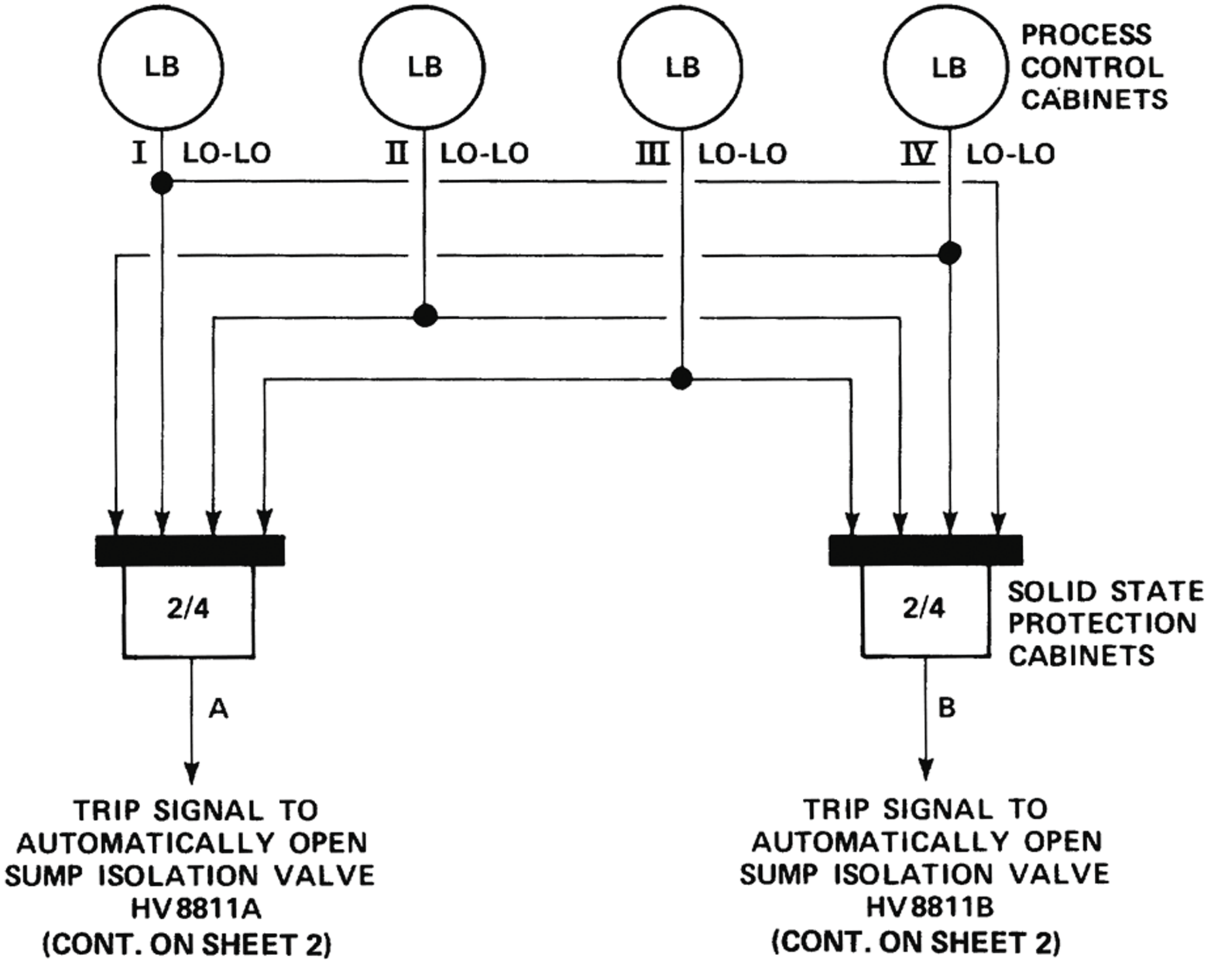
RWST LEVEL CHANNEL BISTABLES

1) NORMALLY DEENERGIZED
2) DEENERGIZED ON LOSS OF POWER
3) TRIP SIGNAL PROVIDED WHEN ENERGIZED
4) ENERGIZED ON LO-LO SETPOINT



REV 14 10/07

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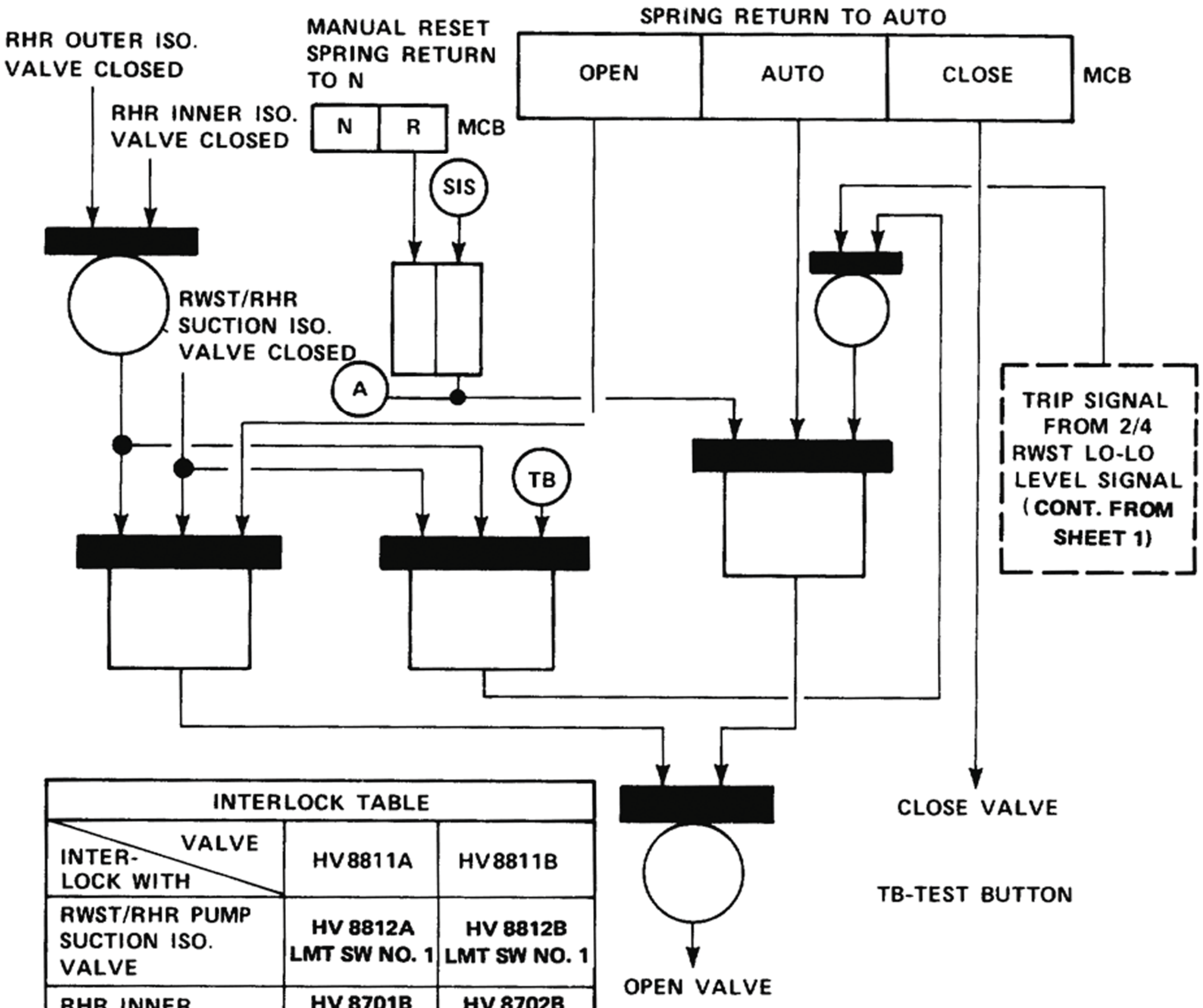
VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

SAFETY INJECTION SYSTEM
RECIRCULATION SUMP AND RHR
SUCTION ISOLATION VALVES

FIGURE 7.6.5–1 (SHEET 1 OF 2)



INTERLOCK TABLE

VALVE INTER-LOCK WITH	HV8811A	HV8811B
RWST/RHR PUMP SUCTION ISO. VALVE	HV 8812A LMT SW NO. 1	HV 8812B LMT SW NO. 1
RHR INNER ISO. VALVE	HV 8701B LMT SW NO. 2	HV 8702B LMT SW NO. 1
RHR OUTER ISO. VALVE	HV 8701A LMT SW NO. 1	HV 8702A LMT SW NO. 2
TRAIN	A	B

APPLICABLE VALVE	
DESCRIPTION	
SUMP TO NO. 1 RHR PUMP	HV8811A
SUMP TO NO. 2 RHR PUMP	HV8811B

LIMIT SWITCH NO. 1 IS THE NORMAL POSITION SIGNAL AND IS USED FOR POSITION SIGNALS BETWEEN VALVES ASSIGNED TO THE SAME TRAIN.
LIMIT SWITCH NO. 2 IS THE STEM MOUNTED POSITION SWITCH AND IT IS USED FOR POSITION SIGNALS BETWEEN VALVES ASSIGNED TO OPPOSITE TRAINS.

Ⓐ **ACTUATION SIGNAL LAMP**

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FIGURE 7.6.5–1 (SHEET 2 OF 2)

7.7 CONTROL SYSTEMS NOT REQUIRED FOR SAFETY

The general design objectives of the plant control systems are:

A. To establish and maintain power equilibrium between the primary and secondary system during steady-state unit operation.

B. To constrain operational transients so as to preclude unit trip and to reestablish steady-state unit operation.

C. To provide the reactor operator with monitoring instrumentation that indicates all required input and output control parameters of the systems and provides the operator with the capability of assuming manual control of the system.

7.7.1 DESCRIPTION OF CONTROL SYSTEMS NOT REQUIRED FOR SAFETY

The plant control systems described in this section perform the following functions:

A. Reactor Control System

  1. Enables the nuclear plant to accept a step-load increase or decrease of 10 percent and a ramp increase or decrease of 5 percent/min within the load range of 15 to 100 percent, without reactor trip, steam dump, or pressurizer relief actuation, subject to possible xenon limitations.

  2. Maintains reactor coolant average temperature (T_{avg}) within prescribed limits by creating the bank demand signals for moving groups of full-length rod cluster control assemblies during normal operation and operational transients. The T_{avg} control also supplies a signal to pressurizer water level control and steam dump control.

B. Rod Control System

  1. Provides for reactor power modulation by manual or automatic control (automatic rod insertion only) of full-length control rod banks in a preselected sequence and for manual operation of individual banks.

  2. Includes systems for monitoring and indicating which:

     - Provide alarms to alert the operator if the required core reactivity shutdown margin is not available because of excessive control rod insertion.

     - Display control rod position.

     - Provide alarms to alert the operator in the event of control rod deviation exceeding a preset limit.

C. Plant Control System Interlocks

  1. Prevent further withdrawal of the control banks when signal limits are approached that indicate the approach to a departure from nucleate boiling ratio limit or kW/ft limit.

  2. Limit automatic turbine load increase to values for which the nuclear steam supply system has been designed.

D. Pressurizer Pressure Control

  1. Maintains or restores the pressurizer pressure to the design pressure ±35 psi (which is within reactor trip and relief and safety valve actuation setpoint limits) following normal operational transients that induce pressure changes by control (manual or automatic) of heaters and spray in the pressurizer.
  2. Provides steam relief by controlling the power relief valves.

E. Pressurizer Water Level Control

Establishes, maintains, and restores pressurizer water level within specified limits as a function of the average coolant temperature. Changes in level are caused by coolant density changes induced by loading, operational, and unloading transients. Level changes are produced by means of charging flow control (manual or automatic), as well as by manual selection of letdown orifices. Maintaining coolant level in the pressurizer within prescribed limits by actuating the charging and letdown system thus provides control of the reactor coolant water inventory.

F. Steam Generator Water Level Control

  1. Establishes and maintains the steam generator water level within predetermined limits during normal operating transients.
  2. Maintains the steam generator water level within predetermined limits and unit trip conditions. It regulates the feedwater flowrate such that under operational transients the water level for the reactor coolant system does not decrease below a minimum value. Steam generator water inventory control is manual or automatic through the use of feedwater regulating valves.

G. Steam Dump Control

  1. Permits the nuclear plant to accept a sudden loss of load without incurring reactor trip. Steam is dumped to the condenser as necessary to accommodate excess power generation in the reactor during turbine load reduction transients.
  2. Ensures that stored energy and residual heat are removed following a reactor trip to bring the plant to equilibrium no-load conditions without actuation of the steam generator safety valves.
  3. Maintains the plant at no-load conditions to permit a manually controlled cooldown of the plant.

H. Incore Instrumentation

Provides information on the neutron flux distribution and on the core outlet temperatures at selected core locations.

7.7.1.1 Reactor Control System

The reactor control system enables the nuclear plant to follow load changes automatically, including the acceptance of step-load increases or decreases of 10 percent and ramp increases or decreases of 5 percent/min within the load range of 15 to 100 percent without reactor trip, steam dump, or pressure relief (subject to possible xenon limitations). The system is also capable of restoring coolant average temperature to within the programmed temperature dead band following a change in load. Automatic control rod insertion may be used for temperature control. However, rod withdrawal can only be performed manually. Manual control rod operation may be performed at any time within the range of defined insertion limits.

The reactor control system controls the reactor coolant average temperature by regulating control rod bank position. The reactor coolant loop average temperatures are determined from hot leg and cold leg measurements in each reactor coolant loop. There is an average coolant temperature (T_{avg}) computed for each loop, where:

$$T_{avg} = \frac{T_{hot} + T_{cold}}{2}$$

The error between the programmed reference temperature (based on turbine impulse chamber pressure) and the highest of the T_{avg} measured temperatures (which is processed through a lead-lag compensation unit) from each of the reactor coolant loops constitutes the primary control signal as shown in general in figure 7.7.1-1 and in more detail on the functional diagrams shown in drawing 1X6AA02-233. The system is capable of automatically restoring coolant average temperature to the programmed value following a decrease in load. Manual rod control may be needed to restore the coolant average temperature to the programmed value following an increase in load. The programmed coolant temperature increases linearly with turbine load from zero power to the full power condition. The T_{avg} also supplies a signal to pressurizer level control and steam dump control and to rod insertion limit monitoring.

The temperature channels needed to derive the temperature input signals for the reactor control system are fed from protection channels via isolation amplifiers.

An additional control input signal is derived from the reactor power versus turbine load mismatch signal. This additional control input signal improves system performance by enhancing response and reducing transient peaks.

The core axial power distribution is controlled during load follow maneuvers by changing (a manual operator action) the boron concentration in the reactor coolant system. The control board $\Delta\phi$ displays (paragraph 7.7.1.3.1) indicate the need for an adjustment in the axial power distribution. Adding boron to the reactor coolant will reduce T_{avg} requiring the control rods to be withdrawn manually. This action will reduce power peaks in the bottom of the core. Removing boron from the reactor coolant will automatically move the rods further into the core to control power peaks in the top of the core.

7.7.1.2 Rod Control System

The rod control system receives rod speed and direction signals from the T_{avg} control system. Control rods may be inserted automatically; however, rod withdrawal can only be performed manually. The rod speed demand signal varies over the corresponding range of 5 to 45 in./min (8 to 72 steps/min), depending on the magnitude of the input signal. Manual control is provided to move control banks in or out at prescribed fixed speeds.

The shutdown banks are always in the fully withdrawn position during normal operation and are moved to this position at a constant speed by manual control prior to criticality. A reactor trip signal causes them to fall by gravity into the core. There are five shutdown banks.

The control banks are the only rods that can be manipulated under automatic control. Each control bank is divided into two groups to obtain smaller incremental reactivity changes per step.

All rod control cluster assemblies in a group are electrically paralleled to move simultaneously. There is individual position indication for each rod cluster control assembly.

Power to rod drive mechanisms is supplied by two motor generator sets operating from two separate 480-V, 3-phase buses. Each generator is the synchronous type and is driven by a 200-h induction motor. The ac power is distributed to the rod control power cabinets through the two series-connected reactor trip breakers.

The variable speed rod drive programmer affords the ability to insert small amounts of reactivity at low speed to accomplish fine control of reactor coolant average temperature about a small temperature dead band, as well as furnishing control at high speed. A summary of the rod cluster control assembly sequencing characteristics is given below:

A. Two groups within the same bank are stepped such that the relative position of the groups will not differ by more than one step.

B. The control banks are programmed such that withdrawal of the banks is sequenced in the following order: control bank A, control bank B, control bank C, and control bank D. The programmed insertion sequence is the opposite of the withdrawal sequence; i.e., the last control bank withdrawn (D) is the first control bank inserted.

C. The control bank withdrawals are programmed such that when the first bank reaches a preset position, the second bank begins to move out simultaneously with the first bank. This preset position is determined by the maximum allowable overlap between banks (typically 100 to 115 steps). When the second bank reaches a preset position, the third bank begins to move out. The first bank will be fully withdrawn before the third bank starts to move. Therefore, it is possible for only two banks to be withdrawn at any one time. This withdrawal sequence continues until the unit reaches the desired power level. The control bank insertion sequence is the opposite.

D. Overlap between successive control banks is adjustable between 0 to 50 percent (0 and 115 steps), with an accuracy of ±1 step.

E. Rod speeds for either the shutdown banks or manual operation of the control banks are capable of being controlled between a minimum of 6 steps/min and a maximum of 72 (+0, -10) steps/min.

7.7.1.3 Plant Control Signals for Monitoring and Indicating

7.7.1.3.1 Monitoring Functions Provided by the Nuclear Instrumentation System

The power range channels are important because of their use in monitoring power distribution in the core within specified safe limits. They are used to measure power level, axial flux imbalance, and radial flux imbalance. Suitable alarms are derived from these signals as described below.

Basic power range signals are:

A. Total current from a power range detector (four signals from separate detectors); these detectors are vertical and have a total active length of 10 ft.

B. Current from the upper half of each power range detector (four signals).

C. Current from the lower half of each power range detector (four signals).

The following (including standard signal processing for calibration) are derived from these basic signals:

A. Indicated nuclear power (four signals).

B. Indicated axial flux imbalance ($\Delta\phi$), derived from upper half flux minus lower half flux (four signals).

Alarm functions derived are as follows:

A. Deviation (maximum minus minimum of four) in indicated nuclear power.

B. Upper radial tilt (maximum to average of four) on upper half currents.

C. Lower radial tilt (maximum to average of four) on lower half currents.

Provision is made to continuously record, on the control board, the eight ion chamber signals; i.e., upper and lower currents for each detector. Nuclear power and axial imbalance are selectable for recording as well. Indicators are provided on the control board for nuclear power and for axial flux imbalance.

The axial flux difference imbalance deviation $\Delta\phi$ alarms are derived from the plant process computer which determines the 1-min averages of the excore detector outputs to monitor $\Delta\phi$ in the reactor core and alerts the operator where $\Delta\phi$ alarm conditions exist. Alarm messages are output immediately when $\Delta\phi$ exceeds the RAOC limits above a preset (50 percent) power level.

Additional background information on the nuclear instrumentation system can be found in reference 1.

7.7.1.3.2 Rod Position Monitoring

Two separate systems are provided to sense and display control rod position as described below:

A. Digital Rod Position Indication System

The digital rod position indication system measures the actual position of each control and shutdown rod using a detector which consists of discrete coils mounted concentrically with the rod drive pressure housing. The coils are located axially along the pressure housing and magnetically sense the entry and presence of the rod drive shaft through its center line. For each detector, the coils are interlaced into two data channels and are connected to the containment electronics (data A and B) by separate multiconductor cables. By employing two separate channels of information, the digital rod position indication system can continue to function (at reduced accuracy) when one channel fails. Multiplexing is used to transmit the digital position signals from the containment electronics to the control board display unit.

The control board display unit contains a column of light-emitting diodes (LEDs) for each rod. At any given time, the one LED illuminated in each column shows the position for that particular rod. Each rod has its position displayed to ±4 steps throughout its range of travel.

Included in the system is a rod at bottom signal for each rod that operates a local alarm. Also a control room annunciator is actuated when any shutdown rod or control bank A rod is at bottom.

B. Demand Position System

The demand position system counts pulses generated in the rod drive control system to provide a digital readout of the demanded bank position.

The demand position and digital rod position indication systems are separate systems, but safety criteria were not involved in the separation, which was a result only of operational requirements. Operating procedures require the reactor operator to compare the demand and indicated (actual) readings from the rod position indication system to verify operation of the rod control system.

7.7.1.3.3 Control Bank Rod Insertion Monitoring

When the reactor is critical, the normal indication of reactivity status in the core is the position of the control bank in relation to reactor power (as indicated by the reactor coolant system loop ΔT) and coolant average temperature. Insertion limits for the control banks are defined as a function of reactor power. Two alarms are provided for each control bank.

A. The low alarm alerts the operator of rod insertion approaching the control bank insertion limits.

B. The low-low alarm alerts the operator of rod insertion at or below the insertion bank limits. If actual control bank position is below the insertion limits, the operator is to initiate action per the Technical Specifications.

The purpose of the control bank rod insertion monitor is to give warning to the operator of excessive rod insertion. The insertion limit maintains sufficient core reactivity shutdown margin following reactor trip, provides a limit on the maximum inserted rod worth in the unlikely event of a hypothetical rod ejection, and limits rod insertion such that acceptable nuclear peaking factors are maintained. Since the amount of shutdown reactivity required for the design shutdown margin following a reactor trip increases with increasing power, the allowable rod insertion limits must be decreased (the rods must be withdrawn further) with increasing power. Two parameters which are proportional to power are used as inputs to the insertion monitor. These are the ΔT between the hot leg and the cold leg, which is a direct function of reactor power, and T_{avg}, which is programmed as a function of power. The rod insertion monitor uses parameters for each control rod bank as follows:

$$Z_{LL} + A(\Delta T)_{auct} + B(T_{avg})_{auct} + C$$

where:

Z_{LL} = maximum permissible insertion limit for affected control bank.

$(\Delta T)_{auct}$ = highest ΔT of all loops.

$(T_{avg})_{auct}$ = highest T_{avg} of all loops.

A, B, C = constants chosen to maintain $Z_{LL} \geq$ actual limit based on physics calculations.

The control rod bank demand position (Z) is compared to Z_{LL} as follows:

If $Z - Z_{LL} \leq D$, a low alarm is actuated.

If $Z - Z_{LL} \leq E$, a low-low alarm is actuated.

Since the highest values of T_{avg} and ΔT are chosen by auctioneering, a conservatively high representation of power is used in the insertion limit calculation.

Actuation of the low alarm alerts the operator of rod insertion approaching the control bank insertion limits. Actuation of the low-low alarm alerts the operator of rod insertion to at or below the control bank insertion limits. If actual control bank position is below the insertion limits, the operator is to initiate action per the Technical Specifications. The value of D is chosen such that the low alarm actuates above the low-low alarm. The value of E is chosen such that the low-low alarm actuates at the insertion limit except near the top of rod motion. Figure 7.7.1-2 shows a block diagram representation of the control rod bank insertion monitor. The monitor is shown in more detail on the functional diagrams shown in drawing 1X6AA02-233. In addition to the rod insertion monitor for the control banks, the plant computer, which monitors individual rod positions, provides an alarm that is associated with the rod deviation alarm (discussed in paragraph 7.7.1.3.4) which warns the operator if any shutdown rod cluster control assembly leaves the fully withdrawn position.

Rod insertion limits are established by:

A. Establishing the allowed rod reactivity insertion at full power consistent with the purposes given above.

B. Establishing the differential reactivity worth of the control rods when moved in normal sequence.

C. Establishing the change in reactivity with power level by relating power level to rod position.

D. Linearizing the resultant limit curve. All key nuclear parameters in this procedure are measured as part of the initial and periodic physics testing program.

Any unexpected change in the position of the control bank under automatic control (insertion only), or a change in coolant temperature under manual control, provides a direct and immediate indication of a change in the reactivity status of the reactor. In addition, samples are taken periodically of coolant boron concentration. Variations in concentration during core life provide an additional check on the reactivity status of the reactor, including core depletion.

7.7.1.3.4 Rod Deviation Alarm

The position of any control rod is compared to the position of other rods in the bank.

The demanded and measured rod position signals are monitored by the plant computer, which drives an input to the main control board annunciator system whenever an individual rod position signal deviates from the other rods in the bank by a preset limit. The alarm can be set with appropriate allowance for instrument error and within sufficiently narrow limits to preclude exceeding core design hot channel factors.

Figure 7.7.1-3 is a block diagram of the rod deviation comparator and alarm system implemented by the plant computer.

7.7.1.3.5 Rod Bottom Alarm

A rod bottom signal for the control and shutdown rods in the digital rod position indication system is used to operate a control relay which generates the "rod bottom rod drop" alarm.

7.7.1.4 Plant Control System Interlocks

The listing of the plant control system interlocks and the description of their derivations and functions are presented in table 7.7.1-1. The designation numbers for these interlocks are preceded by "C." The development of these logic functions is shown in the functional diagrams. (See drawings 1X6AA02-233, 1X6AA02-234, 1X6AA02-235, 1X6AA02-236, 1X6AA02-237, 1X6AA02-238, 1X6AA02-239, and 1X6AA02-240.)

7.7.1.4.1 Rod Stops

Rod stops are provided to prevent abnormal power conditions which could result from excessive control rod withdrawal initiated by either a control system malfunction or operator violation of administrative procedures.

Rod stops are the C-1 through C-4 control interlocks identified in table 7.7.1-1. The C-3 rod stop derived from overtemperature ΔT and the C-4 rod stop derived from overpower ΔT are also used for turbine runback, which is discussed below.

7.7.1.4.2 Automatic Turbine Load Runback

Automatic turbine load runback is initiated by an approach to an overpower or overtemperature condition. This will prevent high power operation that might lead to an undesirable condition which, if reached, will be protected by reactor trip.

Turbine load reference reduction is initiated by either an overtemperature or overpower ΔT signal. Two-out-of-four coincidence logic is used.

A rod stop and turbine runback are initiated for both the overtemperature and the overpower condition when:

$$\Delta T > \Delta T_{\text{rod stop}}$$

for either condition in general:

$$\Delta T_{\text{rod stop}} = \Delta T_{\text{setpoint}} - B_p$$

where:

$\Delta T_{\text{setpoint}}$ = overtemperature and overpower ΔT reactor trip value.

B_p = a setpoint bias.

The turbine runback is continued until ΔT is equal to or less than $\Delta T_{\text{rod stop}}$.

This function serves to maintain an essentially constant margin to trip.

7.7.1.4.3 Turbine Loading Stop

An interlock (C-16) is provided to limit turbine loading during a rapid return to power transient when a reduction in reactor coolant temperature is used to increase reactor power (through the negative moderator coefficient). This interlock limits the reduction in coolant temperature so that it does not reach cooldown accident limits and preserves satisfactory steam generator operating conditions. Subsequent automatic turbine loading can begin after the interlock has been cleared by anincrease in coolant temperature, which is accomplished by reducing the boron concentration in the coolant.

7.7.1.5 Pressurizer Pressure Control

The reactor coolant system pressure is controlled by using either the heaters (in the water region) or the spray (in the steam region) of the pressurizer plus steam relief for large transients. The electrical immersion heaters are located near the bottom of the pressurizer. A portion of the heater group is proportionally controlled to correct small pressure variations. These variations are caused by heat losses, including heat losses resulting from a small continuous spray. The remaining (backup) heaters are turned on when the pressurizer pressure controlled signal demands approximately 100-percent proportional heater power.

The spray nozzles are located on the top of the pressurizer. Spray is initiated when the pressure controller spray demand signal is above a given setpoint. The spray rate increases proportionally with the increasing spray demand signal until it reaches a maximum value. For additional information on the pressurizer heaters and their power supply, see subsection 5.4.10.

Steam condensed by the spray reduces the pressurizer pressure. A small continuous spray is normally maintained to reduce thermal stresses and thermal shock and to help maintain uniform water chemistry and temperature in the pressurizer.

Power relief valves limit system pressure for large positive pressure transients. In the event of a large load reduction, not exceeding the design plant load rejection capability, the pressurizer power-operated relief valves might be actuated for the most adverse conditions; e.g., the most negative Doppler coefficient and the minimum incremental rod worth. The relief capacity of the power-operated relief valves is sized large enough to limit the system pressure to prevent actuation of high-pressure reactor trip for the above condition.

A block diagram of the pressurizer pressure control system is shown on figure 7.7.1-4.

7.7.1.6 Pressurizer Water Level Control

The pressurizer operates by maintaining a steam cushion over the reactor coolant. As the density of the reactor coolant varies with temperature, the steam water interface is adjusted to compensate for cooling density variations with relatively small pressure disturbances.

The water inventory in the reactor coolant system is maintained by the chemical and volume control system. During normal plant operation, the charging flow varies to produce the flow demanded by the pressurizer water level controller. The pressurizer water level is programmed as a function of coolant average temperature, with the highest average temperature (auctioneered) being used. The pressurizer water level decreases as the load is reduced from full load. This is a result of coolant contraction following programmed coolant temperature reduction from full power to low power. The programmed level is designed to match as nearly as possible the level changes resulting from the coolant temperature changes.

To control pressurizer water level during startup and shutdown operations, the charging flow is manually regulated from the main control room. Low level in the pressurizer initiates a control-grade process protection signal to close the letdown isolation valves and deenergize the pressurizer heaters. This action is intended to maintain pressurizer level above the heaters. Failure of the letdown isolation valves to close and terminate letdown has been evaluated and has been found to have no impact on plant safety.

A block diagram of the pressurizer water level control system is shown on figure 7.7.1-5.

7.7.1.7 Steam Generator Water Level Control

Each steam generator is equipped with a three-element feedwater flow controller that maintains a programmed water level, which is capable of being controlled as a function of turbine load, but is really a fixed value. The three-element feedwater controller regulates the feedwater valve by continuously comparing the feedwater flow signal, the water level signal, the programmed level, and the pressure compensated steamflow signal.

The feedwater pump speed is varied to maintain sufficient discharge pressure to support feedwater flow demand. The speed controller receives a demand signal, which is a programmed function of the highest feedwater flow demand across all loops. Continued delivery of feedwater to the steam generators is required as a sink for the heat stored and generated in the reactor following a reactor trip and turbine trip. An override signal closes all feedwater valves when the average coolant temperature is below a given temperature and the reactor has tripped. Manual override of the feedwater control system is available at all times.

When the nuclear plant is operating at very low power levels (as during startup), the steam and feedwater flow signals will not be usable for control. Therefore, a secondary automatic control system is provided for operation at low power. This system uses the narrow range steam generator water level and wide range steam generator water level in a feed forward control scheme to position a bypass valve which is parallel to the main feedwater regulating valve. Transition from the bypass feedwater control system (low power) to parallel use of the main feedwater control valve is performed automatically by the control system at approximately 20-percent power. The feedwater control system automatically closes the bypass valve at approximately 40-percent power.

Block diagrams of the steam generator water level control system and the main feedwater pump speed control system are shown in figures 7.7.1-6 and 7.7.1-7.

7.7.1.8 Steam Dump Control

The plant is designed to accept a 50-percent loss of net load without tripping the reactor.

The automatic steam dump system is able to accommodate this abnormal load rejection and to reduce the effects of the transient imposed upon the reactor coolant system. By bypassing main steam directly to the condenser, an artificial load is thereby maintained on the primary system. The rod control system can then reduce the reactor temperature to a new equilibrium value without causing overtemperature and/or overpressure conditions. The steam dump steamflow capacity is 40 percent of full load steamflow at full load steam pressure.

If the difference between the reference T_{avg} (T_{ref}) based on turbine impulse chamber pressure and the lead-lag compensated auctioneered T_{avg} exceeds a predetermined amount, and if the interlock mentioned below is satisfied, a demand signal will actuate the steam dump to maintain the reactor coolant system temperature within control range until a new equilibrium condition is reached.

To prevent actuation of steam dump on small load perturbations, an independent load rejection sensing circuit is provided. This circuit senses the rate of decrease in the turbine load as detected by the turbine impulse chamber pressure. It is provided to unblock the dump valves when the rate of load rejection exceeds a preset value corresponding to a 10-percent step-load decrease or a sustained ramp-load decrease of 5 percent/min.

Steam dump solenoid valves and circuits in the turbine building are designed to criteria similar to the reactor trip on turbine trip circuits as described in paragraph 7.2.1.1.2.F. A block diagram of the steam dump control system is shown on figure 7.7.1-8.

7.7.1.8.1 Load Rejection Steam Dump Controller

This circuit prevents a large increase in reactor coolant temperature following a large, sudden load decrease. The error signal is a difference between the lead-lag compensated auctioneered T_{avg} and the reference T_{avg} is based on turbine impulse chamber pressure.

The T_{avg} signal is the same as that used in the reactor coolant system. The lead-lag compensation for the T_{avg} signal is to compensate for lags in the plant thermal response and in valve positioning. Following a sudden load decrease, T_{ref} is immediately decreased and T_{avg} tends to increase, thus generating an immediate demand signal for steam dump. Since control rods are available in this situation, steam dump terminates as the error comes within the maneuvering capability of the control rods.

7.7.1.8.2 Plant Trip Steam Dump Controller

Following a reactor trip, the load rejection steam dump controller is defeated and the plant trip steam dump controller becomes active. Since control rods are not available in this situation, the demand signal is the error signal between the lead-lag compensated auctioneered T_{avg} and the no-load reference T_{avg}. When the error signal exceeds a predetermined setpoint, the dump valves are tripped open in a prescribed sequence. As the error signal reduces in magnitude, indicating that the reactor coolant system T_{avg} is being reduced toward the reference no-load value, the dump valves are modulated by the plant trip controller to regulate the rate of removal of decay heat and thus gradually establish the equilibrium hot shutdown condition.

7.7.1.8.3 Steam Header Pressure Controller

Residual heat removal at operating temperature is maintained by the steam generator pressure controller (manually selected), which controls the amount of steamflow to the condensers. This controller operates a portion of the same steam dump valves to the condensers which are used during the initial transient following turbine or reactor trip on load rejection.

7.7.1.9 Incore Instrumentation

The incore instrumentation system consists of chromel-alumel thermocouples at fixed core outlet positions and movable miniature neutron detectors which can be positioned at the center of selected fuel assemblies anywhere along the length of the fuel assembly vertical axis. The basic system for insertion of these detectors is shown in figure 7.7.1-9.

7.7.1.9.1 Thermocouples

Chromel-alumel thermocouples are threaded into guide tubes that penetrate the reactor vessel head through seal assemblies and terminate at the exit flow end of the fuel assemblies. The thermocouples are provided with two primary seals, a core exit thermocouple nozzle assembly

(CETNA) and a swage-type seal from conduit to head. Thermocouple readings are monitored by the plant safety monitoring system.

7.7.1.9.2 Movable Neutron Flux Detector Drive System

Miniature fission chamber detectors can be remotely positioned in retractable guide thimbles to provide flux mapping of the core. The stainless steel detector shell is welded to the leading end of helical wrap drive cable and to stainless steel sheathed coaxial cable. The retractable thimbles, into which the miniature detectors are driven, are pushed into the reactor core through conduits which extend from the bottom of the reactor vessel down through the concrete shield area and then up to a thimble seal table. Their distribution over the core is nearly uniform, with about the same number of thimbles located in each quadrant.

The thimbles are closed at the leading ends, are dry inside, and serve as the pressure barrier between the reactor water pressure and the atmosphere. Mechanical seals between the retractable thimbles and the conduits are provided at the seal table. During reactor operation, the retractable thimbles are stationary. They are extracted downward from the core during refueling to avoid interference within the core. A space above the seal table is provided for the retraction operation.

The drive system for the insertion of the miniature detectors consists basically of drive assemblies, 5-path transfer assemblies, and 10-path transfer assemblies, as shown in figure 7.7.1-9. The drive system pushes hollow helical wrap drive cables into the core with the miniature detectors attached to the leading ends of the cables and small diameter sheathed coaxial cables threaded through the hollow centers back to the ends of the drive cables. Each drive assembly consists of a gear motor which pushes a helical wrap drive cable and a detector through a selective thimble path by means of a special drive box and includes a storage device that accommodates the total drive cable length. Each thimble location can be accessed by at least two detectors controlled from different drive units.

7.7.1.9.3 Control and Readout Description

The control and readout system provides means for inserting the miniature neutron detectors into the reactor core and withdrawing the detectors while plotting neutron flux versus detector position. The control system is located in the control room. Limit switches in each transfer device provide feedback of path selection operation. Each gearbox drives a resolver for position feedback. One five-path transfer selector is provided for each drive unit to insert the detector in one of five functional modes of operation. One 10-path transfer is also provided for each drive unit that is then used to route a detector into any one of up to 10 selectable paths. A common path is provided to permit cross-calibration of the detectors.

The control room contains the necessary equipment for control, position indication, and flux recording for each detector.

A flux mapping consists, briefly, of selecting flux thimbles in given fuel assemblies at various core quadrant locations. The detectors are driven to the top of the core and stopped automatically. An x-y plot (position versus flux level) is initiated with the slow withdrawal of the detectors through the core from top to a point below the bottom. In a similar manner other core locations are selected and plotted. Each detector provides axial flux distribution data along the center of a fuel assembly.

Various radial positions of detectors are then compared to obtain a flux map for a region of the core.

The number and location of these thimbles have been chosen to permit measurement of local to average peaking factors (F_Q) to an accuracy of ±5 percent (95-percent confidence). Measured nuclear peaking factors (F_Q) will be increased by 5 percent to allow for this accuracy, when using ≥ 44 detector thimbles. When using ≥ 29 and < 44 detector thimbles, the measurement uncertainty is 1.05 + [2.0 {3-T / (14.5)}] / 100, where T equals the number of thimbles (reference 45). If the measured power peaking is larger than acceptable, reduced power capability will be indicated.

Operating plant experience has demonstrated the adequacy of the incore instrumentation in meeting the design bases stated.

7.7.1.10 Boron Concentration Measurement System

The boron concentration measurement system utilizes a sample measurement unit which contains a neutron source and neutron detector located in a shield tank. Piping within the shield tank is arranged to maintain coolant sample flow between the neutron source and the neutron detector. Neutron absorption by the boron in the coolant sample flow reduces the number of neutrons which contact the detector per unit time. Therefore, the time required to count a fixed number of neutron contacts is variable and dependent upon the concentration of boron solution.

The sample tank subassembly of the BCMS consists of a 100 gallon stainless steel tank with a cover assembly which includes the annular sample chamber, heat exchange coil, source and detector holders, temperature monitoring and control hardware, and all necessary plumbing. The sample tank is filled with water which provides for coolant sample temperature control and shielding for the neutron source (Am-Be). The sample tank subassembly is designed so that all tank connections are at the top or near the top to preclude the possibility of loss of water shielding due to accidental leakage.

The boron concentration measurement system is designed for use as an advisory system. It is not designed as a safeguards system or component of a safeguards system. The boron concentration measurement system is not part of a control element or control system nor is it designed for this use. No credit is taken for this system in any accident analysis. Therefore, redundancies of measurement components, self-checking subsystems, malfunction annunciations, and diagnostic circuitry are not included in this system. As a general operating aid it provides information as to when additional check analyses are warranted rather than as a basis for fundamental operating decisions.

7.7.1.11 ATWS Mitigation System Actuation Circuitry (AMSAC) Description

7.7.1.11.1 System Description

The ATWS (anticipated transient without scram) mitigation system actuation circuitry (AMSAC) provides a backup to the reactor trip system (RTS) and engineered safety features (ESF) actuation system (ESFAS) for initiating turbine trip and auxiliary feedwater flow in the event of an anticipated transient (e.g., in the event of complete loss of main feedwater). The AMSAC is independent of and diverse from the RTS and the ESFAS with the exception of the final actuation devices and is classified as non-Class 1E. It is a highly-reliable, microprocessor-based, single-train system powered by a non-Class 1E source. The AMSAC meets the applicable requirements of Part 50.62 of Title 10 of the Code of Federal Regulations and the quality assurance requirements of NRC Generic Letter 85-06. No other standards apply to the AMSAC.

The AMSAC continuously monitors main feedwater flow, which is an anticipatory indication of a loss of heat sink, and initiates certain functions when the flow drops below a predetermined setpoint in three of the four main feedwater lines for a delayed amount of time (dependent on turbine load). These initiated functions are the tripping of the turbine, the initiation of auxiliary feedwater, and isolation of the steam generator blowdown and sample lines.

The AMSAC is designed to be highly reliable, resistant to inadvertent actuation, and easily maintained. Reliability is assured through the use of internal redundancy and continual self-testing by the system. Inadvertent actuations are minimized through the use of internal redundancy and majority voting at the output stage of the system. The time delay on the low main feedwater flow and the coincidence logic used also minimize inadvertent actuations.

