Surry Power Station
Updated Final Safety Analysis Report

Chapter 8

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CHAPTER 8 ELECTRICAL SYSTEMS

Note: As required by the Renewed Operating Licenses for Surry Units 1 and 2, issued March 20, 2003, various systems, structures, and components discussed within this chapter are subject to aging management. The programs and activities necessary to manage the aging of these systems, structures, and components are discussed in Chapter 18.

8.1 GENERAL DESCRIPTION AND SUMMARY

The electrical systems include the equipment and the systems necessary to generate power and deliver it to the high-voltage switchyard. They also include facilities for providing power and controlling the operation of electrically driven auxiliary equipment and instrumentation. The main electrical connections are shown in Figure 8.3-1. A review of the effects of the power uprate to a core power of 2589.3 MWt was conducted and the electrical systems were found to be adequate.

This chapter describes the electrical system for Unit 1. The Unit 2 electrical system is identical but completely independent of Unit 1, with the exception of an emergency diesel generator common to both and used as a backup should the individual unit emergency diesel generators fail. The reserve station service transformer banks are common to both Units 1 and 2, and are sized to start up a single unit or to shut down both units.

The output of the main generator is fed into and operated as an integral part of the overall company electrical distribution system.

The normal station service power system is designed to provide continuous power to the station auxiliaries during periods of generation and to transfer automatically to the reserve station service power system to ensure continued power to equipment when the main generator is off the line.

The plant non-safety-related auxiliary systems are supplied by off site power during start-up, shutdown, or hot standby conditions. Safety-related auxiliary systems are normally supplied by offsite power during all modes of plant operation.

In general, all auxiliaries of major equipment will be connected to the same power distribution branch as the major pieces of equipment, the only exceptions being those appurtenances that will be required to operate when the major piece of equipment shuts down. An example is a pump discharge motor-operated valve that must be closed when the pump stops.

Critical instrumentation is fed from a reliable and stable vital bus system to ensure continuous monitoring and control of critical instrument channels.

There are no ac or dc circuits on safety-related systems that, upon voltage failure, automatically switch to an alternate bus energized from a redundant power source. There are provisions which ensure that, on loss of the normal power source to a particular bus, an alternate power source automatically is placed in service to supply the bus. These capabilities are discussed individually in the applicable sections.

Station batteries are provided for circuit breaker control power, emergency lighting, and operating power for vital equipment until normal power is restored or onsite emergency generation is available.

8.2 DESIGN BASES

The electrical systems are designed to supply electrical power to all essential unit equipment during normal operation and under accident conditions.

The main generator, described in Section 10.3.3, establishes the facility operating limits and requires the plant to be operated between a 0.905 lagging and a 0.96 (0.97 for Unit 2) leading power factor. As system reactive load changes, generator excitation can be adjusted to ensure operation within the required power factor limits. The system grid also has banks of shunt reactors that can be connected in order to adjust the power factor.

Electrical system components vital to unit safety, including the diesel generators, are designed and protected as necessary so that their integrity is not impaired by potential earthquakes, high winds, floods, or disturbances on the external electrical system. Cables, motors, and other electrical equipment required for operation of the engineered safeguards are suitably protected against the effects of either a nuclear system accident or a severe external environmental phenomenon, in order to ensure a high degree of reliability. The enclosures for motors and electrical switchgear are selected to suit the local conditions and are designed in accordance with specifications issued by the National Electrical Manufacturers Association (NEMA).

Essential electrical equipment components are specified to withstand, without loss of function, the maximum conditions expected during normal operating and post-accident environments, and during operation of the safeguard equipment during the accident. It is expected that the maximum accident conditions within the containment will be 280°F at 45 psig for 30 minutes. The environmental qualification of safety-related electrical equipment is discussed further in Chapter 7. Should suitable equipment not be available, the detailed plant design incorporates features to modify the environment to be compatible with the equipment.

In the containment, essential electrical components and conductors are protected from the forces generated during an incident by group separation. By physically separating each group and providing conductor barriers where necessary, the failure of one group does not jeopardize any other group. In the case of multiple instrument channels in one location, such as the channels associated with the single pressurizer, physical separation is carried out as far as possible and the circuitry arranged so that multiple instrument failures are always in the safe direction. Electrical cable connections are run from the instrument transmitter to the area outside the crane support wall using the shortest path while providing separation between redundant channels. The crane wall acts as a further barrier against any forces generated during an accident.

In general, the 4160V and 480V switchgear are of metal-clad deadfront construction with closing and tripping control power taken from the station batteries. Each starter or breaker cubicle is isolated from the adjacent cubicle with metal barriers, and each bus section is physically separated from all others. The main feeds to the 4160V switchgear from the unit station service transformers are shielded single conductors with volcanized chlorinated polyethylene based compound jacket installed in ladder type trays, with 1.00 - 2.00-diameter spacings between conductors. The cable portion of the main feeds to the 4160V switchgear from the reserve transformer are hypalon jacketed with maintained spacing of 0.9 diameter to 1.0 diameter. The RSST feeders consist of overhead bus and cable in cable tray. One reserve transformer feeder has separate routing to the 4160V switchgear, physically isolated from all other transformer secondary leads.

All switchgear associated with engineered safeguards equipment is separated from the main switchgear area and is readily accessible in the main control area. For all leads supplying engineered safety equipment, the cable is 3/c with interlocked armor overall, run in ladder trays or properly mounted and supported when run external to ladder trays, or 3-1/c triplexed, run in conduit, with the exceptions of the 480V equipment supplied from motor control centers and the emergency generator leads. The only 480V exceptions are for 30-hp motors and smaller. The emergency generator leads entering the emergency switchgear room from the duct bank have been derated for cable in conduit in accordance with Insulated Power Cable Engineers Association (IPCEA) standards. In Mechanical Equipment Room No. 5, power cables are installed in ladder type trays. In the emergency switchgear room, some of the cables have been run in ladder type trays which have solid covers placed directly on the top of the trays and may have a solid transite or asbestos blanket placed on the bottom of the trays prior to installation of cables. This installation has the same protection integrity as cable in conduit and facilitates installation and inspection of these critical cables.

Power and control cables are distributed from the switchgear and control area by means of rigid metal conduits or ladder type cable trays. Control cables are of single or multiconductor construction with insulation rated at 600 or 1000V and with overall flame-retardant jackets. Low-voltage instrument connections are made using flame-retardant insulated cables, rated at 300 or 600V. These cables are provided with a total coverage electrostatic shield and an overall flame-retardant jacket.

The normal current rating of all insulated conductors is limited to that continuous value which does not cause excessive insulation deterioration from heating. Selection of power conductor sizes are based on *Power Cable Ampacities*, published by the IPCEA.

Fire-resisting fillers, tapes, binders, and jackets were specified for all cable construction. Cable tray installations have approved fire stops in both horizontal and vertical runs and are provided with a solid raised cover or a corrugated solid aluminum cover if minimum separation distance requirements between trays are not maintained. Covers may be omitted on top trays run under solid floors. All conduit installations consist of plastic conduit encased in concrete or exposed rigid metal conduit.

Electrical equipment and cables are specified such that the application is within the normal rating or temperature rise stated by the manufacturer. During normal operating conditions, electrical equipment or cables that are found operating in excess of the manufacturer's stated normal rating or temperature rise are analyzed for continued use.

All connections at the 22-kV voltage level are made with isolated phase construction designed for self-cooling.

The station batteries are sized to operate circuit breaker controls, instrumentation, emergency lighting, and vital nuclear channels for two hours without benefit of any station power. The battery chargers are connected to the emergency bus and provide charging current to the battery and load when the emergency bus is energized.

Lighting distribution and intensities have been selected in accordance with the recommendations of the Illumination Engineering Society (IES).

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8.3 SYSTEM INTERCONNECTIONS

Unit 1 and Unit 2 are connected with the Vepco system at a transmission substation near the station. The connection is essentially a double one, since it is made through both the 230-kV and 500-kV transmission systems.

Electrical energy generated by Unit 1 at 22 kV is raised to 230 kV by the main transformer and delivered to the 230-kV switchyard. Electrical energy generated by Unit 2 at 22 kV is raised to 500 kV by the main transformer and delivered to the 500-kV switchyard by way of a motor operated air breaker (MOAB) and isolation breakers. The MOAB is located between the Unit 2 main transformer and the generator isolation breakers and permits the isolation breakers to be closed while Unit 2 is off the line. Reclosing the isolation breakers while Unit 2 is off-line is important for ensuring proper voltage levels are maintained offsite and hence grid stability. The MOAB is manually operated from the switchyard and is not designed to be operated under load. Control interlocks prevent the MOAB from being operated unless the isolation breakers are open. Figure 8.3-1 and Reference Drawing 1 are single-line diagrams of the transmission substation for the Surry Power Station.

