8.4 EMERGENCY POWER SOURCES

The emergency power sources are designed to furnish onsite power (upon a loss of normal supplies of power) to reliably shut down the plant and maintain it in a safe shutdown condition under all conditions, including accidents. The emergency power sources are part of the ESF electrical system and are designed as Class 1E systems. The diesel generator sets selected for use as standby power supplies have the capability to: (1) power the ESF in rapid succession, and (2) supply continuously the sum of the loads needed to be powered at any one time.

The EDGs are designed to provide a dependable onsite power source capable of starting and supplying the essential loads necessary to safely shut down the plant and maintain it in a safe shutdown condition under all conditions. Four diesel generators are provided for the plant although each Unit requires only one diesel generator to supply the minimum power requirements for its ESF equipment.

If one of the two diesel generators (per Unit) should fail to start or carry load, the system continues to provide an electrically independent channel of emergency power to the Unit. Reliability is increased by the adoption of the two-channel concept, i.e., independent electrical controls and sources supply redundant AC and DC ESF equipment.

Diesel Generator 1A is connected to 4.16 kV Bus 11, 1B is connected to 4.16 kV Bus 14, 2A is connected to 4.16 kV Bus 21, and 2B is connected to 4.16 kV Bus 24 as shown on Figure 8-1.

The EDGs are designed to reach rated speed and voltage and to start accepting load within 10 seconds after the receipt of a starting signal. The diesel generators and their auxiliaries are designed to withstand Seismic Category I accelerations and are installed within Seismic Category I structures.

The Station Blackout (SBO) diesel generator is designed to provide a power source capable of starting and supplying the essential loads necessary to safely shutdown one unit and maintain it in a safe shutdown condition during a SBO event. The SBO diesel generator has the ability to supply any of the four ESF busses.

The SBO diesel is started manually. The diesel is loaded onto a bus when it is determined that the EDG dedicated to that bus is not available to supply the plant loads. The SBO diesel is capable of supplying the same emergency plant loads as the EDGs.

The predicted accident loads for large break LOCA, small break LOCA, and main steam line break are less than 3000 kW.

The diesel generators are started by either a 4.16 kV bus undervoltage or SIAS; however, in the latter case, actual transfer to the bus is not made until the preferred source of power is actually lost. When all four diesel generators are available, the design provides two independently-capable and concurrently-operating systems for safety injection, containment spray, and miscellaneous 480 Volt auxiliary devices for the unit incurring the accident. In addition, the design provides power to operate two sets of equipment for shutting down the non-accident unit; including, for example, two saltwater pumps, two service water pumps, two auxiliary feedwater pumps, containment cooling fans, and emergency turbine auxiliaries.

The independence and redundancy of the auxiliary power system features that initiate and control the connection of diesel generators to the AC emergency busses are described as follows:

a. Each of the redundant 4 kV emergency busses is equipped with one set of four redundant and independent undervoltage relays. This set of relays has three elements to sense various undervoltage conditions. The first set of elements are set to provide a two-out-of-four undervoltage signal upon loss of bus voltage. The second set of elements are set to provide a two-out-of-four undervoltage signal on a transient bus undervoltage. The third set of elements are set to provide a two-out-of-four undervoltage signal on a steady state bus undervoltage. Upon coincidence of two-out-of-four, the preferred supply circuit breakers of the bus with which the undervoltage relays are associated are tripped. The signal from the undervoltage relays of a particular load group acts on circuit breakers of the same load group only.

b. The coincidence of two-out-of-four undervoltage signals from the four relays also initiates starting of the diesel generator which is aligned to the bus with which the undervoltage relays are associated. Again, independence is assured since Load Group A relays initiate starting of a diesel generator redundant to that initiated by Load Group B relays.

c. The SIAS is also capable of initiating diesel generator start. As in the case of undervoltage signal, independence is assured since Load Group A SIAS initiates starting of a diesel generator redundant to that initiated by SIAS Load Group B.

d. For each emergency bus, each control circuit which functions to connect an EDG to the 4 kV emergency busses is exclusively associated with a single diesel generator only. That is, there are four controlling circuits, one for each of the diesel generators. Each of these circuits is physically isolated from, and independent of, the others.

The above system features are designed in accordance with General Design Criterion 18 (February 20, 1971) to permit periodic inspection and testing.

During accident conditions accompanied by simultaneous loss of offsite power, the loss-of-coolant incident (LOCI) sequencers will start automatically to load the diesel generators sequentially. Similarly, the shutdown sequencer for the non-accident unit will start automatically. The LOCI sequencers initially block the SIAS and the containment spray actuation signal to the equipment to be sequenced and then unblock in programmed steps, as shown in Table 8-7. The sequencing is performed so that essential loads are started within the time limits of the appropriate safety analyses.

8.4.1 FAIRBANKS MORSE EMERGENCY DIESEL GENERATORS

8.4.1.1 Description

Three of the four emergency power sources consist of 4.16 kV, three-phase, 60-cycle Fairbanks Morse diesel generators with nominal continuous ratings given below. All generator sets are physically separated and electrically isolated from each other.

The three Fairbanks Morse diesel generators have been upgraded and are rated as follows:

3000 kW	Continuous	(consumes approximately 3.87 gpm fuel oil)
3300 kW	2000 hour	
3500 kW	200 hour	(consumes approximately 4.454 gpm fuel oil)
3600 kW	30 minutes	

At no time during the loading sequence will the frequency and voltage decrease to less than 95% of normal and 75% of normal, respectively. During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel generator will not exceed nominal speed plus 75% of the difference between nominal speed (900 RPM) and 115% of nominal speed. Voltage is restored to within 10% of nominal in less than 40% of each load sequence time interval. Frequency is restored to within 2% of nominal in less that 60% of each load sequence time interval. The nominal values of speed, voltage and frequency are defined in the Technical Specifications.

8.4.1.2 Auxiliary Systems

Separate MCCs are provided for each diesel generator. Each MCC supplies the engine room ventilation fan, fuel oil transfer pump, engine standby warming systems, and air compressor.

