8.4 Station Blackout

The term station blackout (SBO) refers to a complete loss of alternating current (ac) electric power to the non-safety-related and safety-related switchgear buses. An SBO involves a loss of the offsite electric power system (preferred power system) occurring at the same time the emergency diesel generators (EDG) are unavailable. An SBO does not include loss of available ac power to buses fed by station batteries through inverters or by alternate alternating current (AAC) sources specifically provided for SBO mitigation.

8.4.1 Description

The U.S. EPR includes an AAC source that has been designed in accordance with 10 CFR 50.63 and RG 1.155. NUMARC 87-00 was used for clarification, as permitted by RG 1.155. Two separate and independent non-safety-related station blackout diesel generators (SBODG) are provided to mitigate a postulated SBO. The SBODGs have the capacity and capability to bring the plant to and maintain the power plant in a non-design basis accident (non-DBA) safe shutdown condition without any support systems powered from the preferred power supply (offsite grid) or EPSS. Safe shutdown (non-DBA) means bringing the plant to those shutdown conditions specified in the U.S. EPR technical specifications as “hot standby.”

8.4.1.1 Station Blackout Diesel Generators

The SBODGs are located in separate areas of the Switchgear Building. An electrical system failure modes and effects analysis is illustrated in Table 8.3–9—Onsite AC Power System Failure Modes and Effects Analysis. The SBODGs do not share control power, heating, ventilation and air conditioning (HVAC), engine cooling, or fuel systems with the EDGs. Considering the support system independence and the failure modes listed in Table 8.3–9, there are no weather-related events or single active failures that can disable the SBODGs and EDGs simultaneously. For the purposes of the failure modes and effects analysis, failure of an SBODG is equivalent to a failure of switchgear bus 31BBH or 32BBH. Failure of 31BBH or 32BBH is addressed in Table 8.3–9.

The major system loads the SBODGs provide power to during SBO conditions are:

- The division 1 and division 4 emergency feedwater (EFW) pumps.
- HVAC systems to maintain main control room (MCR) habitability and SBO equipment environments.
- Selected instrumentation and controls (I&C) systems.
- MCR lighting
- Main Steam Relief Train (MSRT).

Summaries of the loads supported by the SBODGs are given in Table 8.4–1—Station Blackout Continuous Loading – Train 1 (Estimated) and Table 8.4–2—Station Blackout Loading – Train 2 (Estimated).

RG 1.155, Appendix B, with reference to RG 1.155, Regulatory Position 3.3.5, is used to establish an adequate level of diversity from the EDGs. Conformance with this regulatory position is addressed in Section 8.4.2.6.3.

To minimize the potential for common cause failure with the onsite emergency alternating current power sources, the SBODGs are of a different model than the EDGs. Each SBODG is a self contained unit (including auxiliaries), and is independent of the plant preferred and emergency power sources. The direct current (dc) power system is electrically independent from the preferred and Class 1E power systems. The dc power system is of sufficient capability and capacity for operation of the dc loads associated with the AAC source for the maximum necessary SBO duration. Prior to an SBO event, none of the SBODGs and EDGs share emergency buses or loads, auxiliary services, or control circuitry. The SBODG radiators are cooled by forced air provided by fans powered from the SBODG supplied bus, whereas the EDG heat exchangers are cooled by an external cooling water system. The Electrical (Switchgear) Building is divided so that each SBODG is physically separated from the other SBODG. The SBODGs and EDGs and their associated circuitry and auxiliary systems are physically, electrically, and mechanically separated.

Figure 8.3–2—Emergency Power Supply System Single Line Drawing and Figure 8.3–3—Normal Power Supply System Single Line Drawing, illustrate the connection and distribution of power from the SBODGs to the emergency power supply system (EPSS). In this design, the SBODGs align with these EPSS 6.9 kV buses:

- SBODG XKA50 connects to normal power supply system (NPSS) bus 31BBH.
  - Bus 31BBH is connected to EPSS buses 31BDC and 32BDB .
- SBODG XKA80 connects to NPSS bus 32BBH.
  - 32BBH is connected to EPSS buses 34BDC and 33BDB.

