8 ELECTRIC POWER

This chapter of the safety evaluation report (SER) documents the U.S. Nuclear Regulatory Commission's (NRC) staff (hereafter referred to as "the staff") review of Chapter 8, "Electric Power," of the NuScale Power, LLC (hereafter referred to as "NuScale" or "the applicant"), standard plant design certification application (DCA). This application includes the final safety analysis report (FSAR) for Section 8.1, "Introduction"; Section 8.2, "Offsite Power System"; Section 8.3.1, "Onsite Alternating Current Power Systems"; Section 8.3.2, "Direct Current Power Systems"; and Section 8.4, "Station Blackout." NuScale submitted this DCA for its small modular reactor (SMR) standard plant design.

The staff reviewed the design of the electric power systems that are necessary for the safe design and operation of the plant or whose failure might adversely affect their safety-related or risk significant safety functions. The staff reviewed the design of the electric power systems in accordance with the applicable design specific review standards (DSRSs) or NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (SRP), as applicable, and consistent with the graded review approach described in SER Section 1.9. SER Section 8.1 contains the introduction of the DCA review, and Sections 8.2, 8.3.1, 8.3.2, and 8.4 contain the staff's evaluations of this review. Further evaluation of the classification of SSCs are described and evaluated in FSAR Tier 2, Section 3.2, "Classification of Structures, Systems, and Components," and SER Section 17.4, "Reliability Assurance Program."

In this chapter, the staff uses the term "non-safety-related" to refer to certain structures, systems and components (SSCs) that do not fall under the definition of "safety-related SSCs" described in 10 CFR 50.2. These non-safety-related SSCs include SSCs that both are and are not "important to safety" as that term is used in the General Design Criteria listed in Appendix A to 10 CFR Part 50.

The electric power system for the NuScale design comprises a non-safety-related alternating current (AC or ac) power system and a non-safety-related direct-current (DC or dc) power system. Non-safety-related and non-risk-significant electric power systems for NuScale include a normal ac and dc power system that supply plant loads during startup and shutdown, normal operation, and off normal conditions. The NuScale design does not depend on and, therefore, does not use or include a Class 1E emergency onsite ac power system.

The staff reviewed the non-safety-related and non-risk-significant electric power systems 1) to verify that their failure will not prevent safe shutdown of the plant or result in an unacceptable release of radioactivity to the environment and 2) for compliance with the applicable requirements and conformance to the applicable guidance. These systems include all auxiliary systems and lighting systems.

The SSCs are classified according to nuclear safety classification, seismic category, and quality group. As discussed in Section 3.2 of this report, category "B2" designation is given to SSCs that are determined to be both non-safety-related and not risk-significant. FSAR Tier 2, Section 3.2, discusses the safety and risk-significance of SSCs and provides safety and risk categorization of SSCs for the NuScale design. FSAR Tier 2, Table 3.2-1, "Classification of Structures, Systems, and Components," lists the classifications of SSCs.

This list tabulates the electrical main equipment and auxiliary systems located in various areas of the power plant (i.e., the switchyard, switchgear, batteries and chargers, backup power supplies, grounding, cathodic protection, and other such systems) as category B2. Section 3.2.2, "System Quality Group Classification" and Section 19.1, "Probabilistic Risk Assessment," of this report describe and further evaluate acceptability of the electrical systems safety-significance and risk significance categorizations.

8.1 Electric Power - Introduction

8.1.1 Introduction

The NuScale power plant standard design is modular with 12 nuclear power modules (NPMs), passive, and has safety-related systems for safe shutdown, core and spent fuel assembly cooling, containment isolation and integrity, and reactor coolant pressure boundary (RCPB) integrity. This design does not depend on onsite or offsite ac or dc electrical power, including that from the transmission grid for safe operation. NuScale has stated in its application that the NuScale power plant design does not rely on electrical power, and can accommodate a site location where an offsite transmission grid is not available. NuScale also states that its design can support a microgrid consisting of a group of interconnected loads and distributed energy sources that allows the power plant to operate either connected or not connected to a transmission grid. Therefore, instead of the transmission grid as the offsite source of power, the normal source of power is generated from 1 of the 12 operating power module main generators (MGs) through connections to the switchyard. In the absence of any power module and any offsite transmission grid, an auxiliary ac power source (AAPS) may also provide power to the plant. The onsite electrical power system includes ac power systems and dc power systems and a backup power supply system (BPSS) consisting of back-up diesel generators and the AAPS.

The SER Sections 8.2, 8.3.1, and 8.3.2 discuss and evaluate the offsite and onsite power systems.

The applicant addressed station blackout (SBO), defined as a complete loss of offsite and onsite ac power with a turbine trip and the unavailability of the onsite emergency ac power. The NuScale passive plant design does not rely on the use of onsite or offsite ac power for the performance of the safety-related functions for any design-basis event (DBE). SER Section 8.4 discusses and evaluates the SBO condition and mitigation.

8.1.2 Summary of Application

FSAR Tier 1: FSAR Tier 1, Chapter 2, "Unit Specific Structures, Systems, and Components (SSCs) Design Descriptions and Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)," addresses the electrical ITAAC for reactor systems and equipment. Tier 1, Section 2.1, "NuScale Power Module," describes the ITAAC, which are identified in the ITAAC section below.

FSAR Tier 2: The applicant described the electrical power system in FSAR Tier 2, Section 8.1, summarized, in part, as follows:

> *Offsite Power System: There are no design bases for the offsite power system because this will be designed under the combined license (COL) applicant's responsibility. SER Section 8.2 addresses and evaluates the offsite power.*

Onsite ac and dc Power System: The onsite ac power system supplies all electrical loads of the plant and is nonsafety-related and non-Class1E. It includes a normal ac power system that comprises a 13.8 kilovolt (kV), 4.16 kV, and low-voltage ac electrical distribution system (ELVS) that uses 480 volt ac power and 120 volt ac power. The onsite dc power system is non-Class 1E and nonsafety-related. The dc power systems comprise (1) an augmented quality, highly reliable 125 volt dc power system and (2) a normal nonsafety 250 volt dc power system and nonsafety 125 volt dc power system. SER Sections 8.3.1 and 8.3.2, respectively, address and evaluate the onsite ac and dc power.

ITAAC Tier 1: ITAAC Tier 1, "Certified Design Descriptions and Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)," Table 2.1-4, "NuScale Power Module Inspections, Tests, Analyses, and Acceptance Criteria," provides the electrical ITAAC for electrical penetration assemblies (EPAs) and physical separation between Class 1E and non-Class 1E electrical circuits. SER Sections 8.3.1 and 8.3.2 and Chapter 14, "Initial Test Program and Inspections, Tests, Analyses, and Acceptance Criteria," discuss these ITAAC. Tier 1, Table 2.1-3, "NuScale Power Module Electrical Equipment," lists the NuScale power module electrical equipment. The Table 2.1-4 ITAAC address the physical separation of redundant divisions of the module protection system (MPS) Class 1E instrumentation and control circuits and between Class 1E and non-Class 1E current-carrying circuits. Chapter 7 of this SER discusses the details of the MPS.

ITAAC Tier 2: Tier 2, Section 8.1, "Electric Power, Introduction," has no ITAAC for safety-related Class 1E equipment because the NuScale design does not include any Class 1E electrical equipment.

Technical Specifications: No technical specifications apply to the onsite ac or dc power system because the NuScale design does not include safety-related Class 1E ac and dc electrical power systems.

Certified Design Interfaces (CDIs): FSAR Tier 2, Section 1, Table 1.8-1, "Summary of NuScale Certified Design Interfaces with Remainder of Plant" lists the following CDI related to electric power systems:

- Diesel Generator Building: FSAR Tier 2, Section 1.2.2, includes conceptual design information for this structure.
- AAPS: FSAR Tier 2, Section 8.2 and Section 8.3, includes conceptual design information for this component. SER Sections 8.2 and 8.3.1 discuss the AAPS.
- Lightning Protection and Grounding System Grid: FSAR Tier 2, Section 8.3.1, includes conceptual design information for this system. SER Sections 8.2 and 8.3.1 discuss lightning protection and grounding.
- Offsite Power Transmission System, Main Switchyard, and Transformer Area: FSAR Tier 2, Section 8.2, includes conceptual design information for this system. SER Section 8.2 discusses the offsite power system.
- Diesel Generator: SER Section 8.3.1 discusses this COL item.

Multi-Module Design Considerations: The NuScale design is a 12-module plant (i.e., it consists of 12 NPMs). FSAR Tier 2, Chapter 21, "Multi-Module Design Considerations," describes this modularized design with module operating configurations that consider the common systems, interface requirements, and system interactions. In FSAR Tier 2, Chapter 8, Sections 8.1, 8.2, 8.3, and 8.4 describe the electrical power systems (both ac and dc power systems) that are shared among the modules. FSAR Tier 2, Chapter 21, Table 21-3, "Shared System Interactions (Electrical and Instrumentation and Control System)," describes the following three electrical systems that are shared to support all 12 NPMs:

1. *13.8-kV and switchyard, medium-voltage AC electrical distribution system (EMVS), and low voltage AC electrical distribution system (ELVS). SER Section 8.3.1 describes and evaluates these shared systems.*

2. *Highly reliable DC power system (EDSS) common (EDSS-C). SER Section 8.3.2 describes and evaluates this shared system.*

3. *Normal dc power system (EDNS). SER Section 8.3.2 describes and evaluates this shared system.*

8.1.3 Regulatory Basis

The relevant NRC requirements for the onsite and offsite ac and dc power system and the associated acceptance criteria, are summarized below. SRP Section 8.1 and DSRS Section 8.1 provide the review interfaces with other SRP/DSRS sections.

Acceptance criteria are based on meeting the following relevant NRC requirements:

- General Design Criterion (GDC) 2, "Design Basis for Protection against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," 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.

- GDC 4, "Environmental and Dynamic Effects Design Basis," as it relates to SSCs of the electric power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

- GDC 5, "Sharing of Structures, Systems and Components," as it relates to the sharing of SSCs of the power systems among nuclear units.

- GDC 17, "Electric Power Systems," as it relates to the onsite ac power system's (1) capacity and capability to permit functioning of SSCs important to safety, (2) independence, redundancy, and testability to perform its safety functions 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.

- GDC 18, “Inspection and Testing of Electric Power Systems,” as it relates to inspection and testing of the offsite and onsite power systems.

- 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,” as they relate to the operation of the onsite electric power system in GDC 17 to ensure that the safety functions of the systems described in GDC 34, 35, 38, 41, and 44 are accomplished.

- GDC 50, “Containment Design Basis,” as it relates to the design of containment electrical penetrations that contain ac and dc power system circuits and the capability of electric penetration assemblies in containment structures to accommodate a loss-of-coolant accident (LOCA) without loss of mechanical integrity and the external circuit protection for such.

- 10 CFR 50.34(f)(2)(v), as it relates to Additional Three Mile Island (TMI) Item I.D.3, “Safety System Status Monitoring.”

- 10 CFR 50.34(f)(2)(xiii), as it relates to Additional TMI Item II.E.3.1, “Emergency Power Supply for Pressurizer Heaters.”

- 10 CFR 50.34(f)(2)(xx), as it relates to Additional TMI Item II.G.1, “Emergency Power for Pressurizer Equipment.”

- 10 CFR 50.55a(h), “Protection and safety systems,” as it relates to the incorporation of Institute of Electrical and Electronics Engineers, Inc. (IEEE) Standard (Std.) 603-1991, “Standard Criteria for Safety Systems for Nuclear Power Generating Stations,” including the correction sheet dated January 30, 1995, for protection and safety systems.

- 10 CFR 50.63, “Loss of all alternating current power,” as it relates to the establishment of a reliability program for emergency onsite power sources and the use of the redundancy and reliability of diesel generator units as a factor in limiting the potential for SBO events.

- 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 such activities are performed.

Acceptance criteria that are adequate to meet the above NRC regulatory requirements are available in the following regulatory guidance (RG):

- RG 1.6, “Independence between Redundant Standby (Onsite) Power Sources and between their Distribution Systems,” Regulatory Positions D.1, D.3, and D.4, as they relate to the independence between redundant onsite ac power sources and between their distribution systems.

- RG 1.32, “Criteria for Power Systems for Nuclear Power Plants,” as it relates to the design, operation, and testing of the safety-related portions of the onsite ac power system. RG 1.32 endorses IEEE Std. 308-2001, “IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations,” with the exception of the sharing of safety-related ac power systems in multi-unit nuclear power plants (NPPs).