Starting Air

Each of the three Fairbanks Morse diesel generators has a starting air supply system which includes two redundant subsystems (Figures 8-8A, 8-8B, and 8-8C). There are two redundant air supply headers to which the two redundant air receivers per diesel generator are connected. The individual air headers have cross tied capability with normally closed valves. Each diesel generator includes one electric motor-driven air compressor. The air compressor associated with Diesel Generator 1B can also be driven by a small diesel engine.

Warming System

Each diesel generator is also equipped with a standby warming system which automatically maintains the engine cooling water and lubricating oil temperature at satisfactory levels (Figures 8-8A, 8-8B, and 8-8C).

Fuel Oil

The fuel oil system for the three Fairbanks Morse EDGs consists of two (No. 11 and No. 21) above-ground fuel oil storage tanks (FOSTs), three fuel oil transfer pumps rated at 10 gpm each, and three fuel oil day tanks having a maximum capacity of approximately 485 gallons each. Each FOST is sized to hold approximately 107,000 gallons of usable fuel oil. The FOSTs are redundant, with the exception of the concrete enclosure around No. 21 FOST and the elevation of the internal standpipes. Redundant diesel supply headers interconnect the two independent tanks and manual valves are positioned such that normally each tank supplies a different header. A manual valve in each supply header ensures a failure of No. 11 FOST will not drain No. 21 FOST. The associated piping for the EDGs is designed for Seismic Category I accelerations. However, the transfer piping for the SBO diesel day tank (from No. 11 FOST) is only designated Seismic Category I from the tank to the first seismic anchor downstream of the tie-in isolation valve. The Seismic Category I FOSTs provide fuel oil for operation of the EDGs, auxiliary heating boiler, diesel-driven fire pump, and the SBO EDG. Internal standpipes provide fuel oil to the auxiliary heating boilers and the diesel-driven fire pump. The volume of oil below the standpipes is reserved exclusively for the Fairbanks Morse EDGs (in No. 11 FOST, the volume of fuel oil below the standpipe is also used by the SBO EDG). The standpipe in No. 21 FOST has a height of 11’, while the one in No. 11 FOST has a height of 7’6”.

There are two principal design criteria for the FOSTs: (1) design basis accident requirements, and (2) requirements for protection against external phenomena such as earthquakes and tornadoes. A tornado/missile event is not assumed to occur simultaneously with a design basis accident (LOCA).

The design of the EDG fuel oil system is based on a fuel oil capacity of seven days following a design basis accident. Specifically, IEEE-308 requires that, for multi-unit stations, sufficient fuel oil be available to run one EDG powering one unit under accident conditions (3,500 kW) and one EDG powering the opposite unit under normal shutdown conditions (3,000 kW) for seven days (or the time required to replenish fuel oil from an offsite source following a design basis event, whichever is longer). The specific emergency diesel generator fuel oil volumes (equivalent to duration based requirements) contained in the fuel oil storage tanks referenced in Technical Specification 3.8.3 and the day tanks referenced in Technical Specification 3.8.1 are calculated using the method provided in American National Standards Institute N195-1976, Section 5.4, as endorsed by Regulatory Guide 1.137, Revision 1, Section C.I.c. The fuel oil calculation is based on applying the conservative assumption that the emergency diesel generator is operated continuously at rated capacity. This is one of two approved methods specified in Regulatory Guide 1.137, Revision 1. FOST No. 21 contains a volume of fuel oil in excess of that needed to satisfy this requirement. The minimum required volume under design basis accident conditions (LOCA) and tornado/missile conditions is in the Technical Specifications and is controlled administratively. The standpipe is not a requirement of IEEE-308.

Although protection against earthquakes was an original design criterion for the FOSTs, protection against tornadoes was not. In 1972, the decision was made to protect No. 21 FOST from tornadoes and horizontal tornado missiles by adding a Seismic Category I concrete enclosure. Bursting pressures are relieved by baffled, missile proof vents. This structure will also withstand the impact of a transmission tower falling on it without damage to the FOST. The enclosure also acts as a dike for No. 21 FOST with fuel being supplied by way of a non-safety-related line. In the event of a tornado, only No. 21 FOST is credited. It is assumed that one Fairbanks Morse diesel on each unit would be loaded to 3,000 kW. Thus, the minimum fuel oil requirement is somewhat less than that required under design basis accident conditions. The minimum Technical Specification volume maintained for these conditions in No. 21 FOST is the same as that required under design basis accident conditions.

The fuel oil volume in each day tank is normally maintained by automatic cycling of the fuel oil transfer pump. Operation of the transfer pump is automatic and is controlled by pump start and stop level switches connected to the day tank. High and low day tank level alarms are also provided to warn of abnormal conditions. Although not originally designed to American National Standards Institute N195-1976 (Fuel Oil Systems for Standby Diesel Generators), Calvert Cliffs has adopted the day tank minimum volume recommendations of this standard. The minimum volume required by the Technical Specifications permits at least one hour to correct minor problems in the fuel oil transfer system assuming an EDG load of 3,500 kW.

Additional design and quality control requirements for the storage tanks are given in Section 10.2.4.1.

An additive is used to inhibit deterioration of the fuel oil within the outdoor storage tanks. Samples are taken from the incoming fuel oil and analyzed for water and sediment, specific gravity and viscosity prior to adding the fuel to the storage tanks. Additional samples of the incoming fuel are analyzed for flash point, sulfur, ash, and Btu per gallon, as required, to insure the quality of the fuel. Samples are obtained from the FOSTs every three months and analyzed for oxidation/deterioration products.

<u>Instrumentation and Control</u>

Each diesel generator is equipped with various local and Control Room alarms, as indicated on Figure 8-6. Electrical instruments are provided in the Control Room and at the diesel generator for surveillance of generator voltage, frequency, power, and reactive volt-amperes.

