U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

8.4 STATION BLACKOUT

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the electrical engineering review

Secondary - None

I. AREAS OF REVIEW

The term "station blackout" (SBO) refers to the complete loss of alternating current (ac) electric power to the essential and nonessential switchgear buses in a nuclear power plant (NPP). An SBO, therefore, involves the loss of the offsite electric power system (referred to in industry standards and regulatory guides (RGs) as the "preferred power system") concurrent with a turbine trip and unavailability of the emergency ac (EAC) power system (typically emergency diesel generators (EDGs)). An SBO does not include the loss of available ac power to buses fed by station batteries through inverters or by alternate ac (AAC) sources specifically provided for SBO mitigation. Because many safety systems necessary for reactor core decay heat removal depend on ac power, an SBO could result in a severe core damage accident. The risk of SBO involves the likelihood and duration of the loss of all ac power and the potential for severe core damage after a loss of all ac power.

In 1980, the NRC designated SBO as an unresolved safety issue (USI A-44). The agency documented the findings of the technical studies completed for USI A-44 in NUREG-1032 (Ref. 30). In June 1988, the NRC resolved USI A-44 with the publication of a new rule under 10 CFR 50.63 (Ref. 2) (53 FR 23203) and an accompanying RG (RG 1.155 (Ref. 7)). Concurrently, the Nuclear Management and Resources Council (NUMARC) (now the Nuclear Energy Institute (NEI)) developed NUMARC-8700, Revision 0 (Ref. 38), which RG 1.155 endorses with certain exceptions. Table 1 of RG 1.155 provides a cross-reference to NUMARC-8700, Revision 0, and it notes when the RG takes precedence.

The information presented in the safety analysis report (SAR) should be sufficient to support the conclusion that the plant is capable of withstanding and recovering from a complete loss of ac electric power to the essential and nonessential switchgear buses for a specified period of

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time. The staff will perform the review to ensure conformance with the requirements of 10 CFR 50.63, 10 CFR 50.65, and General Design Criteria (GDC) 17 and 18 in Appendix A to 10 CFR Part 50 by verifying that the licensee is implementing the relevant guidance of RG 1.155, as supplemented by the guidance and criteria herein.

The analyses performed to demonstrate compliance with 10 CFR 50.63 should remain valid for the life of the NPP. Therefore, if the underlying assumptions change during the life of the NPP, licensees are expected to reevaluate the specified coping duration for their NPPs and the accompanying coping analyses using RG 1.155 or NUMARC-8700, Revision 0, as endorsed by RG 1.155.

The specific areas of review are as follows:

1. SBO Coping Duration. The SBO coping duration is defined as the time from the onset of an SBO to the time when either offsite (preferred) or onsite (EDGs) ac power is restored to at least one of the safe shutdown buses. The SBO rule requires each plant to specify an SBO coping duration that is justified by an analysis of site- and plant-specific factors that contribute to the likelihood and duration of an SBO. Because passive plants will not have emergency AC (EAC) power sources, applicants for such plants need not evaluate SBO coping duration as long as they are able to demonstrate that the design selected is capable of performing safety-related functions for 72 hours. The 72 hour approach is consistent with the duration approved by the NRC staff for the AP 1000 design. The review should determine that the selected minimum coping duration conforms to the guidance provided in Section C.3.1 of RG 1.155.

2. SBO Coping Capability. The review should determine that the capability to achieve and maintain safe shutdown (non-design-basis accident (DBA)) during an SBO conforms to the guidance provided in Section C.3.2 of RG 1.155 and that appropriate procedures and training have been developed to implement this capability.

3. AAC Power Sources. Use of an AAC power source that is consistent with the guidance in RG 1.155 and capable of powering at least one complete set of normal shutdown loads is the preferred approach for complying with the requirements of 10 CFR 50.63. The review conducted herein should determine that the information submitted and commitments made regarding the AAC power source provide reasonable assurance of the licensee’s conformance with the rule. To do this, the staff will verify that the design of the AAC power source conforms to the guidelines in Section C.3.3.5 of RG 1.155.

   As described in SECY-90-016 (Ref. 23), new advanced light-water reactor (ALWR) applications, other than plant designs that use passive safety systems (such as the AP1000), should have a spare, full-capacity, AAC power source that meets the guidelines in Section 3.3.5 of RG 1.155 (Ref. 23). Passive plant designs need not include an AAC power source if it can be demonstrated that all safety-related functions can be performed without reliance on ac power for 72 hours after the initiating event and the applicant has implemented a regulatory treatment of nonsafety system (RTNSS) process that conforms to Chapter C.IV.10 of Draft Guide (DG)-1145 (Ref. 28). For combined license (COL) applicants that reference a certified design, the certification will have addressed the implementation of the RTNSS process.

4. Procedures and Training. The review should determine that procedures and training conform to the guidance in Sections C.1.3, C.2, and C.3.4 of RG 1.155. Procedures and training should address all operator actions necessary to (a) restore EAC power when the EAC power system is unavailable, (b) cope with AAC or battery power on the occurrence of an SBO for the specified coping duration during all modes of plant operation, (c) restore offsite power and use of nearby power sources (which may include

such items as nearby or onsite gas turbine generators, portable generators, or hydrogenerators) in the event of a loss of offsite power (LOOP), and (d) restore normal long-term core cooling/decay heat removal once power is restored.

