CHAPTER 8

ELECTRICAL SYSTEMS

8.1 DESIGN BASES

The main generator feeds electrical power at 22 kV through an isolated phase bus to two half-sized main power transformers. The bulk of the power required for station auxiliaries during normal operation is supplied by an auxiliary transformer connected to the isolated phase bus. This practice has been proven highly satisfactory. Deviations from past practices are reflected in the provisions for stand-by or emergency power which have been included to further ensure the continuity of electrical power for critical loads.

The function of the Auxiliary Electrical System is to provide reliable power to those auxiliaries required during any normal or emergency mode of plant operation.

The design of the system is such that sufficient independence or isolation between the various sources of electrical power is provided in order to guard against concurrent loss of all auxiliary power.

[Historical Information] The Authority was engaged in a program to perform a detailed evaluation of safety related electrical equipment to ensure that the equipment will perform their safety functions during and following the postulated accident. The scope of the program includes safety concerns and qualification criteria.

The General Design Criteria presented and discussed in this section are those which were in effect at the time when Indian Point 3 was designed and constructed. These general design criteria, which formed the bases for the Indian Point 3 design, were published by the Atomic Energy Commission in the Federal Register of July 11, 1967, and subsequently made a part of 10 CFR 50.

The Authority has completed a study of compliance with 10 CFR Parts 20 and 50 in accordance with some of the provisions of the Commission's Confirmatory Order of February 11, 1980. The detailed results of the evaluation of compliance of Indian Point 3 with the General Design Criteria presently established by the Nuclear Regulatory Commission (NRC) in 10 CFR 50 Appendix A, were submitted to NRC on August 11, 1980, and approved by the Commission on January 19, 1982. These results are presented in Section 1.3.

An additional diesel generator has been installed to comply with 10 CFR 50 Appendix "R" requirements; also supports compliance with Station Blackout (SBO). The diesel generator is considered non-safety related.

8.1.1 Principal Design Criteria

Performance Standards

Criterion: Those systems and components of reactor facilities which are essential to the prevention or to the mitigation of the consequences of nuclear accidents which could cause undue risk to the health and safety of the public shall be designed, fabricated, and erected to performance standards that will enable such systems and components to withstand, without undue risk to the health and safety of the public, the forces that might reasonably be imposed by the occurrence of an extraordinary natural phenomenon such as earthquake, tornado, flooding condition, high wind or heavy ice. The design bases so established shall reflect: (a) appropriate consideration of the most severe of these natural phenomena that have been officially recorded for the site and the surrounding area and (b) an appropriate margin for withstanding forces greater than those recorded to reflect uncertainties about the historical data and their suitability as a basis for design. (GDC 2 of 7/11/67)

All electrical systems and components vital to plant safety, including the emergency diesel generators, are designed as Class I so that their integrity is not impaired by the maximum potential earthquake, wind, storms, floods or disturbances on the external electrical system. Power, control and instrument cabling, motors and other electrical equipment required for operation of the engineered safety features are suitably protected against the effects of either a nuclear system accident or of severe external environment phenomena in order to assure a high degree of confidence in the operability of such components in the event that their use is required.

Emergency Power

Criterion: An emergency power source shall be provided and designed with adequate independency, redundancy, capacity, and testability to permit the functioning of the engineered safety features and protection systems required to avoid undue risk to the health and safety of the public. This power source shall provide this capacity assuming a failure of a single component. (GDC 39 and GDC 24 of 7/11/67)

Independent alternate power systems are provided with adequate capacity and testability to supply the required engineered safety features and protection systems.

The plant is supplied with normal, standby and emergency power sources as follows:

1) The normal sources of auxiliary power during plant operation are both the generator and offsite power.

2) Offsite power is supplied from Buchanan Substation (approximately ¾ mile from the plant) by 138kV and 345kV feeders, and two underground 13.8kV feeders. The Buchanan Substation has two 345kV and two 138kV circuits to Millwood Substation and a 345Kv circuit to Ladentown Substation which interconnects with the PJM system. Millwood Substation has ties to Pleasant Valley Substation which is the interconnection point between Consolidated Edison Company, Niagara Mohawk and Connecticut Light and Power systems. 138Kv feeders are connected to the 6.9 KV buses through the station auxiliary transformer, and 13.8 kV feeders are connected to the 6.9kV buses through autotransformers. 480 volt engineered safety features are connected to the 6.9kV buses through station auxiliary transformers.

3) Three diesel generators are each connected to their respective engineered safety features buses to supply emergency shutdown power in the event of loss of all other AC auxiliary power. There are no automatic ties between the buses associated with each diesel generator.

   Each diesel will be started automatically on a safety injection signal or upon the occurrence of under voltage on its associated 480 volt bus. Any two diesels have adequate capacity to supply the engineered safety features for the hypothetical accident concurrent with loss of outside power. This capacity is adequate to provide a sage and orderly plant shutdown in the event of loss of outside electrical power.

The diesel generator units are capable of being started and sequence load begun within 10 seconds after the initial signal.

The three diesel-generators are located adjacent to the control building and are connected to three (3) of the four (4) separate 480 volt auxiliary system buses. The fourth 480 volt bus is automatically connected to the third bus during diesel generator operation, and the two buses are operated as a unit from a single diesel generator for this mode of operation only.

4) Emergency power supply for vital instruments, control, and emergency lighting is from the four 125 volt DC station batteries.

5) A 2500 KW diesel generator capable of providing on-site power for safe shutdown loads has been installed in compliance with 10 CFR 50 Appendix “R”; also support compliance with SBO requirements.

8.2 ELECTRICAL SYSTEM DESIGN

8.2.1 Network Interconnection

The offsite transmission system provides two basic functions for the station; namely, it provides auxiliary power as required for startup and normal shutdown and transmits the output of the station.

Electrical energy generated at 22 kV is raised to 345 kV by the two main generator transformers and delivered to the Buchanan 345 kV Switching Station via 345 kV, 3000 Amp, 25,000 MVA synchronizing circuit breakers. The Buchanan Substation has two 345 kV and two 138 kV circuits to Millwood Substation and a 345 kV circuit to Ladentown Substation which interconnects with the PMJ system. Millwood Substation has ties to Pleasant Valley Substation which is the interconnection point between Consolidated Edison Company and Niagara Mohawk and Connecticut Light and Power System. The Buchanan 138 kV Substation has connections to Lovett Station.

Offsite (standby) power is supplied from Buchanan Substation (approximately ¾ mile from the plant) by 138 kV and 345 kV feeders, and two underground 13.8 kV feeders. The 13.8 kV feeders are connected to the 6.9 kV buses through autotransformers. The 480 volt engineered safety feature buses are connected to the 6.9 kV buses through station auxiliary transformers.

Single-Line Diagram

A single-line diagram, showing the connections of the main generator to the power system grid and to standby power source is shown on Plant Drawing 9321-F-33853 [Formerly Figure 8.2-1].

Reliability Insurance

There are four independent sources of emergency power available to Indian Point 3. They are the 138 kV and 345 kV ties from Buchanan and the two 13.8 kV feeders from Buchanan. The 138 kV supply from the Buchanan bus with its connections to the Consolidated Edison Company system and Orange & Rockland County provide a dependable source of station auxiliary power.

A System Reliability Impact Study (SRIS) was conducted for the Power Uprate Project of IP3 (Reference 3). The SRIS analyzed the impact of the IP3 uprate on the New York State Bulk Power Transmission System for a stability perspective. The study concentrated on the impact on the local transmission system and the major transmission interfaces in eastern New York. The SRIS found no significant impact of the IP3 uprate on the local transmission system. Additionally, the SRIS found no significant difference in the stability performance, before and after the uprates, for the normal and extreme contingencies simulated. Furthermore, the SRIS tested the steady state power flow response of the transmission system to three extreme contingencies. No significant differences were found in the transmission system response before and after the IP3 uprate. In addition, a 2500 kw self-contained diesel generator is available to provide on-site power for safe shutdown loads having alternate feed capability.