The main generator feeds electrical power at 22 kV through an isolated-phase bus to the main step-up single-phase transformers and the unit station service transformers located adjacent to the turbine building. The primary side of each 22/4.16-kV station service transformer is connected to the unit isolated-phase bus at a point between the generator terminals and the low-voltage connection of the main step-up transformers. There are three station service transformers per unit. They supply three independent 4160V auxiliary buses and are designed to limit the short-circuit fault duty on any one bus to within the interrupting capability of the 250-MVA air circuit breakers.

During start-up and emergencies, reserve station service power for the auxiliaries of either unit is normally supplied from the Switchyard Transformers No. 1 (which is a 500/36.5-kV transformer that is connected to the 500-kV bus), No. 2, (which is a 230/36.5-kV transformer that is connected to the 230-kV bus #4), or No. 4 (which is a 230/36.5-kV transformer that is connected to the 230-kV bus #3). The 500-kV and 230-kV systems are independent and provide alternative sources of reserve power that can be expanded for future units and lines as required. Each Switchyard Transformer is capable to provide power to an Emergency Bus on each Unit.

The primary sides of the reserve station service transformers are connected to the 36.5-kV windings of either of Transformers Nos. 1, 2 or 4 in the high-voltage switchyard. During start-up, shutdown, or hot standby conditions, station service power is taken from the reserve station service transformers. The screenwell area is supplied through either of two 34.4-kV to 4.16-kV transformers, each of which is supplied from 34.5-kV Buses 5, 6, or 7 in the switchyard. Underground lines are installed to feed each screenwell transformer.

The 230-kV and 500-kV switchyards are of the “breaker and a half” design.

The normal operating ranges are from 220 to 245 kV for the 230-kV switchyard and 505 to 535 kV for the 500-kV switchyard. The emergency buses are serviced by transformers with automatic tap changers that ensure nearly constant load voltages during long-term grid voltage transients. The normal operating range on the emergency buses is 4200 to 4400V.

Two gas turbines are installed at the Surry site east of the 230-kV substation. One unit is rated at 16 MW and the other at 25 MW. These units are a part of the Vepco system and are primarily used for load peaking. One gas turbine has a black start capability with a start-up time of approximately 10 minutes. These two units are controlled and operated locally at the switchyard. The two generators are connected in parallel to the low-voltage side of a 13.2/230-kV transformer. Each generator has a breaker that is used for synchronizing and tripping. The high-voltage side of the transformer is connected to the No. 4 230-kV bus. Four additional combustion turbines rated at 82 MW each are located southeast of the switchyard. These units are controlled and operated independently of Surry Power Station, but their generators are connected to the transmission system via the 230-kV switchyard as shown in Figure 8.3-1 and Reference Drawing 1.

Transmission system connections for Unit 1 consist of the following lines, which are integral parts of the Vepco transmission system:

1. One 230-kV line to the Yadkin substation near Portsmouth, Virginia.
2. One 230-kV lines to the Hopewell substation near Hopewell, Virginia.
3. One 230-kV line to the Chuckatuck substation in Suffolk, Virginia.
4. One 230-kV line to the Churchland substation in Portsmouth, Virginia.
5. One 230-kV line to the Winchester substation in Hampton, Virginia.
6. Two 230-kV lines to the Gravel Neck Combustion Turbines, which are located near Surry Power Station.
7. One 230-kV line to the Colonial Trail substation in Surry, Virginia.

Additional transmission system connections for Unit 2 consist of:

1. One 500-kV line to the Septa substation near Surry, Virginia.
2. One 500-kV line to the Chickahominy substation in Providence Forge, Virginia.
3. One 500-kV line to the Suffolk substation near Portsmouth, Virginia.
4. One 500-kV line to the Skiffe’s Creek substation near Williamsburg, Virginia

Surry Power Station lies along two main transmission line rights-of-way. Each right-of-way includes transmission lines that principally route toward east and west locations in the Vepco system.

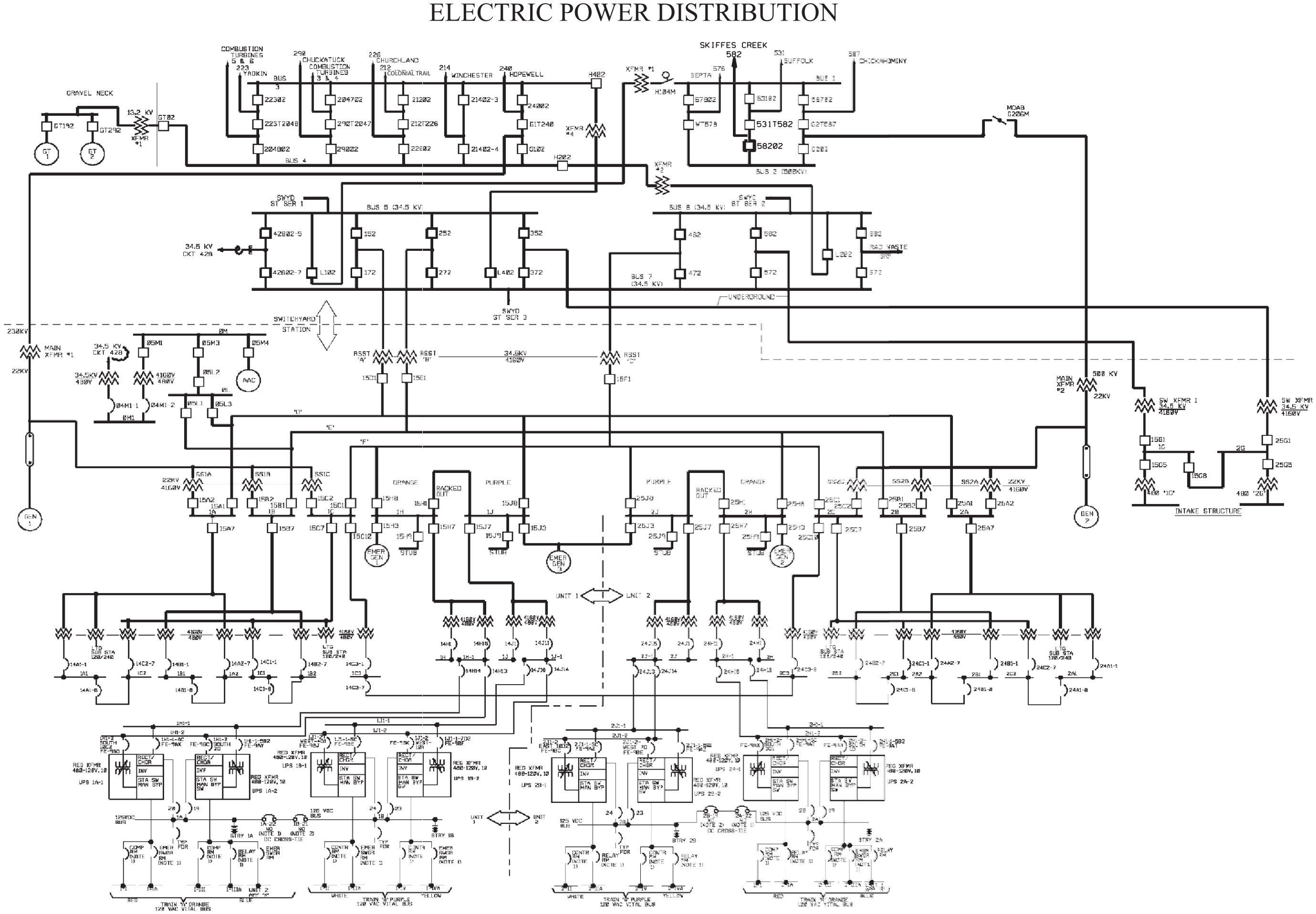
The transmission system can handle the full output of both units at Surry upon the loss of any two transmission circuits connected to the Surry substation. Figure 8.3-2 is a location map showing the Surry Power Station, associated transmission lines, and their system connections.

8.3 REFERENCE DRAWINGS

The list of Station Drawings below is provided for information only. The referenced drawings are not part of the UFSAR. This is not intended to be a complete listing of all Station Drawings referenced from this section of the UFSAR. The contents of Station Drawings are controlled by station procedure.