Physical separation and electrical isolation are maintained between the redundant generator control circuits. The 125 Volt DC control power for Diesel Generator 1B is provided by Battery 12. Diesel Generator 1B is a part of and supplies power to Load Group B. The 125 Volt DC control power for Diesel Generator 2A is provided by Battery 11. Diesel Generator 2A is a part of and supplies power to Load Group A. The 125 Volt DC control power for Diesel Generator 2B is provided by Battery 21. Diesel Generator 2B is a part of and supplies power to Load Group B.

Equipment is provided in the Control Room for each generator, for remote manual starting, remote stopping, remote synchronization, governor and voltage regulation, governor and voltage droop selection, and automatic or manual voltage regulator selection. Equipment is provided locally at each diesel generator for restricted manual starting in case of Control Room emergency, manual starting during routine diesel generator testing or maintenance, manual stopping, governor and voltage regulation, automatic or manual regulator selection, exciter field removal and reset, and remote and automatic or local manual control selection.

Protective Functions

Relay protection, ground connections, structural safeguards, and other protection systems are provided to assure adequate personnel protection and to prevent or limit rapid equipment deterioration during system short circuits or mechanical component failures. Special underfrequency protection is provided for safely separating the diesel generator from the preferred power supply (when previously synchronized to it) without damage to, or shutdown of, the diesel generator.

The following protective functions are provided for each Fairbanks Morse EDG:

a. Start failure relay
b. Engine overspeed
c. High jacket coolant temperature (2/3 logic)
d. Low jacket coolant pressure (2/3 logic)
e. Low lube oil pressure (2/3 logic)
f. High crankcase pressure (2/3 logic)
g. Loss of field
h. Generator differential
i. Generator ground overcurrent

The start failure protective function is provided to stop the starting process in all modes when cranking time for the diesel engine is exceeded. High jacket coolant temperature, low jacket coolant pressure, and high crankcase pressure are non-critical protective functions which are automatically bypassed during SIAS and UV. Reverse power, loss of field, and underfrequency protection are provided but are made permissive to trip only upon diesel generator synchronization to the normal auxiliary power supply.

Time overcurrent with voltage restraint protective relays are provided on the diesel generator feeder breakers. These relays will trip the feeder breaker on overcurrent, but will not shut down the diesel generator.

The only protective functions that are retained during a SIAS or undervoltage (UV) are:

a. Overspeed
b. Lube-oil pressure low
c. Generator differential overcurrent
d. Generator ground overcurrent

These retained functions prevent a rapid destruction of the Fairbanks Morse diesel generators and are therefore the only shutdown functions permitted during SIAS and UV. The pressure shutdown function initiates upon coincidence of two-out-of-three logic to provide additional reliability. Each functione, when actuated, initiates an annunciator in the Control Room. Protection of the diesel generator unit from excessive overspeed, which can result from loss of load, is afforded by the operation of a diesel generator trip.

Service Water

The Service Water System removes the heat from the diesel generator heat exchangers. After operating at full load with a jacket temperature of 185°F, the diesel can continue to operate for one minute without service water cooling before the jacket temperature reaches 200-205°F and the diesel is automatically shut down. With an initial jacket temperature of 140-145°F, the diesel generator can operate three minutes before tripping.

8.4.2 SACM EMERGENCY DIESEL GENERATOR

8.4.2.1 Description

One of the four emergency power sources is the 4.16 kV, three-phase, 60-cycle tandem-engine Societe Alsacienne De Constructions Mecaniques De Mulhouse (SACM) diesel generator which has a nominal continuous rating of 5400 kW. The generator set for the SACM diesel, like those for the Fairbanks Morse diesel generators is physically separated and electrically isolated from the other generator sets.

The SACM diesel is rated as follows:

5400 kW	Continuous
5940 kW	2 hour
1620 kW	Minimum continuous load (Diesel may be operated at lower load for up to 7 days)

During loading of the safety-related SACM diesel generator, the frequency and voltage at the diesel generator terminals will not decrease to less than 95% and 82%, respectively. The diesel generator has the capability of starting the largest single motor with all other sequenced loads running. During recovery from transients caused by step loading or disconnection of full load, the safety-related SACM diesel generator’s speed will not exceed 75% of the difference between nominal and the overspeed trip setpoint or 15% above nominal speed, whichever is lower. In accordance with the recommendations of Regulatory Guide 1.9, Revision 3 (Reference 1), frequency is restored to within 2% of nominal within 60% of each load sequence time interval, and voltage is restored to within 10% of nominal within 60% of each load sequence time interval.

The SACM diesel generator is a redundant, standby onsite power source installed in a separate and independent Category I building. The physical separation requirements of Regulatory Guide 1.75 and IEEE 384-1981 have been satisfied.

Additional details concerning the SACM diesel can be found in the EDG Project SACM Diesel Generator and Mechanical Systems Design Report (Reference 2).

8.4.2.2 Auxiliary Systems

Starting Air

The starting air system (Figure 8-8E) for the tandem SACM diesel generator consists of skid-mounted subsystems which include two pairs of redundant air receivers and two redundant air compressors complete with air dryers. This system supplies pressurized air to the engine mounted starting air distributors.

Only one air receiver per engine is required to be operational in order to successfully start the diesel engines within 10 seconds. The two air systems can be cross connected to recharge all four air receivers from one compressor. The diesel generator starting air system initiates an engine start such that the generator attains the rated frequency and voltage within 10 seconds of receipt of the start signal. Portions of the starting air system which are required to start the diesel generator are designed to remain functional during and after a safe shutdown earthquake. Active components of the diesel generator starting air system are capable of being tested in accordance with 10 CFR Part 50, Appendix A, General Design Criterion 18.

Cooling Water Systems

Each diesel engine of the tandem-driven generator is provided with independent high temperature (HT) and low temperature (LT) closed loop cooling system, which together make up the cooling water system for the SACM EDG. The HT system provides cooling flow to the engine block and turbochargers, while the LT system provides cooling flow to the combustion air coolers and the lube oil heat exchanger. Both systems consist of an engine-driven pump, expansion tank, and thermostatic control valve. Each engine has a radiator with separate HT and LT sections to dissipate heat to the outdoor ambient air.