The AMSAC automatically performs its actuations when above a preselected power level, which is determined using turbine impulse chamber pressure, and remains armed sufficiently long after that pressure drops below the setpoint to ensure that its function will be performed in the event of a turbine trip.

7.7.1.11.2 Equipment Description

The AMSAC consists of a single train of equipment located in a seismically qualified cabinet.

The design of the AMSAC is based on the industry standard Intel multibus format, which permits the use of various readily available, widely used microprocessor cards on a common data bus for various functions.

The AMSAC consists of the following:

1. System Hardware

   The system hardware consists of two primary systems: the actuation logic system (ALS) and the test/ maintenance system (T/MS).

   A. Actuation Logic System

      The ALS monitors the analog and digital inputs, performs the functional logic required, provides actuation outputs to trip the turbine and initiate auxiliary feedwater flow, and provides status information to the test/maintenance system. The ALS consists of three groups of input/output (I/O) modules, three actuation logic processors (ALPs), two majority voting modules, and two output relay panels. The I/O modules provide signal conditioning, isolation, and test features for interfacing the ALS and T/MS. Conditioned signals are sent to three identical ALPs for analog-to-digital conversion, setpoint comparison, and coincidence logic performance. Each of the ALPs perform identical logic calculations using the same inputs and derive component actuation demands, which are then sent to the majority voting modules. The majority voting modules perform a two-out-of-three vote on the ALP demand signals. These modules drive the relays providing outputs to the existing turbine trip and auxiliary feedwater initiation circuits. A simplified block diagram of the AMSAC ALS architecture is presented in figure 7.7.1-14.

B. Test/Maintenance System

The test/maintenance system provides the AMSAC with automated and manual testing as well as a maintenance mode. Automated testing is the continuously performed self-checking done by the system during normal operation. ALS status is monitored by the T/MS and sent to the plant computer and the main control board. Manual testing of the system can be performed on-line to provide assurance that the ALS system is fully operational. The maintenance mode permits, under administrative control, modification of channel setpoints, channel status and timer values, and initiation of channel calibration.

The T/MS consists of a test/maintenance processor, a digital-to-analog conversion board, a memory board, expansion boards, a self-health board, digital output modules, a test/maintenance panel, and a portable terminal/printer.

2. Feedwater Flow Sensing

The AMSAC utilizes the feedwater flow signal as measured with the four differential pressure-type flow transmitters, one for each of the main feedwater lines shown in drawing 1X6AA02-231.

3. Turbine Impulse Pressure

The AMSAC also utilizes the turbine impulse pressure signal as measured with two pressure transmitters located in the steam supply line near the turbine shown in drawing 1X6AA02-240.

4. Equipment Actuation

The output relay panels provide component actuation signals through isolation relays, which then drive the final actuation circuitry shown in drawings 1X6AA02-239 and 1X6AA02-240 for initiation of auxiliary feedwater and for turbine trip.

7.7.1.11.3 Functional Performance Requirements

Analyses have shown that the most limiting ATWS event is a loss of feedwater event without a reactor trip. AMSAC performs the mitigative actuations of automatically initiating auxiliary feedwater, tripping the turbine, and isolating the steam generator blowdown and sampling lines. These are initiated in order to ensure a secondary heat sink following an anticipated transient (ANS Condition II) without a reactor trip, in order to limit core damage following an anticipated transient without a reactor trip, and to ensure that the energy generated in the core is compatible with the design limits to protect the reactor coolant pressure boundary by maintaining the reactor coolant pressure to within ASME Stress Level C.

7.7.1.11.4 AMSAC Interlocks

A single interlock, designated as C-20, is provided to allow for the automatic arming and blocking of the AMSAC (see table 7.7.1-1). The system is blocked at sufficiently low reactor power levels when the actions taken by the AMSAC following an ATWS need not be automatically initiated. Turbine impulse chamber pressure in a two-out-of-two logic scheme is used for this permissive. Turbine impulse chamber pressure above the setpoint will automatically defeat any block, i.e., will arm the AMSAC. Dropping below this setpoint will automatically block the AMSAC. Removal of the C-20 permissive is automatically delayed for a predetermined time. The operating status of the AMSAC is displayed on the main control board.

7.7.1.11.5 Trip System

The feedwater flow and turbine impulse chamber pressure inputs are used by the AMSAC to determine trip demand. Signal conditioning is performed on the transmitter output and used by each of the ALPs to derive a component actuation demand. If three of the four feedwater lines have a low flow at a power level greater than the C-20 permissive, then a trip demand signal is generated. This signal drives output relays for performing the necessary mitigative actions.

7.7.1.11.6 Isolation Devices

AMSAC is independent of the reactor trip and engineered safety features actuation systems. The AMSAC feedwater flow inputs are non-Class 1E signals from the process control cabinets. No isolation into AMSAC is needed for these inputs. The AMSAC turbine impulse chamber pressure inputs are made downstream of Class 1E isolation devices, which are located within the process protection cabinets. These isolation devices ensure that the existing protection system continues to meet all applicable safety criteria by providing isolation. Buffering of the AMSAC outputs from the safety-related final actuation device circuits is achieved through qualified relays. A credible fault occurring in the nonsafety-related AMSAC will not propagate through and degrade the RTS and ESFAS.

7.7.1.11.7 AMSAC Diversity from the Reactor Protection Systems

Equipment diverse from the RTS and ESFAS is used in the AMSAC to prevent common mode failures that might affect the AMSAC and the RTS or ESFAS. The AMSAC is a digital, microprocessor-based system with the exception of the analog feedwater flow and turbine impulse pressure transmitter inputs, whereas the reactor trip system utilizes an analog-based protection system. Also where similar components are utilized for the same function in both AMSAC and the reactor trip system, the components used in AMSAC are provided from a different manufacturer.

Common mode failure of identical components in the analog portion of the RTS that results in the inability to generate a reactor trip signal will not impact the ability of the digital AMSAC to generate the necessary mitigative actuations. Similarly, a postulated common mode failure affecting analog components in ESFAS, affecting its ability to initiate auxiliary feedwater, will not impact the ability of the digital-based AMSAC to automatically initiate auxiliary feedwater.

7.7.1.11.8 Power Supply

The AMSAC power supply is a non-Class 1E vital bus, which is independent from the RTS power supplies, and is backed by batteries which are independent from the existing batteries which supply the RTS.

7.7.1.11.9 Environmental Variations

AMSAC equipment is not designed as safety-related equipment; therefore, it is not required to be qualified as safety-related equipment. The AMSAC equipment is located in a controlled environment such that variations in the ambient conditions are minimized. No AMSAC equipment is located inside containment. The transmitters (feedwater flow and turbine impulse chamber pressure) that supply the input into AMSAC are located outside containment and the turbine building, respectively, and are qualified for the environment in which they are located.

7.7.1.11.10 Setpoints

The AMSAC makes use of two setpoints in the coincidence logic in order to determine whether mitigative functions are required. Feedwater flow in each main feedwater line is sensed to determine a loss of secondary heat sink is imminent. The low-flow setpoint is selected in such a manner that a true lowering of the flow will be detected by the system. The normal small variations in feedwater flow will not result in a spurious AMSAC signal.

The C-20 permissive setpoint is selected in order to be consistent with ATWS investigations showing that the mitigative actions performed by the AMSAC need not be automatically actuated below a certain power level. The maximum allowable value of the C-20 permissive setpoint is defined by these investigations.

To avoid inadvertent AMSAC actuation on the loss of one main feedwater pump, a time delay unit is required on the low main feedwater flow channels to adjust the AMSAC actuation response time. The delay unit is designed such that the delay time is dependent on turbine power. This will ensure the reactor protection system will provide the first trip signals.

To ensure that the AMSAC remains armed sufficiently long to permit its function in the event of a turbine trip, the C-20 permissive is maintained for a preset time delay, after the turbine impulse chamber pressure drops below the setpoint.

The setpoints and the capability for their modification in the AMSAC are under administrative control.

7.7.1.12 REFERENCE

1. Lipchak, J. B., "Nuclear Instrumentation System," WCAP-8255, January 1974 (for additional background information only).

7.7.2 ANALYSIS OF CONTROL SYSTEMS NOT REQUIRED FOR SAFETY

The plant control systems are designed to ensure high reliability in any anticipated operational occurrences. Equipment used in these systems is designed and constructed with a high level of reliability.

Proper positioning of the control rods is monitored in the control room by bank arrangements of the individual position columns for each rod cluster control assembly (RCCA). A rod deviation alarm alerts the operator of a deviation of one RCCA from the other rods in that bank position. There are also insertion limit monitors with visual and audible annunciation. A rod bottom alarm signal is provided to the control room for each full-length RCCA. Four excore long ion chambers also detect asymmetrical flux distribution indicative of rod misalignment.

Overall reactivity control is achieved by the combination of soluble boron and RCCAs. Long-term regulation of core reactivity is accomplished by adjusting the concentration of boric acid in the reactor coolant. Short-term reactivity control for power changes is accomplished by the plant control system, which automatically moves RCCAs. This system uses input signals including neutron flux, coolant temperature, and turbine load.

The axial core power distribution is controlled by moving the control rods through changes in reactor coolant system boron concentration. Adding boron causes the rods to move out, thereby reducing the amount of power in the bottom of the core; this allows power to redistribute toward the top of the core. Reducing the boron concentration causes the rods to move into the core, thereby reducing the power in the top of the core; the result redistributes power toward the bottom of the core.

The plant control systems will prevent an undesirable condition in the operation of the plant that, if reached, will be protected by reactor trip. The description and analysis of this protection is covered in section 7.2. Worst-case failure modes of the plant control systems are postulated in the analysis of off-design operational transients and accidents covered in chapter 15, such as the following:

- Uncontrolled RCCA bank withdrawal from a subcritical or low power startup condition.
- Uncontrolled RCCA bank withdrawal at power.
- RCCA misalignment.
- Loss of external electrical load and/or turbine trip. Loss of all nonemergency ac power to the station auxiliaries (station blackout).
- Feedwater system malfunctions that result in a decrease in feedwater temperature.
- Excessive increase in secondary steamflow.
- Inadvertent opening of a steam generator relief or safety valve.

These analyses show that a reactor trip setpoint is reached in time to protect the health and safety of the public under those postulated incidents and that the resulting coolant temperatures produce a departure from nucleate boiling ratio well above the limiting value. Thus, there will be no cladding damage and no release of fission products to the reactor coolant system under the assumption of these postulated worst-case failure modes of the plant control system.

7.7.2.1 Separation of Protection and Control System

In some cases, it is advantageous to employ control signals derived from individual protection channels through isolation amplifiers contained in the protection channel. As such, a failure in the control circuitry does not adversely affect the protection channel. Test results have shown that a short circuit or the application (credible fault voltage from within the cabinets) of 118-V ac or 140-V dc on the isolated output portion of the circuit (nonprotection side of the circuit) will not affect the input (protection) side of the circuit.

Where a single random failure can cause a control system action that results in a generating station condition requiring protective action and can also prevent proper action of a protection system channel designed to protect against the condition, the remaining redundant protection channels are capable of providing the protective action even when degraded by a second random failure. This meets the applicable requirements of section 4.7 of Institute of Electrical and Electronic Engineers (IEEE) Standard 279-1971.

The pressurizer pressure channels needed to derive the control signals are electrically isolated from control.

7.7.2.2 Response Considerations of Reactivity

Reactor shutdown with control rods is completely independent of the control functions, since the trip breakers interrupt power to the rod drive mechanisms regardless of existing control signals. The design is such that the system can withstand accidental withdrawal of control groups or unplanned dilution of soluble boron without exceeding acceptable fuel design limits. The design meets the requirements of General Design Criterion 25.

No single electrical or mechanical failure in the rod control system could cause the accidental withdrawal of a single RCCA from the partially inserted bank at full power operation. The operator could deliberately withdraw a single RCCA in the control bank; this feature is necessary in order to retrieve a rod, should one be accidentally dropped. In the extremely unlikely event of simultaneous electrical failures which could result in single RCCA withdrawal, rod deviation would be displayed on the plant annunciator, and the individual rod position readouts would indicate the relative positions of the rods in the bank. Withdrawal of a single RCCA by operator action, whether deliberate or by a combination of errors, would result in activation of the same alarm and the same visual indications.

Each bank of control and shutdown rods in the system is divided into two groups of up to four or five mechanisms each. The rods comprising a group operate in parallel through multiplexing thyristors. The two groups in a bank move sequentially, such that the first group is always within one step of the second group in the bank. The group 1 and group 2 power circuits are installed in different cabinets, as shown in figure 7.7.2-1, which also shows that one group is always within one step (5/8 in.) of the other group. A definite schedule of actuation or deactuation of the stationary gripper, movable gripper, and lift coils of a mechanism is required to withdraw the RCCA attached to the mechanism. Since the four stationary gripper, movable gripper, and lift coils associated with the RCCAs of a rod group are driven in parallel, any single failure which could cause rod withdrawal would affect a minimum of one group of RCCAs. As a result of Generic Letter 93-04, "Rod Control System Failure and Withdrawal of Rod Control Cluster Assemblies, 10 CFR 50.54(f)," a test is performed following each refueling outage which ensures that the proper current order timing for the grippers and lift coils is maintained. Mechanical failures are in the direction of insertion or immobility.

Figure 7.7.2-2 illustrates the design features that ensure no single electrical failure could cause the accidental withdrawal of a single RCCA from the partially inserted bank at full power operation.

Figure 7.7.2-2 shows the typical parallel connections on the lift, movable, and stationary coils for a group of rods. Since single failures in the stationary or movable circuits will result in dropping or preventing rod (or rods) motion, the discussion of single failure will be addressed to the lift coil circuits:

A. Because of the method of wiring the pulse transformers which fire the lift coil multiplex thyristors, three of the four thyristors in a rod group could remain turned off when required to fire, if for example the gate signal lead failed open at point X_1. Upon "up" demand, one rod in group 1 and four rods in group 2 would withdraw. A second failure at point X_2 in the group 2 circuit is required to withdraw one RCCA.

B. Timing circuit failures will affect the four mechanisms of a group or the eight mechanisms of the bank and will not cause a single rod withdrawal.

C. More than two simultaneous component failures are required (other than the open wire failures) to allow withdrawal of a single rod.

The identified multiple failures involving the least number of components consists of open circuit failure of the proper 2 out of 16 wires connected to the gate of the lift coil thyristors. The probability of open wire (or terminal) failure is 0.016×10^{-6} per hour by MIL-HDB217A. These wire failures would have to be accompanied by failure or disregard of the indications mentioned above. The probability of this occurrence is therefore too low to have any significance.

Concerning the human element, to erroneously withdraw a single rod cluster control assembly, the operator would have to improperly set the bank selector switch, the lift coil disconnect switches, and the in-hold-out switch. In addition, the three indications would have to be disregarded or ineffective. Such series of errors would require a complete lack of understanding and administrative control. A probability number cannot be assigned to a series of errors such as these.

The rod position indication system provides direct visual displays of each control rod assembly position. The plant computer alarms for deviation of rods from their banks. In addition, a rod insertion limit monitor provides an audible and visual alarm to warn the operator of an approach to an abnormal condition resulting from dilution. The low-low insertion limit alarm alerts the operator to follow emergency boration procedures. The facility reactivity control systems are such that acceptable fuel damage limits will not be exceeded even in the event of a single malfunction of either system.

An important feature of the control rod system is that insertion is provided by gravity fall of the rods.

In all analyses involving reactor trip, the single highest worth rod cluster control assembly is postulated to remain untripped in its full out position.

One means of detecting a stuck control rod assembly is available from the actual rod position information displayed on the control board. The control board position readouts, one for each rod, give the plant operator the actual position of the rod in steps. The indications are grouped by banks (e.g., control bank A, control bank B, etc.) to indicate to the operator the deviation of one rod with respect to other rods in a bank. This serves as a means to identify rod deviation.

The plant computer monitors the actual position of all rods. Should a rod be misaligned from the other rods in that bank by more than 12 steps, the rod deviation alarm is actuated.

Misaligned RCCAs are also detected and alarmed in the control room via the flux tilt monitoring system, which is independent of the plant computer.

Isolated signals derived from the nuclear instrumentation system are compared with one another to determine whether a preset amount of deviation of average power level has occurred. Should such a deviation occur, the comparator output will operate a bistable unit to actuate a control board annunciator. This alarm will alert the operator to a power imbalance caused by a misaligned rod. By use of individual rod position readouts, the operator can determine the deviating control rod and take corrective action. The design of the plant control systems meets the requirements of General Design Criterion 23.

Refer to section 4.3 for additional information on response considerations resulting from reactivity.

7.7.2.3 Step-Load Changes Without Steam Dump

The plant control system is capable of restoring equilibrium conditions, without a trip, following a ±10-percent step change in load demand, over the 15- to 100-percent power range. Automatic control allows control rod insertion only. Control rod withdrawal can only be performed manually. Steam dump is blocked for load decrease less than or equal to 10 percent. A load demand greater than full power is prohibited by the turbine control valve position limit.

The plant control system minimizes the reactor coolant average temperature deviation during the transient within a given value and restores average temperature to the programmed setpoint.

Excessive pressurizer pressure variations are prevented by using spray and heaters and power relief valves in the pressurizer.

The control system must limit nuclear power overshoot to acceptable values following a 10- to 100-percent increase in load.

7.7.2.4 Loading and Unloading

Ramp loading and unloading of 5 percent/min can be accepted over the 15- to 100-percent power range under manual control for loading and automatic control for unloading without tripping the plant. Control rod insertion may be performed automatically. However, control rod withdrawal can only be performed manually. The function of the control system is to maintain the coolant average temperature as a function of turbine-generator load.

The coolant average temperature increases during loading and causes a continuous insurge to the pressurizer as a result of coolant expansion. The sprays limit the resulting pressure increase. Conversely, as the coolant average temperature is decreasing during unloading, there is a continuous outsurge from the pressurizer resulting from coolant contraction. The pressurizer heaters limit the resulting system pressure decrease. The pressurizer water level is programmed such that the water level is above the setpoint for heater cutout during the loading and unloading transients. The primary concern during loading is to limit the overshoot in nuclear power and to provide sufficient margin in the overtemperature ΔT setpoint.

The automatic load controls are designed to adjust the unit generation to match load requirements within the limits of the unit capability and licensed rating.

During rapid loading transients, a drop in reactor coolant temperature is sometimes used to increase core power. (Refer to paragraph 3.9.N.1.1.1.5.) This mode of operation is applied when the control rods are not inserted deep enough into the core to supply all the reactivity requirements of the rapid load increase. (The boron control system is relatively ineffective for rapid power changes.) The reduction in temperature is initiated by continued turbine loading past the point where the control rods are completely withdrawn from the core. The temperature drop is recovered and nominal conditions restored by a boron dilution operation.

Excessive drops in coolant temperature are prevented by interlock C-16. This interlock circuit monitors the auctioneered low coolant temperature indications and the programmed reference temperature, which is a function of turbine impulse pressure, and stops the turbine loading sequence when the decreased temperature reaches the setpoints.

7.7.2.5 Load Rejection Furnished by Steam Dump System

When a load rejection occurs and if the difference between the required temperature setpoint of the reactor coolant system and the actual average temperature exceeds a predetermined amount, a signal will actuate the steam dump to maintain the reactor coolant system temperature within control range until a new equilibrium condition is reached.

The reactor power is reduced at a rate consistent with the capability of the rod control system. Reduction of the reactor power is automatic. The steam dump flow reduction is as fast as RCCAs are capable of inserting negative reactivity.

The rod control system can then reduce the reactor temperature to a new equilibrium value without causing overtemperature and/or overpressure conditions. The steam dump steamflow capacity is 40 percent of full load steamflow at full load steam pressure.

The steam dump flow decreases proportionally as the control rods act to reduce the average coolant temperature. The artificial load is therefore removed as the coolant average temperature is restored to its programmed equilibrium value.

The dump valves are modulated by the reactor coolant average temperature signal. The required number of steam dump valves can be tripped quickly to stroke full open or modulate, depending upon the magnitude of the temperature error signal resulting from loss of load.

7.7.2.6 Turbine-Generator Trip with Reactor Trip

Whenever the turbine-generator unit trips at an operating power level above 40-percent power on Unit 1 and 50-percent power on Unit 2, the reactor also trips. The unit is operated with a programmed average temperature as a function of load, with the full load average temperature significantly greater than the temperature corresponding to saturation pressure at the steam generator safety valve setpoint. The thermal capacity of the reactor coolant system is greater than that of the secondary system, and because the full load average temperature is greater than the no-load temperature, a heat sink is required to remove heat stored in the reactor coolant to prevent actuation of steam generator safety valves for a trip from full power. This heat sink is provided by the combination of controlled release of steam to the condenser and by makeup of feedwater to the steam generators.

The steam dump system is controlled from the reactor coolant average temperature signal, whose setpoint values are programmed as a function of turbine load. Actuation of the steam dump is rapid to prevent actuation of the steam generator safety valves. With the dump valves open, the average coolant temperature starts to reduce quickly to the no-load setpoint. A direct feedback of temperature acts to proportionally close the valves to minimize the total amount of steam which is bypassed.

The feedwater flow is cut off following a reactor trip when the average coolant temperature decreases below a given temperature or when the steam generator water level reaches a given high level.

Additional feedwater makeup is then controlled manually to restore and maintain steam generator water level, while ensuring that the reactor coolant temperature is at the desired value. Residual heat removal is maintained by the steam header pressure controller (manually selected) which controls the amount of steamflow to the condensers. This controller operates a portion of the same steam dump valves to the condensers which are used during the initial transient following turbine and reactor trip.

The pressurizer pressure and water level fall rapidly during the transient because of coolant contraction. The pressurizer water level is programmed so that the level following the turbine and reactor trip is above the heaters. However, if the heaters become uncovered following the trip, the chemical and volume control system will provide full charging flow to restore water level in the pressurizer. Heaters are then turned on to restore pressurizer pressure to normal.

The steam dump and feedwater control systems are designed to prevent the average coolant temperature from falling below the programmed no-load temperature following the trip to ensure adequate reactivity shutdown margin.

7.7.2.7 Core Cooling Monitor

A core cooling monitor (T saturation meter) is provided to meet the requirements of item II.F.2 of NUREG-0737 to provide instrumentation for the detection of inadequate core cooling. For information on the system see the "Summary Report, Westinghouse Reactor Vessel Level Instrumentation System for Monitoring Inadequate Core Cooling."(1)

The core cooling monitor utilizes inputs from the existing hot leg resistance temperature detectors, selected incore thermocouples, and the reactor coolant system pressure sensors. The plant safety monitoring system (PSMS) is employed to calculate the reactor coolant system saturation temperature for the existing system pressure, compares this value to the measured reactor coolant system temperature, and continuously indicates the margin-to-saturation on the PSMS plasma display. Margin-to-saturation is available on the PSMS plasma display based on both auctioneered high hot leg temperature and on auctioneered high incore thermocouples. In addition to the plasma display, alarms are provided to indicate first the development of off-normal conditions and then the approach to loss of normal core cooling.

Details of seismic and environmental qualification can be found in sections 3.10 and 3.11.

Procedures for safety injection and natural circulation require the operator to monitor reactor coolant system temperature for subcooling conditions during the initial phase of the incident and during followup conditions when natural circulation is being verified.

7.7.2.8 Reactor Vessel Level Instrumentation System

A reactor vessel level instrumentation system (RVLIS) is provided to meet the requirement of item II.F.2 of NUREG-0737 to provide instrumentation for the detection of inadequate core cooling. For information on the system see the "Summary Report, Westinghouse Reactor Vessel Level Instrumentation System for Monitoring Inadequate Core Cooling."(1)

Reactor vessel level is also utilized to indicate the need to vent noncondensable gases from the reactor vessel head. The RVLIS utilizes two sets of differential pressure cells to measure reactor vessel level.

The narrow range RVLIS instrument provides an indication of reactor vessel water level from the bottom of the reactor vessel to the top of the reactor vessel when one or no reactor coolant pump is operating. The narrow range instrument also measures the reactor core and internals pressure drop and therefore provides an indication of the relative void content or density of the circulating fluid, when only one reactor coolant pump is operating. When more than one reactor coolant pump is operating, the narrow range instrument reading will be off scale.

The wide range RVLIS instrument provides an indication of reactor core, internals, and outlet nozzle pressure drop for any combination of operating reactor coolant pumps. Comparison of the measured pressure drop with the normal, single-phase pressure drop provides an approximate indication of the relative void content or density of the circulating fluid. The wide range instrument monitors vessel level on a continuous basis.

Details of the seismic and environmental qualification can be found in sections 3.10 and 3.11.

7.7.2.9 Control Systems Failure Analysis

An analysis has been performed on VEGP to confirm that the consequences of a random initiating failure in a control system or its supporting systems will not cause plant conditions more severe than those bounded by the chapter 15 analysis (multiple independent failures are excluded). The analysis addressed the consequences of control system failures due to the following:

- Loss of any single instrument.
- Break of any single instrument line.
- Loss of power to a single inverter.
- Loss of power to a protection set.
- Loss of power to a control group.

7.7.2.10 Anticipated Transient Without Scram (ATWS) Mitigation System Actuation Circuitry (AMSAC) Analysis

7.7.2.10.1 Safety Classification/Safety-Related Interface

The AMSAC is not safety-related and therefore need not meet the requirements of IEEE 279-1971. The AMSAC has been implemented such that the reactor trip system (RTS) and the engineered safety features (ESF) actuation system (ESFAS) continue to meet all applicable safety-related criteria. The AMSAC is independent of the RTS and ESFAS. The isolation provided between the RTS and the AMSAC and between the ESFAS and the AMSAC by the isolator modules and the isolation relays ensures that the applicable safety-related criteria are met for the RTS and the ESFAS.

7.7.2.10.2 Redundancy

System redundancy has not been provided. Since AMSAC is a backup nonsafety-related system to the redundant RTS, redundancy is not required. To ensure high system reliability, portions of the AMSAC have been implemented as internally redundant, such that a single failure of an input channel or actuation logic processor (ALP) will neither actuate nor prevent actuation of the AMSAC.

7.7.2.10.3 Diversity

Diverse equipment has been selected in order that common cause failures affecting both the RTS and the AMSAC or both the ESFAS and the AMSAC will not render these systems inoperable simultaneously. A more detailed discussion of the diversity between the RTS and the AMSAC and between the ESFAS and the AMSAC is presented in paragraph 7.7.1.11.7.

7.7.2.10.4 Electrical Independence

The AMSAC is electrically independent of the RTS and ESFAS from the process control cabinets up to the final actuation devices. Isolation devices are provided to isolate the nonsafety AMSAC circuitry from the safety-related actuation circuits of the auxiliary feedwater system as discussed in 7.7.1.11.6.

7.7.2.10.5 Physical Separation from the RTS and ESFAS

AMSAC needs to be and is physically separated from the existing protection system hardware. The AMSAC outputs are provided from separate relay panels within the cabinets. The two trains are separated (in accordance with Regulatory Guide 1.75, Rev. 2) within the AMSAC cabinet by a combination of metal barriers, conduit, and distance.

7.7.2.10.6 Environmental Qualification

Equipment related to the AMSAC is qualified to operate under conditions resulting from anticipated operational occurrences for the respective equipment location. The AMSAC equipment, with the exception of the isolation devices located outside containment in a mild environment, is not designated as safety-related equipment and therefore is not required to be qualified as safety related per the requirements of IEEE Standard 279-1971, "IEEE Standard for Criteria for Protection Systems for Nuclear Power Generating Stations."

7.7.2.10.7 Seismic Qualification

It is required that only the isolation devices comply with seismic qualification. The AMSAC output isolation device is qualified in accordance with a program that was developed to implement the requirements of IEEE Standard 344-1975, "IEEE Standard for Seismic Qualification of Class 1E Electrical Equipment for Nuclear Power Generating Stations."

7.7.2.10.8 Test, Maintenance, and Surveillance Quality Assurance

NRC Generic Letter 85-06, "Quality Assurance Guidance for ATWS Equipment that is not Safety Related," requires quality assurance procedures commensurate with the nonsafety-related classification of the AMSAC. The quality controls for the AMSAC are, at a minimum, consistent with existing plant procedures or practices for nonsafety-related equipment.

Design of the AMSAC followed procedures relating to equipment procurement, document control, and specification of system components, materials, and services. In addition, specifications also define quality assurance practices for inspections, examinations, storage, shipping, and tests as appropriate to a specific item or service.

A computer software verification program and a firmware validation program have been implemented commensurate with the nonsafety-related classification of the AMSAC to ensure that the system design requirements implemented with the use of software have been properly implemented and to ensure compliance with the system functional, performance, and interface requirements.

System testing is completed prior to the installation and operation of the AMSAC, as part of the normal factory acceptance testing and the validation program. Periodic testing is performed both automatically through use of the system automatic self-checking capability, and manually, under administrative control via the AMSAC test/maintenance panel.

7.7.2.10.9 Power Supply

Power to the AMSAC is from a battery-backed, non-Class 1E vital bus independent of the power supplies for the RTS and ESFAS. The station battery supplying power to the AMSAC is independent of those used for the RTS and ESFAS. The AMSAC is an energize-to-actuate system capable of performing its mitigative functions with a loss of offsite power.

7.7.2.10.10 Testability at Power

The AMSAC is testable at power. This testing is done via the system test/maintenance panel. The capability of the AMSAC to perform its mitigative actuations is bypassed at a system level while in the test mode. Total system testing is performed as a set of three sequential, partial, and overlapping tests. The first of the tests checks the analog input portions of the AMSAC in order to verify accuracy. Each of the analog input modules is checked separately. The second test checks each of the ALPs to verify that the appropriate coincidence logic is sent to the majority voter. Each ALP is tested separately. The last test exercises the majority voter and the integrity of the associated output relays. The majority voter and associated output relays are tested by exercising all possible input combinations to the majority voter. The integrity of each of the output relays is checked by confirming continuity of the relay coils without operating the relays. The capability to individually operate the output relays, confirm integrity of the associated field wiring, and operate the corresponding isolation relays and final actuation devices at plant shutdown is provided.

7.7.2.10.11 Inadvertent Actuation

The AMSAC has been designed such that the frequency of inadvertent actuations is minimized. This high reliability is ensured through use of three redundant ALPs and a majority voting module. A single failure in any of these modules will not result in a spurious AMSAC actuation. In addition, a three-out-of-four low feedwater flow coincidence logic and a time delay (dependent on turbine load) have been selected to further minimize the potential for inadvertent actuations.

7.7.2.10.12 AMSAC Bypass

7.7.2.10.12.1 Maintenance Bypasses. The AMSAC is blocked at the system level during maintenance, repair, calibration, or test. While the system is blocked, the bypass condition is continuously indicated in the main control room.

7.7.2.10.12.2 Operating Bypasses. The AMSAC has been designed to allow for operational bypasses with the inclusion of the C-20 permissive. Above the C-20 setpoint, the AMSAC is automatically unblocked (i.e., armed); below the setpoint, the system is automatically blocked. The operating status of the AMSAC is continuously indicated in the main control room via an annunciator window.

7.7.2.10.12.3 Indication of Bypasses. Whenever the mitigative capabilities of the AMSAC are bypassed or deliberately rendered inoperable, this condition is continuously indicated in the main control room. In addition to the operating bypass, any manual maintenance bypass is indicated via the AMSAC general warning sent to the main control room.

7.7.2.10.12.4 Means for Bypassing. A permanently installed system bypass selector switch is provided to bypass the system. This is a two-position selector switch with "NORMAL" and "BYPASS" positions. At no time is it necessary to use any temporary means, such as installing jumpers or pulling fuses, to bypass the system.

7.7.2.10.13 Completion of Mitigative Actions Once Initiated

The AMSAC mitigative actions go to completion as long as the coincidence logic is satisfied and the time delay requirements are met. If the flow in the feedwater lines is reinitiated before the timer expires and increases to above the low-flow setpoint, then the coincidence logic will no longer be satisfied and the actuation signal disappears. If the coincidence logic conditions are maintained for the duration of the time delay, then the mitigative actions go to completion. The auxiliary feedwater initiation signal is latched in at the component actuating devices and the turbine trip is latched at the turbine digital electrohydraulic control system (DEHC). Deliberate operator action is then necessary to terminate auxiliary feedwater flow, clear the turbine trip signal using the DEHC main control board human machine interfaces (HMIs), and proceed with the reopening of the turbine stop valves.

7.7.2.10.14 Manual Initiation

Manual initiation of the AMSAC is not provided. The capability to initiate the AMSAC mitigative functions manually, i.e., initiate auxiliary feedwater, trip the turbine, and isolate steam generator blowdown and sampling lines, exists at the main control board independently of AMSAC.

7.7.2.10.15 Information Readout

The AMSAC has been designed such that the operating and maintenance staffs have accurate, complete, and timely information pertinent to the status of the AMSAC. A system-level general warning alarm is indicated in the control room. Diagnostic capability exists from the test/maintenance panel to determine the cause of any unanticipated inoperability or deviation.

7.7.2.11 REFERENCE

1. Anderson, T. M., (Westinghouse), to Eisenhut, D. G., (NRC), "Summary Report, Westinghouse Reactor Vessel Level Instrumentation System for Monitoring Inadequate Core Cooling," December 23, 1980.

TABLE 7.7.1-1 (SHEET 1 OF 2)

PLANT CONTROL SYSTEM INTERLOCKS

Designation	Derivation	Function
C-1	1/2 neutron flux (intermediate range) above setpoint	Blocks control rod withdrawal
C-2	1/4 neutron flux (power range) above setpoint	Blocks control rod withdrawal
C-3	2/4 overtemperature ΔT above setpoint	Blocks control rod withdrawal Actuates turbine runback via load reference
C-4	2/4 overpower ΔT above setpoint	Blocks control rod withdrawal Actuates turbine runback via load reference
C-5	1/1 turbine impulse chamber pressure below setpoint	Indication only

TABLE 7.7.1-1 (SHEET 2 OF 2)

Designation	Derivation	Function
C-7	1/1 time derivative (absolute value) of turbine impulse chamber pressure (decrease only) above setpoint	Makes steam dump valves available for either tripping or modulation
C-9	Any condenser pressure above setpoint or no circulating water pumps running	Blocks steam dump to condenser
C-11	Not used.	Not used.
C-16	Reduce limit in coolant temperature above normal setpoint	Stops automatic turbine loading until condition clears
C-20[a]	Two-of-two turbine impulse chamber pressure above setpoint	Arms AMSAC; below setpoint blocks AMSAC (generated in AMSAC; see section 7.7)
P-4	Reactor trip	Blocks steam dump control via load T_{avg} controller Makes steam dump valves available for either tripping or modulation
	Absence of P-4	Blocks steam dump control via plant trip T_{avg} controller

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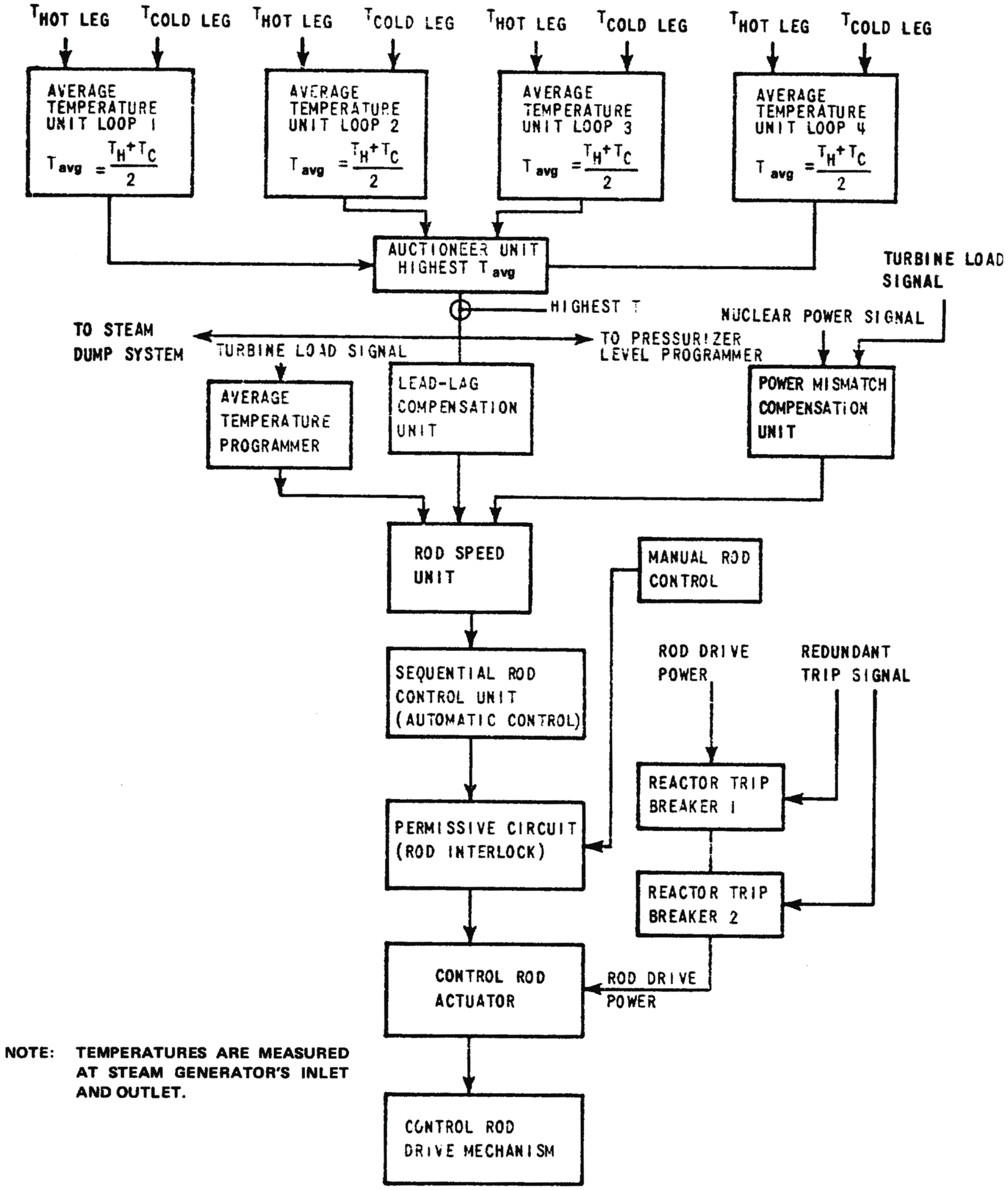
a. Not part of control system (non-Class 1E).



NOTE: TEMPERATURES ARE MEASURED AT STEAM GENERATOR'S INLET AND OUTLET.

