SECTION 8

ELECTRICAL SYSTEMS

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SECTION 8

ELECTRICAL SYSTEMS

8.1 GENERAL DESCRIPTION AND SUMMARY

The electrical systems include the equipment and systems necessary to generate power and deliver it to the high voltage switchyard. They also include facilities for providing power to and controlling the operation of electrically driven auxiliary unit equipment and instrumentation during a normal plant operation and during loss of normal station power. The main electrical connections are shown in Figure 8.1-1.

The output of the main generator is fed into and operated as an integral part of the transmission system. BVPS-1 station service power is supplied from either the main generator, the 138 kv switchyard, or a combination of both. On failure of the preferred source, automatic throwover capability is provided to the alternate source to ensure continuous power to the equipment. Section 8.4 describes the station service system. Section 8.3 describes the electrical system utility grid interconnection shown in Figures 8.3-1 and 8.3-2.

The onsite power system, which consists of the onsite AC power system, 125 V DC power system, and 120 V AC vital bus system, provides power to vital station auxiliaries if a normal source of power is not available.

Two fast starting diesel generator sets provide the source of AC power for the AC onsite power system. A complete description of the onsite power system is found in Section 8.5.

All safety related instrumentation is fed from reliable and stable separate vital buses as described in Section 8.5.4 to guarantee continuous monitoring and control of all instrument channels. Each bus receives power from a separate battery.

Four separate unit 125 V DC batteries with associated chargers are provided for circuit breaker control power, emergency lighting, and operating power for vital equipment until power is restored or onsite emergency power is available. A fifth 125 V DC battery with charger is also provided for miscellaneous services not related to engineered safety features. Figure 8.4-1 illustrates the 120 V AC vital bus and 125 V DC systems.

Redundant circuits for essential systems are run by alternate routes which are physically separated or isolated by barriers to reduce the probability of simultaneous damage.

Safety related AC and DC loads are identified on Figures 8.1-1 and 8.4-2, respectively.

The electrical power systems are designed in accordance with General Design Criteria 17 and 18, Safety Guides 6 and 9, and IEEE Std. 308-1971[1] as more fully described in Section 8.2 through 8.6.

References for Section 8.1

1. "Criteria for Class IE Power Systems for Nuclear Power Generating Stations", IEEE Std. 308-1971, The Institute of Electrical and Electronic Engineers, Inc.

8.2 DESIGN BASES

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

Alternate power systems, each with adequate independence, redundancy, capacity, and testability, are provided to ensure a capability for performing the function required of engineered safety features.

Onsite and offsite power systems each independently provide the total power requirements for essential systems, assuming a failure of a single active component in each system.

All components or portions of the onsite electrical system associated with the power supplied to essential systems such as motors, switchgear, batteries and chargers, etc. are capable of withstanding the maximum forces predicted at the location as a result of extraordinary natural phenomena, including earthquake, tornado, flood, high wind, or icing.

The ability of all Category I electrical equipment, which is part of the onsite power system, to perform its intended function during or following a maximum hypothetical earthquake, must be documented by test or analysis.

The seismic design criteria and method of seismic analysis and seismic testing of Category I electrical equipment is described in Appendix B.

The seismic design criteria and method of seismic analysis and seismic testing of Category I reactor protection system equipment is covered in Section 7.2.1.

The electrical systems meet the requirements of General Design Criteria 17 and 18, Safety Guides 6 and 9 and IEEE Std. 308-1971.[1] The main control room is designed in accordance with General Design Criteria 19. The offsite power system is not designed to withstand a tornado, exceptionally severe hurricanes or ice storms. However, the indoor circuit breakers and control circuits required to ensure isolation of the essential circuits and onsite power systems from the offsite power system are located in a protected area designed to withstand tornadoes, hurricanes or ice storms.

Electrical equipment for essential systems located within the containment structure is designed to operate under the conditions of temperature, pressure, and humidity which occur during and after a loss-of-coolant accident as described in Section 7.

References for Section 8.2

1. "Criteria for Class IE Power Systems for Nuclear Power Generating Stations", IEEE Std. 308-1971, The Institute of Electrical and Electronic Engineers, Inc.

8.3 SYSTEM INTERCONNECTIONS

Generator 1, described in Section 10.3.3, is connected through the generator lead bus to a step-up transformer, rated at 1058 MVA. This transformer steps the generator voltage up to 345 kv to feed two separately protected buses of the 345 kv switchyard (Figure 8.3-1). Each bus of the 345 kv switchyard is connected through 345-138 kv autotransformers to separate buses in the 138 kv switchyard.

BVPS-1 generator 1 and six transmission lines connect to the 345 kv switchyard and seven transmission lines connect to the 138 kv switchyard. Two BVPS-1 station service lines also connect to the 138 kv switchyard. Figure 8.3-1 is a one-line diagram showing the 345 kv and 138 kv switchyards and their connections to the station.

The combined 138 kv and 345 kv switchyards form a major bulk transmission switching point for the transmission system. In addition to lines connecting with other switchyards in the transmission system, there are direct ties with two large neighboring power systems.

Lines converge on the switchyards by means of two or more widely separated routes. Separation of connections to the switchyard buses varies from a center-to-center spacing of more than 400 ft between the most widely separated lines to a minimum of 45 ft for lines which terminate in adjacent bays.

Routing of rights of way, location, height, and distance between towers for lines emanating from the switchyard to the grid is provided in Figure 8.3-3.

Routing of lines from the switchyard to the plant, including an extension for BVPS-2, are shown on Figure 8.3-4. The two 138 kv lines from the switchyard to the plant are each on separate towers and have sufficient separation so that falling of one tower on the adjacent redundant circuit is not a credible accident.

A diagram of the bulk power supply transmission system for BVPS-1 and BVPS-2 in the vicinity of the Beaver Valley Power Station is shown in Figure 8.3-2.

Both switchyards have a double bus arrangement. Buses are rigid-type to provide maximum reliability. The switchyards are designed to withstand the maximum expected wind and ice loading conditions. Each bus, transformer and transmission line connected to the buses is individually protected by two independent protective relay schemes. Transmission line and transformer breakers have separately protected d-c control circuits. Each 345 kv and 138 kv circuit breaker in the switchyard is serviced by two separate 125 v d-c batteries, each feeding two separate d-c distribution panels. The 138 kv and 345 kv circuit breakers have two independent trip coils apiece, each served by separate batteries. Therefore, with a single failure of battery supply, one source is still available to trip the breaker. Single failures of either equipment or control and protective circuits do not cause loss of power at both buses in the 345 kv or the 138 kv switchyard. Reliable offsite power is available to supply BVPS-1 station service and essential systems since offsite power is supplied by two BVPS-1 station service transformers, one from each bus of the 138 kv switchyard. The 138 kv connections between the switchyard buses and the station service transformers are made with overhead lines having separate towers for each line.

Loss of either bus 1 or bus 2 of the 138 kv switchyard reduces station service power for BVPS-1 available from the switchyard to approximately half of full-load requirements. Even without BVPS-1 station service power from the main generator and with either 138 kv bus 1 or 2 out of service, sufficient power capacity remains to provide for an orderly shutdown, and to supply all engineered safety features loads.

The capacity of each of the 138 kv buses 1 and 2 and the 138 kv lines feeding the system station service transformers for both BVPS-1 and BVPS-2, is adequate to meet the power requirements for an accident in one unit and a safe shutdown in the other unit.

An Open Phase Detection (OPD) system is provided to detect single (one of three) and double (two of three) open phase conductors on the high voltage (138 kV) side of the system station service transformers. The OPD system can detect open phase conditions with and without grounded conductors. Upon detection of an open phase condition, the OPD system provides indication to the operator.

Even with the loss of all except one source of power from the switchyard to the system, sufficient power capacity required for essential systems is available.

In the unlikely event that a tornado, flying missile, hurricane, or severe icing would simultaneously take out all incoming transmission lines or both 138 kv switchyard buses, the unit is designed to continue in operation, supplying station service power from the main generator. In the unlikely event of simultaneous loss of offsite power and unit generator power, the buses supplying the essential systems are automatically transferred to onsite emergency power. All indoor equipment and circuits required to ensure isolation of the onsite emergency power systems from the offsite power systems are protected by enclosures designed to withstand damage from tornadoes or flying missiles.

8.3.1 Grid Stability Study

The power network to which the Beaver Valley Power Stations are connected has been analyzed for transient stability using computer simulation.

The loss of any single large unit on the grid will not cause the loss of offsite power to the Beaver Valley Power Stations.

A trip of the BVPS-1 from internal troubles in the Nuclear Steam Supply System and not related to electrical faults has very little effect on the power network. Restoration to normal would be accomplished on a dispatch basis as required by normal control or nearby generation and switching of shunt capacitors connected to the power network. The electrical systems are stable.

Results of stability studies indicate that the 345 kv and 138 kv systems will remain stable and intact for all faults except certain 3 phase faults with delayed clearing. For all single and 3 phase faults at BVPS on the 345 kv and 138 kv busses cleared by the primary protection in accordance with planned relay settings, the remainder of the power network remains stable. When 3 phase faults with breaker failure are postulated on the line side of faulted breakers at the Beaver Valley 345 kv bus, and the fault is cleared by the secondary protection, BVPS becomes unstable. For light load conditions, tripping of the BVPS units allows the remainder of the system to stabilize. For peak load conditions, the nearby Mansfield units and the AES unit

would trip before the system stabilizes, preventing cascading loss of power on the system. These scenarios of 3 phase faults with delayed clearing are Category D - Extreme Event under NERC Planning Standard I A. The impact of these faults on the BVPS units would be a fast bus transfer to the 138 kv power source. Although it is expected that voltages would recover sufficiently for the transfer to be successful, an unsuccessful transfer would result in a trip of the emergency buses and the emergency loads would sequence onto the standby emergency diesel generator power source as designed. It is, therefore, expected that this condition will not adversely affect the 1E systems and their ability to mitigate a design basis accident.

8.4 STATION SERVICE SYSTEMS

The primary side of each of the two BVPS-1 station service transformers is connected to the main generator terminals and the low voltage connection of the main step-up transformer. During normal operation, BVPS-1 station service power is taken from the BVPS-1 station service transformers 1C and 1D which are rated 22 kv-4.36 kv, or may also be taken from the system station service transformers IA and IB described below. Each of the four service transformers has two 4,360 V windings, is rated at 35.8 MVA at 65°C rise, and supplies two independent 4,160 V station service buses.

The primary side of each of the two system station service transformers is connected through separate breakers to separate buses in the 138 kv switchyard, as described in Section 8.3.

During normal operation, any one of the station service transformers or system station service transformers or a combination of both may be selected as the preferred source for operation.

Automatic throwover capability is provided so that failure of the preferred source to any station service bus initiates automatic throwover to the alternate source to ensure continuous power to the equipment. Knife switches in the fast bus transfer breaker closing coil circuits prevent a reverse fast bus transfer. These switches are aligned under administrative control to allow transfer in the desired direction. Regulations (10 CFR 50 Appendix A GDC 17) require immediate ("within a few seconds") access to offsite power in the event of a LOCA. Thus, the knife switches are normally aligned to allow transfer from the station service transformers to the system station service transformers regardless of the selected source.

Unit auxiliary power is normally supplied by the system station service transformers during startup, shutdown, or hot standby conditions. Unit auxiliary power may also be supplied by the unit station service transformers by backfeeding through the main transformer.

Station service transformers are rated to permit continuous full-load operation with either pair of transformers out of service providing that transformers 1A and 1C or 1B and 1D are not out of service simultaneously. Tap changers are provided on both secondary windings of transformers 1A and 1B which improves the voltage regulation of the 4 kv buses 1A, 1B, 1C and 1D. Manual capability for controlling the tap changers is available from the control room.

Each 4,160 V bus section identified above normally supplies two of eight bus sections in the 480 V service systems. Each 480 V bus section is provided with automatic throwover to an alternate source. 4,160 V bus Sections 1A and 1C each supply a separate 480 V bus section for screenwell and cooling tower loads.

Control for the 4,160 V bus supply breakers is provided in the main control room.

The 4,160 V AC and 480 V AC switchgear is of metal-clad, dead front construction, with closing and tripping control power taken from the 125 V DC unit batteries. Each breaker cubicle is isolated from the adjacent cubicle with metal barriers, and each bus section is physically separated from all others.

All switchgear associated with engineered safety features equipment is physically separated from the main switchgear area. The physical arrangement of the emergency switchgear is shown in Figure 8.5-1.

Power and control cables are distributed from the switchgear and control area by means of rigid metal conduits or ladder-type cable trays.

The main feeds to the 4,160 V switchgear are made with metal-clad, cable-type bus ducts. Feeder and motor cables in 4,160 V service are insulated cables rated at 5,000 V and 90°C conductor temperature. The exact construction of the cable and method of support are selected to suit the individual service. Single-conductor cables are provided with a flame-retardant jacket. Three-conductor cables are provided with an interlocked metal armor jacket.

Power cables for the 480 V service are rated at 600 V and 90°C conductor temperature. Single-conductor cables are jacketed. Triplexed cables are 3-single conductors with individual conductors jacketed and no overall jacket. Jackets are of flame-retardant material, and fillers are flame-retardant and nonwicking.

Control cables are single or multiconductor construction, with 600 V insulation minimum and with overall flame-retardant jacket and fillers which are flame-retardant and nonwicking.

Low-voltage instrument connections are made with insulated cables suitable for operation at 300 V or below. These cables are provided with or without an electrostatic shield, as required, with 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 conductor sizes is based on "Power Cable Ampacities," published by the Insulated Power Cables Engineers Association (IPCEA) or manufacturer's data.

Four vital instrument buses, as shown in Figure 8.4-1, are provided for all instrumentation and reactor protection circuits. Each instrument bus is fed from a station inverter. The buses are maintained at 124 $\pm$ 2.48 V and 60 $\pm$ 0.3 Hz. These vital buses are normally free from AC station service transients or voltage variations. Section 8.5.4 described the 120 V AC vital bus system.

The unit batteries are sized to operate turbine-generator emergency shutdown oil pumps, instrumentation, inplant communications, and vital nuclear channels for two hours without benefit of any unit power. After two hours, it is assumed that power will be restored or will be supplied from the onsite emergency power generation equipment. Section 8.5.3 describes the 125 V DC power system.

Lighting distribution and intensities are provided in accordance with the latest recommendations of the Illuminating Engineering Society (IES). Section 8.4.4 describes the lighting system.

Service factor and overload rating are considered in the design and selection of electrical equipment and cables. However, service factor and overload rating are not considered design bases criteria. Electrical equipment and cables are capable of performing required safety functions.

8.4.1 Essential Emergency Systems

The two 138-4.36 kv system station service transformers, which are supplied from separate 138 kv buses in the switchyard, provide redundant sources of offsite power for the emergency systems as well as for normal service systems. Two independent sections of emergency bus, as shown in Figure 8.1-1, are supplied by isolated circuits from two normal service buses. Two breakers in series are provided in each circuit to ensure isolation from the normal service system when emergency power is being supplied by the onsite emergency diesel generators.

All equipment and circuits which normally supply offsite power to emergency systems are designed to supply the emergency loads and all connected normal loads simultaneously.

Class 1E electrical equipment is protected from sustained undervoltage conditions of 90 percent or less of motor nameplate voltage while the 4,160 V emergency buses are supplied by offsite power. The emergency bus undervoltage relays are actually set above 90 percent to account for undervoltage relay inaccuracy and voltage drop of the motor leads.

Faults on circuits supplying nonessential loads are isolated within a few cycles to ensure continuous power to essential systems.

Redundant power circuits for emergency systems are run by alternate physically separated routes or isolated by barrier walls to reduce the probability of simultaneous damage.

8.4.2 4,160 V System

The 4,160 V station service system distributes and controls power for the 4,160 V unit station service demands. The source of power is from the main generator through the BVPS-1 station service transformers 1C and 1D, system station service transformers 1A and 1B or a combination of both, as shown in Figure 8.1-1.

All station service transformers have two secondary windings, each feeding separate buses. Each secondary winding is rated to carry 16 MVA at 55°C rise with capability to supply 112 percent of this rating or 17.92 MVA at a 65°C rise continuously without any change in life expectancy of insulation.