The review should determine that communication agreements and protocols between the plant and its transmission system operator provide assurance that the NPP operator will be kept aware of (a) changes in the plant switchyard and offsite power grid and (b) local power sources and transmission paths that could be made available to resupply the plant following a LOOP (Ref. 15).

5. Quality Assurance (QA) and Specifications for Non-Safety-Related Equipment. The review should determine that QA activities and specifications for non-safety-related equipment used to meet the requirements of 10 CFR 50.63 conform to the recommendations in Section C.3.5 and Appendix A to RG 1.155. The review should also determine that systems and equipment used to meet the requirements of 10 CFR 50.63 conform to the system and station equipment specification recommendations of Appendix A to RG 1.155. Additionally, the review should ensure that non-safety equipment installed to meet the SBO rule does not degrade the existing safety-related systems. This is accomplished by ensuring that the non-safety equipment is as independent as practicable from existing safety-related systems. The staff reviews the electrical independence of the AAC power source (if provided) under SRP Section 8.2.

6. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

7. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. The adequacy of the onsite power system, including standby EAC power sources, safety-related ac distribution systems, station batteries and associated direct current (dc) systems, and instrumentation and control power systems, is reviewed by the organization responsible for electrical engineering as part of its primary review responsibility for SRP Sections 8.3.1 and 8.3.2.

2. The adequacy of the offsite power system, including necessary preferred power circuits to the onsite power system and independence of the preferred power system and AAC power source(s) provided for SBO (if used), is reviewed by the organization responsible for electrical engineering as part of its primary review responsibility for SRP Section 8.2.

3. The organization responsible for the review of SRP Sections 4.6, 5.4.6, 5.4.7, 5.4.12, 6.3, and 9.3.5 determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition.

4. The organization responsible for the review of SRP Sections 6.5.1, 6.7, 9.1.3, 9.1.4, 9.2.1, 9.2.2, 9.2.4, 9.2.5, 9.2.6, 9.3.1, 9.3.3, 9.4.1 through 9.4.5, 9.5.1, 10.4.5, 10.4.7, and 10.4.9 determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition.

5. The organization responsible for the review of SRP Sections 9.1.3, 9.1.4, 9.2.1, 9.2.2, 9.2.4, 9.2.5, 9.2.6, 9.3.1, 9.3.3, and 9.4.1 through 9.4.5 also verifies, on request, the design adequacy and capability of systems and equipment needed to cope with an SBO for the required duration and recovery period.

6. The organization responsible for the review of SRP Section 7.2 determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition and, upon request, also verifies the adequacy of the instrumentation and controls used to cope with and recover from an SBO condition.

7. The organization responsible for the review of SRP Section 16.0 coordinates and performs reviews of technical specifications.

8. The organization responsible for the review of SRP Sections 6.2.2, 6.2.3, 6.2.4, and 6.2.5 determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition.

9. The organization responsible for the review of SRP Section 14.2 determines the acceptability of the preoperational and initial startup tests and programs.

10. The organization responsible for the review of SRP Sections 13.5.1.2 and 13.5.2.2 evaluates the adequacy of administrative, maintenance, testing, and operating procedure programs. In addition, on request, the organization responsible for SRP Sections 13.5.1.1 and 13.5.2.1 reviews potential habitability concerns for those areas that would need operator access during the SBO and recovery period.

11. The organization responsible for the review of SRP Section 17.5 evaluates the design, construction, and operations phases of QA programs, including the general methods for addressing periodic testing, maintenance, and reliability assurance, and RTNSS in passive plant designs.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 17, as it relates to (a) the capacity and capability of onsite and offsite power systems to permit functioning of SSCs important to safety in the event of anticipated operational occurrences and postulated accidents and (b) provisions to minimize the probability of losing electric power from the transmission network (grid) as a result of, or coincident with, the loss of power generated by the nuclear power unit or loss of power from the onsite electric power supplies.

Plants not licensed in accordance with the GDC in Appendix A to 10 CFR Part 50 were licensed to satisfy plant-specific principal design criteria presented in the updated final SAR. These criteria are similar to GDC 17.

2. GDC 18, as it relates to periodic testing and inspection of offsite and onsite power systems important to safety.

3. 10 CFR 50.63, as it relates to the capability to withstand and recover from an SBO.

4. 10 CFR 50.65(a)(4), as it relates to the assessment and management of the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. These activities include, but are not limited to, surveillances, postmaintenance testing, and corrective and preventive maintenance. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17.

5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;

6. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. The guidelines of RG 1.155, as they relate to compliance to 10 CFR 50.63. NUMARC-8700, Revision 0, also provides guidance acceptable to the staff for meeting these requirements. Table 1 of RG 1.155 provides a cross-reference to NUMARC-8700, Revision 0, and notes when the RG takes precedence.

2. The guidelines and criteria of SECY-90-016 and SECY-94-084 (Ref. 25), as they relate to the use of AAC power sources and RTNSS at plants provided with passive safety systems.