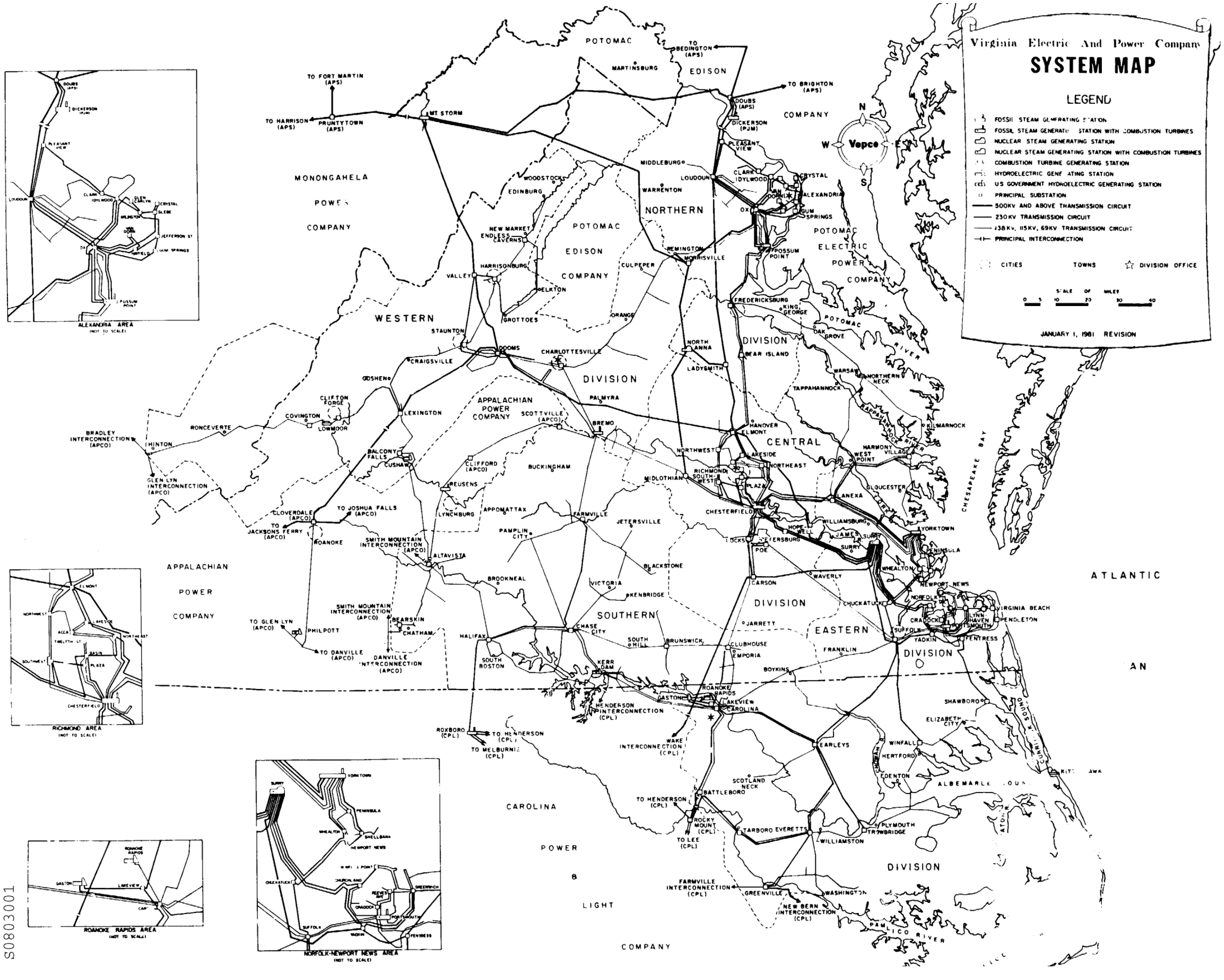
	Drawing Number	Description
1.	11448-FE-1A2	One Line Integrated Schematic, Electrical Power Distribution, Units 1 & 2

Figure 8.3-1
ELECTRIC POWER DISTRIBUTION



The following information is HISTORICAL and is not intended or expected to be updated for the life of the plant.

Figure 8.3-2
TRANSMISSION LINE MAP



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8.4 STATION SERVICE SYSTEMS

8.4.1 4160V System

Alternating current station service power is distributed from the 4160V switchgear. This switchgear is energized from the main generator and unit station service transformers during normal operation, or from the reserve station service transformer source during start-up, hot standby, or shutdown operation (Section 8.2). The 4160V system is duplicated for Unit 2.

The 4160V switchgear is arranged in three independent bus sections. Each bus section has a capacity of about 3000A. Each feeder or motor circuit is protected by overcurrent relays that trip the associated breaker for a sustained overload of a sufficient magnitude or a fault.

During unit start-up, the total ac demand of the unit is supplied from the reserve station service source. After the unit has attained operating conditions and the turbine generator is synchronized and connected to the system, the station service load is transferred to the unit station service transformers. This transfer is performed without a power interruption by momentarily feeding the 4160V switchgear from both the reserve and unit station service transformers. The feeds from the reserve station service transformers are then disconnected and the turbine generator will supply its own auxiliaries.

To include the possibility of two-unit simultaneous loading of the reserve station service (RSS) system, within its design capability, a load shedding system was installed to remove the overloads on the RSS system. This system provides for automatic load shedding of selected non-safety-related loads from both units which limits RSST loading to under 4000A per transformer. The scheme ensures that the voltages available on the emergency buses will be within acceptable limits. A manual override switch is provided in the control room to allow manual restarting of the shed loads under a controlled condition. With the addition of bus cooling, the transfer bus feeder breakers and adjacent bus cubicles (15D1, 15D2, 15E1, 15E2, 15F1, 15F2) are rated for 4000A continuously.

To improve the worst case voltage profiles due to large blocks of load receiving simultaneous starting signals under safety injection (SI) conditions and ensure the successful starting of safety-related loads, modifications to the secondary automatic load tap changers (ALTCs) on the reserve station service transformers (RSSTs), and automatic starting of selected large non-Class 1E loads were made. The modifications included:

1. Upon receipt of an SI signal or two unit load shed signal, the adjustable time delay of the RSST ALTC mechanisms will be bypassed. Under normal conditions the ALTCs are designed for a delay of approximately 30 seconds before the tap changing mechanisms react to a voltage change. The result in bypassing this feature is to enable the ALTC to react as quickly as possible to adjust the secondary RSST voltage to the preset level.

2. The automatic starting of selected large non-Class 1E loads is blocked. These loads that are prevented from auto starting are the condensate, bearing cooling, and component cooling pump motors. The auto-start block will remain in effect for 60 seconds following an SI signal and 315 seconds following a Consequence Limiting Safeguards (CLS) signal. This feature will prevent any voltage degradation of the emergency buses as a result of starting of non-Class 1E loads. These motors may be manually started, however, independent of the auto-start block.

Loss of normal supply to any bus section automatically trips the normal source breaker and closes the alternate source breaker.

Motors larger than approximately 300 hp are operated at 4160V and are arranged for across-the-line starting. One circuit from each bus section feeds two 4160/480V station service transformers. The 480V system is described in Section 8.4.2.

Two independent sections of emergency 4160V bus and switchgear are provided. Each section is sized to carry 100% of the emergency load. These emergency sections are energized from the reserve station service transformer during normal operation, start-up, and shutdown. In the event of total loss of offsite power, the emergency 4160V buses are isolated from the normal supply and energized from the diesel generators, as described in Section 8.5.

A manually operated air circuit breaker location is provided so that a 4160V emergency bus section may be connected to the redundant emergency bus section. This feature is used for maintenance or abnormal conditions only, and is under administrative control. The breaker will be tagged in the disconnect position for an operating unit.

8.4.2 480V System

The 480V ac station service system distributes and controls power for all 480V, 240V, and 120V ac station service demands. The source of power for the 480V ac system buses is from the counterpart 4160V ac system buses. The 480V ac system is divided into three double-ended bus sections, and each section is fed from a counterpart 4160V ac bus through individual 4160/480V ac station service transformers. This system is shown in Figure 8.3-1.

The switchgear is metal-clad, with 125V dc operated air circuit breakers, and arranged with six independent bus sections. The 4160/480V transformers are air-cooled.

Normal operation is with the bus sections independent of each other. Motors up to approximately 300 hp are connected to the 480V switchgear. Reduced unit output is possible with two 480V bus sections out of service.

Motor control centers are located throughout the station and are used for 480V power distribution and control of motors rated at 100 hp or less. In most cases, motor control centers are fed from 480V switchgear buses through breakers, while in some instances, motor control centers dedicated to a specific system are fed from other motor control centers via breakers due to physical space constraints and power supply requirements.

Engineered safeguards equipment items operating at 480V are fed from independent 480V buses and switchgear that are energized from either the reserve station service power or the diesel generators. When 480V emergency power sources are connected in a manner which would provide the capability of manually transferring loads from one source to a second source, isolation breakers are used upstream of the transfer switch to ensure that a single failure will not affect both power sources.