Computer studies were performed which indicate the station service transformers, under loaded conditions, are capable of providing a transfer of the 4 kV buses power supply from a preferred source to an alternate source. The electrical calculation program evaluates modifications to station loads to assure the normal and operating Engineered Safety Features (ESF) loads remain within the ratings of the station service transformers.

The normal 4,160 V switchgear is metal-clad, with stored energy type air circuit breakers and 125 V DC control, and is arranged in four independent bus sections. Each section is normally supplied from a separate winding of either a BVPS-1 station service transformer or a system station service transformer.

Loss of supply to any bus section automatically trips the source breaker and closes the breaker to the alternate system source providing no overload or fault exists on the bus section. A provision is also made for manual transfer, as required. All equipment and circuits are rated to start in any sequence, and to supply the entire unit service load, including emergency loads, from either source without overload.

In general, motors 250 hp and larger are operated at 4,160 V and are arranged for across-the-line starting.

One circuit from each 4,160 V bus section feeds two 4,160 V/480 V unit substation transformers, each of which is on a separate bus. Additionally, one circuit from both the 4,160 V bus 1A and 1C sections feeds a separate 4,160 V/480 V substation transformer, each of which is on a separate bus. These substation transformers supply the 480 V system described in Section 8.4.3.

Two independent sections of emergency 4,160 V bus and switchgear are provided. Each section is sized to carry 100 percent of the emergency load. Each emergency bus section is supplied from normal 4,160 V station service switchgear. Each normal switchgear bus is supplied from the selected source (station service transformers or system station service transformers) with provisions for automatic transfer to the alternate source should the preferred source fail. In the unlikely event of total loss-of-station service power, the emergency 4,160 V buses are isolated from the normal supply and energized from the emergency diesel generators, as described in Section 8.5.

Additional second level undervoltage relays, two on each 4,160 V class 1E bus and two on the secondary side of one of the two, parallel 4,160/480 V substation transformers were installed for degraded grid voltage protection. The relays have a drop out setting above 90 percent of nominal bus voltage and a maximum of 95 second time delay. The relay setting allows for relay setpoint inaccuracy and voltage drop of the motor leads to ensure that 90 percent of motor nameplate voltage is available at the motor terminals. These relays on each of the two voltage levels (4160 V and 480 V) are arranged in a two-out-of-two logic scheme. A similar protective scheme is provided on the redundant train. The primary undervoltage loss of voltage relay's setpoint is greater than or equal to 75 percent of nominal bus voltage. Refer to Technical Specifications for trip setpoint and associated time delay limits. Additional circuitry blocks the undervoltage trip load shedding on the 4160 V class 1E buses when the diesel generators are supplying these buses, and automatically reinstates load shedding when the diesel generator breakers are tripped.

8.4.3 480 V System

The 480 V station service system distributes and controls power for all 480 V and 120 V AC unit station service demands. In general, motors rated from 60 hp to 200 hp are controlled directly by breakers in the 480 V switchgear. The source of power for the 480 V system buses is from 4,160 V station service buses. This system is shown in Figure 8.1-1.

The normal 480 V switchgear is metal-clad, with 125 V DC operated air circuit breakers. The substations 480 V bus tie breaker is closed by procedure while trying to determine the location of bus grounds and to allow maintenance on either set of bus feeder equipment. While the busses are tied together no single failure can cause the loss of both supply sources which ultimately could tie back to the physically independent circuits between the offsite transmission network and the onsite Class 1E distribution system. Each bus section is supplied by a close coupled 4,160 V/480 V air-cooled transformer. Each bus section, with the exception of the 480 V emergency buses, is provided with automatic throwover to an alternate power source on failure of the supplying source. Two additional bus sections, with transformers, supply the screenwell and cooling tower loads.

The 480 V motor control centers are metal-clad, with combination line starters or breakers arranged in individual metal barrier compartments bolted together to form a complete motor control center. Each motor control center is supplied from a breaker in one of the 480 V switchgear buses.

Two independent sections of emergency 480 V bus and switchgear are provided. Each section is sized to carry 100 percent of the emergency load. Each emergency 480 V bus section is supplied by a close coupled 4,160 V/480 V dry type transformer which, in turn, is supplied from a breaker in one of the emergency 4,160 V bus sections.

Emergency 480 V motor control centers are provided. Each emergency 480 V motor control center is supplied by a breaker in one of the emergency 480 V switchgear buses.

Each emergency motor control center which feeds a redundant engineered safety features load is supplied with power from a separate 480 V emergency unit substation such that the loss of power on one motor control center will not affect both redundant loads.

All engineered safety items operated at 480 V AC are fed from either the emergency 480 V switchgear or the emergency 480 V motor control center. In the unlikely event of a total loss-of-station service power, the emergency 480 V switchgear and emergency 480 V motor control centers will be supplied with power from the emergency diesel generator through the emergency 4,160 V AC buses.

8.4.4 Lighting System

Normal lighting for the unit is supplied from the 480 V service system through single phase, 480-120/240 V, dry-type trans-formers.

Emergency lighting for all except control room and remote areas consists entirely of 125 V DC incandescent units or LEDs supplied from the unit battery. These units are normally energized from 120 V AC and are automatically energized from 125 V DC on loss of normal AC voltage. Emergency lighting for remote areas such as the intake structure and the cooling tower area is provided by local self-contained battery-powered emergency lighting units.

Emergency lighting for the control room and main control board consists of a combination of 125 V DC incandescent units supplied from the station battery and 120 V AC fluorescent fixtures. These AC fixtures are fed from 480-120/240 V AC dry-type transformers connected to the 480 V emergency buses and are continuously energized. The 125 V DC incandescent units are energized automatically on loss of normal AC voltage.

8.4.5 Emergency Response Facility Power System

A Quality Assurance Category II diesel-backed substation provides power to the Emergency Response Facility (ERF) and selected equipment in BVPS-1 and BVPS-2 complexes as shown in Figure 8.1-1 Sheet 2 of 2.

The Emergency Response Facility Substation (ERFS) receives normal power from two 32 MVA, 138 kv - 4.36 kv/4.36 kv transformers. A 5 kv nonsegregated phase cable bus system with supports connects each transformer to the 4160 V switchgear assembly (4 KVS-BUS 1G and 1H) located in the ERFS building. Either transformer is capable of supplying both buses simultaneously via a bus tie breaker electrically connecting the two buses.

Each of the 4160 V switchgear supplies the ERF and five 480 V substations. The five substations are located in the Unit 1 turbine building, the Unit 2 Auxiliary Building, the South Office Shops Building, Administration Building and in the ERFS building. The switchgear also supplies the Unit 1 dedicated auxiliary feedwater pump and the Unit 2 steam generator startup feed pump.

The 480 V substations supply five motor control centers (three for Unit 1 and two for Unit 2); Uninterruptible Power Supplies (UPS) No. 1 and No. 2; two Unit 2 Station Air Compressors; and the alternate supply to the 300 kva switchyard backup transformer.

The ERFS building receives standby power from a 2500 kw (at 104°F) ERFS diesel generator (RG-EG-1). The diesel generator supplies highly reliable power to the ERFS 4,160 V switchgear for selected equipment in the ERFS, ERF, BVPS-1, and BVPS-2. Refer to Figure 8.1-1, Sheet 2 for the loads supplied during ERFS diesel operation.

The ERFS diesel generator is housed in a prefabricated enclosure adjacent to and north of the ERFS building. A battery and a battery charger for diesel generator starting is installed in the ERFS building.

A 30,000 gallon (approx. 29,100 gallons available as configured) fuel oil storage tank is buried northwest of the switchyard relay house to provide the diesel with a 7-day fuel oil supply. Two 100 percent capacity fuel oil transfer pumps are installed on top of the fuel oil storage tank to transfer fuel oil to the diesel engine fuel oil day tank located in the southeast corner of the ERFS diesel building. Fuel oil is supplied from the day tank to the diesel fuel injectors by an engine mounted fuel pump and a fuel priming pump.

A 60-cell, 125 V DC control storage battery supplies 125 V DC electrical power, via battery breaker to two DC panels for distribution to the ERFS and ERFS diesel building DC loads.

The ERFS electrical system is controlled and monitored in the ERFS building at the ERFS diesel generator and Air-Circuit Breaker (ACB) control panels. A programmable controller provides automatic load shedding, limiting the diesel generator load to an acceptable level based on generator loading.

A redundant programmable controller system in the ERFS building provides for preprogrammed control of 4 KVS Bus 1G and 1H bus transfer, 480 VUS-Bus 1S and 1T bus transfer, alarming for blown potential transformer (PT) fuses, and for starting and automatic loading of the diesel generator.

A communication system is installed to provide communication between the ERFS building, ERFS diesel building and the BVPS-1 control room.

A heating, ventilating, and air conditioning (HVAC) system is provided for the ERFS building with the air conditioning servicing only the first floor. Heating and ventilating is also provided for the ERFS diesel building.

A ductline manhole system is installed from ERFS to BVPS-1 warehouse extension building, BVPS-2 condensate polishing building, System Station Service Transformers 1A and 1B and switchyard precast concrete cable trench system, and to the ERF. This is used to run the interconnecting service cables between the various stations.

Refer to Figure 1.2-1 for the location of the ERFS Building and the ERF Diesel Generator Building.

8.4.6 Station Blackout (SBO) 4,160 V Cross-Tie

A cross-tie connecting the 4,160 v normal busses 1A, 1D, 2A, and 2D of BVPS-1 and 2, as shown on Figure 8.1-1, Sheet 1 of 2, provides the capability to power up either of the emergency busses at one unit from either of the emergency diesel generators (EDGs) at the other unit.

In conformance with the SBO Rule 10 CFR 50.63, BVPS utilizes the EDGs at each unit as an alternate AC (AAC) power source to operate systems necessary for the required SBO coping duration and recovery therefrom. With the cross-tie, BVPS can cope with a postulated total loss of offsite power to both units coincident with the loss of all onsite power (EDGs) at one unit, by enabling any single available EDG at either unit to supply power to the required SBO loads at both units within one hour.

The design of the SBO cross-tie circuit conforms with guidance provided by Regulatory Guide 1.155 and NUMARC 87-00. The circuit consists of four locally operated 4,160 V breakers installed at switchgear busses 1A, 1D, 2A, and 2D, and interconnected by 5 kv power cables protected against the effects of likely weather-related events. The normal to emergency 4,160 V bus connections and the EDG to emergency 4,160 V bus connections, described in Section 8.5.2, complete the circuit to the AAC.

The cross-tie between the normal 4,160 V busses is disconnected (breakers racked out) during normal plant operation and requires manual operator action to place it into service during SBO conditions. Energization of the cross-tie and startup of equipment to cope with a SBO is administratively controlled and procedurally addressed by Emergency Operating Procedures for BVPS-1 and 2.

8.5 EMERGENCY POWER SYSTEM

8.5.1 General

The emergency power system is an independent, automatic starting power source which supplies power to vital station auxiliaries if a normal power source is not available.

The emergency power system, including the alternating current, direct current, and vital bus systems, is designed in accordance with IEEE Std. 308-1971[2] and is in accordance with AEC Safety Guide 6 and 1971 General Design Criteria (GDC) 17 and 18 and the intent of Safety Guide 9.

While in a test condition, several design limitations prevent the associated EDG from being capable of supplying emergency power within the required time in response to an emergency (SI/LOOP) start signal. Therefore, an EDG is inoperable while in a test condition.

An electrical calculation program is in place to monitor emergency bus load additions and deletions and to update the emergency bus loading calculations. This program ensures the capacity of emergency diesel generators continues to be adequate to power prescribed loads.

Emergency power system equipment capacities and arrangements are indicated throughout Section 8.5.

The BVPS Quality Assurance Program covers the emergency power system equipment. A description of this program is found in Appendix A.

All Category I electrical equipment was designed to withstand a design basis earthquake as described in Appendix B.

The independence between redundant emergency power sources and between their distribution systems is briefly discussed in Safety Guide 6 under Section 1.3.3.6 and is shown in Figure 8.5-1 and 8.5-2. These are summarized below:

1. The electrical power loads for engineered safety features are separated into redundant load groups fed from separate buses such that loss of one group will not prevent operation of minimum safety functions.

2. The redundant power loads are each connected to buses which may have power fed from an offsite power source or an emergency power source (usually a diesel generator).

3. Four 125 V DC systems, each complete with batteries, chargers, switchgear, and distribution equipment are provided for engineered safety features equipment. These systems are not tied together.

4. A standby source of power for one redundant load cannot be automatically paralleled with the standby source of power for the other redundant load.

5. Each redundant a-c engineered safety feature load is supplied with power from a separate emergency diesel generator.

The physical arrangement of major pieces of emergency power system equipment is shown in Figures 1.2-1, 8.5-1, and 8.5-2.

The criteria and bases for the installation of electrical cables are given in Beaver Valley (BVPS-1) Specification BVS-3001, "Criteria for Installation and Identification of Electrical Cables". This document controls the design and installation of all cable and raceway systems. Field quality control inspections ensure compliance with this document.

All cables pertaining to reactor protection and engineered safety features equipment are installed so that redundant circuits are separated and readily identified. The redundant safety-related cables are always routed in separate raceways. In addition, the redundant cables are electrically isolated and physically separated. Physical separation is achieved by following different routes on opposite sides of masonry walls where provided. Where cables must be routed in the same area, separation is obtained by using:

1. Separate exposed or concealed metal conduit. Exposed conduit carrying nuclear instrumentation system cable for neutron detection generally have redundant channels separated by a minimum of two feet where running parallel to each other except where they are converging to termination points.

2. Separate concrete encased plastic or fiber ducts in the same bank.

3. Separate adjacent cable trays with a minimum horizontal separation of three inches between side rails and with solid metal covers.

4. Separate cable trays with a minimum vertical separation of eight inches center to center and with solid metal covers on all trays, except for a top tray which is directly under a poured concrete floor.

5. Separate exposed redundant cables with the use of protective wrap.

Exposed or concealed metallic conduit and concrete encased ducts are considered solid enclosed raceways and qualify as barriers.

Physical separation of redundant cables in the containment penetration area is obtained by using two groups of electrical penetrations separated by a concrete wall. In the cable tunnel, a wall is provided for separation of redundant cables and cable trays are provided with solid covers.

Cables to equipment in the control room are routed through floor sleeves and floor openings from the cable spreading area below. Redundant circuits are kept separate by routing through separate sleeves or using barriers or separate conduits.

Safety related trays running in missile producing areas are installed so as to minimize or eliminate the possibility of damage from potential missiles.

Separation between redundant safeguards wiring and components in control boards, panels, and relay racks, other than those in the supply of the nuclear steam system supplier, is by means of a fire retardant barrier or a maintained air space of one inch minimum as defined in BVS-3001.

To ensure that redundant instrument channels associated with the solid state protection systems are isolated from each other and this separation is easily identified, a color coding system has been used. Channels I, II, III, and IV are color coded red, white, blue, and yellow, respectively. This channel identity need only be maintained until some channel terminating device is used. This device may be an isolating transformer or an electromagnetic relay. These channel codings are generally applied to inputs from primary and secondary process systems which are ultimately fed to the solid state protection systems. Redundant sources of power for primary process and engineered safety features, protective equipment and associated controls are identified as A and B with orange and purple color coding. Where circuits may be supplied from either A or B source, they are designated by C and color coded green.

In most cases redundant power, control, and instrumentation cables are grouped, separated and identified with a permanent type tag attached to each end of each cable. To assist further in the identification, all safety-related cables will have the appropriate color markings at intervals along its length. In no case is a safety related cable of one color code placed in the same conduit or cable tray with a cable of a different color. A non-safety related cable may run in a raceway with a safety related cable, but once associated with one train or channel, it cannot run in a raceway assigned to another train or channel.

Raceway color identification is also indicated at the end of the raceway limits, where raceway passes through a wall or sleeve, and at intervals of 50 ft maximum. The color identification consists of colored triangular decals. Each raceway also has a decal with its identification number on it. These numbers contain a color code.

When two spare source range detectors were added, portions of NIS raceways inside containment that contain cable for the detectors were not relabeled in accordance with the above described identification scheme. However, cables associated with each of the spare source range detectors were relabeled and are contained in separate conduits which extend from the keyway area to the containment penetration. The conduits, however, have only been relabeled at both ends and where easily accessible. Since NIS circuits must be in separate raceways from other circuits to avoid undesirable noise, no problems are anticipated in determining spare source range channel identity. In the keyway area, the exposed cables of redundant channels are 90° to 180° apart around the neutron shield tank.