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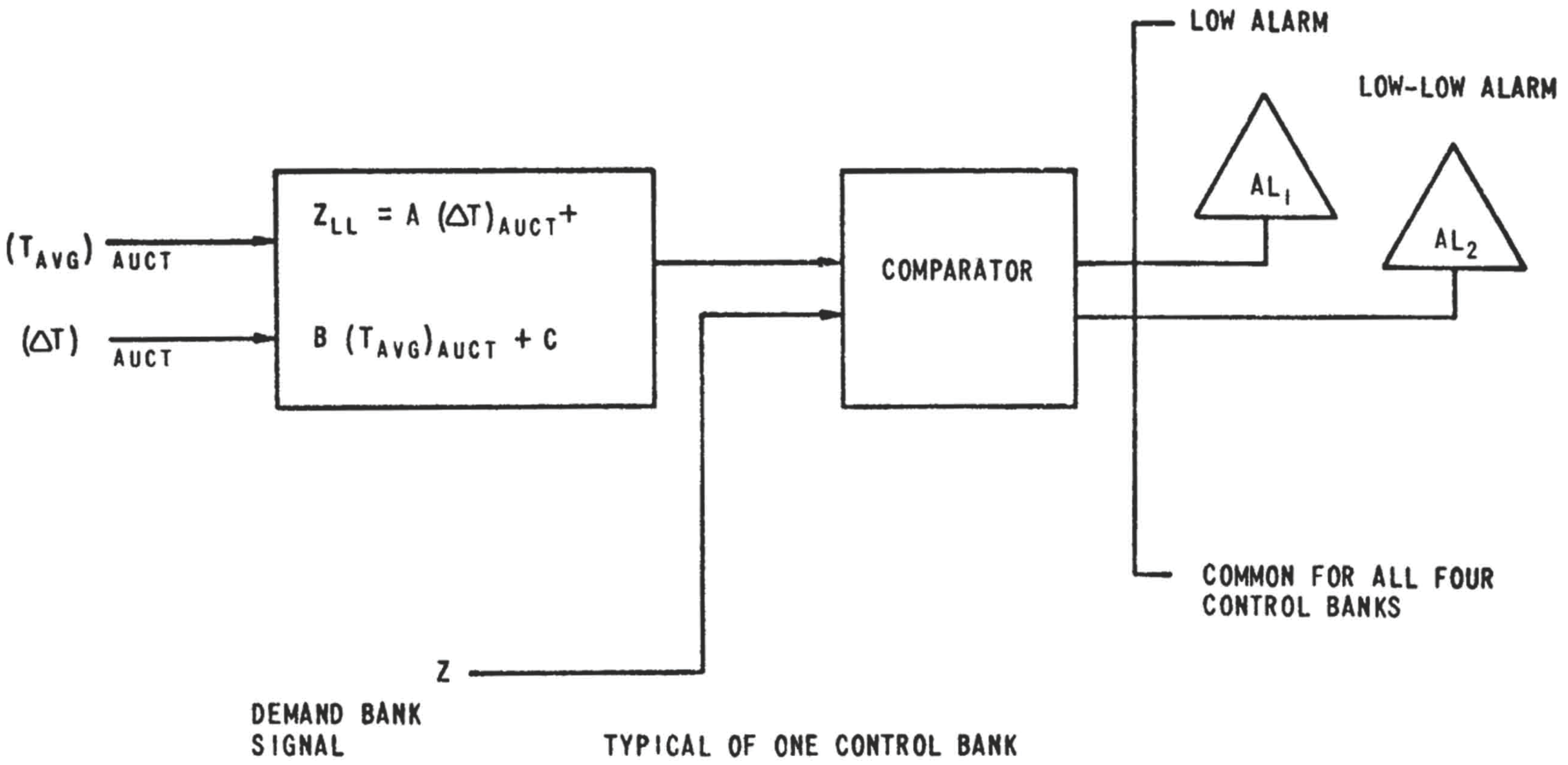
SIMPLIFIED BLOCK DIAGRAM OF REACTOR CONTROL SYSTEM

FIGURE 7.7.1–1



TYPICAL OF ONE CONTROL BANK

NOTE:
1. COMPUTER ALGORITHM IS USED FOR THE COMPARATOR NETWORK
2. COMPARISON IS DONE FOR ALL CONTROL BANKS

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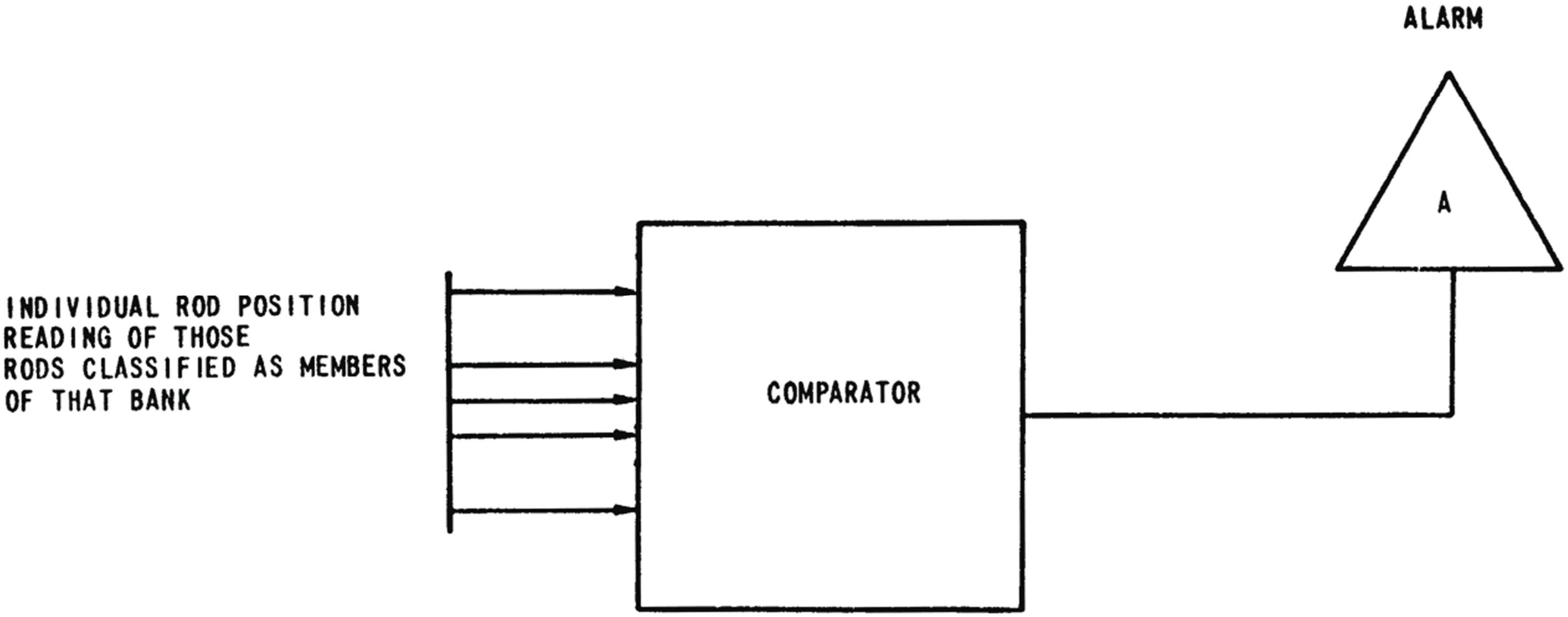
CONTROL BANK ROD INSERTION MONITOR

FIGURE 7.7.1–2



NOTE:
1. DIGITAL OR ANALOG SIGNALS MAY BE USED FOR THE COMPARATOR COMPUTER INPUTS.
2. THE COMPARATOR WILL ENERGIZE THE ALARM IF THERE EXISTS A POSITION DIFFERENCE GREATER THAN A PRESET LIMIT BETWEEN ANY INDIVIDUAL ROD AND THE DEMAND BANK SIGNAL.
3. COMPARISON IS INDIVIDUALLY DONE FOR ALL CONTROL BANKS.

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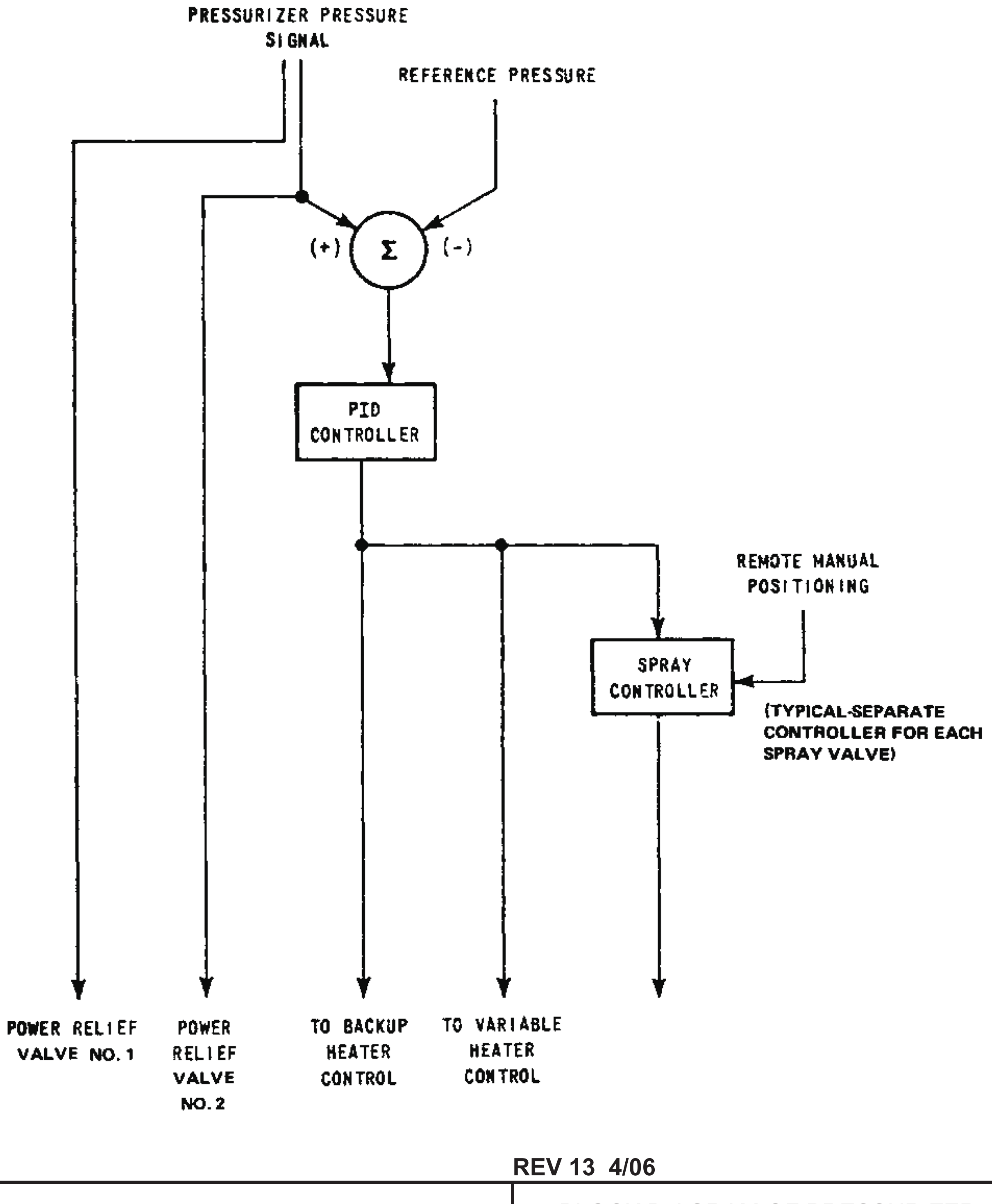
ROD DEVIATION COMPARATOR

FIGURE 7.7.1–3



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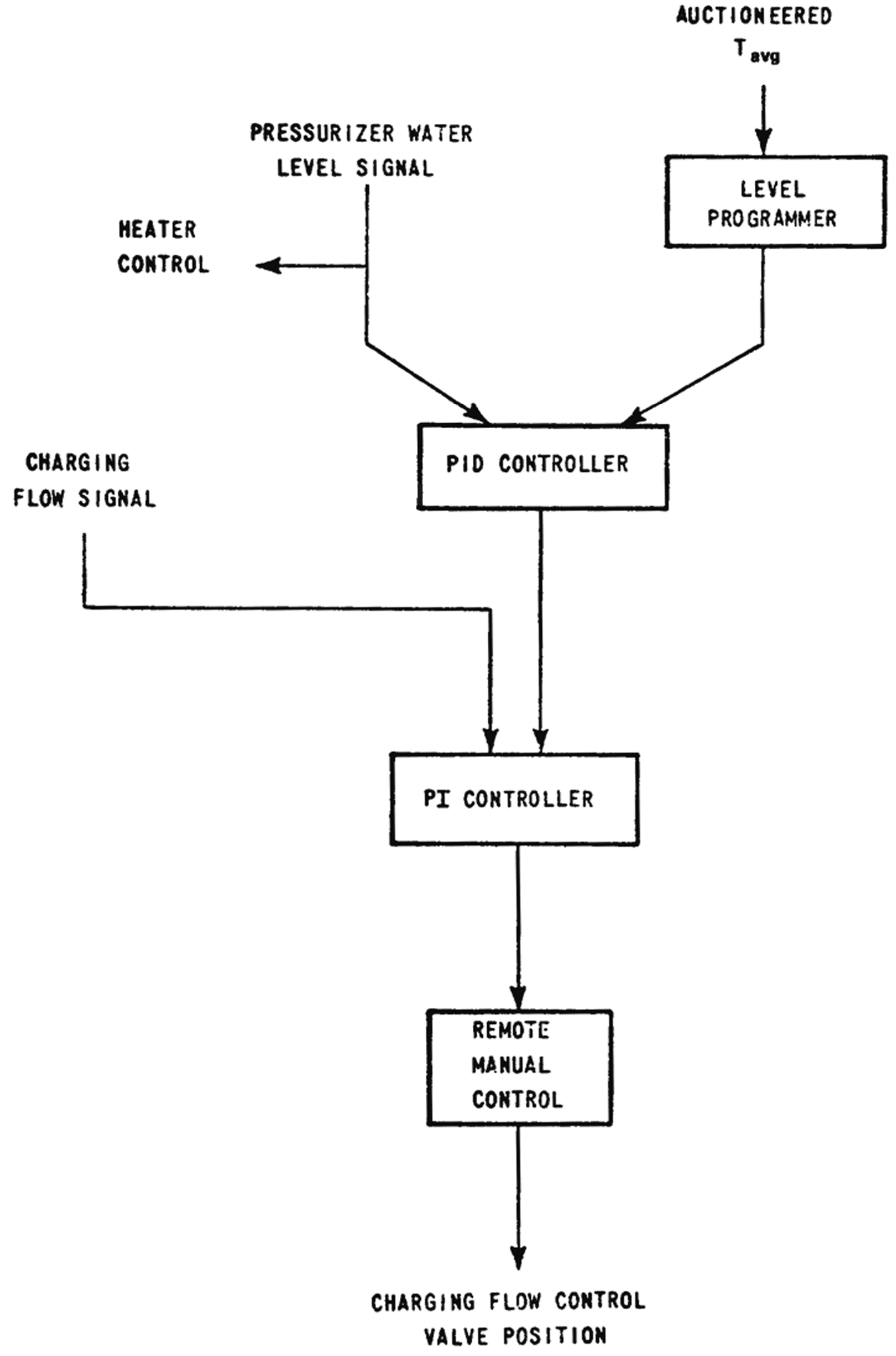
BLOCK DIAGRAM OF PRESSURIZER PRESSURE CONTROL SYSTEM

FIGURE 7.7.1–4



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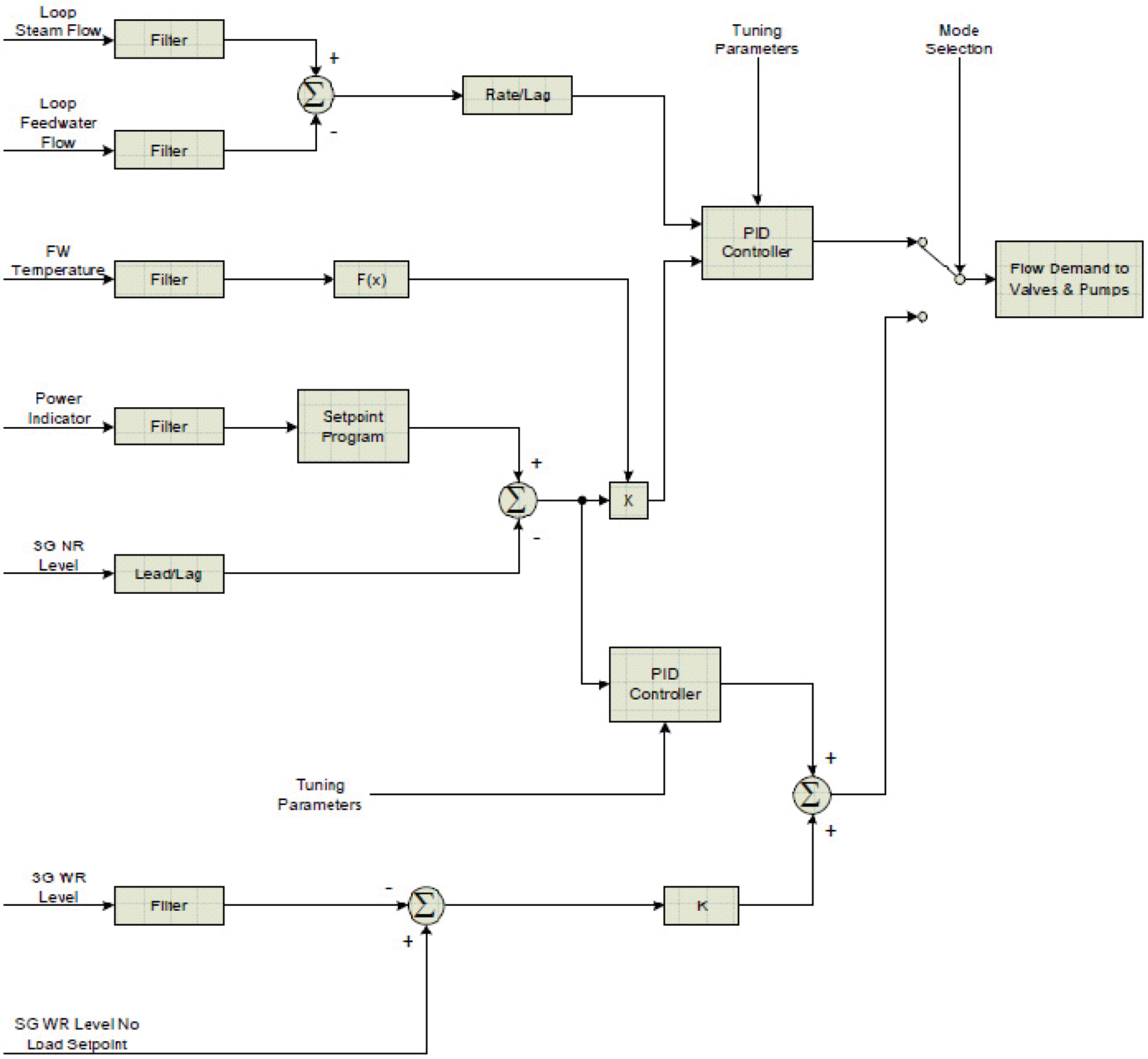
BLOCK DIAGRAM OF PRESSURIZER LEVEL CONTROL SYSTEM

FIGURE 7.7.1–5



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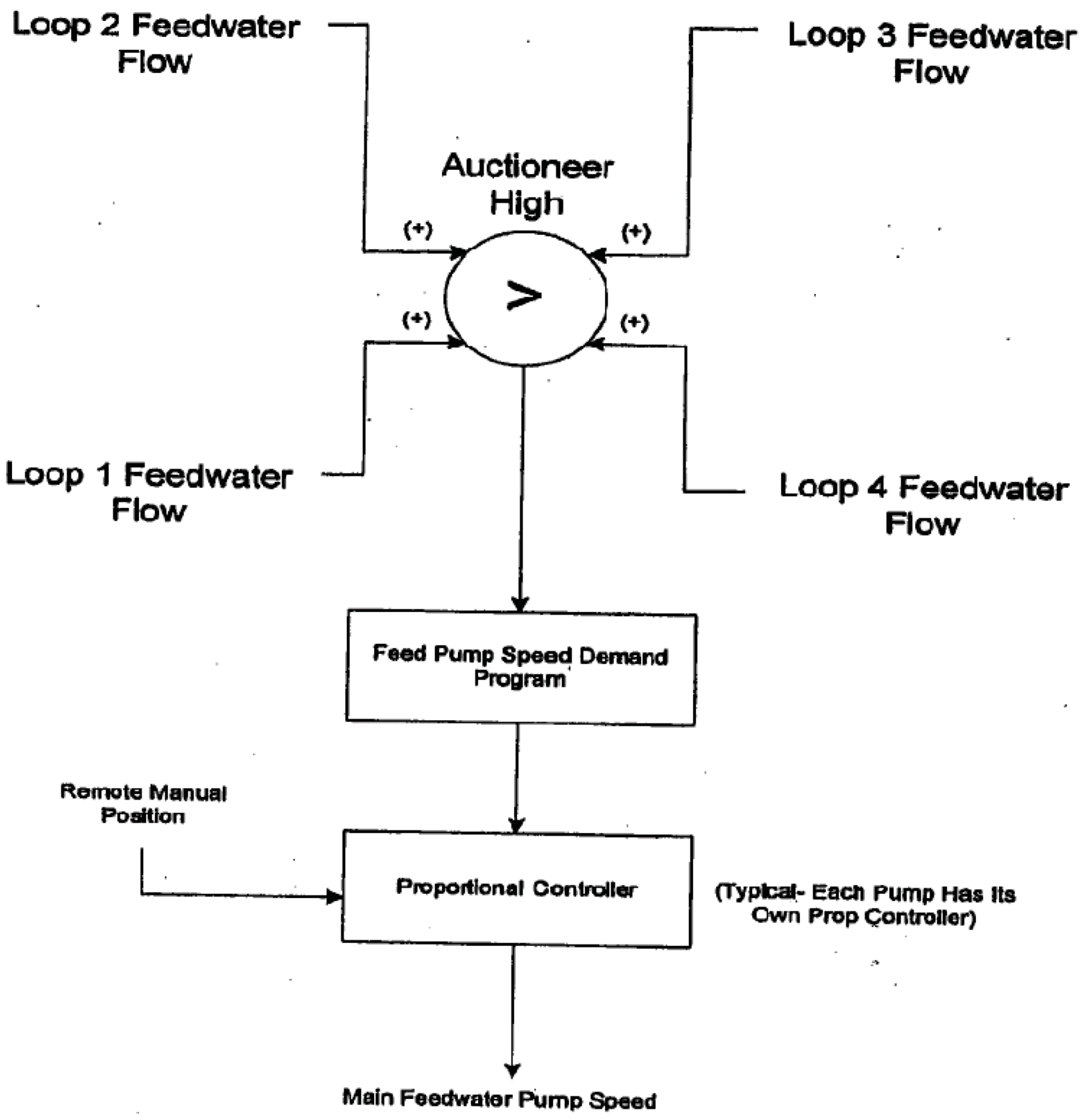
BLOCK DIAGRAM OF STEAM GENERATOR WATER LEVEL CONTROL SYSTEM

FIGURE 7.7.1-6



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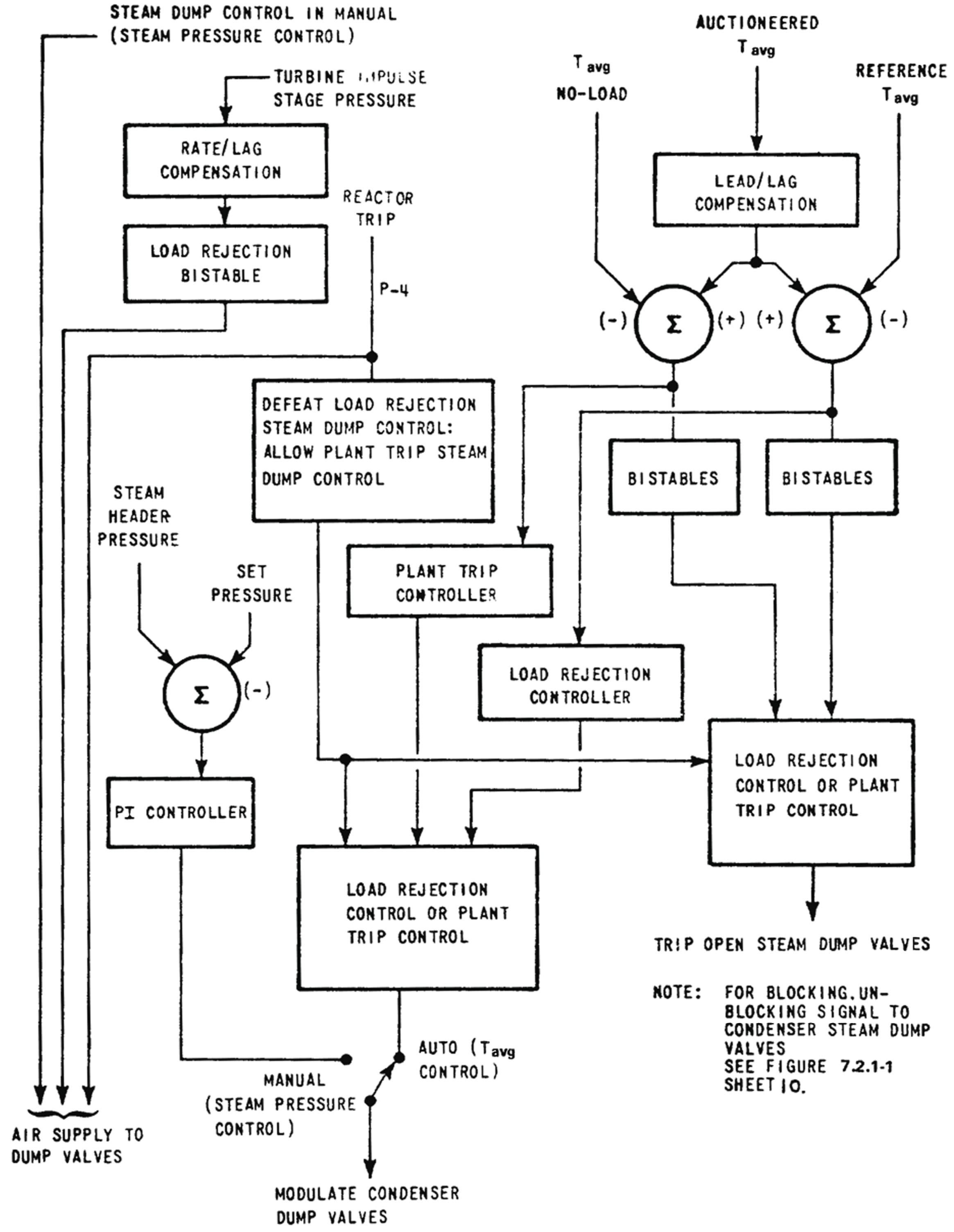
BLOCK DIAGRAM OF MAIN FEEDWATER PUMP SPEED CONTROL SYSTEM

FIGURE 7.7.1-7



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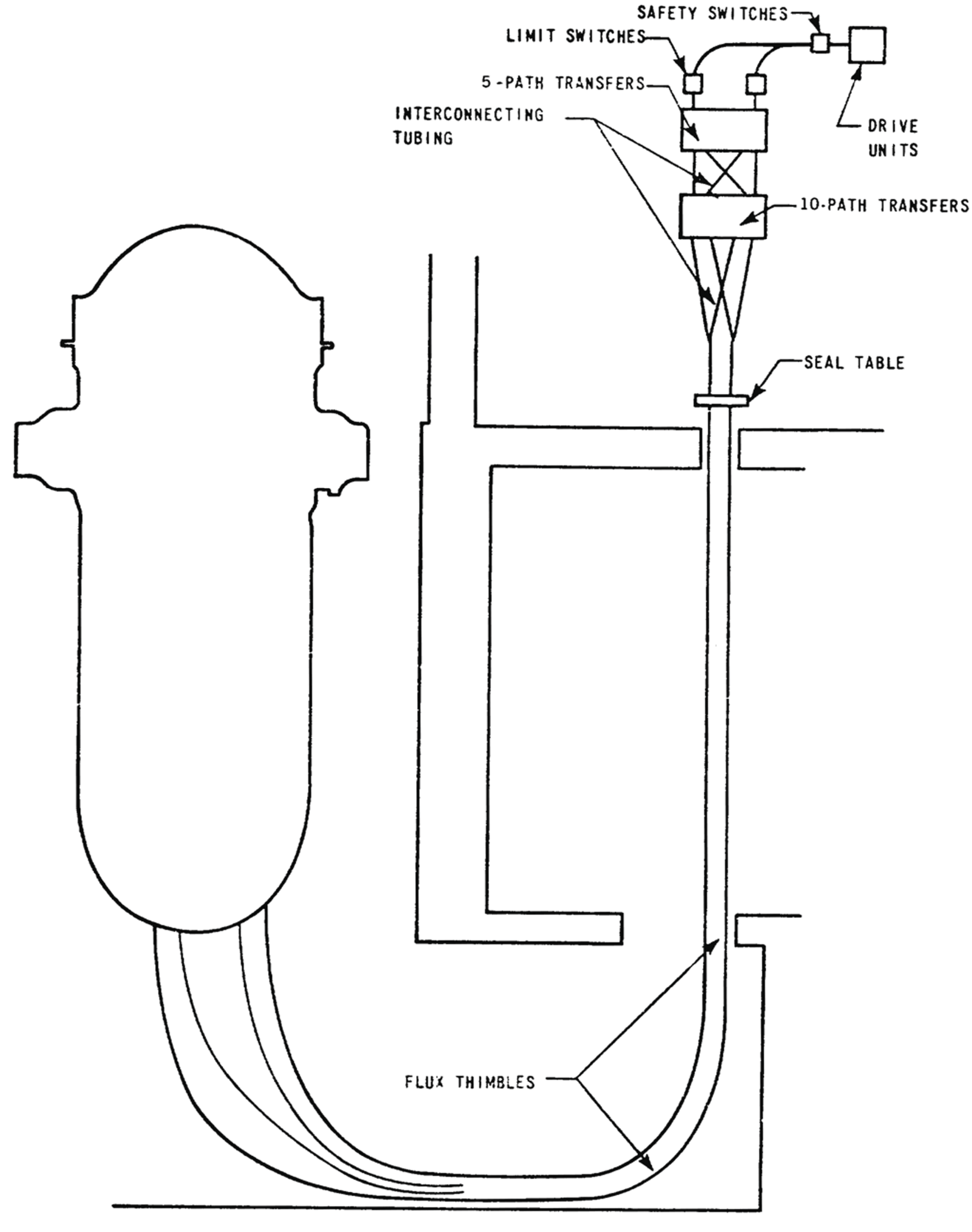
BLOCK DIAGRAM OF STEAM DUMP CONTROL SYSTEM

FIGURE 7.7.1–8



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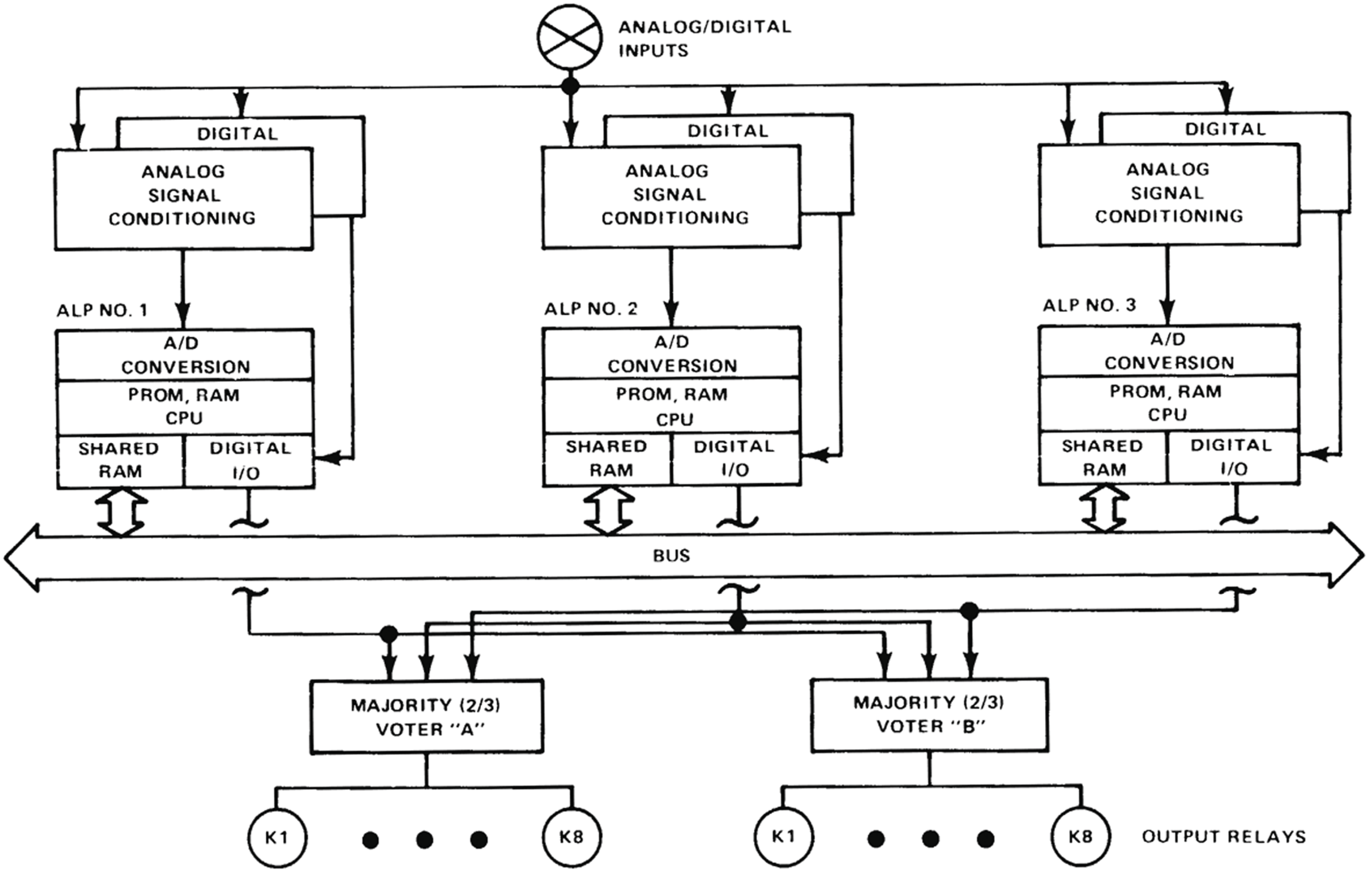
BASIC FLUX–MAPPING SYSTEM

FIGURE 7.7.1–9



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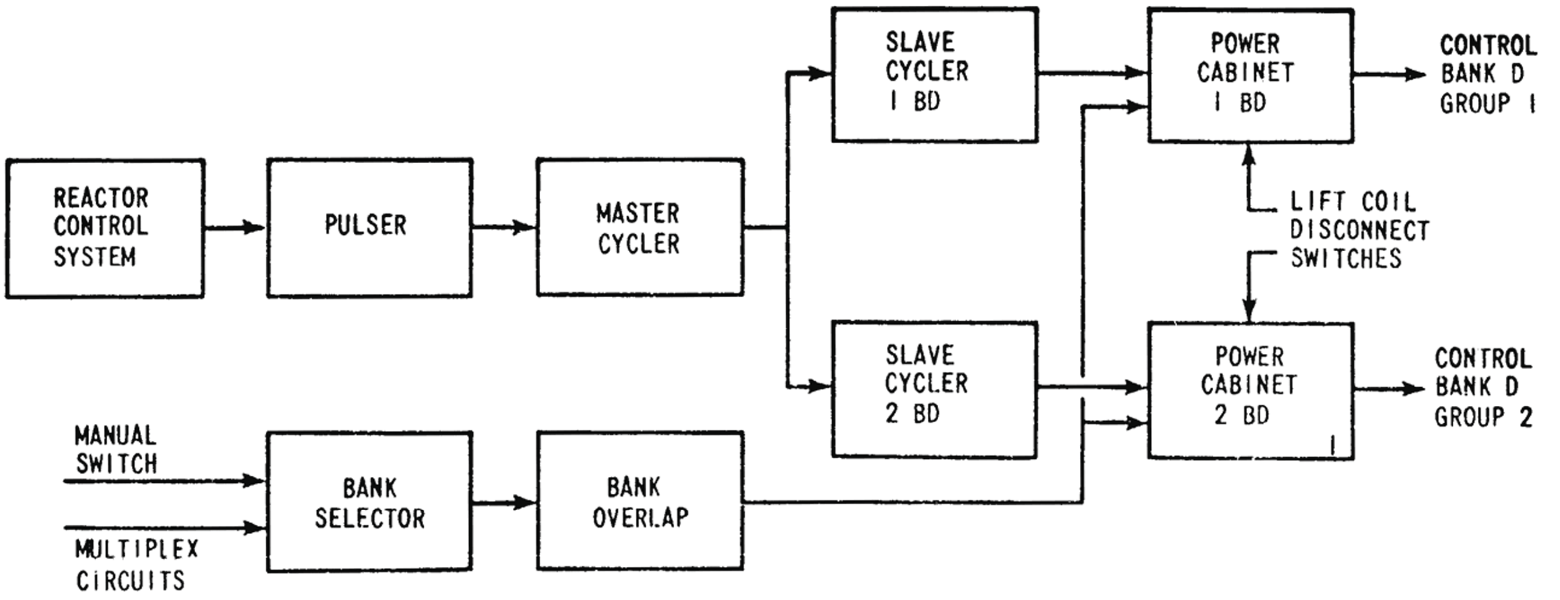
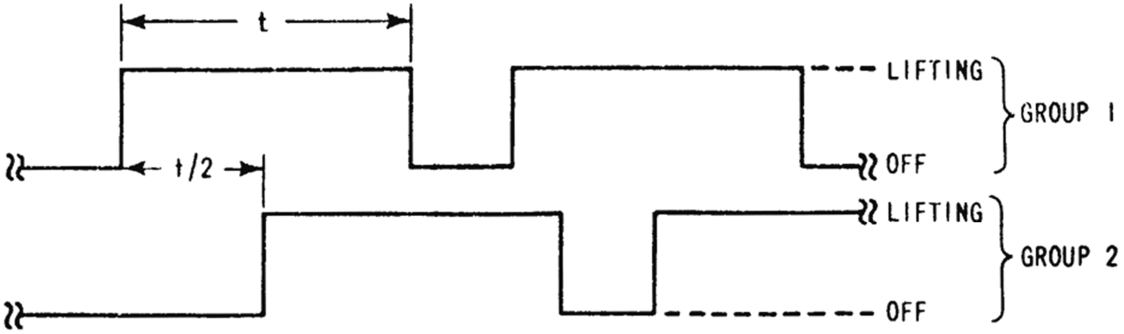
ACTUATION LOGIC SYSTEM ARCHITECTURE

FIGURE 7.7.1-10





NORMAL SEQUENCING OF GROUPS WITHIN BANK

1 NOTE: ONLY CABINETS 1BD AND 2BD SHOWN. FOR MORE COMPLETE DIAGRAM INCLUDING POWER CABINETS 1AC. 2AC. SCDE. AND DC HOLD SCD. SEE REF. 1 IN SECTION 7.7.1.

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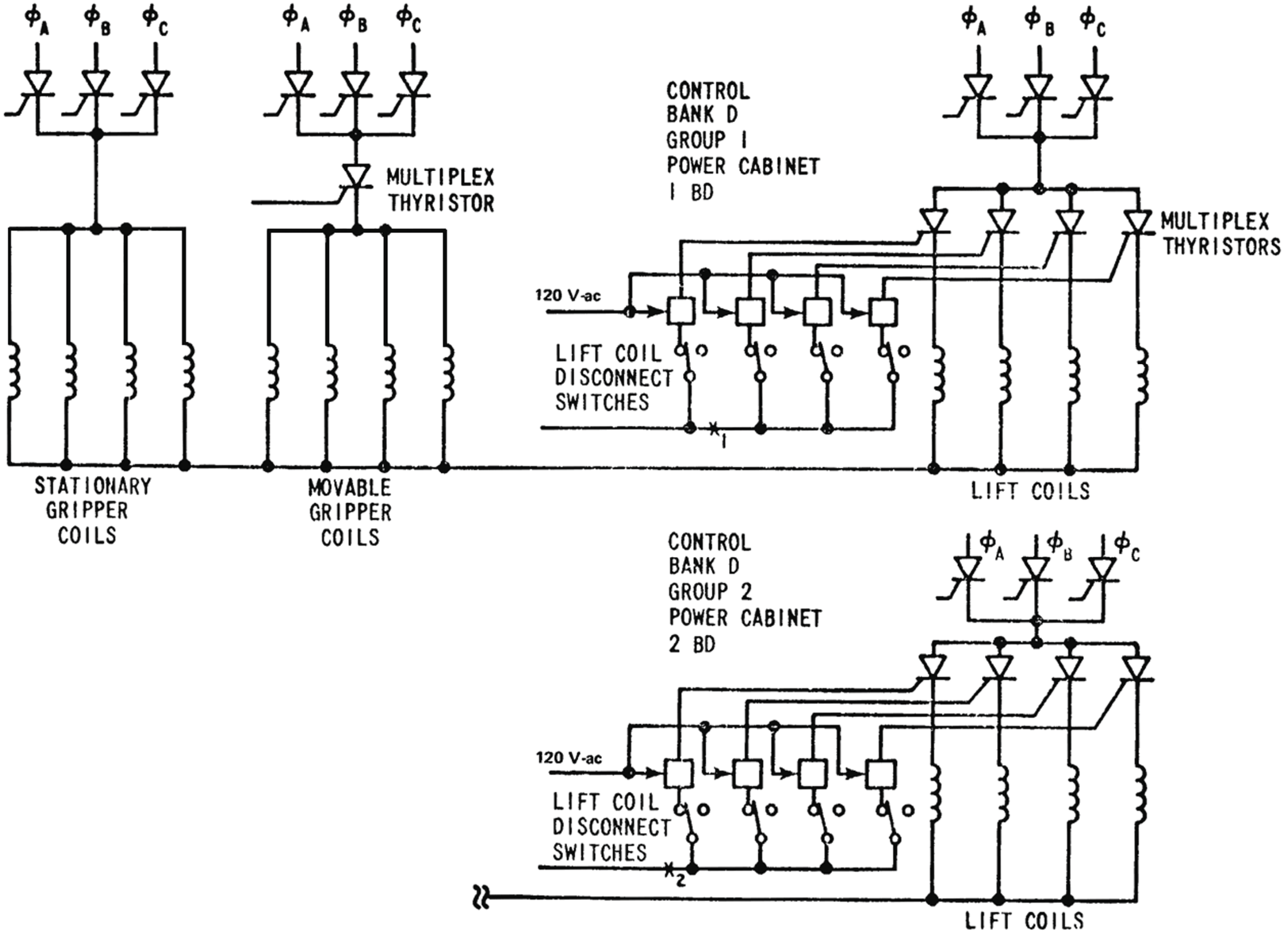
SIMPLIFIED BLOCK DIAGRAM
ROD CONTROL SYSTEM

FIGURE 7.7.2–1



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CONTROL BANK D
PARTIAL SIMPLIFIED SCHEMATIC
DIAGRAM POWER CABINETS 1BD AND 2BD

FIGURE 7.7.2–2

8.0 ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 UTILITY GRID DESCRIPTION

Southern Nuclear Operating Company (SNC) is a member of Southern Company's grid system, whose other members are Alabama Power Company, Georgia Power Company, Gulf Power Company, Mississippi Power Company, Savannah Electric and Power Company, and the Southern Electric Generating Company. The Southern Company is interconnected with Duke Power Company, Florida Peninsula Systems, Middle South Utilities, South Carolina Electric and Gas Company, and the Tennessee Valley Authority. Southern Company's grid system consists of interconnected hydro plants, fossil-fueled plants, and nuclear plants supplying electric energy over a transmission system consisting of various voltages up to 500 kV, as shown on drawing AX6DD402. The figure includes the planned transmission lines for VEGP.

