



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN

8.3.1 AC POWER SYSTEMS (ONSITE)

REVIEW RESPONSIBILITIES

Primary - The organization responsible for electrical engineering review

Secondary - None

I. AREAS OF REVIEW

The descriptive information, analyses, and referenced documents, including functional logic diagrams, electrical single-line diagrams, tables, physical arrangement drawings, and electrical control and schematics, for the onsite alternating current (ac) power system presented in the applicant's safety analysis report (SAR) are reviewed. The intent of the review is to determine that the onsite ac power system satisfies the requirements of General Design Criteria (GDCs) 2, 4, 5, 17, 18, and 50 and will perform its intended functions during all plant operating and accident conditions.

The onsite ac power system includes those standby power sources, distribution systems, and auxiliary supporting systems provided to supply power to safety-related equipment or equipment important to safety for all normal operating and accident conditions. Diesel generator sets have been widely used as the standby power source for the onsite ac power system and will be covered in this Standard Review Plan (SRP) section. Emphasis is placed on those portions of the systems that are safety-related. Those portions that are not related to safety are reviewed to determine potential interactions with safety-related portions. Other standby power sources such as nearby hydroelectric, nuclear, or fossil units, including gas turbine-generator sets, will not be addressed herein. These sources, when proposed, will be evaluated on a case-by-case basis. In addition, those interface areas between the onsite and offsite power systems at the station distribution system level are within the scope of review of this SRP section insofar as they relate to the independence of the onsite power system.

Revision 3 - March 2007

USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan 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 an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

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This SRP revision incorporates considerations for the review of the electric power system design brought about by the new advanced light water reactor (ALWR) designs, including evolutionary plant designs, such as the advanced boiling water reactor (ABWR) and the System 80+, and passive plant designs, such as the AP1000. The passive light water reactor design applications provide passive safety systems that do not need Class 1E ac electric power, other than that provided by the Class 1E direct current (dc) batteries and their inverters, to accomplish the plant's safety-related functions for 72 hours. References are provided in the individual SRP sections identifying regulatory documentation, such as SECY-94-084 and Regulatory Guide 1.206, that specifically address the unique design requirements and review considerations applicable to the ALWR plant designs.

The specific areas of review are as follows:

1. System Redundancy Requirements

The onsite power system is reviewed to determine that the required redundancy of safety-related components and systems is provided such that a system safety function can be accomplished assuming a single failure. This includes an examination of the ac power system configuration, including the power supplies, power supply feeders, switchgear arrangement, loads supplied from each bus, and power connections to the instrumentation and control devices of the power system.

2. Conformance with the Single Failure Criterion

In establishing the adequacy of this system to meet the single failure criterion, both electrical and physical separation of redundant power sources and associated distribution systems are examined to assess the independence of redundant portions of the system. This will include a review of interconnections of redundant buses, buses and loads, and buses and power supplies; physical arrangement of redundant switchgear and power supplies; criteria and bases governing the installation of electrical cables for redundant power systems; and proposed sharing of the ac power system between units at the same site.

3. Onsite and Offsite Power System Independence

In evaluating the independence of the onsite power system with respect to the offsite power system, the scope of review extends to the station distribution load centers that are powered from the unit auxiliary transformers and the startup transformers (considered for the purposes of this SRP section as the offsite or preferred power sources). It includes the supply breakers connecting the "low" side of these transformers to the distribution buses. This evaluation includes a review of the electrical protective relaying circuits and power supplies to ensure that, in the event of a loss of offsite power, the independence of the onsite power system is established through prompt opening of isolation-feeder breakers.

4. Standby Power Supplies

Design information and analyses demonstrating the suitability of the diesel generators as standby power supplies are reviewed to ensure that the diesel generators have sufficient capacity, capability, and reliability to perform their intended function. This will include an

examination of the characteristics of each load and the length of time each load is needed, the combined load demand connected to each diesel generator during the "worst" operating condition, automatic and manual loading and unloading of each diesel generator, voltage and frequency recovery characteristics of the diesel generators, continuous and short-term ratings for the diesel generators, acceptance criteria with regard to the number of successful diesel generator tests and allowable failures to demonstrate acceptability, and starting and load shedding circuits. In addition, where the proposed design provides for the connection of non-safety loads to the diesel generators or sharing of diesel generators between nuclear units at the same site, particular review emphasis is given to the possibility of marginal capacity and degradation of reliability that may result from such design provisions. [For new plants, sharing of diesel generators between units is not recommended.]

5. Identification of Cables, Raceways, and Terminal Equipment

The basis proposed for identifying the onsite ac power system components including cables, raceways, and terminal equipment as safety-related equipment in the plant is reviewed. Also, the identification scheme used to distinguish between redundant Class 1E systems, associated circuits assigned to redundant Class 1E divisions, non-Class 1E systems and their associated cables, raceways, and terminal equipment of the power system is reviewed.

6. Auxiliary Supporting Systems/Features

The instrumentation, control circuits, and power connections of auxiliary supporting systems and features are reviewed to determine that they are designed to the same criteria as those for the safety-related loads and power systems that they support. This will include an examination of the auxiliary supporting system component redundancy; power feed assignment to instrumentation, controls, and loads; initiating circuits; load characteristics; equipment identification scheme; and design criteria and bases for the installation of redundant cables.

7. System Testing and Surveillance

Onsite testing capabilities are reviewed. The means proposed for automatically monitoring the status of system operability are reviewed.

8. Reliability Program for Emergency Onsite AC Power Sources

A reliability program for emergency onsite power sources should be implemented to maintain onsite emergency source reliability at an acceptable level. The program designed to attain and maintain the long-term reliability of each source at or above specified reliability targets is reviewed to verify its adequacy.

9. Other Review Areas

The ac power system is reviewed to determine that:

- A. The system and its components have the appropriate seismic design classification.

- B. The system and its components are housed in a structure with seismic category I classification.
 - C. The system and its components are designed to withstand environmental conditions associated with normal operation, natural phenomena (including lightning discharges), and postulated accidents.
 - D. The system and its components have a "Class 1E" quality assurance classification.
 - E. Variations in voltage, frequency and waveform (harmonic distortion) in the onsite power system and its components during any mode of plant operation do not degrade the performance of any safety system load below an acceptable level.
10. 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.
11. 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. Review of the adequacy of the offsite power system, including preferred power circuits to the onsite power system, and the independence of the preferred power system and any alternate ac (AAC) power sources provided for station blackout, as part of its primary review responsibility for SRP Section 8.2.
2. Review of the adequacy of the onsite dc power systems, including: safety-related dc distribution systems; station batteries, battery chargers, and associated dc systems; inverters and associated dc systems; and dc instrumentation and control power systems, as part of its primary review responsibility for SRP Section 8.3.2.

3. Review of the overall compliance with 10 CFR 50.63 requirements, as part of its primary review responsibility for SRP Section 8.4, including the adequacy of the station blackout analysis, the adequacy of reliability targets for onsite ac sources (diesel generators), the duration for which the plant will be able to withstand or cope with, and recover from, a station blackout event, and the adequacy of dc system power supplies (e.g., batteries and chargers) that are not a part of the onsite dc power system reviewed under SRP Section 8.3.2 with respect to the specified station blackout event/duration.
4. Review of the adequacy of the environmental qualification of safety-related electrical equipment as part of its primary review responsibility for SRP Section 3.11. In particular, the reviewer determines the capability of safety-related electrical equipment to perform its intended safety functions when subjected to the effects of (1) accident environments such as loss-of-coolant accidents (LOCAs) and/or steam line breaks, (2) abnormal environments that may temporarily exceed equipment continuous duty design parameters such as temperature and humidity, (3) abnormal environments caused by degradation or loss of heating, ventilation, and/or air conditioning systems, (4) seismic shaking, and (5) normal design environments on redundant safety-related electrical equipment that does not include design diversity (e.g., redundant components manufactured and designed by the same supplier).

In the review of other areas associated with the onsite power system, the reviewer will coordinate other branches' evaluations that interface with the overall review of the system.

The listed SRP sections interface with this section as follows:

1. The organization responsible for the review of plant systems evaluates the adequacy of those auxiliary supporting systems that are vital to the proper operation and/or protection of the ac power system as part of its primary review responsibility for SRP Sections 9.4.1 through 9.4.5. This includes such systems as the heating, ventilation, and air conditioning systems provided to maintain a controlled environment for safety-related instrumentation and electric equipment. In particular, the organization responsible for the review of plant systems determines that the piping, ducting, and dampering for these heating and ventilation systems are adequate.
2. The organization responsible for the review of plant systems examines the physical arrangement of components and structures for Class 1E systems and their supporting auxiliary systems to determine that single events and accidents will not disable redundant features as part of its primary review responsibility for SRP Sections 3.4.1, 3.5.1.1, 3.5.2, and 3.6.1.
3. The organization responsible for the review of plant systems determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for 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, 10.4.5, 10.4.7, and 10.4.9.