The numbering system for cables and raceways for BVPS-1 commence with the numeral "1". For BVPS-2, the numbers commence with the numeral "2". Equipment numbers for BVPS-2 contain a distinguishable numeral "2", whereas, BVPS-1 equipment does not.

Power cables are sized in accordance with "Power Cable Ampacities," published by the Insulated Power Cable Engineers Association (IPCEA)or manufacturer's data. Sizes are based on 100 percent load factor, 90°C conductor temperature, and at the worst ambient temperature in which the cable is installed. Ampacities of power cable in tray are derated for cable installation one layer deep and six cables across with maintained horizontal spacing. Those cables which are run within the containment are qualified to perform their intended function under the worst possible environmental conditions. All cable in trays is flame retardant and has passed flame tests or has been determined to be adequate for the hazard in accordance with NRC Generic Letter 86-10.

Power cable run in tray is installed in one layer with an average centerline to centerline spacing of not less than 1.25 times cable diameter. When it is impractical to maintain specified horizontal spacing, cables are further derated in accordance with IPCEA.

Power cables run in trays without maintained spacing and in random layers are derated in accordance with IPCEA P-46-426 or ICEA P-54-440.

All cables in trays are installed according to their level of service.

During the construction stage, the following criteria was applied to electrical cabling:

> All cables, with the exception of 500 MCM conductors, triaxial, and coaxial cables associated with neutron detectors and radiation monitoring, are terminated at terminal blocks located on either side of the containment wall at terminal cabinets. Continuity from one terminal cabinet to the other is obtained by passing the cable through the containment wall by means of electrical penetrations, which contain double pressure barrier seals and which are tested in accordance with IEEE Std. 317-1972.[3]
>
> Triaxial and coaxial cables are terminated at the containment electrical penetrations by means of connectors, which are tested.
>
> The 5 kv Kerite power cables and large 480 V feeders are spliced at the containment electrical penetrations. The splices are made at the cable vault area outside containment and also just inside the containment at the penetrations. The 5 kv Kerite power cables are spliced with kits ordered directly from the supplier of the cable and have been tested to be compatible with environmental conditions associated with their location. The 600 V Okonite power cables are spliced using materials furnished by the supplier of the 600 V cable and which are compatible with environmental conditions associated with their location.
>
> The cable splicing was performed in accordance with written instructions and all safety related terminations were inspected. A record was kept of all cable splices and has become part of the Quality Assurance file.
>
> With the exception of the splices noted above, no splicing was done in the cable trays at the time of the original installation.

Any subsequent splices or modifications to this cabling will be installed in accordance with approved procedures to minimize the possibility of fires and to meet environmental qualification requirements.

8.5.2 A-C Emergency Power System

The AC emergency power system includes power supplies, a distribution system, and load groups arranged to provide AC power to Class 1E loads.

8.5.2.1 Emergency Diesel Generators

The system has two 4,160 V, three phase, 60 Hz diesel-driven synchronous generators, as shown in Figure 8.1-1. The two generator sets are electrically and physically isolated from each other. The diesel generators are supplied by Bruce GM Diesel and were identical with those furnished to James A. Fitzpatrick, Maine Yankee, Connecticut Yankee, Surry 1 and 2, Monticello and Brown's Ferry Nuclear Power Stations (at the time of BVPS-1 operating license issuance).

Each emergency diesel generator is selected and sized in accordance with Regulatory Guide 1.9 (formerly Safety Guide 9) as described in Section 1.3.3.9, and is rated as follows:

2,600 kW - 8,760 hr/yr (continuous)

2,850 kW - 2,000 hr/yr

2,950 kW - 168 hr/yr

3,050 kW - 1/2 hr/yr

In sizing the emergency diesel generators, a complete analysis of the engineered safety features loads, including their required time of operation, length of time required and the required running load, was performed. A reanalysis was performed to better define the loads and re-evaluate the maximum loading of diesel generator No. 1. The EDG loading analysis is part of the electrical calculation program which evaluates the impact of load changes.

The diesel generator loading sequences are designed to pick up loads in steps with adequate intervals between steps to permit inrush currents to subside prior to starting the next block of loads. The diesel generators use a stepped loading sequence to assure starting of emergency bus motors during required accident conditions. The time intervals between successive steps has been selected to assure full voltage output prior to the next successive load step. An emergency diesel generator transient analysis was done to evaluate the capability of each emergency diesel generator to accelerate and continue to operate major emergency loads during sequential loading. This analysis is a part of the electrical calculation program that will evaluate the impact of any changes to emergency diesel generator loading.

To ensure that power to the emergency diesel generator load sequence control circuits is not lost when: the 120 V AC vital bus inverter is out of service and bypassed with the 480/120 V vital bus alternate transformer; offsite power is not available; and the generator has started to provide power to the 4,160 V and 480 V emergency bus loads, the source of power will be supplied through two breakers that do not have undervoltage protection. Therefore, when the emergency diesel generator starts, and its output breaker has closed, there will be power available to operate the load sequencer through the entire program.

Each diesel generator is up to speed and capable of accepting loads within ten seconds and energizes designated loads in a stepped sequence within an additional 60 seconds.

Each diesel generator is capable of powering the engineered safety features equipment required (Section 6) following a Design Basis Accident (DBA) as defined in Section 14.3. In the operational mode following a DBA, the inherent capability of each generator unit provides step load starting surge currents and final steady state load carrying margins of at least ten percent above the demand requirements. The diesel generator loads do not exceed the smaller of the 2,000 hour rating (2,850 kW) or 90 percent of the 30 minute rating (0.9 x 3,050 kW = 2,745 kW). Because of the inherent overload capability of the emergency diesel generators and because the maximum connected starting load is a fixed quantity, no additional capacity margin is required in addition to the conservatism included in the determination of loads and hence, any criteria for additional capacity margin are arbitrary. It is therefore concluded that the step load sequence of the diesel generators meets the intent of Regulatory Guide 1.9.[4]

The emergency diesel generators are periodically inspected in accordance with a licensee controlled maintenance program. The emergency diesel generator maintenance program specifies required inspections based on the manufacturer's and Diesel Generator Owners Group recommendations and industry operating experience. Changes to the emergency diesel generator maintenance program are controlled under 10 CFR 50.59 as it currently applies.

8.5.2.2 Diesel Generator Starting Reliability

The diesel generator set is capable of starting and accepting loads with a 0.99 reliability at the 95 percent confidence level. A diesel generator target reliability of 97.5 percent has been designated in accordance with the NUMARC 87-00 document entitled "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors".(8,9) NUMARC 87-00 has been endorsed by the NRC as an acceptable means of satisfying the Station Blackout Rule - 10 CFR 50.63. If diesel generator performance falls below the target reliability level specified, actions will be taken to restore the target reliability level in accordance with guidance contained in Appendix D of the NUMARC 87-00 document. Furthermore, the diesel generator is designed for nuclear power plant service and has included in its system certain redundant subsystems and highly reliable components.

The diesel generator sets were given a 100 start test at the factory. If any two failures had occurred, the test would have to begin again. However, only one failure to start occurred on the first attempt for the first diesel generator set due to a pinion abutment, and no failures occurred on the first attempt for the second diesel generator set.

Preoperational tests involved fast start and accepting loads per the diesel loading sequence described above. Also, at least once a month, one set will be started manually, synchronized with the system, and run for a period of time in accordance with plant technical specifications.

It is concluded that the diesel generators will start and accept loads based on design for nuclear service and load data given to the vendor. The diesel generator sets have been tested at the factory to demonstrate the 99 percent reliability as described above and further to start and accept continuous load and 1/2 hr load rating.

To ensure electrical starting system integrity, the diesel generators are periodically started and exercised in accordance with IEEE Std. 308-1971.(2) (Refer to Table 8.6-1).

8.5.2.3 Diesel Generator Auxiliary Systems

To assure fast, reliable starting and reliable operation, the diesel generators are equipped with certain redundant subsystems and auxiliary equipment. To maintain a high starting reliability, the emergency diesel generators are equipped with 15 kW immersion heaters which supply heat to the engine cooling water when the diesel engines are shut down. Heated water is circulated by thermosiphonic action. Lubricating oil is heated between 125 and 155°F by the flow of this hot water passing through the oil cooler. The warmed oil is circulated through the engine and turbocharger by the lube oil circulating pump and the soak back oil pump and is then returned to the engine oil sump. A lube oil temperature switch will sound an alarm and light an indicator on the engine control cabinet if the oil temperature drops to 115°F.

Each emergency diesel is provided with a starting system sized for five generator starts without outside power. The air dryers for each emergency diesel generator air compressor ensure the reliability of the emergency diesel generator air start system.

Each emergency diesel generator has a fuel oil system, a discussion of which can be found in Section 9.14. The two fuel oil storage tanks are sized for approximately seven days full load operation of one diesel generator. The tanks are buried and covered with a two foot thick concrete slab for missile protection. The fuel oil piping outside the diesel generator building is also buried and covered with a two foot thick concrete slab for missile protection. In addition, the lines from each tank are separated from one another by a concrete partition. Two motor-driven fuel oil transfer pumps (one standby) are available for each diesel engine.

All electrical auxiliary pumps and motors associated with the safety related function of the emergency diesel generators are fed from the emergency buses.

Each emergency diesel generator is provided with two 750 watt strip heaters located below the diesel generator windings. The heaters keep the windings free of moisture when the diesel generator is not in service. The heaters are powered from a non-safety related bus.

8.5.2.4 Diesel Generator Building

The emergency diesel generators are located in a building designed to withstand earthquakes and to protect the diesel generators against tornadoes, hurricanes, flying missiles, flooding, etc. Within the protected building, the emergency diesel generators, including associated starting equipment and other auxiliaries, are completely isolated from one another by means of a reinforced concrete wall. Cooling water piping to the A diesel generator heat exchanger EE-E-1A passes through the B diesel generator room. This cooling water piping is designed to withstand a failure of the diesel generator and other auxiliaries which may result in a missile impact to the piping system. Each unit is provided with a separate missile protected air intake, air discharge, and engine exhaust. All equipment inside the diesel generator building is Seismic Category I except the normally empty, non-pressurized CO_2 fire lines and roof drain line, and electric unit heaters. However, this equipment is seismically supported so that its failure will not cause failure of the Seismic Category I equipment.

The ambient air temperature in the diesel generator building is maintained at a minimum of 65°F by electric space heaters. The temperature and air supply in the diesel generator building is controlled by four dampers located above the access door to each diesel compartment. The control of the damper operator is achieved through the room thermostats controlling the fan. A rise in space temperature above the thermostat setpoint will cause the damper to open when the fan starts, and conversely, a fall in space temperature will cause the damper to close when the fan stops. Each of the four outdoor air intake dampers includes an emergency powered motor operator so that any single failure will not preclude the opening of the redundant damper, thus assuring that a combustible air supply is available for the diesel generator. The operation of the dampers is verified during periodic starting of the diesel engines to assure that they will operate properly as intended.

Since the Design Basis Accident (DBA) and loss of offsite power, assumed to occur at the same time, would result in a requirement for maximum reliability of the onsite power system, the CO_2 fire protection system serving the diesel generator rooms is automatically deactivated during a DBA to ensure maximum reliability of the onsite power system. Modifications have been made to the CO_2 fire protection system control circuits to preclude spurious CO_2 actuations due to postulated fire induced faults external to the diesel generator rooms.

The diesel generators are separated by a 12 inch thick reinforced concrete wall and two back-to-back doors that provide access between the diesel generator compartments. The wall and doors serve as a protective barrier between the diesel generators. The wall and doors have been analyzed for the accidents discussed below:

A Crankcase Explosion with the Crankcase Door Acting as a Missile

In the event of a crankcase explosion, the crankcase door may be dislodged and propelled toward the reinforced concrete wall, which is 12 ft away from the crankcase housing. In a preliminary calculation, it was calculated that a pressure of 215 psig was necessary to dislodge the crankcase door. The resulting nine pound missile will impact the wall at a velocity of 420 ft per second. Using the most conservative Ballistic Research Laboratory Missile Penetration formula (Ref. ORNL-NSIC-22), it was shown that the maximum penetration by the crankcase door missile is three inches. Therefore, the 12 inch reinforced concrete wall is adequate to terminate the flight of the crankcase door missile.

The normal operating pressure in the diesel engine crankcase for the emergency diesel generators is 2 to 7 inches H_20 vacuum with a 4 inch water vacuum average. The crankcases have been supplied with high pressure alarms with setpoints of 1 to 1.7 inches water gauge. According to the diesel generator manufacturer a pressure of 89 psig is required to blow off the crankcase door. Assuming no venting from the diesel generator compartment, the 121 cu ft of crankcase volume will vent into the 24,050 cu ft compartment volume without causing compartment pressure to reach 0.8 psig, the minimum pressure which could be considered to dislodge the compartment door. Thus the value of 215 psig used for the above calculation is extremely conservative.

The diesel generators are located so that crankcase door missiles will not be propelled toward the door separating the two diesel generator compartments.

Failure of One or All of the Air Bottles With Missile Generations from the Bottles

Failure of diesel generator starting air bottles is not considered credible. The air bottles contain air at 200 psig and are provided with three pressure controlling devices to prevent overpressurization. The bottle air supply line contains a pressure control, which is set at 200 psig. Also, each bottle is provided with an individual relief valve on the bottle. Finally, the main air supply to the bottles contains a relief valve. Thus, overpressurization of the air bottles will not occur.

A Diesel Oil Fire in One of the Two Compartments Involving Approximately 1,000 Gallons of Fuel Oil

The 12 inch reinforced concrete wall between the diesel generator compartments has a fire rating in excess of four hours as measured by the "Standard Fire Test" defined in report ASTM Std. E119-1981.[5]

The 3 by 7 foot doors between diesel generator compartments has a three hour fire rating as defined by ASTM Std. E152-1980.[6] The maximum rise in temperature on the exposed surface will be less than 250°F within 30 minutes of exposure.

A diesel oil fire would be extinguished by actuation of the CO_2 fire protection system within the time span required for structural deterioration of the reinforced concrete wall and labeled door.

To assure that the doors between the diesel generator compartments are closed to prevent a fire in one compartment from spreading to the other compartment, the status of the doors will be checked prior to and at the completion of the periodic test procedure for exercising the diesel generators.

A Potential Accident in One Compartment Transmitted to the Adjacent Compartment Through the Pipe Trench Which Passes Under the 12 inch Thick (Reinforced Concrete) Wall Which Separates the Two Compartments

The only ties between the two diesel generator systems through the pipe trench are fuel oil cross connections which run between the two diesel fuel oil pump suction and discharge pipelines. However, these lines contain two normally closed valves, one on each side of the concrete partition.

Loss of a fuel line on either side of the wall would not transmit the accident to the other side.

8.5.2.5 Seismic Considerations

The seismic considerations of the emergency diesel generators for BVPS-1 were similar to those for the James A. Fitzpatrick Nuclear Power Plant (PA SNY), (50-333) supplied by Bruce GM Diesel at the time of the issuance of the BVPS-1 operating license.

Review of the seismic analysis of critical components of diesel generator skid mounted system, prepared by Engineering Design Services Incorporated for Bruce GM Diesel, indicates that engine mounted components have a resonant frequency of well over 100 cps. Components on the accessory rack, however, including stiffening effects of piping have a frequency above 30 cps.

The following accelerations apply to the emergency diesel generator for BVPS-1:

g_1 = .09
g_2 = .11
g_3 = .16 Acceleration in ft/sec^2
g_4 = .19

The above accelerations are less than those used for qualifying the emergency diesel generator for the Fitzpatrick Plant, namely:

g_1 = .30
g_2 = .20
g_3 = .30 Acceleration in ft/sec^2
g_4 = .20

Moreover, the report includes the analysis of the anchorages for the following engine components:

1. Engine
2. Generator
3. Air-intake receivers
4. Accessory rack
5. Engine lube oil coolers
6. Engine lube oil filter
7. Water expansion tank
8. Governor
9. Primary oil pump
10. Scavenging oil filter
11. Scavenging pump
12. Heat Exchangers

The analysis shows that all anchorages are adequate for the expected loads and that very large safety factors exist for all components. Consequently, since the seismic accelerations applicable to the BVPS-1 emergency diesel generators (at the time of the issuing of the operating license) are less than those specified for the Fitzpatrick Plant, all anchorages for the engine components listed above for BVPS-1 emergency diesel generators are adequate for sustaining the corresponding expected loads.