8.1.2 ONSITE POWER SYSTEM DESCRIPTION

The plant is supplied with ac power from a 230-kV switchyard. The Unit 1 generator is connected to the 230-kV switchyard and the Unit 2 generator is connected to the 500-kV switchyard via step-up transformers. Two 230- to 500-kV autotransformers are provided for the interconnection of the two switchyards. The 230-kV switchyard supplies power through two 230/13.8/4.16-kV reserve auxiliary transformers per unit (preferred power source) to the engineered safety features (ESF) buses and the balance of plant (BOP) buses. There is also a "swing" 13.8/4.16-kV, 10/12.5 MVA standby auxiliary transformer (SAT) which may be manually connected to supply power to the ESF buses and to a portion of the BOP loads. The "swing" terminology when used to describe the SAT means that the SAT alignment to the onsite electrical distribution system is selected, with the use of administrative controls and key interlocked disconnect switches, to supply power to any one of the safety-related buses. The standby power source for each ESF bus is its associated emergency diesel generator set. The preferred power source of each unit BOP load is from the 25-kV generator buses through two 25/13.8/4.16-kV unit auxiliary transformers per unit.

The Class 1E ac power system is divided into two independent divisions to provide ac power to the two divisions of ESF loads. The onsite power systems are shown in drawings 1X3D-AA-A01A, 2X3D-AA-A01A, AX3D-AA-A01A, and AX3D-AA-A03A.

Four independent 125-V dc systems supply power to the four independent reactor protection channels and both independent Class 1E ac power systems.

8.1.3 SAFETY-RELATED LOADS

Safety loads are defined as those systems and devices that require electric power in order to perform their safety functions. The ac safety loads are shown in drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B. Tables 8.3.2-1, 8.3.2-2, 8.3.2-3, and 8.3.2-4 list the loads on the Class 1E 125-V dc batteries. Power supplies for the reactor protection system have sufficient stored energy to remain available through any anticipated switching transients. The power supplies are shown on drawings 1X3D-AA-G02A, 1X3D-AA-G02C, and 1X3D-AA-G01B.

8.1.4 DESIGN BASES

8.1.4.1 Offsite Power System

A. Electrical power from the power grid to the plant site is supplied by two physically independent circuits designed and located to minimize the likelihood of simultaneous failure.

B. Based on the grid analysis, two physically independent reserve auxiliary transformers are provided to supply the onsite electrical distribution system. There is also a physically independent standby auxiliary transformer to supply power to the onsite electrical distribution system.

C. The loss of one of the nuclear units at VEGP or the most critical unit on the grid will not result in the loss of offsite power to the Class 1E buses.

D. The switchyard is designed with duplicate and redundant systems; i.e., two independent battery systems, two trip coils per breaker, and protective relay schemes.

E. The impact of open phase conditions on the capability of the reserve auxiliary transformers (RAT 1NXRA, RAT 2NXRA, RAT 1NXRB, and RAT 2NXRB) and the swing standby auxiliary transformer (SAT ANXRA) were evaluated. The conditions analyzed consisted of single (i.e., one of three) and double (i.e., two of three) open phase conductors on the high voltage side (230 kV) of the reserve auxiliary and standby (13.8 kV) transformers. The analysis considered open phase conditions with and without ground. Open phase detection systems for the transformers were installed in accordance with the NEI Open Phase Condition Initiative. Upon detection of an open phase condition, the system will provide operator indication of the open phase condition.

A risk-informed assessment utilizing the Vogtle specific electrical design configuration was performed in accordance with the guidance in NEI 19-02, "Guidance for Assessing Open Phase Condition Implementation Using Risk Insights." The assessment demonstrated that in the event of an open phase condition, the risk associated with an open phase detection system that is reliant on manual operator action versus the automatic actuation of an open phase isolation system was below the threshold of what is generally considered a small change in ∆ CDF (1.0E-6) and ∆ LERF (1.0E-7). Based on the results of the risk-informed assessment, Vogtle has opted to utilize the open phase detection system and operator manual actions to address open phase conditions.

8.1.4.2 Onsite Power System

A. The onsite power system includes a separate and independent Class 1E electric power system for each unit [General Design Criterion (GDC) 17].

B. The onsite Class 1E ac electric power systems for each unit are divided into two independent load groups referred to as trains, each with its own power supply, buses, transformers, loads, and associated 125-V dc control power. Each train is independently capable of maintaining one unit in a safe shutdown condition (GDC 17).

C. One independent diesel generator is provided for each Class 1E ac train in each unit.

The diesel generator unit provides power to the appropriate ventilation equipment to maintain an acceptable environment within the diesel generator buildings.

The diesel generator unit is capable of starting, accelerating, being loaded, and carrying the design load described in paragraph 8.3.1.1.3. The unit energizes its cooling equipment within an acceptable time.

A discussion on conformance to Regulatory Guide 1.9 concerning frequency and voltage limits and basis of the continuous rating is contained in section 1.9.

Mechanical and electric systems are designed so that a single failure affects the operation of only a single diesel generator.

Design conditions such as vibration, torsional vibration, and overspeed are considered in accordance with the requirements of Institute of Electrical and Electronics Engineers (IEEE) Standard 387.

Each diesel governor can operate in the droop mode, and the voltage regulator can operate in the paralleled mode during diesel generator testing. If an underfrequency condition occurs while the diesel generator is paralleled with the preferred (offsite) power supply, the diesel generator breaker is tripped and the governor and voltage regulator are automatically restored to the isochronous and nonparalleled modes, respectively.

Each diesel generator is provided with control systems permitting automatic and manual control. The automatic start signal is functional except when the diesel generator is in the maintenance mode. Also, the automatic start signal will not override the rampup time when the governor is in the slow start mode. The details of the affects during the slow start mode are described in paragraph 8.3.1.1.3.k. Provision is made for controlling each diesel generator from the control room or from the diesel generator room. Paragraph 8.3.1.1.3 provides further description of the control systems.

Voltage, current, frequency, var, and watt metering is provided in the control room to permit assessment of the operating condition of each diesel generator.

Surveillance instrumentation is provided in accordance with IEEE 387, as described in subsections 9.5.4 through 9.5.8.

Tests are conducted on each diesel generator unit in accordance with IEEE 387, as listed in paragraph 8.3.1.1.3.

D. No provisions are made for automatic transfer of trains between redundant power sources.

E. No portion (ac or dc) of the onsite standby power systems is shared between units (GDC 5).

F. The Class 1E electric systems are designed to satisfy the single failure criterion (GDC 17).

G. For each of the four protection channels, one independent 125-V dc and at least one 120-V vital ac power source are provided. Batteries are sized for 165 min of operation for LOSP/LOCA and 240 min for SBO without the support of battery chargers.

H. Separate non-Class 1E dc systems are provided for non-Class 1E controls and dc motors.

I. Raceways are not shared by Class 1E and non-Class 1E cables.

J. Special identification criteria are applied for Class 1E equipment, including cabling and raceways. Refer to paragraph 8.3.1.3.

K. Separation criteria are applied which establish requirements for preserving the independence of redundant Class 1E electric systems. Refer to paragraph 8.3.1.4.1.

L. Class 1E equipment is designed with the capability of being tested periodically (GDC 18).

8.1.4.3 Design Criteria, Regulatory Guides, and IEEE Standards

Compliance to GDC 17, 18, and 50 is discussed in section 3.1 and paragraphs 8.3.1.2, 8.3.2.2, and 8.3.1.1.12. The design of the offsite power and onsite Class 1E electric systems generally conforms with the regulatory guides and standards listed below as clarified in section 1.9. Refer to table 8.1-1 for acceptance criteria and guidelines and their applicability to chapter 8.

A. General Design Criteria

1. GDC 2, Design Bases for Protection Against Natural Phenomena.
2. GDC 4, Environmental and Missile Design Bases.
3. GDC 5, Sharing of Structures, Systems, and Components.
4. GDC 17, Electric Power Systems.
5. GDC 18, Inspection and Testing of Electric Power Systems.
6. GDC 50, Containment Design Basis.

See section 3.1 for a discussion of conformance with each of the general design criteria.

B. Nuclear Regulatory Commission (NRC) Regulatory Guides

See section 1.9 for a discussion of conformance to the regulatory guides listed below.

1. Regulatory Guide 1.6, Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems.
2. Regulatory Guide 1.9, Selection, Design, and Qualification of Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants.
3. Regulatory Guide 1.22, Periodic Testing of Protection System Actuation Functions.
4. Regulatory Guide 1.29, Seismic Design Classification.

5. Regulatory Guide 1.30, Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment.
6. Regulatory Guide 1.32, Criteria for Safety- Related Electric Power Systems for Nuclear Power Plants.
7. Regulatory Guide 1.40, Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants.
8. Regulatory Guide 1.41, Preoperational Testing of Redundant Onsite Electrical Power Systems to Verify Proper Load Group Assignments.
9. Regulatory Guide 1.47, Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.
10. Regulatory Guide 1.53, Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems.
11. Regulatory Guide 1.62, Manual Initiation of Protective Actions.
12. Regulatory Guide 1.63, Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants.
13. Regulatory Guide 1.68, Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors.
14. Regulatory Guide 1.73, Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants.
15. Regulatory Guide 1.75, Physical Independence of Electric Systems.
16. Regulatory Guide 1.81, Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants.
17. Regulatory Guide 1.89, Qualification of Class 1E Equipment for Nuclear Power Plants.
18. Regulatory Guide 1.93, Availability of Electric Power Sources.
19. Regulatory Guide 1.100, Seismic Qualification of Electrical Equipment for Nuclear Power Plants.
20. Regulatory Guide 1.106, Thermal Overload Protection for Electric Motors on Motor-Operated Valves.
21. Regulatory Guide 1.108, Periodic Testing of Diesel Generators Used as Onsite Electric Power Systems at Nuclear Power Plants.
22. Regulatory Guide 1.118, Periodic Testing of Electric Power and Protection Systems.
23. Regulatory Guide 1.128, Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants.
24. Regulatory Guide 1.129, Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants.
25. Regulatory Guide 1.131, Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants.

C. IEEE Standards

The onsite power system is generally designed in accordance with IEEE Standards 279, 308, 317, 323, 334, 336, 338, 344, 379, 382, 383, 384, 387, 450, and 484.

1. IEEE 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.22.
2. IEEE 308-1974, Criteria for Class 1E Power Systems for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.32.
3. IEEE 317-1976, Electrical Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.63.
4. IEEE 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.89.
5. IEEE 334-1974, Type Tests of Continuous Duty Class IE Motors for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.40.
6. IEEE 336-1971, Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations. Refer to Regulatory Guide 1.30.
7. IEEE 338-1977, Criteria for the Periodic Testing of Nuclear Power Generating Station Class 1E Power and Protection Systems. For application of this standard to various systems, refer to paragraph 7.1.2.7 and to Regulatory Guide 1.118.
8. IEEE 344-1975, Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations. Seismic qualification of Class 1E electric equipment and the extent of compliance with IEEE 344-1975 are discussed in section 3.10. Also refer to Regulatory Guide 1.100.
9. IEEE 379-1972, Application of the Single Failure Criterion to Nuclear Power Generating Station Class 1E Systems. Refer to Regulatory Guide 1.53.
10. IEEE 382-1972, Type Test of Class 1 Electric Valve Operators for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.73.
11. IEEE 383-1974, Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations. Refer to Regulatory Guide 1.131.
12. IEEE 384-1981, Criteria for Independence of Class 1E Equipment and Circuits. Refer to Regulatory Guide 1.75.
13. IEEE 387-1977, Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations. Conformance with the design criteria of IEEE 387-1977 is discussed in paragraph 8.3.1.1.3, which addresses the details of the standby power supply. Also refer to Regulatory Guide 1.9.
14. IEEE 450-1995, Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations. Refer to Regulatory Guide 1.129. The safety-related batteries will be tested periodically in accordance with the Technical Specifications and the

version of IEEE 450 as described in the Bases for the Technical Specifications.

15. IEEE 484-1975, Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations. Refer to Regulatory Guide 1.128.
16. IEEE 628-1987, Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations.
17. IEEE 485-1983, Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations

TABLE 8.1-1 (SHEET 1 OF 3)

ACCEPTANCE CRITERIA AND GUIDELINES FOR ELECTRIC POWER SYSTEMS

Criteria		Title	Applicability (FSAR[a] Section/Subsection)			Remarks
			8.2	8.3.1	8.3.2	
1.	GDC Appendix A to10 Code of Federal Regulations (CFR) 50					
	a. GDC 2	Design Bases for Protection Against Natural Phenomena		A	A	
	b. GDC 4	Environmental and Missile Design Bases		A	A	
	c. GDC 5	Sharing of Structures, Systems, and Components	A	A	A	
	d. GDC 17	Electric Power Systems	A	A	A	
	e. GDC 18	Inspection and Testing of Electrical Power Systems	A	A	A	
	f. GDC 50	Containment Design Bases		A	A	
2.	Regulatory Guide (RG)					
	a. RG 1.6	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems		G	G	
	b. RG 1.9	Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants		G		
	c. RG 1.32	Use of IEEE Standard 308, Criteria for Class 1E Power Systems for Nuclear Power Generating Stations	G	G	G	
	d. RG 1.47	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems	G	G	G	

TABLE 8.1-1 (SHEET 2 of 3)

Criteria	Title	Applicability (FSAR[a] Section/Subsection) 8.2	8.3.1	8.3.2	Remarks
e. RG 1.63	Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants		G	G	
f. RG 1.75	Physical Independence of Electric Systems		G	G	
g. RG 1.81	Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants	G	G	G	
h. RG 1.106	Thermal Overload Protection for Electric Motors on Motor-Operated Valves		G	G	
i. RG 1.108	Periodic Testing of Diesel Generators Used as Onsite Power Systems at Nuclear Power Plants		G		
j. RG 1.118	Periodic Testing of Electric Power and Protection Systems		G	G	
k. RG 1.128	Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plant			G	
l. RG 1.129	Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants			G	
3. Branch Technical Position (BTP)					
a. BTP ICSB 4	Requirements on Motor-Operated Valves in the ECCS Accumulator Lines		G		See also FSAR subsection 7.6.4
b. BTP ICSB 8 (PSB)	Use of Diesel-Generator Sets for Peaking		G		
c. BTP ICSB 11 (PSB)	Stability of Offsite Power Systems	G			

TABLE 8.1-1 (SHEET 3 of 3)

	Criteria	Title	Applicability (FSAR[a] Section/Subsection)			Remarks
			8.2	8.3.1	8.3.2	
d.	BTP ICSB 18 (PSB)	Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves		G		
e.	BTP ICSB 21	Guidance for Application of RG 1.47	G	G	G	See also FSAR section 7.5
f.	BTP PSB-1	Adequacy of Station Electric Distribution System Voltages		G		
h.	BTP PSB-2	Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status		G		
NUREG Reports						
a.	NUREG/CR 0660	Enhancement of Onsite Diesel Generator Reliability		G		

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a. A denotes acceptance criteria. G denotes guidance.

8.2 OFFSITE POWER SYSTEM

8.2.1 SYSTEM DESCRIPTION

The Southern Company transmission system supplies the offsite ac energy for operating the safety-related buses as well as startup and shutdown of Units 1 and 2.

Each unit represents about 6 percent of the total installed capacity of the Georgia Power Company system in 1990 and about 3.4 percent of the total installed capacity of the Southern Company system in 1990.

Units 1 and 3 are connected to the 230-kV switchyard and Unit 2 is connected to the 500-kV switchyard through step-up transformers. Two 500/230-kV autotransformers connect each switchyard together. Unit 4 500-kV switchyard is connected to the 500-kV switchyard by overhead tie lines. The Unit 1 and 2 offsite sources are connected via the switchyard to the 230-kV and 500-kV transmission system.

8.2.1.1 Offsite Sources

Drawing AX6DD402 shows the Southern Company transmission system plan for 1990. Construction of the 230-kV and 500-kV lines is summarized in table 8.2.1-1. The transmission lines are not considered to have any unusual features, and the occasional crossings of transmission lines as listed in table 8.2.1-1 are normal design practice for the Georgia Power Company system.

The 230-kV and 500-kV transmission systems are designed to deliver power to the various portions of the Georgia Power Company service area safely, efficiently, and dependably. As a result, the system offers a very dependable power source for the required offsite loads and is the preferred power source for the safety-related loads of the plant.

An additional "swing" preferred offsite power source, the standby auxiliary transformer (SAT), is also available for plant loads in response to emergency conditions or for use during reserve auxiliary transformer (RAT) maintenance. The SAT receives power from the Georgia Power Company Plant Wilson switchyard (see drawing AX3D-AA-A03A). Plant Wilson is a six-unit combustion turbine electric generating facility located approximately 1 mile east of the Vogtle plant site. The SAT is supplied power through a direct buried cable from either the Southern Company 230-kV grid or Plant Wilson's onsite combustion turbine electrical generation, both methods via the Plant Wilson switchyard 13.8-kV power system.

There are five 230-kV lines, one of which is the connection to the Plant Wilson switchyard, and two 230-kV and 500-kV autotransformers that connect the 230-kV and 500-kV switchyards. These transmission elements at the 230-kV bus comprise the power sources to the 230-kV switchyard. The lines approach the plant site on five rights-of-way, from the north-west and south. System load studies indicate that this arrangement has the capacity and capability to supply the power necessary for the safety loads of one unit while placing the other unit in cold shutdown.

The transmission line structures of both the 230-kV and 500-kV systems are designed to withstand standard light and medium loading conditions as specified in National Institute of Standards and Technology Handbook No. 8 (ANSI, C2.2-1960, National Electric Safety Code).

8.2.1.2 Switchyard

The Units 1 and 2 230-kV and 500-kV switchyards are arranged as shown in drawings AX3D-AA-L50A and AX3DL060. The 230-kV breaker-and-a-half arrangement is used to incorporate the redundancy offered by having two energized buses with three breakers to service each pair of connections. The 500-kV breaker-and-a-half bus arrangement allows two breakers to service each terminal connection.

The switchhouse, located in the switchyard, contains two independent 125-V batteries, the primary and secondary relaying for the transmission lines, and the breaker failure relaying. It also contains the 480-V metal-clad switchgear and motor control centers for the substation.

Two trip coils per pole are provided in each 230-kV and 500-kV circuit breaker for independent tripping from the primary and secondary relaying systems. Redundant closing coils are not provided in each circuit breaker. However, the 125-V dc supplies are arranged to ensure that at least one offsite source is available upon the loss of either substation battery. Tables 8.2.1-2 and 8.2.1-3 respectively show the 230-kV and 500-kV circuit breaker control circuits supplied by each battery.

Each of the offsite sources from the 230-kV switchyard can be energized through either or both of the two switchyard circuit breakers. The high voltage switchyard raceway network consists of a system of concrete trenches with concrete lids. Control cables to the four circuit breakers are routed through the trenches in such a way that lengthy trench sections do not include circuits to all four offsite source breakers. Control cables to the plant control room for these breakers are routed outdoors in conduit within a reinforced concrete duct run and within the plant in cable tray. These cables are arranged within these raceways in such a manner that no two breakers from different offsite sources are in a common raceway. Areas in which circuits to all four breakers are common in this duct run are limited to the three pull boxes. Areas in which circuits to all four breakers are routed in a common trench are limited to some areas of the switch house interior and a small area of the trench adjacent to the switch house.

In these areas, the trench is protected by location or adjacent structure (i.e., switch house), and additional separation is not practical. All cable is fire retardant (in accordance with IEEE 383-1974), and no oil containment equipment is located in the vicinity of the cable trench.

Two feeders emerge from the 230-kV substation to supply power to the RATs for both Units 1 and 2. (The arrangement is shown in drawings 1X3D-AA-A01A and 2X3D-AA-A01A.) Offsite source No. 1 supplies Unit 1 RAT 1NXRA and Unit 2 RAT 2NXRB. Offsite source No. 2 supplies Unit 1 reserve auxiliary transformer 1NXRB and Unit 2 RAT 2NXRA. These two offsite sources are separated physically as they leave the 230-kV substation and are arranged so that no one event such as a falling line, tower, or other structure will damage both lines.

The 13.8-kV power circuit to the SAT is above grade only at the Plant Wilson switchyard connection point and in the Vogtle low voltage switchyard at the 13.8-kV switchgear circuit breaker and at the SAT. Between these two points, the power circuit is either direct buried or pulled in conduit through a concrete encased electrical duct run. The 13.8-kV power circuit is therefore physically separated from the other offsite power source lines. No one event, such as a falling line, tower, or other structure will damage the 13.8-kV power circuit and one of the 230-kV power feeders. The 13.8-kV circuit breaker has a single trip coil which, along with the protective relaying, is supplied 125-V-dc power from the turbine building batteries.

The secondary windings of the RATs are connected to the various groups of metal-clad switchgear by Calvert cable busses. The Calvert cable busses from transformers 1NXRB and 2NXRA are carried in underground trenches from the transformers to the turbine building wall. The other Calvert cable busses are run overhead to the turbine building.

The secondary winding of the SAT is connected to the various groups of metal-clad switchgear by a 4.16-kV switchgear circuit breaker, Husky cable bus, and cable bus disconnect switches. The 4.16-kV circuit breaker has a single trip coil which, along with the protective relaying, is supplied 125-V-dc power from the turbine building batteries. The Husky cable bus from the SAT switchgear runs overhead to the vicinity of each RAT. At that point, the Husky cable bus is connected to a switch that may be closed to connect the SAT to the Calvert cable bus between the RAT and the Class 1E switchgear. Another switch in the Calvert cable bus between the Class 1E switchgear and the RAT is opened before the SAT cable bus switch is closed. The two cable bus switches allow the Class 1E switchgear to be connected to either a RAT or the SAT. The manual cable bus switches are key interlocked to prevent having both the RAT and the SAT connected to the same Class 1E bus. The switching arrangement is shown on drawings 1X3D-AA-A01A, 2X3D-AA-A01A, and AX3D-AA-A03A.

The Calvert cable busses enter the turbine building and proceed to the non-Class 1E metal-clad switchgear installed in the turbine building. The Calvert cable busses continue through the cable tunnel between the turbine building and the control building to the Class 1E metal-clad switchgear busses located in the control building. As these busses traverse the buildings, adequate spacing and arrangement to the extent practical are provided to minimize the chances that both offsite sources will be eliminated by one occurrence.

8.2.2 ANALYSIS

8.2.2.1 Loss of VEGP Unit 1 or 2 or the Largest Unit

A study simulating 1990 peak conditions has been made to determine the effect of the loss of either VEGP Unit 1 or 2 on the Georgia Power Company transmission system and its ability to maintain continuity of service to the loads. This study reveals that the transmission system is adequate to maintain continuity of service to the load areas and the offsite power to the safety-related loads at the plant site.

A study simulating 1990 peak conditions has been made to determine the effect of the loss of both Units 1 and 2 and the ability of the offsite source to supply emergency and safety-related loads at VEGP. It was found that the offsite transmission is adequate. The voltage at the VEGP 230-kV bus is above 100 percent under any normal planning criteria.

The largest unit of the Georgia Power Company system is VEGP Unit 1 or Unit 2 and loss of these units as explained above does not result in the loss of the offsite power to the safety-related buses at the plant site. The loss of the next largest unit (Bowen No. 3 or No. 4) likewise does not result in the loss of offsite power to the safety-related buses at the plant site.

8.2.2.2 VEGP Voltage Operating Range

The 230-kV bus voltage will not be less than 230 kV (100 percent) or greater than 242 kV (105 percent) for all system loading conditions and under severe contingencies such as loss of any large generating plant, including VEGP itself (Unit 1 and Unit 2 shutdown and/or loss-of-coolant accident loads), or loss of any single transmission element. (See GPC letters SL-2110 dated March 9, 1987, and GN-1525 dated December 13, 1988, for a detailed description of the effect of switchyard voltages on in-plant loads.)

8.2.2.3 VEGP Transient Stability

Based on the offsite power system described in subsection 8.2.1, a transient stability study simulating 1990 summer peak and spring valley loading conditions has been made to determine the transmission line, bus arrangement, and/or special equipment requirements to ensure stable operation of the grid for VEGP Units 1 and 2. These extreme system loading conditions ensure that the stability performances of VEGP are analyzed under all reactive loading conditions or power factor conditions. The following contingencies are simulated for which the grid is required to remain stable:

A. Three-phase fault with breaker failure anywhere in the system.

B. Sudden loss of any large generating plant.

C. Sudden loss of all lines on any common right-of-way.

D. Sudden loss of any large aggregation of load or load center anywhere in the system.

Of these contingencies, it was found that a three-phase fault with breaker failure results in the largest transient swing. For this severe contingency, grid stability is maintained. Specific stability performance issues of VEGP are discussed below.

A. Frequency Decay Rate

The maximum frequency decay rate possible from theoretical considerations for the 230-kV and 500-kV systems is 5 Hz/s and 5.4 Hz/s, respectively. These frequency decay rates are the theoretical maximums that occur with the simultaneous tripping of many 500-kV, 230-kV and 115-kV lines such that a large island is formed in which all generation, other than one VEGP unit, is off line. The probability for such a scenario is immeasurably small. If for the improbable scenario just described, one additional major generating unit is in operation, the expected frequency decay rate is reduced to approximately 2 Hz/s for VEGP. However, the probability for this system condition is also immeasurably small.

B. Load Dispatch System

Automatic load dispatch is not used at the plant; therefore, the load dispatch system will not interfere with safety actions required of the reactor protection system.

In addition to the transient stability study described above, the stability of the grid is also assessed whenever a major electrical element, such as a bulk power transmission line or a 500/230-kV autotransformer in the vicinity of VEGP, is temporarily out of service. The assessment, although not specifically required, is to verify that preferred power will be available in the event another major transmission system element is lost while the offsite power system is in this temporary configuration. This assessment is based upon the guidelines of the Southeastern Electric Reliability Council (SERC) planning criteria to ensure that preferred power will be available. The assessment considers the actual and projected system power requirements, actual transmission elements in service, intercompany transactions, and other information, as applicable. If the grid is found to be potentially unstable, then appropriate actions will be taken in a timely manner.

8.2.2.4 Conformance to Criteria

The preferred power sources; i.e., the offsite sources, are not Class 1E and are not manufactured and purchased under a quality assurance program as described in chapter 17. However, all material is the highest grade of commercial equipment manufactured to the industrial standards listed below. The design is similar to the Class 1E systems and subjected to the same type of reviews, checks, and calculation methods. As a result, the design is considered to meet General Design Criterion 1 of 10 CFR 50, Appendix A.

To comply with General Design Criterion 3, the offsite power systems have spatial separation and/or totally enclosed raceways over their entire length. Fire protection and detection are provided as discussed in subsection 9.5.1.

To comply with General Design Criterion 4, two of the offsite power sources are either direct buried or routed in duct banks and trenches below grade in exterior areas, and the other offsite source is routed overhead in cable trays.

Thus, all features of the offsite (preferred) power supply are designed to provide maximum practical reliability and redundancy in servicing the station safety load groups. Compliance with General Design Criterion 17, Electric Power System, is demonstrated by supplying the switchyard with ac power by two or more physically independent 230-kV circuits. Furthermore, the offsite power sources to the engineered safety features buses are either brought in by two physically independent circuits from the switchyard through the reserve auxiliary transformers (RAT) or another method of providing offsite power to either one of the engineered safety features buses is available with a 13.8-kV underground circuit emanating from the Georgia Power Company Plant Wilson switchyard through the standby auxiliary transformer (SAT) located in the Vogtle low voltage switchyard. Physical separation, the breaker-and-a-half switching configuration, redundant switchyard protection systems, and the transmission system are designed on load flow and stability studies to minimize simultaneous failure of all offsite power sources.

Compliance with General Design Criterion 18 is achieved by designing testability and inspection capability into the system and then implementing a comprehensive testing and surveillance program. The inspection and testing of the 230-kV and 500-kV breakers or disconnects, and the transmission line protective relaying can be done on a routine basis, without removing either the RATs, the SAT, or most transmission lines from service.

8.2.2.5 Standards and Guides

In addition to the Nuclear Regulatory Commission General Design Criteria, the industry guides and standards listed below, and references thereto, are used in the design and procurement of the offsite power system.

A. Institute of Electrical and Electronic Engineers (IEEE) Standard 450-1995, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries. The safety-related batteries will be tested periodically in accordance with the Technical Specifications and the version of IEEE 450 as described in the Bases for the Technical Specifications.

B. American National Standards Institute (ANSI) C37.010-1972, Application Guide for ac High Voltage Circuit Breakers.

C. ANSI C37.90-1971, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

D. ANSI C57.12.00-1973, General Requirements for Distribution, Power, Regulating Transformers, and Shunt Reactors.

E. Insulated Cable Engineers Association (ICEA) S-19-81 (5th Edition), Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy, Revision 5, 1976.

F. ICEA S-66-524, Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy, Revision 5, 1976.

G. ICEA S-68-516, Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy, Revision 1, 1977.

H. IEEE Standard 383, Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations, February 28, 1974.

I. American Society of Testing Materials (ASTM) B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft, 1971.

J. ASTM-B33, Standard Specification for Tinned Annealed Copper Wire for Electrical Purposes, 1971.

K. ASTM-B189, Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes, 1981.

TABLE 8.2.1-1 (SHEET 1 OF 2)

SUMMARY OF 230- AND 500-kV LINE CONSTRUCTION

Line Name	VEGP – (4) Vogtle Switching Station	VEGP – (2)(6) Warthen	VEGP – West McIntosh(5)	VEGP-(7) Thomson	VEGP - Wilson Combustion Turbine	VEGP - S. Carolina Elec. & Gas	VEGP - Augusta Corporate Park(3)	VEGP – Goshen (White)
Remote termination	Augusta Newsprint Sub.	Warthen	West McIntosh Sub.	Thomson Sub	Comb. Turb. Bus	Savannah River Plant Sub.	Augusta Corporate Park Sub	Goshen Sub.
Operating voltage (kV)	230	500	500	500	230	230	230	230
Scheduled completion	1983	2017	2017	2017	1984	1986	1986	1986
Line length (mi)	19.62(4)	153.70(2)	71.2(1)	55.2	1.35	21.6	14(3)	18.9
R/W width(ft)	2.09 mi @ 100 0.25 mi @ 125 17.28 mi @ 275	8.25 mi @ 262.5 13.00 mi @ 325 14.55 mi @ 400 117.63 mi @ 150	150	150	150	4.5 mi @ 125 17.1 mi @ 100	275	275
Line placement on R/W	2.09 mi-centered 0.25 mi-centered 17.28 mi-62.5' from edge of R/W	153.7 mi-75' from edge of R/W	Centered	Centered	Centered	Centered	62.5' from edge of R/W	137.5' from edge of R/W
Terrain	Flat	Flat to rolling	Flat to rolling	Flat to rolling	Flat	Flat	Flat	Flat
Conductor: configuration size type	single 1351.5 kcmil ACSR	Bundled 1113 kcmil ACSR	Bundled 1113 kcmil ACSR	Bundled 1113 kcmil ACSR	Single 1351.5 Mcmil SSAC	4.5 mi @ Bundled 1351.5 kcmil ACSR; 17.1 mi @ Bundled 1272 kcmil ACSR	Bundled 795 kcmil ACSR	Bundled 795 kcmil ACSR
Phase/phase clearance (ft)	20	28	28	42	20	4.5 mi @ 20 17.1 mi @ 19	20	20
Phase/ground clearance at max. oper. condition (ft)	25	33	33	37	25	4.5 mi @ 25 17.1 mi @ 26	25	25

TABLE 8.2.1-1 (SHEET 2 OF 2)

Line Name	VEGP - (4) Vogtle Switching Station	VEGP – (2)(6) Warthen	VEGP - West McIntosh(5) (Thalman)	VEGP - (7) Thomson	VEGP - Wilson Combustion Turbine	VEGP – S. Carolina Elec. & Gas	VEGP -(3) Augusta Corporate Park (3)	VEGP - Goshen (White)
Unusual oper. conditions	none	none	none	none	none	none	none	none
Major transmission line crossing	none	Waynesboro-Wadley 230-kV; Plant Harllee Branch - Social Circle No. 1 230 kV; Plant Harllee Branch - Social Circle No. 2 230 kV; Plant Harllee Branch - Klondike 230 kV; Plant Harllee Branch – Goshen 230 kV; Plant Harllee Branch - Evans 230 kV	230-kV Wilson combustion turbine Waynesboro	Branch-Goshen 230 kV (MEAG); Thomson-Warrenton 230 kV; Goshen-Waynesboro 115 kV (MEAG); Thomson-Warrenton (White) 115 kV; Thomson-Warrenton (Black) 115 kV	none	115 kV Urquhart-Fairfax (SCE&G)	VEGP-Augusta Newsprint 230 kV; Goshen-Augusta Newsprint 230 kV	VEGP-Augusta Newsprint 230 kV; Goshen-Augusta Newsprint 230 kV

(1) This length includes 2.6 miles added at the VEGP site area after initial construction.
(2) In 2002, VEGP-Scherer line became the VEGP-Warthen, Warthen – Scherer lines with the addition of the Warthen substation approximately 76.5 miles from VEGP.
(3) The VEGP-Goshen (Black) line became the VEGP-Augusta Corporate Park line with the addition of the Augusta Corporate Park substation approximately 14 miles from VEGP.
(4) In 2014, VEGP-Augusta Newsprint line became the VEGP-Vogtle Switching Station and Vogtle Switching Station-Augusta Newsprint lines with the addition of the Vogtle Switching Station approximately 0.5 mile from VEGP.
(5) In 2017, the West McIntosh line was relocated to the VEGP Unit 4 500-kV switchyard. The Unit 4 switchyard busses were connected to the existing 500-kV switchyard busses by overhead tie lines as part of switchyard upgrades to support the output of Units 3 and 4.
(6) In 2017, the Warthen line was relocated to the Unit 5 500-kV switchyard as part of switchyard upgrades to support the output of Units 3 and 4.
(7) In 2017 the Thomson line was connected in place of the Warthen line as part of switchyard upgrades to support the output of Units 3 and 4.

TABLE 8.2.1-2

THE ASSIGNMENT OF 230-kV CIRCUIT BREAKER SUPPLIES TO SUBSTATION BATTERIES

	Battery No. 1			Battery No.2		
230-kV CB	Line Relaying[(a)]	Close	Trip No.	Line Relaying[(a)]	Close	Trip No.
161760	P	X	1	S		2
161860	P	X	1	S		2
161960	P		2	S	X	1
161750[(b)]	P	X	1	S		2
161850[(b)]	P	X	1	S		2
161950[(b)]	P		2	S	X	1
161710	P	X	1	S		2
161810	P	X	1	S		2
161910	P		2	S	X	1
161730	S	X	1	P		2
161830	S		2	P	X	1
161930	S		2	P	X	1
161720	P	X	1	S		2
161820	P	X	1	S		2
161920	P		2	S	X	1
161740	P	X	1	S		2
161840	P	X	1	S		2
161940	P		2	S	X	1
161770	S	X	2	P		1
161990	P		1	S	X	2

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a. P denotes primary; S denotes secondary.

b. Future.

TABLE 8.2.1-3

THE ASSIGNMENT OF 500-kV CIRCUIT BREAKER SUPPLIES TO SUBSTATION BATTERIES

	Battery No. 1			Battery No. 2		
500-kV PCI	Line Relaying[a]	Close	Trip No.	Line Relaying[a]	Close	Trip No.
161520	P	X	1	S		2
161620	P	X	1	S		
161660	P		2	S	X	1
161510	P		1	S	X	2
161600	P		1	S	X	2
161610	P		1	S	X	2
161650	P		1	S	X	2

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a. P denotes primary; S denotes secondary.

TABLE 8.2.2-1

46-, 69-, 115-, 230-, AND 500-kV LINE INTERRUPTIONS CAUSED BY LIGHTNING INTERRUPTIONS FOR 100 MILES FOR YEAR 1979

Type of Lines and Voltage	Miles	No. of Lightning Outages	Outages per 100 Miles
500-kV steel towers	766.83	3.0	0.39
230-kV steel H-frame and wood H-frame	3,289.03	23.0	0.70
115-kV wood H-frame, wood SP, steel SP	5,408.72	305.00	5.64
69-kV wood H-frame wood single pole	464.41	68.00	14.64
46-kV wood single pole	4,006.69	848.00	21.16

230-kV Lines	Month	Day	Time	Duration of Outage (h)	(min)	(s)
Austin Dr.-Klondike 230 kV[(a)]	07	21	1510	000	00	00
Austin Dr.-Scottdale 230 kV([(a)]	07	20	1629	000	00	00
Bio-Center 230 kV([(a)]	06	30	0520	000	00	00
Bonaire-Butler 230 kV[(a)]	04	09	0138	000	00	00
Boulevard-Peachtree 230 kV[(a)]	08	26	1646	000	00	00
Bowen-Hammond No. 1 230 kV	04	12	0720	001	15	00
Bowen-Pinson 230 kV[(a)]	06	30	0442	000	00	00
Branch-Klondike 230 kV[(a)]	08	10	0004	000	00	00
Bremen-Villa Rica 230 kV	06	02	1413	000	00	15
Dum Jon-Evans 230 kV[(a)]	07	18	1403	000	00	00
Dum Jon-Evans 230 kV[(a)]	08	01	1423	000	00	00
E. Dalton-Widows Creek 230 kV[(a)]	05	13	0755	000	00	00
E. Dalton-Widows Creek 230 kV[(a)]	07	21	0929	000	00	00
Farley-S. Bainbridge 230 kV[(a)]	09	01	1936	000	00	00
Gaston AL-Yates 230 kV	08	10	1305	000	00	03
McDonough-Northwest 1 230 kV[(a)]	04	13	0914	000	00	00
McDonough-Northwest 1 230 kV[(a)]	04	13	0915	000	00	00
McDonough-Northwest 1 230 kV[(a)]	09	28	1928	000	00	00
McDonough-Northwest 1 230 kV[(a)]	09	28	1935	000	00	00
McDonough-Peachtree 230 kV[(a)]	05	01	0006	000	00	00
McDonough-Peachtree 230 kV[(a)]	08	31	2000	000	00	00
Nelson-Norcross 230 kV[(a)]	04	13	0834	000	00	00
Nelson-Norcross 230 kV[(a)]	08	11	1200	000	00	00

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a. Instantaneous; time was not recorded.

TABLE 8.2.2-2

SUMMARY OF TRANSMISSION LINE FAILURES - 1979

Type of Failure	Number	Cause of Failure	Number
Pole	9	Lightning	1247
Line insulator	66	Trees	61
Switch	31	High winds	6
		Cold weather	22
Conductors	33	Others[b]	532
Crossarm	14		
Shield wire contact	13		
Others[a]	146		
Total failures	312		1868

Voltage Class	Structure Miles	Number of Failures	Failure per 100 Miles of Line
500 kV	766.83	6	0.78
230 kV	3,289.03	43	1.31
115 kV	5,408.72	495	9.15
69 kV	464.41	109	23.47
46 kV	4,006.69	1527	38.11
Total	13,935.68	2180	15.64

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a. Other types of failure include conductor shorted together, foreign matter on lines, line switch failures, prearranged outages, and unknown causes.

b. Other causes of failure include vandals, automobiles, trucks, airplanes, and unknown causes.

8.3 ONSITE POWER SYSTEMS

8.3.1 AC POWER SYSTEMS

8.3.1.1 Description

The onsite ac power system includes a Class 1E system and a non-Class 1E system.

8.3.1.1.1 Non-Class 1E System

Onsite ac power is supplied from the 230-kV switchyard through reserve auxiliary transformers which feed non-Class 1E and Class 1E buses. Onsite ac power may also be supplied from the SAT, which receives its power from the 13.8-kV system at the Georgia Power Company Plant Wilson switchyard. Non-Class 1E ac power is distributed at 13.8 kV, 4.16 kV, 480 V, 277 V, 240 V, 208 V, and 120 V. Bus arrangements are shown in drawings 1X3D-AA-A01A, 2X3D-AA-A01A, and AX3D-AA-A01A.

