SECTION 8

ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 Utility Grid System and Interconnections

Each unit generates electric power at 25 kV which is fed through an isolated phase bus to the main transformer bank where it is stepped up to 500 kV and delivered to the switching station. The 500-kV switching station design incorporates a breaker-and-a-half scheme for high reliability and is connected to three 500-kV transmission lines. Two transmission lines go north, via separate right-of-way, to two major switching stations: Public Service Electric and Gas (PSE&G) New Freedom Switching Station and Atlantic City Electric's Orchard Switching Station. The New Freedom Switching Station is solidly connected to the PSE&G 230-kV bulk power system via four 500/230-kV autotransformers. Orchard Switching Station is also connected to Atlantic City Electric's 230-kV bulk power system via a 500/230-kV autotransformer. In addition, it is connected to the Pennsylvania / New Jersey / Maryland 500-kV interconnected system. The third transmission line serves as a tie line to the adjacent Hope Creek 500-kV switchyard line which is also integrated into the Pennsylvania / New Jersey / Maryland 500-kV interconnected system.

8.1.2 Onsite Power Systems

The Onsite Power System for each unit consists of the main generator, the auxiliary power and station power transformers, the diesel generators, 40-MW gas turbine generator (one for both units), the group, vital and circulating water bus sections and their related distribution systems. The 4160-V vital buses, which feed safeguard equipment, are energized by station power transformers served by the 13-kV south bus sections. Preferred power is supplied to the 13-kV bus south sections by two sources from the switchyard.

Safeguards loads are divided among the vital buses in three independent load groups. Each of these load groups is provided with a diesel generator which serves as a standby power supply in the event that the preferred source is unavailable.

Each unit has a 125-V dc power system to provide power to safeguards loads. This system also supplies power through inverters to the 115-V ac instrument buses. In addition, each unit is provided with a 250-V dc power system and a 28-V dc control system. The above constitutes station dc sources. Two separate 125-v dc batteries and associated equipment are provided in the circulating water switchgear building to provide power to the switchgear and 13.8 kV south bus section breakers.

8.1.3 Safeguards Loads

Safeguards loads are identified on the following figures:

Load Group	Plant Drawing No.
4160 V ac	203002
460 V ac	203003 and 203063
230 V ac	203003 and 203063
28 V dc	211357
125 V dc	203007 and 223720

8.1.4 Design Bases

8.1.4.1 General

The station has been designed to be capable of being safely shut down from full power in the event of the loss of all offsite power sources. Redundant and independent onsite power sources are provided to ensure the availability of the necessary power for shutdown systems. Total loss of all onsite and offsite ac power is not a design basis event.

The distribution system for each unit and the network interconnections are designed, fabricated, and erected with sufficient independence, redundancy, capacity, and testability to provide reliable power to unit auxiliaries during startup, operation, and shutdown. The Class 1E portion of the distribution system of each unit is designed to meet the intent of IEEE 308-1971, "Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations."

Onsite Electrical Systems and components vital to station safety, including the emergency diesel generators, are designed so that their integrity is not impaired by a design basis earthquake, high winds, floods, or disturbances on the 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 environmental phenomena in order to assure a high degree of confidence in the operability of such components in the event their use is required. Considerations which reflect the above requirements and which have been incorporated in the Electrical System are evidenced by the following:

1. The enclosures for motors and electrical switchgear suit the local conditions and are designed in accordance with specifications issued by the National Electrical Manufacturers Association. All electrical equipment operates within its rated limits.

2. All switchgear is of metal-clad construction. The 4160-V and 460-V switchgear control power is taken from the station 125-V dc sources. Each breaker cubicle is separated from the adjacent cubicle by metal barriers and each bus section is physically separated from all others. Vital switchgear, unit substations, and motor control centers are confined to Seismic Category I areas. Separation of redundant power equipment has been maintained throughout the station. This equipment is designed to permit safe operation under normal, overload, and short circuit conditions. The equipment design provides for satisfactory voltage regulation while short circuit duties remain within the equipment capability.

The station batteries and associated chargers are in separate rooms within a Seismic Category I structure.

3. Adequate communications systems are provided for station operating personnel which include a page and party line communication system, a direct dial telephone system with Telephone Company central office tie lines, and a system of portable transceivers with fixed repeaters. Sound-powered phones are also provided.

8.1.4.2 Cabling

Further information for protection circuits is presented in Section 7.

8.1.4.2.1 Cable Ratings

"Power Cable Ampacity," AIEE Pub. No. 5-135-1/IPCEA Pub. No. P-46-426 was originally used as the criteria to determine allowable cable ratings as appropriate for tray, conduit, and raceway applications. Since 1993, ICEA P-54-440, "Ampacities of Cables in Open-top Cable Trays", has also been used to derive the ampacity of power cables in open air random filled trays.

