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8.0 Electric Power

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8.1 Introduction

An offsite power system and an onsite power system are provided for each unit at the Catawba Nuclear Station to supply the unit auxiliaries during normal operation and the Reactor Protection System and Engineered Safety Features Systems during abnormal and accident conditions.

8.1.1 Utility Grid System and Interconnections

Duke Power Company is an investor-owned utility serving the Piedmont region of North Carolina and South Carolina. The Duke transmission system consists of interconnected hydro plants, fossil-fueled plants, combustion turbine units, and nuclear plants supplying energy to the service area at various voltages up to 525kV. The transmission system is interconnected with neighboring utilities, and together, they form the Virginia-Carolina (VACAR) Subregion of the Southeastern Electric Reliability Council (SERC).

Each Catawba Unit is connected to a common 230kV switchyard and thereby to the Duke 230kV transmission system via two separate and independent transmission lines. The implementation of generator circuit breakers at Catawba, along with the use of two half-size unit step-up transformers, allows these two lines not only to supply power to the transmission system during normal operation, but also to serve as two immediate access sources of preferred power.

A detailed description of the offsite power system is provided in Section 8.2.

8.1.2 Onsite Power Systems

The onsite power system for each unit consists of the main generator, the generator circuit breakers, the unit auxiliary transformers, the diesel generators, the emergency supplement power source, the batteries, and the auxiliary power system. Under normal operating conditions, the main generator supplies power through isolated phase bus and generator circuit breakers to the unit step-up and unit auxiliary transformers which are located adjacent to the Turbine Building. The unit auxiliary transformers are connected to the bus between the generator circuit breaker and the associated unit step-up transformer. During normal operation, station auxiliary power is supplied from the main generator through these unit auxiliary transformers. During startup and shutdown, the generator circuit breakers are open, and station auxiliary power is supplied from the 230kV system through the unit step-up and unit auxiliary power transformers.

The Class 1E loads for each unit are divided into two redundant and independent load groups. Each of these load groups is capable of being supplied from offsite (preferred) power or in the event that the preferred source is unavailable, each load group is provided with a diesel generator which serves as a standby power supply.

Each unit has a 125VDC Vital Instrumentation and Control Power System to provide power to the Class 1E dc loads other than those associated with the diesel generators. This system also provides power to Class 1E 120VAC loads through inverters. Each diesel generator is furnished with a battery and charger to provide power to the dc loads associated with the diesel generators. Additionally, each unit has a 125VDC Auxiliary Control Power System and a 250VDC Auxiliary Power System to supply non-Class 1E dc loads.

The onsite power systems for one unit and their interconnection with the offsite power system are shown on Figure 8-1.

The onsite power systems are described in detail in Section 8.3.

8.1.3 Safety-Related Loads

The Class 1E loads that require electric power to perform their safety function are identified in Table 8-1. This table includes the safety load, the safety function performed, and the type of electric power (ac or dc) required by the load.

8.1.4 Design Bases

The design bases for the offsite power system and the onsite power system are presented below.

Offsite Power System

1. Each of the two offsite power circuits has sufficient capacity, is continuously energized, and is available to supply power to the plant safety-related systems within a few seconds following a loss of coolant accident (LOCA) to assure that core cooling, containment integrity, and other vital safety functions are maintained.
2. The two offsite power circuits (not to include the switchyard) are designed to be independent and physically separate to assure their availability under normal and postulated accident conditions.

Onsite Power System

1. The Class 1E onsite power systems are located in Category I structures to provide protection from natural phenomena.
2. The Class 1E onsite power systems are designed with adequate independence and redundancy to assure that their safety functions can be performed assuming a single failure.
3. The Class 1E onsite power systems have sufficient capacity to safely shutdown the unit or to mitigate the effects of an accident assuming a blackout.
4. The Class 1E onsite power systems are designed to permit appropriate surveillance, periodic inspections, and testing of important areas and features to assess the continuity of the systems and the condition of their components.
5. The onsite standby ac power sources are designed to be automatically initiated in the event of an accident or a loss of offsite power.
6. The vital batteries have adequate capacity for a period of two hours, without chargers, to provide the necessary dc power to perform the required safety functions in the event of a postulated accident assuming a single failure. Calculations and testing have verified that the Catawba batteries have sufficient capacity to supply required loads for four hours during a Blackout event.
7. Each vital battery charger has adequate capacity to supply its assigned steady-state loads while simultaneously recharging its associated battery.

8.1.5 Design Criteria

The design criteria including the General Design Criteria, NRC Regulatory Guides, and IEEE Standards that are considered in the design of the Class 1E ac and dc power systems are presented and discussed below.

8.1.5.1 General Design Criteria

The General Design Criteria of 10CFR 50 Appendix A are discussed in Section 3.1. Additionally, compliance with General Design Criteria 17 and 18 is discussed in Sections 8.2.1.4, 8.3.1.2, and 8.3.2.2.

8.1.5.2 NRC Regulatory Guides

REGULATORY GUIDE 1.6 (Safety Guide 6)

The design of the Class 1E onsite power systems, both ac and dc, complies with the recommendations of Regulatory Guide 1.6 as discussed in Sections 8.3.1.2.3 and 8.3.2.2.3.

REGULATORY GUIDE 1.9 (Safety Guide 9)

The selection criteria for the diesel generators used as standby power sources complies with the requirements of Regulatory Guide 1.9 as discussed in Section 8.3.1.2.4.

REGULATORY GUIDE 1.22 (Safety Guide 22)

Periodic testing of the Class 1E power systems is in accordance with the recommendations of Regulatory Guide 1.22 as discussed in Sections 8.3.1.1.2.3.2 and 8.3.2.1.2.3.2.

REGULATORY GUIDE 1.29 (Revision 3)

Class 1E power system equipment is classified as Seismic Category I in accordance with the recommendations of Regulatory Guide 1.29. Category I electrical equipment is discussed in Section 3.10.

REGULATORY GUIDE 1.30 (Safety Guide 30)

The quality assurance requirements for the installation, inspection, and testing of Class 1E electrical equipment is discussed in Chapter 17.

REGULATORY GUIDE 1.32 (Safety Guide 32)

The design of the Class 1E onsite power systems, both ac and dc, complies with the recommendations of Regulatory Guide 1.32 as discussed in Sections 8.3.1.2.5 and 8.3.2.2.4.

REGULATORY GUIDE 1.40 (Revision 0)

The qualification of continuous duty Class 1E motors installed inside the containment is discussed in Section 3.11.

REGULATORY GUIDE 1.41 (Revision 0)

Preoperational testing to verify the assignment of loads for the Class 1E power systems is discussed in Chapter 14.

REGULATORY GUIDE 1.47 (Revision 0)

Automatic indication of a bypass or deliberately induced inoperable status is provided for Class 1E power systems required for safety. Bypassed and inoperable status indication is discussed in Section 7.8.

REGULATORY GUIDE 1.53 (Revision 0)

The Class 1E onsite power systems, both ac and dc, have sufficient independence and redundancy to perform their safety function assuming a single failure.

REGULATORY GUIDE 1.62 (Revision 0)

Means for manual initiation of Class 1E power systems required for safety are provided in the control room in accordance with the recommendation of Regulatory Guide 1.62.

REGULATORY GUIDE 1.63 (Revision 1, Supplemented 2/78)

The mechanical, electrical, and test requirements set forth in Regulatory Guide 1.63 for the design, construction, and installation of electric penetration assemblies in the containment structure are met with the following clarification to Paragraph C.1:

To assure that the failure of a single overload protective device will not allow a fault current which could cause a loss of mechanical integrity, the incorporation of two circuit overload protective devices in series (two fuses, a circuit breaker and a fuse, or two circuit breakers) are used.

Those circuits which are incapable of supplying a fault current sufficient to cause a loss of mechanical integrity of the penetration do not require circuit overload protection (e.g., thermocouple instrumentation circuits, annunciator and computer points). The margin between the maximum available fault current of these circuits and the rated continuous operating current of the penetration device are listed below:

PENETRATION TYPE	MAXIMUM AVAILABLE FAULT CURRENT	RATED CONTINUOUS OPERATING CURRENT	MARGIN
K	2.5A	5.0A	2.5A
L	0.5A	5.0A	4.5A
H	mA range	1.5A	0.5A
J (coax cable)	0.5A	1.5A	1.0A
(non-coax cable)	0.5A	5.0A	4.5A
M	mA range	3.0A	2.0A

For information regarding the environmental qualification of electrical penetrations, refer to Section 3.11.

REGULATORY GUIDE 1.73 (Revision 0)

The qualification of Class 1E electric valve operators located inside containment is discussed in Section 3.11.

REGULATORY GUIDE 1.75 (Revision 1)

The recommendations of Regulatory Guide 1.75 are not applicable to Catawba based on the implementation date of the guide. The independence of redundant systems is discussed in Sections 7.1.2.2 and 8.3.1.4.

REGULATORY GUIDE 1.81 (Revision 1)

The recommendations of Regulatory Guide 1.81 are not applicable to Catawba based on the implementation date of the guide. The intent of this guide is met in that the Class 1E ac and dc power systems are not shared between units. Capability is provided to connect a source of preferred power from either unit to the Class 1E ac power system of the remaining unit as discussed in Section 8.3.1.1.2.1.

REGULATORY GUIDE 1.89 (Revision 0)

Compliance with Regulatory Guide 1.89 is discussed in Section 1.7.

REGULATORY GUIDE 1.93 (Revision 0)

The recommendations of Regulatory Guide 1.93 are not applicable to Catawba based on the implementation date of the guide. The availability of electric power sources with respect to limiting conditions for operation is presented in the Technical Specifications.

REGULATORY GUIDE 1.100 (Revision 1)

The seismic qualification of Category I instrumentation and electrical equipment is discussed in Section 3.10.

REGULATORY GUIDE 1.106 (Revision 1)

The application of thermal overload protection devices in Class 1E motor operated valve circuits is in compliance with Regulatory Guide 1.106, i.e., thermal overload protection devices are used to provide alarm functions only and are continuously bypassed for tripping functions during normal plant operations.

REGULATORY GUIDE 1.108 (Revision 1)

The periodic testing requirements for the safety-related diesel generators are presented in the Technical Specifications. Regulatory Guide 1.108 has been withdrawn. Catawba's diesel generator reliability testing program is in compliance with Regulatory Guide 1.9 or Catawba's diesel generator reliability is maintained in accordance with the Maintenance Rule as discussed in Regulatory Guide 1.160.

REGULATORY GUIDE 1.118 (Revision 2)

The periodic testing requirements of the electric power and protection systems are presented in the Technical Specifications.

REGULATORY GUIDE 1.128 (Revision 1)

The installation design and installation of Class 1E Batteries is in compliance with Regulatory Guide 1.128 with the following exceptions:

1. A hydrogen survey is not performed or recorded since the amount of hydrogen present during recharging is very small and there are no closed areas in the battery rooms.

   Battery room air flow calculations indicate that a total of 5,700 cubic feet of air per hour will be exchanged with outside air by redundant Class 1E HVAC systems. This means that the air in each battery room will be replaced with outside air more than four times per hour. In the event of failure of the HVAC system, the redundant air system will be activated.

   According to IEEE 484-1975 Section 4.1.4, the maximum hydrogen rate is 0.000269 cubic feet per minute per charging ampere.

   For the NCN-21, 1495 ampere-hour battery, the maximum possible hydrogen rate per hour is 18.48 cubic feet of hydrogen per 60 cell battery. This value assumes that the charger malfunctions and delivers a constant maximum voltage of 155 VDC.

   Based on these calculations, the hydrogen levels in the battery rooms will never exceed 1% and, therefore, it is not possible for a dangerous level of hydrogen to accumulate in any battery room.

2. The diesel generator batteries are flooded lead-acid and the racks are constructed with two tiers. Since the cells involved are very small and easily manageable, problems with cell temperature differences and maintenance are insignificant.

REGULATORY GUIDE 1.129 (Revision 1)

The recommendations of Regulatory Guide 1.129 are not applicable to Catawba based on the implementation date of the guide.

REGULATORY GUIDE 1.131 (Revision 0)

The qualification testing of electric cables, field splices, and connections is discussed in Section 3.11.

REGULATORY GUIDE 1.155 (August 1988)

The ability of Catawba to respond to a Station Blackout is addressed in Section 8.4.

8.1.5.3 IEEE Standards

IEEE 387-1977

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

The preoperational and periodic testing of the emergency diesel generators complies with the requirements of IEEE 387-1977 as discussed in Sections 8.3.1.1.3.9 and 8.3.1.1.3.10.

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8.2 Offsite Power System

8.2.1 System Descriptions

8.2.1.1 Utility Grid System

The primary transmission system of Duke Power Company consists of a highly integrated 525/230kV loop network. Underlying the primary transmission system is an extensive 100kV sub-transmission network integrated into the primary system by means of 230/100kV tie stations. The Duke transmission system is shown on Figure 8-2.

The Duke transmission system and its contiguous neighbors comprise the VACAR Subregion of the Southeastern Electric Reliability Council (SERC). All the companies in the region are interconnected such that the combined networks operate as a single, integrated system.

The 525kV transmission system is constructed of two-conductor, bundled, single-circuit lines supported on latticed-steel towers with the three phases in a horizontal plane. The 230kV transmission system is of double circuit, vertical, configuration supported on latticed steel towers or tapered steel poles. When dictated by circuit loading conditions, two-conductor bundled circuits are also used on the 230kV system.

The design specifications for the 525kV and 230kV steel transmission structures are summarized in Table 8-2.

8.2.1.2 Utility Grid and Switchyard Interconnections

The Catawba switchyard is connected to the primary transmission system by six 230kV double-circuit overhead transmission lines as shown on Figure 8-4. A description of each of these transmission lines is provided in Table 8-3 along with references to appropriate Figure 8-5 through Figure 8-9 and Figure 8-28.

8.2.1.3 Station Switchyard

The general arrangement of the Catawba 230kV switchyard is shown in Figure 8-10. The switchyard is designed in a breaker-and-a-half scheme which allows any one of the power circuit breakers (PCB's) to be isolated from the grid without de-energizing any transmission line or affecting the integrity of the switchyard.

Six double-circuit transmission lines from the primary transmission system terminate in the switchyard with provisions for three additional double-circuit lines to be added in the future. Additionally, each Catawba unit is tied to the 230kV switchyard by two separate and independent overhead lines designated feeders A and B.

The entire switchyard, including the power circuit breakers, cabling system, ac and dc auxiliary power systems, protective relaying system, and control system is divided into two power trains also designated A and B. These designations are consistent with the preferred power feeder designations. Additionally, the incoming transmission lines are also assigned to power trains in such a way as to separate the associated cabling, protective relaying, and controls for each circuit of the double-circuit transmission lines into two distinct sources of offsite power.

The Catawba 230kV switchyard design assures the independence of the redundant offsite power feeders to each nuclear unit.

8.2.1.3.1 230kV Switchyard 480VAC Auxiliary Power System

A 480VAC Auxiliary Power System is provided in the switchyard to supply a reliable source of continuous ac power for the power circuit breaker auxiliaries, battery chargers, relay house air conditioning, and switchyard lighting. This system is composed of two independent 6900/480 volt, outdoor load centers. The load centers are located on the south side of the switchyard relay house and provide ac auxiliary power to their respective preferred power train equipment.

The status of this system is monitored in the switchyard relay house with annunciators and in the Catawba control room via the switchyard supervisory system.

8.2.1.3.2 230kV Switchyard 125VDC Auxiliary Power System

A 125VDC Auxiliary Power System, shown on Figure 8-11, is provided to supply a reliable source of continuous dc power for all relaying, control, and monitoring equipment in the switchyard. This system consists of two independent trains each supplying dc power to its associated preferred power train equipment.

Ground detection and undervoltage monitoring is provided for each train of this system with annunciators located in the switchyard relay house and in the Catawba control room.

8.2.1.3.3 230kV Switchyard Protective Relaying System

The 230kV Switchyard Protective Relaying System is provided to protect switchyard equipment and to contribute to power system stability by promptly and reliably removing a transmission line and/or switchyard bus from service under a fault or an abnormal condition. The switchyard protective relaying equipment is located in the switchyard relay house and is physically and electrically separated into two independent trains corresponding to preferred power trains A and B.

The primary relaying for all transmission lines consists of electromechanical permissive over-reaching transfer trip schemes. Additionally, a two-zone directional distance scheme with separate phase and ground backup overcurrent relaying is provided for secondary protection on all transmission lines.

Each switchyard PCB is provided with redundant trip coils and additionally is protected by a breaker failure scheme that trips adjacent PCB's when a particular PCB fails to trip.

Each unit PCB (PCB's 14, 15, 17, 18, 20, 21, 23, 24) is protected by two breaker failure overcurrent fault detectors and associated timers arranged in a coincident tripping logic scheme to preclude spurious tripping of the preferred power sources to the station.

The switchyard buses are protected by static, high impedance current differential relays which trip the associated bus breakers in the event of a bus fault.

8.2.1.3.4 230kV Switchyard Control System

The 230kV Switchyard Control System consists of all control circuits for operating switchyard power circuit breakers (PCB's) and motor operated disconnect switches (MOD's). Hardwired controls are provided in the control room for the eight PCB's and four MOD's associated with the unit feeder. The remaining breakers are controlled from the area operating center via a supervisory system.

In addition to the controls provided in the control room, each PCB or MOD may be operated at the switchyard relay house or at the local control cabinet of the PCB or MOD.