8.4.3 120V Alternating Current Vital Bus System

There are four separate 120V ac vital buses, each supplied by an independent 15 kVA inverter power supply. The inverter is housed within an electrical cabinet, which also contains a rectifier/charger, a static transfer switch, a manual bypass switch, and a voltage regulating line conditioner (RLC). This configuration is shown in Reference Drawing 1. The inverters are supplied in pairs by a common station battery. Each inverter pair and one battery form a safety train of uninterruptible power. There are two station batteries and inverter pairs per nuclear unit at Surry, which provide two independent redundant uninterruptible power supply (UPS) electrical trains. Normally, the inverter load is absorbed by the UPS rectifier/charger.

Upon rectifier/charger failure, the battery will pick up the inverter load. The UPS outputs are regulated automatically to a nominal 120V ac and 60 Hz. Upon inverter failure, the static switch will transfer the vital bus load to the RLC alternate source (120V ac, nominal) within 1/4 cycle.

The vital buses constitute a very reliable electrical system and provide a stable source of power to vital instruments and equipment. The redundant batteries are classified as passive components and are therefore subject to passive type failures. The definition of a passive failure is a failure which will not occur until after accident mitigation has entered the recirculation phase (post-RMT). Thus should a LOOP/LOCA occur, then the loss of a battery or dc bus will not credibly occur until after the unit enters the recirculation phase. For circuits that have been designed as energize to operate, analyses have been performed to ensure they meet the requirements for active component failure.

Each remote monitoring panel shares certain instrumentation from both units with the instrumentation from one unit being powered by the emergency power system of the other unit when vital buses are not available due to a disabling fire in the control room. This assures that indications of the selected parameters will be available for both units even if the fire disables the emergency power system of the affected unit. See Section 7.7.2 for additional discussion of this capability which was incorporated to satisfy the requirements of 10 CFR 50 Appendix R. In the event of a complete loss of ac power, a portable generator can be used to feed the Remote Monitoring Panels.

Should an Extended Loss of AC Power (ELAP) occur to both Units, backup power to both Remote Monitoring Panels is available for 12 hours via UPS. This ensures continuous monitoring capability is available until a portable generator can be deployed.

A modification to the vital bus voltage indication was accomplished to prevent a false indication of the loss of vital bus voltage. This could occur if the breaker used for the indication were inadvertently left open when the bus was energized. The modification provides for direct tapping of the vital bus via a 6A in-line fuse in lieu of the breaker.

The 120V, 60-Hz output of each UPS inverter is grounded and connected to two distribution cabinets. The distribution cabinets have 15A and 20A branch circuit breakers to feed reactor protection and other vital instrument channels. Reactor protective schemes have redundant channels and the power sources are provided from redundant vital bus cabinets.

Because of the fail-safe circuitry of the reactor protective instrumentation, a power source failure to an instrument channel results in a reactor trip signal from the affected channel. Multiple power supplies are provided to prevent a common power supply failure from initiating a false reactor trip.

The UPS are assembled from high-quality components, conservatively designed for long life and continuous operation. By avoiding the use of electromechanical devices, routine maintenance downtime is greatly reduced. There are no vacuum tubes or moving parts in the completely static vital bus supply system. Magnetic amplifiers, transistors, and silicon rectifiers are used to provide trouble-free operation.

8.4.4 125V Direct Current System

The Class 1E 125V dc batteries supply power for operation of switchgear, annunciators, vital bus inverters, and emergency lighting, as shown in Reference Drawing 2. The 1A battery provides 1 of 2 concurrent feeds to the Unit 1 main control room Hathaway annunciator. (The other concurrent feed is 120V ac from emergency diesel generator backed control room lighting panelboard 01-EP-LP-1C1.) The 2A battery provides 1 of 2 concurrent feeds to the Unit 2 main control room Hathaway annunciator. (The other concurrent feed is 120V ac from emergency diesel generator backed control room lighting panelboard 02-EP-LP-2C1.) The principal equipment items in this system are two nominal 125V dc lead-acid batteries, two UPS rectifier/charger, and two battery distribution switchboards.

The turbine generator emergency auxiliary oil pumps are connected to an independent black 60-cell battery powered from two static battery chargers supplied from normal motor control centers. Additionally, the normal power feed to the AMSAC inverter is from the same bus. The backup power feed to the AMSAC inverter is provided from a normal motor control center or an emergency motor control center via a transfer switch. This system is shown in Figure 8.4-1.

The batteries are of the central power station type and are designed for continuous duty. Each battery consists of a number of cells connected in series comprising a nominal 125V dc.

Each cell is of the sealed type, assembled in a shock-absorbing, clear plastic container, with covers bonded in place to form a leakproof seal. The batteries are mounted on protected, corrosion-resistant, earthquake-resistant racks for security and to facilitate maintenance. The two Class 1E battery areas are separated from each other and from the switchgear room.

Normally, the two battery bus sections are operated independently, with the bus tie breakers open. The UPS rectifier/chargers supply power for operation of equipment connected to that bus section and maintain a floating charge on the associated battery. The manually operated bus tie breakers provide for parallel operation of the bus sections with either battery out of service for maintenance.

The four UPS static battery rectifier/chargers (two per 125V-dc bus) are identical, each having an output of 350A at 130V dc with an input of 480V ac, three-phase. Each UPS rectifier/charger is equipped with a dc voltmeter, ammeter, ac failure relay, and low dc voltage alarm relay. Low ac or low dc voltage is alarmed in the control room. Battery bus ground indicators are located in the control room. Battery voltage is indicated to the operator on the main control board and continuously recorded on recorders located in the Emergency Switchgear Room. The UPSs are energized from emergency motor control centers.

The battery distribution switchboards are NEMA Class II metal-clad structures, each with a 125V dc, two-wire ungrounded main bus, and two-pole manually operated air circuit breakers.

During normal operation, the 125V dc load is fed from the battery chargers with the batteries floating on the systems. Upon loss of station ac power, the entire direct current load is drawn from the batteries. The batteries are sized for two hours of operation, after which it is assumed that station power or emergency generation power will be available to energize the battery chargers. The basis for sizing the station batteries for two hours without benefit of any station power is a carryover from the criteria used on non-nuclear power stations where emergency generators were not available to provide power to the battery chargers or turbine auxiliaries for safe coastdown. The batteries will be required for approximately 10 seconds between loss of station power and the availability of emergency ac power to supply the Class 1E battery chargers.

For each unit, a separate non-Class 1E battery, battery charger, and distribution switchboard are available for use in the screenwell structure.

8.4.5 Lighting System

Normal lighting for turbine areas, reactor containments, auxiliary building, fuel building, and service buildings is provided from local lighting cabinets located in the area of service. These cabinets except those for the control room, are fed from a double-ended lighting switchboard that is energized from two independent 250-kVA, single-phase, 4160-240/120V dry type, self-ventilated transformers. Normally the two buses of the double-ended switchboard are separate. They are capable of being tied together if one transformer fails.

The two control room lighting cabinets are each fed from local 37.5-kVA, single-phase 480-240/120V, dry type, self-ventilated transformers. The Unit 1 control room lighting transformer is supplied from the 480V 1H1-1 (Unit 1) bus and the Unit 2 control room lighting transformer is supplied from the 480V 2H1-1 (Unit 2) bus. The 1H1-1 and 2H1-1 emergency motor control centers are backed by different emergency diesel generators. Control room lighting cabinet (panelboard) 01-EP-LP-1C1 also provides 1 of 2 concurrent feeds to the Unit 1 main control room Hathaway annunciator. (The other concurrent feed is 125V dc from the Class 1E, 1A battery.) Control room lighting cabinet (panelboard) 02-EP-LP-2C1 also provides 1 of 2 concurrent feeds to the Unit 2 main control room Hathaway annunciator. (The other concurrent feed is 125V dc from the Class 1E, 2A battery.)

Normal lighting for the office building and remote areas is supplied through local 480-120/240V, single-phase, dry type transformers. Emergency lighting for remote areas is provided by local self-contained, battery-powered emergency lighting units.

Emergency lighting for turbine areas, auxiliary building, service buildings and various other locations is normally de-energized. These lights are automatically switched to the dc system upon sensing loss of voltage on the lighting switchboard. Emergency lighting for the reactor containment is energized at all times from an independent dc circuit. The turbine room operating floor also has an independent feed from the battery and automatically comes on if lighting intensity falls below certain levels. Emergency lighting feeds are provided from both units to the control room and turbine room mezzanine to provide the best possible protection.

Additional individually battery-powered emergency lanterns have been installed to facilitate access to and egress from the control room, emergency switchgear and relay rooms, service building cable vaults, cable tunnels, turbine building areas, mechanical equipment room no. 5, containment penetration cable vaults, diesel-generator rooms, first aid room and electric shop. These fixtures are automatically energized upon loss of normal ac bus power. They are powered from self-contained 6V or 12V batteries and static battery chargers, and use directionally adjustable lamps. The light fixtures are designed for eight hours.