4. The organization responsible for the review of plant systems examines fire detection and fire protection systems protecting the ac power system and its auxiliary supporting systems to ensure that the adverse effects of fire are minimized as part of its primary review responsibility for SRP Section 9.5.1. This review includes examining the adequacy of protection provided for redundant safe shutdown circuits to determine that a single design basis fire will not disable both redundant circuits.
5. The organization responsible for the review of materials and chemical engineering determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 5.4.8, 9.2.3, 9.3.2, and 9.3.4.
6. The organization responsible for the review of containment systems and severe accidents evaluates the adequacy of those containment ventilation systems provided for maintaining a controlled environment for safety-related electrical equipment located inside the containment as part of its primary review responsibility for SRP Section 6.2.2. The organization responsible for the review of containment systems and severe accidents determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 6.2.2, 6.2.3, 6.2.4, and 6.2.5.
7. The organization responsible for the review of reactor systems determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 4.6, 5.4.6, 5.4.7, 5.4.12, 6.3, and 9.3.5.
8. The organization responsible for the review of instrumentation and controls determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 7.2 through 7.7. In addition, the organization responsible for the review of instrumentation and controls verifies the adequacy of safety-related display instrumentation and other instrumentation systems needed for safety as part of its primary review responsibility for SRP Sections 7.5 and 7.6.
9. The organization responsible for quality assurance and maintenance review determines the acceptability of the preoperational and initial startup tests and programs as part of its primary review responsibility for SRP Section 14.2.
10. The reviews of design, construction, and operations phase quality assurance programs, including the general methods for addressing periodic testing, maintenance, and reliability assurance, are performed by the organization responsible for the review of quality assurance as part of its primary review responsibility for SRP Chapter 17.
11. The organization responsible for mechanical engineering review, as part of its primary review responsibility for SRP Section 3.10, reviews the criteria for seismic qualification and the test and analysis procedures and methods to ensure the mechanical survivability of Category I instrumentation and electrical equipment (including raceways, switchgear, control room boards, and instrument racks and panels) in the event of a seismic occurrence.

12. The organization responsible for the review of technical specifications coordinates and performs reviews of technical specifications as part of its primary review responsibility for SRP Section 16.0.
13. The organization responsible for human factors assessment, as part of its primary review responsibility for SRP Sections 13.5.1.1 and 13.5.2.1, reviews the adequacy of administrative, maintenance, testing, and operating procedure programs.

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 2 as it relates to SSCs of the ac power system being capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.
2. GDC 4 as it relates to SSCs of the ac power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.
3. GDC 5 as it relates to sharing of SSCs of the ac power systems.
4. GDC 17 as it relates to the onsite ac power system's (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence, redundancy, and testability to perform its safety function assuming a single failure; and (c) 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 or the loss of power from the transmission network.
5. GDC 18 as it relates to inspection and testing of the onsite power systems.
6. GDCs 33, 34, 35, 38, 41, and 44 as they relate to the operation of the onsite electric power system, encompassed in GDC 17, to ensure that the safety functions of the systems described in GDCs 33, 34, 35, 38, 41, and 44 are accomplished.
7. GDC 50 as it relates to the design of containment electrical penetrations containing circuits of the ac power system and the capability of electric penetration assemblies in containment structures to withstand a LOCA without loss of mechanical integrity and the external circuit protection for such penetrations.

8. 10 CFR 50.63, as it relates to the establishment of a reliability program for emergency onsite ac power sources and the use of the redundancy and reliability of diesel generator units as a factor in limiting the potential for station blackout events.
9. 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, post-maintenance 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. Programs for incorporation of requirements into appropriate procedures are reviewed under SRP Chapter 13.
10. 10 CFR 50.55a(h), as it relates to the incorporation of Institute of Electrical and Electronics Engineers, Inc. (IEEE) Standard (Std.) 603-1991 (including the correction sheet dated January 30, 1995), and IEEE Std. 279 for protection and safety systems.
11. 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;
12. 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.

In general, the onsite ac power system is acceptable when it can be concluded that this system has the required redundancy, meets the single failure criterion, is protected from the effects of postulated accidents, is testable, and has the capacity, capability, and reliability to supply power to all safety loads and other required equipment in accordance with GDCs 2, 4, 5, 17, 18, and 50. Table 8-1 of SRP 8.1 lists GDCs, regulations, regulatory guides, and branch technical positions used as the bases for arriving at this conclusion.

1. GDC 2 is satisfied as it relates to SSCs of the onsite ac power system being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapter 3 of the SAR, and reviewed by the organizations with primary responsibility for the reviews of plant systems, civil engineering and geosciences, and mechanical engineering.
2. GDC 4 is satisfied as it relates to SSCs of the ac power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation and postulated accidents, as established in Chapter 3 of the SAR and reviewed by the organizations with primary responsibility for the reviews of plant systems, materials, and chemical engineering.
3. GDC 5 is satisfied as it relates to the sharing of SSCs of the ac power system and the following guidelines:
 - A. Regulatory Guide 1.32, as it relates to the sharing of SSCs of the Class 1E power system at multi-unit stations.
 - B. Regulatory Guide 1.81, as it relates to the sharing of SSCs of the ac power system, positions C.2 and C.3.
4. GDC 17 is satisfied as it relates to the onsite ac power system's: (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence, redundancy, and testability to perform its safety function assuming a single failure; and (c) 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 or the loss of power from the transmission network. Acceptance is based on meeting the following specific guidelines:
 - A. Regulatory Guide 1.6, as it relates to the independence of the onsite ac power system, positions D.1, D.2, D.4, and D.5.
 - B. Regulatory Guide 1.9 (see also IEEE Std 387).
 - C. Regulatory Guide 1.32 (see also IEEE Std 308), as it relates to design criteria for onsite ac power systems.
 - D. Regulatory Guide 1.53 (see also IEEE Stds 279 and 603), as it relates to the application of the single-failure criterion to safety systems.
 - E. Regulatory Guide 1.75 (see also IEEE Std 384), as it relates to the onsite ac power system.
 - F. Regulatory Guide 1.153 (see also IEEE Std 603), as it relates to criteria for electrical portions of safety-related systems.
 - G. Regulatory Guide 1.155, as it relates to the use of onsite emergency ac power sources for station blackout.

- H. Regulatory Guide 1.204 (see also IEEE Stds 665, 666, 1050, and C62.23), as it relates to the lightning and surge protection for the onsite ac power system.
- I. NUREG/CR-0660 is incorporated as it relates to the following recommendations:
- I. The diesel generator sets should be capable of operation at less than full load for extended periods of time without degradation of performance or reliability. With offsite power available, no-load operation of the diesel generators will occur following a safety injection signal. Extended no-load operation of this equipment should be minimized. Operating procedures should be provided that limit extended no-load operation of the diesel generators. The procedures should include loading the diesel engine to a minimum of 25% of full load for 1 hour after 8 hours of continuous no-load operation or to a load as recommended by the engine manufacturer.
 - ii. A complete formal training program should be provided for all personnel who will be responsible for the maintenance and availability of the diesel generators. The depth and quality of training shall be at least equivalent to that provided by major diesel engine manufacturers' training programs.
 - iii. A preventive maintenance program should be provided which encompasses investigative testing of components which have a history of repeated malfunctioning and a plan for the replacement of those components that require constant attention and repair with other products of proven reliability.
 - iv. Repair and maintenance procedures should provide for a final equipment check prior to an actual start-run-load test to ensure that all electrical circuits are functional (i.e., fuses in place, no loose wires, test leads removed, etc.) and all valves are in the proper position. The test procedure(s) should explicitly state that upon satisfactory test completion the diesel generator unit should be returned to a ready automatic standby service under the control of the control room operator.
 - v. Except for sensors and other equipment that need to be directly mounted on the engine or associated piping, the controls and monitoring instruments should be installed on a free-standing, floor-mounted panel located on a vibration-free floor area.
- [NOTE: If the floor is not vibration free, the panel should be equipped with vibration mounts.]
- J. Acceptance criteria for the interface between the onsite ac power system and the offsite power system to satisfy the requirements of GDC 17 in evolutionary light water reactor design applications are documented in SECY-91-078, which states that the design should include at least one offsite circuit to each redundant safety division supplied directly from one of the offsite power sources with no intervening non-safety buses in such a manner that the offsite source can power

the safety buses upon the failure of any non-safety bus. The evolutionary light water reactor design should also include an alternate power source to non-safety loads, unless it can be demonstrated that existing design margins will ensure that transients for loss of non-safety power events are no more severe than those associated with the turbine-trip-only event specified in current plant designs.

Passive light water reactor design applications provide passive safety systems that do not need Class 1E ac electric power, other than that provided by the Class 1E dc batteries and their inverters, to accomplish the plant's safety-related functions for 72 hours. However, in accordance with SECY-94-084, SECY-95-132, and Regulatory Guide 1.206 Section C.IV.10, ac power system features will be evaluated using the process for regulatory treatment of non-safety systems (RTNSS) for electrical distribution issues on passive designs. The AP1000 passive plant design certification, for example, includes an exemption to the requirement of GDC 17 for two physically independent offsite circuits, by providing safety-related passive safety systems for core cooling and containment integrity. However, even for this design, one offsite power source with sufficient capacity and capability from the transmission network should be provided to power the safety-related systems and all other auxiliary systems under normal, abnormal, and accident conditions. The offsite power source should be designed to minimize to the extent practical the likelihood of its failure under normal, abnormal, and accident conditions.

Detailed reviews of the offsite ac power system and its interface with the onsite power system for ALWR design applications are covered in Section 8.2, "Offsite Power System."

5. GDC 18 is satisfied as it relates to the testability of the onsite ac power system, and the following guidelines:
 - A. Regulatory Guide 1.32 (see also IEEE Std 308), as it relates to capability for testing of the onsite ac power system.
 - B. Regulatory Guide 1.47, with respect to indicating the bypass or inoperable status of portions of the protection system, systems actuated or controlled by the protection system, and auxiliary or supporting systems that must be operable for the protection system and the system it actuates to perform their safety-related functions.
 - C. Regulatory Guide 1.118 (see also IEEE Std 338), as it relates to the capability for testing the onsite ac power system.
 - D. Regulatory Guide 1.153 (see also IEEE Std 603), as it relates to the onsite ac power system.
6. The design requirements for an onsite ac power supply for systems covered by GDCs 33, 34, 35, 38, 41, and 44 are encompassed in GDC 17.