- RG 1.47, “Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems,” as it relates to the bypass and inoperable status of the onsite power supply.

- RG 1.53, “Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems,” as it relates to the application of the single-failure criterion.

- RG 1.63, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants,” as it relates 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.

- RG 1.75, “Physical Independence of Electrical Systems,” as it relates to the physical independence of the circuits and electrical equipment that constitute or are associated with the onsite electric power system.

- RG 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants,” as it relates to the sharing of SSCs of the electric power system. Regulatory Position C.1 states that multi-unit sites should not share power systems.

- RG 1.118, “Periodic Testing of Electric Power and Protection Systems,” as it relates to the capability to periodically test the onsite ac power system.

- RG 1.128, “Installation Design and Installation of Vented Lead-Acid Batteries for Nuclear Power Plants,” as it relates to installation design and installation of vented lead-acid storage batteries for NPPs.

- RG 1.129, “Maintenance, Testing, and Replacements of Vented Lead-Acid Batteries for Nuclear Power Plants,” as it relates to the maintenance, testing, and replacement of vented lead-acid storage batteries for NPPs.

- RG 1.153, “Criteria for Safety Systems,” as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of the safety systems of NPPs, including the application of the single-failure criterion in the onsite ac or dc power system. As endorsed by RG 1.153, IEEE Std. 603-1991 provides a method acceptable to the staff to evaluate all aspects of the electrical portions of the safety-related systems, including basic criteria for addressing single failures. However, 10 CFR 50.55a(h) states that not all plants are required to comply with IEEE Std. 603-1991.

- RG 1.155, “Station Blackout,” as it relates to the capability and the capacity of the onsite ac power system for an SBO, including the operation of the alternate ac (AAC) power source(s).

- RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” as it relates to the effectiveness of maintenance activities for power systems. Compliance with the Maintenance Rule, including verification that appropriate maintenance activities are covered in the rule, is reviewed under SRP Chapter 17.

- RG 1.204, “Guidelines for Lightning Protection of Nuclear Power Plants,” as it relates to the design, installation, and performance of station grounding systems and surge and lightning protection systems.

- RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition),” as it relates to power system analytical studies and stability studies to verify the capability of the offsite power systems and their interfaces with the onsite power system

- RG 1.212, “Sizing of Large Lead-Acid Storage Batteries,” as it relates to methods and procedures for the sizing of large lead-acid storage batteries for NPPs

- RG 1.218, “Condition-Monitoring Techniques for Electric Cables Used in Nuclear Power Plants,” as it relates to condition-monitoring methods and techniques used to monitor the performance of electric cables in NPPs.

- SECY-90-016, “Evolutionary Light Water Reactor Certification Issues and Their Relationship to Current Regulatory Requirements,” dated January 12, 1990, as it relates to the use of an AAC and the application of the regulatory treatment of nonsafety systems (RTNSSs) at advanced light-water reactors (ALWRs) that have passive safety systems.

- SECY-91-078, “Chapter 11 of the Electric Power Research Institute’s (EPRI’s) Requirements Document and Additional Evolutionary Light Water Reactor (LWR) Certification Issues,” dated March 25, 1991, as it relates to the inclusion of an alternate power source to non-safety-related loads at evolutionary plant designs.

- SECY-94-084, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs,” dated March 28, 1994, as it relates to the policy and technical issues associated with the RTNSS affecting passive plant designs.

- SECY-95-132, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs,” dated May 22, 1995, as it relates to the policy and technical Issues associated with the RTNSS affecting passive plant designs.

- NRC Bulletin 2012-01, “Design Vulnerability in Electric Power System,” as it relates to design vulnerability in electric power systems that involves a loss of offsite power (LOOP) resulting from an open circuit condition.

- NUREG-0718, “Licensing Requirements for Pending Applications for Construction Permits and Manufacturing Licenses” Revision 1, dated July 27, 2012, as it relates to TMI Item I.D.3 with regard to the applicability of RG 1.47.

- NUREG-0737, “Clarification of TMI Action Plan Requirements,” issued November 1980, as it relates to TMI Items II.E.3.1 and TMI II.G.1.

- NUREG/CR-0660, “Enhancement of On-Site Diesel Generator Reliability,” issued February 1979.

8.1.4 Technical Evaluation

The staff reviewed NuScale FSAR Tier 1 and Tier 2 to ensure that the applicant discussed compliance with the regulations in FSAR Tier 2, Table 8.1-1, “Acceptance Criteria and Guidelines for Electrical Systems,” and FSAR Tier 2, Table 1.9-3, “Conformance with NUREG-0800, Standard Review Plan (SRP) and Design Specific Review Standards (DSRS),” for the NuScale SMR passive plant design.

In FSAR Tier 2, Section 8.1.4.3, “Regulatory Requirements and Guidance,” NuScale summarizes the regulatory guidance relevant to electrical systems as applied to the design of a passive SMR design. The applicant has requested exemptions from certain regulations and states in its application that these regulations are not applicable to the NuScale passive reactor design. These exemptions are discussed in Part 7 and the following sections of this chapter.

In FSAR Tier 2, Table 8.1-1, NuScale summarizes the extent to which NRC requirements and guidance relevant to electrical systems are applied in the design of NuScale electrical systems. In FSAR Tier 2, Section 1.9, and FSAR Tier 2, Section 3.1, NuScale also summarizes compliance with NRC requirements and conforms to guidance. In general, electrical systems are designed in accordance with the requirements and guidance, with the exceptions or clarifications provided below, as described in FSAR Tier 2, Section 8.1.4.3.

8.1.4.1 Compliance with 10 CFR Part 50, Appendix A, GDC 2 and GDC 4

The design of the NuScale onsite ac and onsite dc electrical power systems conforms to GDC 2 and GDC 4, as described in FSAR Tier 2, Section 8.3.1, “Onsite AC Power System,” and Section 8.3.2, “Onsite DC Power System.” GDC 2 and GDC 4 do not apply to FSAR Section 8.2 because the offsite power system does not impact the safety-related systems of the power plant. With respect to the onsite ac and dc electrical power systems, SER Sections 8.2, 8.3.1, and 8.3.2 discuss the compliance with GDC 2 for protection against natural phenomena such as earthquakes and tornados and GDC 4 for protection against environmental and dynamic effects.

8.1.4.2 Compliance with GDC 5

The design of the NuScale offsite, onsite ac, and onsite dc electrical systems conforms to GDC 5 as described in FSAR Tier 2, Section 8.2, Section 8.3.1, and Section 8.3.2. GDC 5 requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units. FSAR Tier 2, Section 3.1.1.5, states that the NuScale design conforms to GDC 5. SER Sections 8.2, 8.3.1, 8.3.2, and 8.4 evaluate and discuss this statement.

8.1.4.3 Compliance with GDC 17

As described in FSAR Tier 2, Section 3.1.2.8, and DCA Part 7, Section 4, the NuScale design supports an exemption from GDC 17. In FSAR Tier 2, Section 3.1.2.8, the applicant stated that the plant does not rely on electric power to meet specified acceptable fuel design limits or to protect the RCPB as a result of anticipated operational occurrences or postulated accidents. In addition, the availability of electrical power sources does not affect the plant's ability to achieve and maintain safety-related functions. The staff discusses and evaluates this issue in SER Sections 8.2 and 8.3. The applicant requested an exemption from this criterion in DCA Part 7, Section 4.

8.1.4.4 Compliance with GDC 18

As described in FSAR Tier 2, Section 3.1.2.9, and DCA Part 7, Section 4, the NuScale design supports an exemption from GDC 18. The applicant stated that the electric power supply systems in the NuScale design do not contain any safety-related or risk-significant SSCs that are needed to meet GDC 18. The staff discusses and evaluates this in SER Sections 8.2, 8.3, and 8.4.

8.1.4.5 Compliance with GDC 33, 34, 35, 38, 41, and 44

In FSAR Tier 2, Section 8.1.4.3, the applicant stated that the plant design fulfills a NuScale-derived set of principal design criteria in lieu of GDC 33, 34, 35, 38, 41, and 44, as described in FSAR Tier 2, Section 3.1.4, and supports an exemption from GDC 33, 34, 35, 38, 41, and 44. These principal design criteria do not relate to electric power systems. The request for exemption from complying with GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44 is also described in DCA Part 7, Section 4, and is discussed and evaluated in SER Sections 8.2 and 8.3.

8.1.4.6 Compliance with GDC 50

In FSAR Tier 2, Section 8.1.4.3, the applicant stated that the AC and DC electrical power system circuits do not penetrate the containment vessels; therefore, conformance to GDC 50 is not necessary. Components requiring power inside containment are part of the instrumentation and controls systems. Section 8.3 provides details of the review and evaluation. In FSAR Tier 2, Section 3.1.5.1, the applicant states that the NuScale design conforms to GDC 50.

The applicant stated in FSAR Tier 2, Section 8.1.4.3, that "the AC and DC electrical power system circuits do not penetrate the containment vessels; therefore, conformance to GDC 50 is not necessary." However, in FSAR, Section 3.1.5.1, the applicant also stated that "the NuScale Power Plant design conforms to GDC 50." Because of the inconsistency of the above statements, the staff asked the applicant to clarify this nonconformance to GDC 50 in Request for Additional Information (RAI) 8788, Question 8.01-1. Additionally, in RAI 8788, Question 8.01-1, the staff requested additional information on the description, design, and testing of the EPAs. In its response to RAI 8788, Question 8.01-1, dated July 19, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17200D160), the staff found that the applicant did not provide a complete response with respect to the EPA and its environmental qualification and testing.

Subsequently, the applicant provided a supplemental response on November 3, 2017 (ADAMS Accession No. ML17310A296). The staff evaluates this response in SER Sections 8.3.1 and 3.11. The staff had additional questions because of new information related to the revision of certain EPA safety classifications and EPA circuit protection. The staff issued RAI 9308, Question 8.01-2, to obtain information on these issues. The staff describes and evaluates compliance with GDC 50 in SER Sections 8.3.1 and 3.11.

8.1.4.7 Compliance with 10 CFR 50.34(f)(2)(v)

The design of the NuScale ac and dc electrical systems complies with 10 CFR 50.34(f)(2)(v) (TMI Item I.D.3) as described in Sections 8.3.1 and 8.3.2. SER Sections 8.3.1 and 8.3.2 describe and evaluate the design's compliance with this regulation.

8.1.4.8 Compliance with 10 CFR 50.34(f)(2)(xiii)

The NuScale design does not rely on pressurizer heaters to establish and maintain natural circulation in shutdown conditions. Accordingly, the NuScale design supports an exemption from the requirement in 10 CFR 50.34(f)(2)(xiii) (TMI Item II.E.3.1) to provide pressurizer heater power supply and associated motive and control power interfaces to establish and maintain natural circulation in shutdown conditions. DCA Part 7, Section 12, also describes the exemption from conforming to 10 CFR 50.34(f)(2)(xiii) (TMI Item II.E.3.1). SER Sections 8.3.1 and 8.3.2 describe and evaluate the request for exemption from this regulation.

8.1.4.9 Compliance with 10 CFR 50.34(f)(2)(xx)

The NuScale design does not include pressurizer relief valves or pressurizer relief block valves and level indicators. The NuScale design supports an exemption from the portions of the rule that require vital power buses for pressurizer level indicators, as discussed in DCA, Part 7, Section 11. SER Sections 8.3.1 and 8.3.2 discuss and evaluate the request for exemption from this regulation.

8.1.4.10 Compliance with 10 CFR 50.55a(h)

The extent to which the design of NuScale electrical systems complies with 10 CFR 50.55a(h) is described in SER Sections 8.3.1 and 8.3.2. For the NuScale design, the onsite electrical ac and dc power system equipment is not a protection system and does not perform any safety-related functions. Therefore, the system need not comply with 10 CFR 50.55a(h) and IEEE Standard 603-1991. SER Chapter 7 and Sections 8.3.1 and 8.3.2 describe and evaluate compliance with this regulation.

8.1.4.11 Compliance with 10 CFR 50.63

The NuScale power plant design complies with 10 CFR 50.63, which requires a light water reactor to have the capability to withstand an SBO for a specified duration and recover from an SBO, which is defined in 10 CFR 50.2, "Definitions." SER Section 8.4 describes additional details, discusses, and evaluates compliance with 10 CFR 50.63.