3. The guidelines of RGs 1.9 (Ref. 6) and 1.155, as they relate to the reliability program implemented to ensure that the target reliability goals for onsite EAC power sources (typically diesel generator units) are adequately maintained.

4. The guidelines of RG 1.160 (Ref. 8), as they relate to the effectiveness of maintenance activities for onsite EAC power sources, including grid-risk-sensitive maintenance activities (i.e., activities that tend to increase the likelihood of a plant trip, increase LOOP frequency, or reduce the capability to cope with a LOOP or SBO). Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17.

5. The guidelines of RG 1.182 (Ref. 9), as they relate to conformance to the requirements of 10 CFR 50.65(a)(4) for assessing and managing risk when performing maintenance.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. Compliance with GDC 17 requires that onsite and offsite electrical power be provided to facilitate the functioning of SSCs important to safety. Each electric power system, assuming the other system is not functioning, must provide sufficient capacity and capability to ensure that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents. GDC 17 also requires the inclusion of provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

   Meeting the requirements of GDC 17 provides assurance that a reliable electric power supply will be provided for all facility operating modes, including anticipated operational occurrences and DBAs, to permit the performance of safety functions and other vital functions, even in the event of a single failure. SRP Sections 8.1, 8.2, 8.3.1, and 8.3.2 contain additional information related to the review of compliance with GDC 17.

2. Compliance with GDC 18 requires that electric power systems important to safety be designed to permit appropriate periodic inspection and testing of key areas and features to assess their continuity and the condition of their components. These systems shall be designed to test periodically (a) the operability and functional performance of the components of the systems, such as onsite power sources, relays, switches, and buses, and (b) the operability of the systems as a whole and, under conditions as close to design as practical, the full operation sequence that brings the systems into operation, including operation of applicable portions of the protection system, and the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system. Consequently, the ac power system must provide the capability to perform integral testing on a periodic basis.

   Meeting the requirements of GDC 18 provides assurance that, when necessary, offsite power systems can be appropriately and unobtrusively accessed for required periodic inspection and testing, enabling verification of important system parameters, performance characteristics, and features and detection of degradation and/or impending failure under controlled conditions.

3. Compliance with 10 CFR 50.63 requires that each light-water-cooled NPP be able to withstand and recover from an SBO (as defined in 10 CFR 50.2 (Ref. 1)). Meeting the requirements of 10 CFR 50.63 provides assurance that the NPP will be able to withstand (cope with) and recover from an SBO and will ensure that core cooling and appropriate containment integrity are maintained.

4. Pursuant to 10 CFR 50.65, the NPP operator should know the grid's condition before taking a risk-significant piece of equipment out of service and should monitor the grid for as long as the equipment remains out of service. This provides assurance that grid reliability evaluations are performed before undertaking grid-risk-sensitive maintenance activities (such as surveillances, postmaintenance testing, and preventive and corrective maintenance) under existing or imminent degraded grid reliability conditions that could increase the likelihood of an SBO or impact the plant's ability to cope with an SBO, such as out-of-service risk-significant equipment (e.g., an EDG, a battery, a steam-driven pump, an AAC power source).

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

The SBO rule (10 CFR 50.63) requires each plant to demonstrate the capability to withstand (cope with) and recover from an SBO condition lasting for a specified duration (coping duration). Specifically, all licensees and applicants should do the following:

1. Determine the duration of an SBO that the plant should be able to withstand (coping duration).

2. Evaluate the plant's capability to withstand and recover from an SBO (coping capability) and, if necessary, make modifications to improve the coping ability.

3. Establish minimum reliability goals for onsite EAC power supplies (typically EDGs) and establish a program to ensure the reliability goals are maintained.

4. Develop procedures and training to cope with and recover from an SBO.

The analyses performed to demonstrate compliance with 10 CFR 50.63 should remain valid for the life of the NPP. If the underlying assumptions change during the life of the NPP, licensees are expected to reevaluate the specified coping duration of their NPPs and the accompanying coping analyses using RG 1.155 or NUMARC-8700, Revision 0.

To ensure that the requirements of 10 CFR 50.63 are satisfied, the staff should take the following review steps:

1. <u>SBO Coping Duration</u>. The SBO rule requires each plant to justify its specified coping duration by an analysis of site- and plant-specific factors that contribute to the likelihood and duration of an SBO. Because passive plants will not have EAC power sources, applicants for such plants need not evaluate SBO coping duration as long as they are able to demonstrate that the design selected is capable of performing safety-related functions for 72 hours. The 72 hour approach is consistent with the duration approved by the NRC staff for the AP 1000 design. The rule identifies these factors as follows:

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

The staff will review applicant submittals on SBO (i.e., SBO analysis) to determine that the selected coping duration conforms to the guidance provided in Section C.3.1 of RG 1.155, as supplemented by the criteria contained herein. A series of tables in RG 1.155 define each of the above factors and provide a method for determining an acceptable minimum SBO coping duration for the plant. The following summarizes this process:

A. Characteristics of the offsite power system that have been found to contribute to the expected frequency of a LOOP are examined and an appropriate "Offsite Power Configuration Group" (designated P1, P2, and P3) is selected from Table 4 of RG 1.155. The assumptions used in meeting 10 CFR 50.63 should remain valid for the life of the NPP.