8.2.2 Station Distribution System

The Auxiliary Electrical System was designed to provide a simple arrangement of buses requiring the minimum of switching to restore power to a bus in the event that the normal supply to that bus is lost.

The relays that are used for bus clearing and sequencing of safeguards components on the four 480 volt buses have been physically located in the 480 volt switchgear and the circuitry has been developed on an individual, independent bus scheme. That is, each bus has its own set of bus clearing and load sequencing relays physically located within its own line-up, independent of the other bus sections. Diesel generator No. 31 is connected to bus No. 2A and bus No. 2A is then connected to bus No. 3A in the event of a diesel requirement. Buses No. 2A and 3A together form one of the three 480 volt safeguards power trains with buses No. 5A and 6A used for the remaining two power trains.

In addition, Indian Point 3 has a five-battery DC System. Each of the three 480 volt safeguards power trains and associated circuitry receives its DC control power from its own individual battery (Nos. 31, 32 and 33). Battery No. 36 feeds power panel No. 36. Battery No. 34 feeds instrument bus No. 34.

Batteries 31, 32, 33, and 34 are safety batteries which supply DC power to safe shutdown systems. Battery 36 is a non-safety battery which supplies DC power to non-essential loads.

Single Line Diagrams

The basic components of the station's electrical system are shown on the electrical one line diagrams, Plant Drawings 617F645, 617F643, 617F644, 9321-F-30063, -30083, 9321-H-36933, and 9321-F-39893 [Formerly Figures 8.2-2 through 8.2-6, 8.2-8 and 8.2-9], which include the 6900 volt, the 480 volt, the 120 volt AC instrument, and the 125 volt DC bus systems.

Unit Auxiliary, Station Auxiliary and Station Service Transformers

Unit Auxiliary Transformer

The unit auxiliary transformer is a three phase, two winding, forced oil/air type. During unit operation, it transforms 22 kV power from the main generator bus to 6.9 kV and, through appropriate switching, supplies four of the six 6900 volt auxiliary buses. These four buses supply virtually all of the unit 6900 volt auxiliaries and approximately 50% of the 480 volt auxiliaries.

Station Auxiliary Transformer

The station auxiliary transformer is a three phase, two winding forced oil/air type. It transforms 138 kV power from the offsite network to 6.9 kV and, through appropriate switching, supplies the remaining two of the six 6900 volt auxiliary buses. During unit operation it supplies the 6900 and 480 volt auxiliary loads that are not supplied by the Unit Auxiliary Transformer.

When the Unit Auxiliary Transformer is not available, such as during unit trip, unit downtime, or startup, the four buses normally supplied by this transformer are reconnected to the two remaining buses, and the Station Auxiliary Transformer supplies all auxiliary loads.

Station Service Transformers

The seven station service transformers are three phase, two winding, air insulated, dry type. Insulation material is fire resistant and non-explosive. Solid insulation in the transformers consists of inorganic materials such as porcelain, mica, glass or asbestos, in combination with a sufficient quantity of high temperature binder to impart the necessary mechanical strength to the insulation structure. This insulation is defined by ASA standards as Group III material. The Station Service Transformers transform 6.9 kV power form the 6900 volt buses to 480 volts to supply low voltage auxiliary loads.

The above transformers were designed and constructed in accordance with the applicable standards of ASA, IEE and NEMA. During normal operation and auto engineered safeguards loading, these transformers will not be loaded beyond their rating. However, during peak accident loading scenarios, these transformers are allowed to be loaded up to 3600 amps, for up to 4 hours. This short time overload capability is necessary to support the 480V buses 2A, 3A, 5A, and 6A loading requirements during the manual recovery phase of a design basis accident. Manufacturer shop tests of the transformers were conducted in accordance with the latest revision of American Standard Test Code C 57.12.90. This series of tests consisted of the following:

1) Resistance measurements of all windings,
2) Ratio tests,
3) Polarity and phase relation tests,
4) No-load losses,
5) Exciting current,
6) Impedance and load loss,
7) Temperature test,
8) Applied potential tests, and
9) Induced potential tests.

6900 Volt System

The 6900 volt system is divided into seven buses. These buses supply 6900 volt auxiliaries directly and 480 volt auxiliaries via the station service transformers. Two buses, numbers 5 and 6, are connected to the 138 kV system via bus main breakers and the Station Auxiliary Transformer. An alternate connection is available to the 13.8 kV IP2 SBO / Appendix R diesel and/or the 13.8 kV off-site power network via a step-down auto transformer. Buses No. 1, 2, 3, and 4 are connected to the generator leads via bus main breakers and the Unit Auxiliary Transformer. Buses No. 1 and 2 can be tied to Bus No. 5 and Buses No. 3 and 4 can be tied to Bus No. 6 via bus tie breakers to provide auxiliary power during unit down time. These bus tie connections are automatically initiated, in the event of unit trip, to assist continuity of service.

BUS 3NBY01 is connected to the 13.8 kV off-site power network via a step-down auto transformer.

480 Volt System

The 480 volt system consists of seven buses, each supplied from a 6900 volt bus via a station service transformer. Four of these Buses, No. 2A, 3A, 5A and 6A, supplied from Buses No. 2, 3, 5, and 6 respectively, comprise the safety related 480 volt system. The required safeguards equipment circuits are dispersed among these buses. These buses are provided with diesel generator back-up in the event of voltage failure, and are protected against a sustained undervoltage condition, which could cause mis-operation of, or damage to, safeguards equipment. 480V Buses 2A, 3A, 5A and 6A are each rated 3200 amps continuous. However, during peak accident loading scenarios, these buses can be loaded up to 3600 amps for up to 4 hours, based on a maximum ambient switchgear room temperature of 40°C. For Buses 2A and 3A, this short time limit applies to the combined loading, when these buses are tied together and powered from a single station service transformer. (Buses 2A and 3A are considered a single safeguards bus.)

480 Buses 2A, 3A, 5A and 6A load breakers are rated to interrupt up to 50kA short circuit current. Maximum short circuit current at the 480V load breakers during emergency diesel generator testing parallel to the system, was initially and conservatively calculated to be slightly greater than 50kA. However, taking into account cable and raceway construction, and establishment of “safe zone” areas during diesel testing (CAT I areas), the maximum fault current was analyzed to be less than the 50kA rating which would allow the breaker to safely interrupt a fault if it occurs.

The three remaining 480 volt buses, Buses No. 312, 313, and 3NGY01 are supplied from 6900 volt Buses No. 1, 3 and 3NBY01 respectively, and supply auxiliary power to additional plant facilities installed subsequent to the initial installation. A tie breaker between Buses 312 and 313 permit one bus to serve as a backup for the other. Interlocking prevents the cross connecting of the two 6.9 kV sources to Buses 312 and 313 through the 480 volt system. The interlock can be defeated temporarily for performing a live transfer of 480 volt buses 312 and 313 when both 6.9 kV supply buses are fed from the same 6.9 kV power source.

The 480 volt feeders for the Fire Protection System are from the 480 Volt Buses No. 312 and 313 to the 480 volt Motor Control Center G and H, respectively. Buses No. 312 and 313 are located in the Turbine Hall and Motor Control Centers G and H are located in the Fire Pump House. The motor driven fire pump normal feed is Bus No. 312 and the emergency feed is 480 volt Bus No. 5A. These feeders run through the manual transfer switch which is used to manually transfer the feeders to the motor driven fire pump from the normal feed to the emergency feed and from the emergency feed to normal feed. The electrical feeds to the remaining equipment installed as part of the additional facilities program are supplied through individual breakers. A provision also exists to cross-connect the IP2 SBO / Appendix R DG to the IP3 alternative shutdown loads; and the IP3 Appendix R DG to the IP2 alternative shutdown loads.