7. GDC 50 is satisfied as it relates to the design of containment electrical penetrations containing circuits of the ac power system, and the guidelines of Regulatory Guide 1.63 are followed (see also IEEE Stds 242, 317, and 741), as related to the capability of electric penetration assemblies in containment structures to withstand a LOCA without loss of mechanical integrity and the external circuit protection for such penetrations, as well as to ensure that electrical penetrations will withstand the full range of fault current (minimum to maximum) available at the penetration.
8. 10 CFR 50.63, as it relates to use of the redundancy and reliability of diesel generator units as a factor in limiting the potential for station blackout events. Acceptance is based on meeting the following specific guidelines:
 - A. Regulatory Guide 1.9, as it relates to the adequacy of the diesel generator surveillance criteria provided to attain and maintain the target reliability levels of diesel generator units.
 - B. Regulatory Guide 1.155, as it relates to use of the reliability of emergency onsite ac power sources as a factor in determining the coping duration for station blackout and the establishment of a reliability program for attaining and maintaining source target reliability levels. Determination of station blackout coping time is reviewed in detail in SRP Section 8.4.

Except for passive reactor designs described in the acceptance criteria of SRP 8.3.1 subsection II.4.J above, new applications should provide an adequate AAC source of diverse design (with respect to onsite ac emergency sources) that is consistent with the guidance in Regulatory Guide 1.155 and capable of powering at least one complete set of normal safe shutdown loads. These issues are reviewed in detail under SRP Section 8.4.

9. 10 CFR 50.65, Section 50.65(a)(4), as it relates to the requirements to assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. Acceptance is based on meeting the following specific guidelines:
 - A. Regulatory Guide 1.160, as it relates to the effectiveness of maintenance activities for onsite emergency ac power sources including grid-risk-sensitive maintenance activities (i.e., activities that tend to increase the likelihood of a plant trip, increase loss of offsite power (LOOP) frequency, or reduce the capability to cope with a LOOP or station blackout (SBO)).
 - B. Regulatory Guide 1.182, as it relates to implementing the provisions of 10 CFR 50.65 (a)(4) by endorsing Section 11 to NUMARC 93-01, "Nuclear Energy Institute Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, February 22, 2000.
10. 10 CFR 50.55a(h) as it relates to protection systems for plants with construction permits issued after January 1, 1971, but before May 13, 1999, which must meet the requirements stated in either IEEE Std. 279, "Criteria for Protection Systems for Nuclear Power Generating Stations," or IEEE Std. 603-1991, "Criteria for Safety Systems for

Nuclear Power Generating Stations,” and the correction sheet dated January 30, 1995. For nuclear power plants with construction permits issued before January 1, 1971, protection systems must be consistent with their licensing basis or may meet the requirements of IEEE Std 279-1971. Nuclear power plants with applications filed on or after May 13, 1999 for preliminary and final design approvals (10 CFR Part 52, Appendix O), design certification, construction permits, operating licenses, and combined licenses that do not reference a final design approval or design certification, must meet the requirements for safety systems in IEEE Std 603-1991 and the correction sheet dated January 30, 1995.

Branch technical positions and industry standards that are acceptable to the staff for implementing the requirements of GDCs 2, 4, 5, 17, 18, and 50 are identified in SRP Section 8.1, and Table 8.1. In addition, 10 CFR 50.34(f)(2)(v), (xiii), and (xx), related to Task Action Plan items I.D.3, II.E.3.1 and II.G.1 of NUREG-0718 and NUREG-0737, provide additional guidance for the reviewer.

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 2 requires that nuclear power plant SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquake, tornado, hurricane, flood, tsunami, or seiche without loss of capability to perform their intended safety function.

With regard to the ac power system, this criterion requires that the onsite ac power system be designed to withstand the effects of natural phenomena without loss of capability to perform its safety functions with appropriate consideration of the most severe natural phenomena that have been historically reported for the site and surrounding area. Therefore, the ac power system and its components should normally be located in seismic Category I structures that provide protection from the effects of tornadoes, tornado missiles, and floods. Equipment and components comprising the onsite ac power system should also generally be seismically designed and/or qualified to perform their functions in the event of an earthquake.

Meeting this requirement will provide assurance that equipment and structures will be designed to withstand the effects associated with natural phenomena, thus decreasing the probability that seismically- and/or climatology-related natural phenomena could initiate accidents or prevent equipment from performing its safety function during an accident.

2. Compliance with GDC 4 requires that SSCs important to safety (a) be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and (b) be appropriately protected against dynamic effects, including the effects of missiles, that may result from equipment failures.

The ac power system is necessary to provide power to systems important to safety during normal, abnormal, accident, and postaccident conditions.

Meeting these requirements will provide assurance that the ac power system will supply electric power necessary for operation of systems important to safety even if/when subject to adverse environmental conditions and/or dynamic effects.

3. Compliance with GDC 5 requires that SSCs important to safety not be shared among nuclear power units, unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

Accordingly, component parts of the ac power system should not be shared among units without sufficient justification, thereby ensuring that an accident in one unit of a multiple-unit facility can be mitigated using an available compliment of mitigative 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. SRP Section 8.3.1 cites Regulatory Guides 1.32 and 1.81 to establish acceptable guidance related to the sharing of SSCs of the preferred offsite and onsite power systems. [Sharing of onsite ac electric power systems and components is no longer recommended per Regulatory Guide 1.81. (For new plants, sharing of diesel generators between units is not recommended.)]

Meeting the requirements of GDC 5 provides assurance that an accident within any one unit of a multiple-unit plant may be mitigated irrespective of conditions in other units without affecting the overall operability of the offsite and onsite power systems.

4. 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 assure 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 further requires that electric power from the transmission network to the onsite electric distribution system be supplied by two physically independent circuits designed and located so as to minimize the likelihood of their simultaneous failure under operating, postulated accident, and postulated environmental conditions. Each of these circuits is required to be designed to be available in sufficient time following a loss of all onsite ac power supplies and the other offsite electric power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. One of these circuits is also required to be designed to be available within a few seconds following a LOCA to assure that core cooling, containment integrity, and other vital safety functions are maintained.

GDC 17 requirements for the interface between the onsite ac power system and the offsite power system in evolutionary light water reactor design applications are documented in SECY-91-078, which states that the design should include at least one offsite circuit to each redundant safety division that is supplied directly from an offsite power source with no intervening non-safety buses, thereby permitting the offsite source to supply power for safety buses in the event the non-safety bus(es) fails. The design should also include an alternate offsite power source to non-safety loads, unless it can be demonstrated that existing design margins will ensure that transients for loss of non-safety power events are no more severe than those associated with the turbine-trip-only event specified in current plant designs.

As documented in SECY-94-084 & SECY-95-132, the staff addressed technical issues associated with the RTNSS process in passive plant designs. Risk-important, non-safety-related, active systems in passive light water reactors may have a significant role in accident and consequence mitigation by providing defense-in-depth functions to supplement the capability of the safety-related passive systems. Certified passive designs should demonstrate how the RTNSS evaluation process addresses the resolution of design issues, in accordance with SECY-94-084, SECY-95-132, and Regulatory Guide 1.206 Section C.IV.10. Subsequent COL applications could then reference the RTNSS evaluation in the applicable existing certified design control documents to demonstrate compliance with design requirements for passive design power systems as described in Section C.III.1 of Regulatory Guide 1.206. Further detailed information and guidance on electrical design for passive COL applications is provided in Section C.III.1.8.3.1 of Regulatory Guide 1.206, SECY-94-084, and SECY-95-132.

The COL applicant should submit a reliability assurance program describing the reliability assurance activities it will perform before the initial fuel load. The program should maintain the reliability objectives consistent with the PRA assumptions designed into the plant. Reliability assurance activities for the operating stage are integrated into existing programs (e.g., maintenance rule, surveillance testing, inservice inspection, inservice testing, and quality assurance). Further detailed information and guidance on reliability assurance programs for passive COL applications are provided in Section C.III.17.4 of Regulatory Guide 1.206, SECY-94-084, and SECY-95-132.

Provisions should also be included 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. The trip of the nuclear power unit is an anticipated operational occurrence that can result in reduced switchyard voltage, potentially actuating the plant's degraded voltage protection and separating the plant's safety buses from offsite power. It can also result in grid instability, potential grid collapse, inadequate switchyard voltages, and a subsequent LOOP due to loss of the real and/or reactive power support supplied to the grid from the nuclear unit. Plant technical specifications (TS) limiting conditions for operation (LCO) require the offsite power system to be operable. However, since the capability of the offsite power system cannot be tested except when challenged during an actual event, the design bases for the offsite power system can only be assured through analysis of the grid and plant

conditions. Plant operators should therefore be aware of: (1) the capability of the offsite power system to supply power, as required by TS, during operation and (2) situations that can result in a LOOP following a trip of the plant. Additional information on the adequacy of grid voltage, grid stability and grid reliability challenges due to deregulation of the utility industry, and the effect of grid events on nuclear power plant (NPP) performance, are provided in References 7, 13, and 38.

GDC 17 also requires that the onsite power supplies and the onsite electrical distribution system have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure. Therefore, no single failure will prevent the onsite power system from supplying electric power, thereby permitting safety functions and other vital functions needing electric power to be performed in the event of any single failure in the power system. Guidance on the application of the single-failure criterion is provided in Regulatory Guide 1.53, with applicability as established in 10 CFR 50.55a(h).

SRP Section 8.3.1 cites Regulatory Guides 1.6, 1.9, 1.32, 1.75, 1.153, and 1.155, and NUREG/CR-0660 as establishing acceptable guidance for meeting the requirements of GDC 17.

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 design basis accidents to permit safety functions and other vital functions to be performed, even in the event of a single failure.

5. Compliance with GDC 18 requires that electric power systems important to safety be designed to permit appropriate periodic inspection and testing of important areas and features to assess the continuity of the systems and the condition of their components. These systems shall be designed with a capability to test periodically: (1) the operability and functional performance of the components of the systems, such as onsite power sources, relays, switches, and buses, and (2) the operability of the systems as a whole and, under conditions as close to design as practical, the full operational 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.

Accordingly, the ac power system should provide the capability to perform integral testing of Class 1E systems on a periodic basis. Regulatory Guides 1.9, 1.32, 1.47, 1.118, and 1.153 and Branch Technical Position 8-5 are cited in SRP Section 8.3.1 as establishing acceptable guidance for meeting the requirements of this criterion.