The unit auxiliary transformers and the reserve auxiliary transformers each have one secondary winding rated at 13.8 kV and one secondary winding rated at 4.16 kV. Two 13.8-kV busses and three 4.16-kV busses supply power to nonsafety-related loads. Each 13.8-kV bus can be connected to a secondary winding of one of the reserve auxiliary transformers and also to a secondary winding of one of the unit auxiliary transformers.

The SAT has a single secondary 4.16-kV winding. When required for emergencies or RAT maintenance, the secondary winding may be connected to a Class 1E bus. While the SAT is in service some non-Class 1E loads, up to the SAT load limit, may also be supplied. The SAT loading is administratively controlled.

Two of the 4.16-kV busses can be connected to the secondary winding of one of the reserve auxiliary transformers and also to a secondary winding of the unit auxiliary transformer. The third 4.16-kV bus can be connected to the secondary winding of the second reserve auxiliary and unit auxiliary transformers. During starting of a unit, both 13.8-kV busses and the three 4.16-kV busses are supplied power from the reserve auxiliary transformers. Normally, these busses are then transferred to the unit auxiliary transformers during power generation by a manually initiated transfer.

Automatic fast bus transfer of the 13.8-kV busses with an automatic residual voltage transfer as a backup, from the unit auxiliary transformer to the reserve auxiliary transformers, is provided. For the 4.16-kV bus transfer from the unit auxiliary transformers to the reserve auxiliary transformers, only automatic residual voltage bus transfer is provided.

When the SAT is replacing a RAT, neither the automatic, fast, or residual voltage bus transfer from the affected UAT 13.8-kV bus to the SAT is possible because the SAT does not have a 13.8-kV secondary winding. Therefore, the affected UAT 13.8-kV automatic bus transfer schemes are disabled. Automatic residual voltage transfer of the non-Class 1E 4.16-kV busses are also disabled during this time. The SAT may provide power to some non-Class 1E loads in addition to the connected Class 1E loads, but cannot supply the load of an entire non-Class 1E bus.

Each unit auxiliary transformer has the capacity to supply the connected non-Class 1E load.

8.3.1.1.2 Class 1E System

The Class 1E ac power system is the power source used in or associated with shutting down the reactor and preventing or limiting the release of radioactive material following a design basis event. The system is divided into two independent ac power trains, train A and train B, each fed from an independent Class 1E bus with immediate access to offsite power sources. Drawings 1X3D-AA-A01A and 2X3D-AA-A01A show a schematic of the Class 1E ac power system, for Units 1 and 2.

Each train of Unit 1 and 2 is independent, except the following Class 1E loads are common to Unit 1 and 2. They are powered from Class 1E sources associated with Unit 1 only and have no provision for connection to Unit 2 power supplies.

Load	Source
Fuel Handling Building Post-Accident Unit Heater	
A-1542-NM-001-H01	1ABA10
A-1542-N7-002-H01	1BBA10
Fuel Handling Building Post-Accident Exhaust Fan	
A-1542-N7-001-M01	1ABA08
A-1542-N7-002-M01	1BBA08
Fuel Handling Building Radiation Monitor	
ARX-2532	1AY2A06
ARX-2533	1BY2B06

All safety-related equipment is housed in Seismic Category 1 structures.

The Class 1E ac system distributes power at 4.16 kV, 480 V, and 120 V ac to all safety-related loads. Also, the Class 1E ac system supplies through isolation devices certain selected loads which are not safety related but are important to the plant operation. Drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B indicate the major safety-related and isolated nonsafety-related loads supplied by the Class 1E ac system.

The non-Class 1E ac system supplies preferred (offsite) power to the Class 1E ac system through the reserve auxiliary transformer 4.16-kV windings. Each reserve auxiliary transformer has the capacity to supply all connected non-Class 1E running loads and to start and run the loads of one Class 1E train, or to start and run the loads of both Class 1E trains. During modes 1 through 4, to ensure that one RAT has adequate capacity and capability to start and run both trains of LOCA loads, the following conditions shall be met:

1. Grid voltage shall be maintained at or above the minimum expected 100% grid voltage while the busses are interconnected to one RAT;
2. No additional non-Class 1E 4.16-kV loads, other than those normally fed from the Class 1E safety busses, shall be manually connected to the one RAT feeding both Class 1E busses; and
3. The automatic bus transfer schemes for the non-Class 1E 4.16-kV busses shall be disabled during the interconnection of both trains to one RAT.

The non-Class 1E ac system may also supply preferred offsite power to the Class 1E ac system from the SAT 4.16-kV winding. During modes 1 through 4, the SAT has adequate capacity and capability to start and run the loads of one Class 1E train. The SAT does not have the capacity or capability to simultaneously start and run both trains of LOCA loads. However, in modes 5 and 6, the SAT has adequate capacity and capability to provide power to the safety-related loads on two Class 1E 4.16-kV electrical busses provided one train of the safety injection (SI) signal from the sequencer is blocked. If only one Class 1E bus is supplied by the SAT, additional non-Class 1E loads may be manually added until the SAT capacity is reached. See paragraph 8.3.1.1.2.D for further discussion.

In addition to the above power distribution, the Class 1E ac system contains standby power sources which provide the power required for safe shutdown in the event of a loss of the preferred power sources. The power, control, and instrumentation cables essential for safe shutdown are routed with adequate separation from their redundant counterparts.

The following describes various features of the Class 1E systems:

A. Power Supply Feeders

Each 4.16-kV load group can be supplied by one of two preferred power supply feeders or one diesel generator (standby) supply feeder. The preferred power supply feeders may be connected to either a RAT or the SAT. The SAT shall be connected to only one preferred power supply feeder at a time. Each 4.16-kV bus supplies motor loads and 4.16-kV/480-V load center transformers with their associated 480-V busses.

B. Bus Arrangements

The Class 1E ac system is divided into two redundant trains per unit (trains A and B). For each unit, either one of the trains is capable of providing power to safely reach shutdown for that unit. Each ac train consists of a 4.16-kV bus, 480-V load centers, 480-V motor control centers, and lower voltage ac supplies. The dc control power to each train is provided from dc power supplies of the same train.

C. Loads Supplied from Each Bus

Refer to drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B for a listing of Class 1E system loads and their respective busses.

D. Manual and Automatic Interconnections Between Busses, Busses and Loads, and Busses and Supplies

No provisions exist for automatically connecting one Class 1E train to another redundant Class 1E train or for automatically transferring loads between trains.

Each Class 1E bus is provided with two (normal and alternate) offsite preferred power sources and one onsite standby power source. During normal operation with both offsite sources available, each Class 1E bus is supplied from a separate reserve auxiliary transformer. An additional preferred offsite power source, the SAT, is also available to supply the safety-related loads during an emergency or during RAT maintenance.

A circuit breaker is provided for both the normal and alternate offsite preferred power sources. Transfer to the alternate offsite source would be accomplished under administrative control by performing a manual, hot-bus transfer between the normal and alternate offsite power source. Electrical separation is maintained through the Class 1E circuit breakers on each bus which serve as Regulatory Guide 1.75 separation devices. See paragraph 8.3.1.4.3 and table 8.3.1-4 for further discussion of this subject.

During power operation (modes 1 through 4), and only for purposes of facilitating the transfer of preferred offsite power sources, both Class 1E 4.16-kV busses may be manually connected to the same RAT by administrative control provided:

1. Grid voltage is maintained at or above the minimum expected 100% grid voltage while the busses are interconnected to the one RAT;
2. No additional nonsafety-related 4.16-kV loads, other than those normally fed from the Class 1E 4.16-kV safety busses, shall be manually connected to the RAT while the busses are interconnected; and
3. The automatic bus transfer schemes for the nonsafety-related 4.16-kV busses shall be disabled during the connection of both trains to one RAT.

The 13.8-kV fast and residual voltage bus transfer schemes for the remaining RAT in service need not be disabled. This provides a transfer method and power source for the bus from which two of four reactor coolant pumps are normally fed should a reactor/turbine trip occur during the time the busses are interconnected to one RAT. The SAT should not be utilized as a single source of power for both trains of safety loads during power operation (modes 1 through 4).

During unit shutdown (modes 5 and 6), both Class 1E 4.16-kV busses may be manually connected to the same offsite power source (RAT or SAT) by administrative control provided that the total load on the 4.16-kV non-Class 1E busses powered by the RAT shall not exceed 7500 kVA, or when connected to the SAT, the SAT's 1,735-A secondary winding ampacity rating shall not be exceeded. During modes 5 and 6, the SAT has adequate capacity and capability to provide power to the safety-related loads for two Class 1E 4.16-kV electrical busses provided the safety injection signal from the sequencer for one train is blocked. When one 4.16-kV Class 1E bus is supplied from the SAT, additional non-Class 1E loads may be connected until the SATs load limit is reached.

In all cases, when the 4.16-kV non-Class 1E busses are powered through the backfeed arrangement, then the automatic bus transfer schemes shall be disabled. However, the bus transfer schemes for 13.8-kV busses need not be disabled.

E. Interconnections Between Safety-Related and Nonsafety-Related Busses

No interconnections are provided between the safety- and nonsafety-related busses at the same voltage level. The reserve auxiliary transformers supply power through the same 4.16-kV winding to both non-Class 1E and Class 1E busses.

There is one non-Class 1E 480-V switchgear bus powered through a transformer from each safety-related 4.16-kV bus. The 4.16-kV circuit breaker to which this load is connected is Class 1E qualified for the design life of the plant[a], in accordance with the requirements of Institute of Electrical and Electronic Engineers (IEEE) Standards 323 and 344. This circuit breaker is automatically tripped by the solid state protection system upon the receipt of a safety injection signal, but it can be manually reclosed under administrative control. Isolation is

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[a] The operating licenses for both VEGP units have been renewed and the original licensed operating terms have been extended by 20 years. In accordance with 10 CFR Part 54, appropriate aging management programs and activities have been initiated to manage the detrimental effects of aging to maintain functionality during the period of extended operation (see chapter 19).

therefore provided in accordance with the requirements of Regulatory Guide 1.75.

F. Redundant Bus Separation

The Class 1E switchgear, load centers, and motor control centers for the redundant trains are located in separate rooms of the control building, auxiliary building, and diesel generator building in such a way as to ensure physical separation. Refer to paragraphs 8.3.1.4.1 and 8.3.1.1.7 for the criteria governing redundant bus separation.

G. Class 1E Equipment Capacities

1. 4.16-kV Switchgear

Bus	2000 A continuous
Incoming breakers	2000 A continuous, 350 MVA interrupting
Feeder breakers	1200 A continuous, 350 MVA interrupting

2. 480-V Unit Load Centers

Transformers	1000 kVA, 3 phase, 60 Hz, 4160/480 V Bus 1600 A continuous
Incoming breakers	1600 A continuous, 50,000 A rms symmetrical interrupting
Feeder breakers	800 A continuous, 30,000 A rms symmetrical interrupting

3. 480-V Motor Control Centers

Horizontal bus	800 A continuous, 25,000 A rms symmetrical
Vertical bus	600 A continuous, 25,000 A rms symmetrical
Breaker (molded case)	25,000 A rms symmetrical minimum interrupting (singly for thermal-magnetic breakers and in combination with a starter for magnetic only breakers)

H. Automatic Loading and Load Shedding

The automatic loading sequence of the Class 1E busses is indicated in drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B.

If preferred power is available to the 4.16-kV Class 1E bus following a loss-of-coolant accident (LOCA), the Class 1E loads will be started in programmed time increments by the load sequencer. The emergency standby diesel generator will be automatically started but not connected to the bus. In the event that preferred power is lost following a LOCA, the load sequencer will function to shed loads and connect the standby power source to the Class 1E bus. The load sequencer will then function to start the required Class 1E loads in programmed time increments.

Should a LOCA occur during sequencing after a loss of preferred power, the sequencer will automatically reset and begin sequencing all required loads. Should a LOCA occur after sequencing has been completed, the sequencer will sequence those loads required for LOCA with no load shedding of previously connected loads.

A safety injection signal (SIS) will open the diesel generator breaker if it is paralleled with the offsite power system for testing as described in paragraph 8.3.1.1.3H. The diesel generator breaker will open, but the diesel will remain running as described above.

There are no permissive devices (e.g., lube oil pressure) incorporated into the final actuation control circuitry for large horsepower, safety-related motor-pump combinations.

Refer to paragraph 8.3.1.1.3 for additional information on load shedding and sequencing.

I. Class 1E Equipment Identification

Refer to paragraph 8.3.1.3 for details regarding the physical identification of Class 1E equipment.

J. Instrumentation and Control Systems for the Applicable Power Systems with the Assigned Power Supply Identified

The dc control supplies for switchgear breaker operation are separate and independent so that Class 1E dc train A normally supplies Class 1E train A switchgear. The battery chargers for dc train A are normally fed from the same train motor control centers. Class 1E dc train B supplies Class 1E train B switchgear. The battery chargers for dc trains C and D are normally fed from trains A and B motor control centers, respectively. For further information on the dc power system, refer to subsection 8.3.2.

Each 4.16-kV switchgear bus and 480-V load center bus is provided with common trouble alarm annunciation in the control room. This alarm summarizes bus undervoltage, overcurrent circuit breaker tripping and other miscellaneous improper switchgear conditions. In addition, the 4.16-kV switchgear is provided with bus negative sequence annunciation in the control room. The voltage of each 4.16-kV bus is monitored by instruments in the control room. Each 480-V motor control center is provided with common trouble annunciation in the control room. This annunciation is initiated by either an overload or a loss of control power at each load fed from the motor control center.

For a listing of the loads associated with these busses, see drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B.

K. Electric Circuit Protection Systems

Protective relay schemes or direct-acting trip devices on primary and backup circuit breakers are provided throughout the onsite power system to:

- Isolate faulted equipment and/or circuits from unfaulted equipment and/or circuits.
- Prevent damage to equipment.
- Ensure personnel safety.
- Minimize system disturbances.

The short circuit protective system is analyzed to ensure that the various adjustable devices are applied within their ratings and set to be coordinated with each other to attain selectivity in their operation. The combination of devices and settings applied affords the selectivity necessary to isolate a faulted area quickly with a minimum of disturbance to the rest of the system.

Major types of protection applications that are used consist of the following:

1. Overcurrent Relaying

   Each supply feeder breaker from the unit auxiliary transformers (nonsafety-related) and the reserve auxiliary transformer is provided with three very inverse time phase overcurrent relays with instantaneous trip attachment (one per phase) and two level timers for instantaneous trip for phase-to-phase fault protection. Phase-to-ground fault protection for each supply feeder is provided with one very inverse time residual overcurrent relay without instantaneous unit.

   Each 4.16-kV motor circuit breaker has three overcurrent relays, each with one long time and one instantaneous element for overload, locked rotor, and short circuit protection. Each 4.16-kV motor circuit breaker is also equipped with a ground residual current relay with one long time and one instantaneous element.

   The current for Class 1E motors is monitored by an ammeter at the Class 1E switchgear.

   Each 4.16-kV supply circuit breaker connected to a load center transformer has three overcurrent relays with very inverse time elements with instantaneous attachments. A residual ground overcurrent relay with one time overcurrent element and one instantaneous element provides sensitive ground fault protection.

2. Undervoltage Relaying

   Each 4.16-kV Class 1E bus is equipped with undervoltage relays (located at the sequencer for each Class 1E train) for diesel generator start initiation and undervoltage annunciation. (See paragraph 8.3.1.1.3F for further details.)

   Each 480-V Class 1E load center bus is equipped with undervoltage relays for undervoltage annunciation.

3. Differential Relaying

   The main (nonsafety-related), unit auxiliary (nonsafety-related), and reserve auxiliary transformers are equipped with differential relays. These relays provide high speed disconnection to prevent severe damage in the event of transformer internal faults.

   Motors rated 4500 hp and above are equipped with differential protection.

   The main generator (nonsafety-related) and the standby emergency generator are provided with differential protection.

4. 480-V Load Center Overcurrent Relaying

Each 480-V load center circuit breaker is equipped with a solid-state device which has an adjustable phase overcurrent trip. Breakers feeding motors have an instantaneous trip.

5. 480-V Motor Control Center Overcurrent Relaying

Molded case circuit breakers provide time overcurrent and/or instantaneous short circuit protection for all connected loads. The molded case circuit breakers (MCCB) for motor circuits are equipped with instantaneous trip only. Motor overload protection is provided by thermal trip units in the motor controller. The MCCB for nonmotor feeder circuits provide thermal overcurrent protection as well as instantaneous short circuit protection, with the exception of the Class 1E battery chargers where thermal magnetic or instantaneous trip only MCCB may be utilized due to high inrush current and to coordinate with the thermal magnetic trip breaker furnished locally at the battery chargers.

During startup and periodic testing, all starters for motor-operated valves are equipped with thermal overload relays wired into the control circuitry. Prior to core loading and during plant operation, the thermal overload relay trip contacts for all of the Class 1E valves (ac and dc) are permanently bypassed with jumpers, in accordance with Regulatory Guide 1.106.

The starters and the feeder circuit breakers located in the motor control center are coordinated with the motor control center incoming supply breakers so that, upon a fault, the protective device nearest the fault trips first.

L. Testing of the ac Systems During Power Operation

All Class 1E circuit breakers and motor controllers are testable during reactor operation, except for the electric equipment associated with those Class 1E loads identified in chapter 7. During periodic Class 1E system tests, subsystems of the engineered safety features actuation system, such as safety injection, containment spray, and containment isolation, are actuated, thereby causing appropriate circuit breaker or contactor operation. The 4.16-kV and 480-V switchgear circuit breakers and control circuits can also be tested independently while individual equipment is shut down. These circuit breakers can be placed in the test position and exercised without operation of the associated equipment. The use of jumpers or other temporary test arrangements which would bypass protective functions is not required to verify system capability to operate except during startup testing or as noted in paragraph 1.9.118.2.

M. Sharing of Systems and Equipment Between Units

There is no sharing of Class 1E systems or equipment between units (with the exception of fuel handling building loads discussed in paragraph 8.3.1.1.2) in accordance with the requirements of Regulatory Guide 1.32 and 1.81.

N. Class 1E Equipment Qualification

The equipment identified as safety related has been qualified as Class 1E equipment and is designated as Seismic Category 1. It has been shown to be capable of withstanding the environmental conditions to which it will be exposed. (See sections 3.10 and 3.11 for further details of the equipment qualification.)

8.3.1.1.3 Standby Power Supply

The standby power supply for each safety-related load group consists of one diesel generator complete with its accessories and fuel storage and transfer systems. It is capable of supplying essential loads necessary to reliably and safely shut down and isolate the reactor. Each diesel generator is rated at 7000 kW for continuous operation and 7700 kW for a short-term (2-h) period every 24 h. The voltage and frequency recovery characteristics meet or exceed the requirements of Regulatory Guide 1.9. One diesel generator is connected exclusively to a single 4.16-kV safety feature bus of a load group. Each unit has two 4.16-kV Class 1E trains, and the safety-related equipment on both trains is similar. The trains are redundant, and, for each unit, one train is adequate to satisfy minimum engineered safety features demand caused by a LOCA and a simultaneous loss of preferred power supply. The diesel generators are electrically isolated from each other. Physical separation for fire and missile protection is provided between the diesel generators, since they are housed in separate rooms of the Seismic Category 1 diesel generator building. Power and control cables for the diesel generators and associated switchgear are routed to maintain physical separation.

Ratings for diesel generator sets are determined on the basis of nameplate rating, pump pressure and flow conditions, or motor brake horsepower. The nameplate ratings for each load are noted in drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B. The loading profile for the diesel is shown in table 8.3.1-2. The continuous rating of the diesel generator is based on the maximum total load required at any time. The diesel generator is capable of operation at less than full load for extended periods of time as described in subsection 9.5.5.

The functional aspects of the onsite power system are discussed below:

A. Starting Initiating Circuits

The diesel generators are started on the following:

- Receipt of a safety injection signal.
- Loss of voltage to the respective 4.16-kV Class 1E bus to which each diesel generator is connected.
- Manual switch actuation (control room).
- Manual switch actuation (diesel generator room).
- Emergency manual switch actuation (diesel generator room).

Starting a diesel generator with a safety injection signal, a loss of 4.16-kV Class 1E bus voltage signal, or an emergency manual switch actuation will place that diesel generator in the accident operation mode.

Starting a diesel generator with a manual switch actuation from either the control room or the diesel generator room will place that diesel generator in the nonaccident operation mode.

Refer to the logic diagram provided in drawings 1X4AK01-30 and 1X4AK01-31.

B. Diesel Starting Mechanism and System

Refer to subsection 9.5.6.

C. Tripping Devices

The following protective functions are provided during operation of the diesel generator:

- High jacket coolant temperature.(1)(2)
- High temperature lube oil.(1)(2)
- Low jacket coolant pressure.(1)(2)
- High temperature engine bearing.(1)(2)
- Loss of field.(1)
- Vibration.(1)(2)
- Engine overspeed.
- Low turbocharger oil pressure.(1)(2)
- High crankcase pressure.(1)(2)
- Low lube oil pressure.
- Generator underfrequency.(1)(2)
- Generator differential.
- Generator reverse power.(1)(2)
- Generator negative phase sequence.(1)(2)
- Generator voltage controlled phase overcurrent.(1)

(1) Diesel engine/generator breaker trips blocked during safety injection initiated operation.

(2) Diesel engine and/or generator breaker trips blocked during emergency manual switch or LOSP initiated operation.

Reverse power, negative phase sequence, and underfrequency protection are permitted to trip only during operation of the diesel generator in parallel with the preferred power supply during manually initiated testing.

Underfrequency protection is provided to safely separate the diesel generators from the preferred source (when previously synchronized to it) without damage to or shutdown of the diesel generators. If the engine does not reach 200 rpm within a predetermined time following a start signal, the fail-to-start relay functions to restart the keep warm systems and alarm locally and in the control room.

The protective devices which function to shut down the diesel and which are also retained during an accident consist of the following:

- Engine overspeed.
- Generator differential.
- Low lube oil pressure.

The low lube oil pressure trip is implemented by three independent measurements. Actuation of this trip is initiated by two-out-of-three coincident logic in accordance with Regulatory Guide 1.9.

Although the diesel generators are vital to the safety of the plant, no automatic bypass is provided for the protective devices which function to shut down the diesel during an accident, since each train is provided with one diesel generator. Should one diesel generator be tripped by a protective device, the redundant train will function as a backup. Since the malfunctioning diesel generator is isolated before being seriously damaged, repairs could be performed while the redundant diesel is in operation.

The diesel generator control and monitoring equipment which is not by its nature required to be mounted on the diesel generator skid is located in free-standing control panels for each diesel generator unit to minimize or eliminate mechanical fatigue caused by vibration of the diesel generator during operation.

The diesel generators are monitored from the control room, and each device, when actuated, initiates an annunciator in the control room. These functions are also provided with alarms in the diesel generator room. The alarms, where possible, are set so that they provide a warning of impending trouble prior to tripping of the diesels.

Alarm 46, as shown in table 8.3.1-1, summarizes conditions which cause tripping of the diesel generators, render the diesel generators incapable of responding to an automatic start signal, accepting load, or which will, over time, cause the shutdown of the diesel generators. This alarm is actuated by emergency stop, maintenance lockout, engine overspeed trip, low starting air pressure, generator dc control power failure, the local-remote generator control switch in the local position, generator circuit breaker inoperable, diesel fuel storage tank pumps inoperable, diesel generator building ventilation fan transfer control switch in the local position or the remote control switch in the pull-to-lock position, diesel generator building ventilation fan discharge damper operator power failure, diesel generator failed to start relay, starting air control power failure, or diesel generator barring device engaged. This alarm is located on the system status monitoring panel in the main control room. Capability is provided for a manual initiation of the alarm at the system status monitoring panel to indicate a deliberately induced bypassed condition.

D. Interlocks

Circuit breaker electrical interlocks are provided to prevent automatic closing of a diesel generator breaker to an energized or faulted bus.

If the preferred power has been lost, an undervoltage signal will trip the preferred offsite power incoming breakers as indicated in paragraph 8.3.1.1.3F.

Both 4.16-kV Class 1E busses have a circuit breaker installed in the normal and alternate preferred offsite power source cubicles. Either breaker is capable of connecting the bus to an offsite power source. Both Class 1E 4.16-kV busses may be manually connected and paralleled to the same offsite power source as discussed in paragraph 8.3.1.1.2.D. The connection would be accomplished under administrative control by performing a manual, hot-bus transfer between the normal and alternate offsite sources. Although the preferred offsite power sources are momentarily paralleled during a hot-bus transfer, electrical interlocks are provided to prevent the preferred offsite power sources from remaining paralleled.

E. Permissives

A single switch in the diesel generator room is provided for each diesel generator to block automatic start signals when the diesel is out for maintenance.

When in the local-manual position, an annunciator is initiated in the control room.

A pushbutton in the control room and a local pushbutton in the diesel generator room are provided to allow manual start capability.

An emergency start is provided in the diesel generator room which bypasses the automatic start signals to allow a manual start of the diesel. During periodic diesel generator tests, subsequent to diesel start and synchronization to the preferred system, a switch in the control room allows parallel operation with the preferred power source.

F. Load Shedding Circuits

Upon recognition of a loss of or degraded voltage on a 4.16-kV Class 1E bus, a logic signal is initiated to effect the following on each load group through the safety feature sequencer:

- Shed all loads; load center transformers remain connected.
- Send signal to start diesel generator.
- Trip 4.16-kV preferred power supply breaker.

Two voltage sensing schemes for each Class 1E 4.16-kV bus are employed to initiate the logic signal. One scheme will recognize a loss of voltage, and the other will recognize degraded voltage conditions. Each scheme is provided voltage signals through four potential transformers located on each bus.

Logic is provided to allow load shedding and tripping of the incoming breaker on two-out-of-four undervoltage logic signals. These devices are set to operate with a time delay of 0.8 s at a minimum of 71% of nominal voltage which is below the minimum expected voltage during diesel generator sequencing. The undervoltage sensing device design meets the applicable requirements of IEEE 279.

Additional undervoltage logic circuits are provided for each bus to recognize degraded voltage conditions. These circuits are set to operate at a minimum of 89.6% of nominal voltage with a maximum time delay of 20 s. This setpoint is above the minimum motor starting voltage during normal operation; however, the time delay has been selected to prevent unwanted tripping and undervoltage-induced damage to the safety-related loads. Load shedding and tripping of the incoming breaker is provided by two-out-of-four undervoltage logic.

A two-out-of-four undervoltage logic set at 93.1% of nominal voltage with a time delay of 10 s is also provided to initiate an alarm in the control room to warn the operators of a degraded voltage condition. An SIS subsequent to the initiating of this alarm does not separate the auxiliary power system from the offsite power system. Studies have been performed which indicate that at the degraded voltage trip setpoint indicated above, based on the worst case motor thermal damage curve, the permanently connected Class 1E loads will not be damaged. These studies also indicate that adequate voltage is provided to allow starting of the loads.

After a diesel generator has been started and reaches rated voltage and frequency, the generator circuit breaker connecting it to the corresponding 4.16-kV bus closes, energizing that bus and the associated load center transformers. Each diesel generator is designed to accept loads within 9.5 s after receipt of a start signal, and all automatically sequenced loads are connected to the Class 1E bus within 30.5 s thereafter.

As discussed in subsection 15.0.8, the safety analysis postulates a 12 s diesel start time which includes the initial sequencer loading step. (Refer to drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-02B.) Relays at the diesel generator detect generator-rated voltage and frequency conditions and provide a permissive interlock for the closing of the respective generator circuit breaker. Upon loss of the preferred source of power without a LOCA, the load sequencer system initiates the starting of the diesel generators, trips the 4.16-kV preferred power supply breaker, and sheds all loads. The load sequencer for each diesel then automatically initiates the starting of the safe shutdown loads. When an SIS is present, connection of the diesel generator to the 4.16-kV bus is not made unless the preferred source of power is lost (4.16-kV undervoltage).

Following diesel start and connection to the Class 1E bus, the loads are automatically sequenced onto the bus at programmed 5-s time intervals. The load shed feature is bypassed during sequencing of loads. The load shed signal is automatically or manually reset if the diesel generator breaker opens before all the loads are sequenced onto the bus. A fast responding exciter and voltage regulator ensure voltage recovery of the diesel generator after each load step, in accordance with requirements of Regulatory Guide 1.9. Field flashing is utilized on the diesel generators for fast voltage buildup during the start sequence.

Should a LOCA occur during load sequencing or after sequencing is completed, the SIS will restart the sequencer, which will sequence those loads required for LOCA conditions. No load shedding other than the nonsafety-related loads identified in drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B will occur.

Once load sequencing has been completed, or if the diesel generator breaker opens before all the loads are sequenced onto the bus, the load shed and resequence capability is automatically reinstated for an undervoltage sensed at the 4.16-kV Class 1E bus. Logic has been provided that prevents more than three undervoltage conditions from being recognized within a 2-h period. The first and second undervoltage signal will initiate load shed and resequence of the required loads. The third undervoltage signal will initiate a load shed only. Reinstatement of sequencing can be accomplished by manually resetting a timer located at the sequencer. This limitation is provided to prevent automatically exceeding the manufacturer's recommendations concerning motor start capability of two successive starts within a 2-h period.

The diesel generator sequencers were designed in compliance with the requirements in IEEE 603 (1991). Programmable digital components and devices within them additionally comply with IEEE Std 7-4.3.2 (1993).

A breaker in each 4.16-kV Class 1E bus supplies power through a nonsafety transformer (1/2NB01X and 1/2NB10X) to loads listed in drawings 1X3D-AA-K02A, 2X3D-AA-K02A, 1X3D-AA-K02B, and 2X3D-AA-K02B. An SI signal automatically trips the breaker previously closed. After it has been tripped, the operators can close it under administrative control to reenergize the selected nonsafety loads, should their operation be desired.

The voltage levels at safety-related busses are optimized for the expected load conditions throughout the anticipated range of voltages by the setting of no-load transformer taps. The tap setpoints are based upon the design voltage ranges available from the reserve auxiliary transformers. The Technical Specifications indicate the voltage setpoint parameters of the diesel generators to be compatible with the transformer tap setpoints. Verification of the proper tap selection will be accomplished by actual measurement in the field.

All time delays associated with sequencer trip conditions and sequence stepping include ±50 ms tolerance.

G. Loss of a Diesel Generator

Should a diesel generator fail due to a mechanical or electrical malfunction or be tripped by one of the trip signals listed in paragraph 8.3.1.1.3C, the sequencer will shed all loads after the diesel generator breaker has opened. The diesel generator breaker will open on any one of the trip signals listed in paragraph 8.3.1.1.3C or following a diesel generator stop signal.

After the required repairs have been completed, the diesel generator can be started remotely from the main control room or locally from the engine control panel in the diesel generator building. Once the diesel has started and has reached rated voltage and frequency, it will be loaded as described in paragraph 8.3.1.1.3F.

H. Testing

Because the diesel generators are of the type and size that have been previously used as a standby emergency power source in other nuclear power plants, the following site tests are given during the plant preoperational test program and during the plant operation. The test procedures shall include a final equipment check prior to starting these tests.

1. During the plant preoperational test programs only, 35 consecutive start tests for each diesel generator with no failures are to be run to demonstrate the required reliability.
2. During the plant operation, a single start test on 31-day test intervals will be performed. The periodic testing of diesel generator units during the plant operation is to:

   a. Demonstrate that the diesel starts and gradually accelerates to at least 440 rpm, and verify that the required voltage and frequency are attained.

   b. Demonstrate maximum expected load-carrying capability for an interval of not less than 1 h. The maximum expected loading for VEGP is based on a loss of offsite power without a LOCA.

      This test may be accomplished by synchronizing the generator with the offsite system, by connecting through either a RAT or the SAT, and assuming a load at the maximum practical rate.

   c. Demonstrate that the capability of the diesel generator unit to supply emergency power is not impaired.

3. Diesel generator failures will be addressed in accordance with plant procedures that implement the provisions of 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants."
4. The Technical Specifications will include requirements such that during the preoperational period tests are run during shutdown (except for tests described by items f, g, h, and k) to verify the following. The test procedures shall include a final equipment check prior to starting these tests. Tests described by items f, g, h, and k may be performed during any mode of plant operation as required. Technical Specification frequencies shall be controlled under the Surveillance Frequency Control Program using NEI 04-10 guidelines.
    a. Demonstrate that on loss of offsite power the emergency busses have been deenergized and that the loads have been shed from the emergency busses in accordance with design requirements.
    b. Demonstrate that on loss of offsite power the diesel generators start on the autostart signal, load shed occurs, the emergency busses are energized along with load center transformers, the autoconnected shutdown loads are energized through the load sequencer, and the system operates for 5 min while the generators are loaded with the shutdown loads.
    c. Demonstrate that on a safety features actuation signal (without loss of offsite power) the diesel generators start on the autostart signal and operate on standby for 5 min.
    d. Demonstrate that on loss of offsite power, in conjunction with a safety features actuation signal, the diesel generators start on the autostart signal, load shed occurs, the emergency busses are energized along with load center transformers, the autoconnected emergency (accident) loads are energized through the load sequencer, and the system operates for 5 min while the generators are loaded with the emergency loads.
    e. Deleted
    f. Demonstrate maximum expected load-carrying capability for 24 h, of which 22 h are at a load equivalent to the maximum expected loading of the diesel generator and 2 h at a load equivalent to or greater than 105% of the maximum expected loading of the diesel generator.
    g. Demonstrate functional capability at full load temperature conditions by verifying the diesel starts upon receipt of a manual or auto-start signal, and generator voltage and frequency are attained within the required time limits. This test will be performed within 5 min of shutting down the DG after the DG has operated a minimum of 2 hours at full load in accordance with Technical Specifications.
    h. Demonstrate proper operation during diesel generator load shedding, including a test of the loss of the largest single load and of complete loss

of load. Verify that the overspeed limit is not exceeded.

i. Demonstrate the ability to:

   - Synchronize the diesel generator unit with the offsite system while the unit is connected to the emergency load.
   - Transfer the emergency load to the offsite system.
   - Restore the diesel generator unit to standby status.

j. Deleted

k. Demonstrate that the fuel transfer pumps transfer fuel from each fuel storage tank to the day tank of each diesel generator via installed cross-connection lines.

l. Demonstrate that, with the diesel generator operating in a test mode, connected to its bus, a simulated safety injection signal overrides the test mode by: (1) returning the diesel generator to standby operation, and (2) automatically energizing the emergency loads with offsite power.

5. The test procedures will specifically state that the diesel generator unit is to be reset at the conclusion of the test to allow an automatic start when required.

I. Fuel Oil Storage and Transfer Systems

The diesel generator fuel oil system is described in subsection 9.5.4.

The diesel generator cooling water system is described in subsection 9.5.5.

J. Diesel Generator Cooling and Heating Systems

K. Instrumentation and Control Systems for Standby Power Supply

Equipment is provided in the control room for each diesel generator for the following operations:

- Manual starting and stopping.
- Manual and automatic synchronization.
- Manual frequency and voltage setting.
- Emergency stop.
- Voltage regulator manually actuated droop and reset.

A transfer switch is provided in each diesel room for local remote control selection. The switch is normally in the remote position, whereby the engineered safety features system senses an accident or loss of preferred power and starts the diesel. The transfer switch is placed in the local position to allow manual operation of the diesel locally when it is out for maintenance. Equipment is provided locally at each diesel generator for manual starting in case of a control room evacuation. The local emergency start functions to start the diesel generator, regardless of the position of the transfer switch.

Equipment is provided at each local control panel for the following operations (when the transfer switch is in the local position):

- Manual starting.
- Manual stopping.
- Manual frequency and voltage setting.
- Manual exciter field removal and reset.
- Voltage regulator manually actuated droop and reset.

The local control operation is annunciated in the control room. The dc power source for the safety-related diesel generator instrumentation and control system is of the same load group as the respective diesel generator.

Each diesel generator local control panel is equipped with the alarms listed in table 8.3.1-1. The alarms are duplicated in the control room.

Electrical instruments are provided in the control room for surveillance of generator voltage, current, frequency, power, and reactive volt amperes and at the diesel generator for surveillance of generator voltage, current, and frequency. The breaker status of each 4.16-kV breaker of the engineered safety features system is displayed by red and green indicating lamps in the control room. Local indication is provided at the switchgear.

A light is provided on the system status monitor panel to determine the availability of the diesel generator. This light is activated by the conditions identified in paragraph 8.3.1.1.3C.

There will be a time delay initiated to prevent the starting of the diesel generator when the engine is intentionally shut down such as during periodic surveillance testing. This time delay is for approximately 90 seconds. If during the 90-s time delay period a manual start attempt is initiated, the engine will not start because fuel to the engine will be blocked. If the operator depresses the manual start pushbutton during the 90-s time delay period, the starting air valves will open for 5 s and automatically close after the 5 s have elapsed. This built-in 5-s time limit on the opening of the starting air valves is to prevent the depletion of the starting air.

However, if a diesel generator is being manually stopped and an emergency start signal (loss-of-coolant accident or loss of offsite power) is received at the control panel during the 90-s time delay period, the engine control system will automatically bypass the 90-s time delay and will allow fuel oil and starting air to be admitted to the engine. Also, the 5-s time limit will be automatically bypassed; i.e., the starting air valves remain open until the engine starts (starting air pressure above 150 psig), or until the starting air pressure drops to 150 psig. At this pressure, the automatic start attempt will stop because at 150 psig the starting air valves automatically close. At this point, the engine can only be started manually by pushing the manual start button. Pushing the manual start button will cause the starting air valves to open again. There is no built-in time delay between the conclusion of the automatic start sequence and the manual start attempt in a situation as described above. In other words, if the engine fails to start automatically, a manual start can be initiated immediately. The starting air sequence is designed in this manner so that the manual start attempt capability is available if an automatic start attempt fails. The engine can be manually started in this manner until the starting air pressure drops to 90 psig. Generally, starting air pressure below 90 psig will not start the engine when an attempt is initiated.

There is an additional time delay associated with a diesel manual or emergency start that is received while the diesel is ramping up in speed from a slow start initiation. The engine ramp time is approximately 25 s and will not be affected by any subsequent start signal. An emergency start signal will deactivate the normal trips, but will not affect engine rate of acceleration.

For the diesel generator to be automatically started or started from the control room, the mode switch on the engine control panel must be in the "Operational" position, and the point of control (local/remote) switch on the generator control panel in the "Remote" position. If either of the switches is not in these positions, an alarm in the control room on the system status monitor panel and diesel annunciator panel will alert the operator that the diesel is disabled.

In order to maintain the emergency start capability of the diesel generator, operating procedures will specify that periodic surveillance testing is to be initiated only from the control room; i.e., control switch is in the "Remote" position. Also, the operator will be made aware of the built-in 90-s time delay and will be instructed not to initiate manual starting of the engine during this period.

To minimize the accumulation of dust in the diesel generator building, the floors and walls are coated with epoxy to prevent concrete abrasive dust from becoming airborne and interfering with operation of electrical equipment. Diesel engine control panels located in the diesel generator building are not dusttight; however, the generator control cabinet enclosures are NEMA 12 dusttight, and ventilated with filtered louvers. The generator control cabinets have openings at the bottom to receive conductors from trenches and conduits. After installation, these openings will be sealed to limit entry of dirt, moisture, and oil vapors. General house cleaning and maintenance procedures require cleaning of the control panels as required in accordance with the preventative maintenance program. This will prevent accumulation of dust on electrical components and ensure that starting and operation of the diesel generator are not compromised. Thermostatically controlled space heaters are provided in the generator control cabinets and the engine control cabinets to minimize moisture accumulation inside these cabinets. Combustion air and ventilation provisions associated with the diesel generators are described in subsections 9.5.8 and 9.4.7, respectively.

L. Conformance to Branch Technical Position (BTP) ICSB-8

The emergency diesel generators will not be used for peaking service in accordance with BTP ICSB-8, Use of Diesel-Generator Sets for Peaking.

M. Programs for training, maintenance, and operations will be implemented as discussed in chapter 13.

N. The maintenance/surveillance program, developed by the Cooper-Enterprise Clearinghouse, has been implemented.

8.3.1.1.4 Control Rod Drive Power Supply

Electric power to control rod drive mechanisms is supplied by two full-capacity, motor-generator sets. Each motor-generator set is powered from a separate non-Class 1E 480-V load center.

Each generator is of the synchronous type and is driven by a 200-hp induction motor. The ac power is distributed to the rod control power cabinets through two Class 1E series-connected reactor trip breakers.