The free standing emergency control panels for the diesel generators on BVPS-1 were similar in design to control panels provided by Electro-Motive Division of General Motors for the Brown's Ferry Nuclear Power Station of TVA. The seismic test report submitted for the Brown's Ferry Nuclear Power Station was reviewed and found acceptable for the requirements of BVPS-1. Sufficient similarity has been established between the tested electrical control panel and the equipment supplied to BVPS-1, so as to determine the applicability of the test report. Similarity between the control panels was established by a comparison of detailed design drawings of the tested panel with the panel installed at BVPS-1.

8.5.2.6 Single Failure Analysis

A failure mode analysis was performed to show that no single failure in the standby a-c power system and the auxiliaries such as fuel oil system, cooling water, starting air, combustion air and ventilation, and fire protection will result in the loss of more than one diesel generator set.

A failure of one a-c standby power system supplying power to one diesel generator's auxiliaries will not disable the other diesel generator set. The auxiliaries such as fuel oil transfer pumps, starting air compressors, and motor operated valves are fed from separate redundant circuits.

The diesel generator fuel oil system is designed to ensure that no single failure of any component will result in the loss of more than one diesel generator. Each diesel is furnished with two 100 percent capacity fuel oil transfer pumps which take suction from a seismic and flood protected fuel oil storage tank. There is a cross-connection between the discharge and suction headers for each set of transfer pumps. However, there are two normally closed gate valves that isolate each line so that the loss of any part or the whole of one fuel oil transfer system will not compromise the other fuel system which independently supplies oil to the other diesel.

Redundancy in the cooling water supply system is designed to permit the loss of cooling water to one diesel without losing cooling water from redundant supply headers to the other diesel.

The starting air systems are separate from each other. The loss of any one air system will affect only the diesel generator it serves.

Separate combustion air, ventilation, and fire protection systems are provided for each diesel generator set separated by a fire wall.

A single failure in any one system cannot result in the loss of more than one diesel generator set.

The Technical Specifications provide a limit for the maximum allowable time one emergency diesel generator can be unavailable for maintenance, tests, and repairs without the reactor being shut down.

8.5.2.7 Emergency Power Distribution System

Each emergency bus is continuously energized from the station service system or from emergency diesel generators, as shown in Figure 8.1-1. The automatic transfer from service system to emergency diesel generators, when required, is accomplished by automatically opening the normal source air circuit breakers (ACB). The emergency buses and the supply for all essential components are normally connected to the station service system. Two circuit breakers in series are provided in these supply circuits from the normal buses to the emergency buses.

The normal 4 kv bus 1A and 1D supply power to the safety related buses 1AE and 1DF through two separate circuits, each having two series connected air circuit breakers. Each 4 kv safety bus 1AE and 1DF is located in a separate area from each other and from the normal switchgear. Of the two series connected ACBs, one is located with the safety related bus and the other at the normal switchgear. The two series connected ACBs are thus located in two separate areas. Each series connected ACB receives a trip signal under loss of offsite power to the normal bus or on 90 percent undervoltage of motor nameplate voltage. Bus undervoltage relays are actually set above 90 percent to allow for undervoltage relay inaccuracy and voltage drop of the motor leads. The redundant breakers have independent trip circuits supplied by independent 125 V DC control power sources. Thus the emergency bus will be electrically separated from the offsite power source through the operation of one of the two physically separated series connected circuit breakers.

Class IE electrical equipment is protected from sustained undervoltage conditions of 90 percent or less of motor nameplate voltage while the 4,160 V emergency buses are supplied by normal (onsite or offsite) power. Bus undervoltage relays are actually set above 90 percent to account for undervoltage relay inaccuracy and voltage drop of the motor leads. Undervoltage relays will act to isolate the 4,160 V emergency buses from the normal 4,160 V buses, thereby isolating the emergency buses from the offsite source, if an undervoltage condition persists for more than 90 seconds. The 90 second time delay was chosen to prevent the relays from operating during normal transients due to starting of large motors on the normal 4,160 V bus. The relays are inoperative while the 4,160 V buses are supplied solely by the emergency diesel generators.

Electrical protection for the emergency diesel generators during normal testing and exercising is provided by differential, phase and ground current, loss of generator field, and distance relaying with fault protection. Additional protection is provided by an overspeed trip. Redundant relays are physically separated by masonry walls or metal barriers where applicable.

The emergency diesel generators can be manually started on a signal from the main control room or are automatically started on the receipt of a time delayed undervoltage signal from the emergency bus source, on a safety injection signal or on an opening of either series connected normal supply circuit breakers. Loss of voltage on the normal bus opens both the series connected normal supply circuit and closes the emergency source breaker when the generator voltage is established.

The emergency diesel generator field can be flashed manually from the control room if upon receipt of a fast start signal, the automatic field flash fails with the diesel output breaker in the open position.

A containment isolation phase B signal (Section 7), also trips the bus tie breaker that isolates the short bus section to which non-engineered safety feature pumps are connected so as to protect against an overload of the respective emergency diesel generator. Each emergency stub bus tie breaker receives the containment isolation phase B (CIB) signal from only one train. If the stub bus fails to trip on a CIB signal one of the following conditions would exist:

1. If a CIB signal occurs without a loss of power and the non-emergency bus does not trip, there would not be an overload on the diesel generators, since the normal 4 kv bus will supply the load.

2. If a CIB signal and loss of power occur simultaneously and the stub bus tie breaker fails to trip, the diesel may be overloaded and trip. However, on a single failure criteria, it can be assumed that the other diesel generator will permit a safe shutdown.

However, the diesel generator that may have tripped on overload can be restarted after a manual trip of the stub bus tie breaker or the other non-essential breakers on the stub bus are tripped.

Redundant power sources, circuit breakers, and relays are physically separated by masonry walls or metal barriers. Cabling is installed to preserve the independence of redundant circuits, as described in Section 7.2.

The same criteria apply to the circuits which shed the non- essential loads.

The independence between redundant standby (emergency) power sources and between their distribution systems is in accordance with AEC Safety Guide 6 as discussed in Section 1.3.3.6.

The emergency diesel generator and the normal station service are synchronized only for the following two conditions:

1. Periodic testing.

2. Return of the emergency bus to the normal station service supply following a loss of offsite power occurrence with subsequent restoration of offsite power.

This synchronizing is done manually and automatic synchronizing is not supplied.

All engineered safety feature equipment items are duplicated and connected to separate 4,160 V and 480 V emergency buses. (Refer to Figures 8.1-1 and 8.4-1 for the electrical one line diagrams.) All duplicated safety related equipment is connected to separate buses. If there is a third redundant piece of equipment, it is normally not connected to either emergency bus, but it can be manually connected to either one as described below.

Three 4 kv pump motors, each of which is a third redundant swing unit, (one charging pump, one river water pump, and one primary component cooling water pump) may be supplied from either 4 kv bus (Figure 8.1-1). Dual feeds for these pumps do not form a bus tie because only one of the two breaker cubicles will have a circuit breaker installed at any time. The second redundant 4 kv cubicle of a 4 kv motor will have no circuit breaker installed.

A mechanical key interlock system shown in Figure 8.5-8, is provided to ensure that only one circuit breaker for the dual feed motor can be put into the operating position at one time.

Two 480 V motor circuits, each of which is a third redundant swing unit (one shroud fan motor and one containment air recirculation fan) may be supplied from either 480 V bus (Figure 8.1-1). Each 480 V ACB cubicle is occupied by an ACB unless a breaker is out for maintenance, repair or temporarily used in another location. The load side of each of these ACB on a dual fed circuit is connected to a three pole double throw switch provided and connected as shown in Figure 8.1-1. Because of the three pole double throw switch, the dual feeds for either of these circuits can not form a bus tie. Only one of the two breakers is in the operating position at a given time. The breaker which is not required to operate is locked in the disconnect position (breaker insertion is mechanically prohibited).

Selection of the operating breaker on a third redundant swing unit depends on station requirements and is under administrative control. This arrangement of dual feed, third redundant units, allows maintenance to be performed on any of the units while satisfying single failure criteria.

If any engineered safety features equipment fails to operate automatically, remote manual operation is possible from the main control room. The switchgear sections for each emergency diesel generator are physically and electrically isolated from each other as shown on Figure 8.5-1.

If the loss of normal power is not accompanied by a loss-of- coolant accident, the engineered safety features equipment is not required. Under this condition, other unit auxiliary equipment (e.g., primary component cooling water pump, residual heat removal pump, etc.), may be operated up to the capacity of the emergency diesel generators. Instrumentation is provided to indicate diesel generator loading.

Each piece of engineered safety features equipment is connected to the emergency power with an exclusive circuit. Each circuit has an air switchgear circuit breaker with overcurrent protection, and a control switch with red and white indicating lights mounted in the main control room. The red light shows that the power circuit is energized, the trip coil continuity is monitored, and control power is available. The white light is dimly lit when the power circuit is de-energized and monitors the availability of control power. A bright white light indicates an automatic trip of a feeder or source circuit. Major items have ammeters to indicate running current. Isolation of a failed circuit is automatic and is identified by the indicating lights in the main control room. All automatic tripping functions energize an audible signal to alert the control room operator. Individual protective relays have signal targets to indicate that automatic operation has taken place.

All three-phase power connections are permanent in nature. No temporary connections or jumpers are used during power operation. Once a connection has been made, the phase rotation and direction of motor rotation are fixed. Power connections and phase rotation are rechecked following any major maintenance or repairs which require disconnecting the power leads. If the normal power supply to the emergency bus should be accidentally reversed, this would be immediately detected by those motors that are fed from the emergency bus and which operate continuously. For further protection, a reverse phase relay, which operates an annunciator in the main control room, is connected to each emergency bus.

The voltage level and current loading of all principal station distribution buses are displayed in the main control room. The status of the switchyard breakers and the source of 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 preferred source as discussed below.

The 4 kv buses may be supplied power by either the system station service transformers or unit station service transformers at the selection of the operator, as stated in Section 8.4. Bus transfer is accomplished by the use of two separate 4 kv ACBs control switches, one for each source, and a live transfer selector switch. The live transfer selector switch permits closing both supply ACBs through their own control switches during normal startup or shutdown procedures. When both ACBs are closed, an alarm is initiated.

Arrangement for automatic transfer is accomplished by tripping the ACB for the alternate source, turning the live transfer selector switch to the "Off" position, and then closing the alternate source ACB control switch. This switch is spring-returned to neutral. When returned to neutral after "Close" and with the live transfer switch in "Off", the 4 kv bus is set up for an automatic transfer on loss of power to the bus for reasons other than bus overcurrent.

The initiating contact for an automatic transfer is an auxiliary contact on the preferred source ACB. This ensures that the preferred source is tripping prior to closing the alternate source ACB. A more detailed discussion of the automatic transfer scheme can be found in Reference 1.

The emergency diesel-generator rooms contain instruments and controls to serve the emergency buses. Provision is made in the main control room for synchronizing the emergency diesel generator manually with the normal station service power systems. The emergency diesel generator may be manually loaded in parallel with the normal source of power for periodic load tests.

Emergency 4 kv switchgear is located in a protected control area as shown on Figure 8.5-1. The status of the 4 kv emergency power bus can be determined in the main control room and at the emergency switchgear. Emergency distribution air circuit breakers can be controlled at the switchgear.

All 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 may consist of painted stencils or marked tags, etc., applied or attached to each component to enable an operator, maintenance man etc., to easily identify equipment throughout the plant. Color coding is also applied as previously discussed.

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

All 138 kv equipment associated with the electrical feeds to the emergency buses is outdoor-type, with control equipment enclosed in metal housing and protected from the weather. These enclosures are equipped with thermostatically controlled electric heaters. The 4,160 V and 480 V switchgear are located in a protected area with heating and ventilation. Redundant safety related switchgear is located in physically separated areas.

Each emergency power system was installed and checked out several months prior to criticality. The initial installation was tested and operated, and the starting speed and loading ability is demonstrated before being accepted by the Applicant. After acceptance, the emergency power system is operated on a routine test schedule. The routine operation for several months prior to criticality was intended to identify and correct minor deficiencies in order to achieve a mature system. Section 8.6 describes the test and inspection procedure.

8.5.2.8 Electric Heat Trace

Many of the lines and valves required for containment isolation or engineered safety features operation are located in heated areas, and are not subject to freezing or boric acid precipitation. Lines or valves which are subject to freezing or boric acid precipitation are electrically heat traced and insulated or the immediate areas are provided with adequate local heating.

Vital lines, such as those which contain boric acid solution which may not be in heated areas, are traced by two circuits. Each of these circuits are 100 percent capacity with one designated as the normal circuit and one as standby. On any vital line that has redundant heat tracing, one circuit is connected to one emergency bus, and the second circuit is connected to the second emergency bus. In the event of a loss of power, each emergency bus is supplied by its own emergency diesel generator, thereby providing separate power sources to each heat trace circuit on each vital line.

On all other lines which are not located in an adequately heated area and are subject to freezing, a single heat tracing circuit, which is supplied from the normal buses is provided.

An alarm is provided in the main control room as an indication of an abnormal condition on the heat tracing system.

8.5.3 125 V D-C Power System

The 125 V DC power system includes power supplies, a distribution system, and load groups arranged to provide direct current electric power to the Class 1E direct current loads and for control and switching of Class 1E systems, as required by IEEE Std. 308-1971[(2)] and described below.

The present Category I batteries have been upgraded to be in accordance with IEEE 535-1979, "Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations".

The 125 V DC batteries supply power for operation of turbine generator emergency auxiliaries, switchgear, vital bus inverters, and emergency lighting, and are shown in Figure 8.4-1 and 8.4-2. The principal equipment items in this system are five sets of, lead-acid batteries, five static battery chargers and five battery distribution switchboards.

The 125 V DC power system consists of five stationary batteries, four of which are used to supply emergency power to safety related loads. The fifth battery is not, and cannot, be used to supply power to any safety related loads. This battery is the power source for the 60 hp DC bearing oil pumping motor and emergency DC lighting. Any loads that may be transferred to this battery are non-safety related loads.

The batteries are central power station type and are designed for continuous duty. Battery No. 1 and No. 2 consists of 60 cells connected in series. Battery No. 3 and No. 4 consists of 59 cells connected in series. Battery No. 5 consists of two series connected strings of 59 cells each, connected in parallel. 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 steel racks for security and to facilitate maintenance.

The batteries are located in a protected area provided for electrical equipment as shown in Figure 8.5-1 and 8.5-2. Within this protected area, the batteries are located in two areas separated by masonry walls. This will permit isolation of the 125 V DC power for the two trains. In the same area with each battery are the associated distribution switchboard, battery charger, and vital bus. Adequate physical separation exists between redundant components, as shown, to prevent common mode failure.

The battery room ventilation system includes two 100 percent redundant exhaust fans powered from the emergency buses. The fans exhaust four battery rooms and the two emergency switchgear rooms through a common exhaust duct discharging to outdoor atmosphere. Each battery room and switchgear room exhaust register includes a fire damper to preclude the transfer of fire from any one room. The fans and ductwork system are seismically designed and protected from missiles and flooding. Each battery room is provided with a heat detector that annunciates in the control room. Any fire that might occur in the emergency switchgear rooms would be in the nature of smoldering cables which would be annunciated in the control room by redundant photoelectric-type smoke detectors. It is inconceivable that any single fire or other design basis event could occur that would impair the operation of the common ductwork system to an extent that would result in a total loss of the onsite d-c power system.

Each of the four safety-related batteries are located in a separate battery room as shown in Figures 8.5-1 and 8.5-2. The enclosure walls are seismically designed. The battery rooms are isolated to prevent the ignition of explosive mixtures of hydrogen and oxygen given off by the batteries, by the switchgear or by other means of ignition in the switchgear room. To prevent the buildup of explosive mixtures of hydrogen and oxygen, each battery room has been provided with redundant emergency powered ventilation equipment. The ventilation system exhausts each of the four battery rooms that are isolated individually by fire dampers. The ventilation system ensures that each battery room is continuously ventilated at a rate of at least 20 air changes per hour and maintained at a slightly negative pressure, thereby preventing the buildup of an explosive hydrogen mixture.