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.

6. GDCs 33, 34, 35, 38, 41, and 44 set forth requirements for the safety systems for which the access to both offsite and onsite power sources must be provided. Accordingly, capability should be provided for reactor coolant makeup during small breaks, residual heat removal, emergency core cooling, containment heat removal, containment atmosphere cleanup, and cooling water for SSCs important to safety. These systems should be available during normal and accident conditions, as necessary for the specific system.

GDCs 33, 34, 35, 38, 41, and 44 require safety system redundancy such that, for onsite power system operation (assuming offsite power is unavailable), the system safety function can be accomplished, assuming a single failure. Redundancy must be reflected in the standby power system with regard to both power sources and associated distribution systems. Also, redundant safety loads should be distributed between redundant distribution systems, and the instrumentation and control devices for the Class 1E loads and power system should be supplied from associated redundant distribution systems. For the ac power system, these requirements are met if the minimum design required by GDC 17 is provided.

Meeting these criteria as encompassed by GDC 17 provides assurance that necessary electric power will be provided for all facility operating modes, including transients and design basis accidents so that the safety functions required by these criteria may be performed, even in the event of any single failure.

7. Compliance with GDC 50 requires that the reactor containment structure, including access openings, penetrations, and containment heat removal systems, be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any LOCA. Accordingly, containment electric penetrations should be designed to accommodate, without exceeding their design leakage rate, the calculated pressure and temperature conditions resulting from a LOCA. In addition, the penetration conductors should be able to withstand all ranges of over load and short circuit currents up to the maximum fault current vs time conditions that could occur given single random failures of circuit protective devices.

This criterion, as it applies to this SRP section, relates specifically to ensuring the integrity of containment electrical penetrations in the event of design basis LOCA conditions. SRP Section 8.3.1 cites Regulatory Guide 1.63 and the industry standards, IEEE Std 317 and IEEE Std 741, for electric penetration design and protection, respectively, as guidance acceptable to the staff for meeting the requirements of this criterion.

Meeting the requirements of GDC 50 provides assurance that a LOCA will not cause a containment structure, including its electrical penetrations, to exceed the design leakage rate, thus limiting the consequences of a LOCA.

8. Compliance with 10 CFR 50.63 requires that each light-water-cooled nuclear power plant be able to withstand for a specified duration and recover from a station blackout. As required by 10 CFR 50.63, electrical systems that are necessary support systems for station blackout provide sufficient capacity and capability to ensure that core cooling and appropriate containment integrity are maintained in the event of a station blackout. One acceptable means of complying with 10 CFR 50.63 requirements involves the provision of an alternate ac (AAC) source (as defined in 10 CFR 50.2) of sufficient capacity, capability, and reliability for operation of all systems necessary for coping with station blackout and for the time necessary to bring and maintain the plant in safe shutdown that will be available on a sufficiently timely basis.

Also pursuant to 10 CFR 50.63, through citation of the definition of AAC source in 10 CFR 50.2, there should be minimum potential for common mode failure (i.e., acceptable independence) between any AAC power source used for station blackout and the offsite power system or onsite power sources. Electrical ties between these systems, as well as the physical arrangement of their interface equipment, should not prevent the use of any AAC power source during loss of the offsite power system and/or onsite power sources. It is also important that provisions for an AAC source not adversely affect performance of offsite or onsite power system functions. AAC power sources located at or near the plant should conform to guidance provided in Regulatory Guide 1.155 concerning their capacity, capability, and physical independence from onsite safety-related systems and the preferred power system. See SRP Section 8.4 for details of the review of AAC power sources for SBO.

As specified in 10 CFR 50.63, the reliability and redundancy of emergency onsite ac power sources must be used as a factor in determining the duration for which the plant must be capable of coping with a station blackout event. A reliability program should also be provided to attain and maintain the target reliability levels of emergency onsite ac sources with respect to station blackout considerations. Regulatory Guides 1.9 and 1.155, and SRP Section 8.4 describe guidance acceptable to the staff for meeting the requirements of 10 CFR 50.63 related to addressing emergency onsite ac source reliability for station blackout. Determination of station blackout coping time is reviewed in detail in SRP Section 8.4.

As documented in SECY 94-084, the electrical distribution system for evolutionary light water reactor design plants should include: 1) an alternate offsite power source available for non-safety-related loads, unless the design margins for loss of non-safety-related loads are no more severe than turbine-trip-only events in current plants, and 2) at least one offsite circuit to each redundant safety division supplied directly from offsite power sources, with no intervening non-safety-related buses.

For passive reactor design applications, such as the AP1000, the potential risk contribution of a station blackout is minimized by not needing ac power sources for design-basis events. The safety-related passive systems in these plants do not need any ac power sources to perform safety-related functions. They are designed to automatically establish and maintain safe shutdown conditions after design basis events for 72 hours, without operator action, following a loss of both onsite and offsite ac power

sources. Consequently, a passive reactor design meets the requirements of 10 CFR 50.63 if it can establish and maintain safe shutdown conditions for the specified duration of the station blackout event, without operator action, following a loss of both onsite and offsite ac power sources.

Detailed reviews to verify that evolutionary and passive ALWR design applications satisfy the requirements of 10 CFR 50.63 are covered in SRP Section 8.4, "Station Blackout."

Meeting the requirements of 10 CFR 50.63 provides assurance that the nuclear power plant will be able to withstand or cope with, and recover from, an SBO and will ensure that core cooling and appropriate containment integrity are maintained.

9. 10 CFR 50.65 (a)(4) requires that licensees assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. Grid stability and offsite power availability are examples of emergent conditions that may result in the need for action prior to the conduct of the assessment or that could change the conditions of a previously performed assessment. Accordingly, licensees should perform grid reliability evaluations as part of the maintenance risk assessment before performing "grid-risk-sensitive" maintenance activities (such as surveillances, post-maintenance testing, and preventive and corrective maintenance). Such activities are those which could increase risk under existing or imminent degraded grid reliability conditions, including (1) conditions that could increase the likelihood of a plant trip, (2) conditions that could increase the likelihood of a LOOP or SBO, and (3) conditions that could have an impact on the plant's ability to cope with a LOOP or SBO, such as out-of-service risk-significant equipment (for example, an emergency diesel generator (EDG), a battery, a steam-driven pump, or an AAC power source).

III. REVIEW PROCEDURES

The primary objective in the review of the ac power system is to determine that this system satisfies the acceptance criteria stated in subsection II and will perform its design functions during plant normal operation, anticipated operational occurrences, accident conditions, and post-accident conditions. To ensure that acceptance criteria stated in subsection II are satisfied, the review is performed as detailed below.

The primary reviewer will coordinate this review with the other branch areas of review as stated in subsection I. The primary reviewer obtains and uses such input as necessary to ensure that this review procedure is complete.

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.

1. System Redundancy Requirements

GDCs 33, 34, 35, 38, 41, and 44 set forth requirements with regard to the safety systems that must be supplied by the onsite ac power system. Also, these criteria state that safety system redundancy should be such that, for onsite power system operation (assuming offsite power is not available), the system safety function can be accomplished assuming a single failure. The acceptability of the onsite power system with regard to redundancy is based on conformance to the same degree of redundancy of safety-related components and systems required by these GDCs. As endorsed by Regulatory Guide 1.153, IEEE Std 603 provides criteria used to evaluate all aspects of the electrical portions of safety-related systems and the onsite power system, including criteria addressing redundancy, and IEEE-279 provides criteria for protection systems, with applicability determined by the date of issuance of the construction permit (CP) as described in 10 CFR 50.55a(h). The descriptive information, including electrical single-line diagrams, physical arrangement drawings, and electrical control and schematics, is reviewed to verify that this redundancy is reflected in the standby power system with regard to both power sources and associated distribution systems. Also, it is verified in coordination with other branches that redundant safety loads are distributed between redundant distribution systems and that the instrumentation and control devices for the Class 1E loads and power system are supplied from the related redundant distribution systems.

2. Conformance with the Single Failure Criterion

As required by GDC 17, the onsite ac power system must be capable of performing its safety function assuming a single failure.

In evaluating the adequacy of this system in meeting the single failure criterion, both electrical and physical separation of redundant power sources and distribution systems, including their connected loads, are reviewed to assess the independence of redundant portions of the system.

To ensure electrical independence, the design criteria, analyses, description, and implementation as depicted on functional logic diagrams, electrical single-line diagrams, and electrical control and schematics are reviewed to determine that the design meets the recommendations set forth in IEEE Std 308 and satisfies the positions of Regulatory Guide 1.6. As endorsed by Regulatory Guide 1.153, IEEE Std 603 provides criteria used to evaluate all aspects of the electrical portions of safety-related systems and the onsite power system, including basic criteria for addressing single failures, and IEEE-279 provides criteria for protection systems with applicability determined by the date of issuance of the CP as described in 10 CFR 50.55a(h). Additional guidance in evaluating this aspect of the design is derived from IEEE Std 379, "Guide for the Application of the Single-Failure Criterion to Nuclear Power Generating Station Protection Systems," as augmented by Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems." Other aspects of the design where special review attention is given to ascertain that the electrical independence and physical separation has not been compromised are as follows:

- A. Should the proposed design provide for sharing of the onsite ac power system between units at the same site, the criteria of IEEE Std 308 governing the sharing of this system between units are not specific enough to be used as the basis for assessing the adequacy of the design in meeting the requirements of GDC 5 and satisfying the single failure criterion. Therefore, the acceptability of such a design is determined by reviewing the proposed system design criteria and electrical schematics as well as analyses substantiating the adequacy of the design to withstand the consequences of electrical faults and failures in one unit with respect to the others. Generally, the reviewer is guided by Position C.2 of Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," for CP applications docketed before June 1, 1973. Position C.3 of this Regulatory Guide does not recommend the sharing of onsite power systems between nuclear units for construction permit applications docketed after June 1, 1973. Further details of the review with regard to Position C.2 on sharing of the onsite power system between units are covered in item 4, below. [For new plants, sharing of diesel generators between units is not recommended.]
- B. The interconnections between redundant load centers through bus tie breakers and multi-feeder breakers used to connect extra redundant loads to either of the redundant distribution systems are examined to ensure that no single failure in the interconnections will cause the paralleling of the standby power supplies. To ensure this, the control circuits of the bus tie breakers or multi-feeder breakers should preclude automatic transferring of load centers or loads from the designated supply to the redundant counterpart upon loss of the designated supply (Position D.4 of Regulatory Guide 1.6). Regarding the interconnections through bus tie breakers, an acceptable design should provide for two tie breakers connected in series and physically separated from each other in accordance with the acceptance criteria for separation of the onsite power system, which is discussed below. Further, the interconnection of redundant load centers should be accomplished only manually. With respect to the interconnections through the multi-feeder breakers supplying power to extra redundant loads, the review relates to the use of the extra redundant unit as one of the necessary operating units (if the substituted-for-normal unit is inoperable). If this is the selected mode of operation prior to an accident concurrent with the loss of offsite power, it is verified by reviewing the breaker arrangement and associated control circuits to ensure that no single failure in the feeder breaker that is not connected to the extra redundant unit could cause the closing of this breaker, resulting in the paralleling of the power supplies. To ensure against compromising the independence of the redundant power systems in this situation, an acceptable design for connecting extra redundant loads to either distribution system should provide for at least dual means for connecting and isolating each load from each redundant bus. Such a design should also meet the acceptance criteria for electrical and physical separation of the onsite power system.

In addition, the provisions of the design to automatically break all the interconnections (e.g., open tie and multi-feeder breakers) of redundant load centers immediately following an accident condition concurrent with the LOOP are reviewed to ascertain that the independence of the redundant portions of this system is established given a single failure.

Operating experience has shown that potential single failure and fire vulnerabilities may exist whereby a circuit failure could result in safety bus lockouts and prevent reenergization of the redundant safety bus (see Reference 12). Certain safety bus protection schemes involving three current transformers for individual phase overcurrent relays and a ground overcurrent relay connected in a basic residual scheme were identified, which also included connection to a single common watt-hour meter summing the power for redundant safety buses. A fire-induced fault or watt-hour meter failure resulting in an open circuit could be interpreted by the bus differential protection system as an electrical fault on both safety buses causing in multiple bus lockouts. The reviewer should examine the electrical protection and metering schemes to verify that no such interconnections exist between protection and metering circuits that would constitute a common-mode failure vulnerability.

- C. To ensure physical independence, the criteria governing the physical separation of redundant equipment, including cables and raceways and their implementation as depicted on preliminary or final physical arrangement drawings, are reviewed to determine that the design arrangements satisfy the recommendations set forth in IEEE Std 384 as augmented by Regulatory Guide 1.75. This standard and regulatory guide set forth acceptance criteria for the separation of circuits and electrical equipment contained in or associated with the Class 1E power system. To determine that the independence of the redundant cable installation is consistent with satisfying the recommendations set forth in IEEE Std 384 as augmented by Regulatory Guide 1.75, the proposed design criteria governing the separation of Class 1E cables and raceways are reviewed, including such criteria as those for cable derating; raceway filling; cable routing in containment, penetration areas, cable spreading rooms, control rooms, and other congested areas; sharing of raceways with non-safety-related cables or with cables of the same system or other systems; prohibiting cable splices in raceways; control wiring and components associated with Class 1E electric systems in control boards, panels, and relay racks; and fire barriers and separation between redundant raceways.

Operating experience, as documented in Generic Letter (GL) 2007-01, has shown that undetected degradation of electric cables due to protracted exposure to wetted environments or submergence in water or resulting from pre-existing manufacturing defects could result in multiple equipment failures. The reviewer should verify that underground or inaccessible power and control cable runs that are susceptible to protracted exposure to wetted environments or submergence as a result of tidal, seasonal, or weather event water intrusion are adequately identified, that they are monitored, or that corrective actions are implemented. Underground or inaccessible power cables connecting offsite power to safety

buses or power cables to equipment with accident mitigating functions should be considered in the review. Examples of submerged and wetted underground cable failures from the operating experience are provided in Information Notice (IN) 2002-12 and GL 2007-01.

3. Onsite and Offsite Power System Independence

In ascertaining the independence of the onsite power system with respect to the offsite power system, the electrical ties between these two systems as well as the physical arrangement of the interface equipment are reviewed to ensure that no single failure will prevent the separation of the redundant portions of the onsite power system from the offsite power system when necessary. The scope of the review for independence extends from the supply breakers connected to the low side of the unit auxiliary transformers and startup transformers (referred to as the offsite or preferred power supplies) to the station safety-related distribution system. The number and capability of electrical circuits from the offsite power system to the safety buses should be consistent with satisfying the requirements of GDC 17. Then, downstream of the offsite power breakers at the safety buses, the design must satisfy the requirements for redundancy and independence of GDCs 34, 35, 38, 41, and 44; that is, for onsite power system operation (assuming offsite power is not available), the system safety function can be accomplished assuming a single failure.

To determine that the physical independence of the preferred power circuits to the Class 1E buses is consistent with satisfying the requirements of GDC 17 and the recommendations of IEEE Std 308, the physical arrangement drawings are examined to verify that each circuit is physically separate and independent from its redundant counterparts. In addition, the final feeder-isolation breaker in each circuit through which preferred power is supplied to the safety buses should be designed and physically separated in accordance with the criteria for the onsite power system. Following the loss of preferred power, the safety buses are powered solely from the standby power supplies. Under this situation, the design of the feeder-isolation breaker in each preferred power circuit should preclude the automatic connection of preferred power to the respective safety bus upon the loss of standby power. In this regard, an acceptable design should include the capability for restoring preferred power to the respective safety bus by manual actuation only.

The staff has determined that supplying power to the Class 1E buses from offsite power sources through non-Class 1E buses, or from a common winding to that supplying non-Class 1E loads, is not the most reliable configuration. Such configurations make it difficult to obtain suitable voltage regulation at the Class 1E buses and subject the Class 1E loads to transients caused by non-Class 1E loads (e.g., Reactor Coolant Pump). Such configurations could also result in additional failure points between the offsite power source and the Class 1E buses/loads. Therefore, the staff has concluded that the design should include at least one offsite circuit supplied directly to each redundant safety division from one of the offsite power sources with no intervening non-safety buses in such a manner that the offsite source can power the safety buses in the event of failure of any non-safety bus.

In plants where there is no alternate source to supply power to balance of plant loads such as Reactor Coolant Pumps, Reactor Recirculation Pumps, Feedwater Pumps, etc.; the loss of power to these loads due to a plant trip or a 100% load rejection caused by the opening of the main generator high-side circuit breaker will result in a loss of forced circulation in the reactor coolant system and reduced feedwater flow. Therefore, the electrical drawings should also be examined to ensure that the design includes an alternate power source for non-safety loads, unless it has been demonstrated that the design margins will result in transients for loss-of non-safety-power events that are no more severe than those associated with the turbine-trip-only event in existing plant designs.

As documented in SECY-91-078, evolutionary light water reactor design applications should satisfy the requirements of GDC 17 with an electrical distribution system design that includes at least one offsite circuit to each redundant safety division supplied directly from one of the offsite power sources with no intervening non-safety buses in such a manner that the offsite source can power the safety buses upon the failure of any non-safety bus. Aside from this configuration variation, the review to ascertain the independence of the onsite with respect to the offsite power systems is similar to that for existing plant designs.

Passive light water reactor design applications provide passive safety systems that do not need Class 1E ac electric power, other than that provided by the Class 1E dc batteries and their inverters, to accomplish the plant's safety-related functions for 72 hours. However, as documented in SECY 94-084, SECY-95-132, and Regulatory Guide 1.206 Section C.IV.10, the staff addressed technical issues associated with the RTNSS process in passive plant designs for risk-important, non-safety-related, active systems, such as the ac power system. These systems may have a significant role in accident and consequence mitigation by providing defense-in-depth functions to supplement the capability of the safety-related passive systems. Passive reactor plant designs should, therefore, include one offsite power source with sufficient capacity and capability from the transmission network to power the safety-related systems and all other auxiliary systems under normal, abnormal, and accident conditions. The offsite power source should be designed to minimize to the extent practical the likelihood of its failure under normal, abnormal, and accident conditions. The design review should therefore address the independence of the offsite power system with regard to the onsite ac power criteria to support those risk-important, non-safety-related, active systems identified through the RTNSS process.

Certified passive designs should demonstrate how the RTNSS evaluation process addresses the resolution of design issues, in accordance with SECY-94-084 & SECY-95-132. Subsequent COL applications could then reference the RTNSS evaluation in the applicable existing certified design control documents to demonstrate their compliance with design requirements for passive design power systems as described in Section C.III.1 of Regulatory Guide 1.206. Further detailed information and guidance on electrical design for passive COL applications are provided in Section C.III.1.8.3.1 of Regulatory Guide 1.206, SECY-94-084, and SECY-95-132.

The COL applicant should submit a reliability assurance program describing the reliability assurance activities it will perform before the initial fuel load. This program should maintain the reliability objectives consistent with the PRA assumptions designed

into the plant. Reliability assurance activities for the operating stage are integrated into existing programs (e.g., maintenance rule, surveillance testing, inservice inspection, inservice testing, and quality assurance). Further detailed information and guidance on reliability assurance programs for passive COL applications are provided in Section C.III.17.4 of Regulatory Guide 1.206, SECY-94-084, and SECY-95-132.

