U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD for NuScale SMR 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 (GDC) 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 the associated distribution equipment. NuScale 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 shut down the reactor or accomplish required safety functions.

The NuScale application will include the classification of structures, systems, and components (SSCs), a list of risk-significant SSCs, and a list of equipment categorized as regulatory treatment of nonsafety systems (RTNSS) equipment. Based on this information, the staff will review the application according to NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Sections 3.2, 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 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 design-specific review standard (DSRS) section, insofar as they relate to the independence of the onsite power system.

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The specific areas of review are as follows:

1. <u>System Redundancy Requirements</u>

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, and 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 SSCs.

2. <u>Conformance with the Single Failure Criterion</u>

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 NuScale design, this will include a review of interconnections and the physical arrangement of redundant inverters supplying safety loads, buses, buses and loads, and buses and power supplies; the physical arrangement of redundant switchgear and power supplies; and criteria and bases governing the installation of electrical cables for redundant power systems.

3. <u>Onsite and Offsite Power System Independence</u>

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 the prompt opening of isolation-feeder breakers.

4. <u>Alternate AC Power Sources</u>

The NuScale 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 standby DGs or gas turbine generators (GTGs), may be required to meet post-72-hour requirements. Guidance for the review of nonsafety-related 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 standby 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. Identification of Cables, Raceways, and Terminal Equipment

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. 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 schemes; 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

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 reliability programs for emergency onsite ac power sources 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., standby 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. Any safety-related or RTNSS 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 SSCs related to this DSRS section, in accordance with SRP Section 14.3.6, “Electrical Systems Inspections, Tests, and Acceptance Criteria,” and 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 Sections 14.3 and 14.3.6.

11. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items, 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 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 direct current (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* (10 CFR) 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 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) 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 air conditioning (HVAC) 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 protection of the ac power system as part of its primary review responsibility for SRP Sections 9.4.1 through 9.4.4. This includes such systems as the HVAC systems provided to maintain a controlled environment for safety-related instrumentation and electrical equipment. In particular, the organization responsible for the review of plant systems determines that the pipes and ducts for these HVAC 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 SRP 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, and 10.4.7 and SRP Sections 9.1.4, 9.2.1, 9.2.2, 9.2.4, 9.2.5, 9.2.6, 9.3.1, 9.3.3 and 10.4.5,.

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 9.5.1.1 and 9.5.1.2. 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 SRP Section 9.3.2 and DSRS Section 9.3.4.

10. The organization responsible for the review of containment systems and severe accidents evaluates the adequacy of those containment ventilation systems provided to maintain 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 5.4.7 and 6.3, and SRP Section 4.6, and 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 the design, construction, and operations phases of 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 the review of mechanical engineering, 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.

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. The

organization responsible for probabilistic risk assessment (PRA) and accident analysis in the review of SRP Chapter 19, coordinates the risk-significance determination for the reliability and availability requirements for nonsafety-related onsite ac power supplies as they affect the overall operability of the offsite and onsite power systems.

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, "Design Bases for Protection Against Natural Phenomena"

2. GDC 4, "Environmental and Dynamic Effects Design Bases"

3. GDC 5, "Sharing of Structures, Systems, and Components"

4. GDC 17, "Electric Power Systems"

5. GDC 18, "Inspection and Testing of Electric Power Systems"

6. GDC 50, "Containment Design Basis"

7. GDC 33, "Reactor Coolant Makeup"; GDC 34, "Residual Heat Removal"; GDC 35, "Emergency Core Cooling"; GDC 38, "Containment Heat Removal"; GDC 41, "Containment Atmosphere Cleanup," and GDC 44, "Cooling Water"

8. 10 CFR 50.63, as it relates to the capability to withstand and recover from an SBO

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 the maintenance activities are performed. 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 that 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. As an alternative, and as described in more detail below, an applicant may identify the differences between a DSRS section and the design features (DC and COL applications only), analytical techniques, and procedural measures proposed in an application and discuss how the proposed alternative provides an acceptable method of complying with the NRC regulations that underlie the DSRS acceptance criteria.

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 GDC 2, 4, 5, 17, 18, and 50, as applicable. Table 8-1 of DSRS Section 8.1 lists GDC, regulations, RGs, and branch technical positions (BTPs) used as the bases for arriving at this conclusion. GDC 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]. In the event supplemental guidance is needed regarding these areas, reviewers should refer to SRP 8.3.1.

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.