Warming System

In order to reduce the thermal stress and wear while starting the diesel generator, the HT cooling system is provided with a preheating loop (keep warm system). When the diesel generator is in standby mode, the HT cooling water system motor-driven pump circulates coolant through an electric heater and supplies the warmed coolant to the engine water jacket and the lube oil standby heat exchanger. Startup of the diesel engine de-energizes the keep warm pump and the electric coolant heater.

Fuel Oil

The fuel oil system (Figure 8-8D) for the SACM, safety-related diesel generator consists of a FOST, a recirculation loop and pump, two redundant motor-driven fuel oil transfer pumps, two redundant transfer filters, a common day tank, a leakage tank, a common dirty fuel oil tank, a duplex filter, and an engine-driven fuel oil pump with an AC motor-driven backup fuel oil pump. Each fuel oil transfer pump is capable of meeting the diesel generator's fuel needs at 100% rated load. The common day tank may be partially drained during surveillance testing to verify proper transfer pump operation.

The FOST for the SACM diesel is located in an isolated sector within the Safety-related Diesel Generator Building. The enclosure is large enough to hold the contents of both the FOST and the fuel oil day tank should a rupture occur. The enclosure, as well as the Diesel Generator Building exterior walls, has a three-hour fire rating. Portions of the diesel generator fuel oil system which are required for operation of the diesel generator are designed to remain functional during and after a safe shutdown earthquake.

The design of the FOST allows for replenishment of fuel oil without interrupting operation of the diesel generator, and two tanker fill connections for the FOST (one outside and one inside the Diesel Generator Building) are provided. The diesel fuel oil system provides onsite storage and delivery of fuel oil for operation at 100% continuous rated load for seven days, assuming the loss of all offsite power sources, as required by American Nuclear Society 59.51-1989.

The specific emergency diesel generator fuel oil volumes (equivalent to duration based requirements) contained in the fuel oil storage tanks referenced in Technical Specification 3.8.3 and the day tanks referenced in Technical Specification 3.8.1 are calculated using the method provided in American National Standards Institute N195-1976, Section 5.4, as endorsed by Regulatory Guide 1.137, Revision 1, Section C.I.c. The fuel oil calculation is based on applying the conservative assumption that the emergency diesel generator is operated continuously at rated capacity. This is one of two approved methods specified in Regulatory Guide 1.137, Revision 1.

Instrument and Control

The SACM diesel generator is equipped with various engine-mounted instruments, control panels located both in the Control Room and the Diesel Generator Building Control Room, and two engine auxiliaries desks. The auxiliaries desks include gauges to indicate engine temperatures, pressures, rack position, and engine speed (in RPM).

The 125 Volt DC power for the Safety-related Diesel Generator Building and the SACM diesel generator auxiliaries is supplied by a dedicated 125 Volt DC power system. This system consists of a 125 Volt DC battery, battery charger, a safety-related distribution panel, a non-safety-related distribution panel, and associated 125 Volt DC instrumentation. This system provides a reliable source of continuous power for control and instrumentation in the Diesel Generator Building. In accordance with the recommendations of Safety Guide 6, the 125 Volt DC power system is independent and supports only the electrical load group associated with its diesel generator.

Protective Functions

The following protective functions will be provided for the SACM EDG under normal operating conditions. Protective functions which are designed to prevent rapid destruction of the SACM EDG, and are retained during SIAS and UV, are indicated below:

	PROTECTIVE FUNCTION	RETAINED/BYPASSED DURING SIAS & UV
a.	Engine Overspeed	Retained
b.	Lube Oil Pressure (Lo-Lo)	Retained
c.	Lube Oil Temperature (Hi-Hi)	Bypassed
d.	HT Coolant Temperature (Hi)	Bypassed
e.	HT Coolant Temperature (Hi-Hi)	Bypassed
f.	HT Coolant Pressure (Lo)	Bypassed
g.	LT Coolant Pressure (Lo)	Bypassed
h.	Generator Bearing Temperature (Hi-Hi)	Bypassed
i.	High Crankcase Pressure	Bypassed
j.	Cranking Time Exceeded	[a]
k.	Generator Ground Overcurrent	Retained
l.	Generator Differential Current	Retained
m.	Generator Overvoltage	Bypassed
n.	Generator Voltage Controlled Overcurrent	Bypassed
o.	Excitation Faults	Bypassed

[a] A "Cranking time exceeded" signal is provided to block a start signal in all modes when cranking time for the diesel engine is exceeded.

In addition, the following functions also protect the SACM EDG under normal operating conditions. However, during SIAS or undervoltage conditions, these functions will shift the governor to hydraulic governor control, which can result in EDG operation at frequencies beyond the analyzed range.

a. Load sharing control failure
b. Linear variable differential transformer failure
c. Electronic Governor 24 VDC power supply failure

Reverse power, loss of field, and underfrequency protection are provided for protection of the diesel during parallel operation with the plant auxiliary power distribution system.

The diesel generator and the auxiliary equipment essential for operation in order to safely shut down the reactor or for accident mitigation following a design basis accident, are considered safety-related. Physical identification and methods used to readily distinguish between redundant Class 1E systems and non-Class 1E systems are consistent with those described in Section 8.5.

Loading of the diesel generator is accomplished automatically as described by Table 8-7 with the addition of the 480 Volt loads associated with the Diesel Generator Building auxiliaries.

8.4.3 STATION CONTROL BATTERIES

8.4.3.1 Design Basis

The batteries are designed to furnish a reliable and continuous supply of power to the 125 Volt DC and 120 Volt AC vital systems. They are also used for supplying Control Room emergency lighting and the plant computers.

8.4.3.2 Description and Operation

Description - The station control battery system for the plant consists of four operational and one reserve battery each nominally rated at 125 Volt DC, as shown in Figure 8-5 and Table 8-10. Each cell is of a sealed lead-acid type, assembled in shock-absorbing, clear plastic container, with covers bonded in place to form a leak-proof seal. The batteries are mounted on corrosion-resistant, earthquake-proof racks suitable for use during SSE accelerations. The batteries are located in a Seismic Category I structure and each battery is located in a separate room. Battery capacity calculations verify that each of the four 125 VDC Class 1E batteries have capacity to carry SBO loads for at least one hour. This is sufficient for SBO since the AAC power source (0C Diesel Generator) will be available within one hour to supply the battery chargers.