8.1.4.12 Compliance with 10 CFR 50.65(a)(4)

The 10 CFR 50.65(a)(4) assessment is applied to NuScale design electrical system SSCs that (1) are determined to meet the 10 CFR 50.65(b) criteria and (2) are significant to public health and safety based on a risk-informed evaluation process. FSAR Tier 2, Section 17.6, "Maintenance Rule," describes the Maintenance Rule (10 CFR 50.65) program. FSAR Tier 2, Section 19.0.2 states that the results and insights of PRA are a source of information for Maintenance Rule (i.e. 10 CFR 50.65) implementation. The staff describes and evaluates this issue in SER Sections 8.2, 8.3.1, 8.3.2, and 8.4.

8.1.4.13 Conformance to NUREG-0718

NUREG-0718, Revision 1, includes guidance related to TMI Item I.D.3 (codified in 10 CFR 50.34(f)(2)(v)), TMI Item II.E.3.1 (codified in 10 CFR 50.34(f)(2)(xiii)), and TMI Item II.G.1 (codified in 10 CFR 50.34(f)(2)(xx)). The design of the NuScale ac and dc electrical systems conforms to the above TMI Items I.D.3, II.E.3.1, and II.G.1 as described in SER Sections 8.3.1 and 8.3.2.

8.1.4.14 Conformance to NUREG-0737

NUREG-0737 includes guidance related to TMI Item II.E.3.1 (codified in 10 CFR 50.34(f)(2)(xiii)) and TMI Item II.G.1 (codified in 10 CFR 50.34(f)(2)(xx)). As described above for 10 CFR 50.34(f)(2) in Sections 8.1.4.8 and 8.1.4.9 in this report, the NuScale design supports exemptions from these regulations. SER Sections 7.2.13.6, "Three Mile Island Action Items," 8.3.1, and 8.3.2 evaluate the request for exemption from this regulation.

8.1.4.15 Conformance to NUREG/CR-0660

Portions of NUREG/CR-0660 relevant to the NuScale electrical systems are considered as reference only, consistent with NuScale DSRS Section 8.1. SER Section 19 describes conformance to TMI items, including those addressed in NUREG/CR-0660.

8.1.4.16 Conformance to SECY-90-016

SECY-90-016 pertains to evolutionary ALWR designs and does not directly apply to passive plant designs. As a passive ALWR design, the NuScale electrical system design conforms to the passive plant guidance in SECY-94-084, Section F, "Station Blackout." SER Sections 8.3.1 and 8.3.2 evaluate the nonconformance to this SECY.

8.1.4.17 Conformance to SECY-91-078

SECY-91-078 pertains to evolutionary ALWR designs and is not directly applicable to passive plant designs. As a passive ALWR design, the NuScale electrical system design conforms to the passive plant guidance in SECY-94-084, Section G, "Electrical Distribution." The staff describes and evaluates this in SER Sections 8.2 and 8.4.

8.1.4.18 Conformance to SECY-94-084

The design of NuScale electrical systems conforms to the Commission-approved positions in SECY-94-084, Sections F and G, related to passive plant electrical systems.

The staff describes and evaluates this in SER Sections 8.2 and 8.4.

8.1.4.19 Conformance to SECY-95-132

The evaluation of NuScale electrical systems under the RTNSS process conforms to SECY-94-084, Section A, "Regulatory Treatment of Non-safety Systems," as modified in SECY-95-132 and subsequently established in SRP Section 19.3, "Regulatory Treatment of Non-Safety Systems." The portion of SECY-95-132 that modifies the RTNSS process description in SECY-94-084, Section A, is applied as guidance to the NuScale non-safety-related electrical systems. Specifically, the evaluation of NuScale electrical systems under the RTNSS process conforms to SECY-95-132, "Response to Staff Requirements Memorandum (SRM) on SECY-94-084" Attachment 1 (Item A). The staff describes and evaluates this issue in SER Sections 8.2 and 8.4.

8.1.5 Combined License Information Items

There are no COL items for FSAR Tier 2, Section 8.1. SER Sections 8.2, 8.3.1, 8.3.2, and 8.4 discuss the COL items.

8.1.6 Conclusion

Based on the above review and analysis in the NuScale FSAR Tier 2, Sections 8.1, 8.2, 8.3, and 8.4, the SER remains incomplete pending satisfactory resolution of the RAI/OPEN ITEMs, identified in the staff's technical evaluation in this report. The staff will update SER Sections 8.1, 8.2, 8.3, and 8.4, to reflect the final disposition of the FSAR application.

The staff is still evaluating the exemptions to GDC 17, 18, 33, 34, 35, 38, 41, and 44; therefore, the language in this section may change, as appropriate, to reflect input from other technical branches.

8.2 Offsite Power System

8.2.1 Introduction

FSAR Tier 2, Section 8.2, states that the passive design of the NuScale power plant does not depend on offsite ac power for safe operation and that the availability of offsite ac electrical power does not affect the ability to achieve and maintain safety-related functions, as discussed in the sections below.

The offsite power system for the NuScale power plant includes a switchyard and one or more connections to a transmission grid, microgrid, or dedicated service load. However, the offsite power system is not needed for safe operation such that the ability to achieve and maintain safe shutdown is not affected by the availability of the offsite power system. The objective of the staff's review is to determine whether the offsite power system satisfies the requirements in 10 CFR 50.63; 10 CFR 50.65; and 10 CFR Part 50, Appendix A, GDC 5, 17, 18, 33, 34, 35, 38, 41, and 44 and whether it will perform its design function during all plant operating and accident conditions.

8.2.2 Summary of Application

FSAR Tier 2: The applicant has provided a Tier 2 system description in Section 8.2, summarized, in part, as follows:

> *The offsite power system provides power from the transmission system through the station switchyard to the electrical distribution systems. The offsite power system includes all transmission lines connected to the switchyard and the switchyard equipment (overhead buses, circuit breakers, and disconnect air switches). The interface between the onsite ac power system and offsite power system is the high side (i.e., switchyard side) of the motor-operated disconnect on the high side of the main power transformers (MPTs). The offsite transmission system and connections to the switchyard are site specific. A COL applicant that references the NuScale design certification will provide site-specific information about the offsite transmission system and connections to the switchyard.*
>
> *Offsite power is a secondary source of power for plant startup or shutdown. In the case that an auxiliary AC power source (AAPC) or turbine generator is not available, an offsite power source can backfeed power through the MPTs for startup and shutdown loads.*

ITAAC: There are no ITAAC associated with the offsite power system.

Technical Specifications: There are no technical specifications applicable to the offsite power system.

CDIs: This section of the FSAR contains information related to plant interfaces (i.e., offsite power transmission system, main switchyard, and transformer area) that will be addressed in the COL designs.

8.2.3 Regulatory Basis

SRP Section 8.2 provides the relevant NRC requirements for the offsite power system and the associated acceptance criteria, as summarized below. SRP Section 8.2 provides review interfaces with other SRP sections.

- 10 CFR Part 50, Appendix A, GDC 2, as it relates to the SSCs of the offsite power system being capable of withstanding the effects of natural phenomena,

- GDC 4, as it relates to protection of the SSCs of the offsite power system from dynamic effects, including the effects of missiles, which may result from equipment failures during normal operation, maintenance, testing, and postulated accidents.

- GDC 5, as it relates to the sharing of SSCs of the preferred power systems, including the switchyard and all circuits from the switchyard to the onsite power distribution systems of each module.

- GDC 17, as it relates to the preferred power system's (1) capacity and capability to permit functioning of SSCs important to safety, (2) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies, (3) physical independence, (4) availability, and (5) capability.

- GDC 18, as it relates to the inspection and testing of the offsite electric power system.

- GDC 33, 34, 35, 38, 41, and 44, as they relate to the operation of the offsite electric power system in GDC 17 to ensure that the safety functions of the systems described in GDC 33, 34, 35, 38, 41, and 44 are accomplished under the assumption of a single failure, where applicable.

- 10 CFR 50.63, as it relates to the ability for a passive design to cope with an SBO for 72 hours with no operator actions.

- 10 CFR 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 such activities are performed.

- 10 CFR 52.47(b)(1), which requires a DCA to 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 are met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act, and the Commission's rules and regulations.

- 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 be operated in conformity with the combined license, the provisions of the Atomic Energy Act, and the Commission's rules and regulations.

The following guidance is available:

- RG 1.32, which endorses IEEE Std. 308-2001, as it relates to the availability and number of immediate access circuits from the transmission network.

- RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."

- RG 1.155, as it relates to the adequacy of the AAC source and the independence of the AAC power source from the offsite and onsite power systems and sources.

- New applications must provide an adequate AAC source of diverse design (with respect to ac onsite emergency sources) that is consistent with the guidance in RG 1.155 and capable of powering at least one complete set of normal safe-shutdown loads.

- RG 1.160, as it relates to the effectiveness of maintenance activities for onsite standby ac power sources, including risk-sensitive grid 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).

- RG 1.204; IEEE Std. 665-1995, "IEEE Guide for Generating Station Grounding"; IEEE Std. 666-2007, "IEEE Design Guide for Electric Power Service Systems for Generating Stations"; IEEE Std. 1050-2004, "IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations"; and IEEE Std. C62.23-1995, "IEEE Application Guide for Surge Protection of Electric Generating Plants," as they relate to the design, installation, and performance of station grounding systems and surge and lightning protection systems.

- RG 1.206, as it relates to power system analytical studies and stability studies to verify the capability of the offsite power systems and their interfaces with the onsite power system.

- SECY-91-078, as it relates to the interface between the onsite ac power system and the offsite power system.

- SECY-94-084, as it relates to the policy and technical issues associated with the RTNSS affecting passive plant designs.

- SECY-95-132, as it relates to the policy and technical issues associated with the RTNSS affecting passive plant designs.

- SRP Branch Technical Position (BTP) 8-3, "Stability of Offsite Power Systems," as it relates to stability studies for the electrical transmission grid that would be used to provide offsite power sources to the plant.

- SRP BTP 8-6, "Adequacy of Station Electric Distribution System Voltages," as it relates to adverse effects on the Class 1E loads that can be caused by sustained degraded grid voltage conditions when the Class 1E busses are connected to offsite power.

- SRP BTP 8-9, “Open Phase Conditions in Electric Power System,” as it relates to the vulnerability of the electric power system design resulting from open-phase conditions in offsite electric power systems.

8.2.4 Technical Evaluation

8.2.4.1 Compliance with GDC 2 and GDC 4

GDC 2 states that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. Thus, GDC 2 requires that the capability for the offsite power system to perform its functions be retained during the most severe natural phenomena that have been historically reported for the site and surrounding area.

GDC 4 states that SSCs associated with the offsite power system shall be capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

The staff determined that GDC 2 and GDC 4 do not apply to the offsite power system. In an e-mail, dated January 23, 2009, from Mr. Tom Bergman (NRC) to Mr. Russ Bell (Nuclear Energy Institute (NEI)), the NRC staff agreed that GDC 2 and GDC 4 do not apply to the offsite power system. Specifically, the staff agreed that the current fleet of operating nuclear plants does not require offsite power systems to satisfy GDC 2 and 4. Therefore, GDC 2 and GDC 4 do not apply to the NuScale offsite power system design. The NRC staff’s email to NEI on its position regarding applicability of GDC 2 and GDC 4 to offsite power systems is in ADAMS under Accession No. ML090260039.

8.2.4.2 Compliance with GDC 5

GDC 5 discusses the sharing of SSCs of the preferred power systems, including the switchyard and all circuits from the switchyard to the onsite power distribution systems of each module.

DSRS Section 8.2.II states that an accident in one module of a multimodule facility can be mitigated using an available complement of mitigative features irrespective of conditions in the other units and without giving rise to conditions unduly adverse to safety in another unit and without affecting the overall operability of the offsite power system. FSAR Tier 2, Section 8.2.3.2, “Analysis of Offsite Power System Conformance with Regulatory Framework,” states the following:

> *The passive design of the NuScale Power Plant does not rely on onsite AC power and does not require an offsite power system to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences or to maintain core cooling or containment integrity in the event of postulated accidents, as discussed in [FSAR Tier 2] Section 15.0.0. In addition, the offsite power system is not relied upon to provide power for risk-significant functions.*

Thus, the applicant states that ac power, including the offsite power system, is not needed to maintain core cooling or containment integrity as a result of anticipated operational occurrences or postulated accidents. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the

evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, compliance with GDC 5 is being evaluated as part of **OPEN ITEM 8.3-1**.