8.2.1.4 Station to Switchyard Interconnections

Two separate and physically independent overhead transmission line circuits are provided to connect each Catawba unit to the 230kV transmission network via the 230 KV switchyard as shown in Figure 8-12. Each line is 230kV, three phase with an average length from the transformer yard to the 230kV switchyard of approximately 1,000 feet. Because of the short length of these lines, supporting towers are not required between the station and the switchyard. The conductors are twin-bundle 954 MCM ACSR per phase. Each three-phase line is shielded by two 1/2-inch diameter galvanized steel overhead wires. Each phase conductor is rated at 2020 amperes, 50°/40°C temperature rise. These 230kV transmission lines are designed to withstand the heavy loading conditions defined in the 1973 edition of the National Electric Safety Code.

Compliance with General Design Criterion 17

The offsite power system is designed with sufficient independence, capacity, and capability to meet the requirements of GDC 17. For each unit, the transmission network is connected to the onsite power system by two physically independent circuits.

As shown in Figure 8-12, these two physically independent 230kV circuits connect the switchyard to the two half-size unit step-up transformers and through the plant distribution system to the onsite emergency power system buses. These two circuits maintain their physical independence from the switchyard to the onsite emergency power buses. The isolation of the two circuits from the unit generator is accomplished by two generator circuit breakers. The design concept utilizing two generator circuit breakers and two half-size unit step-up transformers provides two immediate access circuits for supplying offsite power to the unit's safety systems.

The offsite power system is designed to minimize the probability of losing electric power from any supplies as a result of or coincident with the loss of the unit generator, the transmission network, or the onsite electric power supplies.

Compliance with General Design Criterion 18

The requirements of General Design Criterion 18 are implemented in the design of the offsite power system. The design permits periodic inspection and testing of important areas and features. The design includes the capability to periodically test the operability and functional performance of the components of the systems as a whole and under conditions as close to design as practical.

8.2.1.5 Offsite Power System Operational Description

Each nuclear generating unit at Catawba is provided with two independent immediate access circuits of offsite power. Prior to and during start-up of the nuclear unit, the Unit Auxiliary Power System receives power from the 230kV transmission system through these two independent circuits, the two independent unit step-up transformers, and the two independent sets of unit auxiliary transformers. During this period, the generator circuit breakers and their associated motor operated disconnect switches are open.

After the unit generator has been brought to rated speed and its field applied, the three-phase MOD switches located on each side of the two generator circuit breakers are closed. The unit generator is then connected to the system by closing the generator circuit breakers. Automatic and manual synchronization are provided and both are supervised by synchronizing check relays. During normal operation, each unit is connected to the transmission network via the two generator circuit breakers and the two power transport circuits resulting in high unit operational reliability and availability.

8.2.1.5.1 Generator Circuit Breakers

The projected momentary (peak) fault current at Catawba with the addition of future lines and generating capacity exceeds the rating shown in the McGuire Safety Evaluation Report (NUREG-0422). Accordingly, the circuit breakers have been tested at 920 and 935 KA close and latch. The breaker contacts were inspected after completion of the test by both Duke Power Company and Delle-Alsthom representatives. No contact wear was observed since no arcing occurred during this test. However, slight pittings and shifting of the contacts inherent to the electromagnetic stresses were noticed.

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

The above test and inspection was conducted in accordance with applicable portions of ANSI C37.09-1970 Standard.

The other ratings of the generator breaker as listed in the McGuire FSAR envelope the requirements for McGuire and Catawba.

8.2.1.5.2 Offsite Power System Protective Relaying

The offsite power system for each unit is divided into three distinct relay protection zones encompassing (1) the unit generator, (2) preferred power train A and associated transformers, and (3) preferred power train B and associated transformers. This protective relaying system is designed to remove from service with precision and accuracy any element of the offsite power system subjected to an abnormal condition that may prove detrimental to the effective operation or integrity of the unit.

The primary protective relaying scheme for the offsite power system is zone-over-lapping relaying with backup relaying for protection against primary relaying failure.

The offsite power system protective relaying zones are shown on Figure 8-13. Additionally, the types of relays used in each zone are also listed on this figure.

An Open Phase Protection (OPP) System is installed on each Unit 1 and 2 half-size main step-up transformer. The OPP System detects an open phase condition on the high side of its associated main step-up transformer (from the 230 kv transmission system) and actuates a main control board annunciator via alarm lockout relays in the OPP cabinets for Transformer A (or B) Trouble. This annunciator function is enabled when the main step-up transformer is in service. The OPP System was installed based on NEI Initiative 13-12 (Open Phase Condition) and is considered to be a beyond-design-basis enhancement.

8.2.1.6 Reliability Considerations

The Duke transmission system is designed to conform to the reliability criteria established by the Southeastern Electric Reliability Council (SERC). The reliability criteria assures that each of the SERC member systems is designed to avoid system cascading upon the occurrence of any one of the following:

1. <u>Loss of Generation</u>
   a. Sudden loss of entire generating capability in any one plant.
2. <u>Loss of Load</u>
   a. Sudden loss of large load or major load center.
3. <u>Loss of Transmission</u>

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

b. Sudden loss of all lines on a common right-of-way, or

c. Sudden loss of a substation (limited to a single voltage level within the substation plus transformation from that voltage level), including any generating capacity connected thereto, or

d. Delayed clearing of a three-phase fault at any point on the system due to failure of a breaker to open.

Studies are made periodically to insure that the transmission facilities both within the SERC region and interconnections with other reliability councils conform to the above criteria.

In addition to the transmission system design, the breaker-and-a-half switching arrangement in the 230kV switchyard and the redundant relaying that is provided minimizes the probability of losing offsite power to the Catawba Nuclear Station.

8.2.2 Analysis

8.2.2.1 Grid Stability Analysis

Grid stability analyses involving Catawba and its interconnections with the primary transmission system have been performed. Figure 8-14 shows the switchyard arrangement at Catawba, Allen, and Newport. On this figure the locations are indicated where three-phase faults were assumed as a part of the Catawba stability analysis. The four fault locations used in this analysis are considered to provide the most stringent tests for system stability.

Calculation CNC-1381.06-00-0050 shows swing curves (rotor angle as a function of time) for those generating station units most affected by the applied faults. Information regarding each test case is provided in calculation CNC-1381-06-00-0050 and Figure 8-14.

The results of the stability analysis as shown on the above referenced swing curves show that, for each test case, all affected units are rapidly closing the angular difference between them and returning to a stable operating condition. In all the cases considered, the system remained stable. (Note that “affected units” as described here does not include Catawba since that is the location of the fault.)

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The swing curves presented in calculation CNC-1381.06-00-0050 represent the most severe operating conditions on the Duke system from the standpoint of stability. They represent not only three-phase faults imposed on the heaviest busses on the system, but also breaker failure on key transmission lines connected to the busses so that the fault is not cleared until backup relaying actuates. These cases are far more severe than simple loss of load or generation.

These grid stability and frequency decay studies, conducted in calculation CNC-1381.06-00-0050 (summarized in Table 8-4) demonstrate that the operating conditions considered do not lead to system degradation that would adversely affect the (safe shut down of the) plant. The evaluation, therefore, verifies that frequency decay will not cause DNBR excursions below the minimum value (See Section 4.4.2.1).

The effects of the Unit 1 Measurement Uncertainty Recapture (MUR) power uprate on grid stability are evaluated and demonstrated to be acceptable in Reference 1.

8.2.2.2 Transmission System Availability

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

Duke has conducted a study of the bulk power transmission system availability based on the actual performance of the 500 kV and 230 kV networks over a 5-year period. The ratio of the actual in-service time per 100 miles of line to the total time in that period (referred to as the availability factor) provides a useful measure of the bulk transmission system performance. This value has been determined for both the 500 kV and 230 kV networks on the Duke system for the years 1986 through 1990 and the results are tabulated in Table 8-5.

During this period, lightning was the predominant cause of almost all line tripouts. The 230 kV system had relatively few line tripouts and lockouts, and the 500 kV system had even less.

The availability of the bulk power transmission system, as seen from the statistics in Table 8-5, is very high. The probability of losing all power to a primary transmission station is extremely low.

8.2.3 Reference

1. Letter from Jeffery A. Whited, U.S. Nuclear Regulatory Commission to Kelvin Henderson, Duke Energy Carolinas, LLC, Catawba Nuclear Station, Units 1 and 2 Issuance of Amendments Regarding Measurement Uncertainty Recapture Power Uprate (CoC Nos. MF4526 and MF4527), dated April 29, 2016 [ML1601A333].

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8.3 Onsite Power Systems

8.3.1 AC Power Systems

8.3.1.1 System Descriptions

The following sections describe the ac power systems for Catawba.

8.3.1.1.1 Non-Class 1E AC Power Systems

8.3.1.1.1.1 Unit Main Power System

The Unit Main Power System consists of the main generator, associated isolated phase bus, two generator circuit breakers, two half-sized unit step-up transformers (230/20.9kV), four half-sized unit auxiliary transformers (20.9/6.9/ 6.9kV), and one auxiliary transformer (22.8/13.8kV). The primary function of this system is to generate and transmit power to the Duke transmission system while simultaneously supplying power to the unit auxiliaries. In the event that the main generator is not in service, this system is used to supply power from the transmission system to the unit auxiliaries. The Unit Main Power System is shown on Figure 8-19.

The Unit Main Power System (excluding the main generator) is divided into two power trains designated A and B. These designations are consistent with the preferred power feeder designations discussed in Section 8.2. Each train consists of one half-sized unit step-up transformer, one generator circuit breaker, and two half-sized unit auxiliary transformers and supplies power to the unit auxiliaries via the 6900VAC Normal Auxiliary Power System. Transfer capability at the 6900 volt system level allows one train of the Unit Main Power System to supply not only its associated auxiliary loads, but also to supply the loads of the other train.

The unit auxiliary transformers supply power to all unit auxiliaries except the auxiliary electric boiler and the cooling tower fan motors. These two loads are supplied from train A of the Unit Main Power System via the 22.8/13.8kV auxiliary transformer and the 13.8kV Normal Auxiliary Power System.

8.3.1.1.1.2 13.8kV Normal Auxiliary Power System

The 13.8kV Normal Auxiliary Power System is provided to supply the auxiliary electric boiler, the cooling tower fan motors, and the associated cooling tower loads. This system consists of one 13.8kV switchgear assembly which is supplied from train A of the Unit Main Power System via a 22.8/13.8kV auxiliary transformer. A bus tie circuit is provided between the Unit 1 and Unit 2 13.8 kV switchgear assemblies. The 13.8kV Normal Auxiliary Power System for both units is shown on Figure 8-20.

8.3.1.1.1.3 6900VAC Normal Auxiliary Power System

The 6900VAC Normal Auxiliary Power System distributes power to unit auxiliaries required during normal operation and serves as the preferred power supply to the 4160VAC Essential Auxiliary Power System. The 6900VAC Normal Auxiliary Power System is shown on Figure 8-19.

The 6900 volt system consists of four switchgear assemblies of the split-bus design. The two sections of each switchgear assembly are supplied from separate unit auxiliary transformers. Each split-bus tie breaker is interlocked with its associated incoming feeder breakers to prevent the sustained paralleling of two unit auxiliary transformers. During normal operation (i.e., both incoming breakers to each bus section closed and the split-bus tie breaker open), should one of the two normal sources to a 6900 volt switchgear assembly be lost, an automatic transfer scheme will trip the appropriate incoming breaker and close the tie breaker. This transfer will allow the entire switchgear assembly to be supplied from the remaining source. If the two sources are in-sync, a fast transfer will be made with a maximum dead-bus time of 93 milliseconds with arcing. If the two sources are out-of-sync, a residual voltage relay scheme is used to delay the transfer until the residual voltage decays to 25% or less. The fast transfer is defeated when the unit is off line, except during performance of the automatic transfer function testing. No automatic transfer is initiated upon a protective trip on the load side of a normal incoming breaker. Manual transfers may be initiated by the operator. The necessity for transfers is minimized since generator power circuit breakers are used.

As stated above, each 6900 volt switchgear assembly is of the split-bus design. One section of each switchgear assembly (cubicles 1-6) supplies one reactor coolant pump motor and serves as part of the preferred power supply to the 4160VAC Essential Auxiliary Power System.

The other section of each switchgear assembly (cubicles 8-16) supplies balance-of-plant loads such as the condenser circulating water pump motors.

Additionally, a standby source of power to each 4160 volt essential bus is provided from the 6900 volt system via two separate and independent 6900/4160 volt transformers. These transformers are shared between units and provide the capability to supply an additional source of preferred power to each unit's 4160 volt essential buses from either unit's 6900 volt system. A key interlock scheme is provided to preclude the possibility of tying the two units together at either the 6900 volt level or at the 4160 volt level.

Additionally, each of the four 6900 volt switchgear assemblies supplies power to its associated reactor coolant pump via an additional separate and independent 6900 volt switchgear assembly. These additional switchgear assemblies are provided for reactor coolant pump motor electrical penetration protection and are located in the Auxiliary Building.

8.3.1.1.1.3.1 Emergency Supplemental Power Source

The Emergency Supplemental Power Source (ESPS) will be a permanently installed, Non-Safety Related, commercial grade system consisting of the following major components:

- Two 6.9 kV Caterpillar C175-20 ESPS Diesel Generator sets (ESPS DGs) each rated at 3150 kWe @ 0.8pf continuous power and 3500 kWe @ 0.8 prime power.
- 6.9kV switchgear to allow the power output of the two ESPS DGs to synchronize to a common ESPS bus, individual output breakers are provided for connection to the 6900 VAC Normal Auxiliary Power Systems of each unit.
- A 6.9 kV/480 VAC dry transformer for supplying auxiliary power while the ESPS DGs are running.
- A 6000 kWe, 6.9 kV resistive load bank for periodic testing of the ESPS DGs.

The major components of the ESPS will be located inside the plant protected area, and outside the existing power block buildings, in the yard area located to the Northwest of the Unit 2 Turbine Building. The ESPS major components will be physically separated from the existing emergency DGs, the offsite and onsite power systems and the Safety-Related Class 1E 4160V essential busses.

The continuous rating of the ESPS system is 6000 kWe continuous and exceeds the capacity of any one of the EDGs; thus it can substitute for any one of the four EDGs under SBO load requirements and bring the affected unit to cold shutdown if the offsite power or onsite emergency power are not recovered in a timely manner.

The ESPS system provides a supplemental AC power source capable of powering any one of the four 4.16 kV essential buses, via the 6.9kV bus circuit path, within one hour from the start of a SBO event, with the capacity to bring the affected unit to cold shutdown. The ESPS system was added to permit extension of the Technical Specification (TS) completion time for an inoperable DG from 72 hours to 14 days to ensure DG reliability and availability in the following manner:

- Permit longer preventive maintenance work windows to optimize maintenance
- Provide flexibility to resolve EDG deficiencies and avoid potential unplanned plant shutdown, along with the potential challenges to safety systems during an unplanned shutdown, should a condition occur requiring EDG corrective maintenance.

Each ESPS DG is located in its own weather enclosure mounted on top of an above grade sub-base fuel tank. The sub-base fuel tanks are specified to contain sufficient usable fuel to allow for 36 hours of continuous operation at rated load. The switchgear and other auxiliary equipment are located in a third weather enclosure. All three weather enclosures (along with separately mounted components) will be designed to meet commercial International Building Code (IBC) and ASCE 7-10 criteria, including rain, snow, seismic and wind loading up to 130 mph gusts. All critical components are elevated to such that they are above the site maximum precipitation flood plain (100 year flood).

Each ESPS DG engine is equipped with redundant 24 VDC battery starter sub-systems. Each ESPS DG will be equipped with a digital engine control system to maintain the voltage and frequency output within prescribed limits while loads are being applied to the bus as well as during steady state operations. The auxiliary load requirements for the ESPS consist of battery chargers, heaters, ventilation, instrumentation, controls and lighting normally powered from a 480 VAC retail power source. Upon loss of normal power, the ESPS vital controls and instrumentation will be carried by the ESPS battery banks, providing black start capability of the ESPS DGs. The ESPS battery banks are required to maintain the system ready to start for a minimum of four (4) hours following the loss of retail power. Once the ESPS DGs are started, the auxiliary loads will be assumed by the ESPS DGs via an Automatic Transfer Switch (ATS).

The ESPS Switchgear contains a Unit 1 feeder breaker that supplies 6900 VAC Normal Auxiliary Power System busses 1TA and 1TB via dedicated ESPS incoming feeder breakers. It also contains a Unit 2 feeder breaker that supplies 6900 VAC Normal Auxiliary Power System busses 2TC and 2TD via dedicated ESPS incoming feeder breakers. Closing of the ESPS feeder breakers and the 6900 VAC Normal Auxiliary Power incoming feeder breakers are manual actions by the operator. This is administratively controlled to only allow a single 6900 VAC bus to be energized from the ESPS at a time.

Two control panels are provided with ESPS. The Emergency Control Panel (ECP) is located in the Unit 1 Shared Load Center Room of the Service Building. The ECP is located to be convenient to both the control room and the 6900 VAC Normal Auxiliary Power switchgear rooms. From this panel an operator can start and stop both ESPS DGs, manually control (open/close) either unit’s ESPS feeder breaker in the ESPS Switchgear enclosure, and manually control (open/close) each of the four 6900 VAC Normal Auxiliary Power ESPS incoming feeder breakers. The ESPS Switchgear Control Panel is located in the ESPS switchgear enclosure. This panel provides a second location from which both ESPS DGs can be started, and either unit's ESPS station feeder breaker can be operated. The control panel in the ESPS Switchgear enclosure also has a Test/Emergency mode selector switch. In the Emergency mode, select engine protective functions would be disabled to maximize engine operation. In the Test mode position all engine protective functions would be enabled. There are no ESPS controls located in the Control Room.

On a remote start signal, the first ESPS DG will automatically start and on reaching permissible voltage and frequency its associated generator output breaker will automatically close onto the ESPS Switchgear bus. The second ESPS DG will automatically synchronize to the bus by closing its generator output breaker once acceptable parameters have been reached. Metering and protective relaying functions for the generator, switchgear and associated cables will be provided by multifunction digital relays located in the ESPS switchgear enclosure.

The ESPS is equipped with fire detection and suppression. The diesel enclosures are each equipped with a fire detection and fire suppression system while the switchgear enclosure is only equipped with fire detection. The fire detection is connected to the plant fire detection system.

The ESPS system and its associated support equipment are located in an outside area and not in a fire zone within an existing building. A fire in the ESPS zone will not impact systems, structure, or components (SSCs) other than the ESPS itself. Since the ESPS is normally separated from the remainder of the plant with open breakers, an ESPS fire would not cause failures or spurious operations of other SSC's.

The Standby Shutdown Facility (SSF) diesel generator is designed to handle an SBO event and has the capability to maintain hot standby conditions for a period of approximately 72 hours following the loss of plant power. Existing Emergency Procedures direct operator actions during an SBO event to place the SSF in service and to prepare the plant to receive power from any source that becomes available. The ESPS provides a readily accessible source of power that exceeds the capability of any one of the emergency diesel generators. After an SBO, an operator will manually start the ESPS diesels and make the necessary alignments to safely and systematically provide power to one of the SBO plant's essential 4160 volt busses. The ESPS is a defense-in-depth measure for SBO and is not credited in the SBO analysis.

8.3.1.1.1.3.2 Internal Turbine Building Flood Issues

Flood walls were installed in the basements (elevation 568') of both Unit 1 and 2 Turbine Buildings along the western most wall between column lines 16 and 17. These walls (6 total) protect the following equipment from an internal flood: 6.9KV/4.16KV Transformers SATA, SATB, 1(2)ATC, 1(2)ATD, 4.16KV Breakers 1(2)GTA, 1(2)GTB and area termination cabinets 1(2)ATC22, and 1(2)ATC23. These components provide normal AC power to the 4160 VAC Blackout Auxiliary Power System and the 4160 VAC Essential Power System. The design basis for the wall height is an unisolable RC System pipe break which can result in flooding the entire 568' elevation to a depth of 572'-4". The walls were built to a minimum height of 573', providing at least 8 inches of flood margin. A level switch is included within each enclosure with a Control Room Computer Alarm should the accumulation of water (inside an enclosure) commence for any reason (e.g. sprinkler head leak). A drain line with a manual isolation device is also provided for each enclosure to preclude water accumulation to a depth that would damage the protected transformer and ATCs. This would be action taken in response to an alarm.

The Catawba PRA identified this flood as a significant contributor to Core Damage Frequency (CDF). Modification numbers are CNCE-62156 (Unit 1) and CNCE-62157 (Unit 2). These walls are a Design Feature, added to reduce the CDF due to internal floods. There is no Technical Specification or SLC requirement for the walls to be functional. The critical components which comprise the wall (including removable gates) that provide flood protection will influence the ORAM Sentinel model output, be incorporated into the Maintenance Rule Program and be considered in work planning to approximately manage risks. Catawba committed to install these walls in letters dated August 8, 2002 and September 12, 2002 from Gary Peterson to USNRC.

8.3.1.1.1.4 4160VAC Blackout Auxiliary Power System

The 4160VAC Blackout Auxiliary Power System supplies power to those non-Class 1E loads that are automatically connected, or normally connected as required by the licensing basis, following a loss of offsite power. This system consists of two separate and independent 4160 volt switchgear assemblies, 4160/600 volt transformers, 600 volt load centers, and their associated loads. The 4160VAC Blackout Auxiliary Power System is shown on Figure 8-21.

This system is divided into two trains designated A and B with each train normally powered from its corresponding train of the 6900 volt system via a separate 6900/4160 volt transformer and feeder breaker. Each 6900/4160 volt transformer also serves as the normal source to its associated 4160 volt essential switchgear. The incoming breaker for each 4160 volt blackout switchgear is located adjacent to its associated 6900/4160 volt transformer so as to minimize the effects of the 4160 volt blackout system on the 4160 volt essential system.

As stated above, the 4160 volt blackout system is normally supplied from the 6900 volt system. In the event that the normal source is not available, each blackout switchgear assembly can be supplied from the emergency diesel generator through a connection with its associated 4160 volt essential switchgear. Upon the loss of the normal source to each 4160 volt blackout switchgear, all loads are shed and the associated emergency diesel generator is started and automatically connected to its 4160 volt essential switchgear. All essential loads required during the blackout are then sequenced onto the diesel generator. Table 8-6 contains a listing of all blackout loads and their loading sequence.

8.3.1.1.1.5 600VAC Unit Normal Auxiliary Power System

The 600VAC Unit Normal Auxiliary Power System supplies power to non-Class 1E unit-related loads and 600 volt motor control centers. This system is shown on Figure 8-19.

The 600VAC Unit Normal Auxiliary Power System consists of eight load centers, their associated transformers, and motor control centers. Six of the load centers are each fed by a separate 1500KVA, 6900/600 volt load center transformer which is connected to one of the four 6900 volt switchgear assemblies. Each of the other two load centers are normally fed by a separate 2000KVA, 6900/600 volt load center transformer which is also connected to one of the 6900 volt switchgear assemblies. A standby transformer is also provided for these two load centers and is connected by an automatic transfer scheme to either load center should the normal load center transformer be unavailable. The incoming breakers for these load centers are electrically interlocked to prevent parralleling two sources or feeding both load centers simultaneously from the standby load center transformer.

Typically, the motor control centers on the 600VAC Normal Auxiliary Power System are double fed such that if the load center which normally feeds a motor control center is unavailable, a transfer is initiated to the motor control center's alternate source. The normal and alternate load center breakers feeding double ended motor control centers are electrically interlocked to prevent paralleling the two incoming sources. A hot bus transfer, where the two incoming sources are momentarily paralleled, can be made if the controls of both load centers are placed in the manual mode and the two incoming sources are in-sync.

8.3.1.1.1.6 600VAC Station Normal Auxiliary Power System

The 600VAC Station Normal Auxiliary Power System supplies power to the non-Class 1E station related loads and station normal motor control centers. This system is shown on Figure 8-19.

The 600VAC Station Normal Auxiliary Power System consists of eight load centers, their associated transformers, and motor control centers. Six of these load centers are each fed by 1500KVA, 6900/600 volt load center transformers. The other two load centers are normally fed by separate 2000KVA, 6900/600 volt load center transformers. These two load centers are also provided with a standby transformer that serves as an alternate source in the event that one of the normal load center transformers is out of service. The incoming breakers for these load centers are electrically interlocked to prevent paralleling two sources or feeding both load centers simultaneously from the standby transformer.

The load centers receiving power through 1500KVA, 6900/600 volt load center transformers, distribute power to the 600 volt station motor control centers. Typically, each motor control center is double fed such that if the load center which normally feeds a motor control center is unavailable, a dead bus transfer is initiated to the alternate source for the motor control center. These transfers are time delayed transfers. The time delay between the tripping of the original breaker and the closing of the desired breaker insures that the original breaker has fully tripped and that residual bus voltage has sufficiently decayed before the second breaker has closed. The normal and alternate load center breakers feeding double ended motor control centers are electrically interlocked to prevent paralleling the two incoming sources.

8.3.1.1.1.7 600VAC Cooling Tower Auxiliary Power System

The 600 volt Cooling Tower Auxiliary Power System supplies power to the cooling tower fan motors and auxiliaries via the cooling tower motor control centers. This system for both units is shown on Figure 8-20.

This 600VAC system is supplied from the 13.8kV Normal Auxiliary Power System and consists of 18 motor control centers and six 13800/600 volt transformers. This system is arranged such that each transformer supplies three motor control centers.

The six station cooling towers and their associated motor control centers are divided into three groups such that a Unit 1 and a Unit 2 cooling tower are fed from the 13.8kV system through a common feeder. Feeders are arranged so that two cooling towers are fed from each unit's 13.8kV system and two may be fed from either unit. An interlock scheme is provided to preclude the possibility of connecting the two units together at the 13.8kV level through the cooling tower feeder breakers.

The above design allows two cooling towers on each unit to operate with the loss of one 13.8kV source.

8.3.1.1.2 Class 1E AC Power Systems

8.3.1.1.2.1 4160VAC Essential Auxiliary Power System

The 4160VAC Essential Auxiliary Power System supplies power to those Class 1E loads required to safely shutdown the unit following a design basis accident. This system is also available to supply power to the 4160VAC Blackout Auxiliary Power System as discussed in Section 8.3.1.1.1.4. The 4160VAC Essential Auxiliary Power System is shown on Figure 8-21.

The 4160 volt essential system is divided into two completely redundant and independent trains designated A and B, each consisting of one 4160 volt switchgear assembly, three 4160/600 volt transformers, two 600 volt load centers, and associated loads.

Normally each Class 1E 4160 volt switchgear is powered from its associated non-Class 1E train of the 6900VAC Normal Auxiliary Power System as discussed in Section 8.3.1.1.1.3. Additionally, an alternate source of power to each 4160 volt essential switchgear is provided from the 6900 volt system via two separate and independent 6900/4160 volt transformers. These transformers are shared between units and provide the capability to supply an alternate source of preferred power to each unit's 4160 volt essential switchgear from either unit's 6900 volt system. A key interlock scheme is provided to preclude the possibility of connecting the two units together at either the 6900 volt level or the 4160 volt level.

Each train of the 4160VAC Essential Auxiliary Power System is also provided with a separate and independent emergency diesel generator to supply the Class 1E loads required to safely shutdown the unit following a design basis accident. Additionally, each diesel generator is capable of supplying its associated 4160 volt blackout switchgear through a connection with the 4160 volt essential switchgear.

Voltage studies have been performed to optimize the voltage levels at the safety-related buses and transformer tap settings selected accordingly. The results of these studies indicate the voltages are within acceptable limits for the worst case conditions as listed in CNC-1381.05-00-0198 (Unit 1) and CNC-1381.05-00-0199 (Unit 2).

Each of the redundant 4160V essential buses is provided with two levels of undervoltage protection to monitor bus voltage. Each level is provided with a separate set of three under voltage relays which are utilized in a two-out-of-three logic scheme.

The first level of undervoltage relays detect a loss of voltage on the 4160VAC essential bus. The relay setting calculation, CNC-1381.05-00-0017, calls for the relay to drop out if voltage falls below 3450 volts (82.9% of normal bus voltage) and remains there for approximately 10 cycles (Ref. 5). The 10 cycle time delay prevents false diesel starting due to power system transients. The voltage setpoint was selected such that relay operation will not be initiated during normal motor starting; however, these relays will detect loss of voltage and initiate action in a time consistent with the accident analysis.

The second level provides degraded voltage protection. The relay setting calculation, CNC-1381.05-00-0012, specifies a dropout greater than or equal to 3766 volts (approximately 90.5% of normal bus voltage). This second level employs two time delays: the first (5 seconds) establishes the existence of a sustained degraded voltage condition and provides an annunciator alarm in the control room; the second (10 minutes) permits corrective operator action prior to separating the Class 1E and offsite power systems. The occurrence of a safety injection signal subsequent to the first time delay will immediately separate the Class 1E and offsite power systems. In the event of a Degraded Grid Condition, the first time delay may be defeated such that the Class 1E and offsite power systems will be separated immediately upon occurrence of a safety injection signal. This is procedurally controlled and the first time delay feature is restored when Degraded Grid Conditions are exited.

If the first level undervoltage scheme is initiated, the following automatic sequence takes place:

Time (Sec)		Event
T = 0	1.	Bus undervoltage relays operate (two-out-of-three logic initiated)
	2.	Associated diesel generator starts

3.	Timing relay initiated and begins to time out 8.5 seconds.
T = 8.5	Timing relay times out. If the undervoltage condition still exists, the Class 1E switchgear incoming breaker is tripped, thus isolating the bus from the offsite power sources, and the bus is load shed. However, if the undervoltage condition clears before 8.5 seconds, the undervoltage relays will automatically reset and the bus will continue to be supplied from its normal source. When this occurs, the diesel must be manually shut down.
T = 11.0	Diesel generator breaker closes, thus aligning the diesel generator to the essential bus, and the necessary automatic load sequencing begins. This step assumes that the in- itiating undervoltage condition did not clear prior to T = 8.5 seconds.

The thermal capabilities of various Class 1E motors to withstand locked rotor current without damage have been reviewed. By comparison with thermal conditions that could occur when operating equipment at voltages much lower than its rating, there is no reason to expect any equipment damage for the 8.5 second period prior to load shed.

If a blackout condition is the single event to be considered, the diesel generator load sequencer will sequence only those loads required to mitigate the consequences of the blackout. During this condition, 1(2)GTA(B) [the normal incoming breaker to the 4160 volt blackout switchgear] is tripped, and the 1(2)FTA1 [alternate incoming breaker from the associated 4160 volt essential switchgear] is closed. An electrical interlock scheme is provided such that 1(2)GTA(B) must be tripped and 1(2)FTA1 must be closed before 1(2)ETA2 [the 4160 volt essential switchgear feeder breaker] can be closed. Loads required within the first 12 minutes following a blackout are automatically sequenced on the diesel generator. Those loads required after 12 minutes are manually loaded as necessary.

If a blackout condition occurs simultaneously with a loss of coolant accident (LOCA), the same procedure, as defined above for the blackout condition, is followed except only the Class 1E loads required to mitigate the effects of the accident are sequenced onto the diesel generator. The non-Class 1E 4160 volt blackout system is completely disconnected from the Class 1E 4160 volt essential system with interlocks provided to maintain the isolation. If blackout sequencing is in progress when a LOCA input signal is received, the non-Class 1E 4160V system is separated and blocked as described. The load sequencer is then automatically reset and LOCA required loads that are not already energized from the blackout loading sequence are connected to the bus.

If LOCA load sequencing is in progress when a blackout occurs, the non-Class 1E 4160V system will remain de-energized and blocked with the following automatic load sequencer actions occurring:

1. Load sequencer reset
2. Load shedding of the 4160V Class 1E bus
3. LOCA required load sequencing re-initiated

For more information on the Load Sequencer, refer to Section 8.3.1.1.3.6.

All Class 1E equipment is supplied from the two redundant and independent trains of the Class 1E 4160 volt essential system. The 4160VAC Essential Auxiliary Power System has sufficient capacity and capability to supply those systems required to safely shutdown the unit assuming a complete failure of one essential train. The redundant 4160 volt essential switchgear assemblies are located in separate rooms on different elevations within the Category 1 Auxiliary Building.

The independence between redundant trains of the Auxiliary Power System is shown on Figure 8-1. Additionally, a detailed description of the physical identification of Class 1E equipment is provided in Section 8.3.1.3.

The instrumentation and controls for each train of the 4160 volt essential system are supplied from the corresponding train of the Class 1E 125VDC Vital Instrumentation and Control Power System as shown in Table 8-7. Refer to Section 8.3.2.1.2.1 for further discussion of the 125VDC Vital System.

The only Class 1E loads shared between units are two full-capacity redundant and independent air conditioning compressors in the Control Area Chilled Water System. Each compressor is assigned to one of the Class 1E trains of the 4160 volt essential system and has the capability of being supplied from either unit. A manual interlock scheme is provided to prevent both units from simultaneously supplying the compressors. This interlock scheme meets the requirements of Regulatory Guide 1.6.

The protection schemes provided for the 4160VAC Essential Auxiliary Power System are designed to 1) minimize the effect of faulted equipment on the rest of the system and to maximize the availability of the remaining equipment, and 2) to limit damage and out-of-service time of the faulted equipment.

The incoming feeders for each Class 1E 4160 volt train are protected by time-delayed phase-overcurrent relays and ground sensors. Additionally, synchronism-check relay and breaker failure schemes are also provided. The phase-overcurrent relays are set to pickup at 150% of bus full-load current, and the ground-overcurrent relay provides primary ground protection for the bus and is coordinated with the other ground protection relaying on the switchgear.

All feeders from each switchgear are protected with time-delayed and high-set instantaneous phase-overcurrent relays and instantaneous ground-fault sensors. The ground relaying is designed such that tripping for phase-to-ground faults will not occur when the switchgear is isolated from its normal power source and is being powered from its associated diesel generator. This is accomplished by limiting the available ground fault current through the diesel generator to a value below the sensitivity of the ground sensors which protect the essential loads.

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

The protective relay settings for essential systems/equipment are calculated based on equipment manufacturer's data and system parameters. *The initial setpoints are verified during system pre-operational testing.* The setpoints are determined as follows:

I. Bus Protection		
	ANSI Number and Function	Setting
1)	51 (Delayed Overcurrent)	125 to 150% Bus Full Load Current
2)	51G (Ground Overcurrent)	Coordinated with worse case 50G or 51G
3)	50B (Breaker Failure OC)	120% Bus Full Load Current

4)	62B (Breaker Failure Timer)	(Breaker Operation Time) + (50B Reset Time) + 2 Cycles
II. Motor Protection		
	ANSI Number and Function	Setting
1)	50/51 (Instantaneous/Time Delayed OC)	50-1.73 X Locked Rotor Current X 110%/51-125 to 200% Full Load Current (Coordinated with Motor Starting and Thermal Damage Curve)
2)	50G (Ground Overcurrent)	5 Amps at 6 Cycles
III. Transformer Protection		
	ANSI Number and Function	Setting
1)	50/51 (Inst./Time Delayed OC)	50-1.73 X Maximum Low Side Fault Current /51-125 to 200% Transformer Full Load Current
2)	50G (Ground Overcurrent)	5 Amps at 6 Cycles

To avoid protective relay trip setpoint drift problems, all Class 1E relays are tested periodically to verify the relays are within specified limits and are re-calibrated if required.

8.3.1.1.2.2 600VAC Essential Auxiliary Power System

The 600VAC Essential Auxiliary Power System supplies power to the 600 volt essential motor control centers which are located in load concentration areas throughout the plant. Connected to the essential motor control centers are all of the 600 volt essential loads which require power during accident conditions and non-essential loads which are required to be disconnected during accident conditions. Two essential motor control centers (1EMXG and 2EMXH) are provided to supply power to loads which are shared between the two units, e.g. Control Area Chilled Water System. The Train A loads, fed from motor control center 1EMXG, are identified in Table 8-6 in the remarks column. The corresponding Train B loads are fed from 2EMXH. This system is shown on Figure 8-21.

The only non-Class 1E loads which can be powered from the Class 1E AC systems during an accident are the AC emergency lighting transformers and the hydrogen igniter transformers. These loads are automatically disconnected on a LOCA signal and are given a permissive signal which allows manual connection after all LOCA loads are sequenced on. The AC emergency lighting transformers are powered from 600 volt Class 1E motor control centers 1EMXA, 1EMXJ, 2EMXA and 2EMXJ. The hydrogen igniter transformers are fed from 600 volt Class 1E motor control centers 1EMXI, 1EMXB, 2EMXI and 2EMXB. When the A train igniters are manually aligned to the SSF Diesel Generator, the A train igniter transformer is powered from 600 volt Class 1E motor control center EMXS.

The 600VAC Essential Auxiliary Power System is divided into two redundant and independent safety trains, each of which consists of two load centers and their associated motor control centers. Each load center normally receives power from its associated 4160 volt essential switchgear via a separate 1500KVA, 4160/600 volt essential load center transformer. The two load centers in each safety train are provided with a spare transformer which can be manually connected to either load center should the normal load center transformer be unavailable. A key interlock scheme is provided to prevent the spare transformer from being connected to both load centers simultaneously.

In the event of a blackout or blackout coupled with a LOCA, the diesel generator load sequencer automatically sheds the load centers by tripping the load center incoming breakers. Essential loads required during the blackout or blackout/LOCA condition are then automatically sequenced onto their respective bus by the sequencer.

In general, protective devices on the 600 VAC Essential Auxiliary Power System (EPE) are selected and set so that a minimal amount of equipment is isolated from the system for adverse conditions such as a fault. Protective devices protect cable and equipment. In the case of essential motor control center equipment, some incoming breakers may not fully coordinate with motor control center load breakers. The main incoming breakers of essential MCCs 2EMXA, 2EMXB, 2EMXC, 2EMXD, 2EMXI, 2EMXJ, 2EMXK and 2EMXL have been removed in order to enhance the coordination. The feeder breakers of these MCCs coordinate with the upstream breaker in the load center which feeds the MCC. However, the resulting amount of equipment isolation is acceptable, such that there is no impact on the UFSAR Chapter 15 safety analyses and redundant equipment is not affected. The load center breakers are set to protect the cable feeding the essential motor control centers and coordinate with the breakers that feed motor control center loads. The relays on the essential load center transformer feeders are set to protect the transformers and coordinate with the load center breakers.

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

The protective relay settings for essential systems/equipment are calculated based on equipment manufacturer's data and system parameters. *The initial setpoints are verified during system pre-operational testing.* The setpoints are determined as follows:

	ANSI Number and Function	Setting
1)52	(Load Center Incoming Breakers)	Set to protect the cable and equipment and coordinate with feeder breaker settings.
2)52	(Load Center Feeder Breakers)	Set to protect the cable and equipment.

For certain special cases, such as the incoming cables to motor control centers 1EMXG and 2EMXH, load center feeder breakers may trip slightly higher than the 70% cable ampacity rating. These breaker settings were verified during preoperational testing and are documented in the applicable breaker setting calculation.

To avoid protective relay trip setpoint drift problems, all Class 1E relays are tested periodically to verify the relays are within specified limits and are re-calibrated if required.

Refer to Section 8.3.1.4 for a description of the separation of redundant equipment in the 600VAC Essential Auxiliary Power System and to Section 8.3.1.3 for a detailed description of the physical identification of safety-related equipment.

The instrumentation and control power for each redundant train of the 600VAC Essential Auxiliary Power System is supplied from the corresponding train of the 125VDC Vital Instrumentation and Control Power System as shown in Table 8-7. For a further discussion of the 125VDC vital system, refer to Section 8.3.2.1.2.1.

8.3.1.1.2.3 Testing

8.3.1.1.2.3.1 Preoperational Testing

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

Preoperational testing of the Class 1E ac system is performed in accordance with the recommendations of Regulatory Guide 1.41 to verify proper design, installation, and operation. The preoperation test program for the emergency diesel generators is described in Section 8.3.1.1.3.10.

8.3.1.1.2.3.2 Periodic Testing

Inspection, maintenance, and testing of the Class 1E ac systems are performed on a periodic testing program in accordance with the recommendations of Regulatory Guides 1.22 and 1.118. The periodic testing program is scheduled so as not to interfere with unit operation. Where tests do not interfere with unit operation, system and equipment tests may be scheduled with the nuclear unit in operation.

The normal and emergency AC power distribution systems for both units at Catawba are separate during normal operation. During testing on Unit 2, the power systems on Unit 1 will be lined up in their normal operating configurations, which will assure that cross-ties are not present which could affect availability of emergency power to Unit 1 during testing on Unit 2.

The 4160 volt circuit breakers and associated equipment are tested in-service by opening and closing the circuit breakers with the breakers in the "racked out" test position and operated without energizing the circuits, if necessary.

The 600 volt circuit breakers, motor contactors and associated equipment can be tested in-service by opening and closing the circuit breakers or contactors where testing does not interfere with operation of the unit.

Testing of protective relays is performed on a periodic basis. Testing capability is provided in accordance with Regulatory Guides 1.22 and 1.118.

Periodic testing of the emergency diesel generators is discussed in Section 8.3.1.1.3.10.

8.3.1.1.2.4 Fault Current and Capacity

Class 1E Equipment	**Interrupting Capacity (Symmetrical Current Basis)**
4160V Essential Switchgear	35,000 Amps at 4.16KV
600V Essential Load Center	42,000 Amps at 600 Volts
600V Essential Motor Control Center	18,000 Amps at 600 Volts

1. **Notes:** Available fault currents for above listed equipment are documented in calculatons CNC-1381.05-00-0209 (Unit 1) and CNC-1381.05-00-0210 (Unit 2).

8.3.1.1.3 Standby Power Supplies

Each train of the 4160VAC Essential Auxiliary Power System is supplied with emergency standby power from an independent diesel generator. Each diesel generator is rated for continuous operation at 7000 KW with added capability to operate at 7700 KW for a period of two hours out of every 24 hours of operation without affecting the life of the unit. The design basis accident loading requirements for each train of the 4160VAC Essential Auxiliary Power System do not exceed the 7000 KW continuous rating of the diesel generator. (The maximum loading on the essential diesel generators was limited to 5750KW pending resolution of TDI Owners' Group concerns and is reflected in both the Technical Specifications and station procedures. Design basis accident loading requirements of each train of the essential auxiliary power systems has been reviewed to insure that the reduced limits are not exceeded.)

Each diesel generator is designed to attain rated voltage and frequency and to accept load within 11 seconds after receipt of a start signal. The characteristics of the generator exciter and voltage regulator provide satisfactory starting and acceleration of sequenced loads and ensure rapid voltage recovery when starting large motors. The generator voltage and frequency excursions between sequencing steps are in compliance with Regulatory Guide 1.9.

Each diesel generator and its associated auxiliaries are installed in separate rooms and are protected against tornadoes, external missiles, and seismic phenomena. Each diesel generator is separated by interior walls of reinforced concrete. Each diesel generator room sump pump system is designed to remove leakage and equipment drainage from the diesel room (Section 9.5.9). Isolation valves are provided on the nuclear service water pipes to stop the flow of water in the event of a double-ended pipe rupture. The diesel rooms are protected with firewalls which are designed to prevent the spread of fire from one diesel room to the redundant diesel room. In addition, each diesel room is also provided with an automatic cardox CO_2 system for fire protection. No known common failure mode exists for any design basis event, including failure of any diesel.

Each diesel generator room is provided with its own independent ventilation system which is designed to automatically maintain a suitable environment in each diesel room for equipment operation and personnel access. A further description of the Diesel Room Ventilation System is presented in Section 9.4.4.

The diesel generator Class 1E controls and monitoring instrumentation, with the exception of the sensors and other equipment that must necessarily be mounted on the diesel generator or its associated piping, are installed in free standing floor mounted panels. These panels are mounted approximately 20 feet from the diesel on an 8 foot thick concrete mat with a mass of approximately 1.45 E5 pound-second^2 per foot. These panels are designed to Seismic Category 1 requirements.

The Diesel Generator Engine mounted components and piping are Seismic Category 1, seismically qualified in accordance with IEEE Standard 344-1975. The seismic qualification stems from a modal analysis based on mathematical model derived from experimentally generated data from low level impedance test performed by the manufacturers. Engine mounted appendages were shaker table tested using appropriate appendage response output from the modal analysis with actual operating conditions simulated wherever possible. Component performance was monitored during the test and successful inspection after the test verified the component's ability to function during a seismic disturbance and maintain its structural integrity after seismic disturbance.

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

During diesel generator operation the vibration at the centerline of the crankshaft is expected to be between 0.0015 and 0.003 inches at a frequency of 7½ hertz. Vibration mounts are not necessary for the control and instrumentation panels because the damping effect of the massive foundation reduces the already minimal vibration to a negligible amount at the panels.

Reliable start capabilities are assured for Catawba's emergency diesel generators through design features and a comprehensive test program. Warming equipment is provided for the water jacket and lubricating oil systems to minimize the stresses associated with cold starts and improve starting capability. Testing Programs are implemented through the Technical Specification Surveillance Requirements to maintain a reliability goal of 95%.

Modifications have been performed to the emergency diesel generator starting circuits to enable a means of gradual acceleration to synchronous speed during starts, which is allowed per TS 3.8.1 during certain surveillance tests as a means to reduce stress and wear of internal engine parts. In order to maintain operability during periods when slow starts are enabled, this feature is automatically defeated if an emergency start signal is received.

The operators who operate and monitor the emergency diesel generators and the maintenance personnel who perform maintenance on the emergency diesel generators are qualified and trained as indicated in Sections 13.1 and 13.2.

8.3.1.1.3.1 Starting Circuits

Each diesel generator automatically starts whenever any of the following conditions occur:

1. Undervoltage on its associated 4160 volt essential bus (two-out-of-three coincident undervoltage logic)

2. Safety Injection Actuation Signal - SIAS (Refer to Chapter 7 for the conditions that generate an SIAS)

Either of the above signals actuate the load sequencer associated with each diesel generator which, in turn, provides a start initiate signal to the diesel. The start initiate signal from the sequencer remains present in the diesel generator start circuit until the sequencer is manually reset, regardless of the state of the original actuation signal.

If the diesel generator is being tested (i.e., paralleled to the system) and an SIAS is received by the sequencer, the diesel generator breaker is tripped and the diesel remains running in a standby mode. At this point, the sequencer automatically functions to apply the appropriate loads as shown in Table 8-6. Also, if the diesel generator is being tested and a loss of offsite power should occur, the diesel generator will attempt to pick up the load until an instantaneous overcurrent relay trips the diesel generator breaker. At this point the diesel generator will continue to run in a standby mode and the sequencer will initiate load shedding and automatically apply the appropriate loads as shown in Table 8-6. Since redundant diesel generators are not tested simultaneously, the other diesel generator would be started via its associated sequencer just as it would for any condition.

In addition to the above automatic start initiate signals, each diesel generator can also be manually started for test and maintenance purposes from the control room or from the local diesel control panel.

Mode selection (maintenance or operational) is provided so as to afford maximum protection for the plant and also for maintenance personnel. If the system is in the maintenance (or lockout) mode, only the local operator can place the diesel in the operational mode. If the diesel is in the operational mode, simultaneous operation of pushbuttons, local and remote, are required to place the system in the maintenance mode. Operation of this lockout is monitored by both local and control room annunciators.

For maintenance purposes an interlock is provided so that the diesel may be turned over with starting air, provided the diesel is in the maintenance mode and the barring device is locked out.

8.3.1.1.3.2 Starting System

Each diesel-electric generating unit has an independent air starting system with storage to provide at least five fast starts. A further description of the Diesel Starting Air System is presented in Section 9.5.6.

The Catawba diesel generator starting air storage capacity for each redundant diesel engine is sufficient for a minimum of five successful engine starts without the use of the air compressors.

The following is a description of the sequence of events which occurs when starting the diesel generators. When the diesel generator receives an automatic start signal from the diesel generator load sequencer, starting air is admitted to the engine to begin the starting process. Once an emergency start signal is received, the engine starting controls seal-in and continue to admit starting air until either the engine reaches 44% rated speed, or air pressure falls to 150 psig.

If the engine has not reached 44% rated speed within 10 seconds of the start signal, the sequencer initiates a sequencer logic reset and load shed followed by a restart of the loading sequence.

If the diesel starting air pressure drops to ≤ 150 psig, automatic engine start lockout will occur. At this time it is possible that some type of engine maintenance may be required before the diesel will start.

At 150 psig there is enough starting air remaining in the air receivers for at least three manual start attempts. When the diesel is started manually and the sequencer start signal is still present, the control circuitry will automatically place the diesel in the emergency mode of operation.

8.3.1.1.3.3 Combustion Air System

The pistons of the diesel draw combustion air into the engine from outside the building through two air intake lines. The combustion air is then filtered and routed through the intake air silencer before entering the diesel engine turbo-charger. The exhaust from the engine is discharged through an exhaust silencer, then routed outside the building at a point separated and removed from the air intake. The design basis for the combustion air supply is to provide adequate combustion air for operation of the engine at 7700 KW output. The Combustion Air System is discussed further in Section 9.5.8.

8.3.1.1.3.4 Diesel Generator Protection Systems

The diesel generator protection systems initiate automatic and immediate protective actions to prevent or limit damage to the diesel generator. The following protective trips are provided to protect each diesel generator at all times and are not bypassed when the diesel generator is started as a result of an SIAS signal or an undervoltage signal:

1. Engine Overspeed
2. Generator Differential Protection
3. Low-Low Lube Oil Pressure
4. Generator Voltage Controlled Overcurrent (Protection From External Faults)

The implementation of these protective trips is in accordance with Branch Technical Position EICSB-17. Overspeed protection is provided by an electronic over-speed trip, the set-point (517.5 RPM) is above the maximum engine speed on a full-load rejection of approximately 465 RPM. Regulatory Guide 1.9 requires verification that, during a recovery from transients caused by a step load increase or resulting from the disconnection of the largest single load, the speed of the diesel generator unit should not exceed the nominal speed (450 RPM) plus 75 percent of the difference in nominal speed and the overspeed protection (517.5 RPM). Technical Specification Surveillance 3.8.1.10 requires Catawba to verify every 18 months that the Diesel Generator does not trip and speed is maintained ≤ 500 rpm during and following a load rejection of ≥ 5600 kW and ≤ 5750 kW. Therefore, in accordance with Regulatory Guide 1.9, the engine speed resulting from a step increase or decrease in load will not exceed nominal speed plus 75 percent of the difference between nominal speed and the overspeed trip setpoint. Two independent measurements of overspeed are provided, and a diesel generator trip from overspeed requires specific coincident logic. Generator differential protection is provided through protective relaying in the 4160 volt essential switchgear. Low-low lube oil pressure protection is provided by three independent measurements of lube oil pressure which requires two-out-of-three coincident logic to trip the diesel generator. The voltage controlled overcurrent (51V) relays are used in a two-out-of-three logic scheme to isolate the generator from faults on the 4160 volt essential switchgear bus. These relays are set to operate at approximately rated full load current on the diesel generator if the voltage falls below approximately 80% rated; however, they will not operate for any magnitude of current if the voltage is above 80%. These set points prevent relay actuation during motor starting transients as load acceptance testing has demonstrated that bus voltage remains above 80%. Furthermore, the voltage controlled overcurrent relays have been coordinated with the 4160 volt feeder breakers such that the feeder breakers will clear downstream faults prior to 51V actuation.

The diesel generator emergency start circuits are provided with seal-in logic to keep the emergency start relays energized during a blackout. Therefore, non-emergency diesel generator trips are blocked during a blackout even if the emergency start signal is reset.

The following mechanical trips are provided to protect the diesel generators during test periods:

1. Low Pressure Turbo Oil
2. Low Pressure Lube Oil
3. High Pressure Crankcase
4. High Temperature Bearings
5. High Temperature Lube Oil Out
6. High Temperature Jacket Water
7. High Vibration

These seven trips are bypassed in the event of an accident condition. Even though the trips are bypassed while the diesel is running during an accident condition, these parameters are annunciated on the local diesel control panel and in the control room and are logged on the plant computer as sequence of events inputs.

In addition, the following electrical trips are provided to protect the diesel generators during testing periods:

1. Generator Instantaneous Overcurrent Protection
2. Generator Loss of Field Protection
3. Generator Reverse Power Protection
4. Generator Ground Protection

These electrical trips are bypassed in the event of an accident condition.

The diesel generator protective relay setpoints are determined as follows:

	ANSI Number and Function	Setting
1)	87G (Generator Differential)	No Setting - Variable Percentage
		Instantaneous Differential Relay
2)	51V (Voltage Controlled OC)	80% Rated Voltage; Maximum
		Permissible Generator Overload Current
3)	32DGT (Reverse Power)	Set Below Motoring Level for Loss of Prime Mover
4)	40DGT (Loss of Field)	Set to Detect Loss of Field
5)	50DGT (Instantaneous OC)	121% of Rated Full Load Current
6)	59DGN (DG Neutral Overvoltage)	5% of Maximum Ground Fault Voltage

8.3.1.1.3.5 Control Room Indication of Diesel Generator Operational Status

There are two base operating modes for the diesel generators:

1. OPERATIONAL or AUTOMATIC mode
2. MAINTENANCE or LOCKOUT mode

The diesel generators may be controlled manually from either the local (diesel generator room) or the remote (main control room) location.

The local and remote annunciators indicate when the diesel generators are in the maintenance or lockout mode.

The control circuitry is designed such that if the diesels are in either Local Manual or Remote Manual when an emergency start signal, blackout, and/or LOCA is received, the Automatic Mode will override the manual modes of operation. Once the start signal is received from the load sequencer, the diesel generator will automatically start, reach rated speed and voltage, and be ready to accept load within the sequence time.

Various monitoring devices are provided in the diesel room and the control room to give the operator the complete status of operability for the diesels. The following is a listing of the points monitored, the monitoring device and its locations:

1. Diesel Generator Room - Annunciators
    a. Lube Oil Temperature and Pressures
    b. Bearing Temperatures
    c. Cooling Water Temperatures and Pressures
    d. Generator Parameters
    e. Overspeed
    f. Starting Air Pressure

    If any one of the above alarms is energized, the alarm is retransmitted to a common annunciator window, "D/G A Panel Trouble," in the control room. Additionally, alarms that trip the diesel generator provide inputs to the control room events recorder as indicated below:
2. Control Room - Events Recorder
    a. Lube Oil and Turbo Oil Pressure
    b. Bearing Temperatures
    c. Lube Oil and Cooling Water Temperatures
    d. Overspeed
    e. Generator Protection
3. Control Room - Status Light Panel
    a. Diesel Starting
    b. Diesel Running
    c. Diesel in Local Control
4. Control Room - Bypassed and Inoperable Status (Regulatory Guide 1.47) Panel

The following input signals will energize the "Diesel Generator Bypassed" light:

a. Cooling water not available

b. Diesel Generator breaker racked out

c. Diesel generator overspeed

d. Loss of control power

e. Generator fault

f. Low air and oil pressure

g. Maintenance mode

8.3.1.1.3.6 Load Shedding and Sequencing

All Class 1E switchgear and load center breakers that are required to function automatically following an accident and/or blackout condition are controlled by a load sequencer associated with each diesel generator.

Load shedding of all loads at the 4160 and 600 volt levels (except the 4160/600 volt load center transformers) occurs whenever a blackout condition or an accident condition followed by a blackout is experienced.

Following the load shedding operation, the diesel generator load sequencer automatically sequences the required committed loads as shown on Table 8-6. The load sequencer circuitry energizes the required loads in a prescribed sequence to prevent momentary overloading the diesel generator or the auxiliary transformer. The sequencer functions during a blackout and/or a SIAS. An additional feature of the load sequencer is the accelerated sequence. The accelerated sequence is designed to allow advanced loading of the required blackout or LOCA loads ahead of the committed sequence. The accelerated sequence is active when bus voltage and diesel engine speed (frequency) are above approximately 92.5% and 98%, respectively. During accelerated sequence, the load groups are actuated at approximately two-seconds intervals. This allows essential equipment to be loaded onto the bus as soon as possible. If the bus voltage or engine speed drops below the above-mentioned values, the accelerated sequence is halted. The committed sequence continues regardless of bus voltage or engine speed. When bus voltage and engine speed are again within the normal range, the accelerated sequence continues. The committed sequence times will be met whether the accelerated sequence is active or not. Both sequences employ a common loading relay for each group to assure that once a loading signal is applied by the accelerated sequence, it will not be reapplied by the committed sequence.

The loading sequence outlined in Table 8-6 is consistent with the accident analysis and is sufficient to mitigate the consequences of a design basis accident.

If an SIAS signal or a blackout condition occurs while the sequencer is in the test mode, the testing circuitry is automatically negated and the sequencer functions to control the appropriate loads.

When actuated by an SIAS signal with normal auxiliary power available, the diesel engine is started immediately and maintained running in a standby condition until manually shutdown. LOCA required sequencing will start immediately in accordance with Table 8-6 (minus 11 seconds) due to normal power availability.

When the sequencer is actuated by an undervoltage condition (determined by a two-out-of-three logic scheme) on the 4160 volt essential bus, the diesel engine is immediately started. An 8.5

second time delay verifies the undervoltage condition. If normal voltage parameters are re-established before the 8.5 seconds have elapsed, the sequencer will automatically reset and the diesel will continue to run unloaded until manually shutdown. If the undervoltage is sustained, the 4160 volt incoming breaker is tripped, the 4160 volt essential bus is load shed, and the diesel generator breaker is closed when the diesel engine reaches 95% rated speed. Blackout loads are then automatically placed in service in accordance with Table 8-6.

With both actuation signals (SIAS and undervoltage) present simultaneously, the sequencer will load only the Class 1E loads.

When the load shedding occurs, all 4160 volt breakers supplying loads on the essential bus are automatically tripped with the exception of the 4160/600 volt load center transformer feeder breakers. These feeder breakers remain closed so the transformer magnetizing currents are applied to the diesel generator when the bus is initially energized rather than along with their applicable loads. The load center incoming breakers associated with these transformers are load shed and reclosed by the sequencer at the correct point in the loading sequence.

The diesel generator load sequencer automatically blocks load shedding resulting from bus undervoltage conditions any time automatic load sequencing onto the diesel generator is initiated. This load shedding feature will remain blocked until the load sequencer is manually reset.

Manual operation of the diesel generator breaker is blocked whenever the sequencer is actuated. Automatic tripping of the breaker during sequencer operation is limited to only protective relay action and diesel engine shutdown. These protective relays (i.e., diesel generator differential and voltage controlled overcurrent) operate a lockout relay that trips the diesel generator breaker and initiates diesel engine shutdown. The load sequencer then automatically sheds loads from the bus when engine speed decreases to 44 percent of rated speed. These features prevent reclosing the diesel generator breaker onto a loaded bus if the generator is tripped following sequencer actuation and before the sequencer is reset.

As described in Section 8.3.1.1.2.1 and as shown on Figure 8-1, the two separate trains of essential auxiliary power are completely independent and redundant with separation extending through the 6.9 kV Auxiliary Power System and the Unit Main Power System described in Section 8.3.1.1.1.1.

The interaction of each redundant load sequencer with off-site power sources is limited to voltage sensing on the 4.16 kV essential switchgear bus and to the controls necessary to trip the applicable switchgear incoming breaker during sustained undervoltage conditions as described in Section 8.3.1.1.2.1.

The load sequencer associated with each of the redundant power trains controls the application of essential loads onto the bus whether supplied from offsite or onsite power. The only postulated failure related to a load sequencer that could render both onsite and offsite power sources to a single train unavailable is the failure of the incoming breaker to automatically trip following a blackout. A description of this single failure analysis is provided in Table 8-8.

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

Information concerning system reliability and document compliance is listed in Section 8.3.1.2 *and a complete set of diesel generator load sequencer elementary diagrams is included in the Electrical Schematics submittal.*

8.3.1.1.3.7 Lube Oil System

Each diesel generator is provided with an independent lube oil system which supplies the diesel-engine with filtered oil for lubricating all internal moving parts and for cooling the pistons. A semi-wet system is used in which the supply of lubricating oil for the engine system is stored in a separate sump tank and in the engine sump base. The main oil storage is in the lube oil sump tank which is located at the front end of the engine. The oil is picked up from the sump tank by the lubricating oil circulating pump and circulated throughout the engine as required. Additions of oil are made to the sump tank from the clean oil storage tank in the yard. The design basis for the lube oil system is to assure ample oil and oil circulation under all operating conditions. A detailed description of the Diesel Generator Lube Oil System is presented in Section 9.5.7.

8.3.1.1.3.8 Fuel Oil Storage System

Independent fuel oil systems, complete with separate underground storage tanks and one hour day tanks are supplied for each diesel generator. Each diesel generating unit will be fed from two underground storage tanks sized to operate its associated 4160 volt essential auxiliary power train for a period of seven days. The day tanks are sized based upon the fuel oil storage required to successfully start a unit and to allow an orderly shutdown of the diesel unit upon loss of fuel oil from the main storage tanks. A detailed description of the Fuel Oil Storage System is presented in Section 9.5.4.

8.3.1.1.3.9 Cooling System

The Diesel Generator Engine Cooling Water System for each diesel includes a jacket water-intercooler water heat exchanger located within the Diesel Room which is supplied with cooling water from the Nuclear Service Water System. The design basis for the Diesel Generator Engine Cooling Water System is to provide sufficient cooling water to operate the engine at 7700KW output. A detailed description of the Diesel Generator Engine Cooling Water System is presented in Section 9.5.5.

8.3.1.1.3.10 Prototype Qualification Program

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

The test program implemented for the qualification of the emergency diesel generators is outlined below.

1. *At the factory, one of the four Catawba diesel engines was connected to its mating generator and subjected to:*
    a. *The factory commercial test for adjustments, check-out, and loading.*
    b. *A load test to demonstrate the ability of the diesel generator to start and trip a 1000HP electric motor and sustain operation after a trip and re-start. The diesel generator was loaded to 7000KW before the motor was tripped and then restarted.*
2. *Each subsequent diesel engine was placed on the factory test stand and connected to the factory test absorption dynamometer and subjected to the standard commercial shop test for adjustment, check-out and loading. This test included testing each diesel engine up to 110% of the continuous full-load rating.*
3. *Start load tests have been conducted on a diesel generator with an identical engine and generator and equivalent auxiliaries. These tests "type qualify" the Catawba diesel generators in accordance with IEEE-387-1977 as modified by Regulatory Guide 1.9, except*

the IEEE-387 standard was followed regarding the (24) twenty four hour continuous load test. Testing the diesels for 22 hours at 100% load more closely simulates actual plant loading conditions. To verify additional capability of the diesel generator set, a 2 hour load test at 110% load follows the 22 hour load test. However, this additional load is not utilized during actual diesel operation. Based on discussions with the diesel manufacturer, there is no significant difference between the order in which the test is conducted.

The Catawba diesels, generators, governors, exciters, regulators, and control panels were used in the following tests, along with equivalent auxiliaries:

Sequential Loading Test
Load Rejection Test
Margin Test
Load Capability Qualification Test

The diesel, generator, governor, exciter, regulator, control panels, and auxiliaries were used to "type qualify" the Catawba diesels for the following tests:

No Load Endurance Test (7-Day)
300 Start Test

The Catawba diesels, generators, governors, exciters, regulators, control panels and auxiliaries were used for the following:

Factory Testing
Seismic Testing/Analysis

8.3.1.1.3.11 Preoperational and Periodic Testing

In addition to the factory tests described in Section 8.3.1.1.3.10, the following preoperational on-site acceptance tests and periodic tests will be conducted on each diesel generator and their associated auxiliary systems.

1. *Preoperational Testing:*

   Tests as described in:

   a. *IEEE 387-1977, Sections 6.4 and 6.5.*
   b. Catawba Technical Specifications, Sections 4.8.1.1.2.a.3 thru 6 and 4.8.1.1.2.g.2 thru 9 (references are pre-improved Technical Specifications).
   c. *Regulatory Guide 1.9, Rev. 2, Section C.3 and C.4.*
   d. *Regulatory Guide 1.41, Rev. 0, Section C.*
   e. *Regulatory Guide 1.68, Rev. 2, Appendix A, Section 1.g.3.*
   f. *Regulatory Guide 1.108, Rev. 1, Sections C.2.a and C.2.b.*
   g. *Regulatory Guide 1.137, Rev. 1, Section C.1.c.*
   h. *ANSI N195 1976, Section 6.1.*

      These preoperational tests conform with the provisions of Regulatory Guide 1.108, C.2.a and C.2.b regarding tests to be performed on standby diesel generator units.

2. Periodic Testing:

   Periodic testing of the diesel generator requires loading of the diesel generator to at least 25% load during test runs.

Following maintenance or trouble-shooting when the emergency diesel generator is operated at light load or no load conditions, station procedures require operation of diesel at a minimum load of 25% to remove accumulated deposits.

Periodic testing is conducted as described in:

a. IEEE 387-1977, 6.6 and 6.7.

b. Catawba Technical Specifications, Section 3.8.1.

c. Regulatory Guide 1.108, Rev. 1, Sections C.2.a.1 thru 8, C.2.b, C.2.c, C.2.d, C.2.e, and C.3 were the original basis for diesel generator testing, however, this regulatory guide has been withdrawn. Catawba's diesel generator reliability testing program is in compliance with Regulatory Guide 1.9 or Catawba's diesel generator reliability is maintained in accordance with the Maintenance Rule as discussed in Regulatory Guide 1.160.

Maintenance records of inspections, servicing, and repairs on the emergency diesel generators are maintained on a Preventative Maintenance (PM) computer program. The program is updated with work history from the station work requests. Work requests for safety related equipment, such as the emergency diesel generators, are filed in the record storage facility.

The diesel generator is removed from service in accordance with approved procedures. Any maintenance work on the diesels is performed and inspected by qualified personnel in accordance with approved procedures. Upon completion of maintenance work, appropriate tests are completed to assure operability of the diesel generator. Upon completion of testing, appropriate operating procedures restore the diesels to standby readiness.

8.3.1.1.3.12 125VDC Diesel Control Power

A 125VDC Diesel Essential Auxiliary Power System is provided to supply power to the diesel generator control panel associated with each diesel generator. Each system consists of separate battery and battery charger units which are independent and physically separate between trains. The battery chargers are fed from 600 volt essential motor control centers and provide the necessary power for normal bus operation while maintaining the batteries fully charged. Each battery assumes its system load without interruption upon loss of the battery charger or ac power failure. A detailed description of the 125VDC Diesel Essential Auxiliary Power System is presented in Section 8.3.2.1.2.2.

8.3.1.1.4 Design Bases for Class 1E Motors

Class 1E motors are sized to operate their associated driven load continuously in accordance with the motors respective speed-torque and brake horsepower requirements.

The minimum accelerating voltage for Class 1E motors is 80% of motor rated voltage except for diesel generator auxiliary motors not required during a loss of coolant accident or blackout, and Class 1E motor operators for valves.

The diesel auxiliary motors not required during loss of coolant accident or blackout are designed to start at 90% of rated voltage. These motors are listed below:

1. Diesel generator engine jacket water keep warm pump motor

2. Diesel generator engine prelube oil pump motor

The diesel generator Sequential Loading Tests indicate that the maximum voltage dip experienced, below 90% of nominal system voltage, was to 86.2% and recovered to 90% voltage in 0.23 seconds and to 98% frequency in 0.28 seconds. These recoveries are within the requirements of Regulatory Guide 1.9.

At these voltage levels, analyses of the essential power system indicate that the 90% and 85% motors will start and accelerate their loads when powered from the diesel generator. For offsite power operation refer to Section 8.3.1.1.2.1.

The Class 1E valve motor operators are reviewed to ensure adequate starting torque to meet design basis requirements at reduced voltage conditions.

The starting torque for all Class 1E motors is sufficient to provide acceleration of driven equipment at minimum motor operating voltage. Additionally, these Class 1E motors deliver the torque required over pump torque to accelerate their loads within the required time with at least 10% margin.

Motor insulation is selected to be compatible with ambient environmental conditions. Temperature rises are selected to provide long insulation life. Selected insulations have temperature characteristics of NEMA Class F or Class H insulation.

Thermocouples or resistance temperature devices are installed in the stators and bearings of all large Class 1E motors to provide an indication of their stator and bearing temperatures.

8.3.1.2 Analysis

The 4160VAC and 600VAC Essential Auxiliary Power Systems are Class 1E systems and as such are designed to meet the requirements of General Design Criteria 17 and 18, and NRC Regulatory Guides 1.6, 1.9, and 1.32 as discussed below. For a discussion of additional Regulatory Guides and Industry Standards applied in the design of the Onsite Power Systems, refer to Section 8.1.5.

8.3.1.2.1 Compliance with General Design Criterion 17

An independent onsite power system is provided for each unit with sufficient capacity and capability to power those systems and components required for safety. The onsite ac electric power supplies, including the two 7000KW diesel generators per unit and their associated distribution systems, have sufficient independence, redundancy, and testability to perform their safety function assuming a single failure. The 4160VAC Essential Auxiliary Power System consists of two independent and redundant switchgear assemblies each with a connection to preferred power via the 6900 volt system and each with a separate emergency diesel generator. The 4160 volt and 600 volt essential systems supply those systems and components required for safety. (**Note:** Maximum diesel generation loading limited to 5750KW as required by the Technical Specifications.)

A single failure analysis of the onsite ac power system is provided in Table 8-8.

8.3.1.2.2 Compliance with General Design Criterion 18

Provisions are made for periodic testing of all important components of the Class 1E ac power systems. Further provision is made for periodic testing of the emergency diesel generators to assure their capability to start and to accept loads within design limits. Electric power systems important to safety are designed to allow periodic testing to the extent practical. Included in the system design is the capability to periodically test the operability and functional performance of these systems as a whole and under conditions as close to design as practical. Staggered tests are employed to avoid the testing of redundant equipment at the same time.

The 4160 volt circuit breakers and associated equipment are tested in-service by opening and closing the breakers so as not to interfere with the operation of the unit. The 600 volt breakers, motor starters, and associated equipment are also tested in-service by opening and closing the breakers and contactors so as not to interfere with unit operation. Additionally, the protective relaying associated with the 4160VAC and 600VAC Essential Auxiliary Power Systems is inspected, tested, and maintained on a routine basis.

8.3.1.2.3 Compliance with Regulatory Guide 1.6

The design of the Class 1E ac power systems complies with the independence requirements of Regulatory Guide 1.6.

The electrically powered Class 1E ac loads are separated into two redundant and completely independent trains for each unit. There are no automatic or manual ties between redundant trains.

No single failure can prevent operation of the minimum number of required safety loads, and loss of any one train will not prevent the minimum safety functions from being performed. Each Class 1E 4160 volt essential switchgear has access to an offsite power source and an onsite standby power source.

Two diesel generators are provided for each unit. Each diesel generator is connected exclusively to its associated Class 1E 4160 volt essential switchgear which ensures independence of the onsite standby power sources.

8.3.1.2.4 Compliance with Regulatory Guide 1.9

The design of the diesel generators used as standby power supplies complies with the requirements of Regulatory Guide 1.9.

Section 5.1.2, "Mechanical and Electrical Capabilities," of IEEE Std 387-1977 pertains, in part, to the starting and load-accepting capabilities of the diesel-generator unit. In conjunction with Section 5.1.2, each diesel-generator unit should be capable of starting and accelerating to rated speed, in the required sequence, all the needed engineered safety feature and emergency shutdown loads. The diesel-generator unit design should be such that at no time during the loading sequence should the frequency and voltage decrease to less than 95 percent of nominal and 75 percent of nominal, respectively. (A larger decrease in voltage and frequency may be justified for a diesel-generator unit that carries only one large connected load.) Frequency should be restored to within 2 percent of nominal, and voltage should be restored to within 10 percent of nominal within 60 percent of each load-sequence time interval. (A greater percentage of the time interval may be used if it can be justified by analysis. However, the load-sequence time interval should include sufficient margin to account for the accuracy and repeatability of the load-sequence timer.) During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel-generator unit should not exceed the nominal speed plus 75 percent of the difference between nominal speed and the overspeed trip setpoint or 115 percent of nominal, whichever is lower. Further, the transient following the complete loss of load should not cause the speed of the unit to attain the overspeed trip setpoint.

8.3.1.2.5 Compliance with Regulatory Guide 1.32 and IEEE 308-1971

The design of the Class 1E ac power systems complies with the requirements of IEEE 308-1971 as augmented by Regulatory Guide 1.32.

Two immediate access circuits of preferred power are provided for each unit.

8.3.1.2.6 Class 1E Equipment Qualification Requirements

The seismic and environmental qualification of Class 1E ac power system equipment is discussed in Sections 3.10 and 3.11, respectively.

The NRC issued IE Bulletin 88-10, "Nonconforming Molded-Case Circuit Breakers," on November 22, 1988 and Supplement 1 on August 3, 1989. The purpose of this bulletin and supplement was to alert licensees to the possibility of existence of molded-case circuit breakers which were nontraceable and unqualified for safety-related duties at their nuclear facilities. Accordingly, in responses submitted in letters from H.B. Tucker to the NRC, dated April 3, 1989, April 24, 1989, July 17, 1989, and November 9, 1989, Duke Power Company reported its efforts to identify and locate any suspect circuit breakers, to administratively remove applicable breakers from service/perform appropriate testing and equipment operability evaluations, and to describe programmatic controls to prevent future reoccurrence of this supplier problem. Of the group of suspect breakers, some were eventually designated following qualification inspection for use in non-safety applications. Final removal from service of all suspect breakers used in safety related applications was confirmed in the letter from H.B. Tucker to the NRC, dated August 13, 1990. Closure of DPC actions to satisfy IE Bulletin 88-10 was confirmed in the letter from the NRC to M.S. Tuckman on June 7, 1991.

8.3.1.3 Physical Identification of Class 1E Equipment

All Class 1E equipment, cables, and raceways are identified according to the particular safety train or channel with which they are associated.

All major Class 1E equipment, with exception of the diesel generators and their associated equipment, is identified with a nameplate which categorizes the particular equipment according to its associated unit (1 or 2), its safety train, and its safety class. For example, the nomenclature for 600 volt load center 1ELXA specifies that it is associated with Unit 1 as noted by the first character; it is a Class 1E load center as noted by the second character; it is a load center indicated by the third character; it belongs to the 600 voltage class as noted by the fourth character; and it is associated with safety train A as indicated by the fifth character.

All Class 1E cables and raceways are identified by a color coding method. This color coding method is implemented with four basic colors; red, white, blue, and yellow with the colors corresponding to the following safety trains and channels:

Color	Safety Train/Channel Identification
Red	Power Train A and Channel A
White	Channel B
Blue	Channel C
Yellow	Power Train B and Channel D

Non Class 1E cables either have black jackets or bare armor with no color coding added. As discussed in Section 8.3.1.4.5.2, isolation devices are used to separate Class 1E from non Class 1E circuits, thus eliminating the need for associated circuits.

Class 1E cables are marked prior to or during installation with the appropriate color code at intervals not to exceed five feet and are also identified by tags affixed at both ends bearing the appropriate cable number. Color-coded tags are also used to identify Class 1E cable tray and major pieces of equipment.

Cable routing sheets are prepared to establish a permanent record of the cable numbers (Class 1E cables have a unique identifier in the number), cable types, origin, terminations, routing, restriction code, and color code.

All cable trays, conduits, and wireways containing Class 1E cables are also color coded for ease of identification and to assure that separation is maintained. These raceways are marked at each end, at all entrances and exits to rooms, and at intervals not to exceed 15 feet. Raceways are marked prior to the installation of their cables.

8.3.1.4 Independence of Redundant Systems

The physical layout of Class 1E systems is designed to minimize the vulnerability of redundant equipment and cabling to damage. Special consideration is given to potential hazards in the various areas of the plant where Class 1E systems are located. In particular, these areas are analyzed for potential pipe whips, missiles, and other hazards. Separation and/or barriers are provided such that damage from potential hazards does not preclude the performance of a required safety function.

The criteria established to assure the preservation of the independence of Class 1E systems is discussed below.

8.3.1.4.1 Diesel Generators

Two mutually redundant diesel generators are provided per unit and are physically separated in individual Category 1 enclosures to preserve their independence and integrity and to assure their maximum availability. No known common failure mode exists for any design basis event.

8.3.1.4.2 Switchgear and Load Centers

Two completely redundant trains of Class 1E switchgear and associated load centers are provided per unit and are located on separate floor elevations within the Category 1 Auxiliary Building, thereby establishing maximum availability through their separation and independence. No known common failure mode exists between the redundant groups for any design basis event.

8.3.1.4.3 Motor Control Centers

Two completely redundant groups of Class 1E motor control centers are provided per unit. Physical separation is employed to provide the required independence of the two groups. No known common failure mode exists between the redundant groups for any design basis event.

8.3.1.4.4 Batteries, Chargers, Inverters, and Panelboards

Each of the four channels of the 125VDC and 120VAC Vital Instrumentation and Control Power System per unit is located in a separate compartment in the Category 1 Auxiliary Building to preserve its independence. No known common failure mode exists between the redundant groups.

The two redundant trains of the 125VDC Diesel Auxiliary Power System are located in their associated Category 1 diesel generator room. No known common failure mode exists between the redundant trains.

8.3.1.4.5 Cable Installation and Separation

Cables of redundant systems are routed separately to preserve their independence. Separation criteria are established based on location of the cables within the station to preclude any single credible event from preventing the safe shutdown of the unit.

8.3.1.4.5.1 Cable Installation

Cables are installed in open ventilated ladder type trays, open ventilated electray channels, conduit, or wireways. A seismically qualified cable support system is provided for all raceways containing Class 1E cables. Additionally, all raceways are of non-combustible construction.

Cables are routed in separate raceway systems according to voltage level and function. Where practical, a vertical stack of trays is arranged such that the highest voltage level is on top with the lower trays in descending order of voltage levels and finally control and instrumentation trays at the lowest level. Cable splicing is not allowed in raceways.

Class 1E cables routed outside the plant structure are run underground. This underground Class 1E cable system consists of two redundant Category 1 conduit banks designed such that any single design basis event applicable to the location of the conduit banks cannot result in the failure of redundant Class 1E cables.

All known class 1E cables in yard areas are located in conduit banks buried 5 feet minimum below grade, except those cables routed to the Refueling Water Storage Tank are in conduit located within the seismic Category 1 pipe trench. There are no direct buried Class 1E cables.

Conduit banks under roadways and railroads are encased in reinforced concrete capable of support H50 truck loading or E80 railroad loading. The conduit banks under the Dry Cask Transporter Haul Road are not encased in reinforced concrete. However, these conduit banks have been qualified for loadings used for the Haul Road design.

For moisture and freeze protection, all conduit banks are sloped 1/8 inch per foot between manholes. The manholes have either gravity drains or sump pumps which discharge to the yard drainage system.

Where conduit is not encased in concrete, expansion joints are provided between manholes, and between building structures and manholes at intervals not exceeding 200 feet. Also, 4" diameter schedule 40 heavy-wall PVC conduit is used.

For protection of the conduit bank locations, concrete monuments at grade level located every 50 feet on centerline of the conduit bank are provided for identification.

The major Class 1E conduit crossing with non-safety piping is the crossing over the condenser cooling water lines which are moderate energy (70 psi lines). All other crossings are with gravity yard drainage or small process lines. It is anticipated that a break in any CCW line would have minimal affect on the Class 1E conduit since there are no structures built over these areas to prevent near vertical seepage from occurring. Thus, any postulated loss of water will be detected at yard level due to the impervious zone of group I earth backfill confining these areas. Therefore, only minor undermining of the Class 1E conduits could be expected and due to their inherent tensile strength, the cables would be able to span the resulting weakened area without interruption of their power function.

The cable room, located directly below the main control room, is the area where instrumentation and control cables converge prior to entering the control, instrumentation, and interconnection panels. The cable room contains no high energy equipment such as switchgear, transformers, rotating equipment, or piping that could be a potential source of missiles or pipe whip. Also, bulk storage of combustible materials inside or adjacent to safety related buildings (including the control complex) is not allowed by Duke Power Company. Power cables are routed through cable corridors outside the cable room, while circuits in the cable room are limited to those serving the control room and instrument systems.

8.3.1.4.5.2 Cable Separation

The minimum separation between Class 1E cables and between Class 1E and non-Class 1E cables external to equipment enclosures and without the use of barriers is:

1. Three feet horizontal and five feet vertical for the general plant areas.
2. One foot horizontal and three feet vertical for the control complex area (i.e., the area of the Auxiliary Building that houses the control room, cable room, and battery room).

This separation distance is free of interposing structures, equipment, or materials which could aid in the propagation of fire or which could disable Class 1E cables or equipment and is measured between the closest points of the raceways.

Where plant arrangements preclude maintaining the minimum separation distance as outlined above, the cables are run in enclosed raceways that qualify as barriers or other barriers are provided. Interlocked armor cable has been demonstrated through short circuit testing conducted by Duke Power Company to provide an adequate barrier for preventing damage to adjacent cables and may serve as a barrier in these areas with the following restrictions:

1. 12 inch separation is maintained between redundant Class 1E circuits or additional barriers are supplied, and
2. Six inch separation is maintained between Class 1E and non-Class 1E cables or additional barriers are supplied.

The minimum separation distance between enclosed raceways or between an enclosed raceway and an interlocked armor cable is one inch. Based on the cable construction and/or limited power available, field routed cables used for communication, fire detection and lighting applications are exempted from the above criteria. The cables used in these applications are enclosed in a welded seam corrugated aluminum armor or a galvanized steel interlocked armor.

The minimum separation between redundant Class 1E wiring or between Class 1E and non-Class 1E wiring inside equipment enclosures and with potentials less than 150 volts is addressed in Duke Electrical Discipline Design Criteria DC-1.02 Separation – Catawba.

Deleted per 2006 Update.

Physical separation and isolation devices are used to eliminate the need for associated circuits. If a circuit is used for a non-Class 1E function and is 1) connected to a Class 1E power supply or 2) connected to a Class 1E device and physical separation from Class 1E circuits cannot be maintained, the circuit is treated as Class 1E up to and including an isolation device. The portion of the circuit that is on the Class 1E side of the isolation device is identified as Class 1E and routed only in Class 1E raceways. The portion of the circuit on the non-Class 1E side of the isolation device is routed only with non-Class 1E cables.

The only device acceptable as a power circuit isolation device is one that is automatically tripped by an accident signal generated within the same train or one that is tagged/locked open.

Electrical circuits enter the containment through penetration assemblies which are provided with integral connectors (qualification information pertaining to electrical penetrations is discussed in Section 3.11.3). The cables associated with Train A circuits are routed through penetrations which contain no Train B circuits, and vice-versa. The minimum separation between penetrations carrying redundant circuits is five feet in all directions. The minimum separation between Class 1E and non Class 1E penetrations is one foot six inches.

Because no Channel II Conax Penetrations exist, Channel II Source Range and Intermediate Range Nuclear Instrumentation Cable (N32/N36) is routed through Train B Penetration E121 and is color coded "Yellow" (for Train B) inside Containment, through the penetration, up to the Channel II Amplifier Cabinet, 1(2)TBOX0692. Although this cable is routed and labeled as Train B, functionally it is Channel II. The cables from 1(2)TBOX0692 to the Channel II NIS cabinet in the Control Room are "White" (for Ch. II). This arrangement does not fully comply with the requirements of Section 7.1.2.3, but has been evaluated by Engineering Change EC76152 (Unit 1) and EC75788 (Unit 2) to cause no adverse effects. All separation between the "yellow" and "white" cables are maintained up to the entry into 1(2)TBOX0692. The redundant function provided by Channel I of NIS Source Range and Intermediate Range is unaffected by this issue (ex. Train A and Ch. I are both "Red" cables).

8.3.1.5 Cable Derating and Cable Tray Fill

8.3.1.5.1 Cable Derating

The cable ampacities for both ac and dc power cables are derated to assure minimum degradation of cable insulation caused by high temperatures should the cables be loaded to their maximum ampacity rating.

The maximum ampacities for all power cables are determined by multiplying the appropriate cable manufacturer's IPCEA cable ampacity rating by 0.7. This provides a 30% margin between each power cable's rated full load capability and its actual full load application. (Refer to Section 8.3.1.1.2.2.)

Additionally, cable insulations are applied very conservatively. The following guidelines are used in applying cable insulation ratings to various station applications.

Cable Insulation Rating	Application Rating
15,000 volt	13800 volt power cable
8,000 volt	6600 volt power cable
8,000 volt	4160 volt power cable
2,000 volt	600 volt power cable
1,000 volt	Low voltage power and control cable
600 volt	208/120 volt lighting cable
300 volt	120 volt ac and 125 volt dc instrumentation cable

8.3.1.5.2 Cable Tray Fill Criteria

The cable tray fill criterion for those trays containing power cables allows only one single layer of power cables to be routed in any tray, and, in general, separation of one-quarter the diameter of the larger cable is maintained between adjacent power cables within a tray. The cable spacing may vary between tiedown points due to cable snaking or cables entering/exiting a tray; however, if cables touch, the contact is limited to approximately two feet.

The cable tray fill criterion for those trays containing instrumentation and control cables is that the cross-sectional area of these cables will not exceed the usable cross-sectional area of the tray.

8.3.2 DC Power Systems

8.3.2.1

8.3.2.1 System Descriptions

The following sections describe the DC Power Systems for Catawba Unit 1. Unit 2 is similar.

8.3.2.1.1 Non-Class 1E DC Power Systems

8.3.2.1.1.1 125VDC Auxiliary Control Power System

The 125VDC Auxiliary Control Power System consists of two 125 volt batteries, two normal and one standby battery charger, and two 125 volt dc distribution centers. The system is divided into two trains which supply dc power to the non-Class 1E instrumentation and controls, the operator-aid computer power inverter, and the 125VDC-120VAC auxiliary control power inverters. The 125 VDC Auxiliary Control Power System is shown on Figure 8-22.