The battery rooms share a ventilation system consisting of one supply duct, one exhaust duct, one battery room supply fan, and one battery room exhaust fan. The two fans are associated with redundant load groups. Upon loss of either fan, sufficient ventilation is provided by the remaining fan to preclude the possibility of hydrogen accumulation within the battery rooms.

Operation - The associated battery chargers maintain a floating charge on each battery, and are capable of supplying an equalizing charge when necessary. During normal operation, the chargers supply the power required by all the 125 Volt DC loads. Upon loss of auxiliary AC power, the entire DC load is drawn from the batteries. After availability of AC power from the diesel generators, the battery chargers will be energized and resume normal operation.

The 125 Volt DC power for the Safety-related Diesel Generator Building and the SACM diesel generator auxiliaries is supplied by a dedicated 125 Volt DC power system for each diesel/building. This system provides a reliable source of continuous power for control and instrumentation in each Diesel Generator Building. In accordance with the recommendations of Safety Guide 6, the 125 Volt DC power system is independent and supports only the electrical load group associated with its diesel generator. The 125 Volt DC power system consists of a 125 Volt DC battery, battery charger, a safety-related distribution panel, a non-safety-related distribution panel and associated 125 Volt DC instrumentation. The Electrical Engineering Design Report, Diesel Generator Project (Part A) (Reference 3), provides additional design data concerning the 125 Volt DC system for the safety-related Diesel Generator Building and the SACM diesel generator auxiliaries.

8.4.4 TURBINE-GENERATOR COASTDOWN (Unit 2 only)

The turbine-generator coastdown circuits are designed to utilize the kinetic energy of the turbine generator for maintaining primary coolant flow for 20 seconds following a reactor or turbine trip. These trips are associated with the unavailability of system grid power to the plant service transformer feeding the RCPs of the affected reactor unit (Figure 8-7). During the coastdown period, excitation control equipment will function automatically to maintain a constant ratio of volts per Hertz for the protection of transformers and motors. At the outset of coastdown, all plant auxiliaries, with the exception of RCPs, are separated automatically from the coastdown supply. At the conclusion of coastdown, signaled by either 80% generator voltage or 20 seconds elapsed time, the switchyard circuit breaker through which coastdown takes place is opened automatically and the generator field circuit breakers are tripped.

8.4.5 STATION BLACKOUT DIESEL GENERATOR

8.4.5.1 Description

The SBO diesel generator was added as part of the Calvert Cliffs Nuclear Power Plant response to 10 CFR 50.63, “Loss of All Alternating Current Power.” Guidelines set forth in Regulatory Guide 1.155 were used for quality assurance activities and specifications for new non-safety-related equipment used to address 10 CFR 50.63.

The SBO diesel generator is a 4.16 kV, three-phase, 60-cycle tandem-engine SACM diesel generator, similar to the safety-related SACM diesel generator, with a nominal continuous rating of 5400 kW. The SBO diesel generator, and its supporting systems and associated switchgear are housed in the SBO Diesel Generator Building.

The SBO diesel generator is electrically isolated from the ESF buses by two breakers (one Class 1E and one non-Class 1E) in series and a Class 1E disconnect switch, and no provisions exist for automatically connecting redundant safety features busses to the SBO diesel generator. The design of power connections from the SBO diesel generator allow for manual alignment to any one safety-related train in either unit via a Class 1E ESF bus. Manual switching capability is provided through Class 1E disconnect switches and Class 1E breakers.

Loading of the diesel generator is accomplished automatically as described by Table 8-7 with the addition of the 480 Volt loads associated with the SBO Diesel Generator Building auxiliaries.

At no time during the loading sequence will the frequency and voltage at the diesel generator terminals decrease to less than 95% of 60 Hz and 82% of 4.16 kV. During recovery from transients caused by step load increases, including initial step loads, or resulting from the disconnection of full load, the speed of the diesel generator will not exceed 75% of the difference between nominal speed and the overspeed trip setpoint or 15% above nominal, whichever is lower. These load accepting characteristics meet or exceed the design considerations recommended in Regulatory Guide 1.9, Revision 3 (Reference 1).

NUMARC 87-00 gives guidance pertaining to the design requirements for the SBO diesel generator for use as an alternate AC (AAC) power source. The following considerations have been included in the SBO diesel generator design. Calvert Cliffs' method of satisfying the design criteria follows each consideration.

a. The new alternate AC (AAC) system and its components need not be designed to meet Class 1E or safety-related requirements.

   The AAC diesel generator is classified as augmented quality. The AAC diesel generator and diesel generator 1A were purchased under one safety-related equipment specification. The non-SACM components (e.g., structures and piping) associated with the AAC diesel generator are not qualified or certified to industry and regulatory requirements applicable to a Class 1E diesel generator. Appropriate performance requirements are imposed on critical AAC diesel generator equipment in order to ensure the design basis requirements of the AAC diesel generator are maintained.

b. Unless otherwise provided in the NUMARC 87-00 criteria, the new AAC system need not be protected against the effects of:

   (a) failure or misoperation of mechanical equipment, including: (i) fire, (ii) pipe whip, (iii) jet impingement, (iv) water spray, (v) flooding from a pipe break, (vi) radiation, pressurization, elevated temperature or humidity caused by a pipe break, and (vii) missiles resulting from the failure of rotating equipment or high energy systems; or (b) seismic events.

   Hazards internal to the SBO Diesel Generator Building are not evaluated for their potential to cause failure during an SBO event. As required by the Standard Building Code (SBC), likely weather-related external events are considered in the design of the SBO power system and the structures that house AAC diesel generator equipment. The AAC power system and associated structures are not designed to remain functional during or following design basis seismic events.

c. Components and subsystems shall be protected against the effects of likely (i.e., not tornadoes or hurricanes) weather-related events that may initiate the loss of off-site power event.