8.2.4.3 Compliance with GDC 17

GDC 17 states that offsite power shall be provided to allow SSCs important to safety to function and that two physically independent circuits shall supply electric power from the transmission network to the onsite distribution system.

FSAR Tier 2, Section 8.2.3.2, states that offsite power is not required to ensure that specified acceptable fuel design limits and design conditions of the RCPB are not exceeded as a result of anticipated operational occurrences or to maintain core cooling or containment integrity in the event of postulated accidents.

DCA Part 7 discusses NuScale's request for exemption from GDC 17. DCA Part 7, Section 4.2.1, "Technical Basis," states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

Regarding GDC 17, RG 1.206 states, in part, that an applicant should follow the guidance in DSRS Section 8.2, Appendix A, "Guidelines for Generator Circuit Breakers/Load Break Switches." DSRS Section 8.2, Appendix A, states that only devices that have the capability of interrupting the system maximum available fault current (i.e., circuit breakers) will be approved as a means of isolating the unit generators from the offsite power system. Furthermore, DSRS Section 8.2, Appendix A, states that generator circuit breakers (GCBs) should be designed to perform their intended function during steady-state operation, power system transients, and major faults. The staff's concern is that the requirements placed on generator breakers are much more rigorous on those devices if they are used in an immediate-access source of power scheme as opposed to a delayed-access source of power scheme.

Immediate-access devices must be qualified to isolate the MG under maximum postulated fault current conditions. Delayed-access devices do not need this capability because they would not be used to isolate the MG before any fault current is cleared. In **RAI 8768, Question 08.02-3**, dated April 27, 2017 (ADAMS Accession No. ML17117A659), the staff asked the applicant to demonstrate that the design of the GCB conforms to the provisions of Appendix A and, specifically, IEEE Std. C37.013-1997, "Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis."

In its response to **RAI 8768, Question 08.02-3**, dated June 2, 2017 (ADAMS Accession No. ML17153A335), the applicant stated that the GCBs are not part of the offsite power system and are within the scope of the EHVS (EHVS comprises of both the onsite 13.8-kV power system and high voltage switchyard).

The applicant further stated that the circuit breakers are rated and constructed to meet the requirements of IEEE Std. C37.06, "AC High-Voltage Circuit Breaker on a Symmetrical Current Basis (2009)," and rated and constructed to meet the required capabilities of IEEE Std. C37.013-1997. SER Section 8.3.1 evaluates the onsite ac power system. The staff determined that the information is acceptable because the design of the GCBs conforms to IEEE Std. C37.013-1997. The ratings and required capabilities of the GCBs are the designated limits of operating characteristics based on definite conditions, as defined in IEEE Std. C37.013-1997. The staff determined that the response is acceptable and that the issue is resolved because (1) the design of the GCB conforms to IEEE Std. C37.013-1997 and (2) the design of the GCB conforms to the guidance in DSRS Section 8.2, Appendix A.

8.2.4.4 Compliance with GDC 18

GDC 18 discusses the inspection and testing of electric power systems important to safety. FSAR Tier 2, Section 8.2.3.2, states that the NuScale design supports an exemption from GDC 18.

DCA Part 7 states that the electric power supply systems do not contain any safety-related or risk-significant SSCs that are required to meet GDC 18 and that the ac and dc power systems are non-safety-related and non-Class 1E. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the GDC 18 exemption is being evaluated as part of **OPEN ITEM 8.3-1**.

Although the applicant requested an exemption to GDC 18, DCA Part 7, Section 4.2.1, states that the NuScale ac power systems are designed to permit periodic inspection and testing to assess the operability and functionality of the systems and the condition of their components for operational, commercial, and plant investment protection purposes.

8.2.4.5 Compliance with GDC 33, 34, 35, 38, 41, and 44

GDC 33, 34, 35, 38, 41, and 44 state requirements for safety systems for which 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 (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). The applicant has requested an exemption to these criteria in DCA Part 7, Sections 4 and 5.

The DSRS Section 8.2 states the following:

> *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.*

FSAR Tier 2, Section 8.2, states that the NuScale plant design complies with a set of principal design criteria in lieu of GDC 33, 34, 35, 38, 41, and 44 and that these principal design criteria do not include requirements for electric power systems. FSAR Tier 2, Section 8.4.2, "SBO Analysis and Results," states that a safe and stable shutdown is automatically achieved and maintained for 72 hours without operator actions.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this conclusion is confirmed by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. The exemption from the requirements of GDC 33, 34, 35, 38, 41, and 44 is also being evaluated as part of **OPEN ITEM 8.3-1**.

8.2.4.6 Compliance with 10 CFR 50.63 and Conformance to RG 1.155

DSRS Section 8.2.II states that compliance with 10 CFR 50.63 requires that each light-water-cooled NPP be able to withstand or cope with (and recover from) an SBO. Furthermore, DSRS Section 8.2.II states that, if a passive design can cope with an SBO for 72 hours with no operator actions and with the use of only the Class 1E dc power, 10 CFR 50.63 is satisfied. RG 1.155 discusses the independence of an alternate ac power source from the offsite and onsite power systems and sources. The staff reviewed the offsite power system to ensure that the failure of the offsite system will not affect the NuScale power plant's ability to cope with an SBO.

FSAR Tier 2, Section 8.4.2, states that a safe and stable shutdown is automatically achieved and maintained for 72 hours without operator actions. In addition, FSAR Tier 2, Section 8.4.1, "Station Blackout Analysis Assumptions," states that, during an SBO, power from the "highly reliable" dc power system is available. FSAR Tier 2, Section 8.4.3, "Station Blackout Coping Equipment Assessment," states that non-safety-related equipment is not relied on to mitigate an SBO.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this conclusion is confirmed by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. During an SBO, dc power from the EDSS is available. SER Section 8.3.2.3 evaluates the classification of the EDSS. Therefore, the classification of the EDSS, compliance with 10 CFR 50.63, and conformance to RG 1.155 are also being evaluated as part of **OPEN ITEM 8.3-1**.

8.2.4.7 Compliance with 10 CFR 50.65 and Conformance to RG 1.160

The requirements of 10 CFR 50.65(a)(4) (the Maintenance Rule) specify that COL applicants assess and manage the increase in risk that may result from proposed maintenance activities before performing maintenance activities in general, including those involving the offsite power transmission lines. For instance, grid stability and offsite power availability are examples of emergent conditions that may result in the need for assessment or that could change the conditions of a previously performed assessment.

Accordingly, COL applicants should perform grid reliability evaluations as part of the maintenance risk assessment before performing "grid risk-sensitive" maintenance activities (such as surveillances, postmaintenance testing, and preventive and corrective maintenance).

For qualitative risk assessments, the evaluation includes how the risk assessment and management programs will preserve plant-specific key safety functions. These programs are based on Nuclear Energy Institute Guideline NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," which is endorsed by RG 1.160 and relates to the effectiveness of maintenance activities, including grid risk-sensitive maintenance activities (such as a LOOP or SBO).

In Generic (GL) Letter 2007-01, "Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients," dated February 7, 2007 (ADAMS Accession No. ML070360665) and the associated summary report (ADAMS Accession No. ML082760385), the NRC staff discusses cable failures and finds that (1) the predominant factor contributing to cable failures at NPPs appears to be the presence of water or moisture or exposure of cables to submerged conditions and (2) licensees should have a program for using available diagnostic cable testing methods to assess the cable condition. DSRS Section 8.2 states that operating experience has shown that undetected degradation of underground electric cables caused by protracted exposure to wetted environments or submergence in water could result in multiple equipment failures and cables from independent power sources or different divisions could be affected by the same condition. In **RAI 8823, Question 08.02-6**, the staff requested information on how the NuScale design addresses the operating experience in GL 2007-01. Specifically, the staff asked the applicant to (1) identify any inaccessible or underground cables and (2) discuss the inspection, testing, and monitoring programs, if applicable, to detect the degradation of inaccessible or underground cables. In its response to **RAI 8823, Question 08.02-6**, dated July 24, 2017 (ADAMS Accession No. ML17205A551), the applicant (1) stated that the NuScale design partially conforms to GL 2007-01 and (2) explained that power cables within the scope of FSAR Tier 2, Chapter 8, do not include cables that connect offsite power to safety buses, cables that connect an emergency diesel generator (EDG) to a safety bus, or cables that provide power to active emergency core cooling systems. NuScale's request for exemption to GDC 17, as discussed in SER Section 8.2.4.3, is **OPEN ITEM 8.3-1**. The staff has not determined whether the NuScale design is required to have an offsite power system with two or more circuits from the transmission system. Thus, whether an inspection, monitoring, or testing program should include cables that connect offsite power to safety buses, cables that connect an EDG to a safety bus, or cables that provide power to active emergency core cooling systems is **OPEN ITEM 8.3-1**.

Furthermore, in **RAI 8823, Question 08.02-6**, the staff asked the applicant to discuss the applicability of RG 1.218 for the offsite power system if it uses a condition-monitoring program. In its response to **RAI 8823, Question 08.02-6**, dated July 24, 2017 (ADAMS Accession No. ML170205A551), the applicant revised FSAR Tier 2, Table 8.1-1, to indicate that it uses RG 1.218 as guidance for the offsite power system. In addition, the applicant revised FSAR Tier 2, Section 8.2.3.2, to discuss conformance to RG 1.218. The staff agrees that RG 1.218 applies to the NuScale design and finds the response acceptable because the COL applicant will develop the Maintenance Rule program as part of COL item 17.6-1, which will include monitoring the condition of cables within the scope of the Maintenance Rule. Therefore, **RAI 8823, Question 08.02-6**, is **Confirmatory Item 08.02-1**, pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

The applicant states in FSAR Tier 2, Table 8.1-1, that 10 CFR 50.65(a)(4) is guidance for Section 8.2 on offsite power systems. FSAR Tier 2, Section 8.2.3.2, states that the development and implementation of the Maintenance Rule (10 CFR 50.65), including the identification of SSCs that require assessment in accordance with 10 CFR 50.65(a)(4), is described in FSAR Tier 2, Section 17.6. FSAR Tier 2, Section 17.6, includes COL Item 17.6-1, which directs a COL applicant that references the NuScale power plant design certification to describe the program for monitoring the effectiveness of maintenance required by 10 CFR 50.65.

In addition, for the offsite power system, FSAR Tier 2, Table 8.1-1, states that the Maintenance Rule is guidance, whereas FSAR Tier 2, Section 8.2.3.2, indicates that the Maintenance Rule is applicable in accordance with COL item 17.6-1. In **RAI 8839, Question 08.02-8**, the staff asked the applicant to explain whether the Maintenance Rule should be listed as acceptance criteria or guidance in FSAR Tier 2, Table 8.1-1, for offsite power (Section 8.2). In its response to **RAI 8839, Question 08.02-8**, dated July 7, 2017 (ADAMS Accession No. ML17188A464), the applicant revised FSAR Tier 2, Table 8.1-1, to include the Maintenance Rule as acceptance criteria for the offsite power system. The staff finds that the applicant clarified that the Maintenance Rule applies to the offsite power system and that the issue is resolved. Therefore, **RAI 8839, Question 08.02-8**, is **Confirmatory Item 08.02-2,** pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

The staff reviewed the methodology for implementing the Maintenance Rule program (10 CFR 50.65) described in FSAR Tier 2, Section 17.6. COL Item 17.6-1 states that "a COL applicant that references the NuScale Power Plant design certification will describe the program for monitoring the effectiveness of maintenance required by 10 CFR 50.65." Because of the OPEN ITEM associated with this section, the staff is unable to finalize its conclusions on the conformance to RG 1.160.

8.2.4.8 Conformance to RG 1.32

RG 1.32 is related to the criteria for power systems and endorses IEEE Std. 308-2001, "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations." IEEE Std. 308-2001 discusses the offsite power system in Section 5.2.3, "Preferred Power Supply," and states that the preferred power supply consists of two or more circuits from the transmission system.

FSAR Tier 2, Table 8.1-1, states that RG 1.32 is guidance for FSAR Tier 2, Section 8.2, and is noted with a "G" for "guidance" in the column for FSAR Tier 2, Section 8.1, Table 8.1-1.

FSAR Tier 2, Section 8.2.3.2, states that RG 1.32 does not apply to the offsite power system.