Emergency lighting for the Technical Support Center (TSC) automatically transfers to the uninterruptible power supply (UPS) upon detection of the loss of the normal power source. Emergency lighting provides illumination for at least 15 minutes upon transfer to the TSCs UPS which will allow for an orderly shutdown of the Emergency Response Facility Data Acquisition System and exiting the area. The duration of emergency lighting for the TSC can be extended by manual transfer of the backup feed for the TSC UPS to the AAC diesel generator.

A post-fire emergency lighting system has been installed to facilitate operation and/or monitoring of safe shutdown equipment after a postulated fire in any area and access/egress routes thereto. This lighting system incorporates the use of the emergency diesel backed control room lighting system, diesel backed security lighting, self-contained 6V or 12V batteries and static charger units and emergency power units (consisting of self contained batteries, static charger and inverter) all located in the area served. Additionally, portable battery-powered lanterns are available for use in containment. This post-fire emergency lighting system will provide sufficient illumination for a minimum of eight hours to enable an operator to reach the safe shutdown equipment and perform required functions. Added equipment is seismically mounted in areas with safety related equipment and added cables are environmentally qualified in accordance with IEEE 323-1974.

8.4.6 Alternate AC (AAC) System

In response to 10 CFR 50.63, the Alternate AC (AAC) system was installed to provide ac power to one emergency bus on each unit during a Station Blackout (SBO) event. The AAC system is non-safety related and is designed in accordance with Regulatory Guide 1.155 and NUMARC 87-00, Appendix B.2.

The electrical design consists of a single 4160V ac diesel driven generator with a continuous rating of 3300 kW and a 2000-hour rating of 3640 kW. The generator is connected to the station via 4 kV buses 0M and 0L as shown in Reference Drawing 1. Bus 0L is located in the Unit 2 normal switchgear room and provides connection from bus 0M to transfer buses D and E which in turn allows connection to emergency buses 1J and 2H respectively. The diesel generator can provide power to the emergency buses within 10 minutes of determining that an SBO event has occurred and is sized to carry the loads necessary to bring both units to a safe shutdown condition and maintain them in a safe shutdown condition for the postulated 4 hour SBO event duration.

Following the loss of power on either the D or E transfer bus in conjunction with the loss of power on the F transfer bus, the diesel generator receives an automatic start signal. Momentary trip signals to breakers associated with the 0M and 0L buses ensure that the AAC system is initially isolated. Once the generator has reached proper speed and voltage, breakers automatically close to power buses 0M and 0L. Manual action is then required to energize transfer buses D or E. The normal power supply to the TSC UPS and the TSC MCC is from the Unit 2 “C” station service transformer or from RSST “C” via Transfer bus “F.” Following a loss of normal power supply, the TSC UPS and the TSC MCC can be powered from the AAC System via either transfer bus D or E following manual breaker re-alignment.

The AAC diesel generator is independent from the emergency diesel generators. The AAC diesel generator and its auxiliaries are housed in a separate building located south of the Radwaste Facility. The air start system contains sufficient capacity for 5 starts and the fuel oil system for the AAC diesel contains sufficient fuel to operate the diesel generator at 3640 kW for the postulated 4-hour SBO duration. To maintain the system in a standby state, a keep warm system consisting of a jacket water heater with a circulating pump and a lube oil heater with a circulating pump is provided. An ungrounded 125V dc system is provided for the 4 kV and 480V ac switchgear controls, diesel generator controls, and generator protection.

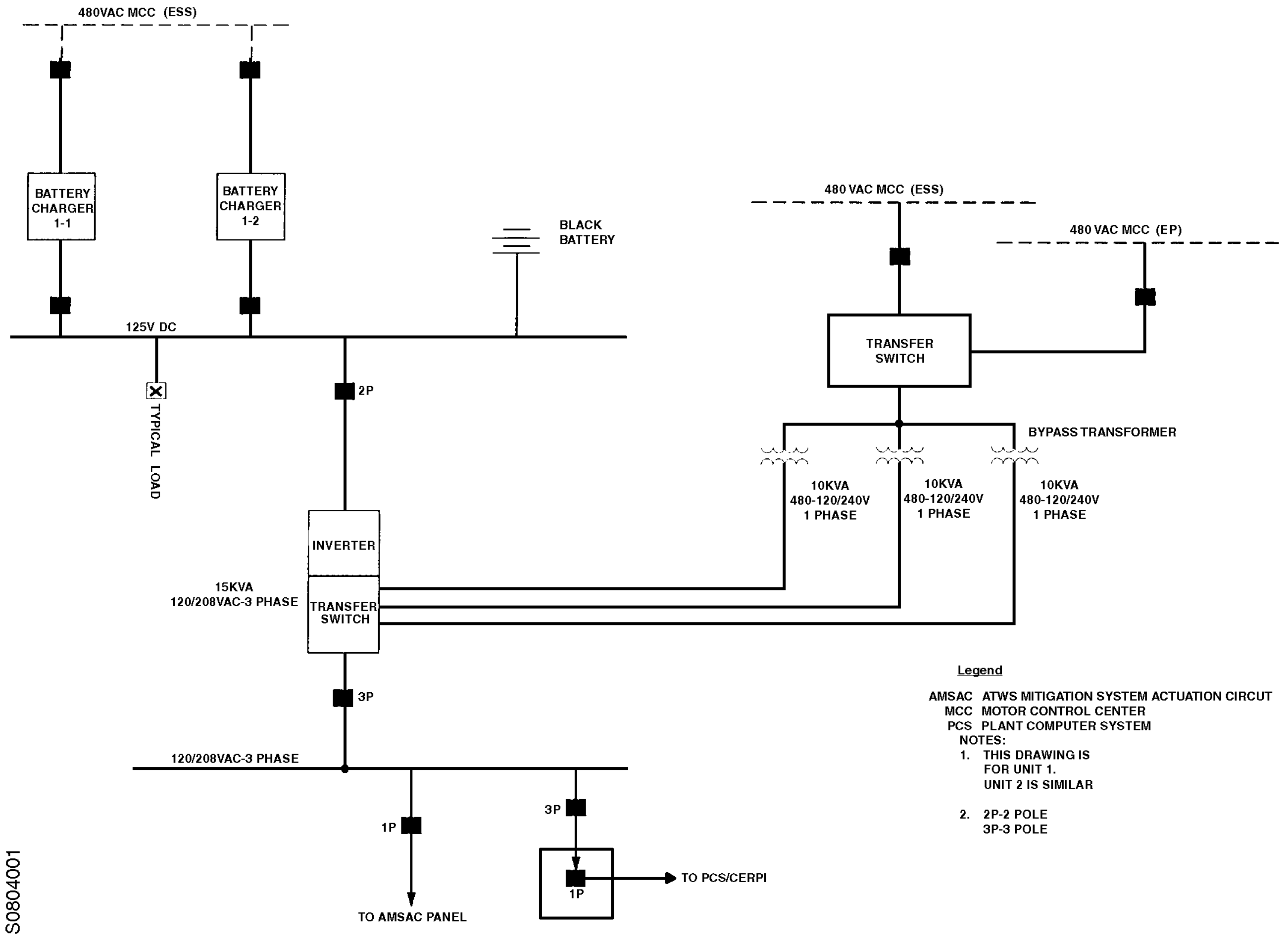
Annunciation is provided in the main control room to alert operators to alarm conditions. An “AAC System Trouble” alarm indicates that a malfunction or system protective action has occurred. An “AAC Diesel Generator Trip” alarm indicates that the diesel generator has tripped due to an engine or generator protective action. An “RSST A Parallel with RSST B” alarm indicates that the two RSSTs have been paralleled through Bus 0L. A “Bus 0L Trouble” alarm indicates that a protective relay actuation or a blown fuse alarm has occurred on this bus. In addition, a local annunciator in the AAC building provides additional details on alarm conditions.

8.4 REFERENCE DRAWINGS

The list of Station Drawings below is provided for information only. The referenced drawings are not part of the UFSAR. This is not intended to be a complete listing of all Station Drawings referenced from this section of the UFSAR. The contents of Station Drawings are controlled by station procedure.

	Drawing Number	Description
1.	11448-FE-1A2	One Line Integrated Schematic, Electrical Power Distribution, Units 1 & 2
2.	11448-FE-1G	One Line Diagram: 125V DC, Unit 1
	11548-FE-1G	One Line Diagram: 125V DC, Unit 2

Figure 8.4-1
BLACK BATTERY (125V DC) SYSTEM



Legend

AMSAC	ATWS MITIGATION SYSTEM ACTUATION CIRCUT
MCC	MOTOR CONTROL CENTER
PCS	PLANT COMPUTER SYSTEM

NOTES:
1. THIS DRAWING IS FOR UNIT 1. UNIT 2 IS SIMILAR
2. 2P-2 POLE
3P-3 POLE

Intentionally Blank

8.5 EMERGENCY POWER SYSTEM

The electrical power distribution system for the Surry Power Station provides duplicate systems for emergency components. Each system is continuously energized from the external system grid or from onsite diesel generators. The system is designed such that should a loss of offsite power (LOOP) occur, the onsite diesel generators will power the emergency power system. A loss of offsite power is defined as a loss of offsite power to both units (see Section 9.9).