   As a minimum, the SBO Diesel Generator Building is designed to withstand the weather-related loads addressed in the local SBC. Electrical cabling between the SBO Diesel Generator Building and the Auxiliary Building is housed in a buried concrete ductbank. In order to run AAC diesel generator cabling into the Auxiliary Building, a raceway is routed up the wall of the Auxiliary Building and across the roof of the Auxiliary Building and Turbine Building. As a minimum, this raceway is designed to meet the requirements of the SBC for weather related events.

d. Physical separation of the new AAC equipment from safety-related components or equipment shall conform with the separation criteria applicable for the unit’s licensing basis.

Some systems (e.g., lube oil drain system) are common to both the SBO Diesel Generator Building and the adjacent Category I Diesel Generator Building. Safety-related, Category I missile barriers are installed in the SBO Diesel Generator Building at wall penetrations (above grade) between the buildings for these common systems. Additionally, some systems in the power block serve equipment in the SBO Diesel Generator Building (e.g., fire protection and demineralized water systems). These systems are connected in such a way as to avoid any adverse effect on safety-related components and equipment. Refer to Section 8.5 for a discussion of electrical separation and group designations.

e. Failure of the new AAC diesel generator components shall not adversely affect Class 1E AC power systems.

Mechanical systems common to the SBO Diesel Generator Building and the Category I Diesel Generator Building have been evaluated to ensure failure of the AAC diesel generator components do not adversely affect the operability of safety-related structures, systems, and components. In order to preclude failure and impact on the adjacent safety-related Diesel

Generator Building, the main girders, columns, and bracing for the SBO Diesel Generator Building have been analyzed for safe shutdown earthquake loads. Miscellaneous AAC related equipment mounted outdoors or on the building roof, which could exceed the parameters for a Spectrum II tornado missile (as defined by Standard Review Plan 3.5.1.4, Revision 2) are anchored to resist tornado wind loads.

f. Electrical isolation of AAC power shall be provided through an appropriate isolation device.

The AAC diesel generator is isolated from the Class 1E emergency busses by two circuit breakers in series. One breaker is Class 1E and the second breaker is non-Class 1E. Additionally, four disconnect switches (one for each emergency bus) provide isolation. The Class 1E circuit breakers serve as the interface between the AAC diesel generator and the 4.16 kV distribution system. The 480 VAC distribution system for the SBO diesel generator is connected to the Class 1E 480 VAC system in the Category I Diesel Generator Building. Devices which electrically isolate the AAC electrical systems from the Class 1E systems in the Category I Diesel Generator Building are designed in accordance with Regulatory Guide 1.75, Revision 2.

g. The AAC power source shall not normally be directly connected to the on-site emergency AC power system for the unit affected by the blackout. In addition the AAC system shall not be capable of automatic loading of shutdown equipment from the blacked-out unit unless licensed with such capability.

The AAC diesel generator is connected to the onsite electrical distribution system through a Class 1E breaker, a non-Class-1E breaker, and a Class 1E disconnect switch, all of which are normally open. The AAC diesel generator is capable of powering a single safety-related train of equipment on one unit. Operator action is required to isolate the safety-related diesel generator dedicated to the emergency bus. The AAC diesel generator is then started manually, connected to the emergency bus, and automatically loaded using the load sequencer.

h. There shall be minimal potential for common cause failure of the new AAC diesel generator. The following system features provide assurance that the minimal potential for common cause failure has been adequately addressed.

   1. The new AAC diesel generator power system shall be equipped with a DC power source that is electrically independent from the blacked-out unit's preferred and Class 1E power system.

      A separate battery system is provided for the AAC diesel generator. The battery is sized in accordance with IEEE 485-1983 to supply its design basis loads (e.g., diesel generator field flashing and instrumentation) for a four hour coping duration. During normal operation, the battery charger is energized from the 480 VAC motor control center located in the SBO Diesel Generator Building. The motor control center in the SBO Diesel Generator Building is normally energized by an offsite power source. In case maintenance is being performed, an alternate 480 VAC feed from the Class 1E 480 VAC unit substation bus (located in the Category I Diesel Generator Building) is manually aligned to energize the SBO Diesel Generator Building's 480 VAC distribution system. Loss of the normal or alternate source of 480 VAC will not interrupt power from the AAC diesel generator battery to the AAC diesel generator DC distribution system. Thus, loss of either 480 VAC feed will not create the possibility of common cause failure of the preferred Class 1E power system and the AAC power source.

   2. The AAC power system shall be equipped with an air start system that is independent of the preferred and the blacked out unit's preferred and Class 1E power supply.

      The AAC diesel generator is equipped with its own starting air system consisting of four air receivers that supply pressurized air to start the AAC diesel generator. The four air receivers of the starting air system are supplied air from an air compressor located in the SBO Diesel Generator Building. This air compressor is energized from the SBO Diesel Generator Building's 480 VAC MCC and is not required to operate during the SBO event.

   3. The AAC power supply shall be provided with a fuel oil supply that is separate from the fuel oil supply for the on-site emergency AC power system. A separate day tank supplied from a common storage tank is acceptable provided the fuel oil is sampled and analyzed consistent with applicable standards prior to transfer to the day tank.

      The AAC diesel generator is provided with two fuel oil day tanks, connected in series, that have a combined capacity sufficient to allow AAC diesel generator operation at 100% nominal load, without fuel transfer to the day tanks, for the design basis SBO coping period of four hours. Replenishment of the fuel oil day tanks is accomplished using the existing No. 11 FOST. The non-safety-related piping will be isolated from the safety-related FOST by a normally closed safety-related manual valve. Fuel oil in the No. 11 FOST is sampled prior to transferring fuel oil to the fuel oil day tanks.

      The oil in the SBO fuel oil day tanks is sampled and analyzed for the same characteristics and parameters and on the same frequency as is currently performed for EDG fuel oil.

4. If the AAC power source is an identical machine to the emergency on-site AC power source, active failures of the emergency AC power source shall be evaluated for applicability and corrective action taken to reduce subsequent failures.