The normal source for Buses No. 5A and 6A is the 138 kV system, via the station auxiliary transformer and 6900 volt Buses No. 5 and 6. The normal source for Buses No. 2A and 3A is the main generator, via the unit auxiliary transformer and 6900 volt Buses No. 2 and 3. When the unit is not operating, Buses No. 2A and 3A are supplied from the 138 kV system, via switching at the 6900 volt level. The normal source for Bus No. 3NGY01 is the 13.8 kV system via an autotransformer and 6900 volt Bus 3NBY01.

The relays that are used for bus clearing and sequencing of safeguards components on the four safety related 480 volt buses have been physically located in the 480 volt switchgear, and the circuitry has been developed on an individual, independent bus scheme. That is, each bus has its own set of bus clearing and load sequencing relays physically located within its own lineup, independent of the other bus sections.

Two independent sets of under-voltage protective relays are installed on each bus: one set to initiate load stripping, diesel generator start, bus transfer, and sequencing of safeguards loads upon bus voltage failure; the other set to initiate bus disconnection from the offsite power source upon the occurrence of a sustained period of voltage low enough to cause mis-operation of, or damage to, safeguards equipment.

Coordination between 480V Buses 2A, 3A, 5A and 6A supply breakers and their downstream load breakers ensures that an entire bus will not be lost due to a fault on any feeder circuit.

One emergency diesel-generator set is connected to bus No. 5A, one to 6A and the third to the combination of Bus No. 2A and Bus 3A. Each diesel generator is automatically started upon under-voltage on its associated 480 volt bus.

Interlocks are provided so that a fault on any bus locks out all possible sources of power to that bus. Interlocks are also provided to prevent circuit breakers connecting emergency diesel generator No. 31, 32 and 33 to Buses No. 2A, 6A and 5A from automatically closing if there is a voltage on the bus. The power for the safeguards valve motors is supplied from two motor control centers which in turn are supplied from the safety related 480 volt system. Each motor control center can be supplied by an emergency diesel generator.

Each of the four 480 volt switchgear bus sections which supply power to the safeguards equipment receives DC control power from its associated battery source. Batteries No. 31, 32, and 33 supply DC control power to 480 volt bus No. 5A, 6A and 2A/3A, respectively.

<u>125 Volt DC System</u>

The 125 volt DC system is divided into five buses with one battery and battery charge (supplied from the 480 volt system) serving each. The battery chargers supply the normal DC loads as well as maintaining proper charges on the batteries.

One battery charger is available to each battery so that the five batteries are maintained at full charge in anticipation of loss-of-AC power incident. This ensures that adequate DC power is available for starting the emergency generators and other emergency uses.

Battery chargers 31, 32, and 33 are also relied upon to support the continued operation of systems and components required to either mitigate the consequences of a design basis accident or provide post-accident monitoring subsequent to depletion of Batteries No. 31, 32, and 33.

The DC system is redundant from battery source to actuation devices which are powered from the batteries. Five batteries feed five DC power panels, which in turn feed major loads, such as instrument bus inverters, switchgear control circuits and DC motors. Two of the DC power panels sub-feed DC distribution panels, which in turn feed relaying and instrumentation loads.

Redundant safeguards relays and devices which use DC as a power source receive their power from one of three DC distribution buses.

Bus ties exist between Power Panels 31 and 32 and between Power Panels 33 and 34. These bus ties are administratively controlled open when the plant is in any condition above cold shutdown, to preserve the 125 VDC system independence. During cold shutdown, only one of these bus ties, either between Power Panel 31 and 32, or between Power Panels 33 and 34 can be closed. The bus tie feature is provided to allow maintenance, and / or removal of one of the four Station batteries. The remaining battery on the two cross connected buses has adequate capacity to supply DC power for the tied Power Panel loads for a minimum of two hours during a loss of AC power design basis event.

Safeguards pump controls which are DC actuated receive power from their associated DC distribution buses.

The physical locations of the DC system equipment is such as to minimize vulnerability of vital circuits to physical damage and prevent concurrent loss of all power as a result of accidents. The DC system is designed such that a single random failure will not result in the loss of redundant DC power and/or Distribution Panels due to a common mode electrical failure.

Major loads with their appropriate operating times on each battery are listed in Table 8.2-2.

120 Volt AC System

The 120 volt AC instrument supply is split into four buses. All four buses are fed by inverters which are in turn supplied from separate 125 volt DC buses. In addition, an alternate power supply is provided for the fourth bus consisting of a constant voltage transformer connected to a 480 volt safeguards motor control center No. 36B. In the event that inverter 34 or the constant voltage transformer is taken out of service, a backup source consisting of a second constant voltage transformer connected to a different 480 volt safeguards MCC is available to feed the associated bus.

Inverters 31, 32, and 33 have manual bypass switches which can bypass the inverter and supply the associated instrument bus from a backup constant voltage transformer connected to a 480 volt MCC. In addition, inverters 31, 32, and 33 have automatic static transfer switches which will transfer to the backup constant voltage transformer supply in the event of loss of inverter voltage, loss of DC voltage, inverter circuit failure, electrical fault or inverter undervoltage.

Inverters 31, 32, and 33, each have a harmonic filter installed to maintain voltage total harmonic distortion (VT_{HD}) within design limits. This reduces instrumentation biases to VT_{HD} sensitive instruments to acceptable limits.

Evaluation of Layout and Load Distribution

The physical locations of the electrical distribution system equipment are such as to minimize vulnerability of vital circuits to physical damage as a result of accidents.

Station and unit auxiliary transformers, and the main transformer are located outdoors and are physically separated from each other.

Lightning arresters are used where applicable for lightning protection. All oil filled transformers are covered by automatic spray systems to extinguish oil fires quickly and prevent the spread of fire. Transformers are spaced to minimize their exposure to fire, water and mechanical damage.

The 6900 volt switchgear and 480 volt load centers are located in areas which minimize their exposure to mechanical, fire and water damage. This equipment is properly coordinated electronically to permit safe operation of the equipment under normal and short circuit conditions.

The 480 volt motor control centers are located in the areas of electrical load concentration. Those associated with the turbine-generator auxiliary system in general are located below the turbine-generator operating floor level. Those associated with the nuclear steam supply system are located in the Primary Auxiliary Building.

Non-segregated, metal-enclosed 6900 volt buses are used for all major bus runs where large blocks of current are to be carried. The routing of this metal-enclosed bus is such as to minimize its exposure to mechanical fire and water damage.

The application and routing of control, instrumentation and power cables are such as to minimize their vulnerability to damage from any source. All cables are designed using conservative margins with respect to their current carrying capacities, insulation properties and mechanical construction. Power cable insulation in the Reactor Building has fire resistant sheathing, selected to minimize the harmful effects of radiation, heat and humidity.

Appropriate instrumentation cables are shielded to minimize induced voltage and magnetic interference. Wire and cables related to engineered safeguard and reactor protective systems are routed and installed to maintain the integrity of their respective redundant channels and protect them from physical damage.

The following design and construction procedures were followed to assure a safe and adequate design:

Redundancy and separation requirements were initiated by the cognizant electrical or mechanical design engineer. These were then reviewed by the designers of the electrical system installation, thus providing a check. The work of the designer, who prepared the applicable circuit schedule sheet (which designates the cable routing and termination), was spot checked by the cognizant electrical engineer.

The construction group installed the cable as directed by the circuit schedule sheet. The installations were verified by WEDCO field engineers and spot checks of circuit installations were made to further ensure that the installation was in accordance with the design. Consolidated Edison spot checked the installation.

Cable loading of trays and consequently heat dissipation of cable throughout the plant has been carefully studied and controlled to ensure no overloading. The criteria for electrical loading has been developed using IPCEA Standard P-46-426, manufacturer recommendations and good engineering practice.

Derating factors for cables in trays without maintained spacing were taken from Table VIII of the IPCEA publication. Derating factors for the maximum ambient temperature existing in any area of the plant were also taken from the IPCEA publication. These factors were applied against capacities selected from appropriate tables in other portions of the standard.