B. The redundancy of the onsite EAC power sources (i.e., the number available for decay heat removal minus the number needed for decay heat removal) is determined and an appropriate "Emergency AC Power Configuration Group" (designated A, B, C, or D) is selected from Table 3 of RG 1.155. The number of EAC power supplies needed for SBO should be based on the ac loads necessary at each unit to achieve and maintain safe shutdown with offsite power unavailable.

   For single unit or multiunit sites having normally dedicated power supplies, the number of EAC power sources needed is determined by counting the number of EAC power supplies on a per-unit basis that are necessary to operate safe-shutdown equipment following a LOOP. For multiunit sites having shared power supplies, the number of EAC power sources needed is determined by counting the total number of standby power supplies necessary to operate safe-shutdown equipment following a LOOP. The determination of EAC power configuration groups does not count special-purpose dedicated diesel generators, such as those associated with high-pressure core spray systems at some boiling-water reactors.

C. The reliability of each EAC power source is determined in accordance with the guidance in Section C.1.1 of RG 1.155. The minimum target reliabilities of EAC power sources should be targeted at 0.95 per demand for each EDG for plants in EAC Groups A, B, and C and at 0.975 per demand for each EDG for plants in EAC Group D.

D. Using the results of the above evaluations (offsite power design characteristic group, EAC power configuration group, and unit average EAC reliability values), an appropriate "Minimum Acceptable Coping Duration" may be selected from Table 2 of RG 1.155.

2. SBO Coping Capability. The staff will review the SAR to determine that the capability to cope with an SBO lasting for the duration determined in Subsection III.1, above, conforms to the guidance in Section C.3.2 of RG 1.155. The review should ensure that the capability to maintain adequate core cooling and appropriate containment integrity for the specified coping duration is adequately demonstrated and appropriate procedures and training are implemented to withstand (cope with) the event.

   In general, two options are available to cope with an SBO—an ac-independent approach and an AAC approach. In the ac-independent approach, the plant relies on available sources of energy that are independent of ac power (e.g., process steam, dc power, and compressed air). If this approach is selected, the review should determine that an analysis conforming to the guidance in Sections C.3.2.1 to C.3.2.4 of RG 1.155 demonstrates the capability to achieve and maintain safe shutdown until ac power is restored. The AAC approach involves the provision of an independent AAC power source. If this approach is selected, the review should ensure that the design conforms to the recommendations in Sections C.3.2.5, C.3.3, and C.3.5 and Appendices A and B to RG 1.155, as described in Subsection III.3 below. Except for passive ALWR plant designs (such as the AP1000), an AAC power source that is fully capable of powering one complete set of normal shutdown loads should be the preferred method of demonstrating compliance with 10 CFR 50.63 (Ref. 25) for new applications licensed under 10 CFR Part 52 (Ref. 5). These plants cannot use the ac-independent approach (i.e., coping with battery power).

The determination of the plant's ability to cope with an SBO should be based on the following general criteria and baseline assumptions (Refs. 7 and 38):

A. Because of the presence of substantial decay heat, events initiated from 100-percent power bound the potential for core damage from an SBO. Therefore, the coping analysis should be performed assuming that the SBO event occurs while the reactor is operating at 100-percent rated thermal power and has been at this power level for at least 100 days.

B. Immediately before the postulated SBO event, the reactor and supporting systems are within normal operating ranges for pressure, temperature, and water level. All plant equipment is either normally operating or available from the standby state.

C. It is assumed that a reasonable set of operator actions will occur to mitigate the effects of an SBO and recover from the event. Operator actions are assumed to follow plant operating procedures for the underlying symptoms or identified event scenario associated with an SBO. Operator actions to strip nonessential loads from batteries should not be credited to commence during the first 30 minutes of the SBO event.

D. Actions specified in procedures for SBO are predicated on the use of instrumentation and controls powered by vital buses supplied by station batteries.

E. The dc power needs for SBO may be estimated using the same methodology for which the plant is licensed; Institute for Electrical and Electronics Engineers (IEEE) Std 485 (Ref. 14) describes the generally accepted methodology. For passive plant designs (e.g., AP1000), where steady-state loads should operate for up to 72 hours under SBO conditions, the staff considers the steady-state loading condition to be the governing factor for determining the Class 1E battery size (Refs. 28 and 34).

F. Since the capacity of battery storage varies with electrolyte temperature, calculations should assume the lowest temperature normally expected of the battery.

G. The capability of all systems and components necessary to provide core cooling and decay heat removal following an SBO should be determined, including station battery capacity, condensate storage tank (CST) capacity, compressed air capacity, and instrumentation and control needs. The non-safety systems identified in Appendix A to RG 1.155 are acceptable to the NRC staff for responding to an SBO.

H. The ability to maintain adequate reactor coolant system inventory to ensure that the core is cooled should be evaluated, taking into consideration shrinkage, leakage from pump seals, and inventory loss from letdown or other normally open lines dependent on ac power for isolation.