However, FSAR Tier 2, Table 8.1-1, and FSAR Tier 2, Section 8.2.3.2, are inconsistent because one states that RG 1.32 is guidance and the other states RG 1.32 does not apply. In **RAI 8823, Question 08.02-4**, the staff asked the applicant to clarify whether RG 1.32 is used as guidance or is not applicable. In its response to **RAI 8823, Question 08.02-4**, dated July 24, 2017 (ADAMS Accession No. ML17205A551), the applicant revised FSAR Tier 2, Table 8.1-1, to show that RG 1.32 does not apply to the offsite power system.

The staff agrees with the applicant that RG 1.32 addresses design criteria for safety-related power systems.

IEEE Std. 308-2001 discusses the offsite power system in Section 5.2.3, "Preferred Power Supply," and states that the preferred power supply consists of two or more circuits from the transmission system. The exemption to GDC 17, as discussed in SER Section 8.2.4.3, is an **OPEN ITEM 8.3-1**, in which the staff has not determined whether the NuScale design is required to have an offsite power system with two or more circuits from the transmission system. The resolution of **OPEN ITEM 8.3-1** with regard to GDC 17 will determine whether RG 1.32 should be applied to the NuScale design in regards to the offsite power system. Thus, conformance to RG 1.32 is **OPEN ITEM 8.3-1**.

8.2.4.9 Conformance to RG 1.68

The DSRS, Table 8.1-1, "Acceptance Criteria and Guidelines for Electric Power Systems," states that RG 1.68 may be used as guidance for offsite power systems.

FSAR Tier 2, Table 8.1-1, states that RG 1.68 is guidance for FSAR Tier 2, Section 8.2, and is noted with a "G" for "guidance" in the column for FSAR Tier 2, Section 8.1, Table 8.1-1. Furthermore, FSAR Tier 2, Table 8.1-1, in the "Remarks" column, refers to FSAR Tier 2, Section 8.2, as it relates to the offsite power system.

FSAR Tier 2, Section 8.2, includes COL Item 8.2-3, which states that a COL applicant will describe the testing of the switchyard and the connections to an offsite power system, if provided, consistent with RG 1.68, Revision 3, issued March 2007.

The staff finds that the NuScale design conforms to RG 1.68 because COL Item 8.2-3 directs the COL applicant to describe the testing of the switchyard and the connections to an offsite power system, if provided, consistent with RG 1.68, Revision 3. The staff finds this acceptable.

8.2.4.10 Conformance to RG 1.204

DSRS Section 8.2 states that adequate provisions are made in the design of the plant and the offsite and onsite power systems for grounding, surge protection, and lightning protection. The reviewer evaluates the plant/station grounding systems, the methods of equipment and structural grounding, ac power system neutral grounding and ground fault current limiting features, surge and lightning protection features for outdoor equipment and circuits, and the measures for isolation of instrumentation grounding systems. RG 1.204; IEEE Std. 665-1995; IEEE Std. 666-1991, "IEEE Design Guide for Electric Power Service Systems for Generating Stations"; IEEE Std. 1050-1996, "IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations"; and IEEE Std. C62.23-1995 provide acceptable guidelines for the design, installation, and performance of station grounding systems and surge and lightning protection systems as discussed in DSRS Section 8.2.

FSAR Tier 2, Table 8.1-1, states that RG 1.204 does not apply to FSAR Tier 2, Section 8.2, on offsite power systems. However, FSAR Tier 2, Table 1.9-2, "Conformance with Regulatory Guides," states the following:

> *The grounding and lightning protection systems are designed, installed, tested, and maintained in conformance to RG 1.204, with the exception that where IEEE Std. 666-1991 (Reaffirmed 1996) and IEEE Std. 1050-1996 are specified, IEEE Std. 666-2007 and IEEE Std. 1050-2004 are applied instead. Reconciliation of the two versions of each standard demonstrates the acceptability of the use of the later versions.*

COL Item 8.2-1 in FSAR Tier 2, Section 8.2.2, "Switchyard," directs a COL applicant that references the NuScale power plant design certification to describe the site-specific switchyard and design, including lightning and grounding equipment. In **RAI 8823, Question 08.02-05**, the staff asked the applicant to (1) explain why the grounding and lightning protection of the switchyard and connections to an offsite and onsite power system does not meet the guidance in RG 1.204 and the applicable standards listed in the above paragraph, as discussed in DSRS Section 8.2 and (2) clarify FSAR Tier 2, Section 8.2, to state conformance to RG 1.204 if the grounding and lightning protection of the switchyard and connections to an offsite and onsite power system does meet the guidance in RG 1.204.

In its response to **RAI 8823, Question 08.02-5**, dated July 24, 2017 (ADAMS Accession No. ML17205A551), the applicant stated that (1) the NuScale design does not rely on an electric power grid connection and grid stability for safe operation and (2) the design of the switchyard and connections would not be required to show compliance with RG 1.204 or industry standards to demonstrate compliance with GDC 17.

The exemption to GDC 17, as discussed in SER Section 8.2.4.3, is **OPEN ITEM 8.3-1** in which the staff has not determined whether the NuScale design is required to have an offsite power system with two or more circuits from the transmission system. The resolution of **OPEN ITEM 8.3-1** with regard to GDC 17 will determine whether RG 1.204 or IEEE standards discussed above would apply to the design of the switchyard and connections. Thus, conformance to RG 1.204 is **OPEN ITEM 8.3-1**.

8.2.4.11 Conformance to RG 1.206 and SRP BTP 8-3

Because the grid is site specific, RG 1.206 calls for the FSAR to include interface requirements for the COL application. COL Item 8.2-1 directs the COL applicant to describe the switchyard layout and design, including offsite power connections. DSRS Section 8.2 states that communications between the NPP and its offsite transmission system operating authorities are implemented to assess whether the offsite power sources are operable; therefore, agreements and protocols between the transmission system operator and NPP should exist. FSAR Tier 2, Section 8.2.3.1, "Analysis of Grid Stability," includes COL Item 8.2-2, which directs the applicant to perform the grid stability study in accordance with transmission system operator requirements, including communication agreements and protocols. The staff finds this acceptable because the COL item directs the applicant to establish communication agreements and protocols with the transmission system operator. The staff determined that the NuScale FSAR directs a COL applicant to provide the necessary interface requirements between the NPP and grid operator; therefore, it conforms to RG 1.206.

Section III.3.F of DSRS Section 8.2 states the following:

> *The results of the grid stability analysis must show that loss of the largest single supply to the grid does not result in the complete loss of preferred power. The analysis should consider the loss, through a single event, of the largest capacity being supplied to the grid, removal of the largest load from the grid, or loss of the most critical transmission line. This could be the total output of the station, the largest station on the grid, or possibly several large stations if these use a common transmission tower, transformer, or a breaker in a remote switchyard or substation.*

FSAR Tier 2, Section 8.2.3.1, provides COL Item 8.2-2, which directs a COL applicant to describe the site-specific offsite power connection and grid stability studies, including the effects of grid contingencies such as the loss of the largest operating unit on the grid, the loss of one NuScale power module (at a 50-megawatt (MW) approximate output), and the loss of the full complement of NuScale power modules (up to 12 modules with a total approximate output of 600 MW). In **RAI 8768, Question 08.02-1**, the staff asked the applicant to explain why the grid stability studies to be performed by the COL applicant do not consider the removal of the largest load from the grid or the loss of the most critical transmission line in accordance with the guidance in DSRS Section 8.2. In its response to **RAI 8768, Question 08.02-1**, dated June 2, 2017 (ADAMS Accession No. ML17153A335), the applicant stated that the NuScale design does not rely on electric grid connections and grid stability for safe operation. Furthermore, the applicant stated that removal of the largest load from the grid or the loss of the most critical transmission line does not affect safe operation of the facility. FSAR, Tier 2, Section 8.3 states that the NuScale design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

RG 1.206 discusses, in part, the equipment that must be considered in the specification of offsite power supplies. COL Item 8.2-1 in FSAR Tier 2, Section 8.2.2, directs the applicant to provide information on the site-specific switchyard layout and design, including offsite power connections, and it conforms to RG 1.206.

SRP BTP 8-3 states that the applicant performs stability studies for the electrical transmission grid that would be used to provide the offsite power sources to the plant. FSAR Tier 2, Section 8.2.2.2, states that the NuScale design is in conformance to SRP BTP 8-3. The staff determined that the NuScale FSAR directs a COL applicant that references the NuScale design to provide a site-specific grid stability analysis as stated in COL Item 8.2-3 and, therefore, determined that it conforms to SRP BTP 8-3.

8.2.4.12 Conformance to SRP BTP 8-6

SRP BTP 8-6 discusses adverse effects on the Class 1E loads that can be caused by sustained degraded grid voltage conditions when the Class 1E buses are connected to offsite power. FSAR Tier 2, Table 8.1-1, states that SRP BTP 8-6 is guidance for FSAR Tier 2, Section 8.2, and is noted with a "G" for "guidance" in the column for FSAR Tier 2, Section 8.2.

FSAR, Tier 2, Section 8.2.3.2, states that SRP BTP 8-6 does not apply to the offsite power system. In **RAI 8768, Question 08.02-2**, staff asked the applicant to clarify whether SRP BTP 8-6 is used as guidance or does not apply to the offsite power system. In its response to **RAI 8768, Question 08.02-2**, dated June 2, 2017 (ADAMS Accession No. ML17153A335), the applicant stated that SRP BTP 8-6 does not apply to the offsite power system (if provided) and was not used as guidance. The applicant revised FSAR Tier 2, Table 8.1-1, to indicate that SRP BTP 8-6 does not apply to offsite power systems. In addition, the applicant revised the information on SRP BTP 8-6 in FSAR Tier 2, Table 1.9-3, to add the applicable Section 8.2.3 and to state that the offsite power system does not supply power to Class 1E loads and does not support safety-related functions. The staff finds the response acceptable because the applicant clarified that SRP BTP 8-6 does not apply to offsite power systems.

Therefore, **RAI 8768, Question 08.02-2**, is **Confirmatory Item 08.02-3**, pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

8.2.4.13 Conformance to SRP BTP 8-9

On July 27, 2012, the staff issued NRC Bulletin 2012-01 to all holders of operating licenses and COLs requesting information about facilities' electric power system designs. The intended purpose of the bulletin was to affirm that all plants comply with the GDC 17 requirements and to evaluate whether any further regulatory action is warranted to address this design vulnerability. SRP BTP 8-9 discusses the vulnerability of the electric power system design resulting from open phase conditions in offsite electric power systems.

FSAR Tier 2, Table 8.1-1, states that SRP BTP 8-9 and NRC Bulletin 2012-01 are guidance for Section 8.2 on open phase conditions in the grid. FSAR Tier 2, Section 8.2, states that there are no failures of the offsite power system, including open phase conditions or an SBO that will prevent the operation of safety-related functions. Furthermore, FSAR Tier 2, Section 8.2, states the following:

> *If the offsite power system is supplying power to the onsite AC power system, the electrical isolation between the EDSS and equipment with safety-related functions, which is described in FSAR Tier 2, Section 7.1.2, ensures that the open phase conditions described in SRP BTP 8-9 would not prevent the performance of safety-related functions.*

DSRS Section 8.2, Section III, Item 3.H, states that (1) no single event, including a single protective relay, interlock, or switchgear failure, in the event of loss of all standby power sources, will prevent the separation of the offsite power system from the onsite distribution system and (2) the offsite power system and standby power supplies should not have common mode failures. In general, a failure modes and effects analysis for the offsite system evaluates the effects of failures, including loss of a relay or switchgear, and an open phase event.

In **RAI 8823, Question 08.02-7**, the staff asked the applicant to provide additional detail and a discussion on a failure modes and effects analysis of the offsite power system to clearly show that no failures of the offsite power system, including open phase conditions, will prevent the operation of safety-related functions, or otherwise provide features for the detection of open phase conditions and an alarm in the main control room, as specified in SRP BTP 8-9, Position B.3, for designs with passive safety features. In its response to **RAI 8823, Question 08.02-7**, dated July 24, 2017 (ADAMS Accession No. ML170205A551), the applicant explained that (1) the offsite power system has no risk-significant or safety-related functions, (2) NuScale is requesting an exemption to GDC 17, and (3) ac equipment failure caused by an open phase condition does not prevent the operation of safety-related equipment.