8.4.1.1.1 SBODG Support Systems

Each SBODG is provided with the following support subsystems:

Starting

The diesel engine starting air system provides compressed air to rotate the engine until combustion begins and the engine accelerates under its own power. The starting air system includes ac driven air compressor(s), compressed air receivers, air filters, air dryers, monitoring equipment, piping and valves. Each SBODG has a separate, independent starting air system. Starting at their low pressure alarm setpoint, the air receivers can crank a cold diesel engine five times without recharging. An alarm is received if the air receiver pressure falls below the minimum allowable value. Accumulated moisture and foreign material in the air receivers and other critical points of the system can be removed through a blowdown connection. The air dryer controls the starting air dew point to at least ten degrees Fahrenheit below the lowest expected ambient temperature.

Fuel

The diesel engine fuel oil storage and transfer system stores adequate and acceptable fuel oil to meet the mission time specified in Section 8.4.2.6.1, at full load operation, including allowances for fuel consumed during routine testing, unusable tank volumes, and measurement uncertainty. Each SBODG has a separate, independent fuel oil storage and transfer system. The system includes a storage tank, electrically driven transfer pump(s), a day tank, a fuel delivery pump, a fuel injection pump, piping, filter(s) and a monitoring system. The fuel oil day tank level switch(es) automatically start and stop the fuel oil transfer pump on low and full fuel oil day tank levels, respectively. Fuel storage for each SBODG is located in its respective building. The day tank elevation for each SBODG provides a slight positive pressure for the engine-driven fuel pump(s), and includes a provision for water removal, and a recirculation line to return excess fuel oil back to the fuel oil storage tank. The fuel oil storage tank can be refilled without interrupting diesel operation.

Lubrication

The diesel engine lubricating oil system, stores and supplies clean lubricating oil, needed for the SBODG engine bearings, crankshaft, turbocharger, and other moving engine parts. Each SBODG has its own lube oil system. Lube oil may be added when the engine is in standby or when the engine is operating. When the engine is in standby, a pump circulates lube oil through a heater. Lube oil storage capacity in the engine sump, will support the mission time specified in Section 8.4.2.6.1. Lube oil temperature sensors provide indication and alarms. Lube oil pressure is monitored when the engine is operating.

Cooling

The diesel engine cooling system dissipates heat from the crank case, cylinder heads, and lubricating oil. The system has an engine driven cooling water pump, air-water radiator(s) with fan(s), a coolant preheater, a preheating circulation pump, a temperature regulating valve, and an expansion tank. A three-way thermostatically controlled valve is provided to control the flow of water through the radiator cooling units to maintain engine temperature at manufacturer specifications. Engine cooling water is continuously heated when the engine is in standby. Temperature indicators and alarms are provided.

Combustion Air

The diesel engine combustion air system supplies filtered outside air to the diesel engine for combustion. Air intake filters remove atmospheric contaminates from the incoming air. Each SBODG has its own combustion air system. Air filters are equipped with differential pressure indicators to monitor for fouling and indicate the need to change filters.

Exhaust

The diesel engine exhaust system collects exhaust gas from the cylinders and transfers it to the environment through the turbocharger and the exhaust gas silencer. Each SBODG has its own exhaust system. The exhaust lines are separated from the combustion air lines to prevent mixing, and are insulated to lower surface temperature and reduce the risk of fire.

8.4.1.2 Generator

Each SBODG generator is an air-cooled, synchronous three-phase machine with internal poles and an external exciter. Nominal output voltage and frequency is 6.9 kV at 60 Hz. A fan mounted on the generator shaft provides cooling air from the diesel room. The excitation system consists of a pilot exciter, a three-phase ac exciter, a voltage regulator, and instrumentation transformers and transducers. A permanent magnet generator provides power to a voltage regulator, which in turn supplies regulated power to the generator exciter for control of the generator output voltage.

The SBODG I&C and grounding provides these features:

- Each SBODG includes:
  - Generator (phase and neutral) instrumentation transformers.
  - Generator protective relaying.
  - Generator excitation system controls and instrumentation.
- The process automation system (PAS) provides the SBODG controls.
  - The PAS is powered by the non-Class 1E two-hour uninterruptible power supply (NUPS). The NUPS power is delivered by 100 percent capacity AC to DC and DC to DC converters operated in parallel, so that the PAS remains powered after a failure of either converter.
- Grounding for personnel protection and generator neutral grounding is consistent with the overall plant grounding requirements.

Each SBODG and its power distribution equipment are sized to provide the voltage and frequency needed for proper operation of their connected loads. The highest expected continuous loading was calculated using conservative estimates of load characteristics. Uncertainties associated with SBODG loading are addressed by maintaining a margin of at least five percent.

8.4.1.3 Alternate AC Power System Performance

During normal plant operation each SBODG remains in standby with the diesel engines ready to be started and loaded. Each diesel engine is prelubricated and its cooling water is preheated. The SBODGs are not normally connected to the preferred or the onsite EAC power system and are separated from the assigned Class 1E bus through two normally open circuit breakers. The circuit breaker located at the Class 1E bus is a Class 1E breaker.

At the start of an SBO event, two-hour rated safety-related batteries supply dc power to safety-related inverters and their critical loads including I&C power and dc control power. A combination of two-hour rated and twelve-hour rated non-safety-related batteries, supply various non-safety-related 250 Vdc switchboards.

When power is lost to the NPSS 6.9 kV switchgear, selected NPSS switchgear load breakers will open on undervoltage. Non-safe shutdown loads are stripped below the machine rating for immediately connected load (typically 25 to 30 percent of the machine continuous rating). The SBODGs will automatically start on a loss of voltage on their associated non-safety-related buses. If the EDGs fail to re-energize the Class 1E buses, the EPSS preferred and emergency power source feeder breakers are opened. Opening these breakers prevents inadvertent paralleling out of phase if the preferred or emergency power supply is restored during SBODG operation. Sufficient controls and indications are available in the MCR and at the local control panel to start the SBODGs from each of those locations. Both SBODGs are started and manually aligned to their respective buses from the MCR within ten minutes from the beginning of the SBO event. The undervoltage signal causes all loads to be stripped from the associated Class 1E and non-Class 1E buses. Non-Class 1E loads are stripped to the extent that the remaining load is less than the SBODG rating for immediately connected loads. This prepares the SBODG bus for loading by the MCR operators.

In Table 8.4–3—Station Blackout Diesel Generator Indications and Alarms, a list of alarms and indications are provided for the SBODG. Engine trip functions are based on manufacturer recommendations for commercial service.

A COL applicant that references the U.S. EPR design certification will provide site-specific information that identifies any additional local power sources and transmission paths that could be made available to resupply the power plant following an LOOP.

When offsite power is restored, the operators will manually shut down the SBODG. Site-specific procedures and training establish the necessary operator actions to cope with an SBO from onset until ac power is recovered and normal long-term core cooling is restored.

8.4.1.4 Periodic Testing

Periodic testing is performed to demonstrate continued capability and availability of the SBODG to perform its intended function. During this testing, complete generator protection is available to prevent equipment damage. Overload protection is provided by the output breaker overload trip circuitry, and by reverse power logic. Each SBODG is also equipped with a synchronization check relay. The governor control system is capable of operation in either droop speed or isochronous speed control. At the end of any testing, including testing terminated due to an actual SBO event, the governor is transferred to isochronous speed control to allow performance of the AAC functions.

The periodic testing program verifies SBODG capability while minimizing the potential for a common cause failure with the preferred power source. The specific tests performed include:

- Every three months, the SBODG is started and brought to rated frequency and voltage to verify SBODG availability.
- Every refueling outage, a timed start of each SBODG will be conducted to verify its availability within ten minutes. This start will be followed by a capacity load test per manufacturer specifications. The continuous rating of 3900 kW (or greater) is sufficient to supply the required loads for mitigating SBO conditions.

The AAC power system reliability target is for each SBODG to meet or exceed 95 percent as determined in NSAC-108 or equivalent methodology.

8.4.2 Analysis

8.4.2.1 10 CFR 50.2 –Definitions and Introduction

As defined in 10 CFR 50.2, station blackout is defined as the complete loss of ac electric power to the non-safety-related and safety-related switchgear buses. An SBO does not include the loss of available power to buses fed by station batteries through inverters or by AAC sources, nor does it assume a concurrent single failure or DBA.

Standby power system sources are not shared among nuclear units; thereby making sure an accident in one unit of a multiple-unit facility can be mitigated using an available compliment of features, including necessary ac power, irrespective of conditions in the other units and without giving rise to conditions unduly adverse to safety in another unit.

Two SBODGs are provided as an AAC to provide power to the 6.9 kV buses 31BDC , 32BDB, 33BDB, and 34BDC in the event of a LOOP and simultaneous failure of station EDGs. During the initial SBO conditions, the Class 1E uninterruptible power supply system (EUPS) continues to provide power to safety-related ac and dc loads in each of the four EPSS divisions. Each SBODG has sufficient capacity to bring and maintain the plant in a safe shutdown condition, to continue core cooling, and to maintain containment integrity during an SBO.

8.4.2.2 10 CFR 50.63 –Loss of All Alternating Current Power

Each light-water-cooled nuclear power plant must be able to withstand for a specified duration and recover from an SBO as defined in 10 CFR 50.2. The U.S. EPR has two AAC power sources, also defined in 10 CFR 50.2. Either of these sources can be started and aligned to one set of required shutdown equipment within ten minutes, and has the capacity and capability to supply one set of required shutdown equipment for the SBO coping duration established in accordance with Section 8.4.2.6.1.

10 CFR 50.63(a) requires that the specified SBO duration shall be based on the following factors:

- The redundancy of the onsite EAC power sources.
- The reliability of the onsite EAC power sources.
- The expected frequency of LOOP.
- The probable time needed to restore offsite power.

10 CFR 50.63 requires that each light-water cooled nuclear power plant licensed to operate after July 21, 1988 submit:

- A proposed SBO duration to be used in determining compliance with 10 CFR 50.63(a), including a justification for the selection based on the four factors identified in 10 CFR 50.63(a).
- A description of the procedures that will be implemented for SBO events for the proposed SBO duration.
- A list of modifications to equipment and associated procedures, if any, necessary to meet the requirements of 10 CFR 50.63(a).

Conformance with 10 CFR 50.63 is addressed in Section 8.4.2.6.1, Section 8.4.2.6.2, and Section 8.4.2.6.3.

8.4.2.3 10 CFR 50.65 –Requirements for Monitoring the Effectiveness of Maintenance of Nuclear Power Plants

10 CFR 50.65 is applicable to systems provided to mitigate SBO, because these systems are used in plant emergency operating procedures. The SBO performance monitoring is included as part of the reliability assessment program described in Section 17.4 and the maintenance rule program described in Section 17.6.

8.4.2.4 Appendix A to 10 CFR Part 50, GDC for Nuclear Power Plants

The following GDC have been identified as applicable to the design of systems for SBO mitigation. Section 8.2 and Section 8.3 describe the compliance to these GDC:

- GDC 17 –Electric power systems.
- GDC 18 –Inspection and testing of electric power systems.

8.4.2.5 RG 1.9 –Application Testing of Safety-Related Diesel Generators in Nuclear Power Plants – Revision 4

RG 1.9 refers to safety-related DGs, and as such is not directly applicable to the SBODGs. However, the design principles included in RG 1.9 were used as guidance in the SBODG design. The IEEE Std 387-1995, “IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Supplies for Nuclear Power Generating Stations,” was also used as guidance.

The SBODG is sized to provide a margin of at least five percent, using conservative estimates of the load characteristics. The SBODG does not have a load sequencer equivalent to the controls for the EDGs. However, the DG is sized and designed to maintain frequency and voltage within acceptable tolerances during the starting, connection or disconnection of any anticipated load. "Within acceptable tolerances" means as necessary to accomplish the safe shutdown function.

Each SBODG is designed to permit testing of the voltage and frequency response to starting, connection or disconnection of any anticipated load. The design permits testing of the DGs to simulate the parameters of operation (for example, manual start, load connection, operating time) that would be expected if an actual demand were placed on the system.

Each SBODG is tested independent of the other SBODG and independent of any EDG. Testing and test equipment will not cause a loss of independence between DGs or between DG load groups. Instrumentation sensors are readily accessible and designed for inspection and calibration in place. The overall design includes status indication and alarm features, as listed in Table 8.4–3—Station Blackout Diesel Generator Indications and Alarms. A surveillance system is provided with remote indication in the control room to display SBODG status (i.e., under test, ready-standby, lockout).

The SBODG will trip automatically on generator-differential overcurrent, or engine overspeed of approximately 115 percent. The differential overcurrent trip protects the generator in the event of an internal fault. The overspeed trip protects the DG in the event of governor failure, or an improperly adjusted control circuit. Other trips which could potentially protect the DGs require two out of three logic to preclude such trips from interfering with the SBODG mission. To facilitate failure or malfunction diagnosis, the surveillance system indicates which of the SBODG protective trips was actuated first. To minimize the potential for common cause failure, the SBODGs are of a different model than provided for the station standby ac power sources.

8.4.2.6 RG 1.155 –Station Blackout

The SBODGs and the loads selected for coping with SBO conditions conform to the requirements of RG 1.155. The DGs are automatically started and manually aligned to the assigned EPSS buses within ten minutes to power equipment necessary to provide adequate core cooling.

8.4.2.6.1 RG 1.155 C.3.1 –Minimum Acceptable Station Blackout Duration Capability (Station Blackout Coping Duration)

The SBO rule requires applicants to assess the capability of their plants to maintain adequate core cooling and appropriate containment integrity during an SBO. The RG 1.155 presents a method acceptable to the NRC staff for determining the specified duration for which a plant should be able to withstand an SBO. This method results in selecting a minimum U.S. EPR SBO capability of not more than eight hours, depending on a comparison of plant characteristics with those factors that have been identified as significantly affecting the risk from SBO. The U.S. EPR design envelopes an eight hour coping duration for the worst case site conditions. A COL applicant based on site-specific coping durations may propose coping durations less than eight hours. Eight hours is the maximum duration that results from applying the RG 1.155 method to the U.S. EPR.

The RG 1.155, Table 2, specifies the required duration of SBO, based on four factors. The first factor is the redundancy of the onsite EAC power sources (i.e., the number of power sources available minus the number needed for decay heat removal). The U.S. EPR design requires one emergency power source for decay heat removal; four are provided. From RG 1.155 Table 3— Emergency AC Power Configuration Group A, is selected.

The second factor is EDG reliability. The RG 1.155 uses two EDG reliability targets (0.95, 0.975) for each EDG in emergency ac power configuration group A. The lower value (0.95) is used. A COL applicant may choose to use the 0.975 reliability target if it is supported by site-specific data.

The third factor is the expected frequency of LOOP events. This factor is developed from site-specific data. Therefore, for the design certification stage, the most conservative offsite power design characteristic group, P3, is selected from RG 1.155 Table 4. COL applicants may choose groups P1 or P2 when supported by site-specific data.

The fourth factor is the probable time needed to restore offsite power. This factor is incorporated into the offsite power design characteristic group. Any enhanced recovery capability or procedures are site-specific, and no credit is taken for enhanced recovery. This is factored into the P3 grouping addressed above.

Therefore, using RG 1.155, the acceptable SBO duration capability is based on the worst-case characteristic groupings of offsite power design and EDG reliability for the appropriate EAC power configuration group. For the EPR, this results in a worst-case duration of eight hours. Subsequent refinement of site-specific data may result in a site-specific reduction to four or two hours.

8.4.2.6.2 RG 1.155 C.3.2 –Evaluation of Plant-Specific Station Blackout Capability (Station Blackout Coping Capability)

The U.S. EPR has been evaluated to determine its capability to withstand and recover from an eight hour SBO. The following considerations were included:

- The evaluation was performed assuming that the SBO occurs while the reactor is operating at 100 percent rated thermal power, and has been at this power level for at least 100 days,
- Immediately before the SBO, the reactor and supporting systems are within normal operating ranges for pressure, temperature, and water level. All plant equipment is either operating normally, or available from the standby state.
- Operator actions are assumed to follow plant operating procedures for the underlying symptoms or identified event scenario for an SBO. Operator actions to strip battery loads are not credited.

- Actions in SBO procedures are based on use of I&C powered by vital buses supplied by station batteries.

- The dc power needs for SBO were estimated using IEEE Std 485-1997, "Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications." Battery sizing calculations are based on the lowest expected battery temperature under normal conditions.

- The capability of systems and components necessary to provide core cooling and decay heat removal following an SBO was determined, including station battery capacity, EFW pool capacity, and I&C requirements. The non-safety-related systems used to respond to an SBO are consistent with RG 1.155 Appendix B, "Guidance Regarding System and Station Equipment Specifications."

- The ability to maintain adequate reactor coolant system (RCS) inventory to cool the core, taking into consideration shrinkage, leakage from pump seals, and inventory loss from letdown or other normally open lines dependent on ac power for isolation.

- The design adequacy and capability of equipment needed to cope with an SBO for the required duration and recovery period was evaluated for the associated environmental conditions, including;

  - Potential failures of equipment necessary to cope with the SBO.

  - Potential environmental effects on the operability and reliability of equipment necessary to cope with the SBO, including possible effects of fire protection systems.

  - Potential effects of other hazards, such as weather, on SBO response equipment (for example, auxiliary equipment to operate onsite buses or to recover EDGs and other equipment as needed).

  - Potential habitability concerns for those areas that would require operator access during the SBO and recovery period.

All equipment required to cope with an SBO is available on site. No coping analysis is needed, because both AAC sources will be available within ten minutes of the onset of SBO.

The AAC source and EUPS provide indication and closure power for containment isolation valves that might be open at the beginning of an SBO, excluding the following:

- Valves normally locked closed during operation.

- Valves that fail closed on a loss of power.

- Check valves.

- Valves in non-radioactive closed-loop systems not expected to be breached in an SBO (excluding lines that communicate directly with containment atmosphere).
- Valves of less than three inch nominal diameter.

SBO Mitigation Strategy

During normal plant operation, each SBODG is in standby with the diesel engines ready to be started. Each diesel engine is pre-lubricated and its cooling water is pre-heated. At the start of an SBO, two-hour rated EUPS batteries supply dc power to EUPS inverters and their critical loads, including I&C power and dc control power. Safe shutdown loads are not connected to the SBODG bus. On a loss of voltage to the 6.9 kV switchgear, Class 1E loads are automatically stripped from their respective buses. Non-Class 1E loads are stripped to the extent that the remaining load is less than the SBODG rating for immediately connected load (typically 25 to 30 percent of the machine continuous load rating). An automatic start signal is issued to the SBODGs. The SBODG output breaker automatically closes onto the non-Class 1E bus upon reaching its nominal frequency and voltage. Safe shutdown loads may be manually added within ten minutes from the start of the event.

The SBO safe shutdown acceptance criteria were developed using ANSI/ANS Std 58.11-1995 (R2002), "Design Criteria for Safe Shutdown Following Selected Design Basis Events in Light Water Reactors." These criteria were developed for design basis events but are considered to be a conservative means of demonstrating successful SBO mitigation. The criteria are:

- Core reactivity is kept at a margin below criticality, consistent with technical specifications.
- Core decay heat is being removed at a controlled rated, sufficient to prevent core or RCS thermal design limits from being exceeded.
- Radioactive material releases are controlled to keep doses within prescribed limits.
- Operation is maintained within design limits of structures, systems, and components necessary to maintain these conditions.

The SBO mitigation strategy was analyzed using the RELAP5 transient analysis program from the RELAP5 Topical Report (Reference 5).

SBO Timeline

1. Prior to the event, consistent with technical specifications, unidentified leakage is one gpm or less, and identified leakage is ten gallons per minute or less.
2. At the beginning of the event, the reactor coolant pumps (RCP) decrease in speed, leading to a reactor and main turbine trip. All feedwater is lost. The SG pressures are controlled at 1370 psig by steaming all SGs with their associated main steam relief train (MSRT). The pressurizer safety valves do not open.

3. Two minutes into the event, all RCP seals are assumed to fail. This is due to the loss of RCP seal injection and the loss of thermal barrier cooling. The RCP seal design specifications limit the seal leakage after a seal failure to 25 gpm per seal or 100 gpm total. Total RCS leakage rises to 111 gpm or less.

4. Ten minutes or less into the event, the SBODGs are available for manual loading of safe shutdown equipment. Operator actions are begun to limit reactor coolant inventory losses through letdown, sampling and pressurizer degasification connections. The HVAC equipment in divisions 1 and 4 can be restored. Some Safeguards Building areas may briefly exceed 122°F before HVAC is restored.

5. Fifteen minutes into the event, the standstill seal system terminates RCP seal leakage. Standstill seal system leakage is 0.5 gpm per standstill seal. Total RCS leakage drops to 13 gpm or less; this leakage continues for the duration of the event.

6. Twenty minutes into the event, the associated EUPS two-hour batteries and battery chargers are loaded onto the SBODGs. Thus, their supplied loads are available during the entire SBO period.

7. Thirty minutes into the event, two EFW pumps are started and begin feeding four SGs. The SG levels in the fed SGs recover from their low of 40 percent (wide range (WR)) to the normal post trip value of 82.2 percent (WR). All EFW pools are cross-connected during normal operations, and remain cross-connected through the SBO.

8. After eight hours, the SGs are maintained at their normal post-trip level, pressurizer level is on scale, and core exit temperature is 602°F and decreasing slowly. Ambient air temperatures in the division 2 and division 3 equipment areas are within limits.

8.4.2.6.3 RG 1.155 C.3.3 –Modifications to Cope with Station Blackout – AAC Power Sources

Consistent with SECY-90-016, Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements, January 12, 1990, the U.S. EPR design provides two full capacity AAC power sources of diverse design, capable of powering at least one complete set of normal safe shutdown loads.

As required by RG 1.155 for AAC power sources selected specifically for satisfying the requirements for SBO, the design meets the following criteria:

- The AAC power sources are not normally directly connected to the preferred or blacked-out unit onsite emergency power system. The SBODGs are normally not running. Two breakers exist between each SBODG and the nearest Class 1E bus.

- There is a minimum potential for common cause failure with the preferred or the blacked-out unit onsite EAC power sources. No single-point vulnerability exists whereby a weather-related event or single active failure could disable any portion of the blacked-out unit’s onsite sources and simultaneously fail the AAC power sources. This is also accomplished by specifying and selecting equipment, including the engine, generator, and primary support equipment, that is different from the corresponding EDG equipment.

- Including the time required to prepare the SBODG bus, the AAC power sources can be connected to their associated EPSS buses within ten minutes after the onset of SBO. When an SBO condition occurs, load and source breakers will be opened on the SBODG bus, as required to separate the SBODG from other power sources, and to reduce the immediately connected (non-Class 1E) load to less than the machine rating, (typically 25 to 30 percent of the machine continuous rating). The SBODGs will then start automatically. If the SBODGs fail to start automatically, they can be manually started from the MCR. One AAC power source is capable of manual connection to the division 1 and division 2 safety buses. The other AAC power source is capable of manual connection to the division 3 and division 4 safety buses. After the generators are connected to their respective Class 1E 6.9 kV buses, safe shutdown loads are added manually.

- The AAC power source has sufficient capacity to operate the systems necessary for coping with an SBO for the time required to bring and maintain the plant in a safe shutdown condition, as described in Section 8.4.1. Fuel consumption is within the transfer capability of the fuel oil system. A minimum fuel supply will be maintained, as necessary to permit operation at the machines continuous rating for the SBO coping duration determined in Section 8.4.2.6.1.

- The AAC power source conforms to diversity guidance provided by RG 1.155, Appendix B, with reference to RG 1.155 Regulatory Position 3.3.5.

Programs to periodically inspect, test, and maintain the AAC power system, are described in Section 8.4.1.4.

RG 1.155 includes a recommendation that an AAC power source serving a multiple-unit site where onsite EPSS sources are not shared between units should have as a minimum, the capacity and capability for coping with SBO in any of the units. This recommendation is not applicable to the U.S. EPR design, because there is no sharing of AAC power sources between an U.S. EPR plant and other units on the same site. Other units on a multiple-unit site must have their own AAC power source. Put differently, this paragraph is not applicable, because an AAC power source will not be permitted to serve a multi-unit site that includes an U.S. EPR plant. Similarly, the subsequent paragraph in RG 1.155, pertaining to the situation where on-site emergency sources are shared between units, is not applicable to the U.S. EPR, because the U.S. EPR design does not permit sharing of emergency sources between units.

The SBODGs are installed in a non-seismically designed building, housing non-safety-related components. The SBODG failures can not affect systems required for a DBA.

8.4.2.6.4 RG 1.155 C.3.4 –Procedures and Training to Cope with Station Blackout (Procedures and Training)

A COL applicant that references the U.S. EPR design certification will address the RG 1.155 position C.3.4 related to procedures and training to cope with SBO.

8.4.2.7 Quality Assurance

RG 1.155 provides quality assurance (QA) and specification guidance for the SBODG. RG 1.155 Appendices A and B provide guidance on QA activities and specifications respectively for non-safety-related equipment used to meet the requirements of 10 CFR 50.63 and not already covered by existing QA requirements in Appendix B or R of 10 CFR 50. The guidance on QA and specifications incorporates a lesser degree of stringency (as compared with 10 CFR 50 Appendix B) by eliminating requirements for involvement of parties outside the normal line organization. It is anticipated that NRC inspections will focus on the implementation and effectiveness of the quality controls described in RG 1.155 Appendices A and B. Equipment installed to meet the SBO rule is implemented so that it does not degrade the existing safety-related systems. This is accomplished by making the non-safety-related equipment as independent as practical from existing safety-related systems. The non-safety-related systems identified in RG 1.155 Appendix B are acceptable for responding to an SBO.

The specific QA guidance for the SBODG is described in Chapter 17.