I. The design adequacy and capability of equipment needed to cope with an SBO for the required duration and recovery period should be addressed and evaluated as appropriate for the associated environmental conditions. This should include consideration of the following:

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

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

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

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

J. Equipment will be considered acceptable for SBO temperature environments if an assessment has been performed that provides reasonable assurance that the necessary equipment will remain operable.

K. In general, equipment necessary to cope with an SBO during the first 8 hours should be available on site. Consideration should be given to the availability and accessibility of offsite equipment in the time required, including consideration of weather conditions likely to prevail during a LOOP.

L. Consideration should be given to timely operator actions inside or outside the control room that would increase the length of time that the plant can cope with an SBO, provided it can be demonstrated that these actions can be carried out in a timely fashion. For example, if station battery capacity is a limiting factor in coping with an SBO, shedding nonessential loads on the batteries could extend the time until the battery is depleted. If load shedding or other operator actions are considered, the plant-specific technical guidelines and emergency operating procedures should incorporate corresponding procedures. Load shedding should not commence during the first 30 minutes of the SBO event.

M. The ability to maintain appropriate containment integrity should be addressed. Appropriate containment integrity for SBO means that adequate containment integrity is ensured by providing the capability, independent of the preferred and blacked-out unit's onsite EAC power supplies, for valve position indication and closure for containment isolation valves that may be in the open position at the onset of an SBO. This does not include the following valves:

   i. Valves normally locked closed during operation

   ii. Valves that fail closed on a loss of power

   iii. Check valves

iv. Valves in nonradioactive closed-loop systems not expected to be breached in an SBO (not including lines that communicate directly with containment atmosphere)

v. Valves of less than 3-inch nominal diameter

3. AAC Power Sources. One acceptable means of complying with the requirements in 10 CFR 50.63 involves the provision of an AAC source of sufficient capacity, capability, and reliability (for operation of all systems necessary for coping with SBO and for the time necessary to bring the plant to, and maintain it in, safe-shutdown condition (non-DBA)) that will be available on a sufficiently timely basis.

For new ALWR plants, the Commission has established a policy (Ref. 23) that such plants should have an AAC power source of diverse design and capable of powering at least one complete set of normal shutdown loads. In SECY-94-084 and SECY-95-132 (Ref. 26), the Commission modified this criteria for ALWRs that use passive safety systems. Specifically, an AAC power source is not necessary for passive plant designs (such as the AP1000) that (a) do not need ac power to perform safety-related functions for 72 hours following the onset of an SBO and (b) meet the guidelines in Section C.IV.10 of RG 1.206 regarding RTNSS.

EDGs in excess of minimum redundancy criteria for NPP onsite power systems, nearby or onsite gas turbine generators, portable or other available compatible diesel generators, or hydrogenerators may serve as AAC power sources. The design should meet the recommendations in Sections C.3.2.5, C.3.3, and C.3.5 and Appendices A and B to RG 1.155. It is acceptable for AAC power sources to be normally used for other purposes and they do not need to be solely dedicated to use as an AAC power source. However, the requisite procedures and interface agreements need to be in place such that the AAC power source is available in an SBO event.

The AAC power source should be available in a timely manner after the onset of SBO and have provisions to be manually connected to one or all of the redundant safety buses as necessary to power all equipment necessary to achieve and maintain safe shutdown (non-DBA). The time necessary for making this equipment available should not exceed 1 hour and should be demonstrated by test. If tests can show the AAC power source to be available in less than 10 minutes, no coping analysis is needed. Otherwise, a coping analysis should be performed for the duration from the onset of the SBO until the AAC power source or sources are started and lined up to operate all equipment necessary to achieve and maintain safe shutdown. The phrase “available within 10 minutes of the onset of SBO” means that circuit breakers necessary to bring power to safe-shutdown buses can be actuated in the control room within that period.

To ensure that the requirements of 10 CFR 50.63 regarding the AAC source are satisfied, the staff will evaluate and verify the applicant’s submittal on SBO regarding the following issues:

A. In accordance with Section C.3.3.5 of RG 1.155, the AAC power source should be capable of supplying power, as necessary, to all loads that are necessary for safe shutdown (non-DBA) in the event of an SBO at any nuclear unit it is credited to serve. The AAC power source should have sufficient capacity to operate the systems necessary for coping with an SBO for the time necessary to bring and maintain the plant in a safe-shutdown condition. The plant systems, functions, and features discussed in Sections C.2 and C.3.3.1 to C.3.3.4 of RG 1.155 should be appropriately addressed as safe-shutdown non-DBA loads (including loads associated with any alternative or added capacity battery charging, water, or air sources to handle SBO). For new applications, the AAC source should be of diverse design (with respect to onsite sources); have adequate capacity, independence, and reliability; and have capability for powering at least one complete set of normal safe-shutdown loads. At sites where units share onsite emergency sources, the AAC power sources should have the capacity and capability to ensure that all units can be brought to and maintained in a safe-shutdown (non-DBA) condition.

B. The staff reviews the independence of the AAC power source under SRP Section 8.2 to verify that the AAC source (or sources) will not adversely affect the preferred power system or its specified functions, and will not adversely affect the onsite power system or its specified safety functions. The review should determine that sufficient information has been provided to demonstrate adequate AAC source independence as follows:

   i. With respect to independence between the AAC power source used for SBO and the preferred and onsite power systems, electrical ties between these systems and the physical arrangement of the interface equipment should minimize the potential for the loss of any system (i.e., preferred, onsite, or AAC) preventing access to any other system and the potential for such a loss to cause further failures in other systems.

   ii. An acceptable design should not have the AAC power source normally directly connected to the preferred power system or to the blacked-out unit's onsite EAC power system. No single point of vulnerability should exist whereby a single active failure or weather-related event could simultaneously fail the AAC and preferred power sources or the AAC and onsite sources. The power sources should have minimum potential for common failure modes.

   iii. The AAC components should be physically separated and electrically isolated from safety-related components or equipment, as specified in the separation and isolation criteria applicable to the unit's licensing basis and the guidelines in Appendix A to RG 1.155. Based upon compliance with all relevant independence criteria and guidelines, it should be demonstrated that provisions for the AAC source will not, at any time, adversely affect the functioning of offsite and/or Class 1E onsite power systems. Also, failure of the AAC power components should not adversely affect the Class 1E ac power systems.

   iv. Careful examination should be made of the physical arrangement of circuits and incoming source breakers (to the affected Class 1E bus or buses), separation and isolation provisions (control and main power), permissive and interlock schemes proposed for source breakers, source initiation/transfer logic, Class 1E load shedding and sequencing schemes that could affect AAC source ability to power safe-shutdown loads, source lockout schemes, and bus lockout schemes.

C. The AAC power source(s) is not automatically loaded for SBO but should have provisions to be manually connected to one or all of the redundant safety buses as necessary.

D. Plant staff in the control room monitor the performance of the AAC power source. As a minimum, monitoring should include the voltage, current, frequency, and circuit breaker position.

E. The AAC source components are enclosed within structures that conform to the Uniform Building Code. Electrical cables connecting the AAC power source to the shutdown buses are protected against the events that affect the preferred ac power system. Buried cables or other appropriate methods can be used to accomplish this.

F. Nonsafety-related AAC power source(s) and associated dedicated dc system(s) should meet the QA guidance in Section 3.5, Appendix A, and Appendix B to RG 1.155.

G. The AAC power system is equipped with a dedicated dc power system that is electrically independent from the blacked-out unit's preferred and Class 1E power systems and is of sufficient capability and capacity for operation of dc loads associated with the AAC source for the maximum necessary duration of AAC source operation.

H. The AAC power system is equipped with a starting system (and motive energy source for starting) that is independent from the blacked-out unit's preferred and Class 1E ac power systems.

I. The AAC power system is provided with a fuel supply that is separate from the fuel supply for the onsite EAC power system. A separate day tank, supplied from a common storage tank, is acceptable if the fuel is sampled and analyzed using methods consistent with applicable standards before its transfer to the day tank.

J. If the AAC power source and an emergency onsite ac power source are identical, procedures are provided to ensure that active failures of each identical power source will be evaluated for common cause applicability and that corrective action has been taken to reduce subsequent failures.

K. The AAC power system is capable of operating during and after an SBO without any support system receiving power from the preferred power supply or the blacked-out unit's EAC power sources. The capability of the AAC to start on demand depends on the availability of the necessary support systems to fulfill their required function. These support systems may need varying combinations of dc or ac power for varying periods to maintain operational readiness. Information Notice (IN) 97-21 (Ref. 17) discusses two examples of a failure of the AAC to start on demand because of an extended loss of auxiliary electrical power sources.

L. The portions of the AAC power system subjected to maintenance activities are/will be tested before returning the AAC power system to service.

M. Plant-specific technical guidelines and emergency operating procedures will be implemented (or are in place, as applicable) that identify those actions necessary for placing the AAC power source in service.

N. The AAC power system will be inspected, maintained, and tested periodically to demonstrate operability and reliability. The reliability of the AAC power system should meet or exceed 95 percent as determined in accordance with NSAC-108 (Ref. 37) or equivalent methodology.

O. Where EDGs are identified as AAC power sources, they should meet the following criteria:

i. At single unit sites, any EAC power source(s) in excess of the number required to meet the minimum redundancy criteria (i.e., single failure) for safe shutdown may be assumed to be available. These EAC power sources may be designated as AAC power sources, provided the guidelines identified in Section C.3.3.5 of RG 1.155 are met.

ii. A single unit that needs one EAC source to place the plant in safe shutdown needs one redundant EAC power source. For SBO, both the EAC power source and the redundant EAC power source are unavailable. An EDG may be designated as an AAC power source only if that EDG is neither the necessary EAC power source nor the redundant EAC power source. Therefore, a single unit requiring one EAC source for safe shutdown should have at least three EDGs, with one EDG that may be designated as the AAC power source meeting RG 1.155 guidance for AAC power sources.

iii. At multiunit sites, where the combination of EAC sources exceeds the minimum redundancy criteria (on a per-nuclear-unit basis) for normal safe shutdown of all units, the excess EAC power sources may be used as AAC power sources, provided they meet the AAC power source guidance in Section C.3.3.5 of RG 1.155. If no EAC power source in excess of the minimum redundancy criteria remains, the occurrence of SBO must be assumed for all of the units.