Each unit has two 4160V emergency buses to supply safety-related auxiliary loads. These buses are normally supplied from the reserve station service transformers, as described in Section 8.3. The reserve station service transformers have automatic tap changers, which ensure nearly constant load voltages during long-term grid voltage transients. Tap changing is activated by any excursion in the reserve station service transformer output voltage, outside of the load tap changer setpoint range, that lasts for greater than 30 seconds. Upon activation, the load tap changer can step, approximately once every 2 seconds for up to 16 steps from neutral, in either the increase or decrease direction to restore transformer output voltage. The change increments average 0.625% of the neutral tap voltage per step. Emergency bus loads are designed to operate within ±10% of rated voltage, and the automatic tap changer configuration maintains emergency bus voltage within this range.

The circuits that supply power to the emergency buses through switchyard Transformers Nos. 1, 2, and 4 are known as “primary sources.” Each primary source is capable to provide power to an Emergency Bus on each Unit.

In addition to the “primary sources,” each unit has an additional offsite power source, which is called the “dependable alternate source.” This source can be made available in eight hours by removing a unit from service, disconnecting its main generator from the isolated phase bus, and feeding offsite power through the main step-up transformer and normal station service transformers to the emergency buses.

In the event of a complete loss of ac power and no emergency diesels, only dc power from the batteries is available. The only equipment operable would be the steam-driven auxiliary feedwater pump for maintaining makeup to the steam generator, and core heat removal, and the instrumentation supplied by the four vital buses whose power is supplied by the dc/ac inverters. There would be a dc lube-oil pump oil supply to the main turbine and the seal-oil pump oil supply to the main turbine and seal of the system for the main generator. Only natural circulation of reactor coolant would be possible, and makeup to the primary would require restoration of power to the ac emergency buses. The procedures used for station blackout and restoration of transmission systems are considered adequate to cope with the postulated event.

As a backup power source for the emergency buses, an onsite, independent, automatically starting emergency power system is provided. It supplies power to vital auxiliaries if a normal power source is not available and consists of three diesel generators for the two units. The Unit 1 diesel generator and the Unit 2 diesel generator are dedicated to emergency buses 1H and 2H, respectively. A third diesel generator is provided as a “swing diesel” and is shared by Units 1 and 2. Each diesel generator has 100% capacity and is connected to independent 4160V emergency buses. The third diesel is configured to preferentially load to the Unit 2 4160V bus (J Bus) with a loss of offsite power without a SI. If a unit experiences an SI signal that unit’s J Bus will be energized by the third diesel. The Unit 1 and Unit 2 diesel generators also supply power for certain common or shared plant systems/components, such as the Auxiliary Feedwater System pumps and cross connect valves, the Main Control Room and Emergency Switchgear Room (MCR/ESGR) Air Conditioning System chillers and air handling units, MCR/ESGR Emergency Ventilation System fans, Auxiliary Building Ventilation System fans, and the Containment Hydrogen Analyzers.

Each emergency bus provides power to the following operating engineered safeguards equipment:

1. One containment spray pump.
2. One charging pump (high-head safety injection pump). Two charging pumps on ‘H’ Bus (only when normal offsite power is available).
3. One low-head safety injection pump.
4. One recirculation spray pump inside containment.
5. One recirculation spray pump outside containment.
6. One motor control center for valves, instruments, control air compressor, fuel-oil pumps, etc.
7. Control area air-conditioning equipment—two air recirculating units, one water chilling unit, one service water pump, and one chilled water circulating pump.
8. One charging pump service water pump for charging pump intermediate seal coolers and lube-oil coolers.
9. One motor-driven auxiliary feedwater pump.

Safeguards equipment items are duplicated and connected to separate emergency buses. In the event of an equipment failure on one emergency bus coincident with a diesel-generator failure on the other bus, it is possible to connect both electrical buses to one generator so that the equipment normally powered from one diesel generator could be powered from another diesel generator if required. The emergency connection would be made under strict administrative control by manual operation of the bus tie breaker. If the loss of normal power is not accompanied by a loss-of-coolant accident, the safeguards equipment is not required. Under this condition, other plant auxiliary equipment, such as a component cooling pump, residual heat removal pump, etc., may be operated manually up to the capacity of the emergency generators. Instrumentation is provided to indicate diesel-generator loading.

If any safeguard equipment fails to operate automatically, manual operation is possible from the control room or at the switchgear. The switchgear for each diesel generator is physically and electrically isolated from the switchgear for the other diesel generators.

Three of five water chilling units (chillers) and the associated auxiliaries in the main control room and emergency switchgear and relay room air conditioning system are capable of being powered from either one of two emergency buses. In addition to providing operational and maintenance flexibility, this manual transfer capability ensures 100% air-conditioning capacity with any credible single failure.

It should be noted that one charging pump motor can be connected to either emergency bus. If an operator selects emergency bus H to energize the swing motor, he locks out the alternate circuit breaker connection to emergency bus J by means of a control switch on the main control board. In addition, a breaker mechanism interlock is provided to block closing of the alternate feeder breaker, when the selected breaker is closed.

Each diesel generator is reliable in operation. This reliability is achieved by use of duplicate or independent components or subsystems as follows:

1. Fuel system - Duplicate fuel systems with independent fuel and transfer pumps, strainers, and filters are provided.
2. Air supply starting system - Duplicate air starting systems with independent compressor, valves, and accumulators are provided.
3. Control storage battery - Each unit has its own independent control storage battery.
4. Control equipment - Each unit has individual control panels, metering, regulation, and excitation equipment.

Each diesel generator is provided with two starting subsystems. Each subsystem is sized for two engine starts without outside power. During automatic starts, both subsystems are activated to start the diesel generator. Each engine also has an independent day tank (combined base tank and auxiliary wall tank) with capacity for at least one hour of full-load operation. The auxiliary wall tanks are filled by transferring fuel from either one of two buried, tornado-missile-protected fuel-oil storage tanks, each having a 20,000-gallon capacity. Two 100%-capacity fuel-oil transfer pumps are provided for each diesel generator and are powered from the emergency buses to ensure that an operating diesel generator has a continuous supply of fuel. The buried fuel-oil storage tanks contain a 7-day supply of fuel (35,000-gallon minimum) for the full-load operation of one diesel generator. In addition, there is a 210,000-gallon above-ground fuel-oil storage tank onsite that is used for transferring fuel to the buried tanks. Provisions are in place to permit inspection and related repair of a buried fuel-oil storage tank during plant operation. While one buried tank is out of service, the verification of onsite and offsite fuel-oil sources is required to ensure an adequate supply of fuel-oil remains available.

The diesel engine starting circuitry accepts the following signals:

1. Undervoltage/degraded voltage or open phase condition on emergency bus.
2. Safety injection signal.
3. High-High consequences limiting safeguards.
4. Manual.

Conditions that render the diesel generator incapable of responding to an automatic emergency start signal are:

1. Diesel-generator output differential current fault.
2. Diesel-generator output overcurrent fault.
3. No diesel-generator field.
4. Overspeed.

(The above four conditions must be reset prior to any start.)

5. Manual stop from local or remote locations.
6. Control room switch in “exercise” instead of “auto.”
7. Engine control cabinet (at the diesel) switch in “local start.”
8. Necessary circuit breakers in “off” position.
9. Low starting air pressure.
10. Less than required fuel inventory.
11. Low battery voltage.

Alarms and annunciators actuate in the control room and the local diesel-generator control panel when a fault condition associated with the diesel generator exists. An emergency diesel auto-start-disabled alarm is obtained in the control room whenever the local diesel control panel selector switch is in the “local start” position or when the “auto-exercise” switch on the remote control room panel is in the “exercise” position. If any of the other disabling conditions exist, an emergency generator trouble alarm will be received in the control room.

If required, the emergency buses can be powered from the onsite diesel generators. During accident conditions, each diesel generator set is sized to start and accept load in equal to or less than 10 seconds of the start signal. The starting load capacity is 12,500 kVA. The diesel generators have a cumulative 2000-hour rating of 2750 kW. The allowable EDG loading will not exceed these values. Engineering controls and incorporates load additions into worst-case voltage profiles and load calculations to ensure EDG ratings are not exceeded. The starting, accelerating, and loading times of the diesel generators using simulated loads were witnessed and checked before the units were accepted from the engine manufacturer. The continued ability to accept load is tested as described in Section 8.6.