FSAR, Tier 2, Section 8.3 states that the design does not rely on safety-related AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

8.2.4.14 Conformance to SECY-91-078, SECY-94-084, and SECY-95-132

The DSRS, Table 8.1-1, states that SECY-94-084 and SECY-95-132 provide guidance that relates to the inclusion of an alternate power source to nonsafety loads at evolutionary plant designs. DSRS Section 8.2.III.3.A states that, for SECY-94-084 and SECY-95-132, the NuScale design review should identify any offsite power requirements to support non-safety-related, risk-significant active systems identified through the RTNSS process. SER Section 19.3 further discusses and evaluates the RTNSS; no RTNSS SSCs are determined to meet the RTNSS criteria.

FSAR Tier 2, Section 8.1.4.3, states that the design of NuScale electrical systems conforms to the Commission-approved positions in SECY-94-084, Section F and Section G, related to passive plant electrical systems. In addition, FSAR Tier 2, Table 8.1-1, states that SECY-94-084 and SECY-95-132 provide guidance for the offsite power system. However, FSAR Tier 2, Section 8.2, does not provide any discussions on the Commission papers cited above.

In **RAI 8839, Question 08.02-9**, the staff asked the applicant to describe how the NuScale design conforms to SECY-94-084 and SECY-95-132 for the offsite power system. In its response to **RAI 8839, Question 08.02-9**, dated July 7, 2017 (ADAMS Accession No. ML17188A464), the applicant revised FSAR, Section 8.2, to discuss that, for conformance to SECY-94-084 and SECY-95-132, (1) the offsite power system has no safety-related or risk-significant loads and (2) an AAC source or safety-related EDG is not needed, as consistent with the guidance in the Commission papers.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, “Safety Classification of Passive Nuclear Power Plant Electrical Systems.” The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

DSRS, Table 8.1-1, states that SECY-91-078 is guidance for offsite power systems as it relates to the inclusion of an alternate power source to nonsafety loads at evolutionary plant designs. However, FSAR Tier 2, Table 8.1-1, states that SECY-91-078 does not apply to the offsite power system. In addition, FSAR Tier 2, Section 8.1.4.3, states that SECY-91-078 does not directly apply to passive plant designs. In **RAI 8839, Question 08.02-10**, the staff asked the applicant to clarify the applicability of SECY-91-078 to the offsite power systems. In its response to **RAI 8839, Question 08.02-10**, dated July 7, 2017 (ADAMS Accession No. ML17188A464), the applicant stated that SECY-91-078 does not apply to the offsite power system and that SECY-91-078 does not apply to passive plant designs. The staff finds the response acceptable because the NuScale design is a passive plant design. In addition, the applicant clarified the applicability of the SECY-91-078 to the offsite power system. The staff finds the issue resolved.

8.2.5 Combined License Information Items

Table 8-1 below lists COL information item numbers and descriptions related to the offsite power system, from FSAR Tier 2, Table 1.8-2.

Table 8-1 NuScale Combined License Information Items for Section 8.2

Item No.	Description	DCD Tier 2 Section
COL 8.2-1	The design of the switchyard and the connections to an offsite power system are site-specific and are the responsibility of the COL applicant. A COL applicant that references the NuScale power plant design certification will describe the site-specific switchyard layout and design, including offsite power connections, control and indication, characteristics of circuit breakers and buses, protective relaying, power supplies, lightning and grounding protection equipment, and compliance with GDC 5.	8.2.2
COL 8.2-2	A COL applicant that references the NuScale power plant design certification will describe the site-specific offsite power connection and grid stability studies, including the effects of grid contingencies such as the loss of the largest operating unit on the grid, the loss of one NuScale power module, and the loss of the full complement of NuScale power modules (up to 12 modules). The study will be performed in accordance with the applicable Federal Energy Regulatory Commission, North American Electric Reliability Corporation, and transmission system operator requirements, including communication agreements and protocols.	8.3.1.2.3
COL 8.2-3	A COL applicant that references the NuScale power plant design certification will describe the testing of the switchyard and the connections to an offsite power system, if provided, consistent with RG 1.68, Revision 3.	8.3.1.2.4

8.2.6 Conclusion

Because of the OPEN ITEM associated with this section, the staff is unable to finalize its conclusions on whether the design of the NuScale offsite power system meets RG 1.32, RG 1.155, RG 1.60, RG 1.204, RG 1.206, BTP 8-9, SECY-94-084, and SECY-95-132. Additionally, the staff is able to conclude that the design of the NuScale offsite power system did meet RG 1.68, BTP 8-3, BTP 8-6, and SECY-91-078.

8.3 Onsite Power Systems

8.3.1 Alternating-Current Power Systems

8.3.1.1 Introduction

The NuScale onsite power system is designed to provide electric power to the plant loads during all modes of plant operation.

The onsite power system power includes ac and dc power systems. This section discusses the ac power system for plant loads, and SER Section 8.3.2 discusses the dc system. The ac power system provides sufficient capacity and capability to ensure that the SSCs perform as intended during all modes of plant operation. NuScale claims that the plant safety-related functions are achieved and maintained without reliance on electrical power; therefore, neither the ac nor dc power systems are needed to be safety-related. The objective of the staff review is to determine that the onsite ac power system will perform its design function during all plant operating conditions and that the design establishes non-reliance on electrical power for accident conditions.

8.3.1.2 Summary of Application

FSAR Tier 1: FSAR Tier 1, Chapter 2, addresses the electrical ITAAC for reactor systems and equipment. FSAR Tier 1, Section 2.1, Table 2.1-4, "NuScale Power Module Inspections, Tests, Analyses, and Acceptance Criteria," provides ITAAC that address the EPA and physical separation of redundant divisions of the MPS Class 1E instrumentation and control circuits and between Class 1E and non-Class 1E current-carrying circuits.

FSAR Tier 2: FSAR Tier 2, Section 8.3.1, describes an onsite electrical power system, as summarized here, in part:

> *Onsite ac Power Systems: The onsite ac power system supplies all electrical loads of the plant, is classified nonsafety related (non-Class1E), and includes a normal ac power system comprising 13.8, kV, 4.16 kV, and low-voltage ac electrical distribution system using 480 Volt and 120 Volt ac power. SER Section 8.3.1.4 addresses and evaluates the onsite ac power system.*

ITAAC: There are no ITAAC associated with the performance of the onsite ac systems. However there are ITAAC associated with the EPAs and cable separation as stated just above.

Technical Specifications: There are no technical specifications for the onsite ac power system because this system does not perform a safety function or directly support safety-related SSCs.

CDIs: This section of the FSAR contains CDIs that are related to the following systems, as listed in FSAR Tier 2, Section 1, Table 1.8-1:

- Diesel Generator Building: FSAR Tier 2, Section 1.2.2, includes conceptual design information for this structure.
- AAPS: FSAR Tier 2, Section 8.3.1, includes conceptual design information for this component.

- Lightning protection and Grounding System Grid: FSAR Tier 2, Section 8.3.1, includes conceptual design information for this system.

- Backup Diesel Generator: SER Section 8.3.1 discusses this COL item.

Plant Interfaces: FSAR Tier 2, Section 8.3.1 contains the COL information items listed below. The COL items relate to the following plant interfaces, which COL applicants that reference the certified design will address.

- COL 8.3-1: The COL applicant will describe the site-specific location, type, and design of the AAPS.

- COL 8.3.2: The COL applicant will describe the site-specific heat tracing system.

- COL 8.3-3: The COL applicant will describe the design of the site-specific plant grounding grid and lightning protection network.

8.3.1.3 Regulatory Basis

DSRS Section 8.3.1 contains the relevant NRC requirements for the onsite ac power system and the associated acceptance criteria, as summarized below. DSRS Section 8.3.1 provides review interfaces with other DSRS sections.

- 10 CFR Part 50, Appendix A, GDC 2, as it relates to the 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.

- 10 CFR Part 50, Appendix A, GDC 4, as it relates to the 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.

- 10 CFR Part 50, Appendix A, GDC 5, as it relates to the sharing of SSCs of the ac power systems.

- 10 CFR Part 50, Appendix A, GDC 17, as it relates to the onsite ac power system's (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. The applicant has requested an exemption to this criterion.

- 10 CFR Part 50, Appendix A, GDC 18, as it relates to inspection and testing of the onsite power systems. The applicant has requested an exemption to this criterion.

- 10 CFR Part 50, Appendix A, GDC 33, 34, 35, 38, 41, and 44, as they relate to GDC 17 to ensure the accomplishment of the safety functions as described therein.

- 10 CFR Part 50, Appendix A, GDC 50, as it relates to the design of containment electrical penetrations that contain circuits of the ac power system and the capability of electric penetration assemblies in containment structures to accommodate a LOCA without loss of mechanical integrity and the external circuit protection for such penetrations.

- 10 CFR 50.34(f), "Additional TMI-related requirements," as it relates to additional TMI-related requirements, specifically the provision of power to: the bypassed and inoperable status indication of ac power systems, the pressurizer heaters, the pressurizer relief valves, block valves, and level indicators.

- 10 CFR 50.55a(h), "Protection and safety systems," as it relates to the incorporation of IEEE Std. 603-1991, including the correction sheet, dated January 30, 1995.

- 10 CFR 50.65(a)(4), as it relates to assessment and management of the increase in risk that may result from proposed maintenance activities before such activities are performed.

The guidance and acceptance criteria for meeting the above regulatory requirements in accordance with the DSRS are as follows:

- RG 1.6, Regulatory Positions D.1, D.3, and D.4, as they relate to the independence between redundant onsite ac power sources and between their distribution systems.

- RG 1.32, as it relates to the design, operation, and testing of the safety-related portions of the onsite ac power system.

- RG 1.47, as it relates to the bypass and inoperable status of safety-related onsite power supplies.

- RG 1.53, as it relates to the application of the single-failure criterion

- RG 1.63, as it relates 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 (GDC 50).

- RG 1.68, as it relates to initial test programs for water-cooled nuclear power plants.

- RG 1.75, as it relates to the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite ac power system.

- RG 1.81, as it relates to the sharing of the SSCs (power sources) of the ac power system.

- RG 1.106, "Thermal Overload Protection for Electrical Motors on Motor-Operated Valves," as it relates to safety-related valves.

- RG 1.118, as it relates to the capability to periodically test the onsite ac power system (GDC 18).

- RG 1.153, as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite dc power system.

- RG 1.155, as it relates to the capability and the capacity of the onsite ac power system for an SBO, including the operation of the AAC power source(s).

- RG 1.204, as it relates to the design, installation, and performance of station grounding systems and surge and lightning protection systems.

- RG 1.206, as it relates to power system analytical studies and stability studies to verify the capability of the offsite power systems and their interfaces with the onsite power system.

- RG 1.218, as it relates to monitoring the condition of cables that have been determined to fall within the scope of the maintenance rule.

- SRP BTP 8-2, which states that EDGs should not be used for peaking service.

- SRP BTP 8-6, as it relates to the analysis, testing, and selection of the undervoltage and degraded voltage setpoints and associated time delays.

- SRP BTP 8-9, as it relates to providing protection to safety-related ac loads in the event of an open phase condition on the high side of a unit auxiliary transformer (UAT).

8.3.1.4 Technical Evaluation

FSAR, Tier 2, Section 8.3 states that the design does not rely on safety-related AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." By letter dated December 13, 2017, NRC staff informed the applicant of the approval of TR-0815-1649 (ML17340A524).

Additionally, this letter clarified that, if the applicant chooses to incorporate by reference TR-0815-16497 as part of its DCA, it must demonstrate that the reactor design meets all of the conditions of applicability (provided in Table 3-1 of TR-0815-1649) and address five additional conditions imposed by the NRC staff. The NRC staff was not able to find the disposition of the conditions of applicability and the five additional conditions in the NuScale DCA. Accordingly, NRC staff issued **RAI 9359, Question 1-1**, requesting the applicant document in the DCA the disposition of the conditions of applicability and the additional conditions associated with TR-0815-16497. NRC staff is evaluating this as OPEN ITEM 8.3-1.

FSAR Tier 2, Section 8.3.1, describes design parameters for the onsite ac power system. It also provides design information for the power distribution systems that provide ac power to the various ac system electrical loads, including those that support power production and the battery chargers.

The onsite ac power systems distribute ac power to the onsite dc power systems (through battery chargers) and to the plant ac electrical loads during startup and shutdown, normal operation, and off-normal conditions. The onsite ac power systems are shared between the NPMs and include the following:

- 13.8 kV and switchyard system (EHVS) (13.8 kV);
- EMVS (4.16 kV);
- ELVS (480 Volts and 120 Volts);
- backup diesel generators (BDGs) (480 volts); and
- auxiliary ac power source (AAPS) (13.8 kV).