Power and control cable insulation selection was based on an optimum combination of insulation, fire resistance, and non-propagation qualities. Appropriate instrumentation cables are shielded to minimize induced voltage and magnetic interference.

8.1.4.2.2 Fire Protection

In areas where safety-related cables are installed, the following fire protection and/or detection is provided:

1. Lower Electrical Penetration Areas at Elev. 78', 460V Electrical Switchgear Rooms at Elev. 84' - photoelectric (smoke) and thermal detectors, automatically operated sprinkler systems.
2. 4160V Electrical Switchgear Rooms at Elev. 64' - photoelectric (smoke) and thermal detectors, automatically operated sprinkler systems.

3. Relay Room (cable spreading rooms) - Ionization-type products of combustion detectors and independent Halon 1301 fire extinguishing system which is actuated either automatically upon receipt of a coincident signal from both zones of the cross zone Fire Detection System, or manually by either operation of a remote pull station or by depressing the STRIKE button on the Halon system control panel.

4. Control Room - Ionization-type products of combustion detectors and manual fire alarm pull-stations.

5. Diesel Generator Compartments - Rate of rise and/or rate compensated thermostats and manual $C0_2$ total flooding systems.

The manual CO_2 systems for the diesel generator CO_2 protected areas have a first-in-with-lockout capability. Upon manual actuation of any one diesel generator area CO_2 system, a permissive circuit is established to the other two systems to shunt-trip the supply breakers for either of these other two systems upon receipt of any actuation signal. Therefore, the first-in signal effects a lockout of the other two systems. Pilot valve actuation of a diesel generator area CO_2 system remains operable with the manual pushbutton response locked out (deenergized).

At all fire barrier walls, floors, and ceilings, fire stops are provided for all openings through which cables pass. A Fire Detection System is installed in critical areas throughout the station. Additional information regarding fire protection is presented in Section 9.5.1.

8.1.4.2.3 Marking

The cable identification system provides distinctive markings in order to readily enable detection of any violation of the independence criteria, by visual inspection. It provides that a cablemark channel (for such nonsafety-related cables that run with safety-related cables), be applied to each cable as it is installed. The locations for these tags are: 1) at each end; 2) in the vicinity of each traymark of the route; 3) both sides of penetrations of walls, etc.; and 4) at the entrance and exit of all conduit or duct runs. Installation conformance to design criteria is assured by quality control surveillance during installation and separate audits performed after installation, as indicated in Section 8.1.4.2.6.

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To facilitate installation audits by others, colored tape is employed to offer further evidence of conformance to the independence criteria. The colored tape is applied during installation, adjacent to the cablemark tags indicated above and will serve for construction conformance purposes only. The tape is a different solid color for each of the four safety-related channels and the same four colors striped for the associated nonsafety-related channels (when nonsafety-related cables are run with safety-related cables, as noted in Section 8.1.4.2.4).

Cable identifications consist of a series of alphanumeric digits associated with its system, origin, or function. Safety-related cables and nonsafety-related cables which are run with safety-related cables are suffixed by a "-" and a letter indicating channel. These cables must follow the rules for routing described below.

Identifying Mark No.	Examples Digits (s)	Significance
1A4D-A	1	Unit No.
(Power Cable)	A	Bus Designation
	4	Breaker Position
	D	Voltage Level
	-A	Safety-related Channel A
1RMS48-GT	1	Unit No.
(Control Cable)	RMS	Radiation Monitoring System
	48	Sequential Designation
	-G	Nonsafety-Related Channel G
	T	Digital Signal

Each cable tray run has its own five-digit identification number. This number defines the unit number, building, elevation, and general area. This number will also appear on cable schematics and on cable and conduit schedules. Safety-related trays are color coded to distinguish the safety-related from the nonsafety-related cable trays. In addition, all wireways containing safety-related cables are distinctly identified as such.

8.1.4.2.4 Separation In-Plant

The routing of control, instrumentation, and power cables is such as to minimize their vulnerability to damage. Power and control cables are distributed from the switchgear and control areas by means of rigid metal conduits or ladder type cable trays.

Three separate trays are provided for 4160 V, 460 V, and 230 V power, control, and instrumentation cables. The 4160 V power cables are limited to a single layer; 460 V power cables are limited to two layers; and 230 V power, control, and instrumentation trays are not filled above the side rails.

Four independent protection channels, A, B, C, and D are provided. In general, the design criteria is a minimum vertical and horizontal spacing between redundant trays of 18 inches and 12 inches, respectively, with additional design conservatism as indicated below. Vertical tiers and crossing of redundant trays are generally avoided. Dissimilar channel designated safety-related trays are color coded at crossover points. For free air cables not installed in limited hazard areas a minimum vertical and horizontal spacing between redundant cables of 18 inches and 12 inches, respectively, shall be used except as noted below.