The emergency buses are protected from either a degraded voltage, a loss-of-voltage, or an open phase condition. The voltage of each bus is monitored on each phase with separate single-phase loss-of-voltage relays, two parallel three-phase degraded voltage relays, and three three-phase open phase relays. Each separate set of relays will provide the input to a coincident two-out-of-three logic scheme. The setpoints (setting limits) for these three protection schemes are provided in the Technical Specifications. The system operation is described below:

- Under degraded voltage conditions (nominally, below 92.7% of rated voltage), the two-out-of-three logic scheme will initiate an alarm in the control room at 10 seconds, start the diesel generators at 50 seconds, and initiate the transfer of the Class 1E emergency buses from the offsite source to the diesel generators at 60 seconds. If a safety-injection or consequence-limiting safeguards signal is concurrent with the degraded voltage, the 10-, 50-, and 60-second time delays are effectively bypassed. The diesel generator is started upon receipt of the safety injection or consequence-limiting safeguards signal and, following the degraded voltage signal 7-second delay, the transfer from offsite to onsite power is initiated. Upon transfer initiation with a safety injection or consequence-limiting safeguards condition, the offsite source feeder breakers to the Class 1E buses, the stub bus tie breaker, the residual heat removal pumps, the component cooling pumps, and one of the two “H” Bus charging pumps are automatically tripped.

- On a loss-of-voltage condition (nominally, below 75% of rated voltage), the separate relays will trip and, after a time delay, initiate an automatic transfer of the Class 1E emergency buses from the offsite source to the diesel generator. The time delay for this first level (loss-of-voltage) protection is nominally 2 seconds. Both this time delay and the nominal 7-second time delay for second level (degraded voltage) conditions, discussed above, meet NRC staff positions on undervoltage protection allowable time delays, in that they will allow for system voltage transients while ensuring that the diesel generator energizes the emergency bus within 10 seconds of the loss-of-voltage signal (assumed in the accident analysis), and they will not cause the failure of any equipment attached to, and associated with, the Class 1E power system.

- For an open phase condition (nominally, above 6% negative sequence voltage), the two-out-of-three logic scheme will energize an Undervoltage Protection auxiliary relay for the associated bus which starts the EDG and transfers following the same process as the Undervoltage/Degraded voltage protection scheme. The open phase condition negative sequence voltage relays include an inverse time characteristic which introduces a trip time delay based on the magnitude of negative sequence voltage sensed. A time dial setting of 10 is used for the open phase of less than 5 seconds for any open phase condition sensed at an emergency bus.

For degraded voltage, loss-of-voltage, and open phase conditions, once the diesel generator reaches the necessary voltage and speed (95 ±2% of nominal bus voltage and 870 ±20 rpm, respectively) and the 2.2-second residual voltage time delay is satisfied, the diesel generator output breaker will close. The time delay relay is actuated when the normal feeder breaker opens. This time delay, based upon analysis, is sufficient to permit residual bus voltages to dissipate to allowable levels and prevents equipment damage that could be caused by an out-of-phase transfer. Upon closing of the output breaker, the loss-of-voltage and under-voltage protection schemes are automatically bypassed so that automatic bus unloading will not occur. However, should the diesel-generator breaker(s) open, both protection schemes are automatically reinstated. The open phase protection scheme is blocked when the normal supply breaker is open.

Safety-injection and consequence-limiting safeguards conditions impact loading on the diesel generator. For a safety injection condition, the charging pump and low-head safety injection pump receive immediate starting signals. At 50 seconds after the safety injection, the steam generator auxiliary feedwater pumps are started. At approximately 90 seconds after the safety injection, the filter exhaust fans are started for a consequence-limiting safeguards condition, the charging pump, low head safety injection pump plus the containment spray pumps receive immediate start signals. In addition to the delayed starting of the steam generator auxiliary feedwater pumps, the filtered exhaust fans start at 90 seconds, the inside recirculation spray pumps start at 120 seconds and the outside recirculation spray pumps start at 300 seconds. On a loss of offsite power or open phase event, the emergency diesel generator load sequencing scheme is initiated to ensure that previously running loads are re-energized without exceeding diesel generator operational ratings. This scheme will trip certain loads, if they have been running, and resequence them onto the emergency bus - provided that all other breaker closure permissives are satisfied.

For running loads, the load sequencing scheme is independent of safety injection or consequence-limiting safeguards logic for the affected loads and, therefore, could be concurrent. The affected loads and their resequence times after EDG breaker closure upon LOOP are listed below.

1. Outside recirculation spray pumps are resequenced after 10 seconds.
2. Inside recirculation spray pumps are resequenced after 20 seconds.
3. Filter Exhaust Fans (1-VS-F-58A & B) are resequenced after 30 seconds.
4. Pressurizer Heaters are resequenced after 180 seconds.
5. Auxiliary feedwater pumps are resequenced after 10 seconds with only an SI signal present and after 140 seconds with hi-hi CLS signal present.

The design basis accident analysis discussed in Chapters 5 and 14 considers a loss of coolant accident (LOCA) to occur coincident with a loss of offsite power (LOOP). It is not necessary to evaluate potential impacts on the performance of other systems resulting from a

LOOP subsequent to a LOCA because that scenario is not part of the Surry licensing basis. NRC Information Notice 85-91, *Load Sequencers for Emergency Diesel Generators*, identified a potential problem with the diesel loading sequence if a LOOP should occur subsequent to a LOCA. Virginia Power evaluated this situation with respect to emergency diesel generator loading even though the Surry licensing basis considers the LOOP to occur coincident with the LOCA. The evaluation identified that, after implementation of appropriate modifications to emergency diesel sequencing logics, a LOOP subsequent to a LOCA would not result in overloading of the emergency diesel generators.

Voltage and frequency for the emergency diesel generators are automatically set. However, voltage and frequency can also be adjusted by the operator if outside of the procedural limits. Frequency is controlled to 59.67-60.33 Hz and voltage is controlled to 4000-4400 volts. These procedural limits have been used in hydraulic calculations for maximum horsepower and minimum and maximum flows that are used in the safety analyses.

The single failure of a dc system (e.g., station battery) can adversely affect the shedding of loads and opening of supply breakers in one emergency power system train. However, because of the redundant trains and the diverse dc supplies to the supply breakers, the system design would not be impacted to such an extent that adequate diesel generator operation could be prevented.

The degraded voltage setpoints were chosen to preclude inadvertent load shedding during transient undervoltage conditions that could potentially occur when large loads are started.

The emergency bus is protected (nominally, between 75% and 92.7% of rated voltage) from a degraded voltage condition after a 60-second time delay. However, safety-grade motors were purchased or analyzed to start at 70% of rated voltage (72% for LHSI pump motors 1-SI-P-1A and 2-SI-P-1A and 2-SI-P-1B); thus, the motors will all start and accelerate through the range of degraded voltage.

General Electric SAM timers have been added in the trip circuit of transfer breakers 15D1, 15El, and 15Fl. The timers provide a time-delay trip of 300 milliseconds if the normal feeder breakers to the emergency breakers do not trip. If they do trip, the timers are dropped out of the delay circuit allowing 15D1, 15E1 or 15FI to remain closed. This prevents a loss of power to transfer bus D, E or F due to an under-voltage condition that might exist on emergency bus 1J, 2H or either 1H or 2J, respectively.

Another level of undervoltage protection exists on the 4 kV transfer buses D, E and F. This protection system has a voltage setpoint greater than or equal to 46.7% of nominal voltage. Actuation of the relays will automatically start the auxiliary feedwater pump and align appropriate motor-operated valves under consequence-limiting safeguards.

Control circuits for safety-related loads are designed so that a degraded voltage will not adversely affect operation. All safety-related loads are operated either by circuit breakers or by motor controllers. The circuit breakers are supplied with 125V dc control power, which comes from the station battery bus. The 125V dc control power is supplied via fuses in the individual breakers. The original fuses were replaced by smaller fuses to allow for electrical coordination with the breaker in the 125V dc distribution panel feeding the entire bus. This change was necessary to conform to the requirements of Appendix R to 10 CFR 50 and assures availability of power sources to safe shutdown equipment. (See Section 9.10.3.4 for additional information.) Therefore, operation of these breakers is independent of emergency bus voltage. The motor controllers are supplied with ac control power from an internal transformer, which steps down line voltage to 120V ac. Therefore, motor controller operation is dependent on line voltage. Safety-related motor controllers will operate satisfactorily with line voltage at values greater than the undervoltage setpoint for diesel-generator loading.

Each piece of vital equipment is connected to the auxiliary electrical power system with an exclusive circuit. Each circuit has an air circuit breaker overcurrent fault protection, and a control switch with red, amber, and green indicating lights mounted in the control room. The red lights show that the power circuit is available. The green light is lit when the power circuit is de-energized and monitors the availability of control power. Simultaneous lighting of the amber and green lights indicates an automatic trip of a feeder or source circuit. Major items have meters to indicate circuit current. Isolation of a failed circuit is automatic and is identified by the indicating lights in the control room. Automatic tripping functions also energize an audible signal to alert the control room operator. Individual protective relays have signal targets to indicate that automatic operation has taken place.