Two batteries are used for redundant solid state loads and miscellaneous loads; each of the other two batteries supply power to each train of safety related equipment and redundant power loads, such as motors, switchgear control, solenoids, etc. However, each vital bus inverter is connected to a separate battery. The battery bus sections which supply power to safety related equipment are operated independently. Each charger supplies power for operation of equipment connected to that bus section and maintains a floating charge on its associated battery.

The fifth battery may be operated at no-load or to carry loads which are not safety related and which can be transferred to it. The battery Number 5 switchboard transfer breakers are mechanically interlocked so that both breakers must be open prior to closing an associated breaker.

Each battery Number 5 switchboard bus transfer switch consists of two ITE Type JL breakers that are mounted end to end horizontally. The normally closed position of each breaker is in the same direction as its associated breaker. A steel bar interlock is placed between the operating levers of the associated breakers in a manner that requires the opening of both breakers prior to closing one breaker. Both associated breakers cannot be closed at the same time. Thus there is no way to interconnect redundant d-c power systems.

When a ground develops on a DC circuit, loads that can be transferred are transferred to the fifth battery while the ground is being corrected.

Each of the five static battery chargers are supplied by 480 V emergency unit substation 1-8 or 1-9, as shown in Figure 8.4-1, through a 480 V circuit breaker. These supply breakers can be manually operated at the breaker. Chargers which supply redundant "train" loads are not fed from the same emergency unit substation and thus have a separate supply.

In the event that one of the permanently installed safety-related battery chargers is out of service, a fully-qualified spare battery charger may be substituted. Spare battery chargers that are not permanently installed, must be designed and installed in a manner to ensure compliance with applicable battery charger design requirements.

Each 125 V DC charger is equipped with indicating meters and alarm devices. Output voltage, output current and breaker position are monitored. Each battery charger is sized to adequately furnish the required energy to all steady state loads which normally operate, with the exception of the vital bus inverters, while restoring the battery from the design minimum charge to its fully charged state.

The vital buses normally receive power from the inverters through a rectifier AC supply and the battery and charger are not required under this condition. The battery will supply the vital bus inverters on loss of AC power.

During normal operation, the 125 V DC load is fed from the battery chargers, with the batteries floating on the system. Upon loss of unit AC power, the entire DC load draws from the batteries. The power load imposed on each battery is initially high due to short time loads such as valve operations. After the turbine generator has coasted to a stop, the DC emergency oil and air side seal oil backup pump motors, rated 60 Hp and 30 Hp, respectively, if in use, may be stopped after dumping the generator hydrogen or upon startup of the AC pump motors. This removes a motor load of approximately 60 Hp from a battery. The remaining load which includes safety related items consists primarily of emergency electrically operated valves, emergency lighting, and vital bus inverters. The batteries are sized to provide power to all essential DC loads for a period of two hours without any source of external power. Batteries are sized conservatively using an operating ambient temperature of 50°F and final cell voltage of 1.84 V (60 cells)/1.864 V (59 cells) as a basis for meeting load requirements. This results in batteries of a larger capacity based on standard conditions of 77°F and 1.75 V so that when the batteries are derated for the specified conditions (system voltage drops, etc.) they will still meet the load requirements. The resulting higher voltages at the end of the design duty cycle (110.4 V and 110 V) assures that the DC equipment has adequate voltage at the terminals of the equipment.

Consequently, the acceptance tests run on the batteries is based on the larger ampere hour capacity using 1.84 V (60 cells) or 1.864 V (59 cells) as a final voltage.

The batteries are sized in accordance with IEEE 485-1983, "Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations", and the assumptions used are summarized below:

1. A loss of 480 V AC; i.e., no battery charger operation
2. A minimum of a two-hour duty cycle
3. Table 8.5-4 lists the sizing criteria for the four safety related batteries and battery number 5.

If a single failure is considered, it is unlikely that the ambient temperature would be reduced to 50°F. The battery operating time will be increased if the ambient temperature is 77°F or greater. A single failure analysis is presented in Table 8.5-3.

Batteries have been sized using a conservative estimate of the worst possible load condition which might exist during the time in which the batteries are required. An electrical calculation program is in place to monitor battery load additions and deletions and to periodically update the battery calculations. A new battery duty cycle shall be calculated for each load addition unless the loads being added are encompassed by the design margin calculation. This program ensures the capacity of the batteries continues to be adequate to power the prescribed loads. Jumpering cells out of the battery sets may be allowed provided an engineering evaluation or calculation is performed to show that the battery still would have the capacity for the two hour duty cycle and maintain the required minimum voltage at the loads.

The battery distribution system is a 125 V DC, two wire ungrounded system consisting of the following:

1. Metal enclosed battery breaker switchgear

2. Battery breaker switchboards with two-pole molded case air circuit breakers

3. Battery distribution panels with molded case air circuit breakers with alarm circuit contacts.

4. Associated cable.

Each of the battery switchboards, 1 through 5, supplies cables which feed large individual DC loads such as the vital bus inverters and emergency lighting, in addition to supplying power to the battery distribution panels.

Each battery distribution panel supplies power for breaker control and other small loads. Each distribution panel branch circuit is protected by a molded case air circuit breaker where a breaker trip provides annunciation in the main control room.

Cables which feed DC panels, switchboards and individual devices are rated 90°C and a minimum insulation rating of 600 V.

Each distribution circuit is capable of transmitting sufficient energy to start and operate all required loads in that circuit. Each distribution circuit which feeds redundant equipment is independent of each other.

During power operation, the unit batteries are periodically checked for specific gravity and individual cell voltages. An equalizing (overvoltage) charge, if required for the cells, is applied long enough to bring all cells up to an equal voltage. Over a period of time, these tests reveal a weak or weakening trend in any cell and replacements are made when necessary. A disconnected battery or a broken cell connector is revealed during these equalizing charges. Periodically, the battery charger is disconnected, and the ability of the battery to maintain voltage and assume the d-c load is verified.

This test uncovers any high-resistance connections or cell internal malfunctions.

The testing and inspection of the 125 V DC system is described in Section 8.6.

8.5.4 120 V AC Vital Bus System

A 120 V AC vital bus system is provided in accordance with IEEE Std. 308-1971,[(2)] as described below.

The 120 V AC vital buses for engineered safeguard protection channels are supplied by four single phase inverters, as shown in Figure 8.4-1. One inverter is connected to each of four station batteries, such that loss of any one source affects only one vital bus. The inverter output is regulated automatically at 124 ± 2.48 V and 60 ± 0.3 Hz.

The vital bus system for the engineered safeguards protection channels is a very reliable electrical system with four redundant sources, each with independent conversion equipment. It provides a stable supply to vital equipment and guarantees proper action when power is required, while eliminating shutdowns from spurious signals.

During normal operation the 120 V AC vital buses are supplied from the 480 v emergency unit substations 1-8 or 1-9 through a rectifier, static switch, and a vital bus inverter with the battery floating.

In the event that the inverter fails, an alternate source of power from the 480 V emergency unit substation through a 480 V - 120 V line voltage regulator is provided as a bypass. At the time of failure a solid state static switch will transfer the vital bus loads from the inverter to the alternate source within one cycle of AC power. As a result an inverter failure will have no noticeable effect on bus loads. If all sources of AC power are unavailable or if transient voltages arise, the 125 V DC station battery assumes the vital bus inverter load. This transfer of power sources takes place without disturbing the vital bus voltage or frequency.

The 120 V AC vital bus system consists of four completely independent subsystems. There is no way, assuming single failure or error, to interconnect the two vital buses of either trains, namely, vital bus 1 or 3 of the orange train, or vital bus 2 or 4 of the purple train. Also, all elements of the purple train are completely isolated physically and electrically from elements of the orange train. The failure of any one vital bus will not cause the protection system to become inoperative.

Since the orange and purple trains, are, for all practical purposes, identical and redundant, this discussion will be limited to the orange train, with the exception of equipment designation. A hard fault on either bus 1 or bus 3 would not affect the other bus. Therefore, three out of four channels of the primary and secondary process protection systems would remain operative. An internal inverter failure would cause a transfer of the static switch with no affect on the vital bus loads. The static switch is a highly reliable device providing the actual power switching function. The static switch logic monitors the inverter voltage, inverter current, and alternate line regulator voltage.

If the inverter voltage or current deviates past specified limits, the static switch transfers to the alternate line regulator. The static switch logic is powered from three different sources through three different power supplies: 1) the inverter output, 2) the alternate line regulator, and 3) the 125 V DC battery bus. If any two sources or power supplies fail, the one remaining source can properly power the static switch logic.

The inverter input has two sources of power available; a station battery and the output of a rectifier which receives its source from the 480 V emergency motor control center 1-E9. The normal source of power for the inverter is the rectifier. This rectifier ensures that the inverter input is always supplied by the rectifier and not from the station battery under normal operation. If the rectifier should fail or the 480 V AC input to the rectifier should fail, the inverter input power will automatically be derived from the station battery by way of a blocking diode. If it is assumed that the loss of the 480 V AC input is due to the failure of the 480 V AC substation 1-8, then the battery can supply power for the inverter operation for a minimum of two hours. A single failure analysis for the 120 V AC and 125 V DC vital power supplies is presented in Table 8.5-3.

The output of each inverter/static switch is connected to a distribution cabinet through a normally closed air circuit breaker.

The distribution cabinets in general have 15 and 20 amp branch circuit breakers to feed reactor protection and other vital instrument channels. Most reactor protective schemes have three or four channels. Redundant instrument channels are fed from redundant vital buses.

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 vital bus rectifiers, static switches and inverters 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 systems. Magnetic amplifiers, transistors and silicon rectifiers are used to provide trouble-free operation.

References for Section 8.5

1. "Safety-Related Schematic Diagrams", Duquesne Light Company Topical Reports DLC-TR-1001 and DLC-TR-1002 (Proprietary).

2. "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations", IEEE Std. 308-1971, The Institute of Electrical and Electronic Engineers, Inc.

3. "Electrical Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations", IEEE Std. 317-1972, The Institute of Electrical and Electronic Engineers, Inc.

4. "Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants", Regulatory Guide 1.9, U.S. Nuclear Regulatory Commission (December 1979).

5. "Fire Test of Building Construction and Materials", ASTM Std. EI19-1981, American Society for Testing and Materials.

6. "Fire Tests of Door Assemblies", ASTM Std. 157-1980, American Society for Testing and Materials.

7. Deleted by Revision 21.

8. Letter from J. D. Sieber (Duquesne Light Company) to the Nuclear Regulatory Commission, Subject: Response to Station Blackout Rule - 10 CFR 50.63. (ND3NSM:3893, Dated April 4, 1989)

9. Letter from J. D. Sieber (Duquesne Light Company) to the Nuclear Regulatory Commission, Subject: Supplemental Response to Station Blackout Rule 10 CFR 50.63. (ND1NSM:4451, Dated March 30, 1990).

8.6 TESTS AND INSPECTIONS

8.6.1 General

All electrical equipment and components supplying power to emergency systems are subjected to a series of preoperational, initial, and inservice tests and inspections to ensure that the following conditions are met:

1. All materials and equipment received at the jobsite are identified in accordance with the latest "approved for construction" drawings, specifications, etc.

2. All materials and/or equipment are not physically damaged upon arrival at the jobsite and no damage incurred during or after construction.

3. All components are operational and correct.

4. All circuits are correct and continuous.

5. All equipment operates within design limits and can meet its performance specifications.

6. No components or systems are deteriorating toward an unacceptable condition.

7. Standby electrical equipment that is not exercised during normal operation is operable.

IEEE Std. 308-1971[l] and IEEE Std. 336-1971[2] are used as guides in developing these tests and inspection procedures.

8.6.2 Tests and Inspections Prior to and During Construction

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

A series of tests and inspection are performed on electrical equipment at the manufacturers' factory prior to shipment to BVPS-1.

In particular, the emergency diesel generators were tested and inspected to ensure that all systems and circuits functioned. All control circuits, alarms, instrumentation, and auxiliary motors are tested. Mechanical equipment and piping are inspected to ensure correctness of design and fabrication. A complete control sequence test is performed and each diesel is subjected to a load run and reliability proof test to ensure that this equipment can start and accept load as required.

Other electrical equipment such as switchgear, motors, batteries, chargers, and uninterruptable power supplies, panels, associated systems, etc., are tested prior to shipment in accordance with applicable standards and codes to ensure their adequacy, operability, and quality of workmanship.

In addition, an inspection of electrical equipment in the manufacturer's factory was performed by a representative of the architect engineer to verify that equipment is in accordance with its specification, approved for construction drawing, applicable codes and standards and has been properly prepared for shipment.

Electrical equipment is properly stored at the jobsite in accordance with recommended procedures.

Installation of all equipment was under the supervision of a qualified electrical construction supervisor. Special attention was given to mechanical alignment and electrical ground connections.

A high degree of field quality control was applied to the electrical equipment during installation and preservice testing, as described in Appendix A, to ensure that all equipment was properly installed and functions as designed.

Prior to initial system tests, the following electrical tests were performed:

1. Insulation (megger) tests
2. High potential tests
3. Circuit continuity tests
4. Polarity and direction of rotation tests
5. Operational tests on motors, breakers, control switches, indicators, etc.

In addition, post-construction physical inspection was performed to ascertain that systems and components have not been damaged during construction and that all equipment is in satisfactory condition to permit post-construction system tests.

8.6.3 Initial System Test

Initial electrical equipment tests were performed with all components installed. These tests are performed to demonstrate that the electrical systems are operational and that individual components of a system are properly coordinated.

The automatic operation of the emergency diesel generators is verified. Each generator was tested to ensure that it can start and accept load as required. The magnitude of loads which require power from the emergency diesel generators was verified by actual tests.

Circuit breaker operation, both manual and automatic, was tested. Testing of automatic operation of the voltage transfer system at the 4,160 V level was performed.

To determine that Category I batteries meet the manufacturer's rating, they were given an initial acceptance test in accordance with IEEE Std. 450-1980.[3] Each battery discharged at its manufacturer's two-hour rating for a temperature compensated two-hour period after which the voltage will be measured at not less than 1.84 V per cell for the 60 cell battery set, and 1.864 V per cell for the 59 cell battery set. (IEEE Std. 450-1980[3] permits shorter test periods for initial temperatures below 77° F and requires longer periods above 77° F).

The operation of the 120 V vital bus system was verified and was given a functional test.

In general, systems tests were performed to ensure that their operation as a complete system were as required.

8.6.4 Inservice Tests and Inspections

Periodic equipment and emergency power system tests generally in accordance with IEEE Std. 308-1971[(1)], Sections 6.3 and 6.4, are performed at scheduled intervals (using Table 8.6-1 as a guide). Station batteries are tested in accordance with IEEE Standard 450-1980 as required by, and with exceptions noted in Technical Specification Amendment 54. These tests demonstrate that standby power equipment and components that are not exercised during normal operation of the station are operable and detect any deterioration of the system toward an unacceptable condition. Testing of power systems important to safety is performed periodically to meet requirements of the General Design Criteria 18.

The control power for operating major motor starters (i.e., 4,160 V and large 480 V motors) is supplied from the 125 V DC system. This system maintains a constant voltage which is monitored continuously for voltage variations or undesired ground connections.

Each major motor or other piece of major electrical equipment is protected by overcurrent relays that disconnect the device if the load current becomes excessive. The protective relays are set and calibrated by trained personnel. The availability and proper action of standby equipment are tested periodically while the unit is in operation.

Testing of automatic power transfer at the 4,160 V level is performed approximately annually during scheduled unit startup or shutdown.

The testing shall be performed in such a manner that full equipment actuation will be achieved. When performing this test, diesel fast start relays and diesel sequencing relays will be given a full operational test. The test shall be performed in accordance with the test specifications.

The emergency diesel generator is tested for full load operation by manually synchronizing to the normal station service system. During the testing of one emergency diesel generator system, the alternate system is available if required.

A preventative maintenance program is followed to periodically test the insulation values of circuits and equipment.

The station batteries are subjected to periodic inspection and an equalizing charge is applied as required based on battery parameters measured during periodic inspections. Discharge tests of the Category I batteries, as described in IEEE Std. 450-1980 and with the exceptions noted in Technical Specification Amendment 54, will be made upon initial service and at 18-month intervals thereafter.

References for Section 8.6

1. "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations," IEEE Std. 308-1971, The Institute of Electrical and Electronic Engineers, Inc.