8.3.1.1.5 Vital Instrument ac Power Supply

Four independent Class 1E 120-V vital instrument ac power supplies are provided to supply the four channels of the protection systems and reactor control systems. Each vital instrument ac power supply consists of an inverter and a distribution panel. Trains A and B are provided with two inverters and two distribution panels.

Each distribution panel has two incoming breakers which are interlocked so that only one breaker can be closed at a time. The normally closed breaker is the inverter supply. The normally open breaker is the 120-V ac inverter backup supply from a 480/120-V regulated transformer.

Normally, the inverter is operating to supply the vital ac bus. Each inverter is supplied by a Class 1E 125-V dc system, as described in subsection 8.3.2. If an inverter is inoperable or is to be removed from service, the vital ac bus can be supplied from the 120-V ac inverter backup supply (480/120-V regulated transformer) associated with the same load group by repositioning the distribution panel input breakers. Administrative controls ensure that no more than one vital ac bus is powered from the regulated transformer backup power supply at any one time during routine preventive maintenance on the associated inverter. Refer to drawings 1X3D-AA-G01A, 1X3D-AA-G02A, 1X3D-AA-G02C, 2X3D-AA-G01A, 2X3D-AA-G02A, and 2X3D-AA-G02C for the arrangement of the vital instrument ac power supplies.

8.3.1.1.6 Non-Class 1E Instrument ac Power Supply

The nonvital 120-V instrument ac power supply is designed to furnish reliable power to all nonsafety-related plant instruments. A schematic of this system is shown in drawings 1X3D-AA-G01B and 2X3D-AA-G01B.

The control building nonvital instrument ac system for each unit consists of six essential instrument panels and five (four on Unit 2) regulated instrument bus panels. Each panel has normal and alternate incoming breakers interlocked so that only one can be closed at a time.

The normal supply to essential instrument panel NY1N is from its associated inverter. The normal supply to regulated instrument bus panel NYR is from its associated regulated transformer. The alternate supply to the regulated instrument bus panel NYR is from the normal supply to regulated instrument bus NYS. The alternate supply to essential instrument panel NY1N is a feeder breaker in regulated instrument bus panel NYR. Regulated instrument bus panel NYS and essential instrument panel NY2N receive power similarly. Essential instrument panel NY4N normally receives power from its associated inverter. An alternate power supply is provided by a mechanically interlocked incoming circuit breaker which is powered from a regulated transformer. Each regulated transformer is sized to supply 120-V ac power to its associated normal essential instrument panels and regulated instrument panels.

A sixth regulated instrument bus panel (1NYJ) is located in the auxiliary building. (Panel 2NYJ is supplied from a nonregulated source.) Its two incoming breakers (interlocked so that only one is closed at a time) receive power from regulated transformers fed from separate normal 480-V ac motor control centers.

Regulated instrument bus panel NYRS has interlocked main incoming breakers which are powered from two separate regulating transformers. Inverter-powered panel NY3N (NY5N, NY01, and NY6N are supplied from NY3N) panel ANYT2 and panel ANYT3 powers the main plant computer and its peripherals. Panel NY3N also supplies panel NY01, which powers the radiation monitoring computer and its peripherals.

Panel NYC2 provides power for the rod position indication systems. It has interlocked main incoming breakers which are powered from two separate Class 1E regulating/isolation transformers.

Essential instrument panels common to both units have also been provided for the technical support center and the central and secondary alarm stations as shown in drawings AX3D-AA-G02B and AX3D-AA-G02C.

8.3.1.1.7 Electrical Equipment Layout

The following are the general features of the electrical equipment layout:

A. Class 1E switchgear, load centers, and motor control centers of redundant load groups are located in separate rooms within Seismic Category 1 buildings.

B. Four Class 1E battery supplies are located in the control building. Each battery is located in a separate room. Battery ventilation considerations are addressed in subsection 9.4.5.

C. The battery charger, inverter, manual transfer switch, and dc busses associated with each of the four subsystems are in separate rooms outside the battery rooms.

D. Two cable spreading rooms are provided, one above and one below the control room. This enhances redundant cable separation.

E. Redundant diesel generators and associated supporting equipment are located in separate rooms in the Seismic Category 1 diesel generator building.

Electrical equipment layout drawings showing the location of electrical equipment are listed in section 1.7.

8.3.1.1.8 Design Criteria for Class 1E Equipment

Design criteria for the Class 1E equipment are discussed below:

A. Motor Size

For all motors rated above 480 V, the nameplate horsepower is generally equal to or greater than the maximum horsepower required by the driven load under normal running or runout conditions except for the centrifugal charging pumps, residual heat removal pumps, containment spray pumps, and auxiliary feedwater pumps which are all under the scope of the nuclear steam supply system (NSSS) supplier.

The containment spray pump, and residual heat removal pump motors have a service factor of 1.15 and the required brake horsepower is within the capability of the motor service factor rating of 1.15. The centrifugal charging pump (CCP) motor is rated at 600 hp with a service factor of 1.15. An engineering study concluded that the Unit 1, Train A CCP motor is capable of a 715-hp rating with a service factor of 1.0. This bounds all normal and runout/transient operating conditions for the Unit 1, Train A CCP. The auxiliary feedwater pump motor is rated at 900 hp, and the maximum brake horsepower required is 962 hp during various plant transient conditions. An engineering study was performed by Westinghouse that concluded the auxiliary feedwater pump motors are acceptable for the overload condition.

B. Minimum Motor Accelerating Voltage

All Class 1E motors fed from the 4.16-kV busses are specified with accelerating capability at 75% of the motor nameplate rating (4000 V). Class 1E motors rated for use on lower voltage busses, which are required to start concurrently with large 4-kV motors, are specified with accelerating capability at 75% of the motor nameplate rating, with the exception of the boric acid transfer pump, which are specified at 80% of the motor nameplate rating.

Calculations have been made indicating that these motors will not be provided power at less than their specified capabilities.

Class 1E motor-operated valve (MOV) torque/thrust capability is based on the available voltage at the MOV's terminals. The MOV voltage analysis includes degraded grid cases with the starting of MOVs simultaneously with other loads as well as individual MOV starts. Some of the available voltages are below the 75 or 80% of the nameplate rating specified accelerating capability. MOV capability and limitations are documented in calculations.

The electrical system is designed so that the motor terminal voltage supplied to each Class 1E motor will permit acceleration of that motor.

C. Motor Starting Torque

The motor starting torque is capable of starting and accelerating the connected load to normal speed within sufficient time to perform its safety function for all expected operating conditions, including the design minimum bus voltage stated in paragraph 8.3.1.1.3.

D. Minimum Motor Torque Margin over Pump Torque Through Accelerating Period

The minimum torque margin (accelerating torque) is such that the pump motor assembly reaches nominal speed within sufficient time to perform its safety function at design minimum terminal voltage.

E. Motor Insulation

Insulation systems are selected on the basis of the particular ambient conditions to which insulation is exposed. For Class 1E motors located within the containment, the insulation system is selected to withstand the postulated accident environment.

F. Temperature Monitoring Devices Provided in Large Horsepower Motors

Each motor in excess of 1500 hp is provided with six resistance temperature detectors (RTD) embedded in the motor slots, two per phase. In normal operation, the RTD at the hottest location (selected by test) monitors the motor temperature and provides a computer alarm in the control room on high temperature. Each 4.16-kV motor bearing (except residual heat removal motor) is provided with one thermocouple which will provide an alarm on bearing high temperature.

G. Interrupting Capacities

The interrupting capacities of the protective equipment are determined as follows:

1. Switchgear

   Switchgear interrupting capacities are greater than the maximum short circuit current available at the point of application. The magnitude of the short circuit currents in the medium voltage systems is determined in accordance with American National Standards Institute (ANSI) C37.010-1972. The offsite power system, a single operating diesel generator, and running motor contributions are considered simultaneously in determining the fault level. All motors connected to the bus are considered to be running when the short circuit is postulated.

   High voltage power circuit breaker interrupting capacity ratings are selected in accordance with ANSI C37.06-1971.

2. Load Centers, Motor Control Centers, and Distribution Panels

   Load centers, motor control centers, and distribution panel circuit breakers have a symmetrical rated interrupting current as great as the determined total available symmetrical current at the point of assumed fault. Symmetrical short-circuit current is determined in accordance with the procedures of ANSI C37.13-1973 for low voltage circuit breakers other than molded case breakers and of National Electrical Manufacturers Association (NEMA) Standards Publication AB 1 for molded case circuit breakers.

H. Electric Circuit Protection

Refer to paragraph 8.3.1.1.2K for criteria regarding the electric circuit protection.

I. Grounding Requirements

Equipment and system grounding has been designed using IEEE 80-1971, Guide for Safety in ac Substation Grounding, and IEEE 142-1972, Recommended Practice for Grounding of Industrial and Commercial Power Systems, as a guide.

J. Safety-Related Cable

The 5-kV safety-related power cable insulation and the 600-V power and control cable insulation utilized in balance-of-plant applications are type EPR/HYP with hypalon in the jacket. The balance of plant safety-related instrument and specialty cable insulation consists of moisture, radiation, and ozone-resistant thermosetting compounds. The jackets used on these cables consist of flame retardant, moisture, radiation, and ozone-resistant thermosetting compounds.

Safety-related cables are qualified for the design life of the plant[a] as described in IEEE 323-1974 and 383-1974. The cable supplied under the NSSS scope is qualified in accordance with the methodology outlined in WCAP-8587 for the applicable system or component in which the cable is installed.

8.3.1.1.9 Heat Tracing Systems

There are no Class 1E heat tracing systems required to ensure the safe operation of the plant. The chemical and volume control system, safety injection system, and the waste processing system liquid are provided with temperature monitoring and alarms for annunciation to help ensure the boric acid is maintained at or above 65°F. The alarms are powered from non-Class 1E busses which are backed by the onsite emergency diesel generators. The heat traced portions of the auxiliary feedwater, vacuum degasifier systems for RMWST and CST, demineralizer water system, and nuclear service cooling water systems are provided with nonredundant heat tracing systems for freeze protection. The Heat Trace circuits associated with the Containment Hydrogen Monitoring System and Radiation Monitors required during a LOSP are powered from non-class 1E busses and backed up by onsite Diesel Generators. The heat tracing for the radwaste processing facility is supplied from the facility's normal power supply.

8.3.1.1.10 Electrical Equipment Subject to Submergence Due to Containment Flooding

Electrical equipment located in the containment building that would be subject to submergence under a LOCA condition includes miscellaneous nonsafety-related and safety-related equipment.

Equipment faults due to submergence would not cause damage to containment building electrical penetrations because the associated power circuits are either disconnected, are protected by redundant overcurrent protective devices, or have fault currents at the penetration below the penetration damage level (see paragraph 8.3.1.1.12).

The nonsafety-related devices are not designed for operation under water; however, there would be no effect on the safety-related power systems, since this equipment is powered from nonsafety-related busses.

The safety-related equipment includes the nuclear instrumentation detectors (source, intermediate, and power range), and extended range excore neutron detectors, reactor vessel level instrumentation system (RVLIS) temperature compensation RTDs, containment reactor cavity sump level transmitter, accumulator isolation valves, one reactor coolant system hot leg wide range pressure transmitter, and the steam generator blowdown flow transmitters. The safety-related excore neutron detectors (source, intermediate, power, and extended range) could be subjected to submergence following a postulated design basis accident. However, the submergence period would allow time for the detectors to perform their intended function of detecting the reactor shutdown and to establish other means of long-term shutdown verification, such as post accident sample analysis. The safety-related reactor cavity sump narrow range level transmitter could also be subjected to submergence following a postulated design basis

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[a] The operating licenses for both VEGP units have been renewed and the original licensed operating terms have been extended by 20 years. In accordance with 10 CFR Part 54, appropriate aging management programs and activities have been initiated to manage the detrimental effects of aging to maintain functionality during the period of extended operation (see chapter 19).

accident. However, the containment wide range level transmitters and narrow range level transmitters on the north and south normal drain sumps would be used to provide diverse and unambiguous indication of containment water level. The hot leg pressure transmitter and the blowdown flow transmitters are not required to be functional, should containment flooding occur. In addition, accumulator discharge valves HV-8808A, B, C, and D could also be submerged following a LOCA. Refer to paragraph 6.3.2.2.16 for a discussion of the consequences of these valves becoming submerged. The submergence of the RVLIS RTDs has been evaluated, and it was concluded that the RVLIS accuracy requirements are within the allowable limits.

8.3.1.1.11 Motor-Operated Valves with Power Lockout

The motor-operated valves that require power lockout to meet BTP ICSB 18 and that have the means to accomplish power lockout are listed and outlined as follows:

A. The following motor-operated valves power lockout and restoration capability is accomplished at the main control board:

HV-8806	Safety injection pump suction from refueling water storage tank
HV-8835	Safety injection pump cold leg injection
HV-8802A, B	Safety injection pump hot leg injection
HV-8840	Residual heat removal pump hot leg injection
HV-8809A, B	Residual heat removal pump cold leg injection
HV-8813	Safety injection pump miniflow isolation

B. The following motor-operated valve power lockout is accomplished by padlocking the circuit breaker at the motor control center during startup and maintained in the locked open position during reactor power operation:

HV-8808A, B, C, D	Accumulator isolation valves

In addition, the emergency core cooling system motor-operated valves (item A) are provided with valve position-indicating light boxes to provide a continuous indication of valve position.

The Technical Specifications list these valves and their required positions.

8.3.1.1.12 Containment Building Electrical Penetrations

The electrical penetrations, with the exception of fiber optic feedthroughs, are protected from damage resulting from overcurrent conditions through the use of redundant overcurrent protective devices as indicated in paragraph 1.9.63.2.

The use of series Class 1E fuses for backup protection on the 480-V switchgear power circuits is justified by the fact that fuses are passive devices which have proven coordination characteristics and reliability. Similarly, for motor control center power circuits, fuses in series with thermal-magnetic breakers is justified by the fact that fuses are passive devices which have proven coordination characteristics and reliability.

Figure 8.3.1-1 provides the overcurrent protection coordination curves for each type of power or control circuit connected to the electrical penetrations. These curves provide justification that, for those circuits having sufficient power to damage the penetration, the overcurrent protective devices will operate to disconnect power prior to such damage occurring, thus maintaining the integrity of the containment pressure boundary in accordance with the requirements of General Design Criterion 50.

Spliced connections at the penetrations are accomplished using compression lugs with heat shrinkable tubing termination kits (such as manufactured by Raychem Corporation). The insulating materials used in these kits contain no epoxy. Splice kits qualified for the design life of the plant[a] in accordance with IEEE 323 and 383 are used on safety-related circuits.

8.3.1.1.13 Residual Heat Removal Isolation Valve Power Supply

Trains A and B residual heat removal isolation valves are powered from train A and B motor control centers, respectively. The train C and D valves are powered through 125-V dc/480-V ac, three-phase inverters and combination starter units from the train C and D Class 1E dc systems, respectively. The inverters and combination starter units are qualified for the design life of the plant[b] in accordance with the requirements of IEEE 323 and 344.

8.3.1.2 Analysis

For discussion of regulatory guides in regard to Class 1E ac systems, refer to section 1.9 and subsection 8.1.4. Compliance with General Design Criteria 17 and 18 is discussed in section 3.1.

A failure modes and effects analysis for the onsite power supply systems is provided in table 8.3.1-3. The failure analysis of the 120-V vital ac system is included in table 8.3.2-5.

Qualification of electrical equipment is addressed in sections 3.10 and 3.11.

8.3.1.3 Physical Identification of Safety-Related Equipment

Each circuit and raceway is given a unique identification number. This number provides a means of distinguishing between circuits and raceways of different voltage level or separation groups. Each raceway is color coded with indelible ink, paint, or adhesive markers (adhesive markers are not used in the containment building) at intervals of 15 ft or less along the length of the raceway and on both sides of floor or wall penetrations. Each cable is color coded at a

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[a] The operating licenses for both VEGP units have been renewed and the original licensed operating terms have been extended by 20 years. In accordance with 10 CFR Part 54, appropriate aging management programs and activities have been initiated to manage the detrimental effects of aging to maintain functionality during the period of extended operation (see chapter 19).

[b] The operating licenses for both VEGP units have been renewed and the original licensed operating terms have been extended by 20 years. In accordance with 10 CFR Part 54, appropriate aging management programs and activities have been initiated to manage the detrimental effects of aging to maintain functionality during the period of extended operation (see chapter 19).

maximum of 5-ft intervals along the length of the cable, and cable markers showing the cable identification number are applied at each end of the cable.

The following color coding is used for all identification purposes, except at the main control board:

Separation Group	Safety Train	Protection Channel	Color Code
A	A	I	Brown
B	B	II	Green
C	C	III	Blue
D	D	IV	Yellow
N	None	None	Black

For the color coding used on the main control board, see chapter 18.

In addition, raceway separation groups are clearly identified on design drawings for all equipment and raceways.

8.3.1.4 Independence of Redundant Systems

8.3.1.4.1 General

The routing of cable and the design of raceways is such that no single credible event is capable of disabling redundant safety-related systems.

8.3.1.4.2 Cable Derating and Cable Tray Fill

The ampacity rating of cables is established in accordance with Insulated Cable Engineers Association (ICEA) P-46-426 and P-54-440. Generally, power cables, feeding loads from switchgear, motor control centers, and distribution panels are sized based on 125% of the full load current at a 100% load factor.

Where cumulative effects of actual operation or installation conditions require encroachment into the 25% allowance, engineering analysis is performed to verify adequacy of cable ampacity for the actual operating or installation condition. In addition, cables are derated in accordance with ICEA P-46-426 where cable spacing in open top punched bottom tray is less than one diameter or the ambient temperature is greater than 40°C. The ampacity of maintained spacing 13.8-kV, 4.16-kV, and 480-V load center power cables in tray have been determined in accordance with ICEA Publication No. P-46-426 for punched bottom, open top trays, ICEA Publication No. P-54-440 for solid bottom open top tray, or punched bottom with solid cover trays. Six hundred-V power cables in trays have been sized in accordance with ICEA Publication No. P-54-440. Where covers in excess of 6 ft in length have been installed on random fill trays, engineering analysis has been performed to assess any ampacity derating effects of the cover. Where maintained spacing cables are routed in solid bottom tray fittings with solid covers in excess of 6 ft in length, the cables have been derated in accordance with ICEA P-46-426 for cables in enclosed raceway. Power cables penetrating fire stops have been derated by 10%.

The 13.8- and 4.16-kV power cables generally maintain a minimum spacing of one cable diameter between adjacent cables in a single layer. The 480-V load center power cables have a minimum spacing of 1/4 cable diameter. Where justified by analysis done on a case-by-case basis, minimum spacing of 1/4 diameter for 13.8- and 4.16-kV power cables and less than 1/4-diameter spacing for 480-V load center power cables have been permitted. Motor control center power cables and control and instrumentation cables are random fill. Control and instrument cable tray design fill is 40% of the area of the tray being used; 4-in. deep trays are used in all areas of the plant except where the 40% maximum fill of the 4-in. deep tray would be exceeded, in which case a 6-in. deep tray is used. Low voltage power trays are limited to a fill of 30% of the area of a 3-in. loading depth tray.

When greater than 40% fill for control tray or 30% for power tray is unavoidable, analysis is performed to ensure the cables' ampacities have been properly derated. Cable trays will not be filled above the siderails except at transitions (tees, elbows, cable entrances and exits, etc.). The cables above the siderails are routed back below the siderails within 12 ft from the transition. Whenever trays are filled above the siderails, the required Regulatory Guide 1.75 separation is measured to the uppermost cable in the tray.

8.3.1.4.3 Cable Routing

There are five separation groups for the cable and raceway system: groups A, B, C, D, and N. Separation group A (4.16 kV, 480 V, 120 V ac, and 125 V dc) contains circuits from safety train A and protection channel I (120 V ac, 125 V dc, and instrumentation). Similarly, separation group B contains circuits from safety train B and protection channel II; group C, train C, and channel III; group D, train D, and channel IV; and group N, normal, nonsafety-related circuits.

Cables of one separation group are run in separate raceways and physically separated from cables of other separation groups. Group N raceways are separated from safety-related groups A, B, C, and D. However, raceways from group N are routed in the same areas as the safety-related groups per the spatial separation requirements of Regulatory Guide 1.75.

In general, the minimum spatial separation requirements are as follows:

A. Within the cable spreading rooms, control room, and shutdown rooms, the minimum vertical separation for open top cable tray is 3 ft, and the minimum horizontal separation is 1 ft. The minimum separation distance between enclosed raceways qualified as barriers is 1 in. The minimum separation distance between non-Class 1E conduit and Class 1E open top cable trays is 1 in.

   Testing and analyses have been performed for circuits of voltage levels 480 volts or lower to determine alternate reduced separation distances where these general minimum separation distances have not been met. The testing and analyses have been performed as allowed by Section 6.1.1.3 of IEEE 384-1981 and by Regulatory Guide 1.75. Refer to table 8.3.1-4 for circuits where analysis has been used.

B. Within general plant areas the minimum vertical separation is 5 ft, and the minimum horizontal separation is 3 ft for open top cable tray. The minimum separation distance between enclosed raceways qualified as barriers is 1 in. The minimum separation distance between non-Class 1E conduit and Class 1E open top cable trays is 1 in.

Testing and analyses have been performed for circuits of voltage levels 480 volts or lower to determine alternate reduced separation distances where these general minimum separation distances have not been met. Analyses have also been performed for reduced separation of Class 1E 4160-V cables from non-1E 480 V and lower voltage cables. The testing and analyses have been performed as allowed by Section 6.1.1.3 of IEEE 384-1981 and by Regulatory Guide 1.75. Refer to table 8.3.1-4 for circuits where analysis has been used.

C. Within panels and control boards,(a) the minimum spatial separation between components or cables of different separation groups (both field-routed and vendor-supplied internal wiring) is 6 in. Where it is not possible to maintain this separation, barriers are installed between components and wiring of different separation groups, or analysis has been performed to determine the minimum separation requirements. Refer to subsection 7.1.2 for separation requirements inside Westinghouse panels and control boards and to table 8.3.1-4 for circuits where analysis has been used.

Where barriers are required, one of the following methods of providing separation is used between any two separation groups within panels and control boards:

1. If both groups are redundant Class 1E circuits, separation is provided by routing the circuits in separate metallic conduit or enclosed wire duct, or by wrapping the wires of one or both of the separation groups in silicon dioxide cloth (siltemp 188 CH).
2. If one of the separation groups is non-Class 1E, only those circuits are required to be routed in metallic conduit or enclosed metallic wire duct. Alternatively, the non-Class 1E cables may be wrapped in silicon dioxide cloth (siltemp 188 CH). See table 8.3.1-4 for further details.
3. A single barrier is provided with a 1-in. maintained air space between the components or cables of redundant separation groups and the barrier.
    a. The control board or panel is considered to extend to the bottom of the floor penetration fire barrier seal including any floor slots, penetrations, etc.

D. Where spatial separation requirements between raceways of different separation groups are not met, fire barriers are installed as follows:

1. Where the minimum vertical separation is not maintained, a barrier is installed which extends at least 6 in. on each side of the tray system or to the wall, if a wall is within 6 in. when the trays are arranged in stacks.

    Within the cable spreading area, where the trays cross each other, a barrier extending at least 1 ft on each side of the tray system is installed.

    Within the general plant areas, however, the barrier extending at least 1 ft on each side of the top trays and 3 ft on each side of the bottom trays is installed. However, for trays containing circuits 480 V or lower voltage and cables 2/0 AWG or smaller, the barrier needs only extend 1 ft. on each side of the top and bottom trays.

(a) The control board or panel is considered to extend to the bottom of the floor penetration fire barrier seal including any floor slots, penetrations, etc.

2. Where the minimum horizontal separation is not maintained, a barrier is installed which extends from at least 1 ft above (or to the ceiling) to at least 1 ft below (or to the floor) the tray system.

E. Where raceways of different separation groups are brought to a single enclosure, separation is accomplished by the use of conduit routed in opposite directions from the enclosure, using the enclosure as a barrier, or by wrapping the cabling of one of the separation groups in silicon dioxide cloth (siltemp 188 CH). Refer to table 8.3.1-4 for details of the use of silicon dioxide cloth as a barrier.

Non-Class 1E circuits are electrically isolated from Class 1E circuits, and Class 1E circuits from different separation groups are electrically isolated with the use of isolation devices, shielding and wiring techniques, physical separation (in accordance with Regulatory Guide 1.75 for circuits in raceways), or an appropriate combination thereof.

When isolation devices are used to isolate Class 1E circuits from non-Class 1E circuits, the circuits within or from the Class 1E equipment or devices to the isolation device(s) are identified as Class 1E and are treated as such. Beyond the isolation device(s) these circuits are identified as non-Class 1E and are separated from Class 1E circuits in accordance with the separation criteria described above.

Certain applications use Class 1E circuit breakers, fuses, or other devices for isolation. Specific cases are described below:

1. The cables feeding the non-Class 1E pressurizer heaters use two non-Class 1E circuit breakers in series as protection for each Class 1E containment penetration. Cables from the nonsafety load centers (two of which are connected to the emergency busses) follow separate routes to the splice box under the pressurizer. The two circuit breakers in series for each circuit are qualified to seismic requirements and are coordinated with the load center supply and feeder breakers. Where the Class 1E distribution systems electrify certain pressurizer heaters, the Class 1E to non-Class 1E isolation is provided by the Class 1E 4.16-kV switchgear by a 4.16-kV qualified isolation device (as noted in paragraph 8.3.1.4.3.E.2.).
2. Class 1E 4.16-kV Circuit Breaker Trips on Safety Injection Actuation Signal.

   The Class 1E 4.16-kV circuit breakers are tripped on receipt of an accident signal which will isolate the downstream non-Class 1E circuits and loads from their respective Class 1E power sources under accident conditions and therefore pose no threat to the Class 1E sources. The Class 1E 4.16-kV circuit breakers are therefore acceptable for use as isolation devices.
3. Circuit Breakers - Redundant, Molded Case Class 1E

   Two molded case circuit breakers are used in series (120-V-ac distribution panel branch breaker and the distribution panel main breaker) to provide isolation between Class 1E 480-V busses and non-Class 1E motor space heaters mounted in Class 1E motors.

The two breakers are coordinated such that protection is provided to the circuit in the event of failure of the primary protection device (branch circuit breaker).

4. Class 1E 13.8-kV Circuit Breaker and Current Transformers

   The RCP motor Class 1E current transformers installed in the RCP motor non-Class 1E circuit, are not to provide isolation, but together with the Class 1E protective relaying, are used to ensure the tripping of the Class 1E circuit breaker when an abnormal overcurrent condition occurs. In any event, the assured tripping of Class 1E circuit breaker will prevent the current transformers and the protective relays from being damaged.

5. Class 1E Battery Charger

   Battery chargers are used as isolation devices between separation groups as shown in drawing 2X3D-AA-G01A.

   A fault on the primary side of the battery charger (fault on 480-V-ac bus) will not affect the secondary side of the battery charger (125-V-dc side) because the fault current on the primary side of the battery charger will be cleared by the battery charger feeder breaker, which is upstream of the battery charger.

   Postulated failures on the secondary side of a battery charger will not result in unacceptable effects on the primary side.

6. Fuses

   Fuses are used in control circuits to provide isolation as follows:

   a. Between Class 1E voltage transformer secondary circuits and non-Class 1E plant fault recorder and between Class 1E voltage transformer secondary circuits and non-Class 1E diesel generator auto synchronizer.

   b. Between the two Class 1E contacts in series (synchronizing switch contact and diesel generator break auxiliary contact) and non-Class 1E diesel generator auto synchronizer. The series contacts are used to give permissive signal to the auto synchronizer.

   c. Between Class 1E control power circuit in the electric hydrogen recombiner control panel and the non-Class 1E temperature controller (used for indication only).

   d. Between Class 1E control power circuits in the nuclear instrumentation system and non-Class 1E circuits used for high flux at shutdown, indication, and annunciation.

7. Isolation Relays

   Auxiliary relays are used in control circuits to provide isolation as follows:

   a. The majority of the auxiliary relays used as isolating relays are barrier-mounted. The barrier effectively isolates the coil and the contact wiring.

   b. Auxiliary relays are used for interfacing diesel generator Class 1E circuit with the nonsafety-related diesel generator autosynchronizer for paralleling the diesel generator with offsite power during testing.

   c. Relays are used for interfacing the safety features sequencer with nonsafety-related 480-V load centers to shed the nonsafety-related load centers from 4.16-kV emergency bus on a safety feature actuation signal.

8. Optical Isolator

   Optical isolators are furnished in the isolation device panels and diesel engine control panel.

   a. Optical isolators in the isolation device panels are the Reliance Electric Company IsoMate digital isolation system. Barrier panels built into the panels provide front-to-rear separation between Class 1E and non-Class 1E wiring compartments. A 5-in. air gap formed by the barriers separates the two compartments.

   b. Optical isolators in the diesel engine control panel are used solely to isolate the Class 1E diesel generator circuitry from a non-Class 1E annunciator mounted in the same panel.

      The non-Class 1E wiring emanating from isolation devices and extending beyond the equipment panels is separated from high energy power cables by routing these cables through control level trays as described in paragraph 8.3.1.4.3.G.

9. Transformer Modulation Isolator

   Validyne Engineering Corporation transformer-modulated isolators are used to provide Class 1E to non-Class 1E isolation for low energy analog instrumentation signals. The analog input signals are modulated, transformed, and demodulated to provide the required isolation. This isolator is used for interfacing Class 1E circuit with nonsafety-related auxiliary feedwater turbine-driven pump speed indicator.

10. Ferro Resonant Transformers

    IEEE Standard 449-1990 covers the ferro resonant transformer voltage regulator of the type that is used as an isolation device. The overload characteristic with unsaturated series inductance, Figure 10 of this standard, describes the performance of the Solidstate Controls, Inc., regulating transformers, which are used at VEGP. This output voltage vs. output current characteristic indicates the constant output over the regulating range to full-rated current and then an overload current with reduced output voltage which proceeds to a limiting short-circuit current. Tests performed by Solidstate Controls, Inc., on a single unit of each transformer model verify this characteristic.

    These transformers limit the input current for an output fault to a range within the limits set forth in IEEE 449 (1990). These transformers also meet the requirement for current limiting isolation devices as specified in Regulatory Guide 1.75 (IEEE 384, 1981).

For additional information on isolation device application, see responses to NRC questions of April 30, 1984.

11. Current Transducer Isolator

    Scientific Columbus Company current transducers are used to provide Class 1E to non-Class 1E isolation for low energy analog instrumentation signals. This isolator is used to interface Class 1E control circuits with the non-Class 1E plant computer system.

    These isolators were qualified by Scientific Columbus to Reference Standard Number 1. The isolators were qualified by Brown-Boveri Electric, Inc. to Reference Standard Numbers 2 and 3. The isolators were evaluated by Georgia Power Company against the requirements of Reference Standard Number 4. In addition, these isolators passed a dielectric breakdown test rated at 1500 volts.

    Reference Standards

    1. IEEE 472, 1974 "Guide for Surge Withstand Capability (SWC) Tests."
    2. IEEE 323, 1974 "Guide for Qualification Class 1E Electrical Equipment for Nuclear Power Generating Stations."
    3. IEEE 344, 1975 "Guide for Seismic Qualification of Class 1E Electrical Equipment For Nuclear Power Generating Stations."
    4. IEEE 384, 1981 "Standard Criteria for Independence of Class 1E Equipment and Circuits."

F. Power and control cables are installed in conduit or ventilated bottom trays (punched or ladder type). Solid tray covers are used in all outdoor locations and indoors where trays run in areas where falling debris is a problem. Instrumentation cables are routed in conduit or solid bottom cable tray with solid tray covers. Communications (voice, data, video) cables not used for the control or monitoring of plant equipment may be routed without the use of conduits or trays and is qualified to IEEE 383-1974 flame test or better.

G. Separate trays are provided for each voltage service level: 13.8 kV, 4.16 kV, 480 V, 120-V ac and 125-V dc, control, and instrument. Vertically stacked trays are arranged from top to bottom as follows:

- 13.8 kV.
- 4.16 kV.
- 480-V power from load centers.
- 480-V low voltage power and 120-V ac or 125-V dc with loads of 10 A or more.
- Control.
- Instrument.

In general a minimum of 10-in. vertical spacing is maintained between trays of different service levels within the same stack.

With the exception of lighting panel feeders, which are routed in trays, lighting circuits are routed in conduit or utilize aluminum sheath (ALS) cable. Lighting circuits inside containment utilize conduit or copper sheath (CUS) cable.

Raceways from safety-related groups A and C are located in the lower cable spreading room. Raceways from safety-related groups B and D are located in the upper cable spreading room. Group N raceway is routed into both upper and lower cable spreading rooms.

All raceways installed in Seismic Category 1 structures have seismically designed supports. Trays and rigid conduit are not attached rigidly to Seismic Category 1 equipment.

Raceways running between Seismic Category 1 structures are designed in the following manner to prevent damage to the raceway or associated cabling during seismic events. Conduits running between structures are either connected with a minimum of 2 ft of flexible conduit or are provided with expansion/deflection fittings. Cable trays running between structures are supported independently in each Category 1 structure with no rigid mechanical connection of the tray at the interface. Those cables which require maintained spacing are not tied down to the tray for a distance of 5 ft on either side of the interface.

A high energy line break analysis and missile impact study is performed for all rooms or compartments containing large rotating machinery or high energy piping. Where hazards to safety-related raceways are identified, a predetermined minimum separation is maintained between the break and/or missile source and any safety-related raceway, or a reinforced concrete barrier designed to withstand the effects of each hazard is placed to prevent damage to raceway of redundant systems. The hazards analysis is further described in appendix 3F.

8.3.1.4.4 Hazard Protection

Where redundant safety-related raceway systems traverse each other, separation in accordance with Regulatory Guide 1.75 as a minimum is maintained. In areas where external hazards such as high energy pipe breaks, missiles and flooding exist, separation and/or barriers shall be as described below.

Where redundant circuits, devices, or equipment (different separation groups) are exposed to the same external hazard(s), predetermined spatial separation shall be provided. Where the spatial separation cannot be met, qualified barriers are installed. For details on fire protection, see subsection 9.5.1.

8.3.1.4.5 Control of Compliance with Separation Criteria During Design and Installation

Compliance with design criteria to ensure the independence of redundant systems is a supervisory responsibility during both the design and installation phases. The responsibility is discharged by:

A. Identifying applicable criteria.

B. Issuing working procedures and construction specifications to implement these criteria.

C. Modifying procedures to keep them current and workable.

D. Checking manufacturing drawings, procedures, and specifications to ensure compliance with criteria and procedures.

E. Controlling installation and procurement to ensure compliance with approved and issued drawings and specifications.

F. Separation and hazard reviews conducted by a multidiscipline physical design review team.

8.3.1.4.6 Cable Splices - See paragraph 1.9.75.2.

8.3.1.5 Standard Review Plan Evaluation

The diesel generator controls and monitoring instruments are not mounted on a vibration-free floor area, and vibration isolators have not been provided on the associated control cabinets.

The mounting requirement for the diesel generator control panels specified by the vendor is that the panels are to be floor mounted with anchor bolts without using vibration isolators. Also, the seismic qualification testing performed on the control panels by the vendor was conducted by bolting the panels to the shake table to simulate actual field mounting condition. The control panels are qualified in accordance with IEEE 323-1974 which addresses vibration aging[a].

The diesel generator buildings for Units 1 and 2 are similar in design. The concrete foundation for each building is 114 ft x 94 ft x 9 ft thick. The diesel generator, control panels, and associated equipment are mounted on the building foundation, and the anticipated vibration is not considered detrimental to the operation of the controls and monitoring instruments.

8.3.2 DC POWER SYSTEMS

8.3.2.1 Description

The dc systems provide a reliable source of continuous power for control, instrumentation, and dc motors. There are four 125-V-dc safety features systems per unit, four 125-V dc nonsafety systems per unit, and seven 125-V-dc nonsafety systems common to both units.

8.3.2.1.1 The 125-V dc Safety Features Systems

There are four safety features 125-V-dc systems (identified A, B, C, and D) per unit. Each system has a 59-cell lead-calcium battery, switchgear (electrically operated drawout circuit breakers), two redundant battery chargers, one manual transfer switch, two inverters, and 125-V-dc distribution panels (molded case circuit breakers). Systems A, B, and C each have a 125-V-dc motor control center for motor-operated valves. An individual cell equalizer (ICE) may be connected across each battery cell. This device provides an alternate path for the electric charge current as a function of the individual battery cell voltage. Within the operation range of the ICE device, the energy input and storage capability of the individual cells are better matched. The operating range of the ICE device is within the normal voltage and float current

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[a] The operating licenses for both VEGP units have been renewed and the original licensed operating terms have been extended by 20 years. In accordance with 10 CFR Part 54, appropriate aging management programs and activities have been initiated to manage the detrimental effects of aging to maintain functionality during the period of extended operation (see chapter 19).

operation of the batteries. There is no capability to connect the dc systems between themselves, between Unit 1 and Unit 2 systems, or between the safety features systems and the nonsafety features systems.

The 125-V-dc systems A, B, C, and D supply dc power to channels 1, 2, 3, and 4, respectively, and are designated as Class 1E equipment in accordance with the applicable sections of Institute of Electrical and Electronic Engineers (IEEE) Standard 308. They are designed so that no single failure in any 125-V-dc system will result in conditions that will prevent the safe shutdown of the reactor plant. The plant design and circuit layout from these dc systems provide physical separation of equipment, cabling, and instrumentation essential to plant safety. Each system is located in an area separated physically from other systems. All the components of the 125-V-dc Class 1E systems are housed in Category 1 structures.

Each 125-V-dc battery is separately housed in a ventilated room apart from its chargers and distribution equipment. Batteries are sized in accordance with IEEE 485 to have sufficient capacity to supply the required loads for a LOCA/LOSP duration of 2 ¾ h and a station blackout (SBO) duration of 4 h. For LOSP/LOCA, they are sized at a minimum temperature of 70°F; their initial capacity was increased by 10% for load growth and 25% for aging. For SBO, 10% design growth was not considered for battery size verification, as other conservatism was applied to the SBO analysis. The required final (end of duty cycle and end of life) battery cell voltages for each load group have been analyzed to demonstrate that adequate voltage is provided to the loads. Batteries are sized to ensure that all battery voltages at the last minute of the 2 ¾-hour LOCA/LOSP discharge cycle or at the last minute of the 4-hour SBO duty profile at a battery room minimum temperature of 70°F are:

Train A	109.7 V/battery
Train B	109.7 V/battery
Train C	108.3 V/battery
Train D	106.2 V/battery

Battery sizes (based on 77°F and 1.80V/cell final voltage) are:

- Unit 1 A and B: 1719 Ah at 2.75-h rate; 2365 A for 1 min.
- Unit 2 A and B: 1629 Ah at 2.75-h rate; 2241 A for 1 min.
- C: 880 Ah at 2.75-h rate; 915 A for 1 min.
- D: 564 Ah at 2.75-h rate; 775 A for 1 min.

Each 125-V-dc battery is provided with two battery chargers, each of which is sized to supply the continuous (long term) demand on its associated dc system while providing sufficient power to replace 110% of the equivalent ampere-hours removed from the battery during a design basis battery discharge cycle (as indicated by the load requirements in tables 8.3.2-1 through 8.3.2-4 and 8.3.2-6 through 8.3.2-9) within a 12-h period after charger input power is restored. A battery fully charged condition is defined as the condition where there is sufficient charge to allow a complete battery discharge cycle upon loss of charger power. The batteries are normally float charged at 2.20- to 2.25-V/cell. The sizing of each battery charger meets the requirements of IEEE 308 and Regulatory Guide 1.32. Load sharing circuitry is provided to ensure that the dc load is properly shared between the two chargers, if it is desired to operate with both battery chargers online. The battery chargers are each provided with an equalizing timer and a manual bypass toggle switch permitting periodic equalizing charges at 2.33 to 2.38

V/cell or 137.5 to 140 V/battery. Equalizing battery charges are performed as required after a deep discharge or as needed based upon cell voltage and/or specific gravity readings. Each charger is provided with automatic current-limiting control which can be adjusted over the range of 100 to 115% of rated current. The battery chargers are specified to maintain an output voltage regulation of ±1% from no load to full load output over the entire input voltage range expected on the 480-V-ac system. The output is filtered to limit the ripple voltage to a maximum of 3% rms with the battery disconnected.

If a dc overvoltage condition is sensed by a battery charger, the battery charger input circuit breaker is automatically tripped and a battery charger trouble alarm is annunciated in the main control room. All equipment connected to the dc power system has been specified to operate continuously at 140 V-dc which exists during the period that the batteries are being equalized. All equipment is also specified to operate at 100 V-dc with the exception of the vital ac buses inverter systems, the reactor trip switchgear, the turbine driven auxiliary feedwater pump controls, inverters for the residual heat removal (RHR) isolation valves which are capable of operation at 105-V-dc minimum. The dc feeder cables are sized to maintain a minimum of 105 V-dc at the vital ac bus inverter inputs and the turbine-driven auxiliary feedwater pump control panel over the entire battery load profile. The reactor trip switchgear is required to operate only in the first minute of the battery discharge load profile when the battery voltage is such that the voltage provided to the switchgear will not be lower than 105 V-dc. In certain instances where equipment is capable of operation at a voltage less than 100 V-dc, dc feeder cables are sized on that basis.