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[1] Refer to SECY-94-084, March 28, 1994 (Reference 16).

3. GDC 5 is satisfied for all new designs when there is no sharing of safety-related SSCs of the ac power system between units. A unit for NuScale is expected to contain 12 modular reactors. See the following guidelines as they relate to any Class 1E portions of the onsite ac power system within a unit:

   A. RG 1.32, as it relates to the sharing of SSCs of a Class 1E ac power system at multiunit stations.

   B. RG 1.81, Position C.3, as it explicitly excludes the sharing of SSCs of a Class 1E ac power system.

4. GDC 17 is satisfied as it relates to the onsite ac power systems: (a) capacity and capability to permit the 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. Acceptance is based on meeting the following specific guidelines:

   A. RG 1.6, Positions D.1, D.2, D.4, and D.5, as they relate to the independence of a Class 1E onsite ac power system

   B. RG 1.32 (see also IEEE Std. 308), as it relates to design criteria for a Class 1E onsite ac power system

   C. RG 1.53 (see also IEEE Stds. 279 and 603), as it relates to the application of the single-failure criterion to a Class 1E safety system

   D. RG 1.75 (see also IEEE Std. 384), as it relates to a Class 1E onsite ac power system

   E. RG 1.153 (see also IEEE Std. 603), as it relates to criteria for electrical portions of a Class 1E onsite ac power system

   F. RG 1.204 (see also IEEE Stds. 665, 666, 1050, and C62.23), as it relates to the lightning and surge protection for an onsite ac power system

5. 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." 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 the capability for testing a Class 1E 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 a Class 1E onsite ac power system

D. RG 1.153 (see also IEEE Std. 603), as it relates to a Class 1E 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 (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) is satisfied as it relates to the requirements to assess and manage the increase in risk that may result from proposed maintenance activities before the maintenance activities are performed. Acceptance is based on meeting the following specific guidelines:

   A. RG 1.160, as it relates to the effectiveness of maintenance activities for onsite standby 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 a LOOP or SBO)

   B. Section 11 to NUMARC 93-01, “Nuclear Energy Institute Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” Revision 4A, April 2011.

8. 10 CFR 50.55a(h) is satisfied as it relates to protection systems that 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) 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 SRP Chapter 14.3.6, “Electrical Systems ITAAC.” BTPs and industry standards that are acceptable to the staff for implementing the requirements of GDC 2, 4, 5, 17, 18, and 50 are identified in DSRS Section 8.1, and Table 8.1. Furthermore, 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 should determine their applicability to the NuScale design.

10. 10 CFR 52.80(a) 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.

Technical Rationale

The technical rationale for applying these acceptance criteria to the areas of review addressed by this DSRS section for passive NuScale 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 NuScale plants, GDC 2 requires all components of safety-related portions of the onsite ac power system (e.g., battery chargers and ac power system SSCs supplied from 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 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 NuScale plants, GDC 4 requires SSCs of the safety-related portions of the onsite ac power system (e.g., battery chargers and ac power system SSCs 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 the operation of safety-related, risk-significant systems even if subject to adverse environmental conditions 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 from the nuclear power unit, the transmission network, or 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 practicable, 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 or impending failure under controlled conditions.

6. GDC 33, 34, 35, 38, 41, and 44 do not present a one-to-one correspondence with the system functions appropriate for the NuScale passive design. To the extent that the analogous requisite NuScale system functions require electrical power, these functions must be available during normal and accident conditions.

7. 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 GDC 33, 34, 35, 38, 41, and 44 for 72 hours. The reviewer must verify that these design parameters hold true for the NuScale design when this review begins. If not, no further review of this topic is necessary.

8. 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 overload and short-circuit currents up to the maximum fault current versus 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 normal plant operations, AOOs, accident conditions, and postaccident 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. Selected Programs and Guidance—In accordance with the guidance in NUREG–0800, "Introduction – Part 2: Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: Light-Water Small Modular Reactor Edition" (NUREG-0800, Intro Part 2), as applied to this DSRS Section, the staff will review the information proposed by the applicant to evaluate whether it meets the acceptance criteria described in Subsection II of this DSRS. As noted in NUREG-0800, Intro Part 2, the NRC requirements that must be met by an SSC do not change under the small modular reactor (SMR) framework. Using the graded approach described in NUREG-0800, Intro Part 2, the NRC staff may determine that, for certain SSCs, the applicant's basis for compliance with other selected NRC requirements may help demonstrate satisfaction of the applicable acceptance criteria for that SSC in lieu of detailed independent analyses. The design-basis capabilities of specific SSCs would be verified, where applicable, as part of completing the applicable ITAAC. The use of the selected programs to augment or replace traditional review procedures is shown in Figure 1 of NUREG-0800, Intro Part 2. Examples of such programs that may be relevant to the graded approach for these SSCs include:

   - 10 CFR Part 50, Appendix A, GDC, Overall Requirements, Criteria 1–5
   - 10 CFR Part 50, Appendix B, Quality Assurance (QA) Program
   - 10 CFR 50.49, Environmental Qualification of Electrical Equipment (EQ) Program
   - 10 CFR 50.55a, Code Design, Inservice Inspection, and Inservice Testing (ISI/IST) Programs
   - 10 CFR 50.65, Maintenance Rule requirements
   - Reliability Assurance Program (RAP)
   - 10 CFR 50.36, "Technical Specifications"

- Availability Controls for SSCs Subject to Regulatory Treatment of Nonsafety Systems (RTNSS)

- Initial Test Program (ITP)

- Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

This list of examples is not intended to be all inclusive. It is the responsibility of the technical reviewers to determine whether the information in the application, including the degree to which the applicant seeks to rely on such selected programs and guidance, demonstrates that all acceptance criteria have been met to support the safety finding for a particular SSC.

2. In accordance with 10 CFR 52.47(a)(8), (21), and (22), and 10 CFR 52.79(a)(17), (20), and (37), for DC or COL applications submitted under 10 CFR 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 which are identified in the version of NUREG-0933, "Resolution of Generic Safety Issues," current on the date up to 6 months before the docket date of the application and which 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), for a DC application, and except paragraphs (f)(1)(xii), (f)(2)(ix), (f)(2)(xxv), and (f)(3)(v),for a COL application. 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.

3. <u>System Redundancy Requirement</u>

   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.

4. <u>Conformance with the Single-Failure Criterion</u>

   As required by GDC 17, the safety-related portions of the onsite ac power system must be capable of performing their safety functions, 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 have not been compromised are as follows:

A. The proposed design should not provide for the sharing of 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 multifeeder 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 multifeeder 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 only be accomplished manually. With respect to any interconnections through multifeeder 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 before 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 multifeeder 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 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 RG 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 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 preexisting 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 water intrusion from tidal, seasonal, or weather events 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.

5. <u>Onsite and Offsite Power System Independence</u>

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. In 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.

A. The NuScale 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. Unless a partial exemption from GDC-17 is requested and approved as part of the review, passive reactor plant designs should include two offsite power lines 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 practicable, 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 system to support those risk-important, nonsafety-related, active systems identified through the RTNSS process. If the reviewer verifies that there are no RTNSS loads in the onsite ac power system, this item does not apply.

B. The NuScale 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 NuScale 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 the 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 (References 16 and 17).

C. 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., the 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 (References 16 and 17).

D. 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 and transient surge protection features, and measures for isolating 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 NuScale 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.

E. 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.

F. 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. SRP 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.”

G. 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 the following:

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 or explosion that propagated damage to adjacent circuit breaker cubicles and resulted in a LOOP (Reference 9)

iv. the 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 practicable, the insights of internal and industry-wide operating experience.

6. <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 standby power supplies (e.g., DG sets) having sufficient capacity and capability to supply the distribution system loads. In addition, the reviewer should verify that standby power supplies meet the design bases and design criteria and have analyses to support the design. Further, the reviewer should verify that standby power supplies have 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 NuScale 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 that 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 Class 1E systems, the isolation device through which standby power is supplied to non-Class 1E loads, including control circuits and connections to Class 1E buses, should be designed to meet Class 1E criteria. Should standby power supplies not have been sized to accommodate 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 prevent the automatic or manual connection of such loads during the transient stabilization period subsequent to this event.

7. 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 RG 1.75. This includes the criteria for differentiating between (1) safety-related cables, raceways, and terminal equipment of different channels or divisions, (2) nonsafety-related cable that 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 multiunit site.

8. Auxiliary Supporting Systems/Features

The reviewer will verify the design adequacy of any 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 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 such 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 auxiliary supporting system redundant instrumentation, control devices, and loads are examined to ensure that they are powered from the same redundant distribution system as the system that they support.