8.4.3 References

1. NUMARC 87-00, Draft Report, "Regulatory Effectiveness of the Station Blackout Rule", Advisory Committee on Reactor Safeguards (ACRS) 2000 Letter Reports, United States Nuclear Regulatory Commission, 2000.

2. IEEE Std 387-1995, “IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.” Institute of Electrical and Electronics Engineers, 1995.

3. IEEE Std 485-1997, “IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.” Institute of Electrical and Electronics Engineers, 1997.

4. ANSI/ANS Std 58.11-1995, “Design Criteria for Safe Shutdown Following Selected Design Basis Events in Light Water Reactors.”, Revised 2002.

5. BAW-10164P-A, Revision 6, “RELAP5/MOD2-BAW-An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analyses,” AREVA NP Inc., June 2007.

6. SECY-90-016, Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements, January 12, 1990.

Table 8.4-1—Station Blackout Continuous Loading – Train 1

Function	Power	Notes
Safety Chilled Water Compressor - Division 1	530 kW	Division 1 is air cooled. Even if powered, the division 2 compressor does not run, because the component cooling water it requires is not available during SBO.
Emergency Feedwater Pump	580 kW	Nominal load adjusted higher for possible efficiency losses. No credit has been taken for the reduced flow rate and hydraulic load expected during SBO. The value listed is conservative.
Class 1E Battery Chargers	200 kW	Includes division 1 and division 2.
Class 1E 480 V Loads Except Battery Chargers -division 1	820 kW	Includes 480 V loads powered from load centers 31BMB and 31BMC and MCCs 31BNB01, 31BNB02, 31BNB03, and 31BNC01.
Class 1E 480 V Loads Except Battery Chargers-division 2	520 kW	Includes 480 V loads powered from load center 32BMB and MCCs 32BNB01, 32BNB02, and 32BNB03.
SBO DG Auxiliaries	230 kW	
Non-Class 1E Battery Chargers	320 kW	Non-Class 1E chargers may be turned off during SBO as needed to maintain load below SBODG continuous rating.
Provision for Site-Specific Non-Class 1E Loads	450 kW	
Total SBO Load	3650 kW	
Asset Protection	940 kW	Load present during LOOP without SBO. Individual loads removed during SBO as needed to maintain load below SBODG continuous rating

Table 8.4-2—Station Blackout Loading – Train 2

Function	Power	Notes
Safety Chilled Water Compressor - Division 4	530 kW	Division 4 is air cooled. Even if powered, the Division 3 Compressor does not run, because the component cooling water it requires is not available during SBO.
Emergency Feedwater Pump	580 kW	Nominal load adjusted higher for possible efficiency losses. No credit has been taken for the reduced flow rate and hydraulic load expected during SBO. The value listed is conservative.
Class 1E Battery Chargers	200 kW	Includes Division 3 and Division 4.
Class 1E 480 V Loads Except Battery Chargers -division 4	1000 kW	Includes 480 V loads powered from load centers 34BMB and 34BMC and MCCs 34BNB01, 34BNB02, 34BNB03, and 34BNC01.
Class 1E 480 V Loads Except Battery Chargers -division 3	550 kW	Includes 480 V loads powered from load center 33BMB and MCCs 33BNB01, 33BNB02, and 33BNB03.
SBO DG Auxiliaries	210 kW	Differs slightly from train 1 due to consideration of loads from the associated 480 V buses.
Non-Class 1E Battery Chargers	320 kW	Non-Class 1E chargers may be turned off during SBO as needed to maintain load below SBODG continuous rating.
Provision for Site-Specific Non-Class 1E Loads	450 kW	
Total SBO Load	3840 kW	
Asset Protection	30 kW	Differs from train 1 because most turbine-generator loads are on train 1. Load present during LOOP without SBO. Individual loads removed during SBO as needed to maintain load below SBODG continuous rating.

Table 8.4-3—Station Blackout Diesel Generator Indications and Alarms

Parameter	Indication		Alarm	
	Control Room	Local	Control Room	Local
Voltage	X	X		
Frequency	X	X		
Current	X	X		
Power	X	X		
Reactive power	X	X		
Winding temperature		X		
Field current		X		
Field voltage		X		
Ground current				X
Generator differential overcurrent				X
Breaker position	X	X		
Starting air pressure		X		X
Lubricating system pressure		X		X
Lubricating system temperature		X		X
Fuel system		X		
Cooling water system temperature		X		X
Engine Trouble			X	