For installations in containment where cables are routed in free air from a conduit to a cable tray that requires separation from adjacent trays, the following minimum horizontal and vertical spacing shall be used:

Control and Instrumentation Cables
1 inch horizontal
3 inches vertical

Low Voltage Power Cables Less Than or Equal to 2/0 AWG
6 inches horizontal
12 inches vertical

There are three instances in the Salem Units where 460 V power cable trays run beneath control cable trays in a vertical tier. These instances do not involve cables from different safety-related channels. The Salem tray design criteria is such that cable trays are arranged in order of ascending voltage except where it is not possible to do so. In these cases, a fire resistant barrier has been provided in the upper tray.

Extensive flame tests performed on the cables proved that the combination of cable construction and minimum spacings used is adequate to prevent propagation of fire.

Even though the tests have proved the 18-inch vertical spacing as acceptable when redundant cables are involved, an additional fire resistant blanket is provided for each tier (except bottom tier) in the Control Room, Relay Room, and all other congested areas where the vertical spacing is 18 inches or less. The blanket is a fire resistant type and will prevent propagation of fire.

In general, the ordinal arrangement of trays is higher voltage trays on top with control cable trays at the bottom.

The safety-related cables are physically separated in accordance with channel designations, A, B, C, and D; nonsafety-related cables are routed, if necessary, in trays containing safety-related cables as follows:

E with B
F with C
G with D
H with A

Where E, F, G, and H are the nonsafety-related cables

Non-safety related cables that can be connected to a non-affiliated channel of the on-site power system must be evaluated to ensure that no loss of a safety function can occur due to the lack of physical separation of cables.

The grouping of penetrations in the electrical penetration area and the selection of conductors for each penetration follows the criteria established for the separation of redundant cables and provides for the implementation of these criteria for the cables approaching and leaving the area.

Written design and installation procedures are established to assure that nonsafety-related cables only run with one safety-related channel.

8.1.4.2.5 Separation in Control Areas and Components

Limited Hazard Areas

Limited hazard areas at Salem are considered to be the Relay Rooms, Elevation 100' and Control Equipment Rooms, Elevation 122'. The required physical separation of cables in free air is designated as 1" horizontal and 3" vertical for instrumentation and control cables and 6" horizontal and 12" vertical for low voltage power cables less than 2/0 AWG.

Control Boards, Panels and Racks

The control boards, panels, and relay racks have been designed to provide independence and separation necessary to fulfill the single failure requirement of IEEE Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations."

Control Console

The control console is a free standing unit that is totally enclosed including a dropped floor with a steel bottom plate. All cables entering the console pass through sealing bushings installed in the steel bottom plate on 6-inch centers. Up to eight cables may pass through a numbered sealing bushing; however, only cables of the same separation designation are permitted in a single bushing. Safety-related and nonsafety-related cables may be assigned to the same bushing in accordance with the criteria stated above.

Once in the console, cables are assigned to a four-section cable lattice arrangement with supports which have a minimum center to center distance of 1 7/8 inches and are 2 inches high. Cables go through the lattice to the plug-in instruments. The lattice is assigned separation designations and is also divided horizontally into a numbered grid system. Each cable is assigned a separation designation, a bushing, and a lattice position number. Therefore, the location and path of each cable in the console is individually defined. Installed cables are fastened to the lattice supports.

The plug-in cables terminate at the rear of the console-mounted equipment. All pushbutton stations and vertical indicators plug into identical steel housings which have a rear-mounted receptacle for the plug-in cable.

The steel housings provide physical separation for adjacent pushbutton stations or indicators. There are no exposed terminations associated with the control stations and indicators.

Each pushbutton station has functions associated with one separation designation. The minimum center-to-center distance between the double barriered control station housings is 1 1/2 inches and is based on the use of low voltage controls and special teflon insulated plug-in cables. This minimum distance occurs at the entrance to plug-in modules containing terminations which are enclosed in a steel housing. From the modules, the cables are separated in the lattice system described above which provides for specific routing of the cables to the floor bushings. Redundant cables are "fanned out" from the modules to achieve a greater separation as soon as practical; however, the separation is never less than 1 1/2 inches, center to center. Safety-related wiring other than the plug-in cables is run in conduit.

The reactor trip switches' wiring is not of plug-in cable construction. Reactor trip wiring is run in conduit (using two separate paths for the two trains) from the entrance to the console up to the switches. Wiring for redundant functions is separated by using the front and rear decks of the multi-deck switch.

Each circuit in the 28-V dc Logic System is protected by circuit breakers. Current overload tests have been performed on the multi-conductor plug-in cable based upon the calculated current which would occur if the circuit protection failed to interrupt a short circuit due to failures in the pushbutton control stations. These tests showed that a fault occurring in a pushbutton control station could not cause a fire in the console space.

Within the console, color coding is used to identify the cables and connectors associated with each of the four safety-related and nonsafety-related channels.

Panels and Racks

Redundant safety-related components/wiring are generally located in physically separated panels or racks. For those exceptions where redundant components/wiring are located in the same panel, and are required for completion of a protection action, then the components' design, the materials and the wiring arrangement are such that the possibility of propagation of an electrical failure/fire from one separation group to the redundant one is minimized. It must be shown by evaluation that no loss of a safety function can occur due to the loss of equipment or wiring in a single enclosure which does not provide physical separation for cables of different designations. Internal cables which carry redundant functions must be separated by a minimum of 6 inches, conduit, or other suitable fire-retardant barrier. Color coding is used to identify panels and racks containing sensors and logic for reactor protection and safeguards actuation.

Pressurizer Heater Cables

Two sets of non-safety related power feeders are provided for the Pressurizer Electric Heaters mounted in the bottom of Pressurizer. The heater feeder cables route from separate cable trays below the Pressurizer in free air to their respective heater terminations. Due to the configuration of the heater banks in the bottom of the Pressurizer, the cables in free air are intertwined and may touch. When the Pressurizer busses are connected to their non-safety related sources, the free air intertwining and touching is acceptable based on non-safety cables routing together.

Each of the non-safety related Pressurizer Busses is backed up by an emergency feeder from the Emergency Diesel Generators (EDG) to support natural circulation of RCS in the event of an accident or transient condition. The 1(2)A 460V Vital Bus provides emergency power to the 1(2)EP Pressurizer Bus and the 1(2)C 460V Vital Bus provides emergency power to the 1(2)GP Pressurizer Bus. When the 1(2)EP Bus is connected to the 1(2)A EDG, the 1(2)EP pressurizer heater cables are considered A Channel and similarly, when the 1(2)GP Bus is connected to the 1(2)C EDG, the 1(2)GP pressurizer heater cables are considered C Channel. Prior to the implementation of DCPs 80095831 and 80096074, the 1(2)EP pressurizer heater cables were partially routed in B Channel safety related cable trays.

A special acceptance of separation criteria has been established by safety evaluation S-C-RC-ESE-0870 to provide the technical basis to allow connection of the EP and GP pressurizer busses to the pressurizer heaters when either or both pressurizer busses are connected to their alternate EDG feeders. S-C-RC-ESE-0870 analyzed the impact on the 1(2)A 460V Vital Bus, 1(2)C 460V Vital Bus and the 1(2)B 460V Vital Bus. After S-C-RC-ESE-0870 was issued, DCPs 80095831 and 80096074 removed the 1(2)EP pressurizer heater cables from the B channel safety related tray. Therefore, the analysis in S-C-RC-ESE-0870 only applies to the intertwined cable at the bottom of the pressurizer in Units 1 and 2.

The 1(2)EP and 1(2)GP pressurizer heater cables and penetration conductors are protected by two Penetration protection fuses in series at the 1(2)EP and 1(2)GP Buses respectively. When the 1(2)EP and/or 1(2)GP Buses are connected to the alternate emergency feeder, additional protection is provided by the upstream Class 1E isolation circuit breaker at the 1(2)A and/or 1(2)C 460V Vital Buses respectively.

Any changes to the 1(2)EP or 1(2)GP Pressurizer Bus and its associated cables must be reviewed in accordance with the safety evaluation S-C-RC-ESE-0870. Any changes to the 1(2)A emergency feeder to the Pressurizer or the 1(2)C emergency feeder to the Pressurizer must be reviewed in accordance with S-C-RC-ESE-0870.

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8.1.4.2.6 Quality Assurance

In addition to the specifications and drawings, documents are prepared to identify the requirements for implementation of the design and construction criteria. These documents are prepared or approved by the responsible engineer and are further reviewed and approved by the responsible supervisory engineering personnel prior to their release.

The following procedures are established to verify that the cable installation is in accordance with the applicable criteria:

1. Each cable has a "pulling card" or data sheet which shows the cable number, segregation code, and cable routing. The foreman or supervisor of each crew installing the cable signs each card certifying that the cable has been installed as specified.

2. Outage Services performs quality verification inspections (as defined in Chapter 10 of the QATR) during safety-related cable installations, and Nuclear Oversight performs independent assessments (as defined in Chapter 18 of the QATR) of randomly selected safety-related cable installations, to ensure proper installation.

8.1.5 Penetrations

Electrical penetrations comply with IEEE Standard 317-1972. A fuse is placed in series with the primary interrupting device for select electrical penetration circuits. This provides a second level of overcurrent protection for the respective penetration assembly where deemed necessary.