The reviewer verifies that adequate provisions are made in the design of the onsite power systems for grounding, surge protection, and lightning protection. The reviewer evaluates onsite power system grounding, ground fault current limiting features, lightning/transient surge protection features, and measures for isolation of instrumentation grounding systems. Regulatory Guide 1.204 and IEEE Stds 665, 666, 1050, and C62.23, which the regulatory guide endorses, provide acceptable guidelines for the design, installation, and performance of lightning protection systems. Guidance with respect to grounding system design and analysis criteria for COL applications that are not based on certified ALWR designs is provided in Regulatory Guide 1.206, Section C.I.8.3.1, and for those COL applications based on certified designs, in Regulatory Guide 1.206, Section C.III.1 Chapter 8. Detailed review of grounding and lightning protection for the generating station and offsite power system is provided in SRP Section 8.2.

Variations in voltage, frequency and waveform (harmonic distortion) in the onsite power system and its components during any mode of plant operation should not degrade the performance of any safety system load below an acceptable level. IEEE Std 308 and other industry standards (Reference 60), and Regulatory Guide 1.206, Section C.I.8.3.1, for COL applications that are not based on certified ALWR designs, provide guidance on system power quality limits and the effects of degraded voltage on instrumentation and protection systems. Regulatory Guide 1.206, Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

In assessing the adequacy of the electrical ties between the onsite and offsite power systems, and the capability of the preferred power circuits to deliver power to the safety-related buses, both primary and secondary backup protective relaying schemes and their coordination, relay settings, and assigned control power supplies are reviewed. The reviewer should ensure that, in the event of an electrical fault, between the preferred power transformer supply breakers and the safety buses, no single failure will result in reducing the number of preferred power circuits to less than the minimum necessary for safety or prevent the separation of the affected circuit from the respective redundant portion of the onsite power system. In addition, it is verified that no single protective relay or interlock failure will prevent separation of the necessary redundant portions of the onsite power system from the preferred power system upon loss of the latter. Industry standards (References 47, 48, and 56) and, for COL applications that are not based on certified ALWR designs, Regulatory Guide 1.206, Section C.I.8.3.1.2, provide further information for the reviewer regarding power system analysis studies - including load flow with voltage regulation, short circuit analysis, equipment sizing studies, protective relay setting and coordination, motor starting, grounding system design and insulation coordination - to verify the capability of the onsite ac power system

and the interface with the offsite power system. Regulatory Guide 1.206, Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

The analysis of the onsite ac power system should consider the effects of the offsite power system, particularly the grid voltage, on the capability of the onsite system and the response of the undervoltage relaying. The review should ensure that the grid stability analysis considers the effect of grid events on the adequacy of offsite grid voltage available at the plant switchyard. Operating experience has shown that a variety of factors, such as power flow through the transmission grid, reactive power capacity, the plant voltage and frequency protective schemes and setpoints, and weather or temperature conditions in the region, can all affect grid voltage levels and overall stability. Branch Technical Position 8-6 and References 7 and 13 provide information for the reviewer regarding degraded transmission grid voltage and the effects of grid events on grid voltage at the plant switchyard. Detailed review regarding the analysis of grid operating conditions and stability and their potential interactions with the onsite power system is covered in SRP Section 8.2 , "Offsite Power System."

In reviewing the mode of operation where both power systems are being operated in parallel (such is the case during full-load testing of standby power supply diesel generator sets), the interlock scheme, including electrical protective relay coordination and settings, is closely examined to verify that the independence of the necessary redundant portions of the onsite power system is established upon a failure in the offsite power system. The event of concern under this mode of operation is an accident concurrent with a LOOP and a single failure preventing the opening of the feeder-isolation breaker through which the paralleling of the power systems was being accomplished. Because the signal to start the diesel generator sets is normally derived from undervoltage relays, and under this situation the voltage is maintained above the trip relay settings by the diesel generator under test, the remaining redundant diesel generators will not be commanded to start running. Consequently, the added capacity resulting from the connection of non-safety-related loads to the diesel generator under test will cause the tripping of this diesel due to overload or underfrequency. The end result could be the total loss of power to the safety buses. However, this power interruption could be of momentary duration if the remaining redundant diesel generators are commanded automatically to start by undervoltage relay action immediately after total power is lost. The diesel generator under test will be inoperable due to the self-locking feature preventing restarting after an overload or underfrequency trip condition. The reviewer ascertains that the time delay introduced in making power available to the safety buses as a result of this event is within the response time limits assumed in the accident analyses. This should include verification that subsequent failures such as those resulting from improper electrical relaying coordination and self-locking features will not impair the automatic starting of the remaining redundant diesel generators required to meet minimum safety criteria. If the time delay introduced in making power available to the safety buses is not tolerable, it either must be demonstrated that the probability of occurrence of this event is low when compared with the frequency and duration of testing each diesel, or the design must provide diverse automatic signals, other than undervoltage, to ensure the availability of standby power to the safety buses.

After reviewing the parallel operation of the offsite and onsite power systems, the staff found the use of the standby power supply (diesel generator) sets to supply power to the electrical system during peak load demand periods to be problematic. The basis for this conclusion is that the frequent interconnections of the offsite and standby power supplies do not minimize the probability of their coincident loss (GDC 17), nor can the design be made immune to common failure modes (Section 5.2.1(5) of IEEE Std 308). Further details amplifying the basis for this conclusion are included in Branch Technical Position 8-2, which sets forth the basis for not using the diesel generator sets for purposes other than emergency standby power supplies.

Operating experience has provided insights into aging-, operation-, and design-related problems associated with medium-and low-voltage switchgear equipment, electrical buses, and circuit breakers used in the onsite ac power system. These include, but are not limited to:

- bus failures, involving the integrity of bus bar splice joints, torque relaxation, cyclical bus loading, and incipient damage resulting from a high fault current transient/arcing fault explosion, that can lead to a LOOP (Reference 8);
- failures of safety-related circuit breakers due to problems with preventive maintenance programs, circuit breaker lubrication, licensee/vendor interface, control voltage criteria, and review of circuit breaker operating experience (References 5 & 6);
- metal-clad switchgear circuit breaker failure involving an energetic arcing fault fire/explosion that propagated damage to adjacent circuit breaker cubicles and resulted in a LOOP (Reference 9); and
- potential for degradation of switchgear control and protection wiring at the circuit breaker cubicle door hinges that could affect safety equipment function (Reference 10).

The review should verify that medium and low-voltage switchgear, metal-enclosed bus preventive maintenance and performance and condition monitoring activities are evaluated periodically in accordance with the Maintenance Rule and that they incorporate, where practical, the insights of internal and industry-wide operating experience.

4. Standby Power Supplies

The reviewer should ensure that the requirements of GDC 17 and the recommendations of IEEE Std 308 have been met with regard to the standby power supply (diesel generator sets) having sufficient capacity and capability to supply the distribution system loads. In addition, the reviewer should verify that the standby power supply meets the design bases and design criteria, and should have analyses to support the design. Further, the reviewer should verify that the standby power supply has been described and implemented as depicted on electrical drawings and physical arrangement drawings. The diesel generator sets are reviewed to verify that the bases for their

selection satisfy the positions of Regulatory Guide 1.9. Specifically, the reviewer first becomes familiar with the purpose and operation of each safety system, including system component arrangement as depicted on physical arrangement drawings, expected system performance as established in the accident analyses, modes of system operation and their interactions during normal and accident conditions, and interactions between systems. Following this, it is verified that the tabulation of all safety-related loads to be connected to each diesel generator is consistent with the information establishing the safety-related systems and loads and their redundancy. The characteristics of each load (such as motor horsepower, volt-amp rating, in-rush current, starting volt-amps, and torque), the length of time each load is required, and the basis used to establish the power necessary for each safety load (such as motor nameplate rating, pump run-out condition, or estimated load under expected flow and pressure) are used to verify the calculations establishing the combined load demand to be connected to each diesel during the "worst" operating condition. In applying this combined load demand to the selection of each diesel generator capacity, an acceptable design should satisfy Positions C.1.2 and C.1.3 of Regulatory Guide 1.9. Further guidance on the review of capacity, capability and reliability criteria of standby power supplies and onsite power system design analysis studies is provided in industry standards (References 47, 48 and 56) and, for COL applications that are not based on certified ALWR designs, in Regulatory Guide 1.206, Section C.I.8.3.1. Regulatory Guide 1.206, Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

To ensure that each diesel generator is capable of starting and accelerating to rated speed all the connected loads in the necessary sequence and within the minimum time intervals established by the accident analyses, the reviewer examines for each diesel generator the loading profile curves, voltage and frequency recovering characteristic curves, and the response time of the excitation system to load variations. This examination should verify that the capability of each diesel generator to respond to voltage and frequency variations satisfies Position C.1.4 of Regulatory Guide 1.9. In addition, the adequacy of the circuit design for starting and disconnecting and connecting safety loads from and to each diesel generator is checked. This includes a review of the starting initiating circuits; manual and automatic sequential loading and unloading circuits; interrupting capacity of switchgear, load centers, control centers, and distribution panels; grounding criteria; and electrical protective relaying circuits, including their coordination, relay settings, and assigned control power supplies for each load and each diesel generator. In reviewing the criteria governing the design of the thermal overload protection for motors of motor-operated safety-related valves, the reviewer is guided by Regulatory Guide 1.106. Motor starting studies, load flow studies, demand load (bus loading) studies, and short circuit studies should be reviewed in accordance with the guidance provided in industry standards (References 47, 48, and 56) and, for COL applications that are not based on certified ALWR designs, Regulatory Guide 1.206, Section C.I.8.3.1. Regulatory Guide 1.206, Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

Regarding the review of the electrical protective trip circuits of the diesel generator sets, Positions C.1.7 and C.1.8 of Regulatory Guide 1.9 are used as an evaluation guide. The capability of the automatic sequential loading circuits to reset during a sustained

low-voltage condition on the diesel generators is reviewed to ensure that upon restoration of normal voltage, the safety-related loads can be connected in the prescribed sequence. Otherwise, the reconnection of all the loads at the same time could result in an overload condition causing the trip of the respective diesel generator. In ensuring that those safety-related loads being powered through latched-type breakers are capable of being reconnected to their respective buses after restoration of power, the design should provide for resetting the breaker anticycle feature when there is an undervoltage condition. The normal function of this feature is to prevent immediate reclosure of a breaker following a trip.

Where the proposed design provides for the sharing of diesel generators between units at the same site, and connection and disconnection of non-Class 1E loads to and from the Class 1E distribution buses, particular attention is given in the review to ensure that the implementation of such design provisions does not compromise the capacity or capability of the standby power supplies.

Pursuant to GDC 5, diesel generators may not be shared unless it can be shown that the diesel generators are capable of performing all necessary safety functions in the event of an accident in one unit and an orderly shutdown and cooldown of the remaining units. In ensuring that the proposed design for sharing diesel generators between units meets the requirements of GDCs 5 and 17 as supplemented by GDCs 34, 35, 38, 41, and 44 and satisfies the positions of Regulatory Guide 1.9, the reviewer is guided by Regulatory Guide 1.81. This guide sets forth two principal positions. Position C.3 applies to those construction permit applications docketed after June 1, 1973, and does not recommend the sharing of onsite power systems between units. Conformance of the design with Position C.3 is verified by reviewing the descriptive information, including electrical drawings, to ensure that the onsite power system of each unit is electrically independent with respect to the onsite power system of other units.

Position C.2 of Regulatory Guide 1.81 establishes acceptable bases under which sharing of onsite power systems between units is permitted. Conformance with Position C.2 with regard to the adequacy of diesel generator capacity and capability under the sharing mode of operation is verified by following the procedure discussed above for tabulating and summing all loads. In particular, the load tabulation and calculations establishing the diesel generator capacity are examined to ensure that the selected capacity is sufficient to power the minimum engineered safety feature (ESF) loads in any unit and safely shut down the remaining units in the event of an accident in one unit and a single failure or spurious or false accident signal from another unit and loss of preferred power to all the units. In addition, the physical arrangement of instrumentation and control devices on control room panels and consoles in one unit with respect to the other units is examined to ensure that the design minimizes the coordination needed between unit operators to accomplish sharing of the standby power systems.

In the absence of specific criteria in IEEE Std 308 governing the connection and disconnection of non-Class 1E loads to and from the Class 1E distribution buses, the review of the interconnections will consider isolation devices as defined in IEEE Std 384 and augmented by Regulatory Guide 1.75 to determine the adequacy of the design. In ensuring that the interconnections of non-Class 1E loads and Class 1E buses will not

result in the degradation of the Class 1E system, the isolation device through which standby power is supplied to the non-Class 1E load, including control circuits and connections to the Class 1E bus, should be designed to meet Class 1E criteria. Should the standby power supplies not have been sized to accommodate the added non-Class 1E loads during emergency conditions, the design should provide for the automatic disconnection of those non-Class 1E loads upon the detection of the emergency condition. This action should be accomplished whether or not the load was already connected to the power supply. Further, the design must also prevent the automatic or manual connection of these loads during the transient stabilization period subsequent to this event.

The description of the qualification test program (CP stage) and the results of such tests (operating license (OL) stage) for demonstrating the suitability of the diesel generators as standby power supplies are judged to be acceptable if they satisfy the acceptance criteria stated in subsection II. In the event that diesel generators have not been selected for a particular plant, a commitment from the applicant to obtain diesel generators of a design that has been previously qualified for use in nuclear power plant applications, or to perform qualification tests on diesel generators of a new design in accordance with the acceptance criteria, is considered acceptable.

The review of the diesel generator auxiliary systems is reviewed in SRP Sections 9.5.4 through 9.5.8.

To ensure that diesel generator reliability and operation will not be degraded, the reviewer evaluates the diesel generator descriptive information and the results of failure modes and effects analyses in the SAR and, using engineering judgment, verifies the following items:

- A. Provisions have been made in the facility design and in the design and installation of electrical equipment associated with the starting of the diesel generators to minimize engine failure to start on demand due to accumulation of dust and other deleterious material ingested via the ventilation system or generated in the diesel engine room during normal plant operation on the electrical starting equipment (e.g., auxiliary relay contacts, control switches, etc.) panel or individually mounted.
- B. The diesel generator sets are capable of operation at less than full load without degradation of performance or reliability and operating procedures limit no-load operation.
- C. A complete formal training program is provided for all mechanical and electrical maintenance, quality control, and operating personnel, including supervisors who are responsible for the maintenance and availability of the diesel generators.
- D. A preventive maintenance program is provided that encompasses investigative testing of components and a replacement plan as specified in subsection II.

- E. The repair and maintenance procedures provide for a final equipment check, and test procedures provide for returning the diesel engine to automatic standby service and under the control of the control room operator.
- F. Except for sensors and other equipment that needs to be mounted directly on the engine or associated piping, the controls and monitoring instruments are installed on a free-standing, floor-mounted panel located on a vibration-free floor area. If the floor is not vibration free, the panel should be equipped with vibration mounts. In the event that the instruments and controls cannot be removed from the engine skid, due to plant design, the controls and instrumentation should be environmentally qualified for vibration service. Until the environmental qualification of the components is completed, the applicant has implemented an augmented inspection, test, and calibration program. Verify that this program has been adequately described in the SAR.

5. Identification of Cables, Raceways, and Terminal Equipment

The identification scheme used for safety-related cables, raceways, and terminal equipment in the plant and internal wiring in the control boards is reviewed to see that it is consistent with IEEE Std 384 as augmented by Regulatory Guide 1.75. This includes the criteria for differentiating between (a) safety-related cables, raceways, and terminal equipment of different channels or divisions; (b) non-safety-related cable which is run in safety raceways; (c) non-safety-related cable that is not associated physically with any safety division; and (d) safety-related cables, raceways, and terminal equipment of one unit with respect to the other units at a multi-unit site.

6. Auxiliary Supporting Systems/Features

The reviewer will verify the design adequacy of those auxiliary supporting systems identified as being vital to the operation of safety-related loads and systems. IEEE Std 603, as endorsed by Regulatory Guide 1.153, provides criteria used to evaluate all aspects of the instrumentation, control, and electrical portions of auxiliary supporting systems and features, including basic criteria that call for auxiliary supporting systems and features to satisfy the same criteria as the supported safety systems. The reviewer will verify the design adequacy of the instrumentation, control, and electrical aspects of the auxiliary supporting systems and features to ensure that their design conforms to the same criteria as those for the systems that they support.

Hence, the review procedure to be followed for ascertaining the adequacy of these systems and features is the same as that discussed herein for the onsite systems. In essence, the reviewer first becomes familiar with the purpose and operation of each auxiliary supporting system and feature, including its components arrangement as depicted on functional piping and instrumentation diagrams (P&IDs). Subsequently, the design criteria, analyses, and description and implementation of the instrumentation, control, and electrical equipment, as depicted on electrical drawings, are reviewed to verify that the design is consistent with satisfying the acceptance criteria for Class 1E systems. In addition, it is verified that the auxiliary supporting system redundant instrumentation, control devices, and loads are examined to verify that they are powered

from the same redundant distribution system as the system that they support. The reviewer will also verify that the auxiliary supporting systems that are associated with the emergency diesel engine - such as the fuel oil storage and transfer system, cooling water system, starting air system, and lubrication system - are in accordance with the acceptance criteria.

The organization responsible for plant systems reviews the other aspects of the auxiliary supporting systems to verify that the design, capacities, and physical independence of these systems are adequate for their intended functions. Included is a review of the heating, and ventilation, and air conditioning (HVAC) systems identified as necessary to Class 1E systems, such as the HVAC systems for the electrical switchgear and diesel generator rooms. The organization responsible for the review of plant systems will verify the adequacy of the HVAC system design to maintain the temperature and relative humidity in the room necessary for proper operation of the safety equipment during both normal and accident conditions. It will also verify that redundant HVAC systems are located in the same enclosure as the redundant unit they serve or are separated in accordance with the same criteria as those for the systems they support.

7. System Testing and Surveillance

In ensuring that the proposed periodic onsite testing capabilities of the onsite ac power system satisfies the requirements of GDC 18 and the positions of Regulatory Guides 1.9 and 1.118, the descriptive information, functional logic diagrams, and electrical schematics are reviewed to verify that the design has the built-in capability to permit integral testing of Class 1E systems on a periodic basis when the reactor is in operation. Basic criteria relevant to the review of the surveillance and testability of safety-related aspects of the ac power system are also described in IEEE Std 603 as endorsed by Regulatory Guide 1.153.

Operating experience (Reference 4) has revealed numerous instances of inadequacies in the logic functional surveillance testing of safety-related circuits in which the testing procedures did not provide sufficient overlap to completely test multiple logic pathways as required by technical specifications. The reviewer should verify that licensees have compared electrical schematic drawings and logic diagrams for the reactor protection system, EDG load shedding and sequencing, actuation logic for the onsite power system and the standby EDG, and actuation logic for ESF systems against surveillance test procedures to ensure that all portions of the logic circuitry, including the parallel logic, interlocks, bypasses and inhibit circuits, are adequately covered to fulfill the TS requirements. The licensee's review should have included relay contacts, control switches, and other relevant electrical components within these systems, utilized in the logic circuits performing a safety function.

The Maintenance Rule Section 50.65(a)(4) requires that licensees assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. Regulatory Guide 1.182, used as a companion guide to Regulatory Guide 1.160, provides guidance for assessing and managing the increase in risk that may result from maintenance activities and for implementing the optional reduction in scope of SSCs considered in the assessment. The review should

verify that grid reliability evaluations are performed, as part of the maintenance risk assessment required by 10 CFR 50.65 before performing “grid-risk-sensitive” maintenance activities, including, but not limited to, surveillances, post-maintenance testing, and corrective and preventive maintenance. Such activities are those which could increase risk under existing or imminent degraded grid reliability conditions, including: (1) conditions that could increase the likelihood of a plant trip, (2) conditions that could increase the likelihood of LOOP or SBO, and (3) conditions that have an impact on the plant’s ability to cope with a LOOP or SBO, such as out-of-service risk-significant equipment (e.g., an EDG, a battery, a steam-driven pump, and alternate ac power source).

