 gallon value includes decay heat removal, removal of sensible heat and steam generator level shrinkage.

8.4.4.2 Battery Capacity

The safety-related station batteries have sufficient capacity for the four-hour Station Blackout coping duration. The methodology for battery sizing is described in more detail in Section 8.3.2.1.b. The Station Blackout battery sizing includes the one battery/two bus configuration described in Section 8.3.2.1.b.

8.4.4.3 Compressed Air

Air-operated valves required during the Station Blackout four-hour coping duration can either be operated manually or have sufficient backup sources of air independent of AC power. The only valves requiring air are the ASDVs whose backup supply is described in Section 9.3.1.1. Operation of the required valves is addressed in plant procedures.

8.4.4.4 Effects of Loss of Ventilation

The areas containing equipment required to cope with a Station Blackout were evaluated for the effects of loss of ventilation. These areas include the emergency feedwater pumphouse, vital switchgear rooms, battery rooms, containment structure, main control room, electrical tunnels including electrical penetration area, mechanical penetration area and main steam/feedwater pipe chases including east electrical room and west stairwell. For all of these areas, the final calculated temperature at the end of the four-hour Station Blackout coping duration was less than the minimum environmental qualification temperature for the equipment located in the area. Procedures require opening of control cabinet doors in the main control room and the Train B essential switchgear room to enhance cabinet cooling. Minimum battery room temperatures were also determined for input into the battery sizing calculations.

8.4.4.5 Containment Isolation

Although it is not specifically required to isolate containment in response to Station Blackout, the capability to establish containment integrity must be provided. Capability means the ability to close and have position indication, independent of offsite power and onsite emergency EDG power, for valves that may be open at the onset of the Station Blackout. RG 1.155 and NUMARC 87-00 permit exclusion from further review the following containment isolation valves:

a. valves normally locked closed during operation,

b. valves that fail closed on a loss of power (Seabrook did not exclude valves powered from DC power because they would not lose power during a Station Blackout),

c. check valves,

d. valves in nonradioactive closed-loop systems not expected to be breached in a Station Blackout (this does not include lines that communicate directly with containment atmosphere), and

e. valves of less than 3-inch diameter.

UFSAR Table 6.2-83 was reviewed against these exclusion criteria. None of the valves required to establish containment integrity are required to be opened during a Station Blackout. Once these valves are closed or verified closed, they would remain in that position for the duration of the Station Blackout. An action to close or verify closed the position of these valves is included in the Station Blackout procedure.

8.4.4.6 Reactor Coolant Inventory

The expected rates of reactor coolant inventory loss under Station Blackout conditions do not result in the core's becoming uncovered in the four-hour Station Blackout duration. The analysis includes loss or leakage of reactor coolant inventory through the reactor coolant pump seals, the sources described in the Technical Specifications and the letdown line. Therefore, makeup systems are not required during Station Blackout to maintain core cooling under natural circulation (including reflux boiling).

8.4.5 Quality Assurance

All equipment required to cope with Station Blackout is safety related. All safety-related equipment is within the scope of the Operational Quality Assurance Program which complies with the requirements of 10 CFR 50, Appendix B, which exceeds the quality assurance requirements described in RG 1.155.

APPENDIX 8A ATTACHMENT C TO AEC LETTER DATED DECEMBER 14, 1973 "PHYSICAL INDEPENDENCE OF ELECTRIC SYSTEMS"

1.0 Scope

The scope of this document is the physical independence of the circuits and electric equipment comprising or associated with the Class 1E power systems, the protection system, systems actuated or controlled by the protection system, and auxiliary supporting systems that are essential to the operation of these systems. This document sets forth criteria for the separation of circuits and equipment that are redundant. The determination of which circuits and equipment are redundant is outside the scope of this document.

2.0 Purpose

The purpose of this document is to delineate acceptable methods of complying with the requirements of IEEE Std 279-1971 and General Design Criteria 17 and 21 with respect to the physical independence of the circuits and electric equipment within the scope of this document.

3.0 Definitions

3.1 Acceptable

Demonstrated to be adequate by the safety analysis of the station.

3.2 Associated Circuits

Non-Class 1E circuits that share power supplies, enclosures, or raceways with Class 1E circuits or are not physically separated from Class 1E circuits by acceptable separation distance or barriers.

3.3 Barrier

A device or structure interposed between Class 1E equipment or circuits and a potential source of damage to limit damage to Class 1E systems to an acceptable level.

3.4 Class 1E

The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment.

3.5 Design Basis Events

Postulated events specified by the Safety Analysis of the station used in the design to establish the acceptable performance requirements of the structures and systems.

3.6 Enclosure

An identifiable housing such as a cubicle, compartment, terminal box, panel or enclosed raceway, used for electrical equipment or cables.

3.7 Flame Retardant

Capable of preventing the propagation of a fire beyond the area of influence of the energy source that initiated the fire.

3.8 Isolation Device

A device in a circuit which prevents malfunctions in one section of a circuit from causing unacceptable influences in other sections of the circuit or other circuits.

3.9 Raceway

Any channel that is designed and used expressly for supporting wires, cables or busbars. Raceways consist primarily of, but are not restricted to, cable trays and conduits.

3.10 Redundant Equipment or System

An equipment or system that duplicates the essential function of another equipment or system to the extent that either may perform the required function regardless of the state of operation or failure of the other.

3.11 Safety Class Structures

Structures designed to protect Class 1E equipment against the effects of the design basis events. For purposes of this document, separate safety class structures can be separate rooms in the same building. The rooms can share a common wall.

3.12 Separation Distance

Space without interposing structures, equipment, or materials that could aid in the propagation of fire or that could disable the Class 1E system.

4.0 General Separation Criteria[*]

4.1 Required Separation

Separation shall be provided to maintain the independence of sufficient numbers of circuits and equipment so that the protective functions required during and following any design basis event can be accomplished. The degree of separation required varies with the potential hazards in a particular area.

4.2 Equipment and Circuits Requiring Separation

Equipment and circuits requiring separation shall be determined and delineated early in the plant design and shall be identified on documents and drawings in a distinctive manner.

---

* Figure 4.0 shows examples of acceptable circuit arrangements

4.3 Methods of Separation

The separation of circuits and equipment shall be achieved by safety class structures, distance, or barriers, or any combination thereof. In general, locating redundant circuits and equipment in separate safety class structures affords a greater degree of assurance that a single event will not affect redundant systems. Therefore, this method of separation should be used whenever practicable and its use does not conflict with other safety objectives.

4.4 Compatibility with Mechanical Systems

The separation of Class 1E circuits and equipment shall be such that the required independence will not be compromised by the failure of mechanical systems served by the Class 1E systems. For example, Class 1E circuits shall be routed or protected such that failure of related mechanical equipment of one redundant system cannot disable Class 1E circuits or equipment essential to the operation of the other redundant system(s).

4.5 Associated Circuits

Associated circuits shall comply with one of the following:

a. They shall be uniquely identified as such and shall remain with, or be separated the same as, those Class 1E circuits with which they are associated; they shall be subject to all requirements placed on Class 1E circuits such as cable derating, environmental qualification, flame retardance, splicing restrictions and raceway fill, unless it can be demonstrated that the absence of such requirements could not significantly reduce the availability of the Class 1E circuits, or

b. They shall be in accordance with 4.5a from the Class 1E equipment to and including an isolation device. Beyond the isolation device a circuit is not subject to the requirements of this document provided it does not again become associated with a Class 1E system, or

c. They shall be analyzed or tested to demonstrate that Class 1E circuits are not degraded below an acceptable level.

NOTE: Preferred power supply circuits from the transmission network and those similar power supply circuits from the unit generator that become associated circuits solely by their connection to the Class 1E distribution system input terminals are exempt from the requirements of Section 4.5.

4.6 Non-Class 1E Circuits

Non-Class 1E circuits shall comply with either Subsections 4.6.1 or 4.6.2

4.6.1 a. The non-Class 1E circuits shall be separated from Class 1E circuits by the minimum separation requirements specified in Subsections 5.1.3, 5.1.4, or 5.6.2, and

b. The non-Class 1E circuits shall be separated from associated circuits by the minimum separation requirements specified in Subsections 5.1.3, 5.1.4 or 5.6.2 or the effects of lesser separation between the non-Class 1E circuits and the associated circuits shall be analyzed to demonstrate that the Class 1E circuits were not degraded below an acceptable level.

4.6.2 The non-Class 1E circuits shall be treated as associated circuits.

4.7 **Documentation of Analyses**

Analyses performed in accordance with Section 4.5c and Subsection 4.6.1b should be submitted as part of the Safety Analysis Report and should identify those circuits installed in accordance with these sections.

5.0 **Specific Separation Criteria**

5.1 **Cables and Raceways**

5.1.1 **General**

5.1.1.1 The routing of Class 1E circuits and location of equipment served by these Class 1E circuits shall be reviewed for exposure to potential hazards such as high pressure piping, missiles, flammable material, flooding and wiring that is not flame retardant. A degree of separation commensurate with the damage potential of the hazard shall be provided such that the independence of redundant Class 1E systems are maintained at an acceptable level. The separation of Class 1E circuits and equipment shall make effective use of features inherent in the plant design such as using different rooms or opposite sides of rooms or areas, except that the use of opposite sides of rooms or areas does not constitute separation if such rooms or areas are confined or otherwise incapable of dissipating the heat generated from a fire; cable tunnels are examples of such confined areas.

5.1.1.2 In those areas where the damage potential is limited to failure or faults internal to the electrical equipment or circuits, the minimum separation distance can be established by analysis of the proposed cable installation. This analysis shall be based on tests performed to determine the flame retardant characteristics of the proposed cable installation considering features such as cable insulation and jacket materials, cable tray fill and cable tray arrangement.

5.1.1.3 The minimum separation distances specified in Subsections 5.1.3 and 5.1.4 are based on open ventilated trays. Where these distances are used to provide adequate physical separation:

a. Cable splices in raceways shall be prohibited;

b. Cables and raceways involved shall be flame retardant;

c. The design basis shall be that the cable trays will not be filled above the side rails and

d. Hazards shall be limited to failures or faults internal to the electric equipment or cables.

If lesser separation distances are used they shall be established as in Subsection 5.1.1.2.

5.1.2 Identification

Exposed Class 1E raceways shall be marked in a distinct permanent manner at intervals not to exceed 15 feet and at points of entry to and exiting from enclosed areas. Class 1E raceways shall be marked prior to the installation of their cables.

Cables installed in these raceways shall be marked in a manner of sufficient durability and at a sufficient number of points to facilitate initial verification that the installation is in conformance with the separation criteria. These cable markings shall be applied prior to or during installation.

Class 1E cables shall be identified by a permanent marker at each end in accordance with the design drawings or cable schedule.

The method of identification used to meet the above requirements shall readily distinguish between redundant Class 1E systems, associated circuits assigned to redundant Class 1E divisions, and non-Class 1E systems. The preferred method of identification is color coding.

5.1.3 Cable Spreading Area and Main Control Room

The cable spreading area is the space(s) adjacent to the control room where instrumentation and control cables converge prior to entering the control, termination or instrument panels. Where practicable, redundant cable spreading areas shall be utilized.

The cable spreading area(s) and main control room shall not contain high energy equipment such as switchgear, transformers, rotating equipment or potential sources of missiles or pipe whip and shall not be used for storing flammable materials. Circuits in the cable spreading area(s) and main control room shall be limited to control functions, instrument functions and those power supply circuits and facilities serving the control room and instrument systems.

Power supply feeders to instrument and control room distribution panels shall be installed in enclosed raceways that qualify as barriers. The minimum separation distance between redundant Class 1E cable trays shall be determined by Subsection 5.1.1.2 or, where the conditions of Subsection 5.1.1.3 are met, shall be one foot between trays separated horizontally and three feet between trays separated vertically. (Horizontal separation is measured from the side rail of one tray to the side rail of the adjacent tray. Vertical separation is measured from the bottom of the top tray to the top of the side rail of the bottom tray.)

Where termination arrangements preclude maintaining the minimum separation distance, the redundant circuits shall be run in enclosed raceways that qualify as barriers or other barriers shall be provided between redundant circuits. The minimum distance between these redundant enclosed raceways and between barriers and raceways shall be one inch. Figure 5.1, Figure 5.2, Figure 5.3 and Figure 5.4 illustrate examples of acceptable arrangements of barriers and solid enclosed raceways where the minimum separation distance cannot be maintained.

5.1.4 General Plant Areas

In plant areas from which potential hazards such as missiles, external fires and pipe whip are excluded, the minimum separation distance between redundant cable trays shall be determined by Subsection 5.1.1.2, or where the conditions of Subsection 5.1.1.3 are met, shall be three feet[1] between trays separated horizontally and five[1] feet between trays separated vertically. If, in addition, high energy electric equipment such as switchgear, transformers and rotating equipment is excluded and power cables are installed in enclosed raceways that qualify as barriers, or there are no power cables, the minimum separation distance may be as specified in Subsection 5.1.3.

Where plant arrangements preclude maintaining the minimum separation distance, the redundant circuits shall be run in solid enclosed raceways that qualify as barriers or other barriers shall be provided between redundant circuits. The minimum distance between these redundant enclosed raceways and between barriers and raceways shall be 1 inch. Figure 5.1, Figure 5.2, Figure 5.3, and Figure 5.4 illustrate examples of acceptable arrangements of barriers and solid enclosed raceways where the minimum separation distance cannot be maintained.

5.2 Standby Power Supply

5.2.1 Standby Generating Units

Redundant Class 1E standby generating units shall be located in separate safety class structures and shall have independent air supplies.

5.2.2 Auxiliaries and Local Controls

The auxiliaries and local controls for redundant standby generating units shall be located in the same safety class structure as the unit they serve or be physically separated in accordance with the requirements of Section 4.0.

5.3 DC System

5.3.1 Batteries

Redundant Class 1E batteries shall be placed in separate safety class structures. Where ventilation is required, these safety class structures shall be served by independent ventilation systems.

5.3.2 Battery Chargers

Battery chargers for redundant Class 1E batteries shall be physically separated in accordance with the requirements of Section 4.0.

---

(1) Horizontal separation is measured from the side rail of one tray to the side rail of the adjacent tray. Vertical separation is measured from the bottom of the top tray to the top of the side rail of the bottom tray.

5.4 Distribution System

5.4.1 Switchgear

Redundant Class 1E distribution switchgear groups shall be physically separated in accordance with the requirements of Section 4.0.

5.4.2 Motor Control Centers

Redundant Class 1E motor control centers shall be physically separated in accordance with the requirements of Section 4.0.

5.4.3 Distribution Panels

Redundant Class 1E distribution panels shall be physically separated in accordance with the requirements of Section 4.0.

5.5 Containment Electrical Penetrations

Redundant Class 1E containment electrical penetrations shall be physically separated in accordance with the requirements of Section 4.0. Compliance with Section 4.0 will generally require that redundant penetrations be widely dispersed around the circumference of the containment. The minimum physical separation for redundant penetrations shall meet the requirements for cables and raceways given in Subsection 5.1.4.

Non-Class 1E circuits routed in penetrations containing Class 1E circuits shall be treated as associated circuits in accordance with the requirements of Section 4.5.

5.6 Main Control Boards

5.6.1 Location and Arrangement

The main control boards shall be located in a control room within a safety class structure. The control room shall protect from and shall not contain high energy equipment such as switchgear, transformers, rotating equipment or potential sources of missiles or pipe whip.

5.6.2 Internal Separation

The minimum separation distance between redundant Class 1E equipment and circuits internal to the control board can be established by analysis of the proposed installation. This analysis shall be based on tests performed to determine the flame retardant characteristics of the wiring, wiring materials, equipment and other materials internal to the control board. Where the control board materials are flame retardant and analysis is not performed, the minimum separation distance shall be six inches. In the event the above separation distances are not maintained, barriers shall be installed between redundant Class 1E wiring.

5.6.3 Internal Wiring Identification

Class 1E wire bundles or cables internal to the control boards shall be identified in a distinct permanent manner at a sufficient number of points to readily distinguish between redundant Class 1E systems and between Class 1E and non-Class 1E systems.

5.6.4 Common Terminations

Where redundant Class 1E circuits are terminated on a common device, the provisions of paragraph 5.6.2 shall be met.

5.6.5 Non-Class 1E Wiring

Non-Class 1E wiring not separated from Class 1E wiring by the minimum separation distance (determined in paragraph 5.6.2) or by a barrier shall be treated as associated circuits in accordance with the requirements of Section 4.5.

5.6.6 Cable Entrance

Redundant Class 1E cables entering the control board enclosure shall meet the requirements of Subsection 5.1.3.

5.7 Instrument Cables

The separation requirements of Section 5.6 apply to instrumentation cabinets. In addition, redundant Class 1E instruments shall be located in separate cabinets or compartments of a cabinet.

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

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

5.8 Sensors and Sensor to Process Connections

Redundant Class 1E sensors and their connections to the process system shall be sufficiently separated that functional capability of the protection system will be maintained despite any single design basis event or result therefrom. Consideration shall be given to secondary effects of design basis events such as pipe whip, steam release, radiation, missiles and flooding.

Large components such as the reactor vessel can be considered a suitable barrier if the sensor to process connecting lines are brought out at widely divergent points and routed so as to keep the component between redundant lines. Redundant pressure taps located on opposite sides of a large pipe may be considered to be separated by the pipe, but the lines leaving the taps must be protected against damage from a credible common cause unless other redundant or diverse instrumentation is provided.

5.9 Actuated Equipment

Locations of Class 1E actuated equipment, such as pump drive motors and valve operating motors are normally dictated by the location of the driven equipment. The resultant locations of this equipment must be reviewed to ensure that separation of redundant Class 1E actuated equipment is acceptable.

SEABROOK STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

CHAPTER 8
ELECTRIC POWER

TABLES

TABLE 8.1-1 SAFETY LOADS AND FUNCTIONS

Safety Load	Function	Power
1. Reactor Protection		
Reactor Trip Switchgear	Shutdown	125V DC
Reactor Protection Instrumentation Cabinets	Reactor shutdown ESF systems activation	120V AC
2. Engineered Safety Features Equipment		
Containment Systems		
Containment Spray Pumps	Mitigate containment structure pressure buildup, containment heat removal, and fission product cleanup	4160V AC
Containment Structure Recirculating Filter Fans	Mix containment atmosphere to prevent excessive hydrogen concentrations	480V AC
Containment Isolation Valves	Prevent radioactive release from the containment	480V AC 125V DC 120V DC
Containment Hydrogen Recombiner, Hydrogen Analyzer, Analyzer Pump, and Analyzer Heat Tracing	Prevent formation of explosive hydrogen-air mixture	480V AC 120V DC
Emergency Core Cooling (see also safe shutdown)		
Centrifugal Charging Pumps	Provide emergency core cooling and boration control	4160V AC
Safety Injection Pumps	Provide emergency core Cooling	4160V AC
Control Room Habitability Equipment		
Air Conditioning Units Makeup Air Fans Cleanup Filter Unit Fans and Air Heaters	Maintain the environment inside the control room within design limits	480V AC 480V AC 480V AC
ESF Filter Units		
Containment Enclosure Emergency Exhaust Filter Fans	Remove airborne radioactivity	480V AC
Fuel Storage Building Filter Fans and Heaters	Remove airborne radioactivity	480V AC

Safety Load	Function	Power
3. Equipment Required for Safe Shutdown (see also ECCS)		
Residual Heat Removal Pumps	Remove reactor decay heat	4160V AC
Emergency Feedwater Pumps	Supply feedwater to steam generator for reactor decay heat removal	4160V AC
Boric Acid Transfer Pumps	Provide borated water to charging system	480V AC
4. Safety-Related Display Instrumentation		
Process Control Instrument Panel	Provide input to Reactor Protection System	120V AC
Post-Accident Monitoring Instrumentation	Provide operator with Instrumentation to monitor plant and ESF system operation	120V AC
5. Electric Power Equipment		
Control Battery Chargers	Maintain battery in a charged state and provide DC power to operate control and instrumentation circuits	480V AC
Control Power for AC Distribution System	Provides power for operation of circuit breakers	125V DC
Vital Inverters	Provide 120 Volts AC power for vital control and instrumentation systems	480V AC 125V DC
Diesel Generator Emergency Power Sequencers	Automatically sequence loads onto the diesel generator	125V DC
Diesel Generator Control Panels	Start DG upon loss of offsite power	125V DC
Control and instrumentation power panels for various safety systems	Provide power to operate control and instrumentation circuits for safety systems	125V DC 120V DC
6. Auxiliary Supporting Features Equipment		
Spent Fuel Pool Cooling Pumps	Remove fuel decay heat	480V AC
Service Water Pumps (ocean) Cooling Tower Pumps and Cooling Tower Fans	Provide auxiliary cooling water for component cooling system and diesel generator auxiliary cooling	4160V AC 4160V AC 4160 and 480V AC
Primary Component Cooling Water Pumps	Provide auxiliary cooling to ESF systems and components	4160V AC

Safety Load	Function	Power
Diesel Generator Air Compressors	Provides source of compressed air for DG start and control functions	480V AC
Diesel Generator Fuel Oil Transfer Pumps	Supply fuel oil for diesel generators	480V AC
Thermal Barrier PCCW Recirculation Pumps	Provide cooling for the RCP bearings and seals	480V AC
Motor Operator Valves (MOVs) for various safety systems*	Support operation of various safety systems	480V AC
Solenoid Operated Valves (SOVs) and dampers for various safety systems	Support operation of various safety systems	120V DC 125V DC
7. Engineered Safety Features Ventilation Equipment		
Control Building Switchgear Area Ventilation Fans	Maintain the environment of ESF equipment areas within design limit.	480V AC
Diesel Generator Area Ventilation Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
Containment Enclosure Cooling Fans, Containment Enclosure and Charging Pump Room Return Air Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
PAB Auxiliary Supply Air Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
Control Building Battery Room Exhaust Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
Service Water Pumphouse and Switchgear Area Ventilation Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
Service Water Cooling Tower and Switchgear Area Ventilation Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
Emergency Feedwater Pumphouse Ventilation Fans	Maintain the environment of ESF equipment areas within design limits.	480V AC
Containment Hydrogen Analyzer Room Supply Fan	Maintain the environment of ESF equipment areas within Design limits	480V AC

TABLE 8.2-1 GENERATOR CIRCUIT BREAKER – QUALIFICATION TESTS

Item No.	Requirements			Remarks
1	Verification of Interruption Capability			
	No. of Operations	Operation	Current rms	Refer to Item No. 12 for revised ratings.
	One	Interrupt	@ 100 kA symmetrical	
	Two	Interrupt	@ 150 kA symmetrical	
	Two	Close-open	@ 180 kA asymmetrical	Tests performed at KEMA[(1)] Laboratories on a Seabrook equivalent pole.
2	Verification of Closing and Latching Capability			
2.1	Two	Closing Operations	@ 622 kA crest	Tests performed at KEMA Laboratories on a similar breaker for Duke Power Company.
*2.2	Close and Latch Current kA peak	Minimum Carrying Time Cycles (60Hz basis)	Interrupt Current kA rms Symmetrical	Tests performed at KEMA[(1)] Laboratories on a Seabrook equivalent pole.
(1)	622	10	-	
(2)	405	3	150	Refer to Item No. 12 for revised ratings.
	Test 2.2 (1) above was for close and carry only - no interruption.			
3	Load Current Carrying Interruption Test			CERDA[(2)] tests performed on a Seabrook equivalent pole.
	40 successive operation @ 35 kA rms sym.			
4	Dielectric Tests			
	(1.2x50 microsecond impulse wave)			

(1) KEMA = N.V. tot Keuring Van elektrotechnische Materialen, Arnhem, the Netherlands

* These tests were not part of the Catawba (Duke Power Company) Qualification Test Program per its PSAR

(2) CERDA = Centre D'Essais et De Recherches Dell-Allstrom; Villeurbanne, France

Item No.	Requirements	Remarks
4.1	(1) 150 kV Basic Impulse Level-full wave	Tests performed at KEMA Laboratories on a similar breaker for Duke Power Company.
	(2) and chopped wave	
	(3) 51 kV rms for 1 minute	
*4.2	Additional Test	
	(1) 170 kV crest to ground	CERDA tests performed on a similar breaker for a European customer.
	(2) 195 kV crest across contacts	
	(3) 75 kV rms to ground for 1 minute	
	(4) 100 kV rms across contacts for 1 minute	
5	Mechanical Life Operations Test	
	2,000 no load operations consisting of:	CERDA tests performed on a breaker similar to the Seabrook breaker.
	1600 at ambient temperature	
	200 at -10°C	
	200 at 105°C	
6	Heat Run Tests	
	Five tests for forced cooled rating; one test for self cooled rating	EdF(5) and CERDA tests performed on breakers similar to Seabrook breaker for Tennessee Valley Authority and Duke Power Company.

* These tests were not part of the Catawba (Duke Power Company) Qualification Test Program per its PSAR

(5) EdF: Electricite de Fance, Clamart, France

Item No.	Requirements	Remarks
*7	Out-of-Phase Switching Current Test	
	Interrupt 75 kA rms sym. current @ 53 kV	KEMA tests performed on a Seabrook equivalent pole
8	Short Time Current Carrying Capability Test	
	150 kA rms sym. for 3 seconds	KEMA test performed on a breaker similar to the Seabrook breaker for Duke Power Company are acceptable on the basis that the thermal energy release (I^2t) requirements are met. Refer to Item No. 12 for revised ratings.
*9	Timing Tests	
	Maximum Interrupting time 3.3 cycles (60 hz basis)	Tests performed on a Seabrook equivalent pole.
10(3)	Rate of KRise of Transient Recovery Voltage (RRTRV) Withstand Capability	
	Interrupt at 16.55 kV/microsecond (the maximum RRTRV of the PSNH system at Seabrook)	Tests performed at KEMA Laboratories on a breaker similar to the Seabrook breaker. Because of laboratory limitations, the test was performed at 6 kV/ microsecond. CERDA technical notes show by calculation that an RRTRV up to 28 kV/microsecond can be handled safely by the breaker. Refer to Item No. 12 for revised ratings.

* These tests were not part of the Catawba (Duke Power Company) Qualification Test Program per its PSAR

(3) Compliance for item 10 is by calculation and test data

Item No.	Requirements		Remarks
*11(4)	Nonzero Interruption Capability (with fixed and varying generator excitation)		
	Interruption with lagging and leading power factors (over and under excitation)		CERDA technical notes show by calculation that the breaker can safely handle nonzero interruption under different generator excitation conditions.
12	Interruption Capability Transient Recovery Voltage Short-time capability Close & Latch capability followed by interruption	160 kA rms 12 kV/microsecond 160 kA/3 seconds 432 kA peak	Revised ratings supported by analysis performed by breaker manufacturer (AREVA), reference FP-35653.

* These tests were not part of the Catawba (Duke Power Company) Qualification Test Program per its PSAR

(4) For item 11, compliance is by calculation only

TABLE 8.3-1 DIESEL GENERATOR LOADING SEQUENCE SAFEGUARD SIGNAL WITH LOSS OF OFFSITE POWER

DEFINITE START LOADS

						kW @ Various Times										Operating Time
QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	Duration (Note 3)
1	Charging Pump	600	690	554	3552	554	554	554	554	554	554	554	554	554	554	1 Day
	*Lighting & Misc Dist Panels (A)	434.69 kVA (Total)	-	389	-	389	389	389	389	389	389	389	389	389	389	7 Days
	*Lighting & Misc Dist Panels (B)	200 kVA (Total)	-	180	-	180	180	180	180	180	180	180	180	180	180	7 Days
1	*Plant Vent WRGM Rad Monitoring (A)	7.5 kVA	-	8	-	8	8	8	8	8	8	8	8	8	8	7 Days
1	*DG Prelube/Filter Oil Pump	15	-	13	96	13	13	13	13	13	13	13	13	13	13	7 Days
1	Contm Encl Emerg Exh Fltr Fan	7.5	-	7	118	7	7	7	7	7	7	7	7	7	7	7 Days
1	Contm Struct Recirc Fltr Fan	30	24.9	20	237	20	20	20	20	20	20	20	20	20	20	7 Days
2	Inverters (NSSS)	7.5 kVA	-	17	-	17	17	17	17	17	17	17	17	17	17	7 Days
1	*DG Crankcase Exhauster Fan	3	-	3	30	3	3	3	3	3	3	3	3	3	3	7 Days
1	Inverter (BOP)	25 kVA	-	33	-	33	33	33	33	33	33	33	33	33	33	7 Days
3	Unit Sub Xfmr Losses (A)	15 kW	-	45	-	45	45	45	45	45	45	45	45	45	45	7 Days
4	Unit Sub Xfrm Losses (B)	15 kW	-	60	-	60	60	60	60	60	60	60	60	60	60	7 Days
1	*5 kV Swgr Aux Bus (A)	15 kW	-	15	-	15	15	15	15	15	15	15	15	15	15	0 Days
	Cable Losses	60 kW	-	60	-	60	60	60	60	60	60	60	60	60	60	7 Days
1	Control Bldg Batt Rm Exh Fan	5	2.55	2	38	2	2	2	2	2	2	2	2	2	2	7 Days
1	*TG Main Seal Oil Pump (A)	20	-	18	116	18	18	18	18	18	18	18	18	18	18	7 Days
1	*TG Recirc seal Oil Pump (A)	7.5	-	7	51	7	7	7	7	7	7	7	7	7	7	7 Days
1	Ctl Rm Emerg Clean-Up Fltr Fan (A)	15	5.1	5	84	5	5	5	5	5	5	5	5	5	5	7 Days
1	Ctl Rm Emerg Clean-Up Fltr Fan (B)	5	5	5	35	5	5	5	5	5	5	5	5	5	5	7 Days
10	Motor Operated Valves (A)	14.32 (Total)	-	20	146	20	20	20	20	20	20	20	20	20	20	1 Hour
9	Motor Operated Valves (B)	12.32 (Total)	-	17	125	17	17	17	17	17	17	17	17	17	17	1 Hour
1	Contm Encl Cooling Fan	125	109	88	682	-	88	88	88	88	88	88	88	88	88	7 Days
1	Contm Encl Return Air Fan (A)	60	50.7	41	326	-	41	41	41	41	41	41	41	41	41	7 Days
1	Contm Encl Return Air Fan (B)	75	50.7	44	465	-	44	44	44	44	44	44	44	44	44	7 Days
1	DG Room Supply Air Fan	50	39.7	34	547	-	34	34	34	34	34	34	34	34	34	7 Days
1	DG Room Return Air Fan	40	34.1	28	274	-	28	28	28	28	28	28	28	28	28	7 Days
1	Safety Injection Pump	450	470	378	3050	-	378	378	378	378	378	378	378	378	378	1 Day
1	Residual Heat Removal Pump	400	430	343	2233	-	-	343	343	343	343	343	343	343	343	7 Days

DEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	Operating Time Duration (Note 3)
1	Containment Spray Pump	600	552	438	3559	-	-	-	438	438	438	438	438	438	438	28 Hours
1	Pri Comp Cooling Water Pump (A)	700	695	549	3949	-	-	-	-	549	549	549	549	549	549	7 Days
1	Pri Comp Cooling Water Pump (B)	700	730	576	3949	-	-	-	-	576	576	576	576	576	576	7 Days
1	Fuel Storage Bldg Filter Fan	60	-	53	653	-	-	-	-	53	53	53	53	53	53	7 Days
1	Cooling Tower Pump (Note 1)	800	755	609	5096	-	-	-	-	-	-	-	-	609	609	7 Days
1	Service Water Pump (Note 1)	600	610	494	4017	-	-	-	-	-	-	-	-	-	-	0 Days
1	Emergency Feedwater Pump (B)	900	850	669	5051	-	-	-	-	-	-	669	669	669	669	1 Day
1	Control Room A/C Panel-Fans	84 kVA	-	67	467	-	-	-	-	-	67	67	67	67	67	7 Days
1	Control Room A/C Pump	15	-	13	94	-	-	-	-	-	13	13	13	13	13	7 Days
2	*Turb Bldg Battery Chargers (A)	36 kVA	-	58	-	-	-	-	-	-	-	-	-	-	58	7 Days
2	Ctl Bldg Battery Chargers	36 kVA	-	58	-	-	-	-	-	-	-	-	-	-	58	7 Days
1	Portable Battery Charger	36 kVA	-	29	-	-	-	-	-	-	-	-	-	-	29	7 Days
1	*TB Computer Rm A/C Unit (A)	24.6 kVA	-	24	63	-	-	-	-	-	-	-	-	-	24	7 Days
2	*Inverters (A)	30 kVA	-	60	-	-	-	-	-	-	-	-	-	-	60	7 Days
1	*Inverter (A)	32 kVA	-	32	-	-	-	-	-	-	-	-	-	-	32	7 Days
1	*Radiation Mon Dist Pnl (A)	6.9 kVA	-	6	-	-	-	-	-	-	-	-	-	-	6	7 Days
1	Rad Monitoring Skid-60 (A)	2.2 kVA	-	2	11	-	-	-	-	-	-	-	-	-	2	7 Days
1	*Ctl Bldg Cable Spread Rm Sup Fan (A)	10	9.2	8	65	-	-	-	-	-	-	-	-	-	8	7 Days
1	*Ctl Bldg Cable Spread Rm Ret Fan (A)	10	6.7	6	65	-	-	-	-	-	-	-	-	-	6	7 Days
1	Ctl Bldg Swgr Area Supply Fan (A)	60	38.8	34	653	-	-	-	-	-	-	-	-	-	34	7 Days
1	Ctl Bldg Swgr Area Return Fan (A)	40	29.4	24	231	-	-	-	-	-	-	-	-	-	24	7 Days
1	Ctl Bldg Swgr Area Supply Fan (B)	40	20.0	17	231	-	-	-	-	-	-	-	-	-	17	7 Days
1	Ctl Bldg Swgr Area Return Fan (B)	20	8.93	8	195	-	-	-	-	-	-	-	-	-	8	7 Days
1	*Cable Tunnel Exhaust Fan (A)	10	9.1	8	65	-	-	-	-	-	-	-	-	-	8	7 Days
	Definite Start Load Addition This Period - Train A		-	-	-	1216	569	343	438	602	80	0	0	609	349	
	Definite Start Load Addition This Period - Train B		-	-	-	971	572	343	438	629	80	669	0	609	112	

INDEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	MANUAL START	Operating Time Duration (Note 3)
1	SW PP House Exhaust Fan	15	14.1	12	92	12	12	12	12	12	12	12	12	12	12		1 Day
1	SW Swgr Rm Supply Fan	2	1.55	2	15	2	2	2	2	2	2	2	2	2	2		1 Day
1	Emerg FW PP Bldg Intake Fan	5	2.7	3	33	3	3	3	3	3	3	3	3	3	3		2 Days
1	PAB Aux Supply Air Fan	5	2.9	3	38	3	3	3	3	3	3	3	3	3	3		7 Days
1	Thermal Barrier PCCW Recirc Pump	30	21.7	18	187	18	18	18	18	18	18	18	18	18	18		7 Days
1	*SUFP Prelube Oil Pump (A)	1	-	1	7	1	1	1	1	1	1	1	1	1	1		1 Day
1	Clg Twr Swgr Rm Supply Fan	2	1.52	1	19	1	1	1	1	1	1	1	1	1	1		7 Days
1	Clg Twr PP Rm Exhaust Fan	5	2.8	3	38	3	3	3	3	3	3	3	3	3	3		7 Days
1	*DG Aux Lube Oil Pump	60	-	50	343	50	50	50	50	50	50	50	50	50	50		0 Days
1	*DG Aux Fuel Oil Pump	2	-	2	14	2	2	2	2	2	2	2	2	2	2		0 Days
1	DG Fuel Oil Transfer Pump	2	1.2	1	14	1	1	1	1	1	1	1	1	1	1		50 Hours
1	Hydrogen Analyzer Rm Supply Fan	2	1 37	1	15	1	1	1	1	1	1	1	1	1	1		7 Days
1	Boric Acid Transfer Pump	15.5 kW	-	16	69	16	16	16	16	16	16	16	16	16	16		5 Hours
1	*Boric Acid Tank Area Heater	20 kW	-	20	-	20	20	20	20	20	20	20	20	20	20		7 Days
2	*DG Bldg Stairtower Heater (A)	10 & 15 kW	-	25	-	25	25	25	25	25	25	25	25	25	25		7 Days
1	*Fuel Oil Day Tank Room Heater	10 kW	-	10	-	10	10	10	10	10	10	10	10	10	10		7 Days
1	Fuel Storage Bldg Fltr Htr Coil	90 kW	-	90	-	-	-	-	-	90	90	90	90	90	90		2 Days
1	*SW Heat Tracing (A)	9 kVA	-	9	-	9	9	9	9	9	9	9	9	9	9		7 Days
1	*SW Heat Tracing (B)	9 kVA	-	9	-	-	-	-	-	-	-	-	-	-	-	9	7 Days
2	*SGFPT Turning Gear Motor (A)	1.5	-	3	28	3	3	3	3	3	3	3	3	3	3		1 Day
2	*SGFPT Main Oil Pumps (A)	40	-	70	468	70	70	70	70	70	70	70	70	70	70		1 Day
1	*TG Turning Gear Oil Pump (A)	50	-	44	289	44	44	44	44	44	44	44	44	44	44		3 Days
1	SF Pool Cooling Pump	20	-	17	98	-	-	-	-	-	-	-	-	-	-	17	7 Days
1	*Charging Pump Oil Pump	5	-	4	37	4	4	4	4	4	4	4	4	4	4		6 Days
1	*CW PP Lube Booster Pump (A)	10	6.3	6	65	6	6	6	6	6	6	6	6	6	6		1 Day
1	Hydrogen Analyzer Heat Tracing	3 kVA	-	3	-	3	3	3	3	3	3	3	3	3	3		7 Days
1	*Elec Tunnel Sump Pump	5	3	3	37	3	3	3	3	3	3	3	3	3	3		1 Day
15	Motor Operated Valves (A)	18.09 (Total)	-	27	221	27	27	27	27	27	27	27	27	27	27		1 Hour
11	Motor Operated Valves (B)	16.77 (Total)	-	29	207	29	29	29	29	29	29	29	29	29	29		1 Hour
8	*TG Bearing Lift Pumps (A)	5	-	35	293	35	35	35	35	35	35	35	35	35	35		3 Days
1	*DG Aux Coolant Pump	50	-	42	263	-	-	-	-	-	-	-	-	42	42		0 Days

INDEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	MANUAL START	Operating Time Duration (Note 3)
1	DG Air Compressor	15	-	13	84	-	-	-	-	-	-	-	-	-	13		1 Day
1	*DG Lube Oil Heater	35 kW	-	35	-	-	-	-	-	-	-	-	-	-	35		0 Days
1	Control Room A/C Panel – Chiller	90 kVA	-	72	610	-	-	-	-	-	72	72	72	72	72		7 Days
1	*Computer Room A/C Panel (A)	55 kVA	-	55	103	55	55	55	55	55	55	55	55	55	55		7 Days
2	*Clg Twr Swgr Rm Heaters	7.5 kW	-	15	-	15	15	15	15	15	15	15	15	15	15		7 Days
1	*TG Turning Gear Motor (A)	60	-	53	470	53	53	53	53	53	53	53	53	53	53		3 Days
1	*Switchyard Station Service (A)	306 kVA	-	275	-	-	-	-	-	-	-	-	-	275	275		5 Days
1	Contm Encl Chg PP Rm Ret Fan (B)	15	14.1	12	92	12	12	12	12	12	12	12	12	12	12		7 Days
1	Contm Encl Chg PP Rm Ret Fan (A)	15	14.1	12	92	-	-	-	-	-	-	-	-	-	12		7 Days
1	*Computer Rm Dry Cooler (A)	7.5 kW	-	8	67	8	8	8	8	8	8	8	8	8	8		7 Days
1	*Contm Bldg Air Compressor	20	-	17	116	-	-	-	-	-	-	-	-	-	17		7 Days
1	*Instrument Air Dryer	27.2 kW	-	27	-	27	27	27	27	27	27	27	27	27	27		7 Days
1	Hydrogen Recombiner	75 kW	-	75	-	-	-	-	-	-	-	-	-	-	75		7 Days
1	Hydrogen Analyzer Pump	1	-	1	9	-	-	-	-	-	-	-	-	-	-	1	7 Days
1	*Service Air Compressor Skid	178 kVA	-	157	1056	-	-	-	-	-	-	-	-	-	157		5 Days
1	*Admin Bldg Count Rm Dist Pnl (A)	5 kVA	-	5	-	5	5	5	5	5	5	5	5	5	5		7 Days
1	*Admin Bldg Fume Hood Exh Fan (A)	5	3.1	3	41	3	3	3	3	3	3	3	3	3	3		7 Days
1	*Pressurizer Heaters	350 kW	-	350	-	-	-	-	-	-	-	-	-	-	-	350	0 Days
1	*Startup FW Pump (A) (Note 2)	1500	1390	1092	8580	-	-	-	-	-	-	-	-	-	-	1092	0 Days
1	Ctl Rm Emerg Cln-Up Fltr Air Htr	3.6 kW	-	4	-	-	-	-	-	-	-	-	-	-	4		7 Days
1	*Clg Twr Fan Gear Red Imrs Htr (A)	3.75 kW	-	4	-	-	-	-	-	-	-	-	-	-	4		1 Day
2	*Clg Twr Fan Gear Red Imrs Htr (B)	3 kW	-	6	-	-	-	-	-	-	-	-	-	-	6		7 Days
1	*FP Booster Pump (A)	20	-	18	129	18	18	18	18	18	18	18	18	18	18		1 Day
2	*Elect Pen Area AC Unit Cndsr (A)	13 kW	-	26	201	-	-	-	-	-	-	-	-	-	-	26	3 Days
2	*Elect Pen Area AC Unit Cndsr (B)	17 kW	-	34	258	-	-	-	-	-	-	-	-	-	-	34	3 Days
2	*Elect Pen Area AC Unit Air Hndlg (A)	1	-	2	17	-	-	-	-	-	-	-	-	-	-	2	3 Days
2	*Elect Pen Area AC Unit Air Hndlg (B)	3	-	5	43	-	-	-	-	-	-	-	-	-	-	5	3 Days
1	Cooling Tower Fan (A)	400	-	317	2982	-	-	-	-	-	-	-	-	-	-	317	7 Days
2	Cooling Tower Fans (B)	250	195	310	2770	-	-	-	-	-	-	-	-	-	-	310	7 Days

INDEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	MANUAL START	Operating Time Duration (Note 3)
	Indefinite Start Load Addition This Period - Train A			-	-	556	0	0	0	90	72	0	0	317	317		
	Definite Start Load Addition This Period - Train A			-	-	1216	569	343	438	602	80	0	0	609	349		
	Cumulative Total Definite & Indefinite Loads This Period - Train A			-	-	1772	2341	2684	3122	3814	3966	3966	3966	4892	5558		
	Indefinite Start Load Addition This Period - Train B			-	-	235	0	0	0	90	72	0	0	42	307		
	Definite Start Load Addition This Period - Train B			-	-	971	572	343	438	629	80	669	0	609	112		
	Cumulative Total Definite & Indefinite Loads This Period - Train B			-	-	1206	1778	2121	2559	3278	3430	4099	4099	4750	5169		

(A) - Train A Only
(B) - Train B Only

Notes
1. Cooling Tower Pump or Service Water Pump, not both, will be loaded on the DG. Cooling Tower Pump load is larger and is therefore listed.
2. Startup FW Pump may be manually connected to Train A diesel generator under contingency conditions.
3. Operating time duration is based on the expected cumulative run times of the various loads with consideration given to the 7 day diesel generator fuel oil system minimum volume.
* Non Class 1E Loads ("Lighting & Misc. Dist Panels" includes both Class 1E and Non Class 1E loads.)

TABLE 8.3-2 DIESEL GENERATOR LOADING SEQUENCE LOSS OF OFFSITE POWER

DEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times: 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	Operating Time Duration (Note 3)
1	Charging Pump	600	690	554	3552	554	554	554	554	554	554	554	554	554	554	1 Day
	*Lighting & Misc Dist Panels (A)	434.69 kVA (Total)	-	389	-	389	389	389	389	389	389	389	389	389	389	7 Days
	*Lighting & Misc Dist Panels (B)	200 kVA (Total)	-	180	-	180	180	180	180	180	180	180	180	180	180	7 Days
1	*Plant Vent WRGM Rad Monitoring (A)	7.5 KVA	-	8	-	8	8	8	8	8	8	8	8	8	8	7 Days
1	*DG Prelube/Filter Oil Pump	15	-	13	96	13	13	13	13	13	13	13	13	13	13	7 Days
2	Inverters (NSSS)	7.5 kVA	-	17	-	17	17	17	17	17	17	17	17	17	17	7 Days
1	*DG Crankcase Exhauster Fan	3	-	3	30	3	3	3	3	3	3	3	3	3	3	7 Days
1	Inverter (BOP)	25 kVA	-	33	-	33	33	33	33	33	33	33	33	33	33	7 Days
3	Unit Sub Xfmr Losses (A)	15 kW	-	45	-	45	45	45	45	45	45	45	45	45	45	7 Days
4	Unit Sub Xfrm Losses (B)	15 kW	-	60	-	60	60	60	60	60	60	60	60	60	60	7 Days
1	*5 kV Swgr Aux Bus (A)	15 kW	-	15	-	15	15	15	15	15	15	15	15	15	15	0 Days
	Cable Losses	60 kW	-	60	-	60	60	60	60	60	60	60	60	60	60	7 Days
1	Control Bldg Batt Rm Exh Fan	5	2.55	2	38	2	2	2	2	2	2	2	2	2	2	7 Days
1	*TG Main Seal Oil Pump (A)	20	-	18	116	18	18	18	18	18	18	18	18	18	18	7 Days
1	*TG Recirc Seal Oil Pump (A)	7.5	-	7	51	7	7	7	7	7	7	7	7	7	7	7 Days
1	Ctl Rm Emerg Clean-Up Fltr Fan (A)	15	5.1	5	84	5	5	5	5	5	5	5	5	5	5	7 Days
1	Ctl Rm Emerg Clean-Up Fltr Fan (B)	5	5	5	35	5	5	5	5	5	5	5	5	5	5	7 Days
1	Motor Operated Valves (A)	0.33 (Total)	-	1	4	1	1	1	1	1	1	1	1	1	1	1 Hour
1	Motor Operated Valves (B)	0.33 (Total)	-	1	4	1	1	1	1	1	1	1	1	1	1	1 Hour
1	Contm Encl Cooling Fan	125	109	88	682	-	88	88	88	88	88	88	88	88	88	7 Days
1	Contm Encl Return Air Fan (A)	60	50.7	41	326	-	41	41	41	41	41	41	41	41	41	7 Days
1	Contm Encl Return Air Fan (B)	75	50.7	44	465	-	44	44	44	44	44	44	44	44	44	7 Days
1	DG Room Supply Air Fan	50	39.7	34	547	-	34	34	34	34	34	34	34	34	34	7 Days
1	DG Room Return Air Fan	40	34.1	28	274	-	28	28	28	28	28	28	28	28	28	7 Days
1	Residual Heat Removal Pump	400	430	343	2233	-	-	343	343	343	343	343	343	343	343	6 Days

DEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	Operating Time Duration (Note 3)
1	*Contm Struct Cooling Fan 1A (B)	200/100	136	109	1482	-	-	-	109	109	109	109	109	109	109	7 Days
1	*Contm Struct Cooling Fan 1B (B)	200	134	106	1052	-	-	-	106	106	106	106	106	106	106	7 Days
1	*Contm Struct Cooling Fan 1C (A)	200/100	136	109	1482	-	-	-	109	109	109	109	109	109	109	7 Days
1	*Contm Struct Cooling Fan 1D (B)	200	134	106	1052	-	-	-	-	-	-	-	106	106	106	7 Days
1	*Contm Struct Cooling Fan 1E (A)	200/100	136	109	1482	-	-	-	109	109	109	109	109	109	109	7 Days
1	*Contm Struct Cooling Fan 1F (A)	200	134	106	1052	-	-	-	-	-	-	-	106	106	106	7 Days
1	Pri Comp Cooling Water Pump (A)	700	695	549	3949	-	-	-	-	549	549	549	549	549	549	7 Days
1	Pri Comp Cooling Water Pump (B)	700	730	576	3949	-	-	-	-	576	576	576	576	576	576	7 Days
1	Fuel Storage Bldg Filter Fan	60	-	53	653	-	-	-	-	53	53	53	53	53	53	7 Days
1	Control Room A/C Panel-Fans	84 kVA	67	467	-	-	-	-	-	-	67	67	67	67	67	7 Days
1	Control Room A/C Pump	15	13	94	-	-	-	-	-	-	13	13	13	13	13	7 Days
1	Cooling Tower Pump (Note 1)	800	755	609	5096	-	-	-	-	-	-	-	-	609	609	7 Days
1	Service Water Pump (Note 1)	600	610	494	4017	-	-	-	-	-	-	-	-	-	-	0 Days
1	Emergency Feedwater Pump (B)	900	850	669	5051	-	-	-	-	-	-	669	669	669	669	1 Day
2	*Turb Bldg Battery Chargers (A)	36 kVA	-	58	-	-	-	-	-	-	-	-	-	-	58	7 Days
2	Ctl Bldg Battery Chargers	36 kVA	-	58	-	-	-	-	-	-	-	-	-	-	58	7 Days
1	Portable Battery Charger	36 kVA		29	-	-	-	-	-	-	-	-	-	-	29	7 Days
1	*TB Computer Rm A/C Unit (A)	24.6 kVA	-	24	63	-	-	-	-	-	-	-	-	-	24	7 Days
2	*Inverters (A)	30 kVA	-	60	-	-	-	-	-	-	-	-	-	-	60	7 Days
1	*Inverter (A)	32 kVA	-	32	-	-	-	-	-	-	-	-	-	-	32	7 Days
1	*Radiation Monitoring Dist Panel (A)	6.9 kVA	-	6	-	-	-	-	-	-	-	-	-	-	6	7 Days
1	Rad Monitoring Skid-60 (A)	2.2 kVA	-	2	11	-	-	-	-	-	-	-	-	-	2	7 Days
1	*Ctl Bldg Cable Spread Rm Sup Fan (A)	10	9.2	8	65	-	-	-	-	-	-	-	-	-	8	7 Days
1	*Ctl Bldg Cable Spread Rm Ret Fan (A)	10	6.7	6	65	-	-	-	-	-	-	-	-	-	6	7 Days
1	Ctl Bldg Swgr Area Supply Fan (A)	60	38.8	34	653	-	-	-	-	-	-	-	-	-	34	7 Days
1	Ctl Bldg Swgr Area Return Fan (A)	40	29.4	24	231	-	-	-	-	-	-	-	-	-	24	7 Days

DEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	Operating Time Duration (Note 3)
1	Ctl Bldg Swgr Area Supply Fan (B)	40	20.0	17	231	-	-	-	-	-	-	-	-	-	17	7 Days
1	Ctl Bldg Swgr Area Return Fan (B)	20	8.93	8	195	-	-	-	-	-	-	-	-	-	8	7 Days
1	*Cable Tunnel Exhaust Fan (A)	10	9.1	8	65	-	-	-	-	-	-	-	-	-	8	7 Days
1	*Ctl Rod Drive Mech Cooling Fan (A)	30	-	24	187	-	-	-	-	-	-	-	-	-	24	7 Days
2	*Ctl Rod Drive Mech Cooling Fan (B)	30	-	48	374	-	-	-	-	-	-	-	-	-	48	7 Days
	Definite Start Load Addition This Period - Train A		-	-	-	1170	191	343	218	602	80	0	106	609	373	
	Definite Start Load Addition This Period - Train B		-	-	-	928	194	343	215	629	80	669	106	609	160	

INDEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	MANUAL START	Operating Time Duration (Note 3)
1	SW PP House Exhaust Fan	15	14.1	12	92	12	12	12	12	12	12	12	12	12	12		1 Day
1	SW Swgr Rm Supply Fan	2	1.55	2	15	2	2	2	2	2	2	2	2	2	2		1 Day
1	Emerg FW PP Bldg Intake Fan	5	2.7	3	33	3	3	3	3	3	3	3	3	3	3		2 Days
1	PAB Aux Supply Air Fan	5	2.9	3	38	3	3	3	3	3	3	3	3	3	3		7 Days
1	Thermal Barrier PCCW Recirc Pump	30	21.7	18	187	18	18	18	18	18	18	18	18	18	18		7 Days
1	*SUFP Prelube Oil Pump (A)	1		1	7	1	1	1	1	1	1	1	1	1	1		1 Day
1	Clg Twr Swgr Rm Supply Fan	2	1.52	1	19	1	1	1	1	1	1	1	1	1	1		7 Days
1	Clg Twr PP Rm Exhaust Fan	5	2.8	3	38	3	3	3	3	3	3	3	3	3	3		7 Days
1	*DG Aux Lube Oil Pump	60	-	50	343	50	50	50	50	50	50	50	50	50	50		0 Days
1	*DG Aux Fuel Oil Pump	2	-	2	14	2	2	2	2	2	2	2	2	2	2		0 Days
1	DG Fuel Oil Transfer Pump	2	1.2	1	14	1	1	1	1	1	1	1	1	1	1		50 Hours
1	Hydrogen Analyzer Rm Supply Fan	2	1.37	1	15	1	1	1	1	1	1	1	1	1	1		7 Days
1	Boric Acid Transfer Pump	15.5 kW	-	16	69	16	16	16	16	16	16	16	16	16	16		5 Hours
1	*Boric Acid Tank Area Heater	20 kW	-	20	-	20	20	20	20	20	20	20	20	20	20		7 Days
2	*DG Bldg Stairtower Heater (A)	10 & 15 kW	-	25	-	25	25	25	25	25	25	25	25	25	25		7 Days
1	*Fuel Oil Day Tank Room Heater	10 kW	-	10	-	10	10	10	10	10	10	10	10	10	10		7 Days
1	Fuel Storage Bldg Fltr Htr Coil	90 kW	-	90	-	-	-	-	-	90	90	90	90	90	90		7 Days
1	*SW Heat Tracing (A)	9 kVA	-	9	-	9	9	9	9	9	9	9	9	9	9		7 Days
1	*SW Heat Tracing (B)	9 kVA	-	9	-	-	-	-	-	-	-	-	-	-	-	9	7 Days
2	*SGFPT Turning Gear Motor (A)	1.5	-	3	28	3	3	3	3	3	3	3	3	3	3		1 Day
2	*SGFPT Main Oil Pumps (A)	40	-	70	468	70	70	70	70	70	70	70	70	70	70		1 Day
1	*TG Turning Gear Oil Pump (A)	50	-	44	289	44	44	44	44	44	44	44	44	44	44		3 Days
1	SF Pool Cooling Pump	20	-	17	98	-	-	-	-	-	-	-	-	-	-	17	7 Days
1	*Charging Pump Oil Pump	5	-	4	37	4	4	4	4	4	4	4	4	4	4		6 Days
1	*CW PP Lube Booster Pump (A)	10	6.3	6	65	6	6	6	6	6	6	6	6	6	6		1 Day
1	Hydrogen Analyzer Heat Tracing	3 kVA	-	3	-	3	3	3	3	3	3	3	3	3	3		7 Days
1	*Elec Tunnel Sump Pump	5	3	3	37	3	3	3	3	3	3	3	3	3	3		1 Day

INDEFINITE START LOADS

						kW @ Various Times											Operating Time
QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	MANUAL START	Duration (Note 3)
13	Motor Operated Valves (A)	15.49 (Total)	-	26	183	26	26	26	26	26	26	26	26	26	26		1 Hour
8	Motor Operated Valves (B)	12.17 (Total)	-	22	156	22	22	22	22	22	22	22	22	22	22		1 Hour
8	*TG Bearing Lift Pumps (A)	5	-	35	293	35	35	35	35	35	35	35	35	35	35		3 Days
1	*DG Aux Coolant Pump	50	-	42	263	-	-	-	-	-	-	-	-	42	42		0 Days
1	DG Air Compressor	15	-	13	84	-	-	-	-	-	-	-	-	-	13		1 Day
1	*DG Lube Oil Heater	35 kW	-	35	-	-	-	-	-	-	-	-	-	-	35		0 Days
1	Control Room A/C Panel – Chiller	90 kVA	-	72	610	-	-	-	-	-	72	72	72	72	72		7 Days
1	*Computer Room A/C Panel (A)	55 kVA	-	55	103	55	55	55	55	55	55	55	55	55	55		7 Days
2	*Clg Twr Swgr Rm Heaters	7.5 kW	-	15	-	15	15	15	15	15	15	15	15	15	15		7 Days
1	*Switchyard Station Servce (A)	306 kVA	-	275	-	-	-	-	-	-	-	-	-	275	275		5 Days
1	*TG Turning Gear Motor (A)	60	-	53	470	53	53	53	53	53	53	53	53	53	53		3 Days
1	Contm Encl Chg PP Rm Ret Fan (A)	15	14.1	12	92	-	-	-	-	-	-	-	-	-	12		7 Days
1	Contm Encl Chg PP Rm Ret Fan (B)	15	14.1	12	92	12	12	12	12	12	12	12	12	12	12		7 Days
1	*Computer Rm Dry Cooler (A)	7.5 kW	-	8	67	8	8	8	8	8	8	8	8	8	8		7 Days
1	*Contm Bldg Air Compressor	20	-	17	116	-	-	-	-	-	-	-	-	-	17		7 Days
1	*Instrument Air Dryer	27.2 kW	-	27	-	27	27	27	27	27	27	27	27	27	27		7 Days
1	*Service Air Compressor Skid	178 kVA	-	157	1056	-	-	-	-	-	-	-	-	-	157		5 Days
1	*Pressurizer Heaters	350 kW	-	350	-	-	-	-	-	-	-	-	-	-	-	350	1 Day
1	*Startup FW Pump (A) (Note 2)	1500	1340	1092	8580	-	-	-	-	-	-	-	-	-	-	1092	0 Days
1	Ctl Rm Emerg Cln-Up Fltr Air Htr	3.6 kW	-	4	-	-	-	-	-	-	-	-	-	-	4		7 Days
1	*Clg Twr Fan Gear Red Imrs Htr (A)	3.75 kW	-	4	-	-	-	-	-	-	-	-	-	-	4		1 Day
2	*Clg Twr Fan Gear Red Imrs Htr (B)	3 kW	-	6	-	-	-	-	-	-	-	-	-	-	6		1 Day
1	*FP Booster Pump (A)	20	-	18	129	18	18	18	18	18	18	18	18	18	18		1 Day
1	*Admin Bldg Count Rm Dist Pnl (A)	5 kVA	-	5	-	5	5	5	5	5	5	5	5	5	5		7 Days
1	*Admin Bldg Fume Hood Exh Fan (A)	5	3.1	3	41	3	3	3	3	3	3	3	3	3	3		7 Days
2	*Elect Pen Area AC Unit Cndsr (A)	13 kW	-	26	201	-	-	-	-	-	-	-	-	-	-	26	3 Days
2	*Elect Pen Area AC Unit Cndsr (B)	17 kW	-	34	258	-	-	-	-	-	-	-	-	-	-	34	3 Days

INDEFINITE START LOADS

QTY	SEQUENCED LOAD	HP	BHP	kW	INRUSH kVA	kW @ Various Times 12 SEC	17 SEC	22 SEC	27 SEC	32 SEC	37 SEC	42 SEC	47 SEC	52 SEC	120 SEC	MANUAL START	Operating Time Duration (Note 3)
2	*Elect Pen Area AC Unit Air Hndlg (A)	1	-	2	17	-	-	-	-	-	-	-	-	-	-	2	3 Days
2	*Elect Pen Area AC Unit Air Hndlg (B)	3	-	5	43	-	-	-	-	-	-	-	-	-	-	5	3 Days
1	Cooling Tower Fan (A)	400	-	317	2982	-	-	-	-	-	-	-	-	-	-	317	7 Days
2	Cooling Tower Fans (B)	250	195	310	2770	-	-	-	-	-	-	-	-	-	-	310	7 Days
	Indefinite Start Load Addition This Period - Train A			-	-	555	0	0	0	90	72	0	0	317	242		
	Definite Start Load Addition This Period - Train A			-	-	1170	191	343	218	602	80	0	106	609	373		
	Cumulative Total Definite & Indefinite Loads This Period - Train A			-	-	1725	1916	2259	2477	3169	3321	3321	3427	4353	4968		
	Indefinite Start Load Addition This Period - Train B			-	-	228	0	0	0	90	72	0	0	42	232		
	Definite Start Load Addition This Period - Train B			-	-	928	194	343	215	629	80	669	106	609	160		
	Cumulative Total Definite & Indefinite Loads This Period - Train B			-	-	1156	1350	1693	1908	2627	2779	3448	3554	4205	4597		

(A) - Train A Only

(B) - Train B Only

Notes

1. Cooling Tower Pump or Service Water Pump, not both, will be loaded on the DG. Cooling Tower Pump Load is larger and is therefore listed.
2. Startup FW pump may be manually connected to Train A diesel generator under contingency conditions.
3. Operating time duration is based on the expected cumulative run times of the various loads with consideration given to the 7 day diesel generator fuel oil system minimum volume.

* Non Class 1E Loads ("Lighting & Misc. Dist Panels" includes both Class 1E and Non Class 1E loads.

TABLE 8.3-3 FAILURE MODE AND EFFECT ANALYSIS FOR AUXILIARY AC POWER SYSTEM

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
1	345 kV offsite power source	Supplies power to reserve auxiliary transformers and unit aux. trans.	Fails to provide power	Loss of power to UATs and RATs.	Protective relays; alarm in control room	None: Offsite power is lost but onsite emergency power is available from the diesel generators.
2	25 kV power source	Supplies power to unit auxiliary transformers X-2A and X-2B	Fails to provide power	Loss of power to X-2A and X-2B	Protective relays; alarm in control room	None: power is lost but emergency power is available from the RAT or the diesel generators.
3	Unit auxiliary transformer X-2A	Supplies preferred power to plant 13.8 kV and 4.16 kV buses and emergency bus E5	Fails to deliver power	Loss of power to buses 1,3, and E5	Protective relays; alarm in control room	None: Offsite power source (Item 1) is available through automatic transfer; diesel generator 1A available for bus E5.
4	Unit auxiliary transformer X-2B	Supplies preferred power to plant 13.8 kV and 4.16 kV buses and emergency bus E6	Fails to deliver power	Loss of power buses 2,4, and E6	Protective relays; alarm in control room	None: Offsite power source (Item 1) is available through automatic transfer; diesel generator 1B avail-able for bus E6.
5	Reserve auxiliary transformer X-3A	Supplies alternate power to plant 13.8 kV and 4.16 kV buses and emergency bus E5	Fails to deliver power	Loss of power to buses 1,3, and E5	Protective relays; alarm in control room	None: Preferred power supply is normally available through UAT. Diesel generator 1A is also avail-able to provide power to bus E5.
6	Reserve auxiliary transformer X-3B	Supplies alternate power to plant 13.8 kV and 4.16 kV buses and emergency bus E6	Fails to deliver power	Loss of power to buses 2,4 and E6	Protective relays; alarm in control room	None: Preferred power supply is normally available through UAT. Diesel generator 1B is also avail-able to provide power to Bus E6.
7	Circuit breaker A51	Protects bus E5 when supplied from X-2A source	1. Fails to open on a fault	1. Failure to open could damage bus and cause loss of X-2A supply	1. Alarm in control room	None: Redundant Bus E6 (Train B) is available
			2. Fails to close	2. Failure to close keeps bus from being energized	2. Periodic testing for operational readiness	

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
8	Circuit breaker A52	Protects bus E5 when supplied from X-3A source	1. Fails to open on a fault	1. Failure to open could damage bus and cause loss of X-3A supply	1. Alarm in control room	None: Redundant Bus E6 (Train B) is available
			2. Fails to close	2. Failure to close keeps bus from being energized	2. Periodic testing for operational readiness	
9	Circuit breaker A71	Protects bus E6 when supplied from X-2B source	1. Fails to open on a fault	1. Failure to open could damage bus and cause loss of X-2B supply	1. Alarm in control room	None: Redundant Bus E5 (Train A) is available
			2. Fails to close	2. Failure to close keeps bus from being energized	2. Periodic testing for operational readiness	
10	Circuit breaker A72	Protects bus E6 when supplied from X-3B source	1. Fails to open on a fault	1. Failure to open could damage bus and cause loss of X-3B supply	1. Alarm in control room	None: Redundant Bus E5 (Train A) is available
			2. Fails to close	2. Failure to close keeps bus from being energized	2. Periodic testing for operational readiness	
11	Bus E5	Distributes electrical power to Train A loads	Fails to deliver power	Loss of Train A safety load group	Protective relays; alarm in control room	None: Redundant Train B from bus E6 available
12	Bus E6	Distributes electrical power to Train B loads	Fails to deliver power	Loss of Train B safety load group	Protective relays; alarm in control room	None: Redundant Train A from bus E5 available

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
13	Circuit breaker A54	Diesel generator 1A supply breaker to bus E5	1. Fails to close;	1. Fails to close; DG 1A cannot supply power to bus E5	Periodic testing; alarm in control room	None: Redundant loads supplied from bus E6 by diesel generator 1B
			2. Fails to open on a fault	2. Fails to open; possible damage to bus E5 or DG-1A		
14	5 kV non-segregated phase bus duct	Connects diesel generator 1A to circuit breaker A54	short circuit; open circuit	Does not transmit power from DG-1A to bus E5	Periodic testing; protective relays.	None: Redundant loads supplied from bus E6 by diesel generator 1B
15	Diesel generator 1A	Provides standby power to Train A loads	Delivers no power to bus E5	No voltage at bus E5	Protective relays; alarm in control room; periodic testing	None: Redundant loads supplied from bus E6 by diesel generator 1B
16	Circuit breaker A74	Diesel generator 1B supply breaker to bus E6	1. Fails to close	1. Fails to close: DG-1B cannot supply power to bus E6	Periodic testing; alarm in control room	None: Redundant loads supplied from bus E5 by diesel generator 1A
			2. Fails to open on a fault	2. Fails to open: possible damage to bus E6 or DG-1B		
17	5 kV non-segregated phase bus duct	Connects diesel generator 1B to circuit breaker A74	Short circuit; open circuit	Does not transfer power from DG-1B to bus E6	Periodic testing; protective relays	None: Redundant loads supplied from bus E5 by diesel generator 1A
18	Diesel generator 1B	Provides standby power to Train B loads	Delivers no power to bus E6	No voltage at bus E6	Protective relays; alarm in control room; periodic testing	None: Redundant loads supplied from bus E5 by diesel generator 1A

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
19	4.16 kV breakers supplying unit substation transformers X-5A, X-5B and X-5E	Protects unit substation transformers	1. Fails to open on a fault	1. Fails to open: backup breakers open, bus E5 de-energized	Alarm in control room; protective relays	None: Redundant loads (Train B) supplied from bus E6
			2. Fails to close	2. Fails to close: loss of power to buses E51, E52 and E53		
20	5 kV cable	Connects unit substation transformers to 5 kV bus	Short circuit, open circuit	Loss of power to buses E51, E52 or E53	Protective relays	None; Redundant loads (Train B) supplied from bus E6
21	Unit substation transformers X-5A, X-5B and X-5E	Supplies 480 volt power to buses E51, E52 and E53	Transformer failure	Loss of power to buses E51, E52 or E53	Protective relays	None: Redundant loads (Train B) supplied from bus E6
22	480 volt circuit breakers	Protects buses E51, E52 and E53	1. Fails to open on a fault	1. Failure to open could damage bus	Alarm in control room; periodic testing	None: Redundant loads supplied by Train B
			2. Fails to close	2. Failure to close: bus not energized		
				3. Backup breaker opens; buses E51, E52, E53 de-energized		
23	480 volt buses E51, E52 and E53	Distributes 480 volt power to Train A loads	Fails to deliver power	Loss of 480 volt Train A loads on E51, E52 or E53	Protective relays, alarm in control room	None: Redundant loads supplied by Train B

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
24	480 volt circuit breakers	Protects MCCs supplied by buses E51, E52 and E53	1. Fails to open on a fault	1. Failure to open; could damage bus. Backup breaker opens; buses E51, E52, E53 de-energized	Alarm in control room; periodic testing	None: Redundant loads supplied from Train B MCCs
			2. Fails to close	2. Failure to close: MCCs not energized		
25	600 volt power cable	Transmits power to MCCs supplied from buses E51, E52 and E53	Open circuit; short circuit	Loss of power to MCC	Alarms in control room	None: Redundant loads supplied from Train B MCCs
26	460 volt MCCs powered from buses E51, E52 and E53	Distribute 480 volt power	Fails to deliver power	Loss of MCC	Alarm in control room; loss of functions with resultant alarms	None: Redundant loads on MCCs supplied from Train B
27	4.16 kV breakers supplying unit sub-station transformers X-5C, D, F and H	Protects unit substation transformers	1. Fails to open on a fault	1. Fails to open: backup breakers open; bus E6 de-energized	Alarm in control room; protective relays	None: Redundant loads (Train A) supplied from bus E5
			2. Fails to close	2. Fails to close: loss of power to buses E61 thru E64		
28	5 kV cable	Connects unit substation transformers to 5 kV bus	Short circuit; open circuit	Loss of power to buses E61 thru E64	Protective relays	None: 1.Redundant loads (Train A) supplied from bus E5 2. Bus E64 remains de-energized; redundant Train A loads perform safety function

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
29*	Unit substation transformers X-5C, D, F and H	Supply 480 volt power to buses E61 thru E64	Transformer failure	Loss of power to buses E61 thru E64	Protective relays	None: Redundant loads (Train A) supplied from bus E5
30	480 volt circuit breakers	Protect buses E61 thru E64	1. Fails to open on a fault 2. Fails to close	1. Failure to open: could damage bus. Backup breaker opens 2. Failure to close: bus not energized 3. Backup breaker opens; buses E61 thru E64 de-energized	Alarm in control room; periodic testing	None: Redundant loads supplied by Train A
31	480 volt buses E61 thru E64	Distributes 480 volt power to Train B	Fails to deliver power	Loss of 480 volt Train B loads on buses E61 thru E64	Protective relays; alarm in control room	None: Redundant loads supplied by Train A
32	480 volt circuit breakers	Protects MCCs supplied by buses E61 thru E64	1. Fails to open on a fault 2. Fails to close	1. Failure to open: could damage bus backup breaker 2. Failure to close: MCCs not energized 3. Backup breaker opens; buses E61 thru E64 de-energized	Alarm in control room; periodic testing	None: Redundant loads supplied from Train A MCCs
33	600 volt power cable	Transmits power to MCCs supplied from buses E61 thru E64	Open circuit; short circuit	Loss of power to MCC	Alarms in control room	None: Redundant loads supplied from A Train MCCs
34	460 volt MCCs powered from buses E61 thru E64	Distribute 480 volt power	Fails to deliver power	Loss of MCC	Alarm in control room; loss of functions with resultant alarms	None: Redundant loads on MCCs supplied from Train A

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
35	Uninterruptible power supplies UPS-1A, 1C and 1E	Provides reliable source of 120 V AC to Channel I and III and Train A instrumentation	Fails to provide power	Loss of power to Channel I and III and Train A instrumentation	Protective relays; alarm in the control room	None: Power is available from redundant UPS-1B, 1D and 1F which are Channels II and IV and Train B instrumentation
36	Uninterruptible power supplies UPS-1B, 1D and 1F	Provides reliable source of 120 V AC to Channel II and IV and Train B instrumentation	Fails to provide power	Loss of power to Channel II and IV and Train B instrumentation	Protective relays; alarm in the control room	None: Power is available from redundant UPS-1A, 1C and 1E and, which are channels I and III and Train A instrumentation
37	Main generator breaker	Opens to isolate main generator from 25 kV system on reactor or turbine trip as well as to protect generator	Fails to open on a fault	Backup breakers operate to de-energize 25 kV system eliminating one of the immediate access sources of offsite power; station buses automatically transfer to alternate source	Protective relays; alarm in the control room	None: The alternate source of offsite power is available to all station buses; diesel generators are available to supply emergency power to Train A and B buses E5 and E6

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
38	Train A emergency power sequencer CP-79(EPS)	Controls the sequential loading of safety related and nonsafety-related loads onto diesel generator 1A upon loss of offsite power	1. Fails to start safety related and nonsafety-related loads	1. Train A safety loads not automatically started	Protective relays; alarms in control room; periodic testing	None: Redundant Train B is available. In addition, the EPS can be bypassed (de-energized) and safety related and nonsafety-related loads can be applied manually
			2. Fails to start safety related loads in proper sequence	2. Potential overload of the DG		
			3. Fails to maintain proper time interval between sequential applications of safety related and nonsafety-related loads onto DG-1A	3. Potential overload of the DG		
39	Train B emergency power sequencer CP-80 (EPS)	Controls the sequential loading of safety related and nonsafety-related loads onto diesel generator 1B upon loss of offsite power	1. Fails to start safety related loads	1. Train B safety loads not automatically started	Protective relays; alarms in control room; periodic testing	None: Redundant Train A is available. In addition, the EPS can be bypassed (de-energized) and safety related and nonsafety-related loads can be applied manually.
			2. Fails to start safety related loads and nonsafety-related in proper sequence	2. Potential overload of the DG		
			3. Fails to maintain proper time interval between sequential applications of safety related and nonsafety-related loads onto DG-1B	3. Potential overload of the DG		

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
40	E5 Circuit breaker (SEPS)	Protects bus E5 from a SEPS system fault	1. Spurious closure with failure to trip during a seismic event	Failure could cause UAT/RAT breaker to open or trip/degrade the emergency diesel generator or emergency bus.	Protective relays; Alarm in Control Room	Redundant Bus E6 (Train B) is Available
41	E6 Circuit breaker (SEPS)	Protects bus E6 from a SEPS system fault	1. Spurious closure with failure to trip during a seismic event	Failure could cause UAT/RAT breaker to open or trip/degrade the emergency diesel generator or emergency bus.	Protective relays; Alarm in Control Room	Redundant Bus E5 (Train A) is Available

TABLE 8.3-4 SEGREGATION OF ALLOWABLE CIRCUITS BY SEPARATION GROUP

Separation Group	Allowable Circuits	
A	a)	Train A power, control and instrumentation
	b)	Channel I instrumentation
	c)	Train A associated power, control and instrumentation
B	a)	Train B power, control and instrumentation
	b)	Channel II instrumentation
	c)	Train B associated power, control and instrumentation
C	a)	Channel III instrumentation
D	a)	Channel IV instrumentation

TABLE 8.3-5 BATTERY LOADING - SAFETY-RELATED BATTERIES

Safety-Related DC Loads

Safety-Related Inverters	Load Size	Duration[1]	DC Bus
Vital Instrument Bus Inverter I-1A-1	50A	2 hours	11A
Vital Instrument Bus Inverter I-1B-1	52A	2 hours	11B
Vital Instrument Bus Inverter I-1C-1	60A	2 hours	11C
Vital Instrument Bus Inverter I-1D-1	40A	2 hours	11D
Vital Instrument Bus Inverter I-1E-1	238A	2 hours	11A
Vital Instrument Bus Inverter I-1F-1	189A	2 hours	11B
Reactor Protection and Safeguard Systems			
Train A Vital Solenoid Valves	30A	2 hours	11A
	9A	1 min.[4]	11A
Train B Vital Solenoid Valves	30A	2 hours	11B
	9A	1 min.[4]	11B
Train A Class 1E Power System Control Power	3A	2 hours	11A
	25A	1 min.[5]	11A
	1A	2 hours	11C
Train B Class 1E Power System Control Power	4A	2 hours	11B
	25A	1 min.[5]	11B
	1A	2 hours	11D
Train A Reactor Trip Swgr. Control Power	12A	1 min.	11A
	1A	2 hours	11A
Train B Reactor Trip Swgr. Control Power	12A	1 min.	11B
	1A	2 hours	11B
Train A Diesel Generator Sequencer and Control; and Bus E5	27A	2 hours	11A
	60A	1 min.[2]	11A
Train B Diesel Generator Sequencer and Control; and Bus E6	27A	2 hours	11B
	60A	1 min.[2]	11B

Nonsafety-Related DC Loads

Computer Inverter I-2A	400A	15 min.[3]	11C
Distribution Panel PP-1111B	2A	2 hours	11B

(1) Duration - Time used with these loads for the design basis 2 hour discharge used to size the batteries.

(2) One minute load in first 1 minute period for initial diesel start attempt and a diesel generator breaker closing, and 1 minute random load for a second attempt at diesel start and diesel generator breaker closing during the design basis 2 hour discharge period.

(3) This load is tripped after 15 minutes.

(4) This load is a 1 minute random load.

(5) One minute load in the first minute for the operation of 480V Unit Substation Breaker Close Coils and Spring Charging Motors.

TABLE 8.3-6 DC POWER SYSTEM SURVEILLANCE AND MONITORING PROVISIONS

		Surveillance Method			
Equipment	Parameter	Instrument	Instrument	Indicating Light	Remarks
Battery/Bus	Bus Voltage	X, O	X		Two low voltage alarms
	Battery Current	X, O	X		
	Ground	X, O	X		
	Position of battery supply breaker		X		
	Position of alternate battery supply breaker		X		
Battery Charger	DC Output Current	O	X		Battery discharge and loss-of-battery charging current alarm
	DC Output Voltage	O	X	O	Alarm on high or low voltage
	Position of charger supply charger supply breaker to the bus		X		
	Input AC voltage		X	O	AC supply failure

X: Denotes main control board
O: Denotes local at the equipment

TABLE 8.3-7 FAILURE MODE AND EFFECT ANALYSIS FOR DC POWER SYSTEM

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
1	Battery B-1A	Provides DC power for transient loads	Loss of capacity	Loss of backup power to bus 11A	Periodic tests, alarms	None: Battery charger BC-1A supplies steady-state load. Alternate battery B-1C may be connected to bus 11A to supply transient loads.
2	Battery B-1B	Provides DC power to transient loads	Loss of capacity	Loss of backup power to bus 11B	Periodic tests, alarms	None: Battery charger BC-1B supplies steady-state load. Alternate battery B-1D may be connected to bus 11B to supply transient loads.
3	Battery B-1C	Provides DC power for transient loads	Loss of capacity	Loss of backup power to bus 11C	Periodic tests, alarms	None: Battery charger BC-1C supplies steady-state load. Alternate battery B-1A may be connected to bus 11C to supply transient loads.
4	Battery B-1D	Provides DC power for transient loads	Loss of capacity	Loss of backup power to bus 11D	Periodic tests, alarms	None: Battery charger BC-1D supplies steady-state load. Alternate battery B-1B may be connected to bus 11D to supply transient loads.
5	Battery Charger BC-1A	Provide DC power for steady-state load and battery B-1A charging	Loss of output	Fails to supply steady-state loads or charge battery	Charger output low voltage alarm, loss of battery charging current alarm	None: Spare battery charger available. Battery B-1A provides DC power for 2 hours minimum.
6	Battery Charger BC-1B	Provide DC power for steady-state load and battery B-1B charging	Loss of output	Fails to supply steady-state loads or charge battery	Charger output low voltage alarm, loss of battery charging current alarm	None: Spare battery charger available. Battery B-1B provides DC power for 2 hours minimum.

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
7	Battery Charger BC-1C	Provide DC power for steady-state load and battery B-1C charging	Loss of output	Fails to supply steady-state loads or charge battery	Charger output low voltage alarm, loss of battery charging current alarm	None: Spare battery charger available. Battery B-1C provides DC power for 2 hours minimum.
8	Battery Charger BC-1D	Provide DC power for steady-state load and battery B-1D charging	Loss of output	Fails to supply steady-state loads or charge battery	Charger output low voltage alarm, loss of battery charging current alarm	None: Spare battery charger available. Battery B-1D provides DC power for 2 hours minimum.
9	Bus 11A	Distributes power to DC loads	Bus Fault	1. Loss of Train A DC control circuits. 2. Loss of DC backup power to inverters I-1A and I-1E	Bus low voltage alarm	1. None: Train B control circuits available, or circuit components go to failsafe or channel trip positions.. 2. None: Normal 480V AC supply available or Train B available
10	Bus 11B	Distributes power to DC loads	Bus Fault	1. Loss of Train B DC control circuits. 2. Loss of DC backup power to inverters I-1B and I-1F	Bus low voltage alarm	1. None: Train A control circuits available, or circuit components go to failsafe or channel trip positions. 2. None: Normal 480V AC supply available or Train A available.
11	Bus 11C	Distributes power to DC loads	Bus Fault	1. Loss of Train A DC control circuits. 2. Loss of DC backup power to inverters I-1C and I-2A	Bus low voltage alarm	1. None: Train B control circuits available, or circuit components go to failsafe or channel trip positions.. 2. None: Normal 480V AC supply available or Train B available.

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
12	Bus 11D	Distributes power to DC loads	Bus Fault	1. Loss of Train B DC control circuits. 2. Loss of DC backup power to inverter I-1D	Bus low voltage alarm	1. None: Train A control circuits available, or circuit components go to failsafe or channel trip positions. 2. None: Normal 480V AC supply available or Train A available.
13	Battery Charger BC-1A Output Breaker - DM2	Supplies power to Bus 11A	Breaker trips open	Battery charger cannot supply charging or steady-state DC power. Battery B-1A discharge	Breaker position alarm, bus low voltage alarm	None: Battery charger may be reconnected to the bus to supply steady-state power and recharge the battery or Train B available.
14	Battery Charger BC-1B Output Breaker - DN4	Supplies power to Bus 11B	Breaker trips open	Battery charger cannot supply charging or steady-state DC power. Battery B-1B discharges	Breaker position alarm, bus low voltage alarm	None: Battery charger may be reconnected to the bus to supply steady-state power and recharge the battery or Train A available.
15	Battery Charger BC-1C Output Breaker - DP6	Supplies power to Bus 11C	Breaker trips open	Battery charger cannot supply charging or steady-state DC power. Battery B-1C discharges	Breaker position alarm, bus low voltage alarm	None: Battery charger may be reconnected to the bus to supply steady-state power and recharge the battery or Train B available.
16	Battery Charger BC-1D Output Breaker - DQ8	Supplies power to Bus 11D	Breaker trips open	Battery charger cannot supply charging or steady-state DC power. Battery B-1D discharges	Breaker position alarm, bus low voltage alarm	None: Battery charger may be reconnected to the bus to supply steady-state power and recharge the battery or Train A available.
17	Battery B-1A Output Breaker DM3	Connects battery B-1A to bus 11A	Breaker trips open	Loss of bus 11A normal battery supply	Breaker position alarmed and loss of battery charging current alarm	None: See Items 1 & 9

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
18	Battery B-1B Output Breaker DN5	Connects battery B-1B to bus 11B	Breaker trips open	Loss of bus 11B normal battery supply	Breaker position alarmed and loss of battery charging current alarm	None: See Items 2 & 10
19	Battery B-1C Output Breaker DP7	Connects battery B-1C to bus 11C	Breaker trips open	Loss of bus 11C normal battery supply	Breaker position alarmed and loss of battery charging current alarm	None: See Items 3 & 11
20	Battery B-1D Output Breaker DQ9	Connects battery B-1D to bus 11D	Breaker trips open	Loss of bus 11D normal battery supply	Breaker position alarmed and loss of battery charging current alarm	None: See Items 4 & 12
21	Battery B-1A Fuses	Protects battery cable	Fuse opens	Loss of battery B-1A	Loss of battery charging current alarm	None: See Item 1
22	Battery B-1B Fuses	Protect battery cable	Fuse opens	Loss of battery B-1B	Loss of battery charging current alarm	None: See Item 2
23	Battery B-1C Fuses	Protect battery cable	Fuse opens	Loss of battery B-1C	Loss of battery charging current alarm	None: See Item 3
24	Battery B-1D Fuses	Protect battery cable	Fuse opens	Loss of battery B-1D	Loss of battery charging current alarm	None: See Item 4
25	Bus 11A and 11C (bus inter-tie closed)	Distributes power to DC loads	Bus Fault	1. Loss of all Train A DC control circuits. 2. Loss of DC backup power to inverters I-1A, I-1C,I-1E and I-2A	Bus low voltage alarm	1. None: Train B control circuits available, or circuit components go to failsafe or channel trip positions. 2. None: Normal 480V AC supply available or Train B available.

Item	Description	Function	Failure Mode	Effect Of Failure	Detection	Safety Implication
26	Bus 11B and 11D (bus inter-tie closed)	Distributes power to DC loads	Bus Fault	1. Loss of all Train B DC control circuits. 2. Loss of DC backup power to inverters I-1B, I-1D and I-1F	Bus low voltage alarm	1. None: Train A control circuits available, or circuit components go to failsafe or channel trip positions. 2. None: Normal 480V AC supply available or Train A available.

TABLE 8.3-8 CONDITIONS THAT CAN RENDER DIESEL GENERATOR INCAPABLE OF RESPONDING TO AN AUTOMATIC EMERGENCY START SIGNAL

Condition	Specific Alarm	Common Alarm	Monitoring Lights
Barring device engaged	-	X	X
DG differential protection	X	X	X
Mode selector switch in maintenance position	-	X	X
DG control panel power lost	-	X	X
Low Low starting air pressure (Note 1)	X	X	X
Mode selector switch in local position	X	X	X
Engine shutdown due to low lube oil pressure (logic)	X	-	-
Engine shutdown due to overspeed	X	-	-
Engine fail to start	X	-	-
Low Engine Lube Oil Temp	X	X	X
Low Jacket Coolant Temp	X	X	X
Jacket Coolant Temperature Controller INOP	-	X	X
Intercooler Temperature Controller INOP	-	X	X

Note 1: Low low pressure in either air receiver.

TABLE 8.3-9 OTHER CONDITIONS THAT MAKE EMERGENCY POWER UNAVAILABLE

Condition	Specific Alarm	Common Alarm
DG breaker control power lost	-	X
Bus fault protection	X	X
DG breaker control switch in "Pull to Lock" position	-	X
EPS loss of power	X	X
Mode selector switch in local position	X	X
DG backup protection (Note 1)	X	X
DG loss of field (Note 1)	X	X
DG breaker in test position	-	X

Note 1 Diesel generator is operational under accident (safety injection) conditions; interlocks bypassed.

TABLE 8.3-10 ELECTRICAL CABLE AND RACEWAY SEPARATION CRITERIA

	Separation Distance	
	Horizontal	Vertical
Cable Tray to Cable Tray (8)		
General Plant Areas (1), (4)	3 foot	5 foot
Cable Spreading Room (2), (4)	2 inches	6 inches
Conduit-to-Cable Tray (2), (3), (4) (8)	½ inch	½ inch
Conduit-to-Conduit (2), (3)	in contact	in contact
(L Level Power, Control & instrumentation)	(0 inches)	(0 inches)
Conduit-to-Conduit (all other levels) (2), (3)	¼ inch	¼ inch
Aluminum Sheath (ALS) (2), (3), (4)	¼ inch	¼ inch
Cable-to-Cable		
Tray/Conduit		
ALS to ALS (2)	in contact	in contact
	(0 inches)	(0 inches)
Main Control Board (2), (5)	1 inch free air space or in contact with opposite sides of a barrier	1 inch free air space or in contact with opposite sides of a barrier
Westinghouse Nuclear Instr., Process Systems, Safeguards Test, and Solid-State Protection System Cabinets (6), (7)	In contact (0 inches)	In contact (0 inches)
Other Internal Panels (1), (5)	6 inches	6 inches

(1) Standard criteria from Updated FSAR Appendix 8A/IEEE 384-1974
(2) Criteria established by test and analysis (see Subsection 8.3.1.4(a))
(3) Conduit includes rigid conduit, flexible conduit, and wireway
(4) See Subsection 8.3.1.4(e) for explanation of the zero reference point for measuring separation to cable trays
(5) This separation applies to wiring and equipment
(6) Wiring within the cabinets in the main control room
(7) See Subsections 8.3.1.4 and 7.1.2.2

SEABROOK STATION
UPDATED FINAL SAFETY ANALYSIS REPORT

CHAPTER 8
ELECTRIC POWER

FIGURES

SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

[redacted]

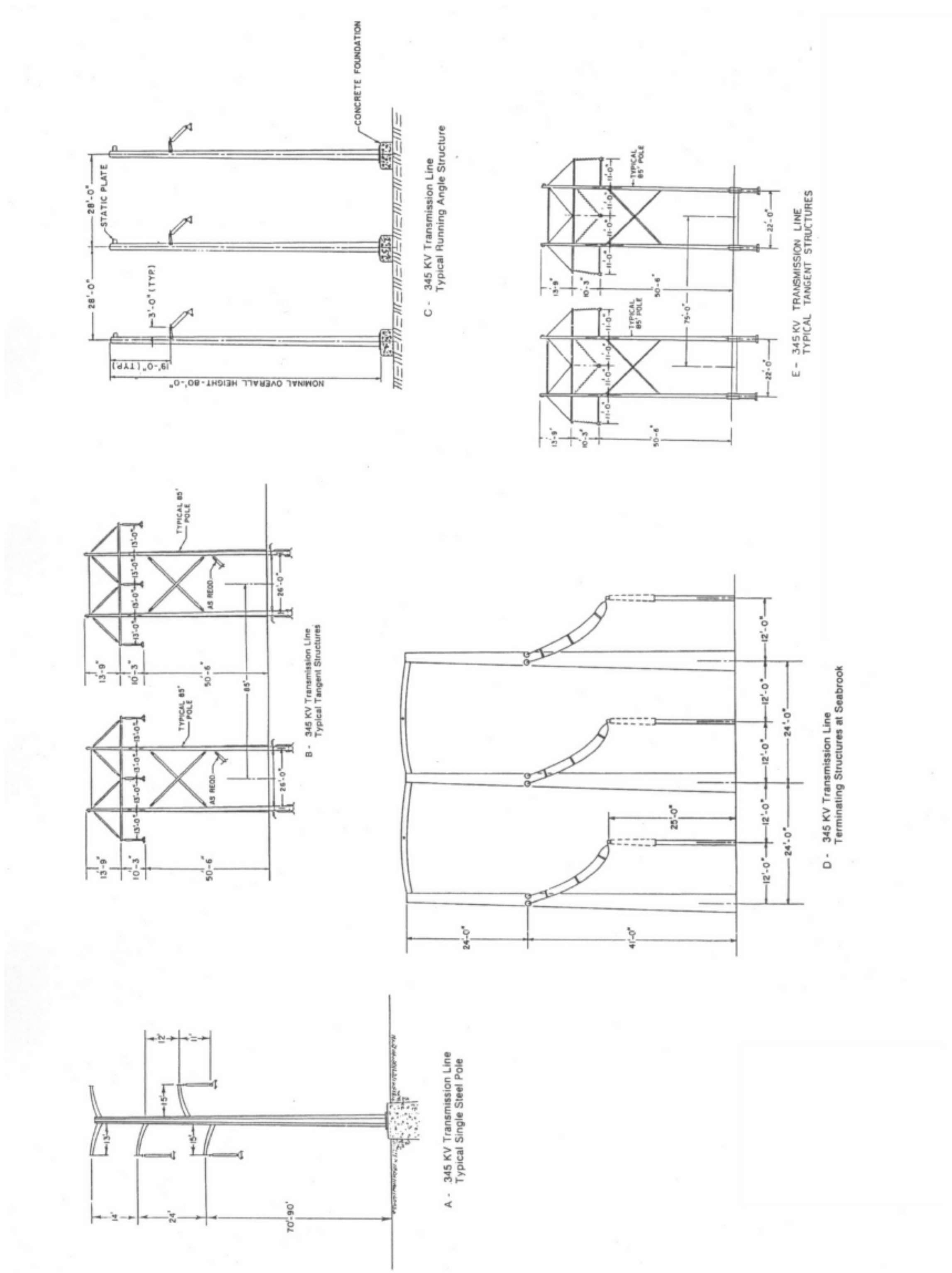
SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

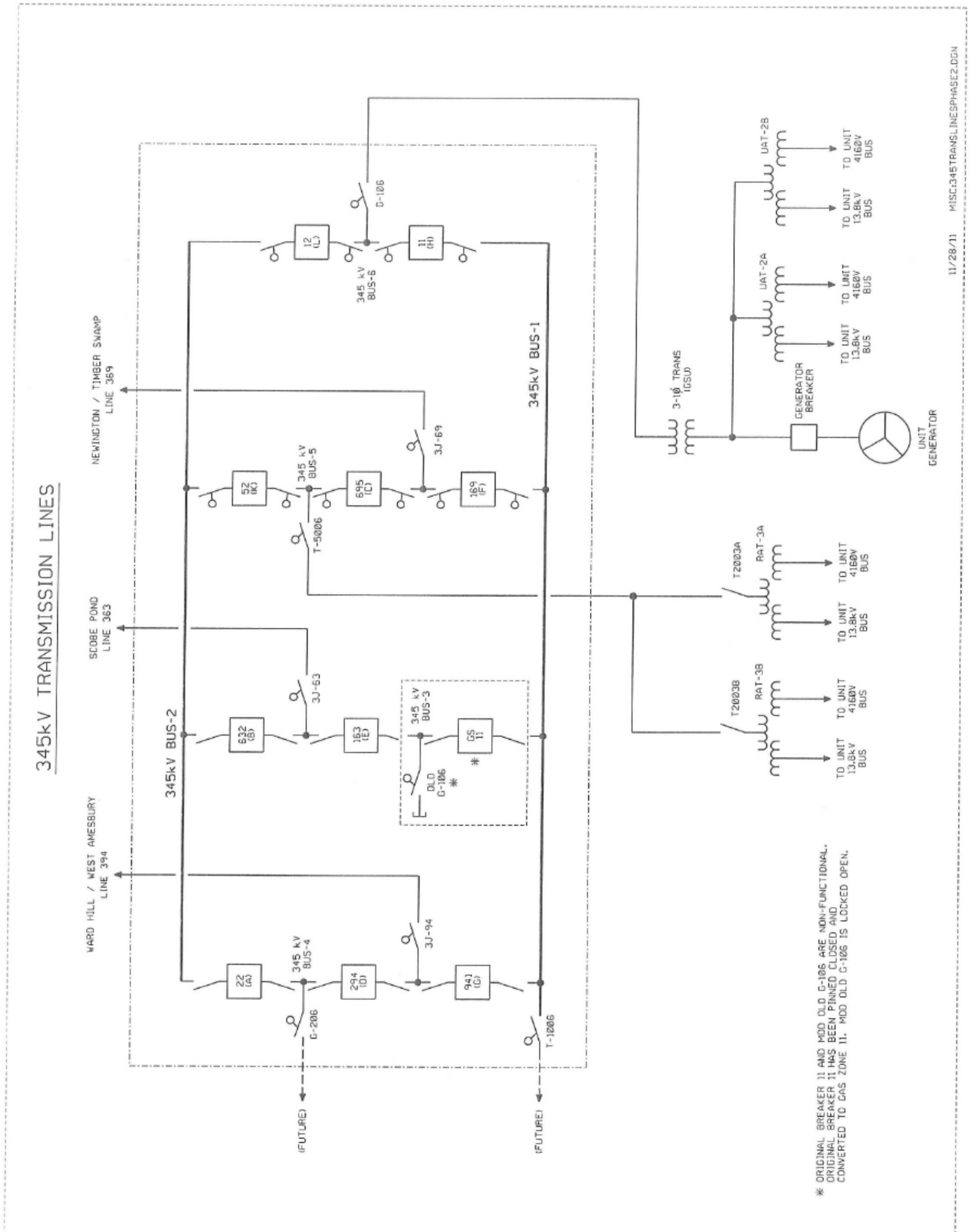
[redacted]

SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

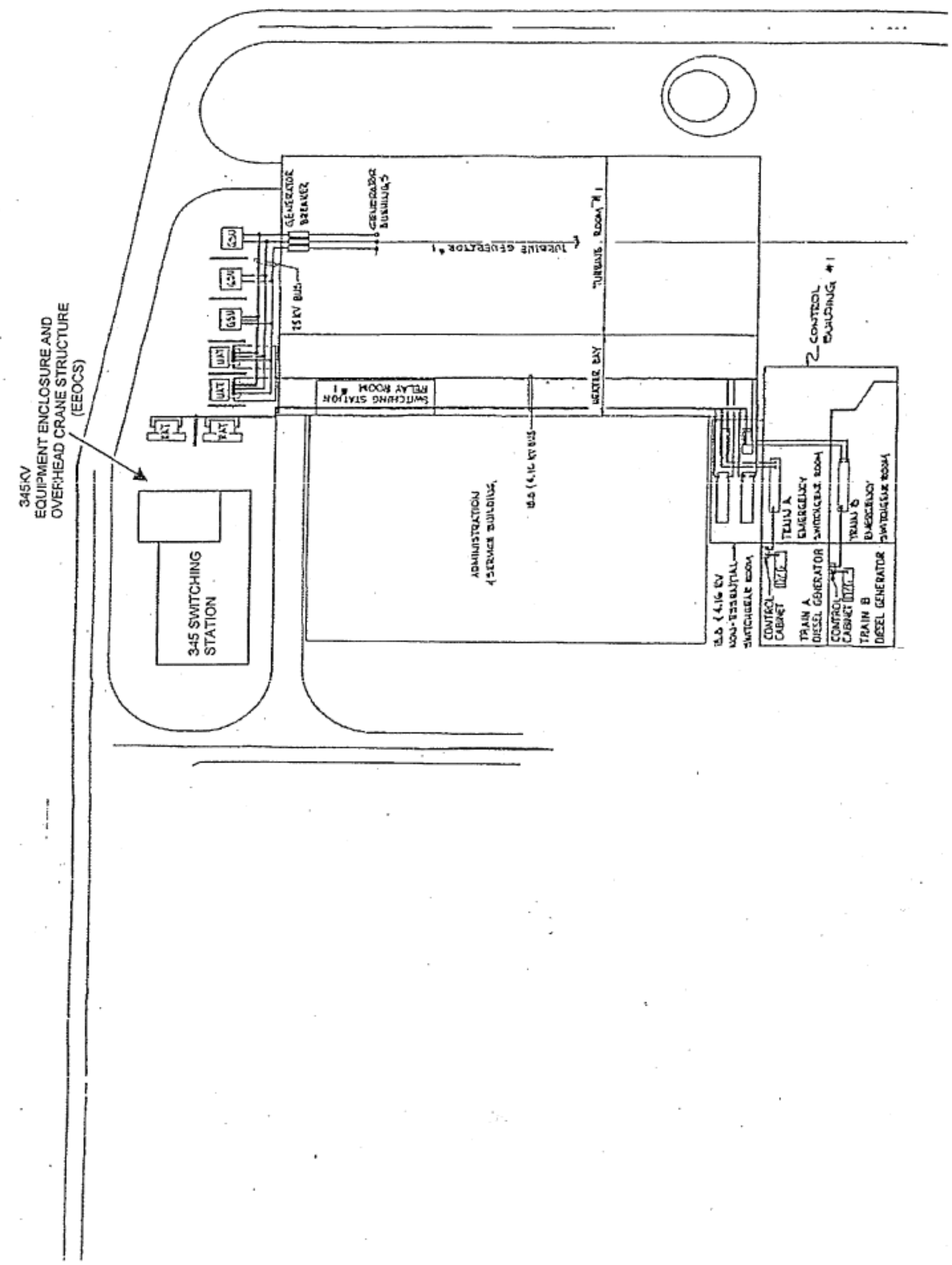
SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	345 kV Transmission Structures (Typical)	
		Figure 8-2-4



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	345 kV Switching Station One Line Diagram	
	Rev. 15	Figure 8.2-5



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	25 kV, 13.8 kV and 4.16 kV Bus Duct Arrangement	
	Rev. 13	Figure 8.2-6

See 309826

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	345 kV Switching Station Arrangement and Interconnections	
		Figure 8.2-7

See 1-NHY-309827

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	345 kV Bus Duct to Terminating Towers Arrangement	
		Figure 8.2-8

See 309830

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	345 kV Switching Station and Termination Area - Relay and Control Duct Banks	
		Figure 8.2-9 Sh. 1 of 2

See 309831

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	345 kV Switching Station and Termination Area - Relay and Control Duct Banks	
		Figure 8.2-9 Sh. 2 of 2

DEVICE	EQUIP. IDENT. NO.*	CONTROL & INDICATION		INDICATION ONLY	
		MCB & R/R	ESCC	R/R	ESCC
CIRCUIT BREAKERS	22 (5)	◆	◆		
	632	◆	◆		
	695	◆	◆		
	294 (5)	◆	◆		
	163	◆	◆		
	169	◆	◆		
	941	◆	◆		
	GS 11(1)				
	52	◆	◆		
	11(4)	◆	◆		
	12(4)	◆	◆		
MOTOR OPERATED DISCONNECT SWITCHES (3)	OLD G-106(1)				
	G-106	◆			◆
	G-206				◆
	T-1006			◆	◆
	T-5006	◆(2)			◆
	3J-94	◆	◆		
	3J-63	◆	◆		
	3J-69	◆	◆		

NOTES:

* See Figure 8.2-5 for equipment identification number assignments

(1) Breaker 11 made non-functional, pinned CLOSED, converted to Gas Zone 11 (GS11), MOD OLD G-106 made non-functional, locked OPEN.

(2) R/R control and indication only.

(3) Original switchyard equipment included manually-operated disconnects and ground switches. Replacement equipment includes motor-operated disconnects and ground switches. Motor-operated disconnects and ground switches intended for maintenance only activities are not listed in the above table.

(4) 345-kV Generator Breakers No. 11 & No. 12 are electrically interlocked so that they can be operated from the ESCC only if MOD G-106 is open or if the other of the two breakers (No. 12 or No. 11) is closed.

(5) 345-kV Generator Breakers No. 22 & No. 294 are electrically interlocked so that they can be operated from the ESCC only if MOD G-206 is open or if the other of the two breakers (No. 294 or No. 22) is closed.

LEGEND

MCB - MAIN CONTROL BOARD
R/R - RELAY ROOM
ESCC - ELECTRIC SYSTEM CONTROL CENTER

See FP-80034

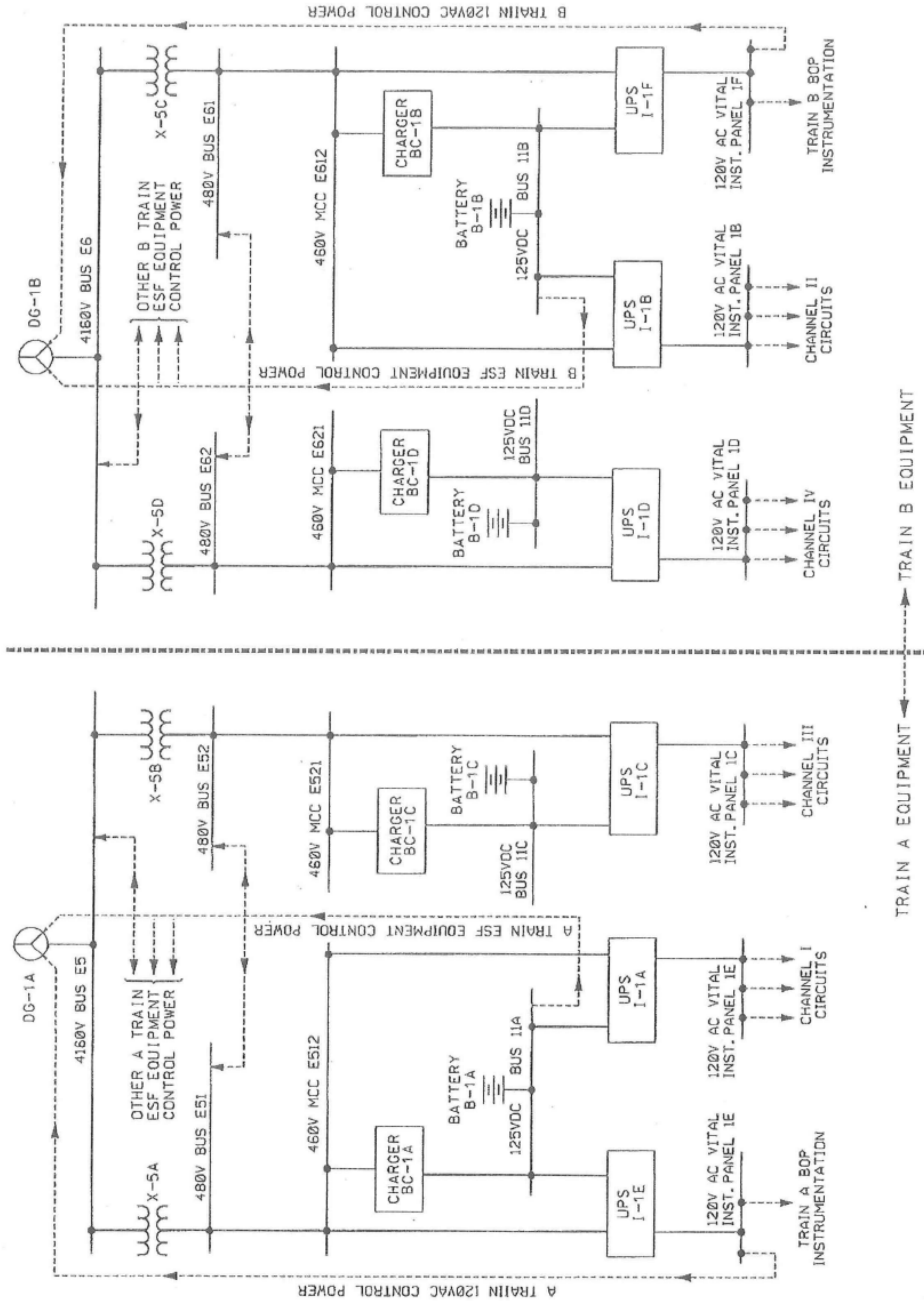
See 1-NHY-310002

Unit Electrical Distribution - One Line Diagram

Figure 8.3-1

See 1-NHY-310041

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	125V DC and 120V AC Instrument Buses - Key One Line Diagram	
		Figure 8.3-2



UFSAR Sketch DGN 7/31/2013 2:16:18 PM

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Separation of Instrument and Control Power Sources	
	Rev. 16	Figure 8.3-3

See 1-NHY-310043 Sh. 1

See 1-NHY-310043 Sh. 2

See 1-NHY-310004

See 1-NHY-310005

See 1-NHY-310009 Sh. 1

See 1-NHY-310009 Sh. 2

See 1-NHY-310007

See 1-NHY-310008

See 1-NHY-310010 Sh. 1

See 1-NHY-310010 Sh. 2

See 1-NHY-310013

See 1-NHY-310051

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	480V Unit Substation Bus 1-E53 - One Line Diagram	
		Figure 8.3-12

See 1-NHY-310014

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	480V Unit Substation Buses 1-E61 and 1-E62 - One Line Diagram	
		Figure 8.3-13

See 1-NHY-310052

See 1-NHY-301704

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	480V Unit Substation Buses 1-E64 and 2-E64 - One Line Diagram	
		Figure 8.3-15

See 1-NHY-310023

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Diesel Generator Building 460V Motor Control Center 1-E511 - One Line Diagram	
		Figure 8.3-16

See 1-NHY-310024

See 1-NHY-310057

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Control Building 460V Motor Control Center 1-E512 - One Line Diagram	
		Figure 8.3-17 Sh. 2 of 2

See 1-NHY-301705

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Cooling Tower Electrical Switchgear Room 460V Motor Control Center 1-E513 and 2-E513 - One Line Diagram	
		Figure 8.3-18

See 1-NHY-301104

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Service and Circulating Water Pump House 460V Motor Control Center 1-E514 and 2-E514 - One Line Diagram
	Figure 8.3-19

See 1-NHY-310027

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Control Building 460V Motor Control Center 1-E521 - One Line Diagram	
		Figure 8.3-20

See 1-NHY-310028

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Control Building 460V Motor Control Center 1-E522 and 1-E622 - One Line Diagram	
		Figure 8.3-21

See 1-NHY-310029

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Diesel Generator Building 460V Motor Control Center 1-E611 - One Line Diagram	
		Figure 8.3-22

See 1-NHY-310030

See 1-NHY-310058

See 1-NHY-301105

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Service and Circulating Water Pump House 460V Motor Control Center 1-E614 and 2-E614 - One Line Diagram
	Figure 8.3-24

See 1-NHY-310033

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Control Building 460V Motor Control Center 1-E621 - One Line Diagram	
		Figure 8.3-25

See 1-NHY-301706

Cooling Tower Electrical Switchgear Room 460V Motor Control Center 1-E641 and 2-E641 - One Line Diagram

Figure 8.3-26

See 1-NHY-310431

Control Building Elev. 21'-6 Electrical General Arrangement

Figure 8.3-27

See 1-NHY-310105, Sh. E01a

See 1-NHY-310105, Sh. E02a

See 1-NHY-310105, Sh. E03a

See 1-NHY-310105, Sh. E04a

See 1-NHY-310105, Sh. EH9a

See 1-NHY-310105, Sh. EHOa

See 1-NHY-310105, Sh. EISa

See 1-NHY-310105, Sh. EITa

SECURITY-RELATED INFORMATION –
WITHHELD UNDER 5 USC SECTION 552(b)(4)
AND 5 USC SECTION 552(b)(7)(F)

See 1-NHY-310042 Sh. 1

See 1-NHY-310042 Sh. 2

See 1-NHY-310059 Sh. 1

See 1-NHY-310059 Sh. 2

See 1-NHY-310107, Sh. E93a

See 1-NHY-310107, Sh. E87a

See 1-NHY-310107, Sh. E94a

See 1-NHY-310107, Sh. E88a

[redacted]

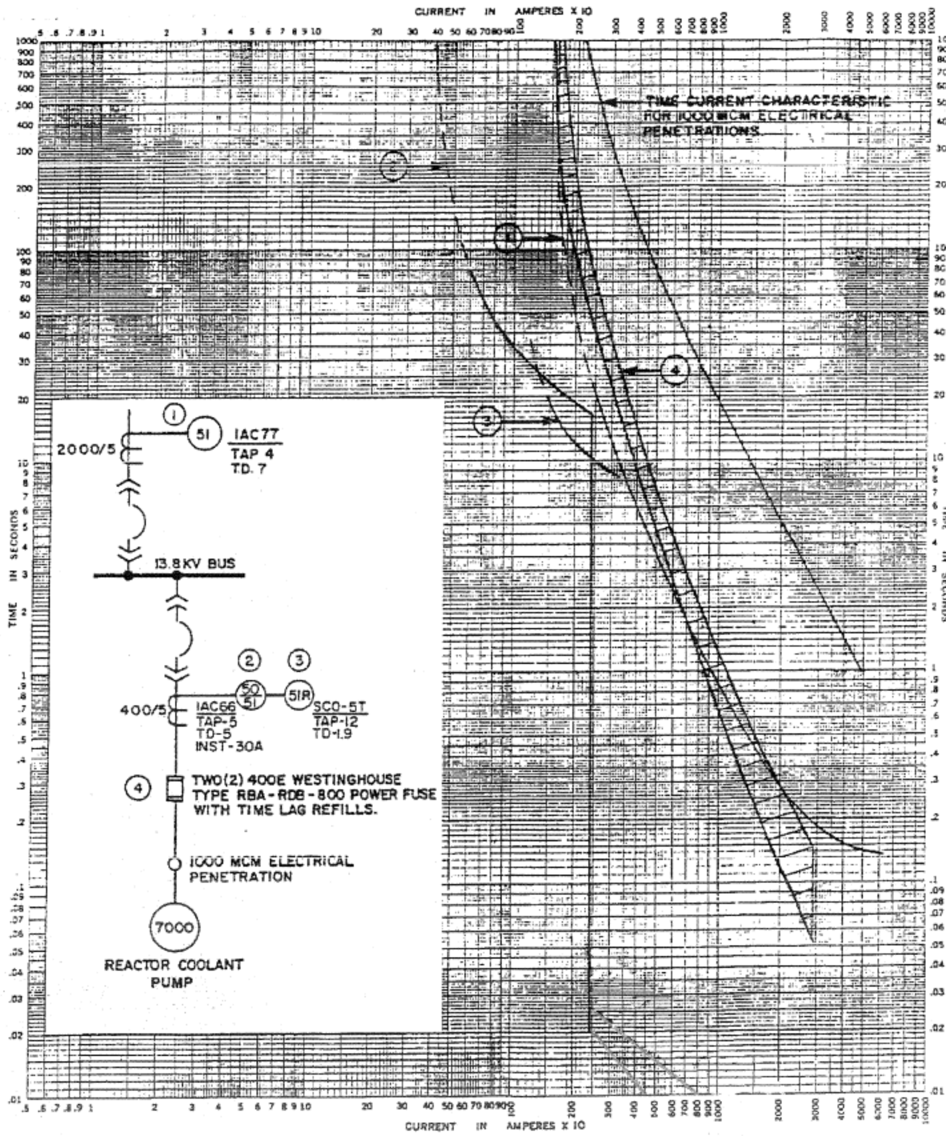
SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

[redacted]

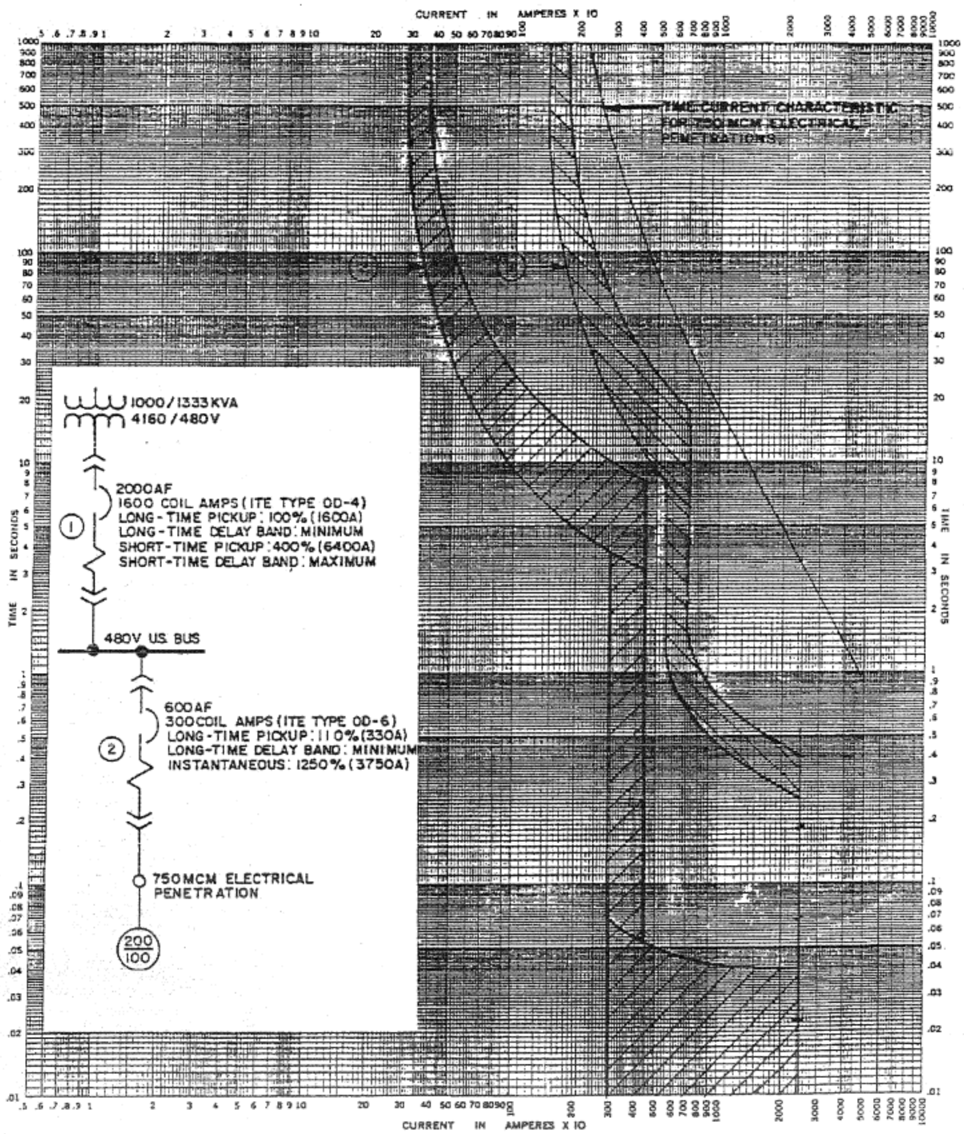
SECURITY-RELATED INFORMATION – WITHHELD UNDER 5 USC SECTION 552(b)(4) AND 5 USC SECTION 552(b)(7)(F)

See 1-NHY-310890, Sh. B43a

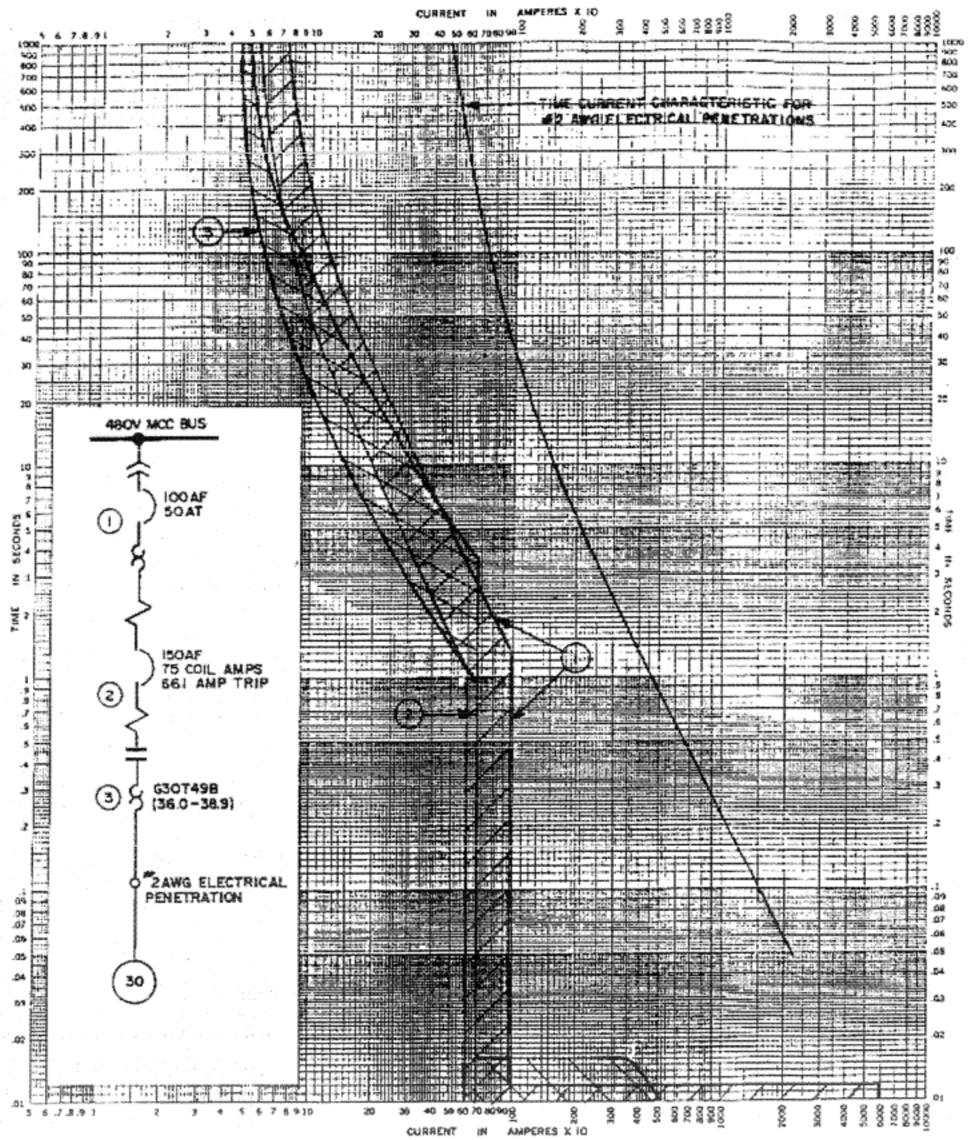
See 1-NHY-310108, Sh. 5a



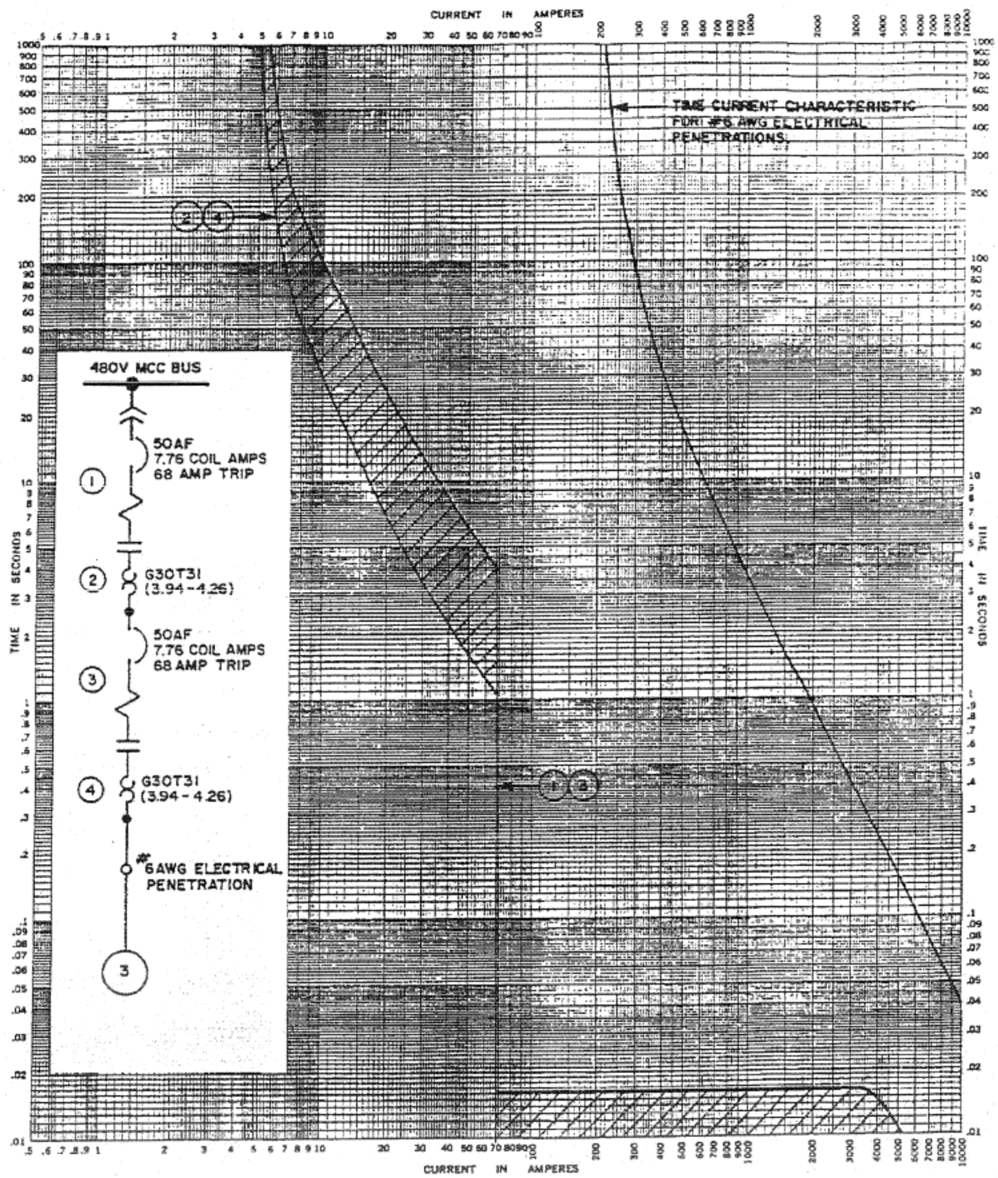
SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Protection of 13.8 kV Containment Electrical Penetrations for Reactor Coolant Pump Feeders	
		Figure 8.3-47



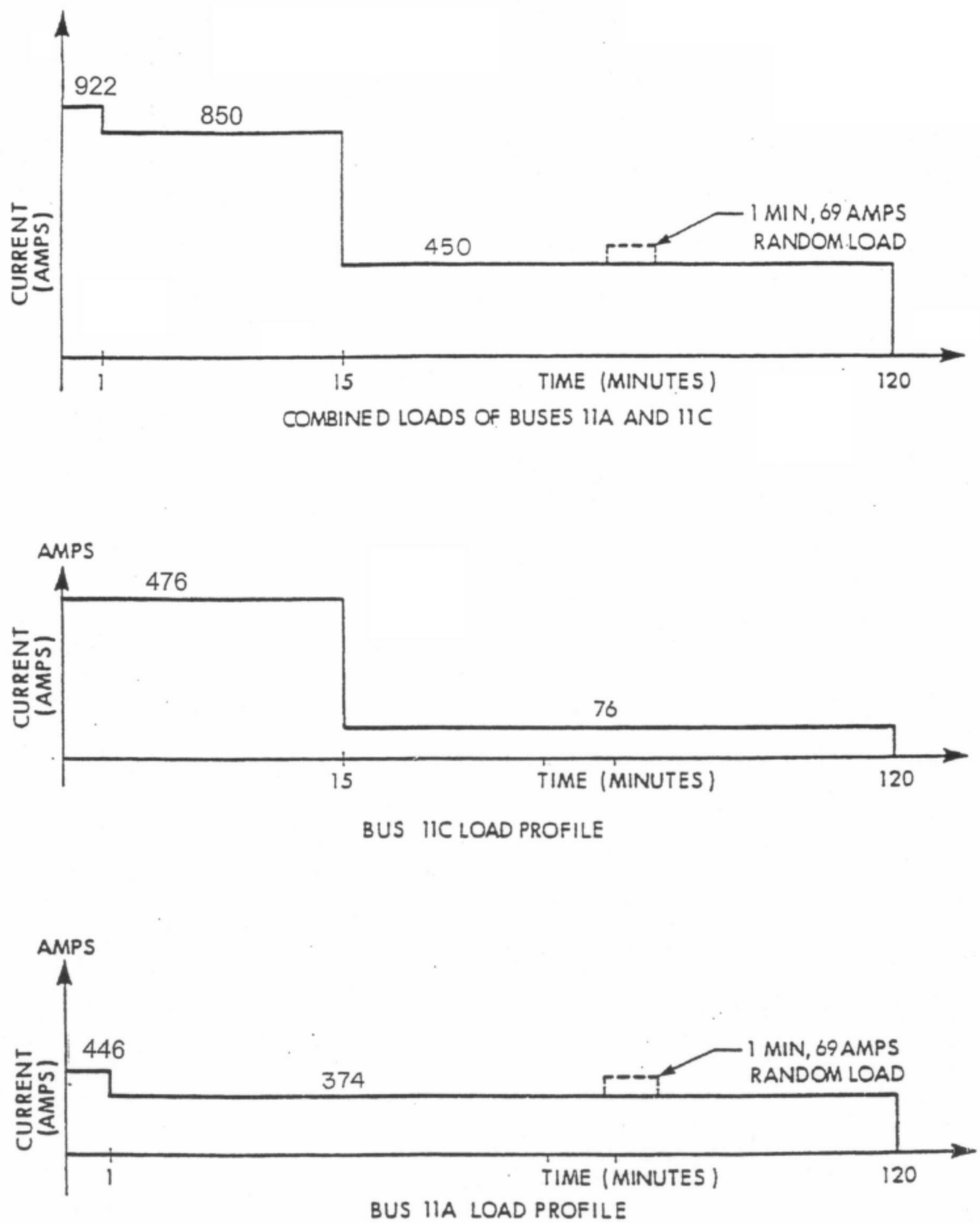
SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Protection of 480 V Containment Electrical Penetrations Typical For Motors Feed From 480 V Unit Substations	
		Figure 8.3-48



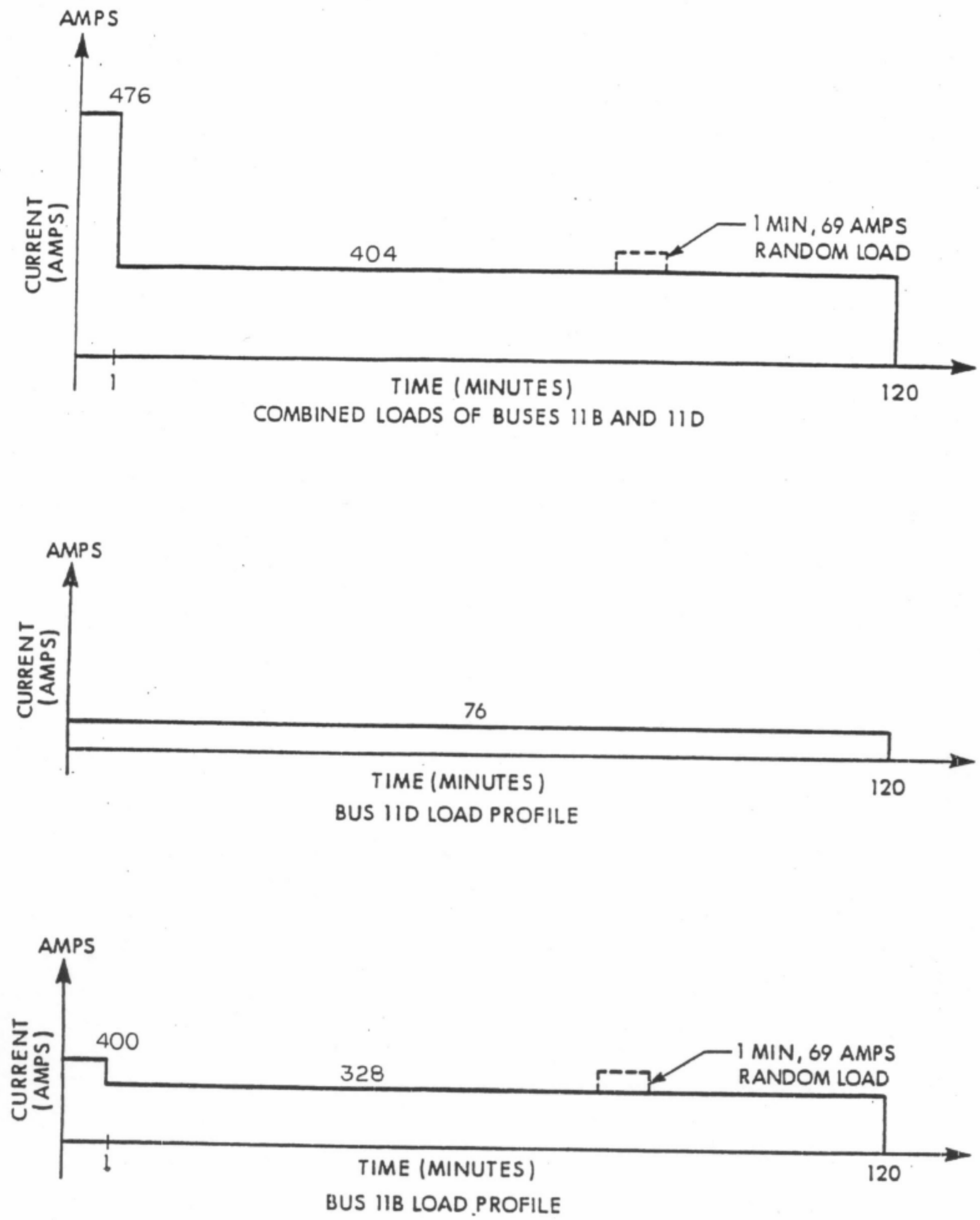
SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Protection of 480V Containment Electrical - Typical for Motors Greater Than 5 HP Fed From 460V MCCs	
		Figure 8.3-49



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Protection of 480V Containment Electrical Penetrations - Typical for Motors Less Than 5 HP Fed From 460V MCCs	
		Figure 8.3-50



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Train A and Train B Batteries Duty Cycle Diagrams
	Figure 8-3-51 Sh. 1 of 2



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Train A and Train B Batteries Duty Cycle Diagrams	
		Figure 8-3-51 Sh. 2 of 2

See 1-NHY-310032

See 1-NHY-310067

See 1-NHY-310026

See 1-NHY-310066

See 1-NHY-310046

SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Turbine Building 460V Motor Control Center 1-E523 One-Line Diagram	
		Figure 8.3-54

CABLE SEPARATION GROUPS

	PURPOSE	INSULATION LEVEL	A	B	C	D
CHANNEL and/or TRAIN	POWER	15000 V	○ ⊔	○ ⊔		
		5000 V	○ ⊔ ⊓	○ ⊔ ⊓		
		600 V (1)	○ ⊔	○ ⊔		
		600 V (2)	○ ⊔	○ ⊔		
		600 V (3)	○ ⊔			
	CONTROL	600 V	○ ⊔	○ ⊔	○ ⊔	○ ⊔
	LOW LEVEL INSTRU.	300 V	○ ⊓	○ ⊓	○ ⊓	○ ⊓
		SPECIAL	○	○	○	○
		CIRCUIT TYPES	TR A CH I A Associated	TR B CH II B Associated	CH III	CH IV
CABLE JACKET COLOR		Class IE	Red	White	Blue	Yellow
		Associated	Black/Red	Black/White		

NOTES:

(1) For 480 VAC, 120 VAC & 125 VDC feeders requiring cables 4/0 AWG and larger.

(2) For 480 VAC, 120 VAC & 125 VDC feeders requiring cables 2/0 AWG and smaller.

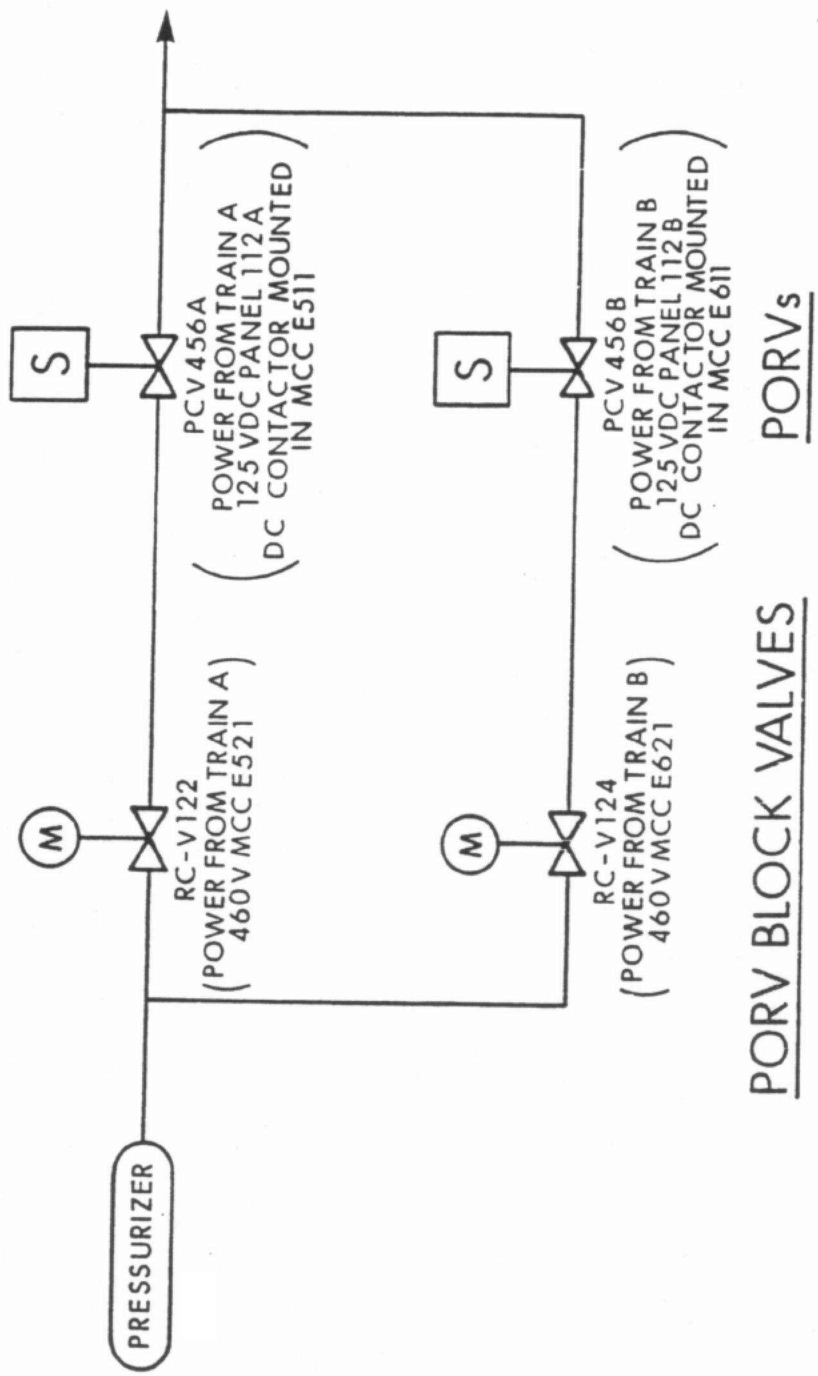
(3) Reserved for Control Rod Drive power feeders only.

SEABROOK STATION
UPDATED FINAL SAFETY
ANALYSIS REPORT

Cable Separation Groups

Figure 8.3-55

See 1-NHY-300210



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Pressurizer Relief Valves-Diverse Power Supplies
	Figure 8.3-57

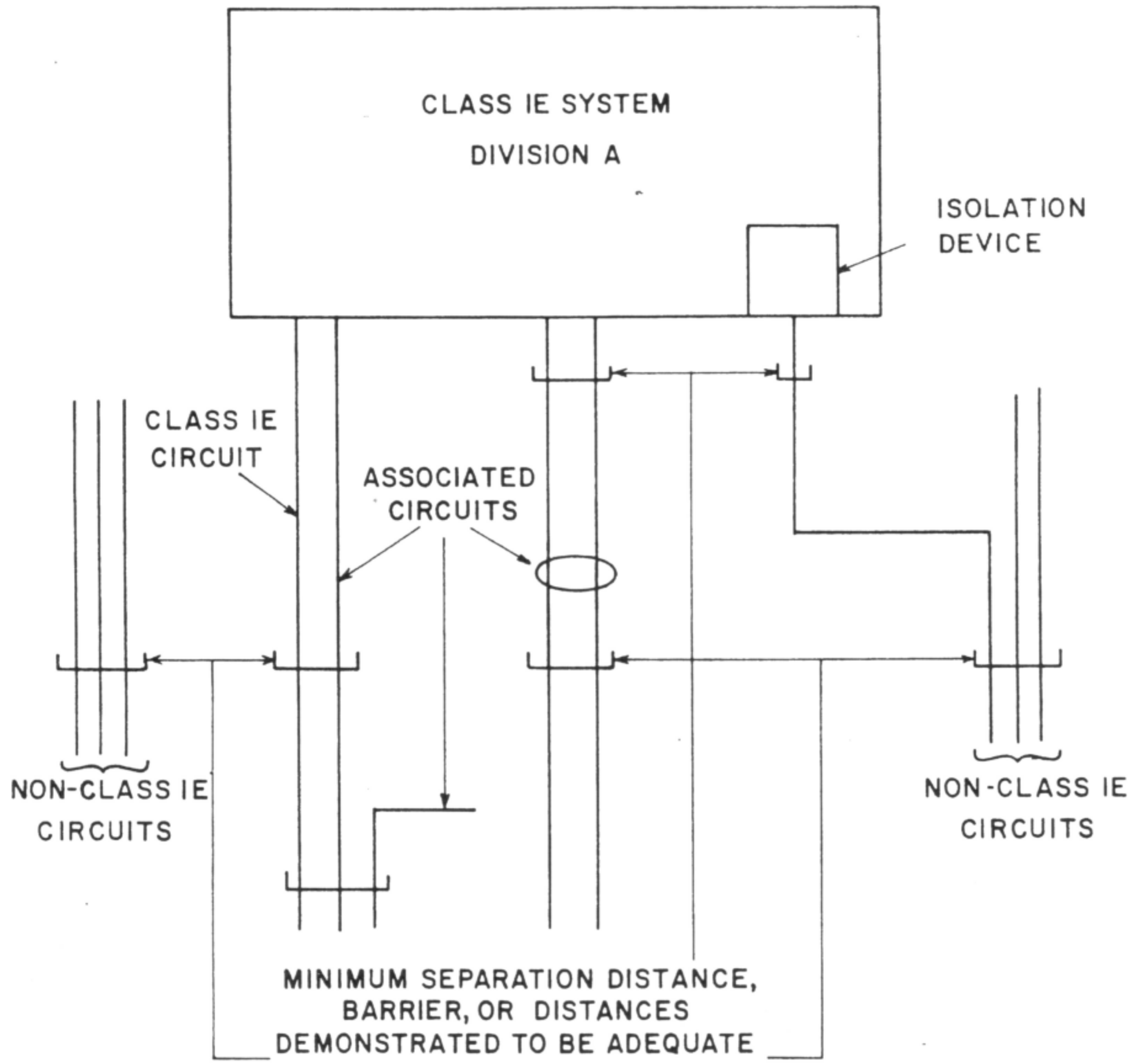
See 1-NHY-310107, Sh. EG1a

See 1-NHY-310107, Sh. EG2a

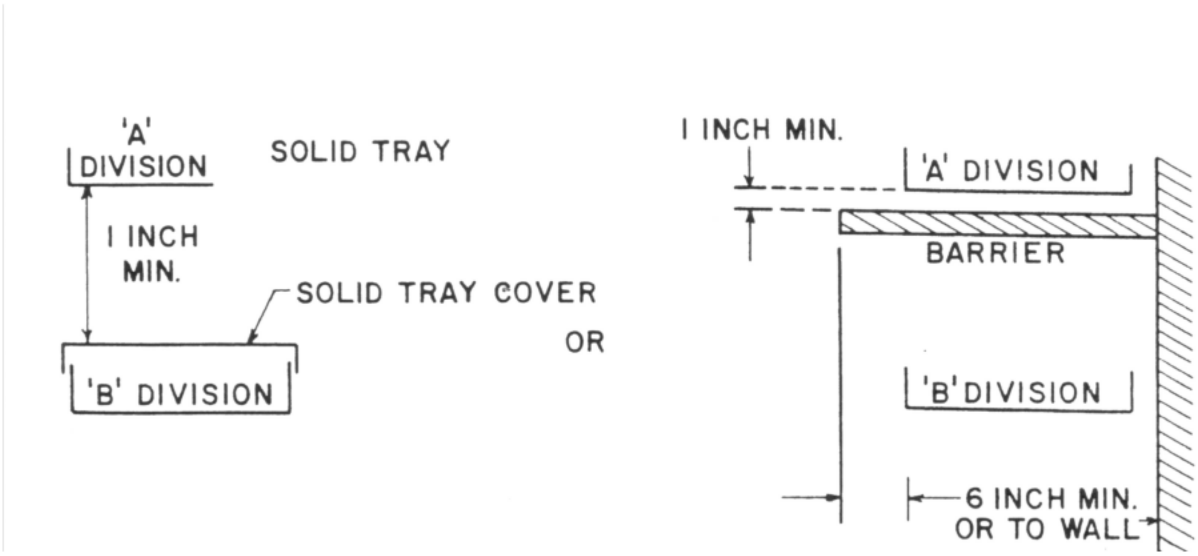
SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	125V DC Bus 1 - SWG-11D Distr. Panel 1-PP-111D Schedule	
		Figure 8.3-59

See 1-NHY-310107, Sh. E2Ta

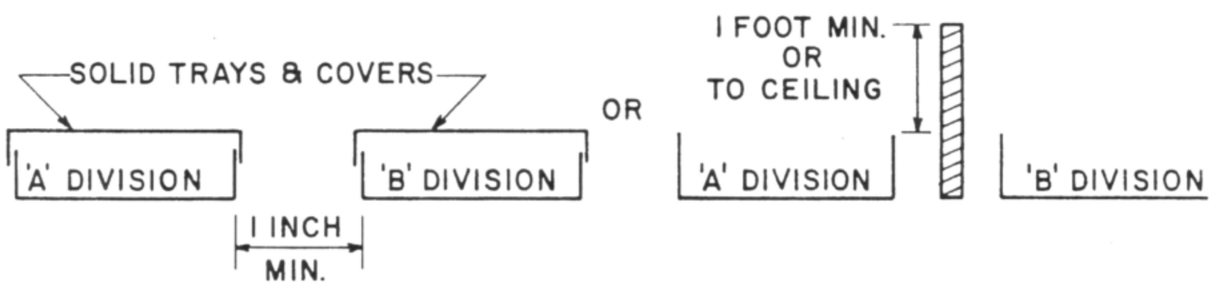
See 1-NHY-310107, Sh. E2Ua



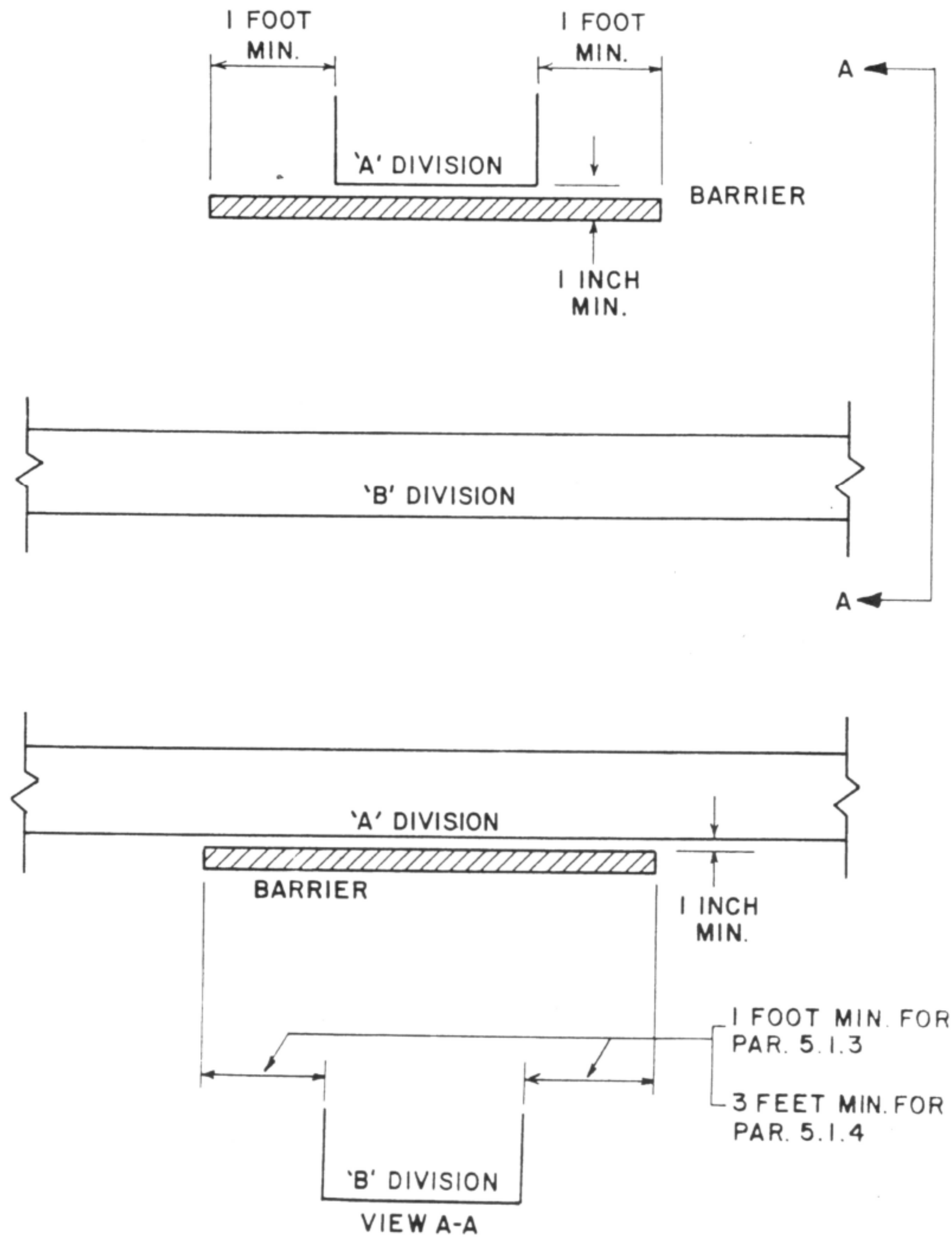
SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Example of Acceptable Circuit Arrangements	
		Figure 4.0



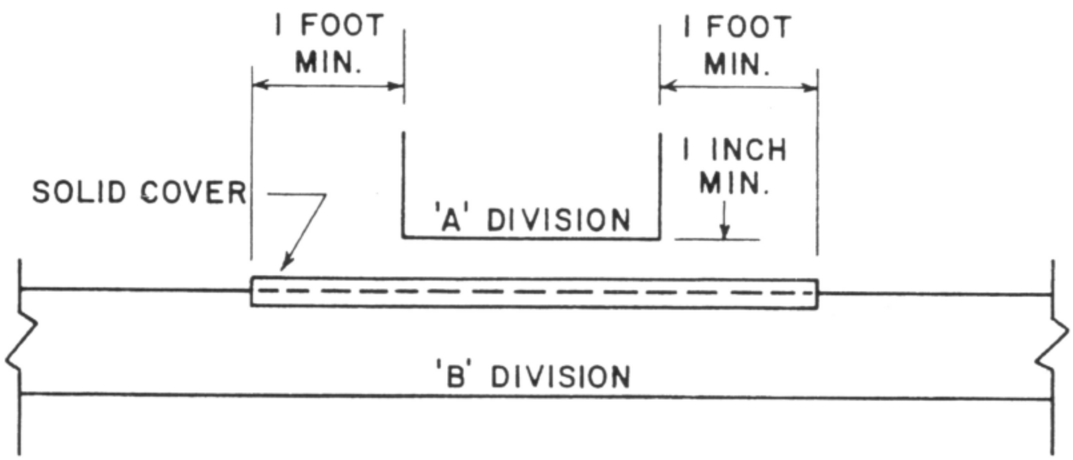
SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Example of Acceptable Arrangement Where Vertical Separation Distance Cannot Be Maintained	
		Figure 5.1



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Example of Acceptable Arrangement Where Horizontal Separation Distance Cannot Be Maintained	
		Figure 5.2



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Example of Acceptable Arrangement For Redundant Cable Tray Crossings Where Vertical Separation Distance Cannot Be Maintained	
		Figure 5.3



SEABROOK STATION UPDATED FINAL SAFETY ANALYSIS REPORT	Example of Acceptable Arrangement For Redundant Cable Tray Crossings Where Vertical Separation Distance Cannot Be Maintained	
		Figure 5.4