2. "Installation, Inspection and Testing Requirements for Class 1E Instrumentation and Electric Equipment at Nuclear Power Generating Stations," IEEE Std. 336-1971, The Institute of Electrical and Electronic Engineers, Inc.

3. "Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations," IEEE Std. 450-1980, The Institute of Electrical and Electronic Engineers, Inc.

TABLES FOR SECTION 8

Table 8.5-3

120 V A-C, 125 V D-C VITAL POWER SYSTEMS - SINGLE FAILURE ANALYSIS

Equipment	Operating Mode	Incident	Results
Battery Chargers 1,2,3, or 4	Continuous	Charger Failure	Battery charger failure alarm - battery on failed charger has adequate capacity for minimum of 2 hrs. Redundant batteries continuing to supply power to redundant trains and channels.
Battery 1,2,3, or 4	Normal Floating	Low Voltage	Low voltage alarms - redundant batteries continue to supply power to redundant trains and channels.
Inverter 1,2,3, or 4	Normal Floating on DC input operating on AC input	Inverter Failure	Inverter failure alarm - static transfer switch will change to power the bus from the alternate line regulator with no detectable loss of bus operability.
Inverter 1,2,3, or 4	Normal Floating on DC input, operating on AC input	Loss of AC input or DC input	Inverter failure alarm Uninterruptible power supply is static system - loss of AC transfers over to DC - Loss of both can use bypass 120 V AC to supply vital bus.
Static Switch 1,2,3, or 4	Normal Powering Vital Bus from the Inverter	Loss of Alternate Line, or DC Bus, or Inverter	No effect on bus or static switch since static switch logic is powered from three different sources.
		Static switch Logic or Power Component Failure.	Vital bus problem alarm - only one bus will be affected and the static switch may be bypassed with operator action.

Table 8.5-4

Criteria for Sizing 125 V Batteries

	Temperature[1] Correction Factor to 50°F	Aging Factor
Battery No. 1 (60 Cells)	1.19	1.25
Battery No. 2 (60 Cells)	1.19	1.25
Battery No. 3 (59 Cells)	1.19	1.25
Battery No. 4 (59 Cells)	1.19	1.25
Battery No. 5[2]	1.19	1.25

1. Operation of the batteries at any temperature above 50°F will result in a margin as determined by Table 1, Page 11, of IEEE Std. 485-1983. At the standard temperature of 77°F the battery will have a 19% margin.

2. Battery No. 5 consists of two series connected strings of 59 cells each, connected in parallel.

Table 8.6-1

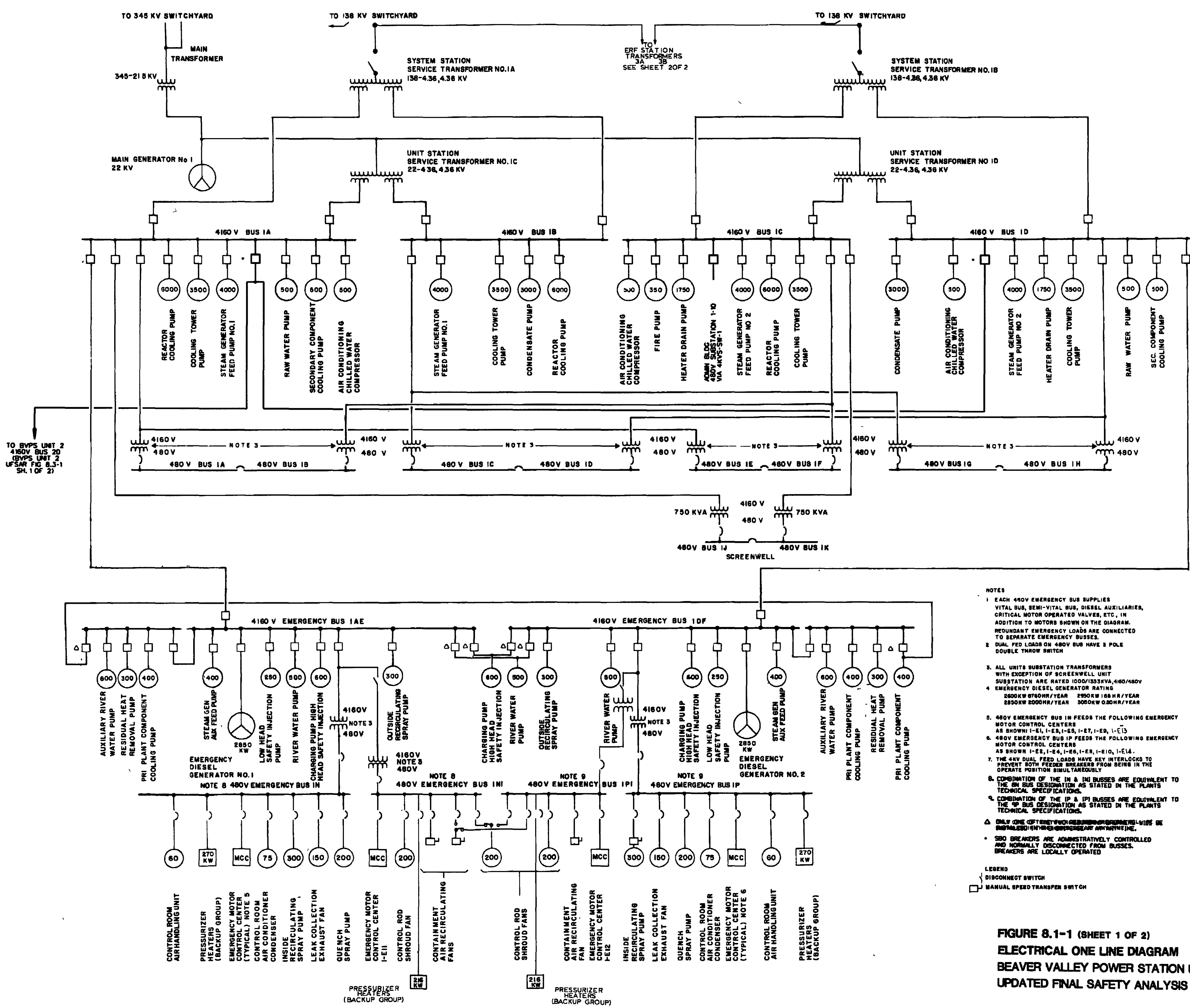
PERIODIC TESTING OF ELECTRICAL EQUIPMENT

Item	Periodic Test Description	Test Interval
Switchgear Above 600 V	Operation test Mechanical inspection, and Insulation test*	**
		36 months, alternate safety-related bus each refueling**
	Overhaul	When required
600 V and below	Operation test	**
	Mechanical inspection	36 months, alternate safety-related bus each refueling**
	Overhaul	When required
	Overcurrent trip test	**
Power transformers	Insulation test	36 months**
	Energize (normally de-energized)	1 year
Batteries	Battery terminal Voltage	Once per 7 days
	Pilot cell	
	Electrolyte level	Once per 31 days
	Float voltage	Once per 31 days
	Specific gravity	Once per 31 days
	Visual inspection of terminals and connectors	Once per 92 days
	Each connected cell	
	Electrolyte level	Once per 92 days
	Float voltage	Once per 92 days
	Specific gravity	Once per 92 days
	Visual inspection and performance tests	Once per 18 months
	Capacity test	Once per 60 months
Battery charger	Visual inspection	Weekly
	Performance test	Yearly or at each refueling thereafter
Indicators	Visual inspection	8 hours
	Calibration	As required
Emergency diesel generator	Operation test	1 month

* Test cables and motor insulation together at switchgear terminals.

** When permitted by operating configuration.

REV 29



NOTES

1 EACH 480V EMERGENCY BUS SUPPLIES VITAL BUS, SEMI-VITAL BUS, DIESEL AUXILIARIES, CRITICAL MOTOR OPERATED VALVES, ETC, IN ADDITION TO MOTORS SHOWN ON THE DIAGRAM. REDUNDANT EMERGENCY LOADS ARE CONNECTED TO SEPARATE EMERGENCY BUSSES.

2 DUAL FED LOADS ON 480V BUS HAVE 3 POLE DOUBLE THROW SWITCH

3. ALL UNITS SUBSTATION TRANSFORMERS WITH EXCEPTION OF SCREENWELL UNIT SUBSTATION ARE RATED 1000/1333KVA, 4160/480V

4 EMERGENCY DIESEL GENERATOR RATING
2600KW 8760HR/YEAR 2950KW 168 HR/YEAR
2850KW 2000HR/YEAR 3050KW 0.50HR/YEAR

5. 480V EMERGENCY BUS 1N FEEDS THE FOLLOWING EMERGENCY MOTOR CONTROL CENTERS AS SHOWN: 1-E1, 1-E3, 1-E5, 1-E7, 1-E9, 1-E13

6. 480V EMERGENCY BUS 1P FEEDS THE FOLLOWING EMERGENCY MOTOR CONTROL CENTERS AS SHOWN 1-E2, 1-E4, 1-E6, 1-E8, 1-E10, 1-E14.

7. THE 4KV DUAL FEED LOADS HAVE KEY INTERLOCKS TO PREVENT BOTH FEEDER BREAKERS FROM BEING IN THE OPERATE POSITION SIMULTANEOUSLY

8. COMBINATION OF THE 1N & 1N1 BUSSES ARE EQUIVALENT TO THE 8N BUS DESIGNATION AS STATED IN THE PLANTS TECHNICAL SPECIFICATIONS.

9. COMBINATION OF THE 1P & 1P1 BUSSES ARE EQUIVALENT TO THE 9P BUS DESIGNATION AS STATED IN THE PLANTS TECHNICAL SPECIFICATIONS.

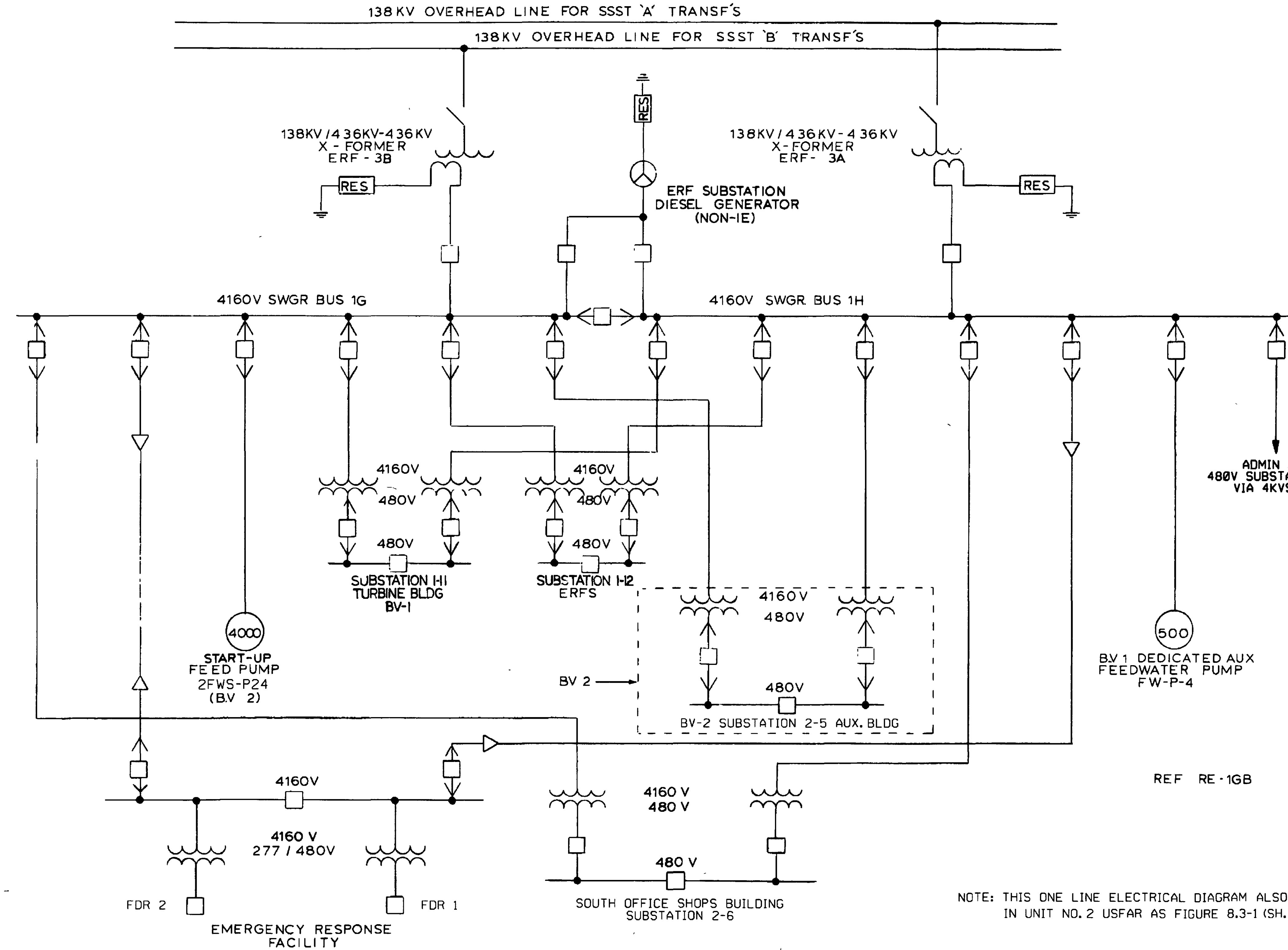
△ ONLY ONE OF [illegible] WILL BE INSTALLED IN [illegible] AT ANY TIME.

• SBO BREAKERS ARE ADMINISTRATIVELY CONTROLLED AND NORMALLY DISCONNECTED FROM BUSSES. BREAKERS ARE LOCALLY OPERATED

LEGEND
DISCONNECT SWITCH
MANUAL SPEED TRANSFER SWITCH

FIGURE 8.1-1 (SHEET 1 OF 2)
ELECTRICAL ONE LINE DIAGRAM
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

REV. 29



NOTE: THIS ONE LINE ELECTRICAL DIAGRAM ALSO APPEARS IN UNIT NO. 2 USFAR AS FIGURE 8.3-1 (SH. 2 OF 2)

FIGURE 8.1-1 (SH. 2 OF 2)
ELECTRICAL ONE LINE DIAGRAM

BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

REV. 18

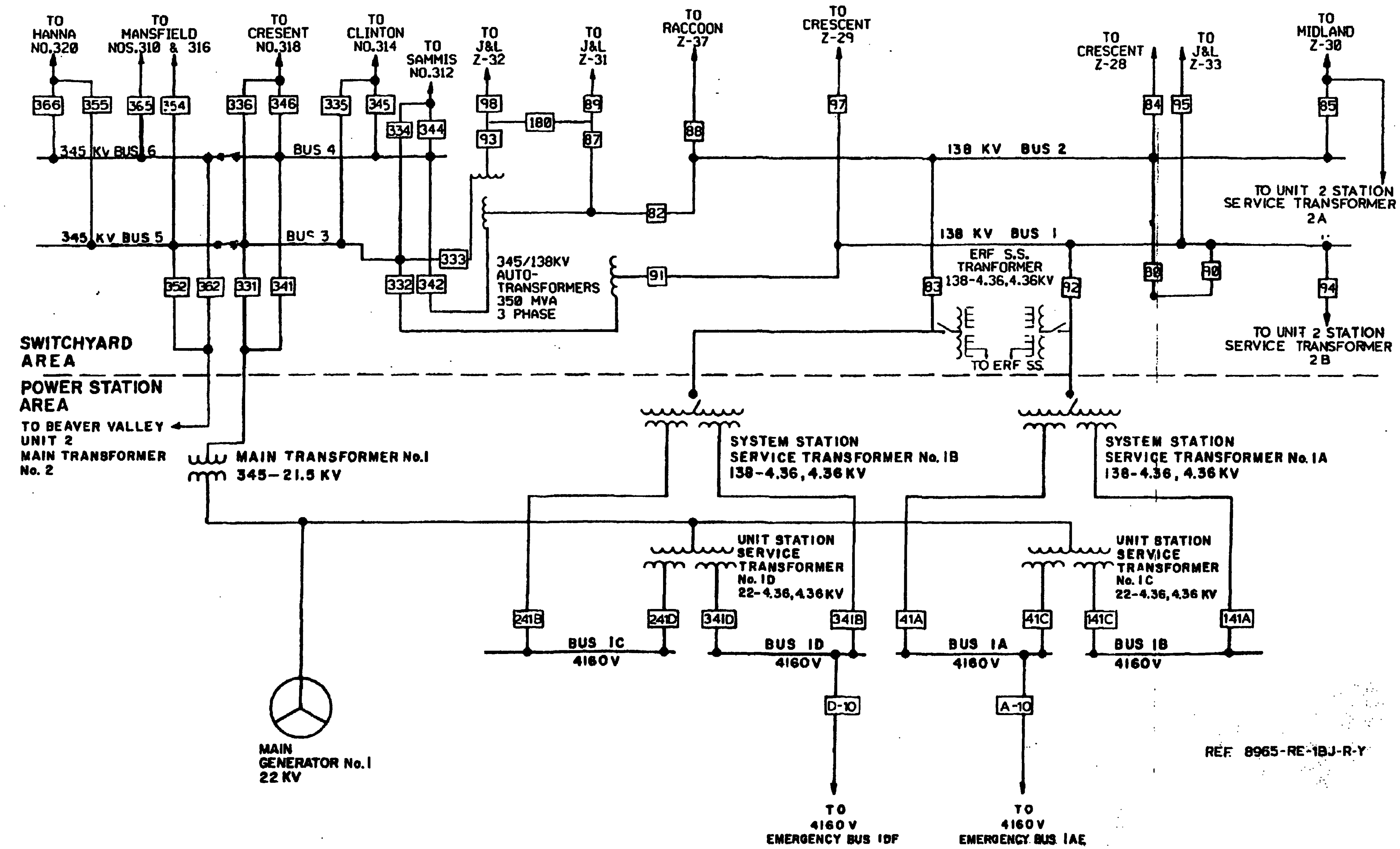


FIGURE 8.3-1
ELECTRICAL INTERCONNECTIONS SWITCHYARD - POWER STATION

BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

Removed in Accordance with RIS 2015-17

FIGURE 8.3-2
BULK POWER TRANSMISSION SYSTEM
BEAVER VALLEY POWER STATION NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