For physical loading of trays, the following criteria was followed: 6.9 kV power, one horizontal row of cables with spacing was allowed in a tray; 480 volt power, two horizontal rows of cables were allowed in a tray (if derating requirements did not dictate less); for control and instrumentation, the tray was filled to a point just below the top (the total cable area for this configuration is 60% of tray cross-sectional area). A computer program was used to monitor cable routing and tray loading.

Cables which do not require channeling may be run in any tray or conduit; however, once it entered a tray or raceway containing a channeled cable, it does not leave this channel and enter another tray containing a cable from a different channel.

To assure that only fire retardant cables were used throughout the plant, a careful study of cable insulation systems was undertaken early in the design. Insulation systems that have superior flame retardant capability were selected and manufacturers were invited to submit cable sample for testing. An extensive flame testing program took place which included ASTM vertical flame testing and Consolidated Edison Company vertical flame and bonfire tests as described below. These flame tests were used as one of the means of qualifying cables and specifications were written on the basis of the results from the tests.

The following tests were made to determine the flame resistant qualities of the covering and insulation of various types of cables for Indian Point 3:

1) Standard Vertical Flame Test – made in accordance with ASTM-D-470-59T, "Test for Rubber and Thermalplastic Insulated Wire and Cable."*

2) Five-Minute Vertical Flame Test – made with cable held in vertical position and 1750 F flame applied for five minutes.

3) Bonfire Test – Consisting of exposing, for five minutes, bundles of three or six cables to flame produced by igniting transformer oil in 12-inch pail. The cable was supported horizontally over the center of the pail, the lowest cable three inches above the top of the pail. The time to ignite the cable and the time the cable continued to flame after the fire was extinguished were noted.

On the basis of these tests, the cables were selected for the Reactor Containment Building for Indian Point 3. New cables are selected to conform with IEEE 383-1974.

Cables are protected in hostile environments by a number of devices. Running the cable in rigid, galvanized conduit is the most frequently of used method protection. For underground runs, PVC heavy wall conduit encased in a concrete envelope provides maximum protection. When cable is run in a tray, peaked covers are used in areas where physical damage to cables may result from falling objects or liquids. In addition, covers are provided on horizontal cable trays which are exposed to the sun.

Fire protection measures to prevent propagation of flame are discussed in Section 9.6-2. Fire detection is provided for areas where there are large groupings of cables in stacked cable trays. The plant has a protective signaling system that transmits fire alarm and supervisory signals to the Control Room where audible and visual alarms are provided. The system includes signals for actuation of fire detectors, and automatic sprinkler, water spray, foam and CO2 systems. Electrical supervisory signals are received from tamper switches on fire water system control valves.

Cables and wireways are marked by means of metal tags attached at each end. These tags are embossed to conform with the identification given in the Conduit and Cable Schedule. At each multiple conductor cable termination, a plastic covering is attached which as been premarked to indicate the terminal designation of each conductor. In addition, cable trays are marked at frequent intervals to indicate the channel number and voltage level of the tray. Color coding is discussed in Section 7.2.

In areas where missile protection could not be provided (such as near the Reactor Coolant System) redundant instrument impulse lines and cables were run by separate routes. These lines were kept as far apart as physically possible, or were protected by heavy (1/4") metal plates interposed where inherent missile protection could not be provided by spacing.

8.2.3 Emergency Power

Sources Description

Standby power required during plant startup, shutdown and after turbine trip is supplied from one 345kV feeder and one 138 kV feeder from the Buchanan Substation (approximately 3/4 mile from the plant) which as connections to the Millwood Substation and the Lovett Station of the Orange and Rockland system. These connections are made through the station auxiliary transformer.

In addition, there are two underground 13.8 kV feeders from the Buchanan Substation. The 13.8 kV feeders are connected to the 6.9 kV buses via autotransformers. If these sources should fail, the on-site sources of emergency power are three emergency diesel generator sets, each consisting of an Alco model 16-251-E engine coupled to a Westinghouse 2188 KVA, 0.8 power factor, 900 rpm, 3 phase, 60 cycle, 480 volt generator. Each unit has a 2000 hour and a 2 hour rating of 1950 kW and a 1750 kW continuous rating. There is also a vendor stated maximum ½ hour rating of 2000 kW. This is not an operational limit but an area of additional margin for handling power surges and spikes which may occur during testing. In addition, an alternate on-site source of power for safe shutdown loads is available from the Appendix “R” Diesel Generator which consists of an ALCO model 251 engine coupled to a KATO model 8P103600 3125 KVA, 0.8 power factor, 900 rpm, 3 phase, 60 cycle, 6900 volt Generator.

On July 21, 1988, 10 CFR 50 was amended to include a new Section 50.63 entitled, “Loss of All Alternating Current Power,” (Station Blackout). The Station Blackout (SBO) Rule requires that each light-water-cooled nuclear power plant be able to withstand and recover from an SBO of specified duration.

The Authority submitted to the NRC its response to the SBO rule. The NRC responded by issuing a Safety Evaluation dated December 23, 1991 and a Supplemental Safety Evaluation dated June 8, 1992. Based on these safety evaluations, and IPN-94-127, dated October 13, 1994, the following SBO-related items are resolved:

1) Habitability of the areas from which the AFW flow control valves and steam generator PORVs are operated during the first hour after the onset of an SBO event was evaluated and determined acceptable.

2) In order to address the effects of loss of ventilation of the control room, control room cabinet doors will be opened within 30 minutes of the onset of an SBO event.

3) The containment Isolation Valve design and operation meets the intent of the guidance described in Regulatory Guide 1.155. Specific containment isolation valves which cannot be excluded based on the 5 criteria given in Regulatory Guide 1.155 are documented to justify their exclusion and ensure that containment integrity will be maintained during an SBO event.

4) All equipment required for response to an SBO shall be classified (at least) Augmented Quality Related, and included in the QA Program.

5) The EDG reliability program follows the guidance and meets the intent of Regulatory Guide 1.155. This program includes monitoring of EDG reliability, surveillance and testing of the EDGs, maintenance program, an information and data collection system and management oversight.

6) The coping duration categorization of IP3 has been revised from four to eight hours.

Any two emergency diesel generator units, as a backup to the normal standby AC power supply are capable of sequentially starting and supplying the power requirement of one minimum required set of safeguards equipment. The three units are located in a seismic Class I structure located near the Control Building.

Each emergency diesel is automatically started by two redundant air motors, each unit having a complete 53 cu ft air storage tank and compressor system powered from a 480 volt motor. The piping and the electrical services are arranged so that manual transfer between units is possible. Each air receiver has sufficient storage for 4 starts. The diesel will consume, however, only enough air for one automatic start during any particular power failure. This is due to the engine control system which is designed to shutdown and lock out any engine which did not start during the initial try.

The emergency units are capable of being started and sequence load begun within 10 seconds after the initial signal. The starting system is completely redundant for each diesel generator. The units have the capability of being fully loaded within 30 seconds after the initial starting signal.

To ensure rapid start the units are equipped with water jacket and lube oil heating and pre-lube pump for circulation of lube oil when the unit is not running. The units are located in heated rooms.

An audible and visual alarm system is located in the main control room and will alarm off-normal conditions of jacket water temperature, lube oil temperature, fuel oil level, and starting air pressure.

The abnormal conditions that can shut down the diesel generator during an accident are:

1) overcranking
2) low oil pressure
3) overspeed

An auto shutdown alarm system provided three alarms in the Control Room; one for each emergency Diesel Generator. The alarm annunciates when a shutdown, lock out, control switch off auto or loss of DC power condition occurs. These alarms, located in the Control Room, will identify the diesel generator that has been tripped or is prevented from starting, because of a lock-out shutdown condition or loss of DC power.