Testing of the overvoltage protective functions is addressed as a part of the qualification of the safety-related battery chargers and will be periodically verified in the course of equipment testing during plant operation.

The bus and feeder arrangement of each switchgear, including the description of loads being supplied, is indicated in drawing 1/2X3D-AA-G01A. The main bus bar ratings are shown on the single-line diagrams listed in this figure. The switchgear is of metal clad construction and is equipped with two-pole drawout type locally controlled air circuit breakers. The continuous current ratings and trip ratings are given on the single-line diagrams. The specific loads connected to the various systems can be identified by reference to the single-line diagrams indicated in drawing 1/2X3D-AA-G01A.

The dc distribution panels connected to each dc switchgear bus supply safety-related loads as indicated on the single-line diagrams. The breakers are of molded case construction. The main bus and breaker ratings are given on the single-line diagrams referenced in drawing 1/2X3D-AA-G01A.

Systems A and C receive power from train A 480-V-ac engineered safety features (ESF) buses, and systems B and D receive power from train B 480-V-ac ESF buses. System A is described here; systems B, C, and D are identical with the exception that system D does not include a motor control center. The equipment numbering used is identical for all four systems, with the first letter indicating the system.

Drawing 1X3D-AA-G01A shows the overall 125-V-dc safety features systems to be provided for Unit 1. The Unit 2 systems are essentially identical. Battery 1AD1B feeds into dc switchgear designated 1AD1. Normal and backup battery chargers designated 1AD1CA and 1AD1CB are normally fed from ESF motor control centers 1ABA and 1ABE. If normal AC power is lost and will not be available in a suitable timeframe following a Beyond Design Basis External Event, one of the battery chargers will be fed by a 480-V FLEX diesel generator. The 125-V-dc system A is formed at the switchgear 1AD1, and power is fed to motor control center 1AD1M, inverters 1AD1I1 and 1AD1I11, and dc distribution panels 1AD11 and 1AD12. Note that systems C and D have only one dc distribution panel per system.

Each 125-V-dc motor control center supplies power to safety features motor-operated valves. The 125-V-dc distribution panels supply power for safety features control, switching, and field flashing for the emergency diesel generators. See tables 8.3.2-1 through 8.3.2-4 for load lists.

System C provides all power required for successful operation of the turbine-driven auxiliary feedwater pump, with the exception of the steam generator-to-auxiliary feedwater turbine motor-operated valves (redundant valves) which are provided power from the system A and B dc motor control centers. The specific associated loads can be identified by reference to the single-line diagrams as shown in drawing 1/2X3D-AA-G01A for the system A, B, and C dc distribution equipment.

8.3.2.1.2 The Unitized 125-V-dc Nonsafety Features Systems

Each of the four utilized 125-V-dc nonsafety features systems for each unit include 59-cell lead-calcium battery, two redundant battery chargers, and are similar in design to the safety features systems, except for the number of distribution panels and inverters on each system and the absence of motor control centers. Drawing 1X3D-AA-G01B shows the 125-V-dc nonsafety features systems. The Unit 2 systems are essentially identical. Batteries are sized in accordance with IEEE 485 to have sufficient capacity to supply the required loads for 2 h with the exception of switchyard batteries, which have sufficient capacity to supply the required loads for 4 h. They are sized at a minimum temperature of 70°F. All other sizing criteria are the same as for the 125-V-dc safety features systems. The only interface with safety features systems is that one battery charger in each system receives power from non-ESF 480-V-ac buses, which in turn are powered from ESF ac buses. However, these buses are shed on a safety injection signal. The battery charger design is similar to that of the safety features battery chargers. Each pair of battery chargers is capable of load sharing but is normally operated with one charger inservice and the other charger aligned for standby. The same criteria as outlined in paragraph 8.3.2.1.1 apply to the nonsafety vital ac buses inverter systems. The plant annunciator, auxiliary relay rack 1, rod control motor generator set controller, and boron recycle waste gas processing panel are also specified to operate over a 105- to 140-V-dc input range.

Battery sizes (based on 77°F and 1.80V/cell final voltage) are:

- 1176 Ah at 2-h rate; 1400 A for 1 min.
- 1386 Ah at 2-h rate; 2116 A for 1 min.
- 1330 Ah at 2-h rate; 1548 A for 1 min (two batteries of this size).

The 125-V-dc nonsafety features systems supply dc power to nonsafety motors, control, switching, and instrumentation as shown on the single-line diagrams identified in drawing 1/2X3D-AA-G01B.

8.3.2.1.3 Common 125-V-dc Nonsafety Features Systems

There are seven common 125-V-dc nonsafety systems: the river intake structure, the service building, the switchyard (two systems), the technical support center, and the security system (two systems). With the exception of the switchyard, each system has a 59-cell lead-calcium battery, distribution equipment, and two redundant battery chargers. These systems receive 480-V-ac power from normal busses. The technical support center system will receive 480-V-ac power from a 480-V-ac FLEX diesel generator following a Beyond Design Basis External Event.

The battery charger design is similar to that of the safety features battery chargers. Each pair of battery chargers is capable of load sharing but is normally operated with one charger inservice and the other charger aligned for standby.

The switchyard system has two batteries (each having 59 cells), six distribution panels, and three battery chargers. A further description is provided in paragraph 8.2.1.2. Each switchyard battery has a normal battery charger with a backup charger shared between both batteries. Battery charger load sharing is not provided for the switchyard battery chargers. Note that Unit 1 will supply power to all three battery chargers.

These batteries are sized as discussed in paragraph 8.3.2.1.2, with the exception of the technical support center battery and the river intake structure battery which have been sized to supply required loads at a minimum temperature of 65°F and 25°F, respectively. Georgia Power Company is responsible for maintaining the switchyard battery and battery charger sizing calculation.

Battery sizes (based on 77°F and 1.80 V/cell final voltage) are:

- River intake structure - 46 Ah at 2-h rate; 96 A for 1 min.
- Service building - 416 Ah at 2-h rate; 654 A for 1 min.
- Technical support center - 1176 Ah at 2-h rate; 1400 A for 1 min.
- Security central alarm station - 1426 Ah at 2-h rate; 1643 A for 1 min.
- Security secondary alarm station - 784 Ah at 2-h rate; 915 A for 1 min.

The 125-V-dc common nonsafety features systems supply dc power for control, switching, vital security and technical support center loads, and the plant telephone/page communication system as shown in the single-line diagrams identified in drawings AX3D-AA-G02A, AX3D-AA-G02B, and AX3D-AA-G02C.

8.3.2.1.4 Ventilation

Battery rooms are ventilated to remove the hydrogen gases that may be produced during charging of the batteries. The ventilation system for the ESF batteries is safety related. See subsection 9.4.5 for a further discussion of the associated ventilation systems.

8.3.2.1.5 Maintenance and Testing

All components of the 125-V-dc systems will undergo periodic maintenance tests to determine the condition of each individual subsystem. Batteries are checked for liquid level, float current, and cell voltage and are visually inspected following the manufacturer's recommended guidelines for procedures. An initial composite test of onsite ac and dc power systems will be performed as a prerequisite to initial fuel loading. This test will establish that the capacity of each battery is sufficient to satisfy a real-time safety load demand profile under the conditions of a loss-of-coolant accident (LOCA) and simultaneous loss of offsite power. Thereafter, periodic capacity tests will be conducted in accordance with the Technical Specifications and the version of IEEE 450 as described in the Bases for the Technical Specifications, Regulatory Guide 1.129, and the manufacturer's schedule recommended for cyclic test discharge/equalizing charge rates. These tests will ensure that the battery has the capacity to continue to meet safety load demands. Battery chargers are periodically checked by visual inspection and performance tests.

Testing for safety-related batteries will be done in accordance with Technical Specifications.

Testing for nonsafety-related batteries is in accordance with plant procedures as governed by 10 CFR 50 Appendix B. Testing includes the following:

A. The battery float current, electrolyte temperature and level, and voltage of the pilot cell of each battery will be measured and logged.

B. Battery service test: The voltage of each cell will be measured at the lowest battery terminal voltage during the discharge and logged.

C. Performance discharge test: The voltage of each cell will be measured at the end of the discharge while the load is still applied and logged.

8.3.2.2 Analysis

The regulatory guides regarding dc power systems are discussed in section 1.9 and subsection 8.1.4. Compliance with the general design criteria is discussed in section 3.1. Table 8.3.2-5 is the failure modes and effects analysis.

The 125-V-dc systems A and C form the train A safety features dc system. Their normal and backup chargers normally receive power from two Class 1E train A motor control centers. Following a Beyond Design Basis External Event, one of the battery chargers per dc train will be powered by a 480-V FLEX diesel generator. The 125-V-dc systems B and D form the train B safety features dc system. Their normal and backup chargers normally receive power from two Class 1E train B motor control centers. Following a Beyond Design Basis External Event, one of the battery chargers per dc train will be powered by a 480-V FLEX diesel generator. The train C and D battery chargers are qualified as isolation devices in accordance with IEEE 384 and Regulatory Guide 1.75. The train A safety features dc system supplies power to train A loads, and the train B safety features dc system supplies power to train B loads. Each individual system (A, B, C, and D) supplies power to a separate instrument channel (1, 2, 3, or 4). In this way, separation between the independent systems is maintained, and the power provided to the chargers can be from either offsite or onsite sources (General Design Criterion 17). The dc system is so arranged that the probability of an internal system failure resulting in loss of dc power is extremely low. Important system components are either self-alarming locally and/or in the control room upon failure or capable of being tested during service to detect faults. Each battery set is located in its own ventilated room. All abnormal conditions of important system parameters are annunciated in the main control room. The safety features battery circuit breakers have dedicated annunciation in the main control room which alarm on a circuit breaker open condition. There is no cross-connection between the independent 125-V-dc systems.

The design of the 125-V-dc safety features systems provided for VEGP is based on the criteria described in IEEE 308 and 450. The safety-related batteries will be tested periodically in accordance with the Technical Specifications and the version of IEEE 450 as described in the Bases for the Technical Specifications. Each battery consists of 59 lead-calcium storage cells, designed for the specific service in which they are to be used. Ample capacity is available to serve the loads connected to the system for the duration of the time that alternating current is not available at the station site. Each division of Class 1E equipment is provided with a separate 125-V-dc system to avoid a single failure involving more than one system. Batteries are located in well-ventilated rooms which limit hydrogen concentration to less than 2% by volume. A hydrogen survey was performed during preoperational checkout to verify that the ventilation system limits hydrogen concentration to this level in accordance with Regulatory Guide 1.128. For battery replacements, hydrogen evolution for the new battery will be calculated and compared to the battery being replaced, at which time an engineering evaluation will be performed to determine if a hydrogen survey is necessary in accordance with subsection 1.9.128. Additionally, a new survey may be required if the battery room configuration or battery room ventilation system is modified in a manner that reduces air flow or creates a new dead air space in the battery room. Adequate aisle space and space above cells are provided.

Eyewash facilities are provided in all battery rooms. They are designed to preclude spilling of water from these facilities on the battery installation.

Seismic Category 1 battery racks provide for the mounting of battery cells in a two-step configuration.

The same criteria as that indicated in paragraph 8.3.1.1.12 applies to dc circuits that are connected to containment penetrations. See figure 8.3.1-1 for the overcurrent protection coordination curve for the dc feeders (General Design Criterion 50).

Fire detection sensors and alarms are provided as described in subsection 9.5.1.

Before installation, cells are stored in a clean, level, dry, and cool location. Extremely low ambient temperatures and localized sources of heat are avoided. During installation, any cell with electrolyte level 1/2 in. or more below the top of the plates is replaced.

Each battery charger has enough capacity for the steady-state operation of connected loads required during normal operation while maintaining its battery in a fully charged condition. Each battery charger and battery charger supply has sufficient capacity to restore a battery from the design basis discharged state to a fully charged state while supplying the normal steady-state loads. The battery charger’s normal supply is from an engineered safety features system motor control center within its division. Following a Beyond Design Basis External Event, one battery charger per train will be powered by a 480-V FLEX diesel generator. Battery chargers are provided with disconnecting means and feedback protection. The chargers are specified to limit dc current feedback during loss of ac input power to 0.200 A under any condition. An individual cell equalizer (ICE) may be connected across each battery cell. This device provides an alternate path for the electric charge current as a function of the individual battery cell voltage. The operating range of the ICE device is within the normal voltage and float current operation of the batteries and has no effect on the operation or capability of the battery chargers to restore a battery from the design basis discharged state to a fully charged state. Periodic tests will be performed to ensure the readiness of the system to deliver the required power (General Design Criterion 18). A qualified ground detector system provides indication of any grounds which may occur in the system.

Battery current and system voltage indications are provided in the main control room for each dc system.

The following common annunciator windows are provided in the main control room for safety-related dc systems:

A. Switchgear trouble.

B. Battery charger trouble.

C. Inverter trouble.

D. 125-V-dc panel trouble.

E. 125-V-dc motor control center trouble.

F. Battery circuit breaker open alarm (dedicated alarm).

Quality assurance requirements are described in chapter 17.

8.3.3 FIRE PROTECTION FOR CABLE SYSTEMS

Refer to paragraph 8.3.1.4.4, subsection 9.5.1, and appendix 9A.

TABLE 8.3.1-1 (SHEET 1 OF 3)

DIESEL GENERATOR ANNUNCIATOR POINTS

1. Low temperature lube oil - in
2. Low temperature lube oil - out
3. High temperature lube oil - in
4. High temperature lube oil - out
5. Trip - high temperature lube oil
6. Low level lube oil
7. Trip - high temperature engine bearing
8. Trip - high crankcase pressure
9. Trip - vibration
10. Trip - overspeed
11. Low temperature jacket water - in
12. Low temperature jacket water - out
13. High temperature jacket water - in
14. High temperature jacket water - out
15. Trip - high temperature jacket water
16. Low pressure jacket water
17. Trip - low pressure jacket water
18. Low level jacket water
19. Deleted
20. Generator trouble
21. High generator bearing temperature
22. High generator control panel temperature
23. Deleted
24. Generator fault
25. Trip - generator differential
26. Maintenance lock out

TABLE 8.3.1-1 (SHEET 2 OF 3)

27. Low pressure lube oil
28. Trip - low pressure lube oil
29. Low pressure turbo oil - right
30. Low pressure turbo oil - left
31. Trip - low pressure turbo oil
32. High ΔP fuel oil filter
33. Low pressure fuel oil
34. High level diesel fuel oil storage tank
35. Low level diesel fuel oil storage tank
36. High/low level diesel fuel oil day tank
37. Low pressure control air
38. Low pressure starting air
39. High pressure starting air
40. Failed to start
41. Switch not in auto
42. Barring device engaged
43. Panel intrusion
44. High engine control panel temperature
45. Emergency start
46. Diesel generator bypassed(a)
47. High ΔP lube oil filter
48. Low oil pressure sensor malfunction
49. Low voltage
50. Engine control in local
51. Diesel generator emergency trip not reset
52. Generator underfrequency
53. Diesel generator circuit breaker inoperable
54. Loss of generator dc control power
55. Loss of starting air dc control power

TABLE 8.3.1-1 (SHEET 3 OF 3)

56. High level fuel injection burst protection tank
57. Diesel generator engine panel annunciator power failure (b)
58. Engine control panel power A failure
59. Engine control panel power B failure

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a. This alarm is displayed on the system status monitoring panel in the control room only.

b. This alarm is displayed on the control room annunciator only.

TABLE 8.3.1-2

DIESEL GENERATOR LOADING PROFILE FOR LOCA AND LOSS OF OFFSITE POWER

	Inrush			Running (Cumulative)[b]		
Step	kW	kVAr	kVA	kW	kVAr	kVA
0	2384[a]	23881[a]	24000[a]	0	0	0
0.5	2471	4912	5499	1041	597	1200
5.5	1795	3509	3995	1399	747	1586
10.5	2021	2802	3455	1767	921	1993
15.5	2745	3683	4593	2278	1108	2533
20.5	4414	9255	10254	3527	1672	3903
25.5	5922	10257	11844	4675	2261	5193
30.5	5275	3889	6553	4900	2571	5334
36.0(RESET)[c]	6791	8093	10564	5716	3062	6485
For Loss of Offsite Power (No LOCA)						
0	3178[a]	31842[a]	32000[a]	0	0	0
0.5	2292	4828	5344	993	571	1146
5.5	0	0	0	993	571	1146
10.5	2558	2271	3421	2212	1074	2459
15.5	3376	4563	5676	2837	1306	3123
20.5	4923	9457	10662	4085	1870	4493
25.5	6453	10448	12280	5233	2458	5781
30.5	5938	4475	7435	5440	2613	6035
31.5(RESET)[c]	7284	8147	10929	6444[d]	3102	7152

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[a] The 4160/480V SWGR transformer inrush contribution during energization. This transformer inrush is present for approximately six cycles.

[b] Running load includes; running load of previous steps plus the equivalent running load of the loads which are started during that step.

[c] Loads added after RESET step are connected manually and randomly up to the diesel generator capacity.

[d] EDG surveillance testing per Technical Specification 3.8.1 is performed at a load ≥ 6500 kW, though the actual maximum load is < 6500 kW.

TABLE 8.3.1-3 (SHEET 1 OF 12)

ONSITE POWER SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
1.	1AA02, control building 4160-V 1E switchgear, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	None; loss of train A; train B available	During a LOSP when the bus is fed from the diesel generator, a single ground fault will not cause a trip of train A
2.	Breaker 05,[(c)] preferred power to item 1, 1E switchgear, train A, normally closed	Open on loss of preferred power and remain open	A	Fail to open	Failure to open alarm in control room from item 5	None; loss of train A; train B available	This breaker electrically interlocked with item 3 and item 77 breakers
				Inadvertent closure	None	None; loss of train A; train B available	
3.	Breaker 19,[(c)] diesel generator 1A power to item 1, 1E switchgear, train A, open	Close on loss of offsite power and remain closed	A	Fail to close	Alarm in control room; safety equipment failed to start from item 5 sequencer	None; loss of train A; train B available	This breaker electrically interlocked with item 2 and item 77 breakers
				Inadvertent opening	Switchgear trouble alarm in control room	None; loss of train A; train B available	
4.	Diesel generator 1A, train A	Provide onsite ac power upon loss of preferred power	A	Fail to start	Diesel generator failed to start alarm in control room	None; loss of train A; train B available	Diesel generator started by item 5 sequencer upon loss of preferred power or receipt of a safety injection signal
				Fail to run	Various specific alarms provided in control room and at local diesel generator control panels	None; loss of train A; train B available	

TABLE 8.3.1-3 (SHEET 2 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
5.	Sequencer, train A	Shed all loads from train A Class 1E power system upon loss of preferred power and reconnect all required safe shutdown loads to diesel generator, item 4, via item 1 switchgear in a programmed manner	A	Fail to operate$^{(d)}$	Sequencer trouble alarm, audio and visual, in control room	None; loss of train A; train B available	
6.	Breaker 10,$^{(c)}$ item 1, 1E 4160-V switchgear, to item 7, 1AB15X transformer, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
7.	1AB15X transformer, item 1, 4160-V switchgear, to item 9, 480-V switchgear, train A	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
8.	Breaker 01,$^{(c)}$ item 7 transformer to item 9, 480-V switchgear, train A, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 5 sequencer	None; partial loss of train A; train B available	
9.	1AB15, 1E, 480-V switchgear, auxiliary building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Partial loss of train A; train B available	System can operate with a single grounded phase
10.	Breaker 10,$^{(c)}$ item 9, 480-V switchgear, to item 11 MCC, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
11.	1ABD, 1E MCC, auxiliary building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Item 9 switchgear trouble alarm	Partial loss of train A; train B available	Ground would be sensed and alarmed in control room from item 9 switchgear (see item 1 method of failure detection); system can

TABLE 8.3.1-3 (SHEET 3 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
							operate with a single grounded phase
12.	Breaker 9,(c) item 9, 480-V switchgear, to item 13 MCC, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
13.	1ABB, 1E MCC, auxiliary building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 11	Same as 11	Ground would be sensed and alarmed in control room from item 9 switchgear (see item 1 method of failure detection); system can operate with a single grounded phase
14.	Breaker 21,(c) item 1, 1E 4160-V switchgear, to item 15, 1AB05X transformer, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
15.	1AB05X transformer, item 1, 4160-V switchgear, to item 17 480-V switchgear, train A	Reduce 4160 V to 480 V		Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
16.	Breaker 01,(c) item 15 transformer to item 17, 480-V switchgear, train A, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 5 sequencer	None; partial loss of train A; train B available	
17.	1AB05, 1E 480-V switchgear, control building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Same as 9	System can operate with a single grounded phase
18.	Breaker 14,(c) item 17, 480-V switchgear, to item 19 MCC, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
19.	1ABF, 1E MCC, diesel	Receive and distribute	A	Grounded,	Item 17 switchgear	Same as 9	Ground would be

TABLE 8.3.1-3 (SHEET 4 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
	generator building, train A	electric power via breakers		bus fault	trouble alarm		sensed and alarmed in control room from item 17 switchgear; system can operate with a single grounded phase
20.	Breaker 5,[(c)] item 17, 480-V switchgear, to item 21 MCC, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
21.	1ABC, 1E MCC, control building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 19	Same as 9	Ground would be sensed and alarmed from item 17 switchgear; system can operate with a single grounded phase
22.	Breaker 2,[(c)] item 17, 480-V switchgear, to item 23 MCC, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
23.	1ABA, 1E MCC, control building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 19	Same as 9	Ground would be sensed and alarmed from item 17 switchgear; system can operate with a single grounded phase
24.	Breaker 20,[(c)] item 1, 1E 4160-V switchgear, to item 25, 1AB04 transformer, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
25.	1AB04X transformer, item 1, 4160-V switchgear, to item 27, 480-V switchgear, train A	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
26.	Breaker 01,[(c)] item 25 transformer to item 27, 480-V switchgear, train A, normally closed	Open on load shedding and reclose on sequencer program		Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 5 sequencer	None; partial loss of train A; train B available	

TABLE 8.3.1-3 (SHEET 5 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
27.	1AB04, 1E 480-V switchgear, control building, train A	Receive and distribute electric power via breakers		Grounded, bus fault	Switchgear trouble alarm in control room	Same as 9	System can operate with a single grounded phase
28.	Breaker 02,[c] item 27, 480-V switchgear, to item 29 MCC, train A, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available	
29.	1ABE, 1E MCC, control building, train A	Receive and distribute electric power via breakers	A	Grounded, bus fault	Item 27 switchgear trouble alarm	Same as 9	Ground would be sensed and alarmed in control room from item 27 switchgear; system can operate with a single grounded phase
30.	Breaker 22,[c] item 1, 1E 4160-V switchgear, to item 31, 1NB01X non-1E transformer, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; loss of train A oriented non-1E power; train B oriented non-1E power available	The sequencer does not automatically reclose this breaker under safety injection conditions; it can be closed manually under administrative control
31.	1NB01X transformer, item 1, 1E 4160-V switchgear, to item 33, 480-V switchgear, train A oriented	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; loss of train A oriented non-1E power; train B oriented non-1E power available	
32.	Breaker 01,[c] item 31 transformer to item 33, 480-V switchgear, train A oriented, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 5 sequencer	None; partial loss of train A; train B available, but power is train A and B oriented non-1E	The sequencer does not automatically reclose this breaker under safety injection conditions; it can be closed manually under administrative control
33.	1NB01, non-1E 480-V switchgear, control building, train A oriented	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Same as 30	System can operate with a single grounded phase

TABLE 8.3.1-3 (SHEET 6 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
34.	Breaker 02,[c] item 33, 480-V switchgear, to item 35 MCC, train A oriented, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A oriented power; train B oriented power available	
35.	1NBS, non-1E MCC, control building, train A oriented	Receive and distribute electric power via breakers	A	Grounded, bus fault	Item 33 switchgear trouble alarm	Same as 30	Ground would be sensed and alarmed in control room from item 33 switchgear; system can operate with a single grounded phase
36.	Breaker 08,[c] item 33, 480-V switchgear, to item 37 MCC, train A oriented, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train A; train B available, but power is train A and B oriented non-1E	
37.	1NBI, non-1E MCC, diesel generator building, train A oriented	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 35	Same as 30	Ground would be sensed and alarmed in control room from item 33 switchgear; system can operate with a single grounded phase
38.	1BA03, control building, 4160-V 1E switchgear, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	None; loss of train B; train A available	During a LOSP when the bus is fed from the diesel generator, a single ground fault will not cause a trip of train B
39.	Breaker 19,[c] diesel generator 1B power to item 38, 1E switchgear, train B, normally open	Close on loss of offsite power and remain closed	A	Fail to close	Alarm in control room; safety equipment failed to start from item 42 sequencer	None; loss of train B; train A available	This breaker electrically interlocked with item 40 and item 78 breakers
				Inadvertent opening	Switchgear trouble alarm in control room	None; loss of train B; train A available	
40.	Breaker 01,[c] preferred power to item 38, 1E switchgear, train B, normally closed	Open on loss of preferred power and remain open	A	Fail to open	Failure to open alarm in control room from item 42 sequencer	None; loss of train B; train A available	This breaker electrically interlocked with item 39 and item 78 breakers
				Inadvertent closure	None	None; loss of train B; train A available	

TABLE 8.3.1-3 (SHEET 7 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
41.	Diesel generator 1B, train B	Provide onsite ac power upon loss of preferred power	A	Fail to start	Diesel generator failed to start alarm in control room	None; loss of train B; train A available	Diesel generator started by item 42 sequencer upon loss of preferred power or receipt of a safety injection signal
				Fail to run	Various specific alarms provided in control room and at local diesel generator control panels	None; loss of train B; train A available	
42.	Sequencer, train B	Shed all loads from train B Class 1E power system upon loss of preferred power and reconnect all required safe shutdown loads to diesel generator, item 4, via item 1 switchgear in a programmed manner	A	Fail to operate[d]	Switchgear trouble alarm, audio and visual, in control room	None; loss of train B; train A available	
43.	Breaker 09,[c] item 38, 1E 4160-V switchgear, to item 44, 1BB16X transformer, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
44.	1BB16X transformer, item 38, 4160-V switchgear, to item 46, 480-V switchgear, train B	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
45.	Breaker 01,[c] item 44 transformer to item 46, 480-V switchgear, train B, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 42 sequencer	None; partial loss of train B; train A available	
46.	1BB16, 1E 480-V switchgear, auxiliary building, train B	Receive and distribute electrical power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Same as 38	System can operate with a single grounded phase

TABLE 8.3.1-3 (SHEET 8 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
47.	Breaker 10,[c] item 46, 480-V switchgear, to item 48 MCC, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
48.	1BBD, 1E MCC, auxiliary building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Item 46 switchgear trouble alarm	Same as 47	None; would be sensed and alarmed in control room from item 46 switchgear
49.	Breaker 9,[c] item 46, 480-V switchgear, to item 50 MCC, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
50.	1BBB, 1E MCC, auxiliary building, train B	Receive and distribute electric power via breakers	A	Grounded	Same as 48	Same as 47	None; would be sensed and alarmed in control room from item 46 switchgear
51.	Breaker 04,[c] item 38, 1E 4160-V switchgear, to item 52, IBB07X transformer, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
52.	1BB07X transformer, item 38, 4160-V switchgear, to item 54, 480-V switchgear, train B	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
53.	Breaker 01,[c] item 52 transformer to item 54, 480-V switchgear, train B, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 42 sequencer	None; partial loss of train B; train A available	
54.	1BB07, 1E 480-V switchgear, control building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Same as 47	System can operate with a single grounded phase

TABLE 8.3.1-3 (SHEET 9 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
55.	Breaker 14,[c] item 54, 480-V switchgear, to item 56 MCC, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
56.	1BBF, 1E MCC, diesel generator building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Item 54 switchgear trouble alarm	Same as 47	Ground would be sensed and alarmed in control room from item 54 switchgear
57.	Breaker 5,[c] item 54, 480-V switchgear, to item 58 MCC, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
58.	1BBC, 1E MCC, control building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 56	Same as 47	Ground would be sensed and alarmed in control room from item 54 switchgear
59.	Breaker 2,[c] item 54, 480-V switchgear, to item 60 MCC, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
60.	1BBA, 1E MCC, control building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 56	Same as 47	Ground would be sensed and alarmed in control room from item 54 switchgear
61.	Breaker 06,[c] item 38, 1E 4160-V switchgear, to item 62, 1BB06X transformer, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
62.	1BB06X transformer, item 38, 4160-V switchgear, to item 64, 480-V switchgear, train B	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
63.	Breaker 01,[c] item 62 transformer to item 64, 480-V switchgear, train B, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step

TABLE 8.3.1-3 (SHEET 10 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 42 sequencer	None; partial loss of train B; train A available	
64.	1BB06, 1E 480-V switchgear, control building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Same as 47	System can operate with a single grounded phase
65.	Breaker 02,(c) item 64, 480-V switchgear, to item 66 MCC, train B, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available	
66.	1BBE, 1E MCC, control building, train B	Receive and distribute electric power via breakers	A	Grounded, bus fault	Item 64 switchgear trouble alarm	Same as 47	Ground would be sensed and alarmed in control room from item 64 switchgear
67.	Breaker 18,(c) item 38, 1E 4160-V switchgear, to item 68, 1NB10X non-1E transformer, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; loss of train B oriented non-1E power; train A oriente non-1E power available	The sequencer does not automatically recluse this breaker under SI conditions; it can be closed manually under administrative control
68.	1NB10X transformer, item 38, 1E 4160-V switchgear, to item 70, 480-V switchgear, train B oriented	Reduce 4160 V to 480 V	A	Fail to operate	Switchgear trouble alarm in control room	None; partial loss of train B oriented non-IE power; Train A oriented non-IE power available	
69.	Breaker 01,(c) item 68 transformer to item 70, 480-V switchgear, train B oriented, normally closed	Open on load shedding and reclose on sequencer program	A	Fail to open	None	None	Slightly heavier load on initial sequencer step
				Fail to reclose	Alarm in control room; safety equipment failed to start from item 42 sequencer	None; loss of train B; train A available, but power is train A and B oriented non-1E	The sequencer does not automatically reclose this breaker under safety injection conditions; it can be closed manually under administrative control

TABLE 8.3.1-3 (SHEET 11 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
70.	1NB10, non-1E 480-V switchgear, control building, train B oriented	Receive and distribute electric power via breakers	A	Grounded, bus fault	Switchgear trouble alarm in control room	Loss of train B oriented non-1E power; train A oriented non-1E power available	System can operate with a single grounded phase
71.	Breaker 02,[(c)] item 70, 480-V switchgear, to item 72 MCC, train B oriented, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available, but power is train A and B oriented non-1E	
72.	1NBR, non-1E MCC, control building, train B oriented	Receive and distribute electric power via breakers	A	Grounded, bus fault trouble alarm	Item 70 switchgear trouble alarm	Same as 70	Ground would be sensed and alarmed from item 70 switchgear
73.	Breaker 12,[(c)] item 70, 480-V switchgear, to item 74 MCC, train B oriented, normally closed	Provide continuity and protect circuit	A	Inadvertent opening	Switchgear trouble alarm in control room	None; partial loss of train B; train A available, but power is train A and B oriented non-1E	
74.	1NBO, non-1E MCC, diesel generator building, train B oriented	Receive and distribute electric power via breakers	A	Grounded, bus fault	Same as 72	Same as 70	Ground would be sensed and alarmed from item 70 switchgear. System can operate with a single grounded phase line; train B
75.	Preferred power from offsite power supply via reserve auxiliary transformer 1NXRA (train A), 1NXRB (train B), or standby auxiliary transformer ANXRA to item 1 switchgear via item 2 or item 77 breaker (non-1E power)	Provide preferred power to train A safety-related buses	A	Loss of power	Switchgear trouble alarm in control room	None; momentary loss of power until item 4 diesel generator comes on available	

TABLE 8.3.1-3 (SHEET 12 OF 12)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
76.	Preferred power from offsite power supply via auxiliary transformer 1NXRB (train B), 1NXRA (train A), or standby auxiliary transformer ANXRA to item 38 switchgear via item 40 or item 78 breaker (non-1E power)	Provide preferred power to train B safety-related buses	A	Loss of power	Switchgear trouble alarm in control room	None; momentary loss of power until item 41 diesel generator comes on line; train A available	
77.	Breaker 01,[c] alternate preferred power to item 1, 1E switchgear, train A, normally open	When closed, opens on loss of preferred power and remains open	A	Failure to open	Failure to open alarm in control room from item 5, sequencer	None; loss of train A; train B available	This breaker electrically interlocked with item 2 and 3 breakers
				Inadvertent closure	Switchgear trouble alarm in control room	None; loss of train A; train B available	
78.	Breaker 05,[c] alternate preferred power to item 38, 1E switchgear, train B, normally open	When closed, opens on loss of preferred power and remains open	A	Failure to open	Failure to open alarm in control room from item 5, sequencer	None; loss of train B; train A available	This breaker electrically interlocked with item 39 and 40 breakers
				Inadvertent closure	Switchgear trouble alarm in control room	None; loss of train B; train A available	

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a. Plant operating mode A represents a loss of offsite power and/or safety injection; offsite power is the preferred power source. The only postulated failures of interconnecting power cable are a short circuit and/or a ground on the 4-kV system cabling, which would result in inadvertent opening of the associated circuit breaker. All power is reestablished to Class 1E buses following loss of preferred power automatically and requires no operator action.

b. Unit 1 shown; Unit 2 essentially identical.

c. It is to be understood that the failure of any one circuit breaker to open when required to under fault conditions will result in the loss or partial loss of the associated train with the redundant train still available.

d. A Diversity and Defense-in-Depth Analysis addressed software common-mode failure effects.

TABLE 8.3.1-4 (SHEET 1 OF 6)

CIRCUITS ANALYZED FOR SEPARATION REQUIREMENTS

A.[a] 1. 7300 Process Control System
2. Nuclear Instrumentation System
3. Solid State Protection System

B. An analysis was performed for selected Unit 1 cables larger than 8 AWG and terminating in multitrain panels. The analysis determined which cables could not ignite under fault conditions (i.e. where there is insufficient available energy or where the backup protection was fast enough to open the faulted circuit before the cables could ignite). Those cables which could not ignite under fault conditions were exempted from separation verification.

C. VEGP generally complies with the separation requirements of IEEE 384-1981. A series of tests and analyses has been performed for circuits of 480-V or lower voltage to establish alternate reduced minimum separation distances where separation distances specified in IEEE 384 are not met. Analyses have also been performed to justify separation of Class 1E 4160-V cables from non-1E 480 V and lower cables. These tests and analyses have been performed as allowed by Sections 6.1.1.3 and 6.6.2 of IEEE 384-1981 and Regulatory Guide 1.75. The test results are documented in Wyle Laboratories Test Report No. 48141-02 and Wyle Laboratories Test Report No. 17959-02, which have been submitted for review by the NRC under separate cover.

Based on the Wyle Laboratories test results,[b] the following minimum separation distances were established:

The separation distances are applied between raceways and cables of any separation group for both vertical (above and below) and horizontal (side by side) physical configurations or as noted.

TABLE 8.3.1-4 (SHEET 2 OF 6)

	Configuration/Service Level	Minimum Spatial Separation Distance
1.	Between trays carrying cables of 480 V or lower voltage of sizes 2/0 AWG or smaller.	12 in.
2.	Cables in tray with cover on the bottom from non-class 1E cables in tray or free air (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller and located below or along side Class-1E tray).	3/4 in.
3.	Cables in tray or free air running either vertically, or horizontally (side-by-side) from horizontal non-Class 1E cable in tray (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	1 in.
3a.	Cables in tray or free air running either vertically, or horizontally (side-by-side) from horizontal non-Class 1E cable in free-air (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	1-3/4 in.
4.	Tray (a) or free-air cables to a non-Class 1E rigid steel conduit carrying cables of 480 V or lower voltage and sizes 2/0 AWG or smaller.	Contact
4a.	Tray or free-air cables to a non-Class 1E rigid steel conduit carrying cables of 480 V or lower voltage and sizes 3/0 AWG through 500MCM.	3/4 in.
5.	Tray or free-air cables to a rigid steel conduit (the free-air cables, cables in the tray, and in the conduit are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	1/2 in.
5a.	Cables in tray to a rigid steel conduit routed below or beside the tray (the cables in the tray, and in the conduit are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact
6.	Tray or free-air cables to a non-Class 1E flexible conduit (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	1 in.
6a.	Tray or free-air cables to a non-Class 1E stripped flexible conduit (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact

TABLE 8.3.1-4 (SHEET 3 OF 6)

	Configuration/Service Level	Minimum Spatial Separation Distance
7.	Tray or free-air cables to a flexible conduit (the free-air cables, cables in the tray and in the conduit are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	1 in.
8.	Tray or free-air cables to a non-Class 1E aluminum sheathed cable of size 8 AWG or smaller or non-Class 1E electrical metallic tubing (EMT) carrying cables of sizes 8 AWG or smaller. (Limited to lighting, communications, and fire detection cables)	1 in.
9.	Tray or free-air cables to a non-Class 1E metal-clad cable (type MC) of size 8 AWG or smaller.	3/4 in.
10.	Tray or free-air cables to a non-Class 1E steel-armored 480-V cable (500 MCM or smaller).	3/4 in.
10a.	Tray or free-air cables (480V or lower voltage and size 2/0 AWG or smaller) to steel-armored 480-V cable (500 MCM or smaller).	3/4 in.
11.	Cables in flexible conduit to cables in flexible conduit (the cables are limited to 480 V or lower voltage and size 500 MCM or smaller).	1 in.
11a.	Cables in stripped flexible conduit to non- Class 1E cables in stripped flexible conduit (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact
11b.	Cables in stripped flexible conduit to cables in stripped flexible conduit (the cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact
12.	Cables in flexible conduit to non-Class 1E cables in rigid steel conduit (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact
13.	Between two rigid steel conduits (the cables in the conduits are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact
13a.	Cables in rigid steel conduit to non-Class 1E cables in rigid steel conduit (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller).	Contact
14.	Between perpendicular rigid steel conduits carrying cables of 480 V or lower voltage and sizes 3/0 AWG	1/8 in.

TABLE 8.3.1-4 (SHEET 4 OF 6)

	Configuration/Service Level	Minimum Spatial Separation Distance
	through 500 MCM.	
15.	Cables in rigid steel conduit crossing non-Class 1E cables in tray or free air (the non-Class 1E cables are limited to 480 V or lower voltage and size 2/0 AWG or smaller). The angle of crossing shall be 30° or greater.	Contact
16.	Free-air cables to free-air cables, where one of the groups is wrapped in three layers (200 percent overlap) of silicon dioxide cloth (Siltemp 188 CH). Service voltage is limited to 480 V or lower voltage and sizes of 500 MCM or smaller.	6 in.
16a.	From non-Class 1E free air cables 480 V or lower voltage and size of 500 MCM or smaller, wrapped with three layers (200 percent overlap) of silicon dioxide cloth (Siltemp 188 CH) to Class 1E free-air cables.	6 in.
17.	Free-air cables 480 V or lower voltage and size of 500 MCM or smaller, to free air control or instrumentation cables (8 AWG or smaller). The control or instrumentation cables are wrapped in two layers (100 percent overlap) of silicon dioxide cloth (Siltemp 188 CH).	1 in.
18.	Between free air instrumentation or control cables of 125 V-dc or 120 V-ac or lower, sizes number 8 AWG or smaller.	1 in.
19.	Between free air instrumentation or control cables (125 V-dc or 120 V-ac or lower sizes number 8 AWG or smaller) with either group of cables wrapped in two layers (100 percent overlap) of silicon dioxide cloth (Siltemp 188 CH).	Contact
20.	Free-air, class 1E cable(s) to free-air non-class 1E cables with the class 1E cables wrapped in two layers (100 percent overlap) of silicon dioxide cloth. The non-class 1E cables are limited to 480 V or lower voltage of sizes 500 MCM or smaller.	1 in.
21.	Within panels and control boards:	
	a. Between instrumentation or control cables of 125 V-dc or 120 V-ac of sizes number 8 AWG or smaller.	1 in.

TABLE 8.3.1-4 (SHEET 5 OF 6)

Configuration/Service Level	Minimum Spatial Separation Distance
b. Between instrumentation or control cables with either group of cables wrapped in two layers (100 percent overlap) of silicon dioxide cloth (Siltemp 188 CH). The cables are limited to 120 V-ac, 125 V-dc, or lower voltage of sizes number 8 AWG or smaller.	Contact
c. Separation distances shown for general plant areas in items 4, 5, 6, 10, 13, and 14 have been applied to separation requirements within panels.	
d. Separation distances for cable installed in rigid steel or flexible conduit inside panels are the same as those tested in items 11, 11a, 11b, 12, 13, 13a, and 14.	