Original plant design included two 4160/480V load center transformers per unit, 1H and 1J and 2H and 2J. With the addition of the 1H1, 1J1, 2H1 and 2J1 transformers, studies were performed in 1979 for Unit 1 (Reference 1) and in 1980 got Unit 2 (Reference 2) to confirm the load capability of the 480V emergency power system and to verify the adequacy of voltage profiles on Class 1E buses during various modes of plant operation. (The 480V emergency power system is shown on Figure 8.3-1.)

In accordance with the NRC Generic Letter (Reference 3), dated August 8, 1979, entitled *Adequacy of Station Electrical Distribution System Voltages*, Vepco performed analyses to determine the adequacy of the Surry Power Station electrical distribution system. The review consisted of:

1. Analytically determining the capacity and capability of the offsite power system and onsite distribution system to automatically start as well as operate all required loads within their required voltage ratings in the event of: (1) an anticipated transient, or (2) an accident (such as a LOCA) without manual shedding of any electric loads.
2. Determining if there are any events or conditions which could result in the simultaneous or consequential loss of both required circuits from the offsite network to the onsite electrical distribution system and thus violate the requirement of General Design Criterion 17.

The criteria used in the technical evaluation of the analysis included General Design Criterion 5 (Sharing of Structures, Systems, and Components), General Design Criterion 13 (Instrumentation and Control), and General Design Criterion 17 (Electric Power System) of Appendix A to 10 CFR 50, IEEE Standard 308-1974, ANSI C84.1-1977 and the NRC staff positions and guidelines provided in the August 8, 1979, letter.

In Reference 4 it was concluded that the Surry Units 1 and 2 offsite power system and the onsite distribution system are capable of providing acceptable voltages for worst-case station electric load and grid voltages. Analysis results are included in Reference 5. Continued assurance that acceptable voltages are available is maintained using calculation(s) which are periodically updated.

The voltage level and current loading of all station distribution buses are displayed in the control room. The status of the switchyard breakers and the source of reserve station power are readily available to the operator. Indicating lights show the source of power to each bus. Alternate sources may be manually selected by the operator, but prearranged automatic transfer takes place on failure of the normal source. The following instruments are provided in the control room to monitor emergency bus voltage performance:

1. Battery voltage indication.
2. Battery ground indication.
3. Emergency bus voltage.
4. Emergency bus frequency.
5. Emergency bus undervoltage alarm.
6. Low battery voltage alarm.
7. Emergency bus overvoltage alarm.
8. Hi battery voltage alarm.
9. Emergency bus open phase condition alarm.

Routine control of normal and standby electrical power is from the control room. However, essential loads can also be controlled from the emergency switchgear located below the control room. The emergency switchgear is designed so that local operation is possible with or without control power.

Control switches on the main control board are clearly identified by system. Emergency switchgear and control centers are identified as control devices for essential components.

The diesel-generator panel contains instruments and controls to serve the emergency bus. Provisions for synchronizing the diesel generator manually with the reserve station service power systems are also provided. The generators are manually synchronized with the system and loaded for periodic load tests.

The diesel generators and associated equipment are located in a Class I and tornado-protected structure. Each generator and its associated equipment will withstand, without loss of function, either the design-basis earthquake or the atmospheric pressure drop associated with the design tornado.

Emergency switchgear is located in the shielded control area below the control room. Status of the emergency power bus can be determined at the emergency switchgear. Emergency distribution air circuit breakers can be manually operated at the switchgear (Section 7.7).

Switchgear associated with the electrical feeds to the emergency buses are enclosed in metal housings and protected from the weather.

Essential electrical components and circuits are located and distributed within protected zones. All cables, conductors, motors, pumps, control stations, etc., are identified by a mark number or by function. The markings consist of painted stencils or marked tags applied or attached to each component.

Lines, valves and equipment subject to freezing or crystallization of boron are electrically heat traced and insulated. The heat source is automatically energized when the temperature drops below preset limits. Therefore, icing or crystallization could not interfere with the or injection of coolant during accident conditions.

8.5 REFERENCES

1. Letter from C. M. Stallings, Vepco, to H. R. Denton, NRC, Subject: *Surry Power Station Units 1 and 2 480-V Emergency Power System,* dated June 18, 1979.
2. Letter from B. R. Sylvia, Vepco, to H. R. Denton, NRC, Subject: *Surry Unit 2 480-V Emergency Bus,* dated May 22, 1980.
3. Generic Letter from the U. S. Nuclear Regulatory Commission, to all Licensees, Subject: *Adequacy of Station Electrical Distribution System Voltages,* dated August 8, 1979.
4. Letter from S. A. Varga, NRC, to R. H. Leasburg, Vepco, Subject: *Safety Evaluation Surry Power Station Units 1 and 2, Adequacy of Station Electric Distribution System Voltages,* dated October 6, 1982 (with enclosures).
5. Letter from R. H. Leasburg, Vepco, to H. R. Denton, NRC, Subject: *General Design Criteria 17 Analysis, Surry Unit Nos. 1 and 2,* dated March 31, 1982.
6. Letter from W. L. Stewart, Virginia Electric and Power Company, to NRC, Subject: *Transmittal of Final Survey Report, Emergency Diesel Generator Sequencing*, dated May 4, 1989.

8.6 TESTS AND INSPECTIONS

All electrical equipment was specified for manufacture in strict accordance with the latest requirements of the National Electrical Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), or the American National Standards Institute, Inc. (ANSI) standards, where applicable.

Electrical equipment was protected during shipment and was properly stored at the job site during construction.

The installation of all equipment was under the supervision of a qualified electrical construction engineer. Special attention was given to mechanical alignment and electrical ground connections. The dielectric of all insulation was measured and corrected if necessary before the equipment was energized.

The control power for operating major motor starters is supplied from the station batteries. These batteries are kept at a constant voltage, and they are monitored continuously for voltage variations or undesired ground connections.

Each major motor or other piece of electrical equipment is protected by overcurrent relays that will disconnect the device if fault current is present. The protective relays are set and calibrated by Vepco trained personnel.

The availability and proper action of standby equipment are checked periodically while the unit is in operation.

Testing of the automatic operation of the voltage transfer system at the 4160V level can be performed. Successful operation of the 4160V transfer scheme does not prevent a unit shutdown but is designed to provide station service power automatically when a main generator is out of service.

Each standby power system was installed and checked out several months before criticality. The initial installation was tested to verify the starting speed and loading ability before being accepted. After acceptance, the emergency power systems were operated on a routine test schedule. These routine operations for several months before criticality recognized the initial failure rate and were sufficient to achieve a proven and mature standby power system.

The diesel generators are essential parts of the engineered safeguards system. Starting, loading, and full-load operability of the diesel generators are tested in accordance with Technical Specifications. One method of conducting this test is to connect all operating safeguards equipment to an emergency bus that is not to be tested. The alternative emergency bus is then given a full operational test by opening its normal source breaker. The loss of voltage on the bus being tested automatically starts the emergency generator, closes the generator breaker, and re-energizes that emergency bus system. By placing the starters in either the operating or test position, individual components or systems may be checked completely or the test may be limited to the operation of the motor starters. During the testing of one emergency generator system, the alternative system is still available if required.

The Technical Specifications also include a refueling test requirement for simulating the loss of offsite power in conjunction with a safety injection actuating signal. To preclude a potential reactor coolant system pressurization transient, the breakers for the high-head and low-head safety injection pumps are placed in the test mode so that the pumps will not start. (The operability of these pumps is the subject of a separate monthly test.) This refueling test verifies diesel-generator starting and loading, as well as the starting of required loads.

During power operation, the station batteries and diesel-generator batteries are periodically checked in accordance with Technical Specifications to provide an indication of battery cells becoming unserviceable before they fail. An equalizing or overvoltage charge is applied to the batteries and is applied long enough to bring all cells up to an equal voltage. If these tests reveal a weak cell or a weakening trend in any cell, replacements are made as necessary. A disconnected battery or broken cell connector would be revealed during these equalizing charges. Periodically, the battery charger is disconnected and the ability of the battery to maintain voltage and assume the dc load is verified. This test will uncover any high-resistance connections or cell internal malfunctions.

During construction, checks and inspections were made to ensure that complete separation was maintained between vital equipment to ascertain redundant systems. The separation of the dc power supply system was verified before operation by performing functional checks on the two battery trains. Verification was provided by removing one battery train from service and operating the equipment on the other train. Checks were made to ascertain that the proper equipment was actuated. This procedure was followed for checking both dc battery trains.