The normal battery chargers provide a float charge to the auxiliary control power batteries and supply power to the auxiliary control power 125 volt dc distribution centers. The normal battery chargers are powered from the Blackout Auxiliary Power System described in Section 8.3.1.

A fault on the 125 VDC Non-Class 1E Auxiliary Control Power System Bus Tie or a fault on the output of the auctioneering diode assemblies will not affect either 4160 V Class 1E division.

8.3.2.1.1.2 240/120VAC Auxiliary Control Power System

The 240/120VAC Auxiliary Control Power System consists of 125VDC-120VAC inverters, automatic and manual transfer switches, 600 volt ac voltage regulators, distribution centers, and panelboards as indicated in Figure 8-22. The system is divided into two trains, each supplying non-interruptible 120 volt ac power to non-Class 1E instrumentation and controls and 240/120 volt ac power to the operator-aid computer.

Two 125VDC-120VAC inverters supply power from the 125VDC Auxiliary Control Power System to separate non-interruptible 120 volt ac panelboards. Backup power is available for each 120 volt ac panelboard from an associated 240/120 volt ac regulated power distribution center.

Each of the two 240/120VAC regulated power distribution centers is powered from a separate 600 volt ac voltage regulator and a 600/240/120 volt transformer. Power to the 600 volt ac voltage regulators is from the 600VAC Normal Auxiliary Power System. Each of the 240/120 volt ac regulated power distribution centers provides power to a 240/120 volt ac panelboard, and backup power to the non-interruptible 120 volt ac panelboards and the operator-aid computer.

Auctioneering diode assemblies from both trains of the 125VDC Auxiliary Control Power System supply power to the operator-aid computer 125VDC-120VAC inverter. This inverter provides the normal source of power to the 120/120/240 volt ac operator-aid computer isolation transformer; backup power is available from one of the 240/120 volt ac regulated power distribution centers.

8.3.2.1.1.3 250VDC Auxiliary Power System

The 250VDC Auxiliary Power System consists of a 250 volt battery, one battery charger, and one distribution center; a standby battery charger is also provided and is shared with the other unit. This system is shown on Figure 8-23.

The 250VDC Auxiliary Power System supplies power to high inrush dc loads that generally serve as backups to ac loads. The current limiting battery charger is normally connected to the 250 volt dc distribution center to maintain the charge on the battery. The charger is sized to recharge the battery or to carry the largest single dc load for testing purposes. Power to the normal battery charger is from the Blackout Auxiliary Power System described in Section 8.3.1, while the shared standby charger is powered from a 600 volt station normal auxiliary load center.

The bus tie circuit in the 250 VDC Auxiliary Power System employs manually actuated circuit breakers that are used only if one of the batteries has to be removed from service. Should a fault occur when the bus tie is in use, either the bus tie breaker, the distribution center incoming breaker, or the battery charger output breaker will clear the fault.

8.3.2.1.1.4 120VAC Electrical Computer Support UPS Power System

The 120VAC Electrical Computer Support UPS Power System consists of two Uninterruptible Power Supply Systems. Each system consist of an inverter, battery charger, battery cabinets, bypass transformer and 120VAC distribution panel. Each UPS shall be powered from a shared 600VAC MCC. The UPS is a single source 600VAC input and includes a bypass transformer to develop the necessary 120VAC backup power source. In the event that the primary 600VAC source is lost, the systems shall operate from the battery source.

Each UPS shall provide 120VAC power to a distribution panel located in the OAC room.

8.3.2.1.1.5 230kV Swtchyard 125VDC Power System

The 230kV Switchyard 125VDC Power System is described in Section 8.2.1.

8.3.2.1.2 Class 1E DC Power Systems

8.3.2.1.2.1 125VDC and 120VAC Vital Instrumentation and Control Power System

The 125VDC and 120VAC Vital Instrumentation and Control Power System provides a reliable, continuous source of power to Class 1E instrumentation and controls. The system consists of four independent and physically separated load groups that supply instrumentation and control channels A, B, C, and D. Each load group includes a battery, a battery charger, a dc distribution center and associated dc panelboard, an inverter, and an ac panelboard. This system is shown on Figure 8-24.

Deleted per 2004 update.

Two swing static inverters (one per train) can provide Class 1E power to an AC panelboard should its associated vital inverter fail or be unavailable. The swing inverters will allow an inoperable inverter, or one taken down for preventative maintenance, to be removed from service but allow its associated panelboard to remain on Class 1E inverter-backed power.

The 125VDC and 120VAC Vital Instrumentation and Control Power System is a seismic Category 1 system and is located in the Auxiliary Building. Each of the four 125 volt batteries are located in separate rooms within the Auxiliary Building. The dc portion of the vital instrumentation and control power system is an ungrounded system.

The adequacy of safety-related DC power supplies was assessed in the Duke response (letter from M.S. Tuckman to USNRC, dated October 9, 1991) to NRC Generic Letter (GL) 91-06, "Adequacy of DC Safety-related Power Supplies," which identified specific alarms/annunciators and indications to monitor DC power and specific procedures for maintenance and surveillance activities. The NRC approved the response in a letter from David B. Matthews to H.B. Tucker, dated June 5, 1992.

The NRC issued Generic Letter 91-11, "Resolution of Generic Issues 48, 'LCOs for Class 1E Vital Instrument Buses,' and 49. 'Interlocks and LCOs for Class 1E Tie Breakers,' Pursuant to 10 CFR 50.54(f)," on July 18, 1991. This generic letter required licensees to have in place appropriate procedures which fulfilled the following requirements:

1. Limit the time that a plant is in possible violation of the single-failure criterion with regard to the Class 1E vital instrument buses and tie breakers,
2. Require surveillances of these components, and
3. Ensure that, except for the times covered in Item (1) above, the plant is operating in an electrical configuration consistent with the regulations and its design bases.

In DPC's response to the NRC (letter from H.B. Tucker to the NRC, dated January 31, 1992), Catawba Nuclear Station was verified to be in compliance with these requirements. Specifically, that CNS has in place appropriate administrative controls, procedures and/or mechanical devices (i.e., Kirk-Key Interlocks) that ensure conformance with the intent and guidance provided by Generic Letter 91-11.

8.3.2.1.2.1.1 125VDC Vital Instrumentation and Control Power Battery Chargers

Each load group of the 125VDC Vital Instrumentation and Control Power System is provided with a separate and independent 125 volt battery charger. The battery chargers of load groups A and C are powered from Train A of the Essential Auxiliary Power System; the chargers of load groups B and D are powered from Train B. Each charger is capable of supplying the steady-state loads of its own load group while charging its associated battery. A spare battery charger is provided to serve as a backup for any one of the normal battery chargers.

Each battery charger normally supplies the loads of its associated distribution center while maintaining a float charge on its associated battery. The battery chargers are designed to prevent a battery from discharging back into any internal charger load in the event of a charger malfunction or ac power supply failure.

Should a battery be removed from service, either the normal charger associated with the isolated battery or the spare charger would be used such that the two inter-tied channels would have one battery and two chargers in operation. Each charger is rated at 200 amperes and can recharge its associated battery, assuming the battery was discharged for one hour, in approximately 8 hours while also supplying worst-case steady state loads.

Each battery charger is provided with an overvoltage sensing board which is set to operate at 155 volts. This setpoint was selected so as to provide protection for the battery during equalization as well as for the DC equipment during normal operation. Although this setpoint is above the operating voltage range for most DC equipment, past experience indicates that the output voltage on a charger will rise instantaneously to high values should a failure occur. If an overvoltage is sensed on the charger output, the output circuit breaker will automatically be tripped. In addition, procedures require the operator to verify that each charger is in the float mode prior to connecting it to its associated distribution center.

The battery chargers are designed to function properly and remain stable in the event they are isolated from their associated battery. However, it is not anticipated that a charger will be connected to its load group without a battery also connected. If it becomes necessary to disconnect a battery from its load group, bus tie breakers will be closed to provide a battery-backed supply to the affected load group. The bus tie capability is discussed in Section 8.3.2.1.2.1.3.

The battery charger has sufficient capacity to supply the bus load requirements while maintaining battery float charge level. In the event the battery is required to supply bus loads upon failure of the battery charger, the drop in voltage below the float level would result in an undervoltage alarm. Further decay of battery voltage would initiate another undervoltage alarm. The battery would be required to supply bus loads only in the event of a charger failure at which time control room alarms would be initiated.

The following voltage parameters and operating conditions would also apply to the 125 VDC Diesel Essential Auxiliary Power System. The Class 1E dc loads have an operating voltage range of 105 to 135 volts. The minimum battery discharge voltage is 105 VDC. The batteries are float charged at approximately 132 volts. Although the batteries are equalized at approximately 141 volts, the battery and its associated charger are isolated from the distribution center during equalization.

8.3.2.1.2.1.2 125VDC Vital Instrumentation and Control Power Batteries

Each of the four independent load groups of 125 volt dc vital instrumentation and control power is provided with a separate and independent 125 volt battery. Each battery is sized to supply the continuous emergency load of its own load group and the loads of another load group for a period of two hours. Each battery is also capable of supplying the anticipated momentary loads during this two hour period. The load duty cycle used to size the 125 volt vital batteries is provided in Figure 8-25.

The batteries on Channels A, B, C and D are rated for 1495 ampere-hours. The 1495 ampere-hour batteries have adequate capacity, at the minimum anticipated battery room temperature and the end of battery service life, to supply these loads for two hours. Should a 1495 ampere-hour battery be connected to two channels via the bus-tie circuit, the associated battery can supply power to the Auxiliary Feedwater pump controls for two hours as required by the NRC Branch Technical Position.

During normal operation the 125 volt batteries are floated on the dc distribution centers, and, therefore, are available to assume the loads without interruption upon loss of a battery charger or ac power source.

Each vital battery consists of 60 cells in individual transparent, shock absorbing containers with covers, racks, and accessories. Each battery is located in a separate room in the Auxiliary Building with each room ventilated by redundant Class 3 air handling systems as described in 9.4.1.

For information on conformance to the Station Blackout Rule (10CFR 50.63), pending completion of Duke Power commitments, refer to the NRC Safety Evaluation Report dated January 10, 1992.

8.3.2.1.2.1.3 125VDC Vital Instrumentation and Control Power Distribution Centers and Panelboards

Six 125 volt dc distribution centers are provided for the 125VDC Vital Instrumentation and Control Power System. Four distribution centers, one per load group, supply the four independent channels of vital instrumentation and control, and are each powered directly from an independent 125 volt battery and battery charger. Each of the four distribution centers supplies one dc panelboard and one 125VDC-120VAC static inverter. The remaining two dc distribution centers supply the following particular train-related loads:

1. Essential Auxiliary Power System switchgear and load center control power
2. Diesel generator load sequencer panels
3. Auxiliary shutdown panels
4. Turbine driven auxiliary feedwater pump controls

Each of these two remaining dc distribution centers are powered from two independent sources via auctioneering diode assemblies. One of the auctioneered distribution centers is powered from 125 volt dc vital load group A and train A of the 125VDC Diesel Essential Auxiliary Power System. The other auctioneered distribution center is powered from vital load group D and train B of the 125VDC Diesel Essential Auxiliary Power System. The two auctioneered distribution centers, along with their associated auctioneering diode assemblies, are located in separate rooms in the Auxiliary Building so that a fire in the control complex would not result in the loss of control power to the minimum equipment required to safely shutdown the unit.

The two dc distribution centers whose battery chargers are powered from the same train of essential auxiliary power may be interconnected. A tie breaker is provided in each of these four load group distribution centers to allow the train-associated distribution centers to be cross-connected.

An additional 125 VDC distribution center (1EDS) is provided for use with the spare battery charger. This distribution center contains two circuit breakers which are kirk-key interlocked such that only one can be closed at any one time so as to prevent interconnecting Train A and B related channels. The spare charger also has a power panel on the AC side (1EMS) with two kirk-key interlocked breakers to prevent interconnecting Trains A and B. An annunciator is provided in the control room to alert the operator should the spare charger be connected to Train A on the input and Train B on the output or vice-versa.

The bus tie breakers between 1EDA-1EDC and 1EDB-1EDD are used as follows:

1. To allow the standby charger to feed a vital bus in case its normal charger is out of service.
2. To allow the opposite battery to float on the bus when performing an equalizing charge on the buses main battery.

The tie breakers are manual breakers and are operated in accordance with approved procedures. The breakers alarm in the Control Room when they are closed.

8.3.2.1.2.1.4 120VAC Vital Instrumentation and Control Power System

The 120VAC Vital Instrumentation and Control Power System consists of four separate and independent 120 volt ac power panelboards, each powered from a 125 volt dc load group distribution center via a 125VDC-120VAC static inverter. Each 120 volt ac power panelboard supplies one channel of ac vital instrumentation and controls. The 120VAC Vital Instrumentation and Control Power System is shown in Figure 8-24.

Two swing static inverters (one per train) can provide Class 1E power to an AC panelboard should its associated vital inverter fail or be unavailable. The swing inverters will allow an inoperable inverter, or one taken down for preventative maintenance, to be removed from service but allow its associated AC panelboard to remain on Class 1E inverter-backed power. Regulated Non-1E 120 volt AC power is provided to serve as an alternate power source to any single 120 volt ac panelboard when transferring between its dedicated inverter and its train's swing inverter.

8.3.2.1.2.1.5 125VDC and 120VAC Vital Instrumentation and Control Power System Status Information

Each of the four load groups of the 125VDC and 120VAC Vital Instrumentation and Control Power System, as described in Section 8.3.2.1.2.1, are provided with the following status indications:

1. A 125 volt dc essential power channel trouble annunciator is provided in the control room for each channel. A 125 volt dc trouble annunciator is initiated by any of the following load group conditions:
   a. Battery charger output voltage low
   b. Battery charger output voltage high
   c. Loss of ac input to battery charger
   d. Battery charger output circuit breaker (located on the battery charger) open
   e. Vital distribution center battery charger circuit breaker open
   f. Vital distribution center battery circuit breaker open
   g. Vital distribution center tie breaker closed
   h. Vital 125 volt dc panelboard undervoltage
   i. Distribution Center positive or negative leg ground
   j. Vital distribution center undervoltage
   k. Auctioneering diode assembly input undervoltage (load groups 1 and 4 only)

   Indication of the specific condition that initiated the 125VDC channel trouble alarm is provided on a local alarm module near the 125VDC vital instrumentation and control power equipment.

2. A 120 volt ac vital power channel trouble annunciator is provided in the control room for each channel. A 120 volt ac trouble annunciator is initiated by any of the following load group conditions:
   a. Inverter 125 volt dc input failure
   b. Inverter ac output voltage low

c. Inverter manual bypass switch in alternate source position

d. Inverter alternate source abnormal (frequency)

e. 120 volt ac inverter panelboard undervoltage

Indication of the specific condition that initiated the 120 volt ac channel trouble alarm is provided on a local alarm module near the 120 volt ac vital instrumentation and control power equipment.

3. Status lights are provided in the control room for the following:

a. Vital I and C Spare charger AC Power Panel Breaker Status

b. Static inverter manual bypass switch position

c. 120 volt ac regulated distribution center breaker status

4. A point description printout and a graphics display based on the system one-line diagram are provided in the control room by the unit computer. The following status information is provided by the computer output:

a. All conditions that initiate the 125 volt dc channel trouble annunciator described in 1 above

b. All conditions that initiate the 120 volt ac channel trouble annunciator described in 2 above

c. Each of the control room status lights described in 3 above

d. Load group dc distribution center main breaker status

e. Status of both breakers connecting the auctioneered distribution center to its auctioneering diode assemblies (load groups A and D only)

f. Auctioneered distribution center undervoltage

g. Spare battery charger trouble

h. Spare battery charger train A ac supply breaker status

i. Spare battery charger train B ac supply breaker status

j. Spare battery charger distribution center train A dc supply breaker status

k. Spare battery charger distribution center train B dc supply breaker status

l. Spare battery charger output breaker status

m. Inverter alternate source ac voltage low

n. Inverter alternate source frequency abnormal

o. 120 volt ac regulated distribution center voltage low

p. 120 volt ac regulated distribution center incoming breaker status

5. The following indication is provided locally on the 125 volt dc load group equipment:

a. Vital instrumentation and control dc distribution center bus voltage

b. Battery leg-to-ground voltage

c. Battery charger output current and voltage

6. Indication of the load group vital instrumentation and control dc distribution center bus voltage is provided in the control room.

8.3.2.1.2.2 125VDC Diesel Essential Auxiliary Power System

The 125VDC Diesel Essential Auxiliary Power System provides a separate and independent train of 125 volt dc power to each diesel generator. Each train consists of a 125VDC battery and a battery charger powered from its associated train of 600 volt essential auxiliary power. The 125VDC Diesel Essential Auxiliary Power System is shown in Figure 8-26.

The diesel generator batteries are Flooded Lead-Acid Class 1E batteries. These batteries are sized to carry their assigned loads for 2 hours. The load duty cycle used to size the diesel generator batteries is shown in Figure 8-27. The duty cycle represents the total load used for battery sizing including the following factors in accordance with IEEE 485-1983:

1) Aging Factor
2) Temperature Correction Factor
3) Design Margin

Each battery charger normally supplies its associated diesel generator control power system loads while maintaining a float charge on its associated battery. A fuel oil booster pump motor may be connected to the system for maintenance purposes; however, it will be disconnected during normal operation. Each diesel battery is available to assume its associated loads upon the loss of its battery charger or ac power source.

Since the diesel generator battery charger and the train related vital instrumentation and control charger are sequenced onto the diesel generator within 11 seconds after a blackout, neither the vital instrumentation and control battery nor the diesel generator battery will experience an appreciable discharge regardless of the dissimilar voltage discharge characteristics between the two.

Each 125VDC Diesel Essential Auxiliary Power System train supplies the auxiliaries of its associated diesel generator and also supplies an auctioneering diode assembly which serves as one of the power sources to a 125VDC Vital Instrumentation and Control Power System distribution center as described in Section 8.3.2.1.2.1.3. Loads are supplied from the diesel generator batteries as follows:

1. Control Loads -
    a. Essential Switchgear Control Power
    b. Essential Load Center Control Power
    c. Diesel Generator Load Sequencer Panel
    d. Turbine Driven Auxiliary Feedwater Pump Control
    e. Auxiliary Shutdown Panel Control
2. Diesel Generator Loads (Worst case) -
    a. Field Flash
    b. Engine Panel
    c. Generator Panel

    Each of the two load groups of the 125VDC Diesel Essential Auxiliary Power System are provided with the following status indications:

1. A 125 volt DC diesel generator control power system trouble annunciator is provided in the control room for each train and is initiated by any of the following load group conditions:
   a. Battery charger output circuit breaker open
   b. Battery circuit breaker open
   c. Battery charger output voltage low
   d. Battery charger output voltage high
   e. Loss of AC input to battery charger
   f. Battery positive or negative leg ground
   g. Battery undervoltage
   h. Auctioneering diode assembly input voltage low
   i. Battery charger supply to diesel generator control panel circuit breaker open

   Indication of the specific condition that initiated the 125VDC train trouble alarm is provided on a local alarm module near the 125VDC diesel essential auxiliary power equipment.
2. A point description printout and a graphics display based on the system one-line diagram are provided in the control room by the unit computer. The computer output provides the status of all conditions that initiate the 125VDC train trouble annunciator described in 1 above.
3. The following indication is provided locally on the 125 volt DC load group equipment:
   a. Battery charger output current and voltage
   b. Battery leg-to-ground voltage
4. Indication of the load group diesel generator distribution center bus voltage is provided in the control room.

For information on conformance to the Station Blackout Rule (10CFR 50.63), pending completion of Duke Power commitments, refer to the NRC Safety Evaluation Report dated January 10, 1992.

8.3.2.1.2.3 Testing

8.3.2.1.2.3.1 Preoperational Tests

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

Preoperational testing of the Class 1E dc systems is performed in accordance with the recommendations of Regulatory Guide 1.41 to verify proper design, installation, and operation. Testing of panelboard circuit breakers and all circuit breakers associated with the 120 volt regulated ac power system consists of operating the breakers to assure proper functioning. System voltage levels are verified and, in the 120 volt ac system, the capability to perform manual transfers from the inverters and regulated power supply is demonstrated. Independence of the redundant power sources and load groups is verified in the Engineered Safety Features Actuation System Functional Test.

HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

DC loads are verified to be in accordance with battery sizing assumptions. The battery capacity is verified by a discharge performance test in accordance with IEEE 450-1975. Operability of vital loads is verified at reduced system voltage.

Proper installation and operability of the Class 1E dc systems is demonstrated by verifying proper breaker operation, voltage levels and transfer schemes to alternate sources.

8.3.2.1.2.3.2 Periodic Tests

Inspection, maintenance, and testing of Class 1E dc systems are performed on a periodic testing program in accordance with the station Technical Specifications and the recommendations of Regulatory Guide 1.22. The periodic testing program is scheduled so as not to interfere with unit operation. Where tests do not interfere with unit operation, system and equipment tests may be scheduled with the nuclear unit in operation.

The essential DC power distribution systems for both units at Catawba Nuclear Station are separate during normal operations. The systems are designed with no cross-ties between units 1 and 2. Therefore, testing of an essential DC power system on a unit will not affect the availability of emergency power to the opposite unit.

The batteries are performance tested initially at the factory; in addition, each battery is tested in accordance with the Station Technical Specifications to prove its continued capability to supply power to the emergency loads for the specified two hour load duty cycle. The performance and acceptance test for the Class 1E batteries are in compliance with Section 5 of IEEE 450-1975 and/or section 6 of IEEE 450-1980.

The typical in-service inspection of the batteries includes visual inspection for leaks, corrosion or other deterioration, level of electrolyte, and individual cell voltage readings.

Circuit breakers, contactors and associated equipment are tested in-service by opening and closing the circuit breakers and contactors so as not to interfere with the operation of the station.

The continuous operation of the vital instrumentation and control system inverters is indicative of their operability and functional performance since accident conditions do not substantially change their load. The means for manual transfer to the various power sources available to the 120 volt ac vital power system are functionally verified on a periodic basis to assure their operation.

8.3.2.2 Analysis

The 125VDC and 120VAC Vital Instrumentation and Control Power System, and the 125VDC Diesel Essential Auxiliary Power System are Class 1E systems and as such are designed to meet the requirements of General Design Criteria 17 and 18, and Regulatory Guides 1.6 and 1.32. For a discussion of additional Regulatory Guides and Industry Standards applied in the design of the Onsite DC Power System, refer to Section 8.1.5.

8.3.2.2.1 Compliance with General Design Criterion 17

The 125VDC and 120VAC Vital Instrumentation and Control Power System has sufficient capacity and capability to supply the instrumentation and control loads required for safe shutdown of the reactor assuming a loss of offsite power.

The 125VDC Diesel Essential Auxiliary Power System has sufficient capacity and capability to supply the diesel auxiliary loads necessary to allow the diesel operation required for safe shutdown of the reactor assuming a loss of offsite power.

The design of these two systems incorporates sufficient independence, redundancy, and testability to assure the performance of their safety functions assuming a single failure. A single failure analysis of the dc and ac portions of the vital instrumentation and control power system is provided in Table 8-10 and Table 8-11.

Steam generator tube rupture scenarios with failure of the 125 VDC Vital Instrumentation and Control System Distribution Center EDE or EDF are excluded from the design and license bases of Catawba Nuclear Station per Facility Operating License Amendment 217/211 given that both of the following alignments are in place at each nuclear unit when it is in Mode 1, 2, and 3.

1. Distribution Center EDE shall not be operated without at least Distribution Center EDA aligned to a Train A vital battery and charger or Distribution Center DGDA aligned to Battery DGBA and charger.
2. Distribution Center EDF shall not be operated without at least Distribuiton Center EDD aligned to a Train B vital battery and charger or Distribution Center DGDB aligned to Battery DGBB and charger.

In any case, the system alignment shall conform to the applicable plant technical specifications.

Refer to Section 15.6.3.2 and Reference 49 of Section 15.6.

A single failure analysis of the diesel essential dc system is provided in Table 8-12.

8.3.2.2.2 Compliance with General Design Criterion 18

The Class 1E dc power systems are designed to permit appropriate periodic testing and inspection as required by GDC 18. These systems are provided the capability to periodically test the operability and functional performance of system components and the operability of the system as a whole.

8.3.2.2.3 Compliance with Regulatory Guide 1.6

The design of the Class 1E power systems complies with the independence requirements of Regulatory guide 1.6.

The 125VDC and 120VAC Vital Instrumentation and Control Power System loads are separated into redundant load groups such that the loss of any one load group does not prevent the performance of the minimum required safety functions.

The 125VDC Diesel Essential Auxiliary Power System is separated into two independent trains, one per diesel. The loss of any one train does not prevent the required safety functions of the redundant diesel generator.

Each dc load group of the vital instrumentation and control systems, and each train of the diesel essential dc system are supplied by a separate and independent battery and battery charger. The battery/battery charger combinations have no automatic interconnections between trains or load groups.

8.3.2.2.4 Compliance with Regulatory Guide 1.32, IEEE Standard 308-1974, and Section 5 of IEEE 450-1975 and/or Section 6 of IEEE 450-1980

The design of Class 1E DC power systems complies with the requirements of IEEE 308-1974 as augmented by Regulatory Guide 1.32 with the following clarification:

In general, protective devices on the 125 VDC Vital Instrumentation and Control Power System (EPL) are selected and set so that a minimal amount of equipment is isolated from the system for adverse conditions such as a fault. Protective devices protect cable and equipment. In the case of DC distribution system breakers that may not fully coordinate, the resulting amount of equipment isolation is acceptable, such that there is no impact on the UFSAR Chapter 15 safety analyses and redundant equipment is not affected.

The Class 1E batteries are given a service test at an interval not to exceed 18 months. The 125 Vdc Vital Instrumentation and Control Power System (EPL) Battery service test frequency of 18 months is consistent with the recommendations of Regulatory Guide 1.32 with the exception that the Catawba Technical Specifications allow the service test to be performed online as well as during refueling outages or some other outage.

Additionally, the Class 1E battery performance and acceptance tests comply with Section 5 of IEEE 450-1975 and/or section 6 of IEEE 450-1980.

8.3.2.2.5 Class 1E Equipment Qualification Requirements

The seismic and environmental qualifications of Class 1E dc power system equipment are discussed in Sections 3.10 and 3.11, respectively.

The NRC issued IE Bulletin 88-10, "Nonconforming Molded-Case Circuit Breakers," on November 22, 1988 and Supplement 1 on August 3, 1989. The purpose of this bulletin and supplement was to alert licensees to the possibility of existence of molded-case circuit breakers which were nontraceable and unqualified for safety-related duties at their nuclear facilities. Accordingly, in responses submitted in letters from H.B. Tucker to the NRC, dated April 3, 1989, April 24, 1989, July 17, 1989, and November 9, 1989, Duke Power Company reported its efforts to identify and locate any suspect circuit breakers, to administratively remove applicable breakers from service/perform appropriate testing and equipment operability evaluations, and to describe programmatic controls to prevent future reoccurrence of this supplier problem. Of the group of suspect breakers, some were eventually designated following qualification inspection for use in non-safety applications. Final removal from service of all suspect breakers used in safety related applications was confirmed in the letter from H.B. Tucker to the NRC, dated August 13, 1990. Closure of DPC actions to satisfy IE Bulletin 88-10 was confirmed in the letter from the NRC to M.S. Tuckman on June 7, 1991.

8.3.2.3 Physical Identification of Class 1E Equipment

The physical identification of the Class 1E dc systems equipment is discussed in Section 8.3.1.3.

8.3.2.4 Independence of Redundant Systems

The independence of redundant Class 1E dc systems is discussed in Section 8.3.1.4.

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8.4 Station Blackout

8.4.1 Introduction

On July 21, 1988 the NRC amended its regulations to require that each light-water-cooled nuclear power plant be able to withstand and recover from a Station Blackout (SBO) event of a specified duration. 10CFR50.63 identifies the factors that must be considered in specifying the SBO duration and requires that the plant be capable of maintaining core cooling and appropriate containment integrity.

SBO is the complete loss of alternating current (AC) electric power to the essential and nonessential switchgear busses in a nuclear power plant unit (i.e., loss of offsite electric power system concurrent with turbine trip and unavailability of the onsite emergency ac power system). SBO does not include the loss of available ac power to busses fed by station batteries through inverters or the loss of power from alternate ac sources, nor does it assume a concurrent single failure or design basis accident.

For Catawba, the SBO scenario assumes that both units experience a loss of offsite power (LOOP) and that one unit's emergency diesel generators (EDGs) completely fail to start. At least one EDG is assumed to start for the non-SBO unit.

8.4.2 Station Blackout Duration

NUMARC 87-00, Section 3 was used to determine the SBO required coping duration category. The results show that Catawba Units 1 and 2 are in the 4 hour coping duration category.

The following plant factors were identified in determining the proposed station blackout duration:

1. Offsite Power Design Characteristics

Catawba's AC power design characteristic group is "P1" based upon:

   a. Expected frequency of grid-related LOOPS does not exceed once per 20 years,

   b. Estimated frequency of LOOPS due to extremely severe weather (ESW) is less than 3.3×10^{-4} per year which places the plant in ESW Group "1",

      Note: Site specific meteorological data was used in this evaluation.

   c. Estimated frequency of LOOPS due to severe weather (SW) is less than 3.3×10^{-3} per year which places the plant in SW Group "1", and

      Note: Site specific meteorological data was used in this evaluation.

   d. The offsite power system is in the I 1/2 Group.

2. Emergency AC Power Configuration Group is C Based on:

   a. There are two emergency AC power supplies per unit not credited as alternate AC power sources,

   b. One emergency AC power supply is necessary per unit to operate safe shutdown equipment following a loss of offsite power.

3. EDG Reliability:

   A target EDG reliability of 0.95 was determined based on having a nuclear unit average EDG reliability for the last 100 demands greater than 0.95 consistent with NUMARC 87-00 Section 3.2.4. Actual unit averages were used in this determination.

With regard to maintaining the 0.95 reliability target value, rigorous programs of maintenance, testing, surveillance, and root cause investigation exist. Periodic testing is done in accordance with Technical Specifications.

4. Alternate AC (AAC) Source:

An AAC source is provided at Catawba which meets the criteria specified in NUMARC 87-00, Appendix B. The AAC source is the Standby Shutdown Facility (SSF) diesel generator which is the power source for the Standby Shutdown System (SSS). The SSF diesel generator is available within 10 minutes of an SBO event. However, it cannot be started from the Catawba main Control Room which is an exception to the NUMARC 87-00 guidance. The SSF diesel generator is manually started from the SSF Control Room. Testing has demonstrated the ability of plant operators to start the SSF diesel within 10 minutes of the SBO event which satisfies the intent of the NUMARC guidance. The 700 kw SSF diesel generator has sufficient capacity and capability to operate equipment necessary to maintain a safe shutdown condition for the 4 hour SBO event.

The SSF is provided with its own control room, AC and DC distribution systems, HVAC system, and lighting system which are independent from the normal plant.

8.4.3 Condensate Inventory for Decay Heat Removal

Condensate makeup for decay heat removal during the 4 hour SBO is provided by the Turbine Driven Auxiliary Feedwater Pumps. The condensate supply of water to the TD Auxiliary Feedwater Pumps is from the Auxiliary Feedwater condensate storage tank (one tank per unit), upper surge tanks, and condenser hotwell. In addition, the SSF has the ability to align to the Condenser Circulating Water System which has the capability to maintain hot standby conditions for approximately 72 hours.

8.4.4 Reactor Coolant Inventory

Reactor Coolant System makeup during an SBO event makeup is provided via the Standby Makeup Pump, located in the annulus of each unit. This pump is sized to accommodate normal system leakage, reactor coolant pump seal leakage, and additional flow for system make-up. The spent fuel pool is used as the source of borated water. The Standby Makeup Pump and valves in the flow path are controlled from the SSF and are powered from the SSF Diesel Generator.

8.4.5 Class 1E Battery Capacity

The Catawba Class 1E batteries are sized to support design loads for 2 hours (See Section 8.1.4). A site-specific SBO load calculation was performed using actual component loads established during testing, and this calculation shows that these batteries are capable of carrying the SBO loads for four hours without load shedding.

8.4.6 Procedures and Training

Plant procedures have been developed to address the following areas of NUMARC 87-00, Section 4: Response to Station Blackout, AC Power Restoration, and Severe Weather.

Operations personnel receive periodic training on SBO response procedures.

8.4.7 Compressed Air

No air-operated valves are relied upon to cope with a four-hour SBO event. Air can be supplied from a diesel-driven air compressor and/or an instrument air system compressor powered from the non-SBO unit. This backup air capability provides operators with flexibility to maintain hot standby conditions from the main control room. Power Operated Relief Valves (PORVs) and auxiliary feedwater flow control valves can be manually operated to maintain hot standby conditions during the four hour SBO duration.

8.4.8 Containment Isolation

Procedures have been developed to ensure that appropriate containment isolation can be provided during an SBO event for the required duration. Acceptable means of valve closure include manual operation, DC-powered operation, and AAC-powered operation. The valve position indication and closure of certain containment isolation valves is provided independent of the preferred or Class 1E power supplies.

8.4.9 Effects of Loss of Ventilation

Based upon the methodology in NUMARC 87-00, containment, annulus, turbine driven AFW pump rooms, turbine driven AFW pump pit, mechanical penetration rooms, and the inboard doghouses were identified as dominant areas of concern (DAC). These same evaluations determined that the Control Room, switchgear room, and turbine building were not DACs. Evaluations conducted using NUMARC 87-00, Appendix F and/or the Topical Report conclude there is reasonable assurance that SBO response equipment located in these areas will be operable for the SBO coping duration. HVAC will be available to the control room after approximately 45 minutes by manually aligning power from the non-SBO unit's available EDG.

8.4.10 References

1. Letter, H.B. Tucker (Duke) to USNRC, subject: Station Blackout Analysis, dated February 28, 1992
2. Letter, USNRC to Duke, subject: Station Blackout Analysis for Catawba Site, dated January 10, 1992
3. Letter, USNRC to Duke, subject: Supplemental Safety Evaluation for Station Blackout (10CFR50.63) Catawba Nuclear Station, dated June 16, 1992
4. Letter, USNRC to Duke, subject Notice of Deviation. dated December 10, 1993
5. Letter, USNRC to Duke, subject: Catawba Nuclear Station, Units 1 and 2, Issuance of Amendments Regarding Non-Conservative Technical Specification Allowable Value (CAC Nos. MF5293 and MF5294), dated 12/18/15.

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