Where:

Tray -	Ventilated (punched bottom) tray or tray fittings, solid bottom tray, or tray fittings
Conduit -	Hot dipped galvanized rigid steel conduit
Flexible Conduit -	Flexible steel conduit, sealtite, type UA
Steel-Armored -Cable	EPR insulation/hypalon jacket with galvanized steel armor. Used for 480-V switchgear loads in tray only.
Aluminum Sheathed – Cable (ALS)	A factory assembly of insulated conductors enclosed in a smooth continuous aluminum sheath. Used for lighting system application.
Metal-Clad Cable - (MC)	A factory assembly of one or more conductors each individually insulated, covered with an overall insulating jacket, and all enclosed in a metallic sheath of interlocking galvanized steel. Used in non-1E circuit only.
Electrical - Metallic Tubing (EMT)	Thinwall, steel conduit which conforms to ANSI standard C80.3-1977. This material provides a barrier equal to, or better than, the aluminum sheathing on ALS because it is manufactured from steel which has higher strength and a higher melting temperature than aluminum.

Free-air cables may consist of steel armored or nonarmored cables, ALS, or type MC cables of any size or voltage level unless otherwise limited in the specific configuration description.

TABLE 8.3.1-4 (SHEET 6 OF 6)

D. Non-class 1E fire detection Protectowire has been used in safety related cable tray within containment to detect cable tray fires. This wiring is installed in a zig-zig fashion along the length of the tray in close proximity to the cables. It consists of two conductors individually encased in heat sensitive material. The encased conductors are twisted together to impose a spring pressure between them. When heated to the critical for operating temperature the heat sensitive material yields to the pressure on it, permitting the conductors to move into contact with each other. A supervisory current of 2.5 mA at a maximum of 26.4 V dc normally flows through the Protectowire. During an alarm condition this current rises to a maximum of 20 mA. Therefore, Protectowire is considered a low energy circuit, which is designed to short during an alarm condition, and cannot cause degradation of any Class 1E cables in the vicinity. A separate Protectowire panel is provided for each train thereby providing electrically independent monitoring of the cable tray temperatures in each train. Based on the discussion above, no separation is required between the non-class 1E fire protection Protectowires and any class 1E cables.

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a. The analyses/tests performed for the above equipment are further described in paragraph 7.1.2.2.1.

b. The test configuration of target cables above the fault cable represents the worst case, since heat/flame has tendency to flare vertically upwards.

c. For the purpose of testing, the cables in the punched bottom tray are considered the same as cables in free air since the cables in the tray are directly exposed to the heat generated by the faulted cable in the areas of the tray that have been punched.

TABLE 8.3.2-1

125-V-dc BATTERY A LOAD REQUIREMENTS (LOCA/LOSP)

Load Description	Unit[(b)]	Current Required per Time Interval after ac Power Loss (A) 0-1 min	1-165 min	Random Load
Total load includes inverters, MOV[(a)], dc distribution panels,[(a,c)] dc switchgear, MCC indication and relaying.	1 2	590 593	255 273	202 150

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a. The field flash current has not been added to the first period or random load and the MOV current has not been added to the random load since the peak load occurring during the period has been considered. The peak load is due to the breakers closing, which does not occur coincidentally with the field flash or MOV currents.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panels include the following loads: Class 1E ac switchgear circuit breaker operation, safety features status indication relays and lights, diesel generator field flashing, diesel generator control, reactor trip switchgear, solenoid valves, and Class 1E control cabinet circuit indicators.

TABLE 8.3.2-2

125-V-dc BATTERY B LOAD REQUIREMENTS (LOCA/LOSP)

		Current Required per Time Interval after ac Power Loss (A)		
Load Description	Unit[b]	0-1 min	1-165 min	Random Load
Total load includes inverters, MOV[a], dc distribution panels,[a,c] dc switchgear, MCC indication and relaying.	1 2	590 590	257 255	162 130

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a. The field flash current has not been added to the first period or random load and the MOV current has not been added to the random load since the peak load occurring during the period has been considered. The peak load is due to the breakers closing, which does not occur coincidentally with the field flash or MOV currents.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panels include the following loads: Class 1E ac switchgear circuit breaker operation, safety features status indication relays and lights, diesel generator field flashing, diesel generator control, reactor trip switchgear, solenoid valves, and Class 1E control cabinet circuit indicators.

TABLE 8.3.2-3

125-V-dc BATTERY C LOAD REQUIREMENTS (LOCA/LOSP)

		Current Required per Time Interval after ac Power Loss (A)		
Load Description	Unit[b]	0-1 min	1-165 min	Random Load
Total load includes inverters, MOV[a], dc distribution panels,[c] dc switchgear, MCC indication and relaying.	1	224	92	82.3
	2	217	84	82.3

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a. The RHR isolation valve is not required to operate when ac power is not available to the RHR system.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panel includes the following loads: turbine-driven auxiliary feedwater pump control panel, safety features status indication relays and lights, miscellaneous control, and dc switchgear space heaters.

TABLE 8.3.2-4

125-V-dc BATTERY D LOAD REQUIREMENTS (LOCA/LOSP)

Load Description	Unit[b]	Current Required per Time Interval after ac Power Loss (A) 0-165 min
Total load includes inverters, MOV[a], dc distribution panels,[c] dc switchgear, MCC indication and relaying.	1	77
	2	70

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a. The RHR isolation valve is not required to operate when ac power is not available to the RHR system.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panel includes the following loads: miscellaneous control and train D switchgear space heaters.

TABLE 8.3.2-5 (SHEET 1 OF 10)

CLASS 1E 125-V dc AND 120-V VITAL ac SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

Item No.	Description of Component	Safety Function	Plant Operating ode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
1.	Redundant battery charger; train A 1AD1CA, train B 1BD1CA train C 1CD1CA, train D 1DD1CA	Provide dc power when ac power available and maintain battery in a charged condition; either item 1 and/or item 2 in service at any time	A, B	No output	Annunciator in main control room; one battery charger trouble alarm for input undervoltage, output overvoltage, and loss of output	None; item 2 charger available; battery can provide 2 3/4 h without charger; train B available	For single failure analysis; since these components are redundant to item 2, failure of items 1 and 2 components would require two single failures; thus, this would not be considered.
			C	No input	Annunciator in main control room; one battery charger trouble alarm for input undervoltage, output overvoltage, and loss of output	None; battery available for 4 h	This component cannot function during blackout
2.	Redundant battery charger; train A 1AD1CB, train B 1BD1CB, train C 1CD1CB, train D 1DD1CB	Provide dc power when ac power available and maintain battery in a charged condition, either item 1 and/or item 2 in service at any time	A, B	No output	Annunciator in main control room; one battery charger trouble alarm for input undervoltage, output overvoltage, and loss of output	None; item 2 charger available; battery can provide 2 3/4 h without charger; train B available	For single failure analysis; since these components are redundant to item 1, failure of items 1 and 2 components would require two single failures; thus this would not be considered
			C	No input	Annunciator in motor control room; one battery charger trouble alarm for input undervoltage, output overvoltage, and loss of output	None; battery available for 4 h	This component cannot function during blackout

TABLE 8.3.2-5 (SHEET 2 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
3.	Battery; train A 1AD1B, train B 1BD1B, train C 1CD1B, train D 1DD1B	Backup to battery charger during load cycling (in rush current) and provide dc power for 2 ¾ h without battery charger output for LOCA/ LOSP conditions, and 4 h for SBO conditions.	A, B	No output	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position	None; battery chargers (items 1 and 2) available; train B available	
			C	No output	Control room voltmeter, annunciator isolation device panel trouble alarm, loss of related control room equipment indicating lights.	None; train B available	
4.	125-V dc switch-gear; train A 1AD1, train B 1BD1, train C 1CD1, train D 1DD1	Distribute power via breakers to loads from chargers and battery	A, B, C	Grounded, bus fault	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position; for bus fault, no switchgear alarm. Annunciator isolation device panel trouble alarm for bus fault.	None; train B available	Power still available with a single ground. Power not available with bus fault.
5.	Breaker(b) train A 1AD106, train B 1BD107, train C 1CD106, train D 1DD106	Provide circuit continuity and protection between item 1 battery charger and item 4 switchgear	A, B	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position	None; item 2 charger available; battery can provide 2 3/4 h without charger; train B available	
			C	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position	None; battery available for 4 h	This component cannot function during blackout

TABLE 8.3.2-5 (SHEET 3 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
6.	Breaker[(b)] train A 1AD107, train B 1BD106, train C 1CD107, train D 1DD107	Provide circuit continuity and protection between item 2 battery charger and item 4 switchgear	A, B	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position	None; item 1 charger available; battery can provide 2 3/4 h without charger; train B available	
			C	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position	None; battery available for 4 h	This component cannot function during blackout
7.	Breaker[(b)] (normally closed); train A 1AD101, train B 1BD101, train C 1CD101, train D 1DD101	Provide circuit continuity and protection between battery and item 4 switchgear	A, B	Inadvertent opening	One switchgear trouble alarm in main control room for bus under voltage, ground detection, and improper breaker position; plus breaker open alarm in main control room	None; battery chargers (items 1 and 2) available; train B available	
			C	Inadvertent opening	Control room voltmeter, annunciator isolation device panel trouble alarm, loss of related control room equipment indicating lights.	None; train B available	
8.	Breaker[(b)] (normally closed); train A 1AD109, train B 1BD109	Provide circuit continuity and protection between item 4 switchgear and 125-V dc panel 1 (A, B) D12	A, B, C	Inadvertent opening	Annunciator isolation device panel trouble alarm.	None; train B available	

TABLE 8.3.2-5 (SHEET 4 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
9.	Breaker[(b)] (normally closed); train A 1AD105, train B 1BD105, train C 1CD104, train D 1DD104	Provide circuit continuity and protection between item 4 switchgear and 125-V dc panel 1 (A,B, C, D) D11	A, B	Inadvertent opening	One switchgear trouble alarm in main control room for bus under voltage, ground detection, and improper breaker position; plus one panel trouble alarm per panel in main control room for bus undervoltage, ground detection, and branch breaker overload. For 1CD104 and 1DD104, failure detection is control room annunciator isolation device panel trouble alarm.	None; train B available	
			C	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position; plus one panel trouble alarm per panel in main control room for bus under voltage, ground detection, and branch breaker overload. For 1CD104 and 1DD104, failure detection is control room annunciator isolation device panel trouble alarm.	Single failure on auxiliary feedwater turbine-driven pump control panel functions; blackout does not require single failure criteria	For 1CD104 breaker auxiliary feedwater function only; for other function train D available

TABLE 8.3.2-5 (SHEET 5 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
10.	BreakerLhM (normally closed); train A 1AD110, and 1AD104 train B 1BD110, and 1BD104 train C 1CD109 and 1CD108, train D 1DD109 and 1DD108	Provide circuit continuity and protection between item 4 switchgear and inverter 1AD1I1, 1BD1I2, 1CD1I3, 1CD1I5, 1DD1I4, 1DD1I6, 1AD1I11, 1BD1I12	A, B, C	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position; plus inverter trouble alarm in main control room.	None; system safety function can be met with loss of one channel	
11.	BreakerLhM (normally closed); train A 1AD111, train B 1BD111, train C 1CD111	Provide circuit continuity and protection between item 4 and 125-V dc MCC 1 (A, B, C) D1M	A, B	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position; plus one MCC trouble alarm in main control room for bus undervoltage	None; train B available	For breaker 1AD111 and 1BD111
			C	Inadvertent opening	One switchgear trouble alarm in main control room for bus undervoltage, ground detection, and improper breaker position; plus one MCC trouble alarm in main control room for bus undervoltage	Single failure on auxiliary feedwater turbine-driven pump motor-operated valves and associated controls; blackout does not require single failure criteria None; train B available	For breaker 1CD111 For breakers 1AD111 and 1BD111.

TABLE 8.3.2-5 (SHEET 6 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
12.	Inverter; train A 1AD1I1, 1AD1I11 train B 1BD1I2, 1BD1I12 train C 1CD1I3, train D 1DD1I4	Convert 125-V dc to 120-V ac and provide voltage to vital instrument panels 1AY1A, 1BY1B, 1CY1A, 1DY1B, 1AY2A, 1BY2B	A, B,C,	No output, high output voltage, high output frequency	Common annunciator in main control room for - Low dc voltage - High dc voltage - Low ac output voltage - High ac output voltage - Inverter trouble.	None; system safety function can be met with loss of one channel	No high ac output for Westinghouse inverters, no high dc voltage for Elgar inverters, inverter failure for solid-state controls inverters only.
13.	Regulated transformer; [c] train A 1ABB40RX and 1ABC09RX train B 1BBB40RX and 1BBA07RX train C 1ABA07RX train D 1BBC09RX	Backup to inverter (item 12) when it is isolated for maintenance or malfunction (requires local manual switching at item 14 panel)	A, B	No output	None	None; train B available	For single failure analysis: since these components are redundant to item 1, failure of item 1 and 2 components would require two single failures; thus this should not be considered; however, these components are redundant to item 12
			C	No input	None	None; train B available	This component cannot function during blackout
14.	120-V ac vital instrument panel; train A 1AY1A, 1AY2A, train B 1BY1B, 1BY2B, train C 1CY1A, train D 1DY1B	Distribute power via breakers to loads	A, B, C	Ground and bus fault	Panel trouble alarm in main control room for ground detection and bus undervoltage	None; system safety function can be met with loss of one channel	Power still available with a single ground.

TABLE 8.3.2-5 (SHEET 7 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
15.	Interlock breaker[(b)] one per train (located at item 14 panel)	Provide local manual switching between inverter (item 12) and regulated transformer (item 13) and preclude both being connected together; also provide incoming overload protection	A, B,	Inadvertent transfer	Panel trouble alarm in main control room for ground detection and bus undervoltage	None; momentary loss of power to item 14 panels; train B available	
			A, B	Inadvertent opening	Panel trouble alarm in main control room for ground detection and bus undervoltage	None; train B available	
			C	Inadvertent opening	Panel trouble alarm in main control room for ground detection and bus undervoltage	None; panels are normally fed from inverters which are backed by batteries that are available for 4 h	
16.	125-V dc panel; train A 1AD12, train B 1BD12	Distribute power via breakers to loads	A, B, C	Ground, bus fault	One panel trouble alarm per panel in main control room for branch breaker overload. Bus fault will provide an annunciator isolation device panel trouble alarm. Ground detection provided by control room alarm for the panel supply switchgear.	None; train B available	Power still available with a single ground Power not available with bus fault.
17.	125-V dc panel; train A 1AD11 train B 1BD11	Distribute power via breakers to loads	A, B, C	Ground, bus fault	One panel trouble alarm per panel in main control room for bus undervoltage and branch breaker overload. Ground detection provided by control room alarm for the panel supply switchgear.	Same as 16	Power still available with a single ground

TABLE 8.3.2-5 (SHEET 8 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
18.	125-V dc MCC; train A 1AD1M, train B 1BD1M	Distribute power via breakers to loads	A, B, C	Ground, bus fault	MCC trouble alarm in main control room for bus undervoltage, and branch breaker overload. Ground will provide a control room alarm for the MCC supply switchgear.	None; train B available	Power still available with a single ground
19.	125-V dc panel; train C 1CD11, train D 1DD11	Distribute power via breakers to loads	A, B, C	Ground, bus fault	One panel trouble alarm per panel in main control room for branch breaker overload. Bus fault will provide control room annunciator isolation device panel trouble alarm. Ground detection provided by control room alarm for the panel supply switchgear.	None; train D available	Power still available with a single ground Power not available for bus fault.
			C	Ground, bus fault	One panel trouble alarm per panel in main control room for branch breaker overload. Bus fault will provide control room annunciator isolation device panel trouble alarm. Ground detection provided by control room alarm for the panel supply switchgear.	Single failure; single failure on auxiliary feedwater turbine-driven pump space heater and control panel functions; blackout does not require single failure criteria	For 1CD104 breaker auxiliary feedwater function only; for other function train D available

TABLE 8.3.2-5 (SHEET 9 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
20.	125-V dc MCC; train C 1CD1M	Distribute power via breakers to loads	A, B	Ground, bus fault	MCC trouble alarm in main control room for bus undervoltage, and branch breaker overload. Ground will provide a control room alarm for the MCC supply switchgear.	None; ac drive auxiliary feedwater available	
			C	Ground, bus fault	MCC trouble alarm in main control room for bus undervoltage, and branch breaker overload. Ground will provide a control room alarm for the MCC supply switchgear	Single failure; single failure on auxiliary feedwater turbine-driven pump motor-operated valves and associated controls; blackout does not require single failure criteria	
21.	Inverter; train C 1CD1I5, train D 1DD1I6	Convert 125-V dc to 480 V, 3ϕ to provide power to operate residual heat removal isolation valves	A, B, C	No output	One inverter trouble alarm per inverter in main control room	None; trains A and B and train C or D available	
22.	Motor starter; train C 1CD1I5N, train D 1DD1I6N	Controller for residual heat removal isolation valves	A, B, C	Inadvertent opening of input breaker	One starter trouble alarm per starter in main control room for loss of voltage and motor overload	None; trains A and B and train C or D available	
				Motor overload	One starter trouble alarm per starter in main control room for loss of voltage and motor overload	None; trains A and B and train C or D available	
				No operation	No change in status of indicating lights in main control room	None; trains A and B and train C or D available	

TABLE 8.3.2-5 (SHEET 10 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
23.	Individual Cell Equalizer	None	A, B, C	Open	A. Cell voltage reading B. Measure ICE current.	None; the battery cell will be effectively returned to its original configuration	A short in the ICE device will fail to an open state.

---

a. Plant operating modes are represented as follows:

A - normal (offsite power available).
B - loss of offsite power.
C - blackout (loss of all ac systems, except 120-V ac vital system).

System success criteria are as follows:

125-V dc system - one of two (train A or B and train C or D) channels required. 120-V ac vital system - three of four channels required.

b. It is to be understood that the failure of any one circuit breaker to open when required to under fault conditions will result in the loss of the associated train with redundant train still available.

c. Unit 2 transformer numbers are suffixed by “RX” in lieu of “X.”

TABLE 8.3.2-6

125-V-dc BATTERY A LOAD REQUIREMENTS (SBO)

	Current Required per Time Interval after ac Power Loss (A)			
Load Description	Unit[b]	0-1 min	1-240 min	Random Load
Total load includes inverters, MOV[a], dc distribution panels,[a,c] dc switchgear, MCC indication and relaying.	1 2	441 375	255 273	62 31

---

a. The field flash current has not been added to the first period or random load and the MOV current has not been added to the random load since the peak load occurring during the period has been considered. The peak load is due to the breakers closing, which does not occur coincidentally with the field flash or MOV currents.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panels include the following loads: Class 1E ac switchgear circuit breaker operation, safety features status indication relays and lights, diesel generator field flashing, diesel generator control, reactor trip switchgear, solenoid valves, and Class 1E control cabinet circuit indicators.

TABLE 8.3.2-7

125-V-dc BATTERY B LOAD REQUIREMENTS (SBO)

Load Description	Unit[b]	Current Required per Time Interval after ac Power Loss (A) 0-1 min	1-240 min	Random Load
Total load includes inverters, MOV[a], dc distribution panels,[a,c] dc switchgear, MCC indication and relaying.	1	444	257	82
	2	429	255	50

---

a. The field flash current has not been added to the first period or random load and the MOV current has not been added to the random load since the peak load occurring during the period has been considered. The peak load is due to the breakers closing, which does not occur coincidentally with the field flash or MOV currents.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panels include the following loads: Class 1E ac switchgear circuit breaker operation, safety features status indication relays and lights, diesel generator field flashing, diesel generator control, reactor trip switchgear, solenoid valves, and Class 1E control cabinet circuit indicators.

TABLE 8.3.2-8

125-V-dc BATTERY C LOAD REQUIREMENTS (SBO)

Load Description	Current Required per Time Interval after ac Power Loss (A) Unit[(b)]	0-1 min	1-240 min	Random Load
Total load includes inverters, MOV[(a)], dc distribution panels,[(c)] dc switchgear, MCC indication and relaying.	1 2	224 217	92 84	82.3 82.3

---

a. The RHR isolation valve is not required to operate when ac power is not available to the RHR system.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panel includes the following loads: turbine-driven auxiliary feedwater pump control panel, safety features status indication relays and lights, miscellaneous control, and dc switchgear space heaters.

TABLE 8.3.2-9

125-V-dc BATTERY D LOAD REQUIREMENTS (SBO)

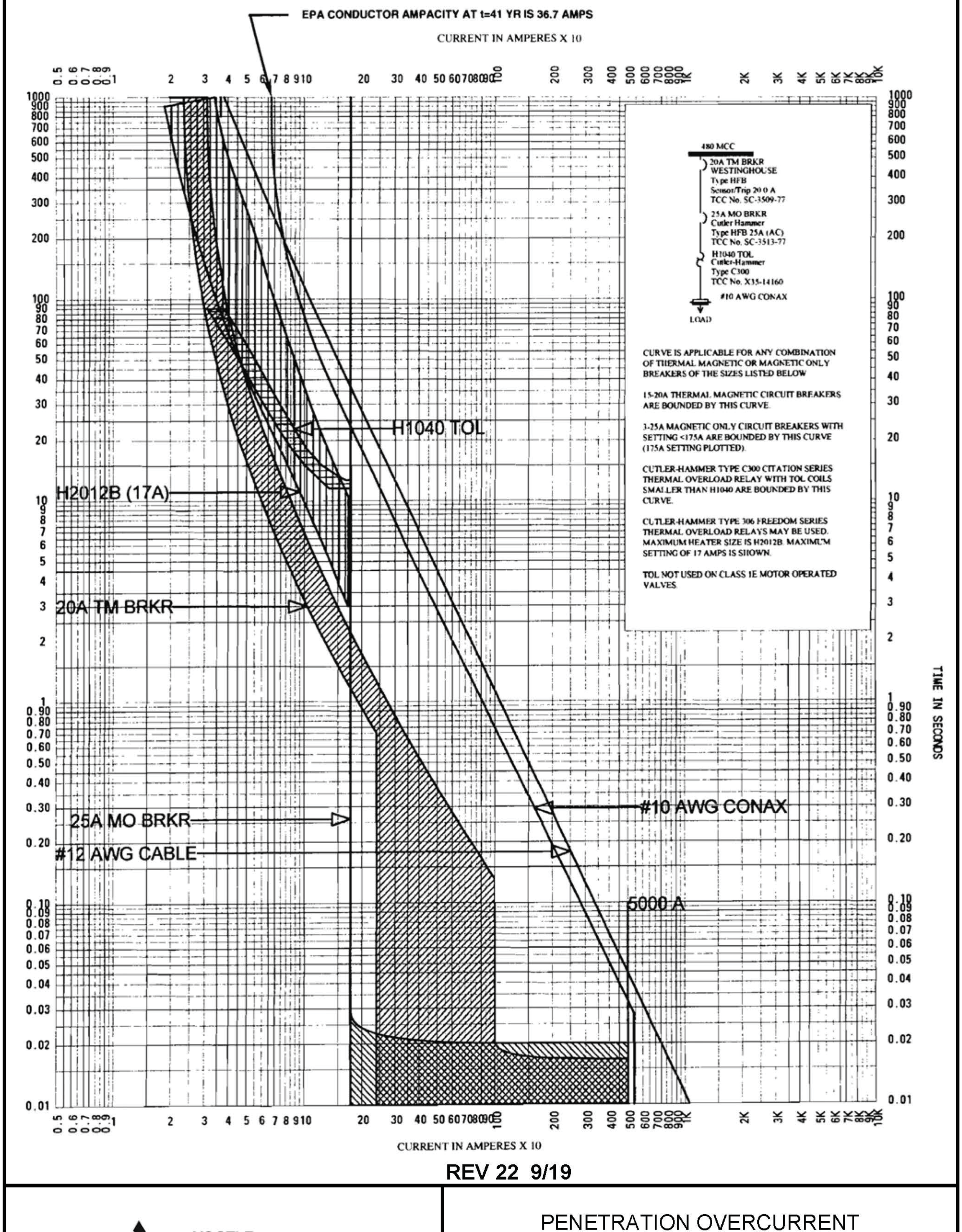
	Current Required per Time Interval after ac Power Loss (A)	
Load Description	Unit[(b)]	0-240 min
Total load includes inverters, MOV[(a)], dc distribution panels,[(c)] dc switchgear, MCC indication and relaying.	1	77
	2	70

---

a. The RHR isolation valve is not required to operate when ac power is not available to the RHR system.

b. Differences between switchgear and control load design configurations cause amperages to vary between Units 1 and 2.

c. The dc distribution panel includes the following loads: miscellaneous control and train D switchgear space heaters.



CURVE IS APPLICABLE FOR ANY COMBINATION OF THERMAL MAGNETIC OR MAGNETIC ONLY BREAKERS OF THE SIZES LISTED BELOW

15-20A THERMAL MAGNETIC CIRCUIT BREAKERS ARE BOUNDED BY THIS CURVE.

3-25A MAGNETIC ONLY CIRCUIT BREAKERS WITH SETTING <175A ARE BOUNDED BY THIS CURVE (175A SETTING PLOTTED).

CUTLER-HAMMER TYPE C300 CITATION SERIES THERMAL OVERLOAD RELAY WITH TOL COILS SMALLER THAN H1040 ARE BOUNDED BY THIS CURVE.

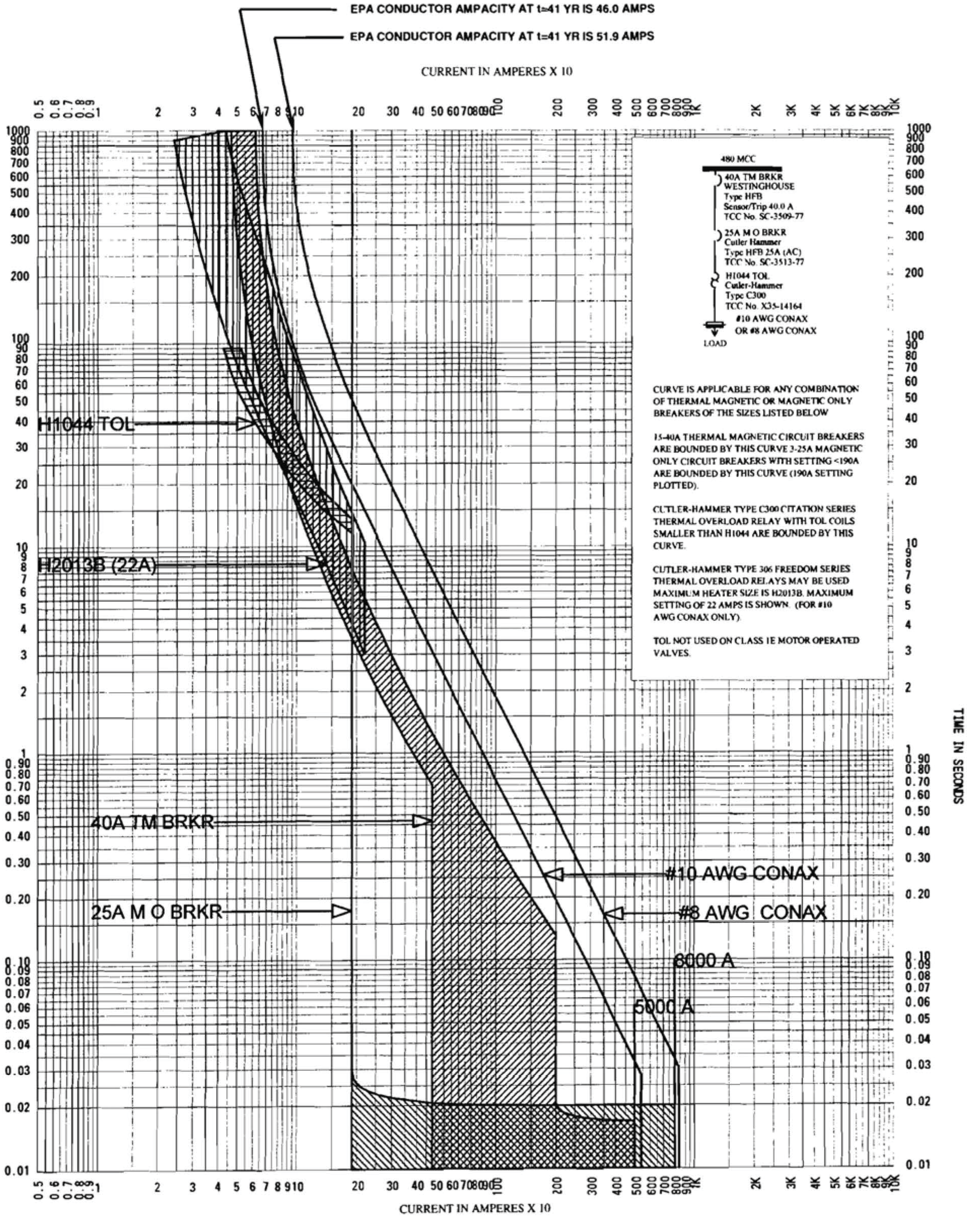
CUTLER-HAMMER TYPE 306 FREEDOM SERIES THERMAL OVERLOAD RELAYS MAY BE USED. MAXIMUM HEATER SIZE IS H2012B. MAXIMUM SETTING OF 17 AMPS IS SHOWN.

TOL NOT USED ON CLASS 1E MOTOR OPERATED VALVES.

REV 22 9/19

PENETRATION OVERCURRENT
PROTECTION COORDINATION CURVES

FIGURE 8.3.1–1 (SHEET 1 OF 35)



CURVE IS APPLICABLE FOR ANY COMBINATION OF THERMAL MAGNETIC OR MAGNETIC ONLY BREAKERS OF THE SIZES LISTED BELOW

15-40A THERMAL MAGNETIC CIRCUIT BREAKERS ARE BOUNDED BY THIS CURVE 3-25A MAGNETIC ONLY CIRCUIT BREAKERS WITH SETTING <190A ARE BOUNDED BY THIS CURVE (190A SETTING PLOTTED).

CUTLER-HAMMER TYPE C300 CITATION SERIES THERMAL OVERLOAD RELAY WITH TOL COILS SMALLER THAN H1044 ARE BOUNDED BY THIS CURVE.

CUTLER-HAMMER TYPE 306 FREEDOM SERIES THERMAL OVERLOAD RELAYS MAY BE USED MAXIMUM HEATER SIZE IS H2013B. MAXIMUM SETTING OF 22 AMPS IS SHOWN. (FOR #10 AWG CONAX ONLY).

TOL NOT USED ON CLASS 1E MOTOR OPERATED VALVES.

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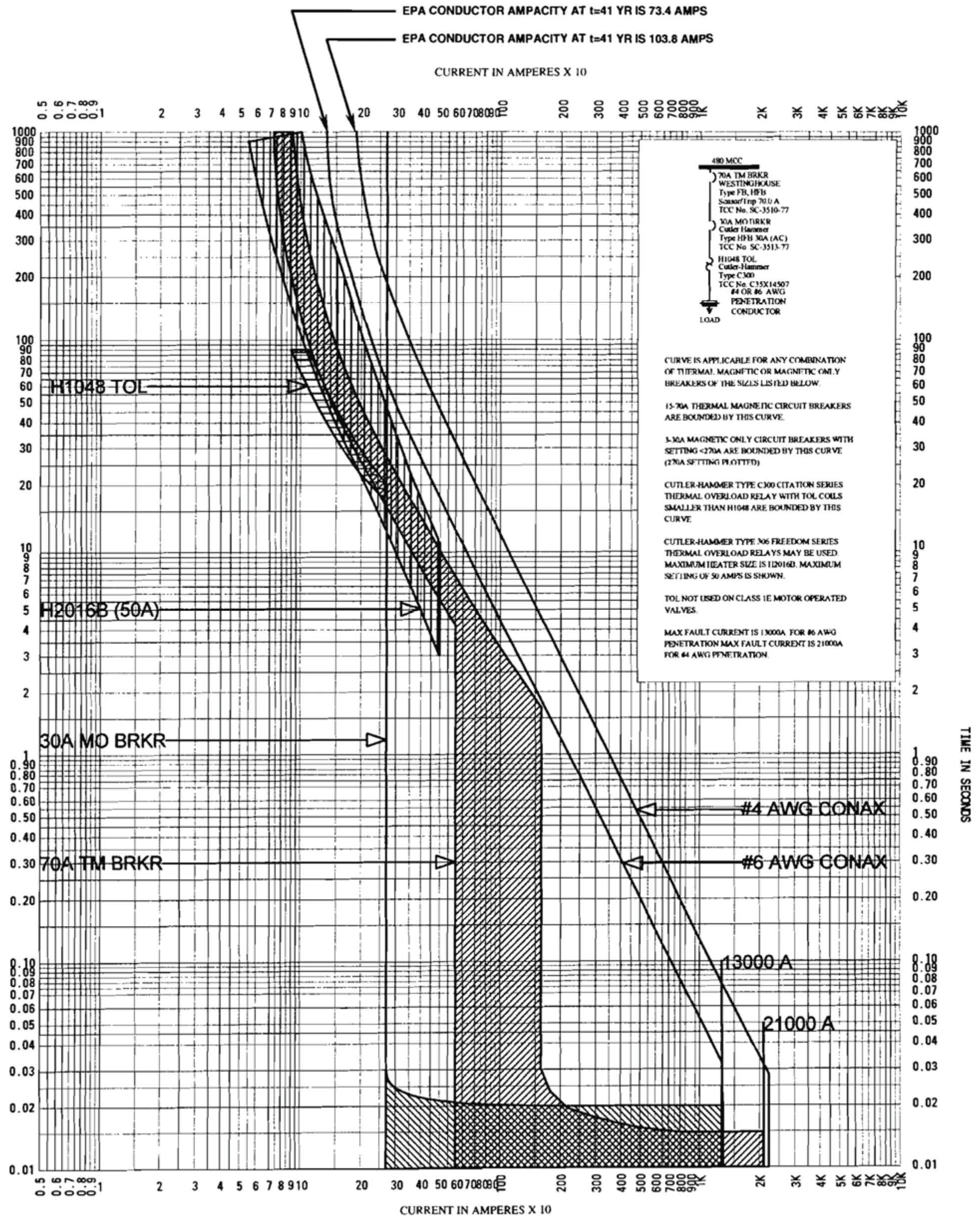
SOUTHERN COMPANY

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

PENETRATION OVERCURRENT PROTECTION COORDINATION CURVES

FIGURE 8.3.1–1 (SHEET 2 OF 35)



CURVE IS APPLICABLE FOR ANY COMBINATION OF THERMAL MAGNETIC OR MAGNETIC ONLY BREAKERS OF THE SIZES LISTED BELOW.

15-70A THERMAL MAGNETIC CIRCUIT BREAKERS ARE BOUNDED BY THIS CURVE.

3-30A MAGNETIC ONLY CIRCUIT BREAKERS WITH SETTING <270A ARE BOUNDED BY THIS CURVE (270A SETTING PLOTTED)

CUTLER-HAMMER TYPE C300 CITATION SERIES THERMAL OVERLOAD RELAY WITH TOL COILS SMALLER THAN H1048 ARE BOUNDED BY THIS CURVE.

CUTLER-HAMMER TYPE 306 FREEDOM SERIES THERMAL OVERLOAD RELAYS MAY BE USED. MAXIMUM HEATER SIZE IS H2016B. MAXIMUM SETTING OF 50 AMPS IS SHOWN.

TOL NOT USED ON CLASS 1E MOTOR OPERATED VALVES.

MAX FAULT CURRENT IS 13000A FOR #6 AWG PENETRATION MAX FAULT CURRENT IS 21000A FOR #4 AWG PENETRATION.

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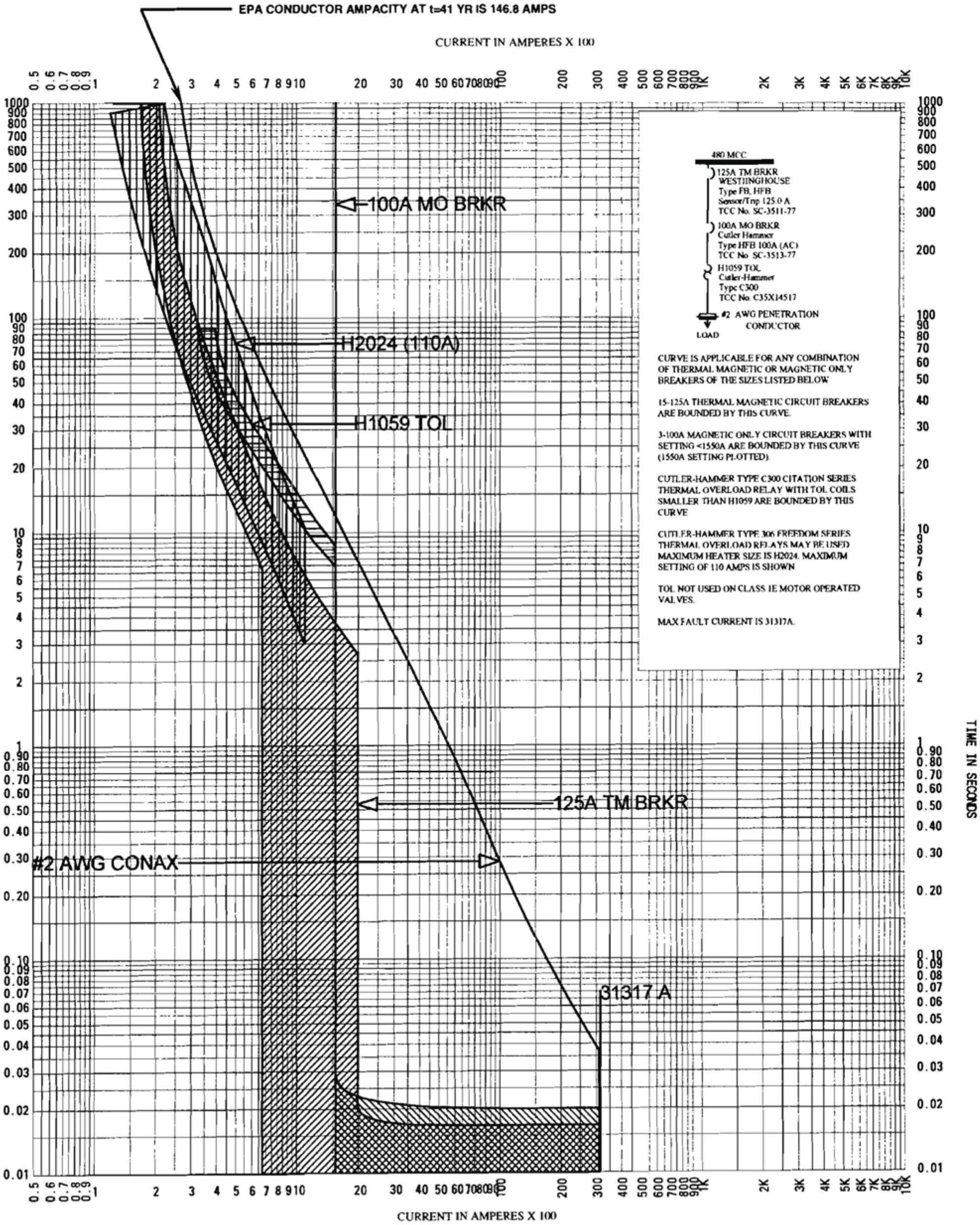
SOUTHERN COMPANY

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

PENETRATION OVERCURRENT
PROTECTION COORDINATION CURVES

FIGURE 8.3.1–1 (SHEET 3 OF 35)



CURVE IS APPLICABLE FOR ANY COMBINATION OF THERMAL MAGNETIC OR MAGNETIC ONLY BREAKERS OF THE SIZES LISTED BELOW

15-125A THERMAL MAGNETIC CIRCUIT BREAKERS ARE BOUNDED BY THIS CURVE.

3-100A MAGNETIC ONLY CIRCUIT BREAKERS WITH SETTING <1550A ARE BOUNDED BY THIS CURVE (1550A SETTING PLOTTED).

CUTLER-HAMMER TYPE C300 CITATION SERIES THERMAL OVERLOAD RELAY WITH TOL COILS SMALLER THAN H1059 ARE BOUNDED BY THIS CURVE

CUTLER-HAMMER TYPE 306 FREEDOM SERIES THERMAL OVERLOAD RELAYS MAY BE USED MAXIMUM HEATER SIZE IS H2024. MAXIMUM SETTING OF 110 AMPS IS SHOWN

TOL NOT USED ON CLASS IE MOTOR OPERATED VALVES.

MAX FAULT CURRENT IS 31317A.

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SOUTHERN COMPANY

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

PENETRATION OVERCURRENT
PROTECTION COORDINATION CURVES

FIGURE 8.3.1–1 (SHEET 4 OF 35)