Each emergency diesel generator was designed to start and come up to speed within ten seconds after initiation of the starting signal. Failure of the engine to start within the timing period of the overcrank time indicates a malfunction. The overcrank relays have a setpoint (approximately 15 seconds) that allows the diesel engine enough time to start and at the same time, does not allow the air tank to deplete itself. Shutdown conserves the starting air supply so that the engine can be subsequently started after the malfunction is corrected. Low oil pressure indicated by two out of three oil pressure switches shuts down the diesel generator, since the engine cannot run without proper lubrication. Shutdown permits corrective action to be taken before the engine is damaged, and the diesel generator can then be returned to normal operation.

An overspeed condition causes improper generator output and therefore the diesel generator should be shut down for corrective action to be taken to restore the generator output to normal.

For operator indication that one or more emergency diesel generators have been disabled for test or maintenance purposes there is an annunciator window labeled “SAFEGUARDS EQUIPMENT LOCKED OPEN.” This alarm is initiated on signals from various safeguards components including the diesels. From any one of the three diesels the following signals would actuate the alarm:

1) Main Control Board Generator Breaker Control Switch in pull-out position
2) Local Generator Breaker Control Switch in pull-out position
3) Local Diesel Control Switch in off or manual position.

Fuel oil for the emergency diesel generators is stored in three 7,700 gallon underground storage tanks located on the south side of the Diesel-Generator Building. There is one common truck hose connection and a 4-inch fill line for all three tanks, complete with a four-inch shutoff valve at each tank. The overflow from any tank will cascade into an adjacent tank. Each tank is equipped with a single vertical fuel oil transfer pump that discharges to either a normal or emergency header. Each header independently supplies the day tank at each diesel. An alarm will sound in the control room if the level in any underground storage tank approaches the level equivalent of the minimum total required inventory identified below less the indicating uncertainty. Administrative action will be taken to refill the tank. In addition, there is a low-level pump cutout switch located on each tank to prevent damage to the fuel oil transfer pump. Each tank is also equipped with a sounding connection and a level indicator. Decrease in level in a day tank to approximately 115 gallons (65% full) will cause the transfer pump in the corresponding underground storage tank to start. Once started, the pump will continue to run until the day tank is filled. When the tank is filled, a level switch will initiate closing of the day tank inlet valve and discontinue operation of the fuel oil transfer pump.

The minimum required usable inventory for each of the three storage tanks is specified in the Technical Specifications. The safety design criteria are based on the need to provide adequate fuel to support forty-eight (48) hour operation of minimum safeguards equipment following a design basis accident. The minimum required inventory (gallons) for fulfillment of the safety design criterion is based on the following:

	31 Tank	**32 Tank**	**33 Tank**
Calculated consumption (TS Required Usable)	5,365	5,365	5,365
*Total minimum required inventory (when using dipstick)	6,339	6,339	6,380
*Total minimum required inventory (when using uehling indicator)	6,555	6,555	6,596

*Note 1: includes unusable volume at fuel oil transfer pump cutoff and allowances for instrument error, specific gravity tolerances, volume lost to re-coating, and other similar items

No credit is taken in the above tabulation for the inventory of oil in the EDG day tanks. Each emergency diesel is equipped with a 175-gallon day tank. The transfer pump start and fill valve open function is initiated when the level in the tank approaches (decreases toward) 65% (of nominal full) level, approximately 115 gallons. The 32 fuel oil storage tank was re-coated during RO10. A conservative estimate of the volume reduction of the tank was made and the required inventory for fulfillment of the safety design criterion adjusted accordingly.

Fuel flows by gravity to the engine, insuring a static head of fuel oil on the injection manifolds. Excess fuel oil is collected in a drip tank located in the base of the diesel engine. A manually operated drain pump is provided so that the drip tank can be emptied. The diesel fuel oil storage and transfer system diagram is shown in Plant Drawing 9321-F-20303 [Formerly Figure 8.2-7].

A usable amount of 37556 gallons of fuel oil is required to operate two emergency diesels at minimum safeguards load continuously for 168 hours. An assumed 10730 gallons is available assuming the unlikely event that one underground storage tank is unavailable. [Deleted] An additional minimum usable storage of 26,826 gallons is necessary to assure continuous operation of two diesels at minimum safeguards load for a total of 168 hours. This reserve is in addition to the storage requirements for other plants at the site. The usable amount of 37,556 gallons of fuel oil is necessary to operate two diesels for seven days to maintain the unit in a cooldown condition concurrent with a loss of offsite power.

The Technical Specifications require 26,826 gallons of fuel as minimum usable storage available for Indian Point 3 usage in other normal supply tanks on site or at the Buchanan Substation. Also, additional supplies of diesel fuel oil are available locally.

There are two 30,000 gallon seismic Class III tanks located in the Indian Point 1 Superheater Building and a 200,000 gallon seismic Class III tank in the Buchanan Substation located immediately across Broadway. These tanks contain fuel oil for operation of the IP2 SBO / Appendix R diesel. Each tank has a level indicator and a capacity check is made weekly. The maximum consumption of the IP2 SBO / Appendix R diesel generator over a three (3) day operating period is 12,500 gallons. A truck with hose connections compatible with the underground storage tanks will be provided. If the diesels require the reserves in these tanks, the contents of these tanks would be transported by truck to the underground diesel storage tanks. Additional supplies of diesel oil are available locally. Under normal conditions, 25,000 gallons can be delivered on a one or two-day notice. Additional supplies are also maintained in the region (about 40 miles from the plant) and are available for use during emergencies, subject to extreme cold weather conditions (increased domestic heating usage) and available transportation.

All components of the emergency diesel fuel oil supply system are seismic Class I and as such were designed in accordance with the criteria of Section 16.1. In addition, all components of the diesel fuel oil supply system are tornado protected and as such are able to withstand the design tornado and the tornado driven missiles delineated in Section 16.2. These components are also protected against the turbine missiles described in Appendix 14A of Chapter 14. The power supply and control system for the diesel fuel oil transfer system were designed in accordance with IEEE-279, meeting fully the single failure criteria specified therein.

Fuel oil for the emergency diesel generators is stored in three buried storage tanks. Each tank is equipped with a single vertical fuel oil transfer pump that discharges oil into either of two headers according to the manual valving arrangement selected. Both of these headers connect to a 175-gallon day tank mounted on each of the three diesel engines.

Decrease in level in any one of the three day tanks to the 65 percent level automatically starts its associated fuel oil transfer pump (local manual controls are also available). The fuel oil transfer pumps are powered from motor control centers 36C, 36D, and 36E. Since each pump is capable of supplying fuel oil to all three diesels, this arrangement assures the availability of fuel oil to each diesel.

Each day tank is provided with AC normal level and low level indicating lights. In addition, each day tank has a DC low-low alarm on its respective diesel generator control panel which also annunciates a common Diesel Generator Trouble Alarm on the supervisory panels in the Control Room.

Diesel-Generator Separation

The emergency diesel generators are located in a tornado-proof reinforced concrete building immediately adjacent to the Control Building. The diesel generators are arranged on 13'-0" centers, parallel to each other with approximately 10'-0" between engine components. The structure is provided with internal walls to separate the three diesel generators and their associated cabling and control panels from each other for fire protection. Fire protection and detection systems for the diesel generators are discussed in Section 9.6.2.

Each control panel contains relays and metering equipment for its diesel generator. In the event of an electrical fire the event is annunciated in the main control room. With the compartmentalized diesel generator separation design, and the fire protection systems provided, spread of fire from one unit and its associated equipment to the other units is minimized.

Each emergency diesel generator has its own small fuel storage (day) tank that feeds the fuel oil pump on the engine. All day tanks are automatically filled during engine operation from three separate underground storage tanks outside the diesel generator building. Each storage tank has its own supply pump mounted in a manhole opening in the top of the tank above oil level. It is therefore unlikely that a fire associated with any one of the small fuel oil storage (day) tanks would prevent oil from being supplied to the remaining two diesels.