iv. When an SBO occurs at one unit of a multiunit site, the EAC power source(s) and the redundant EAC power source(s) are unavailable. An SBO on one unit does not assume a concurrent single failure; however, the remaining unit(s) should still meet the normal operating single failure criteria. Therefore, an EDG could be designated as an AAC only if (1) the EDG is neither the necessary EAC power source nor the redundant EAC power source for the unit experiencing the SBO and (2) the EDG is not necessary as an emergency or redundant EAC power source for the remaining units. Where an EDG is used as an AAC, it is desirable that the EDG be connectable to all buses essential for normal safe shutdown. Review of the applicant's station onsite ac power system should determine whether such a capability exists.

v. Multiunit sites may not use EDGs with 1-out-of-2 (shared) and 2-out-of-3 (shared) ac power configurations as AAC power sources.

vi. For EDGs used as an AAC source, the engine support systems should conform with the relevant criteria used to evaluate them under SRP Sections 9.5.4 through 9.5.8.

4. Procedures and Training. The staff will review procedures and training to ensure that they conform to the guidance in Sections C.1.3, C.2, and C.3.4 and Appendix B to RG 1.155 and include all operator actions necessary to do the following:

A. Cope with the occurrence of an SBO for the specified coping duration during all modes of plant operation and include actions necessary to place AAC power sources in service (if used) and maintain acceptable environmental conditions for equipment necessary to mitigate the event. Procedures developed to cope with an SBO should be integrated with the plant-specific technical guidelines and emergency operating procedures developed using the emergency operating procedure upgrade program established in response to Supplement 1 of NUREG-0737. The task analysis portion of the emergency operating procedure upgrade program should include an analysis of instrumentation adequacy during an SBO.

B. Restore standby (Class 1E) power sources when the EAC power system is unavailable.

C. Restore offsite power sources and use of nearby power sources (which may include nearby or onsite gas turbine generators, portable generators, hydrogenerators, and black start fossil power plants) in the event of a LOOP. As a minimum, the reviewer should consider the following potential causes for a LOOP:

i. Grid undervoltage and collapse.

ii. Weather-induced power loss.

iii. Preferred power distribution system faults that could result in the loss of normal power to essential switchgear buses. This includes such failures as distribution system hardware, switching and maintenance errors, and lightning-induced faults.

D. Actions necessary to restore normal long-term core cooling/decay heat removal once ac power is restored.

In addition, the reviewer should determine that plant operating procedures developed to respond to an SBO event are consistent with the following general guidelines:

E. The procedure should specify actions necessary to assure that shutdown equipment (including support systems) necessary in an SBO can operate without ac power.

F. The procedure should recognize the importance of decay heat removal systems (auxiliary feedwater, high-pressure coolant injection, high-pressure core spray, reactor core isolation cooling) during the early stages of the event and direct operators to invest appropriate attention to ensuring their continued reliable operation throughout the event.

G. Plant operating procedures should identify the sources of potential inventory loss and specify actions to prevent or limit significant loss.

H. Plant operating procedures should ensure the prompt establishment of a flowpath for makeup flow from the CST to the steam generator/nuclear boiler and identify backup sources to the CST in order of intended use. In addition, plant operating procedures should specify clear criteria for transferring to the next preferred source of water.

I. The procedure should identify individual loads that need to be stripped from the plant dc buses (both Class 1E and non-Class 1E) to conserve dc power.

J. Plant operating procedures should specify actions to permit appropriate containment isolation and safe-shutdown valve operations while ac power is unavailable.

K. Plant operating procedures should identify the portable lighting necessary for ingress and egress to plant areas containing shutdown or AAC equipment requiring manual operation.

L. Plant operating procedures should consider the effects of ac power loss on area access, as well as the need to gain entry to other locked areas where remote equipment operation is necessary.

M. Plant operating procedures should consider the effects of a loss of ac power on communications capabilities, including the potential for a loss of communications with offsite agencies.

N. Plant operating procedures should consider the loss of heat tracing effects for equipment necessary to cope with an SBO.

O. To provide assurance that the NPP operator will be kept aware of changes in the plant switchyard and offsite power grid, plant or site procedures should establish appropriate communication protocols between the NPP and its transmission system operator (Ref. 15). With regard to SBO, these protocols should aid the operator in determining the following:

i. The performance of grid-risk-sensitive maintenance activities (such as surveillances, postmaintenance testing, and preventive and corrective maintenance) that could increase the likelihood of an SBO or impact the plant's ability to cope with an SBO, such as out-of-service risk-significant equipment (e.g., an EDG, a battery, a steam-driven pump, an AAC power source)

ii. The availability of local power sources and transmission paths that could be made available to resupply the plant following a LOOP event

5. QA and Specification Guidance for SBO Equipment That Is Not Safety-Related. The staff will review QA activities and specifications for non-safety-related equipment used to meet the requirements of 10 CFR 50.63 to ensure that they conform to the recommendations in Section C.3.5 and Appendix A to RG 1.155. The review should also determine that systems and equipment used to meet the requirements of 10 CFR 50.63 conform to the system and station equipment specification recommendations of Appendix B to RG 1.155. The NRC staff will accept the nonsafety systems identified in Appendix B to RG 1.155 for responding to an SBO.