REV13 1-95

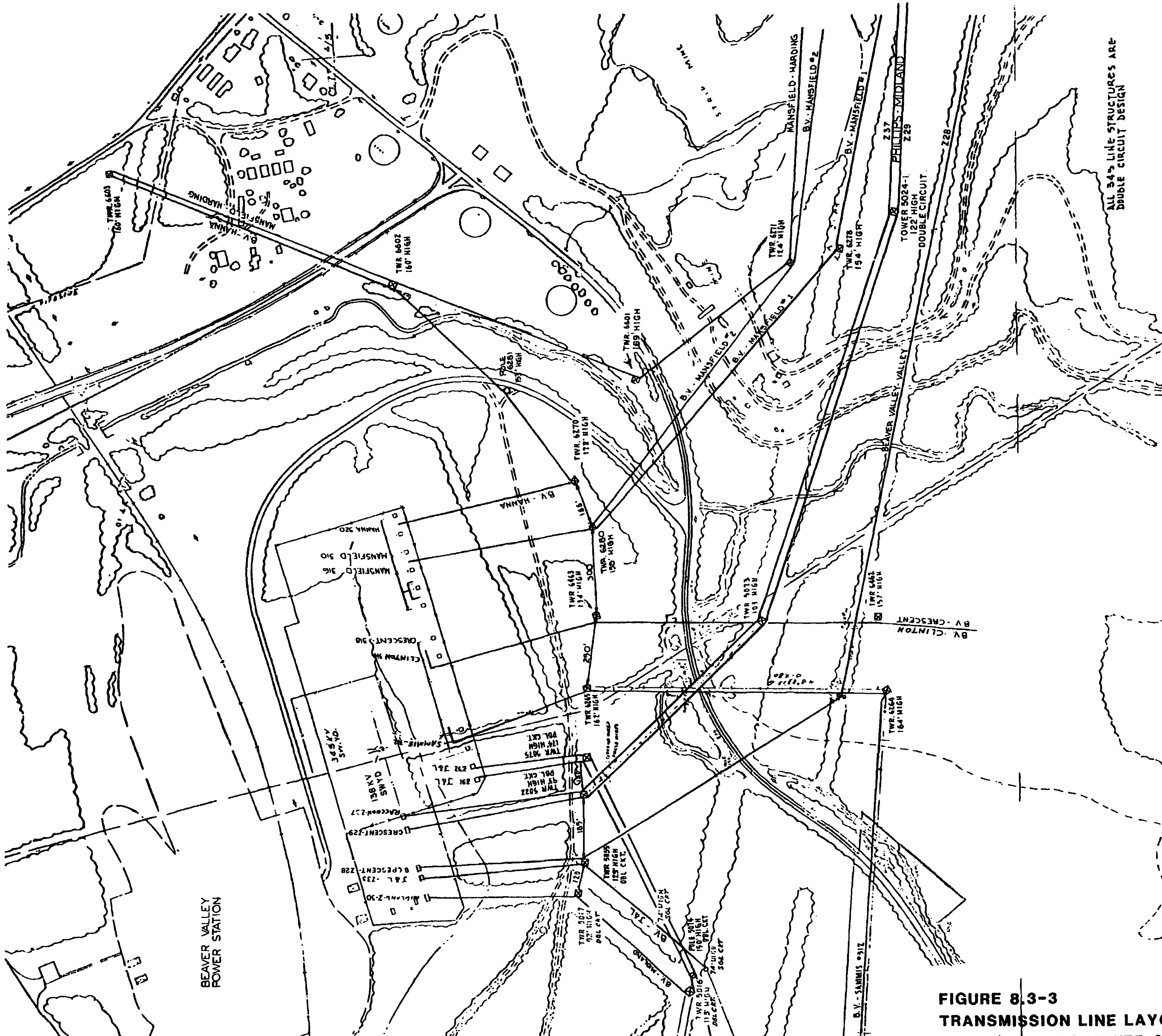


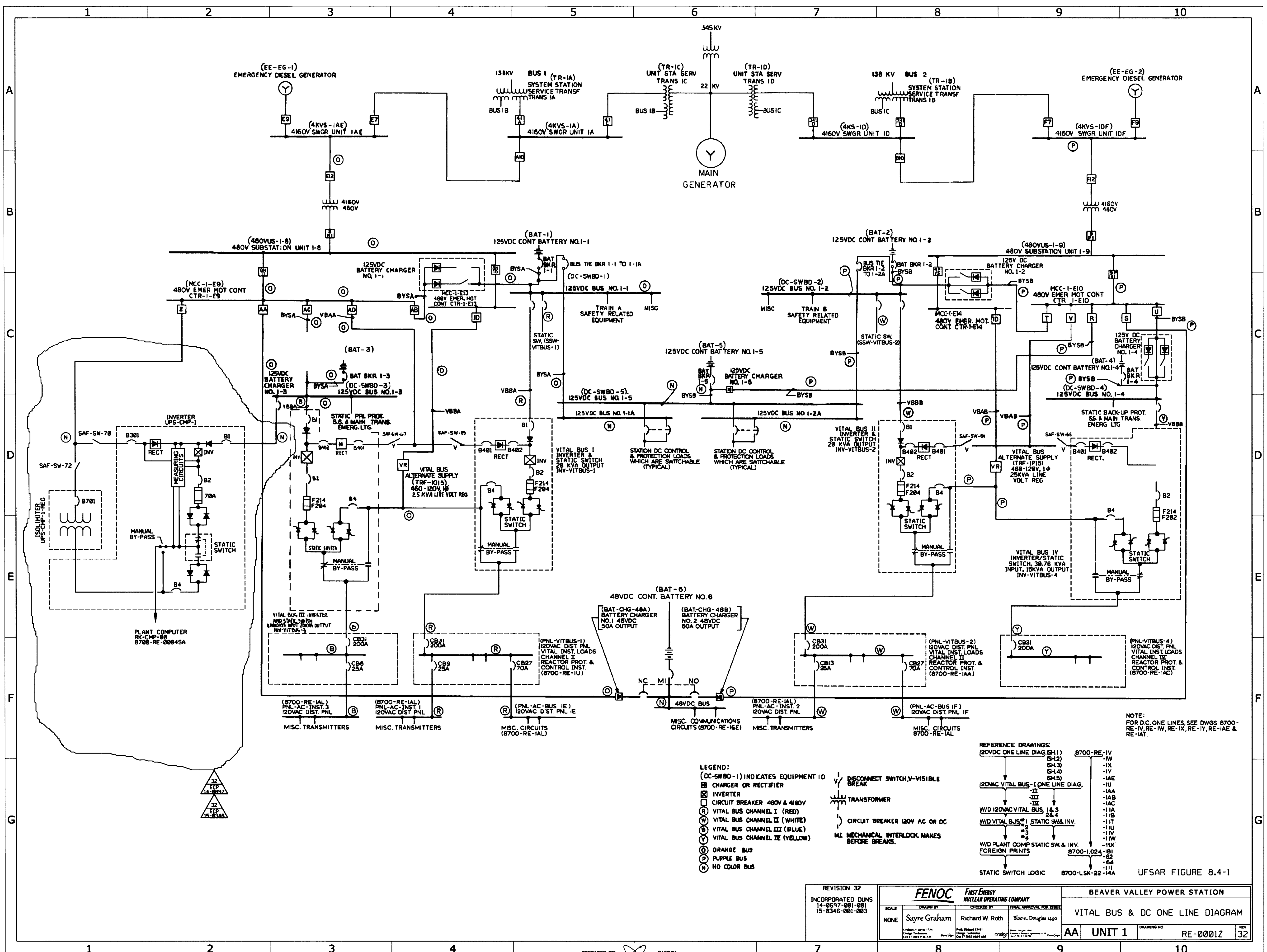
FIGURE 8.3-3
TRANSMISSION LINE LAYOUT
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

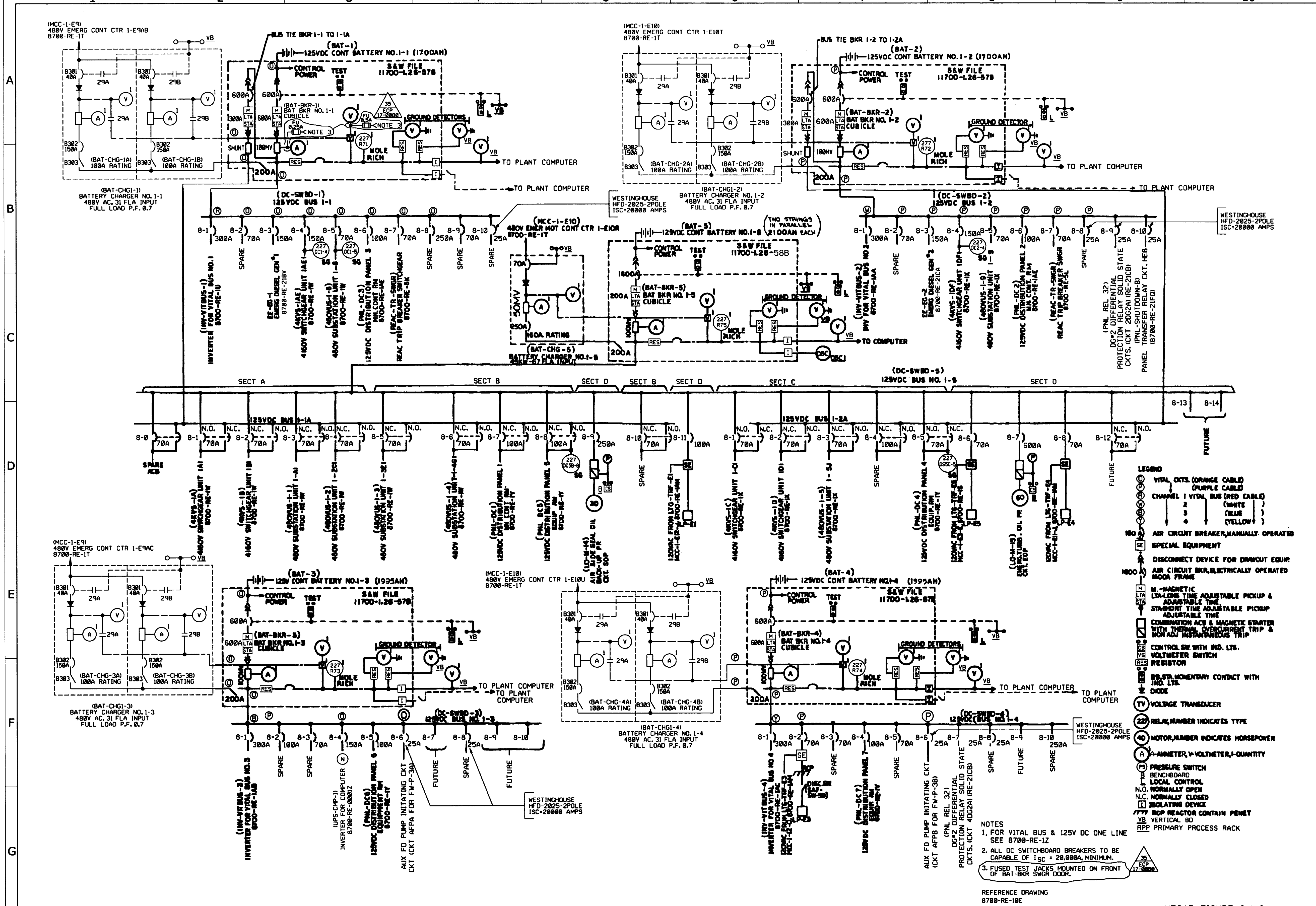
REV. 2 (1/84)

REFER TO FIGURE 1.2-1

FIGURE 8.3-4

TOWER AND LINE ARRANGEMENT
FROM SWITCHYARD TO PLANT
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT


345KV
138KV BUS 1 (TR-1A) SYSTEM STATION SERVICE TRANSF TRANS 1A
(TR-1C) UNIT STA SERV TRANS 1C
(TR-1D) UNIT STA SERV TRANS 1D
22 KV
138 KV BUS 2 (TR-1B) SYSTEM STATION SERVICE TRANSF TRANS 1B
(EE-EG-1) EMERGENCY DIESEL GENERATOR
(EE-EG-2) EMERGENCY DIESEL GENERATOR
(4KVS-1AE) 4160V SWGR UNIT 1AE
(4KVS-1A) 4160V SWGR UNIT 1A
(4KS-1D) 4160V SWGR UNIT 1D
(4KVS-1DF) 4160V SWGR UNIT 1DF
MAIN GENERATOR
(480VUS-1-8) 480V SUBSTATION UNIT 1-8
(480VUS-1-9) 480V SUBSTATION UNIT 1-9
(BAT-1) 125VDC CONT BATTERY NO.1-1
(BAT-2) 125VDC CONT BATTERY NO.1-2
(BAT-3)
(BAT-4) 125VDC CONT BATTERY NO.1-4
(BAT-5) 125VDC CONT BATTERY NO.1-5
(BAT-6) 48VDC CONT. BATTERY NO.6
(MCC-1-E9) 480V EMER MOT CONT CTR-1-E9
MCC-1-E10 480V EMER MOT CONT CTR 1-E10
(DC-SWBD-1) 125VDC BUS NO.1-1
(DC-SWBD-2) 125VDC BUS NO.1-2
(DC-SWBD-3) 125VDC BUS NO.1-3
(DC-SWBD-4) 125VDC BUS NO.1-4
(DC-SWBD-5) 125VDC BUS NO.1-5
125VDC BUS NO.1-1A
125VDC BUS NO 1-2A
TRAIN A SAFETY RELATED EQUIPMENT
TRAIN B SAFETY RELATED EQUIPMENT
INVERTER UPS-CMP-1
VITAL BUS I INVERTER & STATIC SWITCH 20 KVA OUTPUT INV-VITBUS-1
VITAL BUS II INVERTER & STATIC SWITCH 20 KVA OUTPUT INV-VITBUS-2
VITAL BUS IV INVERTER/STATIC SWITCH, 38.76 KVA INPUT, 15KVA OUTPUT INV-VITBUS-4
STATION DC CONTROL & PROTECTION LOADS WHICH ARE SWITCHABLE (TYPICAL)
(BAT-CHG-48A) BATTERY CHARGER NO.1 48VDC 50A OUTPUT
(BAT-CHG-48B) BATTERY CHARGER NO.2 48VDC 50A OUTPUT
48VDC BUS
MISC. COMMUNICATIONS CIRCUITS (8700-RE-16E)
(PNL-VITBUS-1) 120VAC DIST. PNL VITAL INST. LOADS CHANNEL I REACTOR PROT. & CONTROL INST. (8700-RE-1U)
(PNL-VITBUS-2) 120VAC DIST. PNL VITAL INST. LOADS CHANNEL II REACTOR PROT. & CONTROL INST. (8700-RE-1AA)
(PNL-VITBUS-4) 120VAC DIST. PNL VITAL INST. LOADS CHANNEL IV REACTOR PROT. & CONTROL INST. (8700-RE-1AC)
PLANT COMPUTER RK-CMP-00 8700-RE-0004SA
MISC. TRANSMITTERS
MISC. CIRCUITS (8700-RE-1AL)
NOTE: FOR D.C. ONE LINES, SEE DWGS 8700-RE-1V, RE-1W, RE-1X, RE-1Y, RE-1AE & RE-1AT.
LEGEND:
(DC-SWBD-1) INDICATES EQUIPMENT ID
CHARGER OR RECTIFIER
INVERTER
CIRCUIT BREAKER 480V & 4160V
VITAL BUS CHANNEL I (RED)
VITAL BUS CHANNEL II (WHITE)
VITAL BUS CHANNEL III (BLUE)
VITAL BUS CHANNEL IV (YELLOW)
ORANGE BUS
PURPLE BUS
NO COLOR BUS
DISCONNECT SWITCH, V-VISIBLE BREAK
TRANSFORMER
CIRCUIT BREAKER 120V AC OR DC
M.I. MECHANICAL INTERLOCK MAKES BEFORE BREAKS.
REFERENCE DRAWINGS:
UFSAR FIGURE 8.4-1
REVISION 32
INCORPORATED DUNS 14-0697-001-001 15-0346-001-003
FENOC FIRST ENERGY NUCLEAR OPERATING COMPANY
BEAVER VALLEY POWER STATION
VITAL BUS & DC ONE LINE DIAGRAM
UNIT 1
RE-0001Z
32
PREPARED ON THE BVPS CAEDDI SYSTEM