   The AAC diesel generator is procured from the same manufacturer and is of the same basic design as Diesel Generator 1A. Any corrective actions identified for one SACM diesel generator are reviewed for incorporation on the other SACM diesel generator.

5. No single point vulnerability shall exist whereby a likely weather-related event or single active failure could disable any portion of the on-site emergency power sources or the preferred power sources, and simultaneously fail the new AAC power source(s).

   Protection for AAC diesel generator structures, systems, and components from likely weather-related events is provided by: (1) housing the AAC diesel generator in a structure designed to meet SBC requirements, and (2) routing cabling from the AAC diesel generator to the plant through ductbanks described above. The design of the AAC power source precludes a single active failure from disabling any portion of the existing power sources listed above and simultaneously fail the new AAC power source.

6. The AAC power system shall be capable of operating during and after a station blackout without any support systems powered from the preferred power supply, or the blacked-out unit's Class 1E power sources affected by the event.

   Mechanical systems and electrical distribution systems for the AAC diesel generator are self-supporting and do not require support from the blacked-out unit's buses or from existing on-site electrical power sources in order to cope with an SBO event. Alternate AC diesel generator auxiliary systems are provided with adequate amounts of starting air, fuel oil, lube oil, and cooling water in order to meet the requirements of the AAC diesel generator during the SBO event.

7. The portions of the AAC power system subjected to maintenance activities shall be tested prior to returning the AAC power system to service.

   The AAC power system is designed for periodic maintenance and testing through the Class 1E engineered safety features buses. Procedures have been established to ensure portions of the AAC power system subjected to maintenance activities shall be used prior to returning the AAC power system to service.

i. The AAC power system shall be sized to carry the required shutdown loads for four hours and be capable of maintaining voltage and frequency within the limits consistent with established industry standards that will not degrade the performance of any shutdown system or component.

   The AAC diesel generator is sized to accommodate the largest loading on any of the four emergency busses for at least a four hour duration, and is designed to maintain voltage and frequency within the limits specified by IEEE 387-1984.

j. The AAC power source shall be started and loaded at least every three months following the manufacturer's recommendations or using plant-developed procedures. A timed start and rated load capacity test shall be performed at least once each refueling outage.

   Procedures have been established that start and load the AAC diesel generator in a manner consistent with its functions as an alternate AC power source at intervals not longer than three months. In addition, a timed start and a rated load capacity test of the AAC diesel generator will be performed once every refueling outage interval for either Unit 1 or Unit 2.

k. Alternate AC system surveillance and maintenance activities shall be implemented considering the manufacturer's recommendations or in accordance with plant-developed procedures.

l. The AAC system shall be demonstrated by initial test to be capable of powering the required shutdown equipment within one hour of a station blackout event.

   Acceptance testing for the AAC diesel generator demonstrates the capability to power the required shutdown equipment within one hour.

m. The AAC system should be maintained at a target reliability of 0.95 per demand.

   The AAC diesel generator is maintained as a standby system. The diesel generator design features, periodic testing, and maintenance programs are designed to maintain system reliability at the target of 0.975 per demand.

Additional design data concerning the SBO diesel generator can be found in the Alternate AC Power Source Design Report (Reference 4).

8.4.5.2 Auxiliary Systems

Starting Air

The starting air system (Figure 8-8G) for the SBO diesel generator consists of four air receivers and an air compressor complete with air dryers. This system supplies pressurized air to the engine mounted starting air distributors.

Cooling Water Systems

Each diesel engine of the tandem-driven generator is provided with independent HT and LT closed loop cooling system, which together make up the cooling water system for the SACM diesel generator (Figure 8-8G). The HT system provides cooling flow to the engine block and turbochargers, while the LT system provides cooling flow to the combustion air coolers and the lube oil heat exchanger. Both systems consist of an engine-driven pump, expansion tank, and thermostatic control valve. Each engine has a radiator, with separate HT and LT sections to dissipate heat to the outdoor ambient air.

Warming System

In order to reduce the thermal stress and wear while starting the diesel generator, the HT cooling system is provided with a preheating loop (keep warm system). When the diesel generator is in standby mode, the HT cooling water system motor-driven pump circulates coolant through an electric heater and supplies the warmed coolant to the engine water jacket and the lube oil standby heat exchanger. Startup of the diesel engine de-energizes the keep warm pump and the electric coolant heater.

Fuel Oil

The fuel oil system for the SBO diesel generator (Figure 8-8F) consists of a day tank, an auxiliary day tank, a fuel oil transfer filter, and a 100% fuel oil transfer pump. The day tank and auxiliary day tank are connected in series and have a combined capacity sufficient to allow operation, at rated load, for the four-hour coping duration, without transfer of fuel to the day tanks. Fuel Oil Storage Tank No. 11 supplies fuel oil to the day tanks via non-safety-related piping and a normally closed safety-related manual valve. Fuel oil transfer from No. 11 FOST to the day tanks is under operator control.

Instrument and Control

The SBO diesel generator is equipped with various engine-mounted instruments, control panels located both in the Control Room and the SBO Diesel Generator Building control room, and two engine auxiliaries desks. The auxiliaries desks include gauges to indicate engine temperatures, pressures, rack position, and engine speed (in RPM).

125 Volt DC power for the SBO Diesel Generator Building and SBO diesel generator auxiliaries is supplied by a dedicated 125 Volt DC power system. This system provides a reliable source of continuous power for control and instrumentation in the SBO Diesel Generator Building. The 125 Volt DC power system consists of a 125 Volt DC battery, battery charger, and associated 125 Volt DC instrumentation.