The organization responsible for plant systems reviews other aspects of the auxiliary supporting systems to verify that the design, capacities, and physical independence of such systems are adequate for their intended functions. Included is a review of the 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 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.

9. System Testing and Surveillance

In ensuring that proposed periodic onsite testing capabilities of the onsite ac power system satisfy 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 surveillance and testability of safety-related aspects of the ac power system is provided in RGs 1.32, 1.47, 1.118, and 1.153, and IEEE Std. 603, as endorsed by RG 1.153.

10. Reliability Program for Emergency Onsite AC Power Sources

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 for passive plants, if a plant meets the appropriate guidelines of RG 1.155, "Station Blackout."

The reviewer should verify the design is capable of performing all safety-related functions for 72 hours without an alternate onsite ac power system (standby DG/GTG) available. If so, the design need not be evaluated for an SBO coping duration. The 72-hour approach is consistent with the duration approved by the NRC staff for the AP1000 design. Conformance to 10 CFR 50.63 is reviewed in accordance with DSRS Section 8.4.

11. 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 9.5.1.1 and 9.5.1.2. 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.

12. DC and COL Applications

For review of the NuScale DC application, the reviewer should follow the above procedures to verify the design, including requirements and restrictions (e.g., interface requirements and site parameters), as 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 NuScale DCD.

For review of both DC and COL applications, SRP Section 14.3, and 14.3.6 should be followed for the review of ITAAC. The ITAAC review 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, as presented in the DCD, 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 NuScale covered the descriptive information, functional logic diagrams, electrical single-line diagrams, and preliminary (or final) physical arrangement drawings.

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 GDC of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDC 2, 4, 5, 17, 18, and 50. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, 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, 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, with respect to SSCs of the onsite ac power system. The onsite ac power system and components associated with a multiunit facility are housed in physically separate seismic Category I structures and are not shared between units. Sharing of SSCs important to safety between reactor modules within a unit conforms to the requirements of the design criterion.

4. The applicant has met the requirements of GDC 17, 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, 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 shut down. This meets the positions of RG 1.118.

6. The applicant has met the requirements of GDC 50, 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 overload and short-circuit currents up to the maximum fault current versus time conditions that could occur given single random failures of protective devices. Also, for each electrical penetration, the applicant has provided redundant circuit breakers and 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 regulations in 10 CFR 52.17(a)(1)(xii), 10 CFR 52.47(a)(9), and 10 CFR 52.79(a)(41) establish requirements for applications for ESPs, DCs, and COLs, respectively. These regulations require the application to include an evaluation of the site (ESP), standard plant design (DC), or facility (COL) against the SRP revision in effect 6 months before the docket date of the application. While the SRP provides generic guidance, the staff developed the SRP guidance based on the staff's experience in reviewing applications for construction permits and operating licenses for large light-water nuclear power reactors. The proposed SMR designs, however, differ significantly from large light-water nuclear power plant designs.

In view of the differences between the designs of SMRs and the designs of large light-water power reactors, the Commission issued Staff Requirements Memorandum (SRM)-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights To Enhance Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010. In the SRM, the Commission directed the staff to develop risk-informed licensing review plans for each of the SMR design reviews, including plans for the associated preapplication activities. Accordingly, the staff has developed the content of the DSRS as an alternative method for evaluating a NuScale-specific application submitted pursuant to 10 CFR Part 52, and the staff has determined that each application may address the DSRS in lieu of addressing the SRP, with specified exceptions. These exceptions include particular review areas in which the DSRS directs reviewers to consult the SRP and others in which the SRP is used for the review. If an applicant chooses to address the DSRS, the application should identify and describe all differences between the design features (DC and COL applications only), analytical techniques, and procedural measures proposed in an application and the guidance of the applicable DSRS section (or SRP section, as specified in the DSRS), and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria.

The staff has accepted the content of the DSRS as an alternative method for evaluating whether an application complies with NRC regulations for NuScale SMR applications, provided that the application does not deviate significantly from the design and siting assumptions made by the NRC staff while preparing the DSRS. If the design or siting assumptions in a NuScale application deviate significantly from the design and siting assumptions the staff used in preparing the DSRS, the staff will use the more general guidance in the SRP, as specified in 10 CFR 52.17(a)(1)(xii), 10 CFR 52.47(a)(9), or 10 CFR 52.79(a)(41), depending on the type of application. Alternatively, the staff may supplement the DSRS section by adding appropriate criteria to address new design or siting assumptions.

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. SRP 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 Inspections," 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.

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