Loading Description

Each unit is to be started on the occurrence of either of the following incidents:

1) Initiation of safety injection operation;
2) Undervoltage on its own bus.

On occurrence of undervoltage without safety injection the engines are started and connected to their respective bus.

If there is coincident or subsequent requirement for engineered safeguards, automatic sequencing is initiated as follows:

1) Emergency diesel No. 31 is connected to and capable of supplying bus No. 3A in addition to bus No. 2A (via a bus tie between buses No. 2A and 3A) in the event of a safeguards system requirement.
2) All 480 volt breakers, except those feeding the motor control centers numbers 36A, 36B, 36C, 36D, 311 and 36E are tripped and all automatically operated non-safeguards' feeders are locked out. All engineered safeguards motors are operated from the 480 volt buses.
3) Connect the diesel generators to their respective buses.
4) Magnitude of loads for each emergency diesel generator is given in Table 8.2-1A.

If a diesel fails to start or a bus fault occurs, the loads as indicated on the associated bus will not start. The remaining loads on the unaffected buses meet the minimum safeguards requirements.

The recirculation phase is manually initiated by control switches on the supervisory panel in the main control room. As the sequence switches are operated, the bus loads are modified to give those shown in Reference 1 for the respective Design Basis Accidents.

Emergency Diesel Generator Loading

The following "minimum safeguards" equipment is required and assumed to be operating for a design basis event at Indian Point Unit 3:

2 of 3 Safety Injection (SI) Pumps
1 of 2 Residual Heat Removal (RHR) Pumps
1 of 2 Motor Driven Auxiliary Feedwater (AFW) Pumps
1 of 2 Recirculation Pumps
3 of 5 Containment Recirculation (CR) Fans
1 of 2 Containment Spray (CS) Pumps
1 of 3 Nonessential Service Water (NE SW) Pumps
2 of 3 Essential Service Water (ESW) Pumps
1 of 3 Component Cooling Water (CCW) Pumps

Due to interactions between systems, minimum requirements for safety vary with the loss of any one diesel generator. See Chapter 14.3 for details.

This configuration is based on the assumptions of a single active failure of an emergency diesel generator and that 1 CCW and 1 NE SW pump may be out of service at the time of the accident. In addition to the required equipment listed above, the operator may manually load other equipment during the recovery process as instructed by the Emergency Operating Procedures (EOPs) or System Operating Procedures (SOPs).

The maximum steady state power requirements for equipment that is either automatically or manually loaded in the emergency diesel generators following a loss of offsite power and SI actuation have been conservatively calculated in Reference 1. The diesel generator loading in each of the following design base accidents; large break loss of coolant, small break loss of coolant, main steam line break, and steam generator tube rupture are evaluated in Reference 1 for the actual sequence of loading that the control room operators would initiate as they respond to a DBA. In the initial stage for the worst case accident, the peak load is less than 1950 kW. As the plant approaches steady state (accident stabilized) conditions the EDG loading is less than the unit 1750 kW continuous rating. The maximum steady state power requirements for equipment loading in the emergency diesel generators following a reactor trip without engineered safeguard actuation (SI) with loss of offsite power have been conservatively calculated in Reference 2. Similar to the SI accident scenarios, at the initial stage of the accident the peak load is less than 1950 kW. At steady state, the diesel load is less than 1750 kW. Equipment loading range on the EDG's for both the SI and Non-SI accidents is summarized in Table 8.2-1A.

The worst case transient loading histories were computed assuming the possibilities of a diesel failure combined with equipment out of service.

Design basis events which do not actuate the safety injection system will result in lower emergency diesel loading than those that do.

<u>Testing</u>

To verify that the emergency power system will respond within the required time limit and when required, the following tests shall be performed periodically.

a) Manually initiated demonstration of the ability of the diesel generators to start and deliver power up to nameplate rating when operating in parallel with other power sources. Normal plant operation will not be affected. The duration of the test is at least one hour to at least 50% of continuous rating.

b) Demonstration of the readiness of the system and the control systems of vital equipment to automatically start or restore to operation particular vital equipment by simulating a loss of all normal AC station service power supplies. This test is conducted as required by the Technical Specifications.

The starting of the diesel generator sets can be tested from the Diesel Generator Building. The ability of the units to start within the prescribed time and to carry intended loads are checked periodically. (See Section 8.5).

In addition, each diesel generator shall be inspected and maintained following the manufacturer's recommendations for this class of standby service.

Batteries and Battery Chargers

Lead acid station Batteries No. 31, 32, 33, and 34 have been sized to carry their expected shutdown loads following a plant trip and a loss of all AC power for a period of 2 hours without battery terminal voltage falling below its minimum required voltage. Lead acid station Battery No. 36 has been sized to carry its load for a period of 3 hours without falling below 105 volts. Major loads with their approximate operating times on each battery are listed in Table 8.2-2.

The five battery chargers have been sized to recharge the above partially discharged batteries within 15 hours while carrying its normal load. Battery chargers 31, 32, and 33 are also relied upon to support the continued operation of systems and components required to either mitigate the consequences of a design basis accident or provide post-accident monitoring subsequent to depletion of Batteries No. 31, 32, and 33.

Battery Charger 35 is an installed spare charger which can be utilized as a replacement for any one of Battery Chargers 31, 32, 33, or 34. Battery Charger 35 can be supplied from either MCC -36C, -36D, or –36E via a plug / receptacle arrangement. This arrangement will allow BC 35 to be supplied from the same source as the Battery Charger it is being used to replace, or in the case when it is replacing BC 34, a more reliable source. This will allow BC35 to be supplied from the proper train for its intended use.

The battery system consists of four batteries (No. 31, 32, 33, and 34), each of which generates hydrogen during a floating charge or an equalizing charge. For batteries No. 31, 32, and 34 with the worst case assumptions of the exhaust fan out of service and no natural ventilation, or for battery No. 33 with no exhaust systems or any natural ventilation in effect, with temperatures as high as 104°F, the time to accumulate a hydrogen buildup to four percent under various charging conditions is:

Battery No. 31	floating charge equalizing charge	>23 hours >3 hours
Battery No. 32	floating charge equalizing charge	>30 hours >3 hours
Battery No. 33	floating charge equalizing charge	>77 hours >7.7 hours
Battery No. 34	floating charge equalizing charge	>11.5 hours >3.8 hours
Battery No. 36	floating charge equalizing charge	>17 hours >7.8 hours

The ventilation system for Battery Rooms No. 31, 32, 34 and 36 operate continuously, to preclude any hydrogen build-up. (Station Battery No. 33 is located in Diesel Generator Room No. 31 and does not require forced ventilation.) Loss of the battery room ventilation is annunciated in the Control Room; loss of diesel operating room ventilation is detected by supervisory personnel observations and/or normal operating maintenance procedures.

Normally the batteries are on continual floating charge. They are placed on equalizing charge as deemed necessary based on recorded cell voltages and specific gravities. (Manual actuation is reuired at the battery chargers to place the batteries on equalizing charge.)

There is one (1) annunciator window labeled "Battery Charger Trouble." This alarm is set off on the following signals from battery chargers as indicated:

SIGNAL	CHARGERS
1) Low DC Voltage	31, 32, 33, 34, 35, & 36
2) Ground Detection	31, 32, 33, 34, 35, & 36
3) AC Power Failure	31, 32, 33, 34, 35
4) High-Low AC Voltage	36
5) Over Temp	31, 32, 35 & 36
6) High DC Voltage	36
7) High DC Voltage Shutdown	31, 32, & 35
8) Battery Discharge	31, 32, 35 & 36
9) Charger Failure	36

Each individual signal can be isolated on each individual charger listed. Indication is provided at each charger when at any signal is isolated on that charger.

Reliability Assurance

The electrical system equipment is arranged so that no single contingency can inactivate enough safeguards equipment to jeopardize the plant safety. The 480-volt safeguards equipment is arranged on 4 buses. The 6900-volt equipment is supplied from 7 buses.