Protective Functions

The following protective functions are provided for the SBO diesel generator under normal operating conditions. Protective functions which are retained during emergency manual switch operation and which are designed to prevent rapid destruction of the diesel generator are presented below:

	PROTECTIVE FUNCTION	**RETAINED/BYPASSED DURING EMERGENCY OPERATION**
a.	Engine Overspeed	Retained
b.	Lube Oil Pressure (Lo-Lo)	Retained
c.	Lube Oil Temperature (Hi-Hi)	Bypassed
d.	HT Coolant Temperature (Hi)	Bypassed
e.	HT Coolant Temperature (Hi-Hi)	Bypassed
f.	HT Coolant Pressure (Lo)	Bypassed
g.	LT Coolant Pressure (Lo)	Bypassed
h.	Generator Bearing Temperature (Hi-Hi)	Bypassed
i.	High Crankcase Pressure	Bypassed
j.	Cranking Time Exceeded	(a)
k.	Generator Ground Overcurrent	Retained
l.	Generator Differential Current	Retained
m.	Generator Overvoltage	Bypassed
n.	Generator Voltage Controlled Overcurrent	Bypassed

	PROTECTIVE FUNCTION	RETAINED/BYPASSED DURING EMERGENCY OPERATION
o.	Excitation Faults	Bypassed

[a] A “cranking time exceeded” signal is provided to block a start signal in all modes when cranking time for the diesel engine is exceeded.

In addition, the following functions also protect the SBO diesel generator under normal operating conditions. However, during emergency manual switch operation, these functions will shift the governor to hydraulic governor control, which can result in EDG operation at frequencies beyond the analyzed range.

a. Load sharing control failure
b. Linear variable differential transformer failure
c. Electronic Governor 24 VDC power supply failure

Reverse power, loss of field, and underfrequency protection are provided for protection of the diesel during parallel operation with the plant auxiliary power distribution system.

Protective functions which are retained during an emergency manual switch operation and which are designed to prevent rapid destruction of the diesel generator are as follows:

Engine overspeed
Lube oil pressure, Lo Lo
Generator ground over current
Generator differential current

8.4.6 REFERENCES

1. Regulatory Guide 1.9, Revision 3, July 1993, Selection, Design, and Qualifications of Diesel Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants
2. Letter from R. E. Denton (BGE) to Document Control Desk (NRC), dated July 20, 1993, Emergency Diesel Generator Project - SACM Diesel Generator and Mechanical Systems Design Report
3. Letter from R. E. Denton (BGE) to Document Control Desk (NRC), dated July 26, 1993, Emergency Diesel Generator Project - Electrical Engineering Design Report
4. Letter from R. E. Denton (BGE) to Document Control Desk (NRC), dated March 7, 1994, Alternate AC Power Source Design Report

TABLE 8-7

LOAD SEQUENCING

SEQUENCER STEP NO.	TIME (Seconds)	SERVICE	EQUIPMENT NUMBER FED BY EACH 4 kV BUS 1ZA BUS 11	1ZB BUS 14	2ZA BUS 21	2ZB BUS 24
-	0(1)(3)	Reactor Motor Control Centers	114	104	214	204
		Turbine Bearing Oil Pump *(2)	-	-	21	-
		1E Battery Chargers	11 & 14	12 & 13	22 & 23	21 & 24
		Transformer for 208/120 Volt Instrumentation Busses	11	12	21	22
		Penetration Room Exhaust Fan	11	12	21	22
		Diesel Generator Room Exhaust Fan	-	1B	2A	2B
		Control Room HVAC Fans	11	-	-	12
		Control Room Air Conditioning Condenser Fans *	11	-	-	12
		Saltwater System Air Compressor	11	12	21	22
		Motor-Operated Valves	various	various	various	various
		Emergency Core Cooling System Pump Room Air Coolers	11	12	21	22
		Emergency Core Cooling System Pump Room Exhaust Fans	11	12	21	22
		Boric Acid Storage Tank Heaters *	two	two	two	two
		Heat Tracing System *	11	12	21	22
		Diesel Building 1A and Auxiliaries	1A	-	-	-
		Switchgear Room HVAC Fans	11	12	21	22
		1E Battery Room Fans	one Exhaust fan and one redundant Supply fan			
		Service Water Pump	11	12	21	22
		Containment Vent Isolation	6900	6901	6900	6901
1	5	High Pressure Injection Pump(6)(8)	11	13	21	23
		High Pressure Injection Pumps Motor-Operated Valves	various	various	various	various
2	10	Charging Pumps	11 & 13	12 & 13	21 & 23	22 & 23
		Boric Acid Pump	11	12	21	22
		Boric Acid Motor-Operated Valve	508	-	508	-
		Saltwater Pump	11	12	21	22

TABLE 8-7

LOAD SEQUENCING

SEQUENCER STEP NO.	TIME (Seconds)	SERVICE	EQUIPMENT NUMBER FED BY EACH 4 kV BUS 1ZA BUS 11	1ZB BUS 14	2ZA BUS 21	2ZB BUS 24
3	15	Containment Air Coolers	11 & 12	13 & 14	21 & 22	23 & 24
		Containment Spray Pump	11	12	21	22
4	20	Component Cooling Pump	11	12	21	22
		Containment Filter Units	11 & 13	12 & 13	21 & 23	22 & 23
5	25	Low Pressure Injection Pump	11	12	21	22
6	30	Control Room Air Conditioning Compressor(7)	11	-	-	12
		Switchgear Room Air Conditioning Compressor *	11	12	21	22
6A	45	Auxiliary Feed Water Pump	13	-	-	23
6B	40	Computer Room HVAC Unit *	-	11	12	-

NOTES:

(1) At time 0 seconds, the generator breaker is closed and the loads listed for the 0-second time step are energized independent of sequencer action.

(2) The loads identified with * are process controlled. The load feeder breaker will be closed at the time listed but the equipment will not run until called for by the process signal.

(3) There are additional minor loads energized at time 0 not shown in table.

(4) Low voltage equipment is indirectly fed by 4 kV Busses through step-down transformers and low voltage busses.

(6) HPSI Pumps 12 and 22 are normally in pull-to-lock and will not start.

(7) The Control Room air conditioning compressor is normally process controlled. However, during load sequencing, the compressor is forced to start within a certain amount of time and then run continuously until after the auxiliary feedwater pump has been sequenced and started. The Control Room air conditioning compressor control then automatically reverts back to process control.

(8) HPSI Pumps 13 and 23 have an additional 1 second time delay downstream of sequencing device by design.