FSAR, Tier 2, Section 8.3.1.1.1, describes the EHVS, EMVS, and ELVS power distribution systems. The non-safety-related EHVS provides electrical connections from the turbine generators, the 13.8-kV switchyard system, and AAPS to the onsite power electrical distribution system. The EHVS is a shared system in which four 13.8-kV buses are used for connecting six generators in division I (North Side) of the NPM physical configuration. Division II (South Side) of the NPM physical configuration includes the other six generators.

FSAR Tier 2 states that, during normal plant operation, each turbine generator (up to 12 per plant site) supplies power to the 13.8-kV generator buses as shown in FSAR Tier 2, Figure 8.3-2a and Figure 8.3-2b, "13.8 kV and Switchyard System," through its own dedicated GCB. The offsite power system is connected to the generator buses through the switchyard, MPTs, and switchyard grid breakers. The staff asked the applicant to provide additional clarification on the short-circuit capacity of the GCB; SER Section 8.2 contains the documentation and the staff's evaluation of this.

FSAR, Tier 2, Section 8.3.1.1.1, classifies the EMVS as non-safety-related, and its primary function is to supply 4.16-kV power to plant loads during normal power module operation, including NPM startup and shutdown. There are four ELVS buses, and a UAT connects each EHVS bus to the corresponding low-voltage ELVS bus as depicted in FSAR Tier 2, Figure 8.3-1, "Station Single Line Diagram." The loads on these EMVS buses serve multiple NPMs, but the NPM-specific loads are not shared between NPMs. Therefore, the staff determined that operational flexibility is provided by the capability to cross-connect the EMVS buses, designed with automatic transfer from one EMVS bus to another EMVS bus for a UAT lockout relay operation or bus undervoltage condition. EMVS buses are also divided into two divisions for operation flexibility.

The nonsafety ELVS consists of the onsite electric power distribution circuits that operate at 600 volts or less. The ELVS buses also provide power, through Class 1E isolation devices, to the Class 1E MPS for certain loads such as the circuit breakers connected to the pressurizer heaters. ELVS buses are also divided into two divisions.

The detailed distribution of the above-mentioned EHVS, EMVS, and ELVS buses are provided in the single line diagrams in the figures in FSAR Tier 2, Section 8.3.

In FSAR Tier 2, Section 8.3.1.1.2, there are two 480-volt BDGs that are connected to ELVS buses. SER Section 8.3.1.4.4 describes and evaluates BDGs, which are nonsafety systems.

FSAR Tier 2, Section 8.3.1.1.1, discusses island-mode operation. In island mode, the plant turbine generators independently provide power to onsite ac loads.

In FSAR Tier 2, Section 8.3.1.1.1, the applicant further stated that the island mode is a non-safety-related and non-risk-significant design feature that is not credited to meet any regulatory or safety-related criteria. The staff requested a clarification on the initial test program of the island-mode function to ensure the testing fully covered island mode operation. The NRC staff issued an **RAI 8978, Question 14.02-3**. The applicant responded by letter dated November 2, 2017 (ADAMS Accession No. ML17306B390) and stated that, for the plants with a transmission grid connection, island mode also includes an automatic control function to transition to island mode and maintain power to onsite ac loads in the event that the grid is lost or becomes unstable. This automatic function separates the plant from the grid, maintains the operating reactors critical, and maintains uninterrupted power to the onsite ac loads. The service unit is a preselected unit (a single NPM and turbine generator combination) that provides power to the plant house loads and sets the ac system frequency and voltage upon automatic transfer to island mode. All units in the plant have the capability to be designated as the service unit. The staff found that the applicant adequately responded and clarified that, during transition to island-mode operation, the plant shall maintain the voltage and frequency during the transfer. The applicant has proposed a change in FSAR Tier 2, Section 8.3.1.1.1, to add the concept of a service unit. Therefore, **RAI 8978, Question 14.02-3**, is **Confirmatory Item 08.03.01-1**, pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

Additionally, FSAR Tier 2, Chapter 14.2, provides initial tests on island-mode operation of the plant. Island mode is a capability of the multi-module design systems that FSAR Tier 2, Chapter 21, Section 21.3.2.1, and FSAR Tier 2, Section 19.2, also describe. As described in Section 19.1, island mode is not credited in the probabilistic risk assessment for any of the DBEs.

The DSRS, Table 8-1, lists GDC, RGs, standards, and SRP BTPs that are generally applicable to electrical power systems of passive reactor designs. The staff has reviewed the following FSAR information that relates to compliance with requirements applicable to onsite ac power system design and conformance to applicable guidance as described below.

8.3.1.4.1 Compliance with GDC 2

The GDC 2 requires that SSCs important to safety be capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.

The NuScale design is a passive design, and the applicant stated that the onsite ac power sources neither perform nor support any safety-related SSC functions. Accordingly, the applicant stated that there is no need for the onsite ac power system to be qualified to seismic Category I. The applicant further stated that any non-safety-related SSCs (including electrical components, as applicable) with the potential for adverse seismic interactions are designed to seismic Category II requirements. SER Chapter 3 evaluates seismic qualification.

The applicant did not request any exemption from the compliance to GDC 2 in DCA Part 7 because it stated that the design does not include any safety-related electrical equipment. In FSAR Tier 2, Section 8.3.1.1, the applicant further stated that the loss of electrical load capability is not a safety-related function. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, “Safety Classification of Passive Nuclear Power Plant Electrical Systems.”

The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

8.3.1.4.2 Compliance with GDC 4

GDC 4 requires that SSCs important to safety be capable of withstanding the effects of missiles and environmental conditions associated with normal operation; maintenance; testing; and postulated accidents, including LOCAs.

The NuScale design is a passive design, and the applicant stated that the onsite ac power sources neither perform nor support any safety-related SSC functions. The applicant further stated that non-safety-related ac power system SSCs are designed to operate within the environmental conditions associated with normal operation, maintenance, and testing. Failure of the onsite ac power system components does not introduce adverse environmental conditions that would affect the ability of any safety-related SSC to perform its intended function.

The applicant did not request any exemption from the compliance to GDC 4 in DCA Part 7 because it stated that the design does not include any safety-related electrical equipment. In FSAR Tier 2, Section 8.3.1.1, the applicant further stated that the loss of electrical load capability is not a safety-related function. FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

8.3.1.4.3 Compliance with GDC 5

GDC 5 requires SSCs important to safety to not be shared among other nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

FSAR Tier 2, Section 8.3.1.2.7, "Onsite Alternating Current Power System Conformance with Regulatory Framework," states that failures affecting the onsite ac power systems do not affect the ability to achieve and maintain safety functions for any NPM, including a DBE in one NPM. FSAR Tier 2, Section 8.3.1.2.7, did not provide sufficient clarity to assess the design concept of each NPM for its safe operation to meet the requirement of GDC 5. In FSAR Tier 2, Figure 8.3-1, the staff found that the six NPMs in a division share buses; therefore, the staff's concern was whether the medium-voltage and low-voltage loads are shared.

In regards to the non-module-specific issue of sharing buses as depicted in FSAR Tier 2, Figure 8.3-1, the staff asked the applicant in **RAI 9006, Question 8.03.01-2a** (ADAMS Accession No. ML17217A016), to clarify whether this design feature presented any of the concerns on sharing related to GDC 5. Specifically, the staff asked the applicant to clarify how failure in one EHVS bus will not affect the ability to achieve and maintain safety functions for any NPM when the EHVS buses are shared.

By letter dated September 15, 2017 (ADAMS Accession No. ML17258A865), the applicant provided its response to **RAI 9006**, **Question 8.03.01-2a**, explaining that any failures affecting any one of the EHVS buses would not affect the ability to achieve and maintain safety functions for any NPM, including a DBE in one of the NPMs.

The applicant stated that, as described in FSAR, Section 8.1.4.2, the EHVS and EMVS systems are non-Class 1E systems whose functions are non-safety-related and not risk significant. Because the onsite power systems are not required nor credited to support DBE mitigation, EHVS failures do not affect the ability to achieve and maintain safety-related functions for any NPM, including a DBE in one NPM, consistent with GDC 5.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**.

8.3.1.4.4 Compliance with GDC 17

GDC 17 states that ac onsite power shall be provided to permit functioning of SSCs important to safety and electric power from the onsite ac electric power supplies to the onsite distribution system.

The applicant has requested an exemption to GDC 17, as described in DCA Part 7.

DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. The exemption request to GDC 17 is being evaluated as part of **OPEN ITEM 8.3-1**.

Although the applicant requests an exemption from GDC 17 for the electrical system design, the staff reviewed certain aspects of the onsite ac system design that are apparently asymmetrical in design configuration or do not provide clarity with respect to nomenclature. Therefore, the staff sought clarifications as discussed below.

<u>Voltage-Regulating Transformer</u>

During the review of FSAR Tier 2, Section 8.3.1.1.1, as depicted in FSAR Tier 2, Figure 8.3.1, the staff noted that four UATs serve the six MGs in the north turbine generator building (TGB) and that four UATs serve the six MGs in the south TGB. The applicant further stated in this section that the capability to cross-connect the EMVS buses on the north and south sides provides operational flexibility. Additionally, the applicant stated that the loss of a UAT or voltage-regulating transformer (VRT) is mitigated by automatically transferring the affected EMVS bus to an adjacent EMVS bus. The staff noted in FSAR Tier 2, Figures 8.3-2a and 8.3-2b, that a VRT is provided in only one of the four UAT feeder circuits and required clarification on the function of this VRT. With regard to the use of a VRT in only one of the four UAT feeder circuits (FSAR Tier 2, Figures 8.3-2a and 8.3-2b), the staff sought clarification in **RAI 9006, Question 8.03.01-1** (ADAMS Accession No. ML17217A016), as to how the overall design would function with this asymmetry (i.e., one VRT usage for four UATs).

By letter dated September 15, 2017 (ADAMS Accession No. ML17258A865), the applicant stated that the FSAR figures in question show a VRT in only one of the four UAT's feeder circuit as a conceptual design information feature that is not within the scope of the certified design. The purpose of any additional VRTs would be to accomplish voltage regulation. Alternately, the COL applicant may use reactive or capacitive load banks in the switchyard in place of VRTs. A COL grid analysis and load flow analysis, as applicable, would address this issue. To clarify this situation, the response includes proposed revisions to the text in FSAR Tier 2, Section 8.3.1.1.1, and to Note 3 in FSAR, Tier 2, Figures 8.3-2a and 8.3-2b.

The staff has reviewed the applicant's explanation to offer conceptual design information for the use of VRT that is outside of the scope of the design certification. The staff also reviewed the proposed revision to FSAR Tier 2, Section 8.3.1.1.1. The staff finds that, with the proposed revision to the FSAR, this issue is resolved. Therefore, this is **Confirmatory Item 08.03.01-2,** pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

Medium-Voltage Bus Configuration and Bus Transfer

FSAR Tier 2, Section 8.3.1.1.1, states that the design of the EMVS is such that any two UATs can supply the load requirements for six NPMs. Under the scenario that a UAT has a fault, the EMVS bus is transferred and powered by an adjacent UAT. For example, if UAT 2 has a fault, the EMVS bus 2 associated with it may be transferred to adjacent EMVS Bus 3, sharing the combined loads of both EMVS Bus 2 and Bus 3. It appeared to the staff that, with all the possible combinations of combining EMVS buses (with or without postulated bus faults) to UATs, each UAT might have to be sized to power as many as four EMVS buses, as depicted in FSAR Tier 2, Figure 8.3-1. Therefore, the staff sought clarification in **RAI 9006, Question 8.03.01-2b** (ADAMS Accession No. ML17217A016), for confirming sizing criteria for the UATs.

By letter dated September 15, 2017 (ADAMS Accession No. ML17258A865), the applicant provided a response to **RAI 9006, Question 8.03.01-2b**, explaining that the UATs do not need to be, and are not, sized to carry four EMVS buses. The applicant stated that each UAT is sized to carry loading of three NPMs on a given UAT. All adjacent bus transfers will result in EMVS bus loads that are below the capacity of the accepting/transferred UAT. The protection logic that will be developed during the detailed design process will prevent an automatic transfer of additional load to a single UAT if the combined load would be in excess of the transformer capacity limits. The staff understood the design and accepted that the results of the adjacent bus transfers between other buses connected from UATs are similar.

Based on the applicant's response, which clarifies the philosophy behind the bus transfers, and the restatement of the protection provided to ensure no UAT overloading, the staff finds this concern resolved.