The plant auxiliary equipment is arranged electrically so that multiple items receive their power from the two different sources. The charging pumps are supplied from the 480 volt buses No. 3A, 5A and 6A. The nine service water pumps and the five containment fans are divided among five of the 480-volt buses. Valves are supplied from motor control centers, No. 36A, 36B, and 36C which are supplied from buses No. 2A, 5A and 6A.

The outside source of power is adequate to run all normal operating equipment. The 138 kV – 6.9 kV station transformer can supply all the auxiliary loads.

The bus arrangements specified for operation ensure that power is available to an adequate number of safeguards auxiliaries.

Minimum engineered safeguards can be carried by any two diesel generators. These safeguards can adequately cool the core and maintain containment pressure within the design value for the Design Basis Accident.

One battery charger is available to each battery so that the four batteries will always be at full charge in anticipation of loss-of-AC power incident. This ensures that adequate DC power will be available for starting emergency generators and other emergency uses.

8.2.4 Engineered Safeguards Components

The initiation, control and sequencing design of engineered safeguards components, Auxiliary Feedwater System, and Component Cooling Water System is as shown on the schematics listed on Table 8.2-3.

References

1) Calculation IP3-CALC-ED-00207, 480V Bus 2A, 3A, 5A & 6A and EDGs 31, 32 & 33 Accident Loading.

2) Calculation IP3-CALC-ED-00358, Electrical Load Study 480 Volt Safeguard Bus Loading Reactor Trip / No SI, and Loss of Feedwater Transient / No SI, with Offsite Power Available.

3) Report IPEC-RPT-04-00116, Rev. 0, "System Reliability Impact Study: Extend Power Uprate of Indian Point Units 2 and 3."

TABLE 8.2-1A

LOAD SCHEDULE FOR DIESEL GENERATORS

Loads on Bus 5A (Emergency Diesel Generator 33)

Automatic Loads		Manual/Optional Loads	
Equipment	Load Range (KW)	Equipment	Load Range (KW)
SI Pump 31	325-329	CR Pump 31	202-311 (3)
CS Pump 31	305-309	NE SW Pump 31	278-283
CR Fan 31	127-131	CCW Pump 31	173-222
CR Fan 33	127-131		
ESW Pump 34	278-283	MCC 39	112-158
MCC 36A	68.9-72.9 (1)	Chg Pump 31	138-142
		Przr Htrs 33	208-485
MCC 36E	18-22	MCC 38	78-82
MCC 311	0 (4)	MCC 311	0 (5)

Loads on Bus 2A/3A (Emergency Diesel Generator 31)

Automatic Loads		Manual/Optional Loads	
Equipment	Load Range (KW)	Equipment	Load Range (KW)
SI Pump 32	325-329	NE SW Pump 32	278-283
RHR Pump 31	286-318 (2)	CCW Pump 32	173-222
AFW Pump 31	376-381	MCC 32	13-15
CR Fan 32	127-131	MCC 35	60-64
CR Fan 34	127-131	Chg Pump 32	138-142
ESW Pump 35	278-283	Przr Htrs 31	208-555
MCC 36C	92-96 (1)	Przr Htrs 32	208-415
		PAB Vent Fan 31	112-116
		MCC 34	49-95

Loads on Bus 6A (Emergency Diesel Generator 32)

Automatic Loads		Manual/Optional Loads	
Equipment	Load Range (KW)	Equipment	Load Range (KW)
SI Pump 33	325-329	CR Pump 32	202-311 (3)
CS Pump 32	317-321	NE SW Pump 33	278-283
RHR Pump 32	286-318 (2)	CCW Pump 33	173-222
AFW Pump 33	373-378	MCC 37	64.06-267.06
CR Fan 35	127-131	Chg Pump 33	138-142
ESW Pump 36	278-283	PAB Vent Fan 32	112-116
MCC 36B	65-75 (1)	Przr Htrs Cntl Group	277
MCC 36D	18-22		

(1) Does not include transient MOV Loads
(2) This load is reduced to 182 KW when RHR pump is in mini-flow
(3) This load is reduced to 204-207 KW on Post-Recirculation Spray and Hot Leg Recirculation with 1 heat Exchanger in service.

(4) Auto Closure loads on MCC 311 (BFD 90-1 through 90-4 and BFD 5-1 through 5-4) are transient loads
(5) Manual Load MCC 311 as required by EOP to restore Feedwater to faulted Steam Generator are transient loads

TABLE 8.2-2

MAJOR BATTERY LOADS

Battery No. 31	
Inverter No. 31 (25 KVA)	2 Hours
Emergency Lighting & Control Power (17 KW)	2 Hours
Battery No. 32	
Inverter No. 32 (25 KVA)	2 Hours
Emergency Lighting & Control Power (23 KW)	2 Hours
Battery No. 33	
Control Power (1.8 KW)	2 Hours
Inverter No. 33 (25 KVA)	2 Hours
Battery No. 34	
Inverter No. 34 (7.5 KVA)	2 Hours
Battery No. 36	
Turbine Generator Emergency Oil Pump (60hp)	3 Hours
Boiler Feed Pump Emergency Oil Pump (15 hp)	3 Hours
Air Side Seal Oil Back-up Pump (25 hp)	3 Hours
PCE LCI Drives (10.875kW)	2 Hours

TABLE 8.2-3

ENGINEERED SAFEGUARDS COMPONENTS, AUXILIARY FEEDWATER AND COMPONENT COOLING SYSTEMS INITIATION, CONTROL & SEQUENCING SCHEMATICS LIST

Drawing No.	Sheet No.	[Deleted]
500 B 971	5	
	6	
	7	
	9	
	10	
	11	
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	13	
	14	
	27	
	28	
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	92	
	93	
	94	
	95	
	96	
	96A	
	96B	
	97	
	98	
	99	

TABLE 8.2-3
(Cont.)

ENGINEERED SAFEGUARDS COMPONENTS, AUXILIARY
FEEDWATER AND COMPONENT COOLING SYSTEMS
INITIATION, CONTROL & SEQUENCING SCHEMATICS LIST

Drawing No.	Sheet No.	[Deleted]
	105	
	106	
	107	
	108	
	110	
	111	
	112	
	113	
	114	
	115	
	116	
	117	
	117A	
	117B	
	119	
	119A	
	120	
	121	
	122	
	123	
	124	
	124A	
	124B	
	124C	
	124D	
	124E	
	125	
	125A	
	125B	
	126	
	127	
	128	
	129	
	130	
	131	
	132	
	132A	
	133	
	134	
	135	
	136	
	137	
	138	
	139	
	140	

TABLE 8.2-3
(Cont.)

ENGINEERED SAFEGUARDS COMPONENTS, AUXILIARY FEEDWATER AND COMPONENT COOLING SYSTEMS INITIATION, CONTROL & SEQUENCING SCHEMATICS LIST

Drawing No.	Sheet No.	[Deleted]
	141	
	152	
	153	
	154	
	155	
	160	
	183	
	209	
	210	
	211	
113 E 301	4	
	5	
113 E 302	1	
	2	
	3	
113 E 303	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
9321-LL-31313	10	
	13	
	15	
	15A	
9321-LL-31343	3	
	7	
9321-LL-31333	1	
	2	
	3	
	4	
	6	
	9	
	11	
	14	
	15	

TABLE 8.2-3
(Cont.)

ENGINEERED SAFEGUARDS COMPONENTS, AUXILIARY FEEDWATER AND COMPONENT COOLING SYSTEMS INITIATION, CONTROL & SEQUENCING SCHEMATICS LIST

Drawing No.	Sheet No.	[Deleted]
9321-LL-31173	1	
	2	
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	5	
	6	
	6B	
	7	
	8	
	10	
	12	
	13	
	14	
	18	
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	20	
9321-LL31183	1	
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8.3 MINIMUM OPERATING CONDITIONS

The minimum operating conditions for electrical systems are given in Sections 3.8.1 and 3.8.10 of the Technical Specifications.