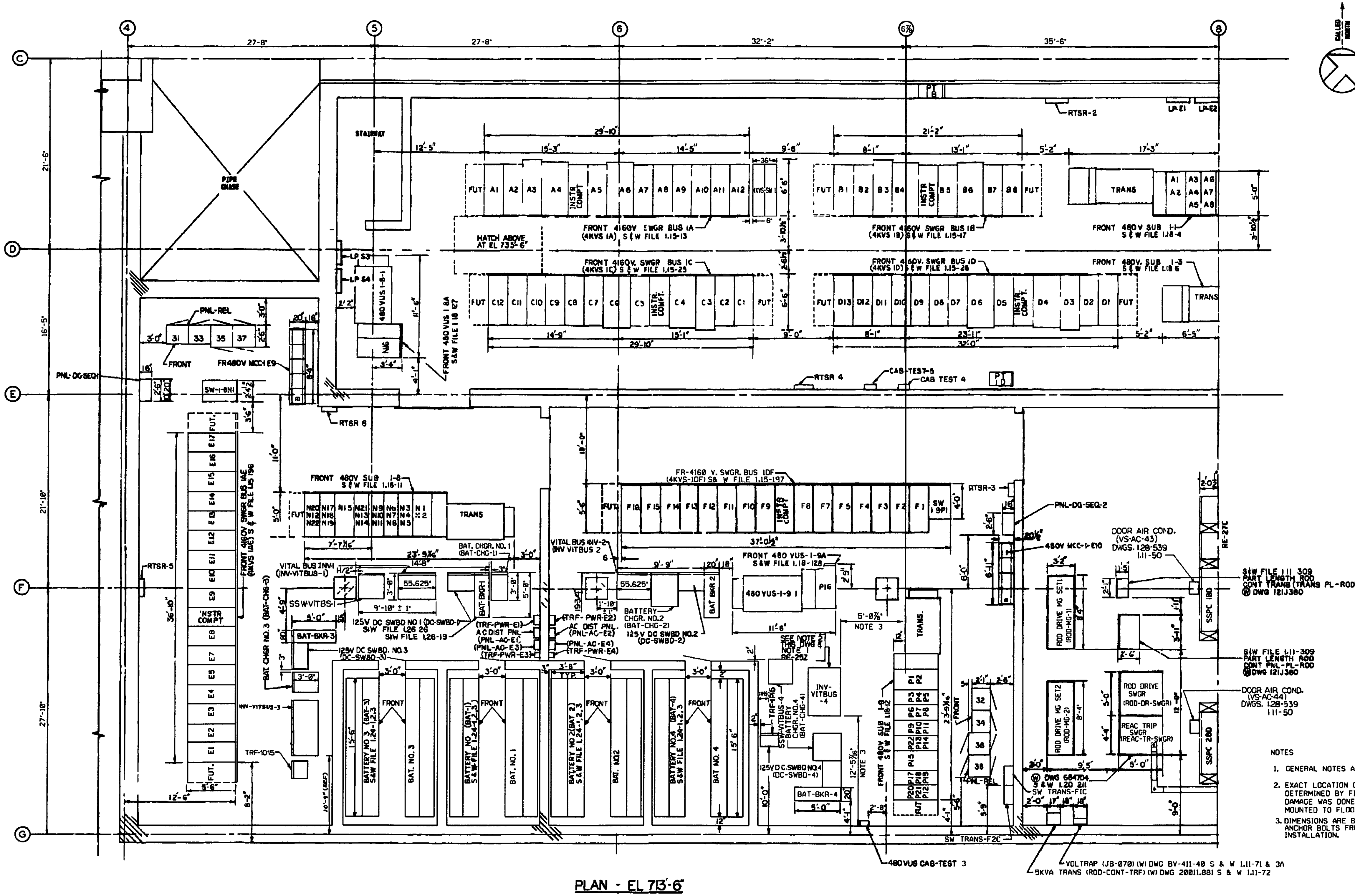


UFSAR FIGURE 8.4-2

REVISION 35	BEAVER VALLEY POWER STATION
INCORPORATED DUN 17-0080-001-001	125V DC ONE LINE DIAGRAM SH. 1
FENOC FirstEnergy Nuclear Operating Company	
SCALE NONE	DRAWN BY Sayre Graham / CHECKED BY Richard W Roth / FINAL APPROVAL FOR ISSUE Bloom, Douglas
AA UNIT 1	DRAWING NO RE-0001V REV 35

PREPARED ON THE BVPS CAEDDI SYSTEM

REV 29



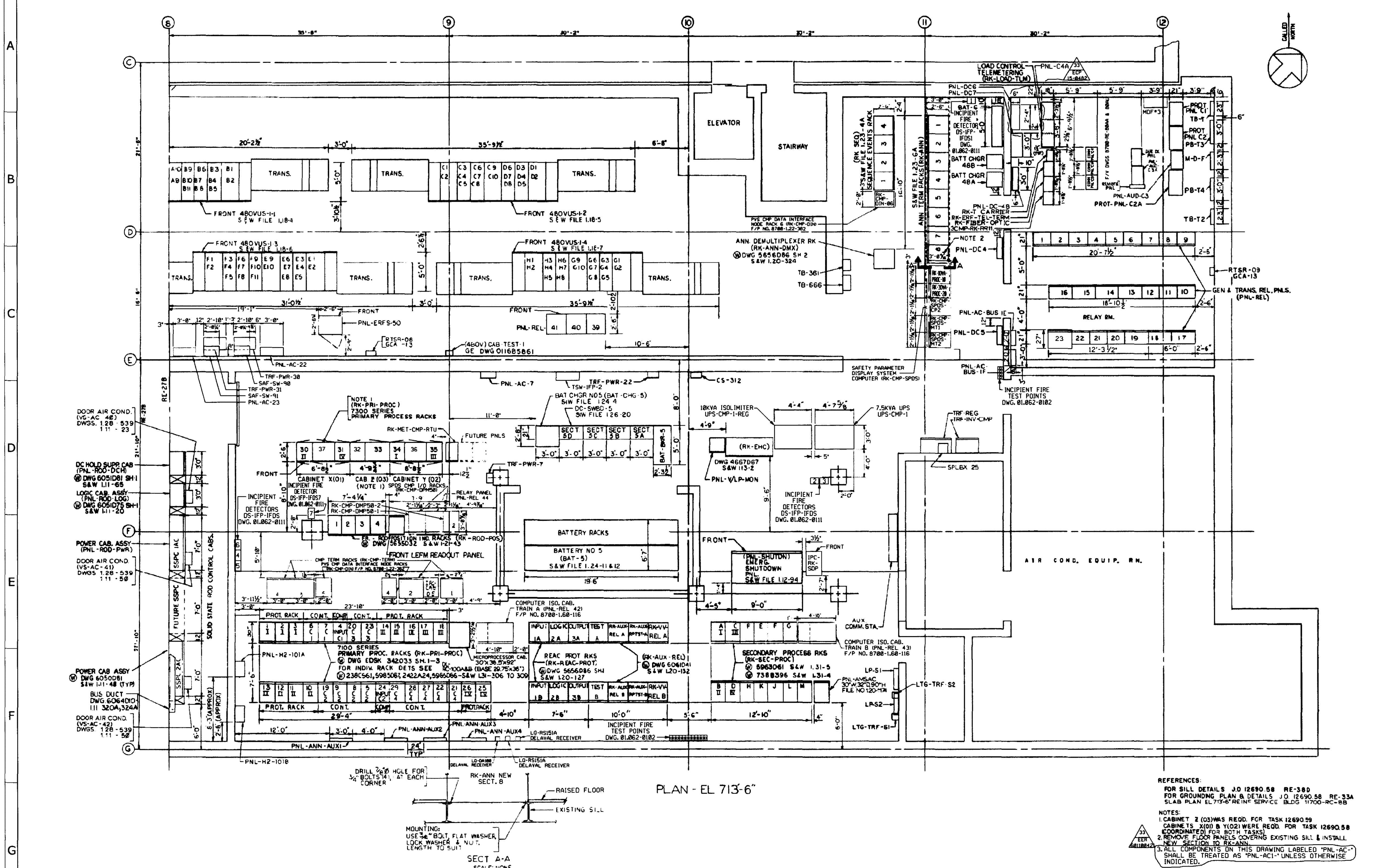
NOTES

1. GENERAL NOTES AND REFERENCES, RE-27A
2. EXACT LOCATION OF INV-VITBUS-3 & 4 DETERMINED BY FIELD TO INSURE NO DAMAGE WAS DONE TO REBARS WHEN MOUNTED TO FLOOR.
3. DIMENSIONS ARE BASED ON REUSING EXISTING ANCHOR BOLTS FROM PREVIOUS INV-VITBUS-4 INSTALLATION.

FIGURE 8.5-1
ARRANGEMENT SWITCHGEAR ROOM SH. 1

BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

m /u1/re0270b0 d19



REFERENCES:

FOR SILL DETAILS J.O 12690.58 RE-38D
FOR GROUNDING PLAN & DETAILS J.O. 12690.58 RE-33A
SLAB PLAN EL 713'-6" REINF SERVICE BLDG 11700-RC-8B

NOTES:

1. CABINET Z (03) WAS REQD. FOR TASK 12690.59
CABINETS X(01) & Y(02) WERE REQD. FOR TASK 12690.58 (COORDINATED FOR BOTH TASKS)
2. REMOVE FLOOR PANELS COVERING EXISTING SILL & INSTALL NEW SECTION TO RK-ANN.
3. ALL COMPONENTS ON THIS DRAWING LABELED "PNL-AC-" SHALL BE TREATED AS "PNL-AC1-" UNLESS OTHERWISE INDICATED.

33 EER 601100421

33 ECP 17-0349

UFSAR FIGURE 8.5-2

REVISION 33 INCORPORATED
DUN 15-0482-002-004
PDUN 17-0349-001-093
PDUN 601100421-039

FENOC FIRST ENERGY NUCLEAR OPERATING COMPANY

SCALE	DRAWN BY	CHECKED BY	FINAL APPROVAL FOR ISSUE
1/4" = 1'-0"			M S Ressler

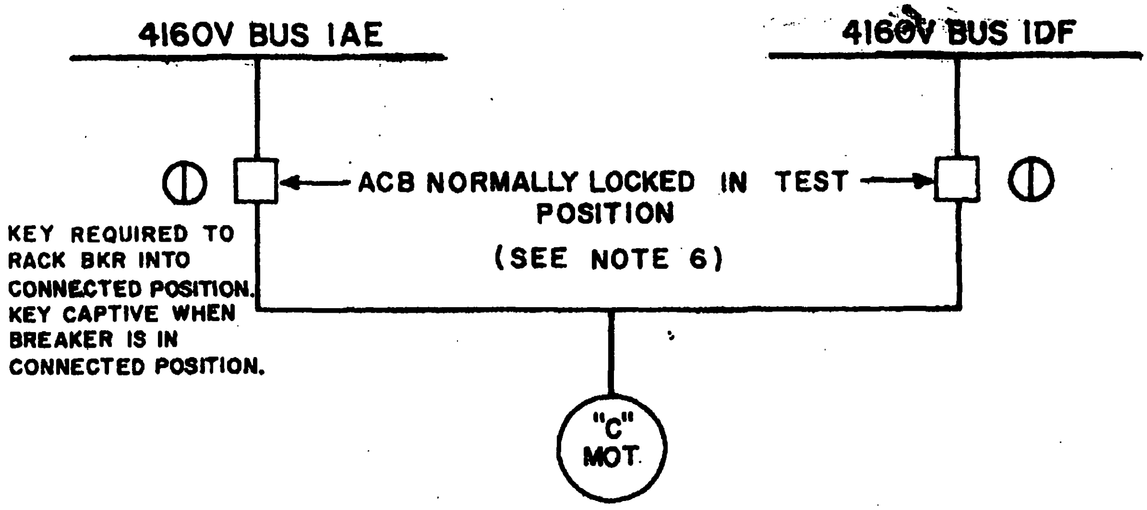
BEAVER VALLEY POWER STATION

ARRGT. SWITCHGEAR ROOM - SH. 2

AA UNIT 1 DRAWING NO RE-0027C REV 33

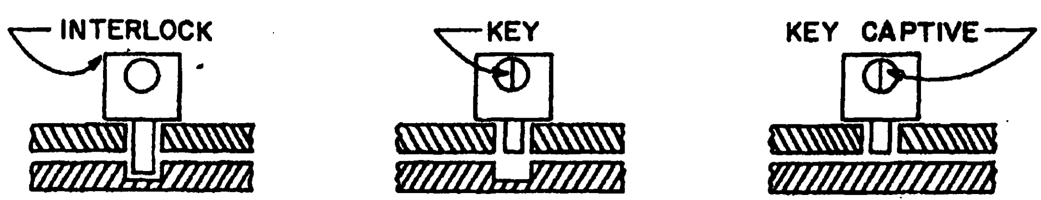
PREPARED ON THE BVPS CAEDDS SYSTEM

M:\u1\re0270c0.d28



NOTES:

1. TWO KEY INTERLOCKS, ONE AT EACH BREAKER.
2. ONLY ONE KEY TO ALLOW ONLY ONE BREAKER TO BE RACKED INTO CONNECTED POSITION.
3. KEY IS RELEASED WHEN BREAKER IS IN "TEST" OR "WITHDRAWN" POSITION, BY LOCKING BREAKER IN EITHER POSITION.
4. BREAKER No.1 CAN BE RACKED INTO CONNECTED POSITION WHEN KEY IS IN INTERLOCK AND TURNED.
5. KEY IS CAPTIVE WHEN BREAKER IS IN CONNECTED POSITION. BREAKER CAN BE OPERATED NORMALLY IN THIS POSITION. KEY WILL NOT TURN IN THIS POSITION.
6. ONLY ONE REDUNDANT BREAKER WILL BE INSTALLED IN THE SWITCHGEAR AT ANY TIME.



BKR LOCKED IN TEST OR WITHDRAWN POSITION.

BKR IN TEST POSITION WITH KEY IN LOCK AND TURNED. KEY IS NOW CAPTIVE.

BKR IN OPERATE POSITION.

FIGURE 8.5-8
KEY INTERLOCKS FOR SWING BREAKERS
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT