U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR DESIGN

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 consists of the normal preferred power system, the standby ac power supply system, and associated distribution equipment. The integral pressurized-water reactor (iPWR) designed by mPower^{TM}, uses passive safety systems capable of performing their intended safety functions independent of operator action, offsite support, or ac power for up to 72 hours after an initiating event. The main sources of ac power (i.e., either the normal preferred power supplies or standby diesel generators (DGs)) are not needed to shutdown the reactor or accomplish required safety functions.

The mPower^{TM} onsite ac power system includes the following classifications of equipment:

- Safety-related risk-significant (Class 1E) equipment
- Safety-related nonrisk-significant (Class 1E) equipment
- Nonsafety-related risk-significant Regulatory Treatment of Nonsafety Systems (RTNSS) equipment
- Nonsafety-related nonrisk-significant equipment

The mPower^{TM} application will include the classification of SSCs, a list of risk-significant SSCs, and a list of RTNSS equipment. Based on this information, the staff will review according to Design-Specific Review Standard (DSRS) Section 3.2, Standard Review Plan (SRP) Sections 17.4 and 19.3 to confirm the determination of the safety-related and risk-significant SSCs.

Emphasis is placed on confirming the functional adequacy of the safety-related portions of the onsite electric power system and ensuring that these systems have adequate redundancy, independence, and testability in conformance with the current regulatory criteria. Those

ADAMS Accession No. ML12269A010

portions that are not related to safety are reviewed to ensure RTNSS components described above have been properly identified and to determine potential interactions with safety-related portions.

Other standby power sources such as nearby hydroelectric, nuclear, or fossil units 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 DSRS section insofar as they relate to the independence of the onsite power system.

The specific areas of review are as follows:

1. System Redundancy Requirements

   The design of the onsite ac power system is reviewed to determine that an adequate level of redundancy is provided to enable the accomplishment of its safety functions, assuming a single failure. This includes an examination of the onsite ac power system configuration, including the power supplies, power supply feeders, switchgear arrangement, loads supplied from each bus, and power connections to safety-related equipment. In addition, the review should determine if the applicant identified RTNSS functions and availability controls for structures systems and components.

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 safety-related power sources and associated distribution systems are examined to assess the independence of redundant portions of the system. For the mPower™ design, this will include a review of interconnections and physical arrangement of redundant inverters supplying safety loads, buses, buses and loads, and buses and power supplies; physical arrangement of redundant switchgear and power supplies; and criteria and bases governing the installation of electrical cables for redundant power systems.

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 DSRS 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 (LOOP), the independence of the onsite power system is established through prompt opening of isolation-feeder breakers.

4. Alternate AC Power Sources

   The mPower™ design does not require an alternate ac power source to perform safety functions for 72 hours after an initiating event. After 72 hours, nonsafety-related, risk-significant power supplies, such as ancillary DGs or gas turbine generators (GTGs), may be required to meet post-72-hour requirements. Guidance for the review of

nonsafety-related (ancillary) DGs or GTGs, which provide ac power to meet post-72-hour power requirements following an extended loss of all other ac power sources, is provided in DSRS Section 8.4.

Design information and analyses demonstrating the suitability of the DGs or GTGs as alternate ac power supplies are reviewed to ensure that the generators have sufficient capacity, capability, and reliability to perform their intended function. This will include their seismic classification, associated support equipment, electrical bus configuration, and operating requirements. The capability of ancillary DGs to perform their RTNSS function of providing ac power following an extended loss of all other ac power sources (i.e., post-72 hours), is reviewed in DSRS Section 8.4.

5. <u>Identification of Cables, Raceways, and Terminal Equipment</u>

The basis proposed for identifying the onsite ac power system components (e.g., cables, raceways, panels, racks and terminal equipment) identified as safety-related and nonsafety-related risk-significant (RTNSS) is reviewed to ensure they are identified by color-coding, so that their electrical divisional assignment will be apparent and so that an observer can visually differentiate between safety-related equipment and wiring of different divisions, and between safety-related and nonsafety-related equipment and wiring.

Also, the identification scheme used to distinguish between redundant Class 1E systems (safety-related, risk-significant), associated circuits assigned to redundant Class 1E divisions, non-Class 1E systems (nonsafety-related, risk-significant) and their associated cables, raceways, and terminal equipment of the power system is reviewed.

6. <u>Auxiliary Supporting Systems/Features</u>

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. <u>System Testing and Surveillance</u>

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

8. <u>Reliability Program for Emergency Onsite AC Power Sources</u>

Passive designs do not rely on an onsite ac power system to achieve and maintain safe-shutdown. Hence, Regulatory Guide (RG) 1.9 and RG 1.155 criteria regarding a reliability program for emergency onsite ac power source are not applicable. Guidance for the review of nonsafety-related DGs which provide ac power to meet post-72-hour power requirements following an extended loss of all other ac power sources is provided in DSRS Section 8.4.

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. All components of safety-related systems are housed in seismic Category I structures designed to protect them from natural phenomena. RTNSS components, such as alternate ac power sources (e.g., ancillary DGs / GTGs) and their associated auxiliaries, controls, electrical distribution buses, and fuel oil tanks are seismic Category II and are housed in a seismic Category II structure.

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. Safety-related, systems and 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 DSRS 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 DSRS 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 DSRS 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 power sources provided for station blackout (SBO), as part of its primary review responsibility for DSRS Sections 8.2 and 8.4.

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 DSRS Section 8.3.2.

3. Review of the overall compliance with Title 10 of the *Code of Federal Regulations* (CFR), Section 50.63 requirements, as part of its primary review responsibility for DSRS Section 8.4, including the adequacy of the SBO analysis, the adequacy of reliability targets for onsite ac sources (e.g., DGs), the duration for which the plant will be able to withstand or cope with, and recover from, an SBO 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 DSRS Section 8.3.2.

4. Review of the adequacy of the environmental qualification of safety-related electrical equipment as part of its primary review responsibility for DSRS 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).

5. 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 DSRS 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, and ducting, for these heating and ventilation systems are adequate.

6. 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 DSRS Sections 3.4.1, 3.5.1.1, 3.5.2, and 3.6.1.

7. 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 DSRS Sections 9.1.3, , 9.2.1, 9.2.2, 9.2.4, 9.2.5, 9.2.6, 9.3.3, 10.4.5, 10.4.7, and 10.4.9; and SRP Sections 9.1.4 and 9.3.1.

8. 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.

9. 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 DSRS Sections 9.3.2 and 9.3.6, and SRP Section 5.4.8.

10. 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 DSRS 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 DSRS Sections 6.2.2, 6.2.4, and 6.2.5.

11. 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 DSRS Sections 4.6, 5.4.7, and 6.3, and SRP Section 5.4.12.

12. 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 DSRS Chapter 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 DSRS Chapter 7.

13. 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 DSRS Section 14.2.

14. 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.

15. The organization responsible for mechanical engineering review, as part of its primary review responsibility for DSRS 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.

16. The organization responsible for the review of technical specifications coordinates and performs reviews of technical specifications as part of its primary review responsibility for DSRS Section 16.0.

17. 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.

18. The organization responsible for probabilistic risk assessment (PRA) and accident analysis coordinate the risk-significance determination for the reliability/availability requirements for nonsafety-related onsite ac power supplies as affecting the

The specific acceptance criteria and review procedures are contained in the referenced DSRS and 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 between units.

4. GDC 17, as it relates to the onsite ac power systems: (1) capacity and capability to permit functioning of SSCs important to safety; (2) independence, redundancy, and testability to perform its safety function assuming a single failure; and (3) 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 the capability for periodic 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 ac 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 appropriately for the mPower™ design.

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 as factors in limiting the potential for SBO 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).

11. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed 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 facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission's (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 COL, the provisions of the AEA, and the NRC's regulations.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are set forth below. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the requirements in 10 CFR 52.47(a)(9), "Contents of applications; technical information." The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

In general, the onsite ac power system provided for passive plants 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 DSRS Section 8.1 lists GDCs, regulations, RGs, and branch technical positions (BTPs) used as the bases for arriving at this conclusion. GDCs 33, 34, 35, 38, 41, and 44 are not applicable to passive designs having the capability to automatically establish and maintain safe-shutdown conditions after design-basis events

(DBEs) for 72 hours, without operator action, following a loss of both offsite and onsite ac power sources[1].

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 onsite 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 for all new designs (e.g., mPower™) when there is no sharing of safety-related SSCs of the ac power system between units. See the following guidelines:

    A. RG 1.32, as it relates to the sharing of SSCs of the Class 1E power system at multi-unit stations and its specific exclusion of the subject guidelines in IEEE Std. 308.

    B. RG 1.81, as it explicitly excludes the sharing of SSCs of the ac power system, Position D.

4. GDC 17 is satisfied as it relates to the onsite ac power systems: (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence and redundancy in order 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. RG 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. RG 1.32 (see also IEEE Std. 308), as it relates to design criteria for onsite ac power systems.

    C. RG 1.53 (see also IEEE Stds. 279 and 603), as it relates to the application of the single-failure criterion to safety systems.

    D. RG 1.75 (see also IEEE Std. 384), as it relates to the onsite ac power system.

    E. RG 1.153 (see also IEEE Std. 603), as it relates to criteria for electrical portions of safety-related systems.

    F. RG 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.

[1] Refer to SECY-94-084, March 28, 1994 (ADAMS Accession No. ML003708098).

Detailed reviews of the offsite ac power system and its interface with the onsite power system are covered in DSRS 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. RG 1.32 (see also IEEE Std. 308), as it relates to capability for testing of the onsite ac power system.

   B. RG 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. RG 1.118 (see also IEEE Std. 338), as it relates to the capability for testing the onsite ac power system.

   D. RG 1.153 (see also IEEE Std. 603), as it relates to the onsite ac power system.

6. 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 RG 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.

7. 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. RG 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 LOOP frequency, or reduce the capability to cope with an LOOP or SBO).

   B. RG 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.

8. 10 CFR 50.55a(h), as it relates to protection systems must meet the requirements for safety systems in IEEE Std. 603-1991 and the correction sheet dated January 30, 1995.

9. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed 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 facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the AEA, and the NRC’s regulations. The staff’s review of

electrical systems is conducted in accordance with Chapter 14.3.6, “Electrical Systems ITAAC,” of the DSRS.

BTPs 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 DSRS 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 who must determine their applicability to the mPower^{TM} design.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section for passive mPower^{TM} reactor designs 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.

   As applied to mPower^{TM} plants, GDC 2 requires all components of safety-related portions of the onsite ac power system (e.g., safety-related batteries and inverters) to be housed in seismic Category I structures that are designed to protect them from natural phenomena. The environmental qualification of electrical equipment is evaluated in DSRS Section 3.11.

   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 (1) be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and (2) be appropriately protected against dynamic effects, including the effects of missiles, that may result from equipment failures.

   As applied to mPower^{TM} plants, GDC 4 requires SSCs of the safety-related portions of the onsite ac power system (e.g., ac power supplied from safety-related batteries and inverters) to be capable of accommodating environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and be protected against dynamic effects, including the effects of missiles, that may result from equipment failures. The environmental qualification of electrical equipment is evaluated in DSRS Section 3.11.

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

3. Compliance with GDC 5 requires that onsite power system SSCs important to safety not be shared among nuclear power units. 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 (AOOs) and that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

   The COL applicant should submit a reliability assurance program describing the reliability assurance activities it will perform before the initial fuel load. (The design control document (DCD) should include an interface requirement to this effect.) 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 RG 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.

   GDC 17 also requires that the onsite power supplies and the onsite electrical distribution system have sufficient independence and redundancy 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 RG 1.53, with applicability as established in 10 CFR 50.55a (h).

   DSRS Section 8.3.1 cites RGs 1.6, 1.32, 1.75, and 1.153, 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 AOOs 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 onsite ac power system should provide the capability to perform integral testing on a periodic basis. RGs 1.32, 1.47, 1.118, and 1.153 are cited in DSRS 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 electric power sources must be provided. Compliance with these criteria requires that capability be provided for reactor coolant makeup during small breaks (GDC 33), residual heat removal (GDC 34), emergency core cooling (GDC 35), containment heat removal (GDC 38), containment atmosphere cleanup (GDC 41), and cooling water for SSCs important to safety (GDC 44). These systems must be available during normal and accident conditions, as required by each specific GDC.

   For the AP1000 passive reactor design, the potential risk contribution of each DBE was determined to be minimized by not requiring ac power sources for any DBEs. Such passive reactor designs incorporate passive safety-related systems for core cooling and containment integrity, and therefore, do not depend on the electric power grid connection and grid stability for safe operation. They are designed to automatically establish and maintain safe-shutdown conditions after DBEs for the first 72 hours, without operator action, following a loss of both onsite and offsite ac power sources. Consequently, such passive reactor designs are not required to meet the requirements of GDCs 33, 34, 35, 38, 41, and 44 for 72 hours. The reviewer must verify that these design parameters hold true for the mPower™ design when this review commences. If so, no further review of this topic is necessary.

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 DSRS section, relates specifically to ensuring the integrity of containment electrical penetrations in the event of design-basis LOCA conditions. DSRS Section 8.3.1 cites RG 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.

III. REVIEW PROCEDURES

The primary objective in the review of the onsite 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, AOOs, 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 DSRS 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. For new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues that are identified in the version of NUREG-0933 current on the date 6 months before application and that are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). Reference: 10 CFR 52.47(a)(21), 10 CFR 52.47(a)(22), and 10 CFR 52.47(a)(8), respectively. These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.

2. System Redundancy Requirement

   The design of the safety-related ac power system should be consistent with the guidance of RG 1.153 and IEEE Std. 603 as endorsed by RG 1.153. The redundant safety-related loads should be distributed between redundant distribution systems, and power should be supplied from the related redundant distribution systems.

3. Conformance with the Single Failure Criterion

As required by GDC 17, the safety-related portions of 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 RG 1.6. As endorsed by RG 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. 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 RG 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. The proposed design should not provide for sharing of the safety-related portions of the onsite ac power system between multiple modules at the same site.

B. Any 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 RG 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, any interconnection of redundant load centers should be accomplished only manually. With respect to any interconnections through 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 LOOP, 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 such a 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-cause 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 RG 1.75. This standard and RG 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 RG1.75, 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 nonsafety-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.

4. Onsite and Offsite Power System Independence

A. 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, as described in DSRS Section 8.2. To determine that the physical independence of the preferred power circuits to the Class 1E buses is consistent with 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.

B. 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 nonsafety loads, unless it has been demonstrated that the design margins will result in transients for loss-of nonsafety-power events that are no more severe than those associated with the turbine-trip-only event in existing plant designs.

C. The mPower™ reactor design provides 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 RG 1.206, Section C.IV.10, the staff addressed technical issues associated with the RTNSS process in passive plant designs for, nonsafety-related risk-significant, 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, nonsafety-related, active systems identified through the RTNSS process.

D. The mPower™ DCD should demonstrate how the RTNSS evaluation process addresses the resolution of design issues, in accordance with SECY-94-084 and SECY-95-132. Subsequent COL applications could then reference the RTNSS evaluation in the mPower™ design control documents to demonstrate their compliance with design requirements for passive design power systems as described in Section C.III.1 of RG 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 RG 1.206, SECY-94-084, and SECY-95-132.

E. 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 RG 1.206, SECY-94-084, and SECY-95-132.

F. 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. RG 1.204 and IEEE Stds. 665, 666, 1050, and C62.23, which the RG 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 mPower™ COL applications is provided in RG 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 DSRS Section 8.2.

G. 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 RG 1.206, Section C.III.1, Chapter 8, provide guidance on system power quality limits and the effects of degraded voltage on instrumentation and protection systems.

H. 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. BTP 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 DSRS Section 8.2, "Offsite Power System."

I. 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:

i. 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);

ii. 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 and 6);

iii. 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

iv. 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.

5. <u>Standby Power Supplies</u>

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 (DG 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 review should assess the adequacy of physical separation provided for equipment, cabling, and instrumentation essential to plant safety. For the mPower™ design, this includes safety-related low-voltage (120 Vac) systems and equipment. The equipment of each division of the safety-related distribution system should be located in an area separated physically from the other divisions. In addition there should be no provisions which permit the interconnection of the safety-related buses of one division with those of another division or nonsafety-related power. The equipment of each division of the safety-related distribution system should be located in an area separated physically from the other divisions and all components of safety-related ac systems should be housed in seismic Category I structures.

As endorsed by RG 1.32, IEEE Std. 308-2001 describes a method acceptable to the NRC staff for complying with the NRC's regulations for the design, operation, and testing of electric power systems in nuclear power plants. 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 RG 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.

6. <u>Identification of Cables, Raceways, and Terminal Equipment</u>

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 RG 1.75. This includes the criteria for differentiating between (1) safety-related cables, raceways, and terminal equipment of different channels or divisions; 2b) nonsafety-related cable which is run in safety raceways; (3) nonsafety-related cable that is not associated physically with any safety division; and (4) safety-related cables, raceways, and terminal equipment of one unit with respect to the other units at a multi-unit site.

7. <u>Auxiliary Supporting Systems/Features</u>

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 RG 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. 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 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 support Class 1E systems. 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.

8. <u>System Testing and Surveillance</u>

In ensuring that the proposed periodic onsite testing capabilities of the onsite ac power system satisfies the requirements of GDC 18 the descriptive information, functional logic diagrams, and electrical schematics are reviewed to verify that offsite and onsite power systems that supply ac power to SSCs important to safety are testable. Review guidance relevant to the review of the surveillance and testability of safety-related aspects of the ac power system is provided in the guidance of RGs 1.32, 1.47, 1.118, and 1.153, and IEEE Std. 603 as endorsed by RG 1.153.

9. <u>Reliability Program for Emergency Onsite AC Power Sources</u>

10 CFR 50.63, “Loss of All Alternating Current Power,” requires that each light water-cooled nuclear power plant be able to withstand and recover from an SBO (i.e., loss of offsite and onsite emergency ac power systems) for a specified duration. Conformance to 10 CFR 50.63 is generally deemed acceptable if a plant meets the following guidelines:

A. RG 1.9, “Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants.”

B. RG 1.155, "Station Blackout."

The reviewer must verify the design is capable of performing all safety-related functions for 72 hours without an alternate onsite ac power system (DG / GTG). If so, it need not be evaluated for an SBO coping duration, provided the applicant has implemented an appropriate RTNSS process. The 72-hour approach is consistent with the duration approved by the NRC staff for the AP1000 design. Thus, RG 1.155 and RG 1.9 are not applicable to iPWR designs. However, these systems should be reviewed to confirm that they are capable of providing post-72-hour power requirements to onsite loads. Conformance to 10 CFR 50.63 is reviewed in accordance with DSRS Section 8.4.

10. 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 retardance, 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.

11. DC and COL Applications

For review of the mPower™ 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 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 mPower™ DCD.

For review of both DC and COL applications, DSRS 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 SER. 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 and RTNSS components and systems. The review of the ac power system for mPower™ 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, as appropriate.

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 a multi-unit facility are housed in physically separate seismic Category I structures, are not shared between units.

4. The applicant has met the requirements of GDC 17, "Electric Power Systems," with respect to the onsite ac power systems: (1) capacity and capability to permit functioning of SSCs important to safety; (2) independence and redundancy to perform its safety function assuming a single failure; and (3) 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, as appropriate for the passive design, the positions of RGs 1.6, 1.32, 1.75, 1.153, 1.155, and 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 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 shutdown. This meets the positions of RG 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 nonsafety 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 RG 1.63.

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 DSRS section.

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

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower^{TM}-specific DC, or COL, applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower^{TM} and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor reviews, including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower^{TM}-specific DC, or COL submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the Standard Review Plan (SRP) revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9), as long as the mPower^{TM} DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47(a)(9). Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41), for COL applications.

VI. REFERENCES

1. DSRS 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 DSRS Chapter 8 sections, including listing of relevant NRC-endorsed versions of standards)

2. DSRS BTPs 8-2, 8-3, and 8-6.

3. DSRS Section 8.4, "Station Blackout."

4. NRC GL 1996-01, "Testing of Safety-Related Logic Circuits," January 10, 1996.

5. NRC IN 98-38, "Metal-Clad Circuit Breaker Maintenance Issues Identified by NRC Inspection," October 15, 1998.

6. NRC IN 99-13, "Insights from NRC Inspections of Low- and Medium-Voltage Circuit Breaker Maintenance Programs," April 29, 1999.

7. NRC IN 2000-06, "Offsite Power Voltage Inadequacies," March 27, 2000.

8. NRC IN 2000-14, "Non-Vital Bus Fault Leads to Fire and Loss of Offsite Power," September 27, 2000.

9. NRC IN 2002-01, "Metal-Clad Switchgear Failures and Consequent Losses of Offsite Power," January 8, 2002.

10. NRC IN 2002-04, "Wire Degradation at Breaker Cubicle Door Hinges," January 10, 2002.

11. NRC IN 2002-12, "Submerged Safety-Related Electrical Cables," March 21, 2002.

12. NRC IN 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.

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