The descriptive information and the design implementation (as depicted on electrical drawings) of the means proposed for automatically indicating at the system level a bypassed or deliberately inoperative status of a redundant portion of a safety-related system are reviewed to ascertain that the design is consistent with Regulatory Guide 1.47 and Branch Technical Position 8-5. This position establishes the basis to be considered in arriving at an acceptable design for the inoperable status indication system.

8. Reliability Program for Emergency Onsite AC Power Sources

Regulatory Guide 1.155 provides guidance for setting minimum reliability goals for emergency onsite ac power sources. Review is conducted in accordance with SRP Section 8.4 to verify that the target reliability for such sources satisfy the positions of Regulatory Guide 1.155. Regulatory Guide 1.155 also recommends that the reliable operation of emergency onsite ac power sources be ensured by a reliability program designed to maintain and monitor the reliability level of each power source over time for assurance that the target reliability levels are being achieved. The reliability program is reviewed to verify its adequacy with respect to station blackout considerations. The reviewer verifies that the reliability program includes provisions that conform with Position C.1.2 of Regulatory Guide 1.155 and Positions C.2.2 and C.2.3 of Regulatory Guide 1.9. The reviewer also verifies that the effectiveness of maintenance activities under the program are monitored in accordance with the Maintenance Rule (10 CFR 50.65) and Regulatory Guide 1.160, including the periodic monitoring of the condition and performance of emergency onsite ac power sources against licensee-established goals, periodic evaluation of performance and condition monitoring activities and associated goals and preventive maintenance activities, evaluation of operating experience, and incorporation of appropriate corrective actions when performance or condition of emergency onsite ac power sources do not meet established goals.

9. Fire Protection for Cable Systems

In ensuring that the requirements of GDC 3 have been met, the organization responsible for plant systems will review the design of the fire stops and seals, including the materials, their characteristics with regard to flammability and fire retardancy, and their fire underwriters rating, in accordance with SRP Section 9.5.1. All cable and cable tray

penetrations through walls and floors, as well as any other types of cable ways or conduits, should have fire stops installed. The reviewer will verify the design adequacy of cable derating and raceway fill to ensure compliance with accepted industry practices.

10. 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.

The onsite power system includes the standby power sources, distribution systems, auxiliary supporting systems, and instrumentation and controls required to supply power to safety-related components and systems. The review of the ac power system for the _____ plant covered the descriptive information, functional logic diagrams, electrical single-line diagrams, preliminary and final physical arrangement drawings, and electrical control and schematics.

The basis for acceptance of the ac power system in this review was conformance of the design criteria and bases to the Commission's regulations as set forth in the GDCs of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDCs 2, 4, 5, 17, 18, and 50. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, "Design Basis for Protection Against Natural Phenomena," with respect to SSCs of the ac power systems being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods by locating the ac power system and components in seismic Category I structures which provide protection from the effects of tornadoes, tornado missiles, and floods. In addition, the ac power system and components have a quality assurance designation of Class 1E.

2. The applicant has met the requirements of GDC 4, "Environmental and Dynamic Effects Design Bases," with respect to SSCs of the ac power system being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, and being appropriately protected against dynamic effects, including the effects of missiles, that may result from equipment failures, by having an adequate plant design and an adequate equipment qualification program.
3. The applicant has met the requirements of GDC 5, "Sharing of structures, systems, and components ," with respect to SSCs of the onsite ac power system. The onsite ac power system and components associated with the multi-unit facility are housed in physically separate seismic Category I structures, are not shared between units, and the applicant has met the positions of Regulatory Guide 1.32, Position C.2.a, and Regulatory Guide 1.81, Positions C.2 and C.3.
4. The applicant has met the requirements of GDC 17, "Electric Power Systems," with respect to the onsite Class 1E ac power system's: (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence and redundancy to perform its safety function assuming a single failure; and (c) 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 or the loss of power from the transmission network. Acceptability was based on the applicant meeting the positions of Regulatory Guides 1.6, 1.9, 1.32, 1.75, 1.153, 1.155, 1.204, and NUREG/CR-0660.
5. The applicant has met the requirements of GDC 18, "Inspection and Testing of Electric Power Systems," with respect to the onsite Class 1E ac power system. The ac power system is designed to be testable during operation of the nuclear power generating station as well as during those intervals when the station is shut down. This meets the positions of Regulatory Guide 1.118.
6. The applicant has met the requirements of GDC 50, "Containment Design Bases," with respect to penetrations containing circuits of the safety and non-safety ac power system. Containment electric penetrations have been designed to withstand all ranges of over load and short circuit currents up to the maximum fault current vs time conditions that could occur given single random failures of protective devices. Also, for each electrical penetration, the applicant has provided redundant circuit breakers/fuses to assure containment integrity. This meets the positions of Regulatory Guide 1.63.
7. The applicant has met the requirements of 10 CFR 50.63, "Loss of All Alternating Current Power," with respect to appropriate use of the redundancy and reliability of emergency onsite ac power sources as factors in determining an appropriate station blackout duration for which the plant should be capable of withstanding or coping with, and recovering from. The applicant has committed to suitable target reliability levels for emergency onsite ac power sources and a program that provides reasonable assurance that reliability targets will be

achieved and maintained. The acceptable program is based on meeting the relevant positions of Regulatory Guides 1.9 and 1.155. The applicant's overall compliance with the requirements of 10 CFR 50.63 is discussed in further detail in Sections 8.2 and 8.4 of the safety evaluation report (SER).

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 following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

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 docketed six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. SRP Section 8.1, Table 8-1, "Acceptance Criteria and Guidelines for Electric Power Systems." (See Table 8-1 for a detailed list of acceptance criteria and guidance references for all SRP Chapter 8 sections, including listing of relevant NRC-endorsed versions of standards)
2. SRP Branch Technical Positions 8-2, 8-5, and 8-6.
3. SRP, Section 8.4, "Station Blackout."
4. NRC Generic Letter 1996-01, "Testing of Safety-Related Logic Circuits," January 10, 1996.
5. NRC Information Notice 98-38, "Metal-Clad Circuit Breaker Maintenance Issues Identified by NRC Inspection," October 15, 1998.
6. NRC Information Notice 99-13, "Insights from NRC Inspections of Low- and Medium-Voltage Circuit Breaker Maintenance Programs," April 29, 1999.

7. NRC Information Notice 2000-06, "Offsite Power Voltage Inadequacies," March 27, 2000.
8. NRC Information Notice 2000-14, "Non-Vital Bus Fault Leads to Fire and Loss of Offsite Power," September 27, 2000.
9. NRC Information Notice 2002-01, "Metal-Clad Switchgear Failures and Consequent Losses of Offsite Power," January 8, 2002.
10. NRC Information Notice 2002-04, "Wire Degradation at Breaker Cubicle Door Hinges," January 10, 2002.
11. NRC Information Notice 2002-12, "Submerged Safety-Related Electrical Cables," March 21, 2002.
12. NRC Information Notice 2005-04, "Single-Failure and Fire Vulnerability of Redundant Electrical Safety Buses," February 14, 2005.
13. NRC Regulatory Issue Summary 2000-24, "Concerns About Offsite Power Voltage Inadequacies and Grid Reliability Challenges Due to Industry Deregulation," December 21, 2000.
14. SECY 90-016, "Evolutionary Light Water Reactor Certification Issues and Their Relationships to Current Regulatory Requirements," January 12, 1990.
15. SECY 91-078, "EPRI's Requirements Document and Additional Evolutionary LWR Certification Issues," 1991. Approved in the SRM of August 15, 1991.
16. SECY 94-084 "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs," dated March 28, 1994.
17. SECY-95-132 "Policy and Technical Issues Associated with the Regulatory Treatment of Non-safety Systems (RTNSS) in Passive Plant Designs." Approved in the SRM of June 28, 1995.
18. NRC Memorandum; From: D. Crutchfield; To: File; Subject: Consolidation of SECY-94-084 and SECY-95-132, July 24, 1995.
19. SECY-05-0227, "Final Rule – AP1000 Design Certification," dated December 14, 2005. Approved in the SRM of December 30, 2005.
20. NRC Regulatory Guide 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6)."
21. NRC Regulatory Guide 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants."
22. NRC Regulatory Guide 1.32, "Criteria for Power Systems for Nuclear Power Plants."

23. NRC Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems."
24. NRC Regulatory Guide 1.53, "Application of the Single Failure Criterion to Safety Systems."
25. NRC Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants."
26. NRC Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems."
27. NRC Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants."
28. NRC Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems."
29. NRC Regulatory Guide 1.153, "Criteria for Safety Systems."
30. NRC Regulatory Guide 1.155, "Station Blackout."
31. NRC Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants."
32. NRC Regulatory Guide 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants."
33. NRC Regulatory Guide 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants."
34. NRC Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition).
35. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License," Revision 1, June 1981.
36. NUREG-0737, "Clarification of TMI Action Plan Requirements," November 1980.
37. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Draft Report for Comment, Section 8.3.1, Appendix I, and Appendix II, April 1996.
38. NUREG-0933, "A Prioritization of Generic Safety Issues," November 2005.
39. NUREG-1462, "Final Safety Evaluation Report C80+," August 1994.
40. NUREG-1503, "Final Safety Evaluation Report ABWR," July 1994.

41. NUREG-1784, "Operating Experience Assessment - Effects of Grid Events on Nuclear Power Plant Performance," December 2003.
42. NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design," September 2004.
43. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," February 1979.
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PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

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