8.4 CABLE AND PENETRATION SEPARATION

The reactor protection and engineered safety system cable circuits are divided into as many channels as is required to preserve the basic redundancy and independence of the systems. Channel separation is maintained as indicated below and is continuous from the sensors to the entrance to the receiver racks, logic cabinets, and actuation devices in such a manner that failure within a single channel is not likely to cause the loss of the basic protection system or cause a failure which would prevent actuation of the minimum safeguards devices when called for.

In general, this requires the use of four (4) protection system instrumentation channels (Section 7.2), three (3) heavy power channels, two (2) medium power channels and four (4) control channels. In addition to such channels of separation, cables are assigned to individual routing systems, in accordance with their voltage level, size and function, by means of a three digit circuit code identification.

The circuit code is broken down as follows:

FIRST CHARACTER – Voltage level
B = heavy 6900V
C = heavy 480V or DC
D = control, misc. 120V AC/DC
F = medium AC or DC power
G = vibration pick-up
H = rod control
J = instrumentation

SECOND CHARACTER – Channel
A = Channel I
B = Channel II
C = Channel III
D = Channel IV
E = Channel V

THIRD CHARACTER – Category – cables required to be in a particular channel to provide separation of redundant circuits are assigned a circuit code whose description includes the channel identification. Non-vital cables of the same voltage level, which are routed in the same channel, are assigned one of the remaining circuit codes (e.g., a safety injection pump would be assigned CA1, while a pressurizer heater would be assigned CA2. Both cables would be routed in the same tray where their paths are parallel).

There is no mixing of vital cables of the above categories in the same tray or conduit, except inside the containment building, where due to space limitations it becomes necessary to mix D and F (first character) cables of the same channel in the same tray. For the most part, these F cables are for valve motors which are less than ten (10) horsepower, and are energized only intermittently.

Conduit fill for all systems is based on standard National Electric Code recommendations.

Tray fill for 6900 volt power cables is limited to one (1) layer of cables. Tray fill for heavy 125 volt DC power cables, heavy 480 volt AC (over 100 hp) power cables, lighting panel feeders and medium power (greater than No. 12 AWG wire size) 480 volt AC cables is limited to two (2) layers of cables. Cables included for control and light power are 120 volt AC and DC control and power cables, alarm, communication, instrument transformer, and 480 volt AC power cables. In most cases, these cables are a maximum of No. 12 AWG wire size. Tray fill limitation for control and small power cables is that total cross sectional area of cables will not exceed 60% of the tray's cross sectional area. Exceptions occur where a larger wire size has been used to limit voltage drop on long runs.

Separation of channels is established throughout the plant by the use of separate trays or conduit (exceptions are documented and justified in Reference 1). In addition, whenever in a heavy power tray is located less than three (3) feet beneath any tray of a different channel a transite or marinite fire barrier is installed between the trays. A vertical barrier is installed where trays of different channels are installed less than one (1) foot apart, horizontally. Additionally, a horizontal barrier is installed where trays (other than heavy power) are installed less than one (1) foot beneath any tray of a different channel.

Fire retardant barriers have been installed between cable trays carrying cables for safety related pumps. Isolating switches are provided for fire protection of the control circuits of Diesel Generator No. 31, the control circuits for feeder breakers to 480 volt buses 2A and 3A and the tie breaker between the two buses. Safety related instrumentation have isolation switches and alternate power supplies for fire protection.

In some areas of the turbine-generator building, separation between D, F, and J cables of the same channel is by means of a 16-gauge sheet metal barrier, 4" high, within the tray. The barriers are used as a means of providing a continuous identifiable route of a given voltage level. Raceways in the turbine hall were laid out and installed specifically for the Low Pressure Steam Dump System. Among the cables in these raceways are those associated with the overspeed protection systems. The bypass system was designed to nuclear protection system criteria of redundancy, separation and reliability.

The electrical tunnels, which run from the control building past the primary auxiliary building, to the containment penetration vault, consist of two (2) concrete conduits located one above the other. Both the upper and lower tunnels are eight feet wide by eight feet high.

Channel separation in the tunnel is maintained by placing all Channel 1 trays on the left hand side of the upper tunnel (as viewed when facing north), and Channel 2 trays on the right hand side. Channel 3 and 4 trays are located on the left and right side of the lower tunnel respectively.

In the lower tunnel, two (2) 480 volt power feeders from bus 5A (to MCC 38 and to the Pressurizer Heater Backup Group 33) run with redundant cables from bus 2A. Also, one (1) 480 volt power feeder from bus 6A (to the Pressurizer Heater Control Group) runs with redundant cables from bus 3A. These feeders are not redundant and may be run in any channel provided they remain in that channel throughout their route.

The electrical penetrations are in a single area, comprised of some sixty-four assemblies (including spares). The main group of assemblies (penetration canisters) are arranged four rows high, with each row separated from another row by three (3) feet. Each assembly in a row is spaced on approximately three (3) foot centers. Each assembly contains only one category of circuit, except D and F cables previously noted as running in the same tray will also be in the same assembly. The various penetration canisters consist of units of #12 AWG, shielded twisted pairs, shielded twisted quads, #8 AWG, #2 AWG, 250 MCM, 350 MCM, triax and coax.

The penetrations are capable to withstand short circuit currents under worst case operating conditions, and to maintain their pressure boundary integrity until either the primary protection (for safety related circuits) or backup protection (for safety or non-safety related circuits) protective devices operate.

As may be seen on Plant Drawing 9321-F-30533 [Formerly Figure 8.4-1], the canisters are arranged according to separation channels, and those canisters identified by a given channel will carry only cables whose entire route are of the same channel.

In general, the separation between redundant or channelized circuits is expected to be greater than the spacing between two adjacent assemblies. However, some channels are in adjacent units and free air spacing can be expected to be twenty-eight inches or more at the face of the penetration. The control, instrument, and small power assemblies are furnished with factory installed pigtails. The cable spreading and penetration areas are in a concrete vault.

The four (4) channels of nuclear instrumentation sensor cables are in individual conduits, which are supposed from the ceiling of the two tunnels, above the trays of the same channel.

Fire Protection for the electrical system is as described in Sections 8.22 and 9.6.2.

References

1) NSE 94-3-124 ED. Revision O, "Evaluation of Cable Channelization Deficiencies."

8.5 TESTS AND INSPECTIONS

The tests discussed in this Section are designed to demonstrate that the Diesel Generators will provide power for operation of equipment. They also assure that the emergency generator system controls and the control systems for safeguards equipment will function automatically in the event of a loss of all normal 480 volt AC station service power.

The testing frequency dictated by the Technical Specifications provides for testing often enough to identify and correct deficiencies to systems under test before they can result in a system failure. The fuel supply and starting circuits and controls are continuously monitored and any faults are indicated by alarms. An abnormal condition in these systems would be signaled without having to place the Diesel Generators themselves on test.

To verify that the emergency power system does respond properly and within the required time limit when required, the following tests are performed periodically:

a) Manually initiated demonstration of the ability of the Diesel Generators to start, and deliver power up to name plate rating, when operating in parallel with other power sources. Normal plant operation will not be affected. The duration of the test shall be at least one hour to at least 50% of continuous rating.

b) Demonstration of the readiness of the system and control systems of vital equipment to automatically start or restore to operation particular vital equipment by initiating an actual loss of all normal AC station service power supplies. This test is conducted as dictated by the Technical Specifications.

The starting of the diesel-generator sets can be tested from the Diesel Generator Building. The ability of the units to start within the prescribed time and to carry intended loads is checked periodically.

To verify that the 480 V safeguards bus undervoltage alarms operate properly they shall be tested monthly and calibrated every 24 months.

In addition, each diesel generator shall be inspected and maintained following the manufacturer's recommendations for this class of standby service.