Applicants that propose a design that includes passive safety systems should define the active systems that are relied upon for defense in depth and that are necessary to meet passive ALWR plant safety and investment protection goals. The agency describes this process, referred to as RTNSS, in SECY-94-084 and SECY-95-132. The staff reviews QA controls applicable to the SSCs within the RTNSS process under SRP Section 17.5.

6. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

> On the basis of the staff's detailed review and evaluation of the station blackout capability described in the SAR for ___(Facility)____, the staff concludes that the (applicant/licensee) has appropriately evaluated the facility against the guidelines of RG 1.155 and this SRP section. Alternatives to or differences from these recommendations, as described in the applicable section of this safety evaluation, are acceptable. The SAR acceptably demonstrates that the plant is in compliance with the provisions of GDC 17 and 18 and 10 CFR 50.63, as they relate to the capability to achieve and maintain safe shutdown (non-DBA) in the event of a station blackout.
>
> Accordingly, the staff concludes that the plant design is acceptable and meets the requirements of GDC 17 and 18 of Appendix A to 10 CFR Part 50, as they relate to the requirements of 10 CFR 50.63 and 10 CFR 50.65.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR 50.2, "Definitions."

2. 10 CFR 50.63, "Loss of All Alternating Current Power."

3. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."

4. 10 CFR Part 50, Appendix A, GDC 18, "Inspection and Testing of Electric Power Systems."

5. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

6. Regulatory Guide 1.9, "Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants."

7. Regulatory Guide 1.155, "Station Blackout."

8. Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants."

9. Regulatory Guide 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants."

10. Standard Review Plan, Section 8.1, Table 8-1, "Acceptance Criteria for Electric Power."

11. Standard Review Plan, Section 8.2, "Offsite Power."

12. IEEE Standard 308-2001, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations."

13. IEEE Standard 765-1983, "IEEE Standard for Preferred Power Supply (PPS) for Nuclear Power Generating Stations." (2002 is latest revision)

14. IEEE Standard 485-1987, "Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications."

15. Generic Letter 2006-02, "Grid Reliability and the Impact on Plant Risk and the Operability of Offsite Power," February 1, 2006.

16. Information Notice 97-05, "Offsite Notification Capabilities," February 27, 1997.

17. Information Notice 97-21, "Availability of Alternate AC Power Source Designed for Station Blackout Event," April 18, 1997.

18. Information Notice 98-07, "Offsite Power Reliability Challenges from Industry Deregulation," February 27, 1998.

19. Information Notice 2000-06, "Offsite Power Voltage Inadequacies," March 27, 2000.

20. Information Notice 2006-06, "Loss of Offsite Power and Station Blackout Are More Probable During Summer Period," March 3, 2006.

21. Regulatory Issue Summary 2000-24, "Concerns About Offsite Power Voltage Inadequacies and Grid Reliability Challenges Due to Industry Deregulation," December 21, 2000.

22. Regulatory Issue Summary 2004-05, "Grid Reliability and the Impact on Plant Risk and the Operability of Offsite Power," April 15, 2004.

23. SECY-90-016, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," January 12, 1990. Approved in the staff requirements memorandum dated June 26, 1990.

24. SECY-91-078, "EPRI's Requirements Document and Additional Evolutionary LWR Certification Issues," 1991. Approved in the staff requirements memorandum dated August 15, 1991.

25. SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs," March 28, 1994. Approved in the staff requirements memorandum dated June 30, 1994.

26. SECY-95-132, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs." Approved in the staff requirements memorandum dated June 28, 1995.

27. NRC Memorandum from D. Crutchfield to File, Subject: Consolidation of SECY-94-084 and SECY-95-132, July 24, 1995. SECY-94-084 was approved in the staff requirements memorandum dated June 30, 1994. SECY-95-132 was approved in the staff requirements memorandum dated June 28, 1995.

28. Regulatory Guide 1.206 "Combined License Applications for Nuclear Power Plants (LWR Edition)," June 30, 2006.

29. NUREG-0933, "A Prioritization of Generic Safety Issues," Supplement 29, June 2005.

30. NUREG-1032, "Evaluation of Station Blackout Accidents at Nuclear Power Plants," June 1998.

31. NUREG-1776, "Regulatory Effectiveness of the Station Blackout Rule," August 2003.

32. Electric Power Research Institute ALWR Utility Requirements Document, Volume II, "Evolutionary Plants," Chapter 11, "Electric Power Systems," Revision 6, December 1993.

33. NUREG-1784, "Operating Experience Assessment—Effects of Grid Events on Nuclear Power Plant Performance," December 2003.

34. NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design," September 2004.

35. NUREG/CR-6890, "Reevaluation of Station Blackout Risk at Nuclear Power Plants - Analysis of Loss of Offsite Power Events: 1986-2004," December 2005.

36. Temporary Instruction 2515/120, "Inspection of Implementation of Station Blackout Rule."

37. NSAC-108, "The Reliability of Emergency Diesel at U.S. Nuclear Power Plants," September 1986.

38. NUMARC-8700, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout in Light Water Reactors," Revision 0, November 1997.