Unit Auxiliary Transformer Load Tap Changers

During the review of FSAR Tier 2, Section 8.3.1.1.1, the staff noted that the UATs are provided with either no-load or load-manual tap changers to maintain secondary voltage within the established voltage limits. The voltage limits are derived from the EMVS load requirements for the expected range of voltage variations on the EHVS and for the anticipated transformer loading conditions up to the maximum transformer rating. With regard to the tap changers on UATs, the staff did not fully understand the nomenclature provided in the FSAR.

Therefore, in **RAI 9006, Question 8.03.01-3** (ADAMS Accession No. ML17217A016), the staff asked the applicant to clarify what UAT tap changer type it will use

By letter dated September 15, 2017 (ADAMS Accession No. ML17258A865), the applicant provided a response to **RAI 9006, Question 8.03.01-3**, explaining that the term "load-manual" was incorrect and that the applicant proposed a revision to state that the UATs are provided with tap changers that provide voltage regulation and to maintain secondary voltage within the established voltage limits.

The staff has reviewed the proposed FSAR markup and finds the change acceptable. Therefore, **RAI 9006, Question 08.03.01-3** is **Confirmatory Item 08.03.01-3**, pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

Backup Diesel Generator Connections with a Portable Generator

During the review of FSAR Tier 2, Section 8.3.1.1.2, the staff noted that the onsite BDGs are provided with instrumentation and controls for facilitating manual startup and shutdown, either locally or from the main control room, and for monitoring and control during operation. Each BDG is connected to its own BDG switchgear. Each BDG switchgear is connected to two distribution switchgears that provide power to 480 volt MCCs. In addition, the BDG switchgear is provided with a plug-in connection to connect a portable generator for diverse and flexible coping strategy purposes. With regard to the connection configuration of the portable generator to the BDG switchgear, the staff's clarification question was related to the interlocking of the BDG to the portable generator. Therefore, in **RAI 9006, Question 8.03.01-4** (ADAMS Accession No. ML17217A016), the staff asked the applicant to clarify under what conditions the portable generator would be connected to the BDG bus.

By letter dated September 15, 2017 (ADAMS Accession No. ML17258A865), the applicant provided a response to **RAI 9006, Question 8.03.01-4**, explaining that the portable generator would only be connected if the BDG was unavailable. These two sources would not be connected in parallel. The BDG switchgear is provided with a plug-in connection for connecting a portable generator. The applicant also provided the proposed revision to the FSAR. The staff has reviewed the proposed FSAR markup included in the response and finds this connection configuration adequately described. Therefore, **RAI 9006, Question 08.03.01-4** is **Confirmatory Item 08.03.01-4**, pending verification that the applicant has incorporated the proposed changes into the next FSAR revision.

8.3.1.4.5 Conformance to RG 1.6

RG 1.6, issued March 1971, describes an acceptable degree of independence between redundant standby (onsite) power sources and between their distribution systems, as part of compliance with GDC 17. The staff evaluated FSAR Tier 2, Section 8.3.1, in regards to conformance to RG 1.6, because this relates to the independence between redundant onsite ac power sources and between their distribution systems. In FSAR Tier 2, Section 8.3.1.2.7, in regard to conformance to RG 1.6, the applicant stated that the onsite ac electrical power system design does not contain any Class 1E distribution system. FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being

evaluated as **OPEN ITEM 8.3-1**. Therefore, RG 1.6 and the GDC 17 exemption are being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.6 Conformance to RG 1.32

RG 1.32 pertains to the design, operation, and testing of the safety-related portions of the onsite ac power system. The staff evaluated the FSAR with respect to RG 1.32, Revision 3, issued March 2004, as it relates to the design, operation, and testing of the safety-related portions of the onsite dc power system. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated with regard to RG 1.32 that the NuScale design uses passive safety systems that do not require ac electric power to fulfill safety- related functions and that the onsite electric ac power system are non-safety-related. Therefore, RG 1.32 is not applicable.

DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, RG 1.32 conformance is being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.7 Conformance to RG 1.47

RG 1.47 pertains to the bypass and inoperable status of safety-related onsite power supplies.

The staff evaluated the FSAR with respect to RG 1.47. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated with regard to RG 1.47 that the onsite ac power systems conform to RG 1.47 to the extent described in the discussion of compliance with 10 CFR 50.34(f)(2)(v). SER Chapter 7 describes and evaluates the staff's evaluation on conformance to RG 1.47.

8.3.1.4.8 Conformance to RG 1.53

RG 1.53 pertains to the application of the single-failure criterion. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated that the NuScale onsite ac power sources do not perform any safety-related functions; therefore, the application of the single-failure criterion to the systems is not required.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, RG 1.53 conformance is being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.9 Conformance to RG 1.68

DSRS, Table 8.1-1, states that RG 1.68 may be used as guidance for the initial test program for the onsite power systems. FSAR Tier 2, Section 8.3.1.2.7, states that preoperational testing of the onsite ac electrical system is performed as part of the initial test program described in FSAR Tier 2, Section 14.2.12.

SER Section 14.2 describes and evaluates the initial test program for the onsite ac system.

8.3.1.4.10 Conformance to RG 1.75

The RG 1.75 pertains to the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite ac power system. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated that the onsite electric ac power systems do not perform any safety-related functions and do not contain any Class 1E circuits. However, implementation of the guidance in RG 1.75 for these non-safety-related ac onsite power system circuits is accomplished by requiring physical separation from safety circuits throughout the plant. This guidance forms the basis for the design, routing, and modeling of electrical cable trays and raceways.

Although the onsite ac power system neither contains nor supports safety-related SSCs, the applicant has stated that it will use the separation criteria in the RG 1.75 to maintain separation between the non-Class 1E power system and the Class 1E circuits within the MPS. The staff finds this acceptable for the onsite ac power system. SER Chapter 7 evaluates electrical isolation with respect to the MPS.

8.3.1.4.11 Conformance to RG 1.81

RG 1.81 pertains to the sharing of Class 1E power sources within the onsite ac power system. The staff evaluated the FSAR with respect to RG 1.81 as it relates to the sharing of the ac power sources. SER Section 8.3.1.4.3 discusses the applicability of RG 1.81 as it applies to the ac onsite power systems, in regards to GDC 5 **(OPEN ITEM 8.3-1)**.

8.3.1.4.12 Conformance to RG 1.106

RG 1.106 provides guidance with respect to thermal overload protection for Class 1E motor-operated valves (MOVs). In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated that the NuScale design does not include safety-related MOVs. Therefore, the staff determined that this RG does not apply to the onsite ac power system to power any safety-related MOV because there are no safety-related MOVs.

8.3.1.4.13 Conformance to RG 1.153

The staff evaluated the FSAR with respect to RG 1.153 as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite ac power system. As endorsed by RG 1.153, IEEE Std. 603-1991 provides a method acceptable to the staff to evaluate all aspects of the electrical portions of the safety-related systems, including basic criteria for addressing single failures.

In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated the following with regard to RG 1.153:

> *As described in the discussion of conformance to 10 CFR 50.55a(h), no onsite electrical AC power system equipment is required to conform to 10 CFR 50.55a(h) and IEEE Standard 603-1991.*

SER Chapter 7 discusses the evaluation of IEEE Std. 603-1991 and 10 CFR 50.55a(h).

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the GDC 17 exemption is being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.14 Conformance to RG 1.155

RG 1.155 pertains to the capability and the capacity of the onsite ac power system to accommodate an SBO, including the operation of the AAPS power source. SER Section 8.4 contains the staff evaluation of the SBO capability of the AC power system.

8.3.1.4.15 Conformance to RG 1.204

RG 1.204 endorses IEEE Std. 665-1995 (reaffirmed 2001), IEEE Std. 666-1991 (reaffirmed 1996), IEEE Std. 1050-1996, and IEEE Std. C62.23-1995 (reaffirmed 2001). The applicant stated in FSAR Tier 2, Section 8.3.1.2.4, "Grounding and Lightning Protection," that the electrical grounding and lightning protection system is designed in accordance with these standards. The applicant has also provided COL Item 8.3-3, which directs the COL applicant to describe the design of the site-specific plant grounding grid and lightning protection network to ensure its compatibility with the NuScale design. The staff finds this to be in accordance with RG 1.204 and, therefore, acceptable.

8.3.1.4.16 Conformance to RG 1.206

RG 1.206 pertains to power system analytical studies and stability studies performed to verify the capability of the offsite power systems and their interfaces with the onsite power system.

FSAR Tier 2, Section 8.3.1.2.8, describes the various studies that were performed. The applicant has performed the following electrical power system studies:

- load flow studies and undervoltage/overvoltage protection;
- short-circuit studies;
- equipment sizing studies;
- equipment protection and coordination studies;
- insulation coordination (surge and lightning protection); and
- power quality limits.

In the NuScale design, the electrical power system calculations and distribution system studies used the Electrical Transient Analyzer Program (ETAP) to analyze the ac distribution system for load flow, voltage regulation, motor starting, and short-circuit studies. In FSAR, Tier 2, Section 8.3.1.2.8, the applicant stated that equipment sizing was developed from a load list and subsequently verified using the ETAP power system studies.

In regards to the equipment protection and coordination studies, the applicant stated that the distribution system circuit breakers and fuses are selected to carry design loads and to interrupt overloads and the maximum fault current available at their point of application. Using this selection process, only the protective device nearest the fault operates to isolate the fault or faulted equipment. The staff determined that the applicant developed a load list, performed the power system studies for the plant, and verified the equipment capability for operation with adequate information from the electrical power system studies.

The staff finds that the applicant follows the guidance of RG 1.206 with respect to electrical power system studies and finds it acceptable.

8.3.1.4.17 Conformance to SECY 91-078

SECY-91-078 pertains to the interface between the offsite ac power system and the Class 1E onsite power system. In FSAR Tier 2, Table 8.1-1, the applicant states that guidance does not apply to the NuScale design. This guidance pertains to GDC 17, and the applicant has requested an exemption to GDC 17, as described in DCA Part 7. DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, the applicant states that the "NuScale Power Module design does not rely on electrical power to achieve and maintain safe shutdown, to provide core cooling, to ensure containment vessel isolation and integrity, or to ensure RCPB integrity during and following a design basis event." FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the GDC 17 exemption is being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.18 Compliance with GDC 18

GDC 18 requires that electric power systems important to safety, which include the onsite ac power system, be designed to permit appropriate periodic inspection and testing. The applicant states in FSAR Tier 2, Section 8.3.1.2.7, that the NuScale design supports an exemption from the GDC 17 requirements and that, accordingly, it supports an exemption from GDC 18. The applicant requested an exemption to GDC 18 in DCA Part 7, Section 4.2.1.

Furthermore, FSAR, Tier 2, Section 8.3 states that neither the AC power systems nor DC power systems are needed to be safety-related, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. NRC staff is evaluating the exemption to GDC 18 as part of **OPEN ITEM 8.3-1**.

8.3.1.4.19 Conformance to RG 1.118

RG 1.118 pertains to the capability to periodically test the safety-related onsite ac power system (GDC 18). In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated that periodic testing of onsite ac power equipment is described in FSAR Section 8.3.1.3.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this conclusion is confirmed by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Because this guidance pertains to GDC 18 and NuScale has requested an exemption to GDC 18 in DCA Part 7, Section 4.2.1, NRC is evaluating conformance with RG 1.118 as part of **OPEN ITEM 8.3-1**.

8.3.1.4.20 Compliance with GDC 33, 34, 35, 38, 41, and 44

GDC 33, GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44 identify plant safety-related functions, including electric onsite ac power system requirements for those functions. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated that the plant design complies with a set of principal design criteria in lieu of these GDC, as described in Tier 2, Section 3.1.4. The principal design criteria do not include requirements for electric power systems. FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. The exemption from the requirements of GDC 33, 34, 35, 38, 41, and 44 is also being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.21 Compliance with GDC 50

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. Containment electric penetrations must therefore be designed to accommodate, without exceeding their design leakage rate, the calculated pressure and temperature conditions resulting from a LOCA. This criterion applies specifically to ensure the integrity of containment electrical penetrations in the event of design-basis LOCA conditions.

In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated with regard to GDC 50 that there are no onsite ac electrical power system cables that penetrate the containment vessels. In addition, in FSAR Tier 2, Section 8.1.4.3, the applicant stated that the ac and dc electrical power system circuits do not penetrate the containment vessels; therefore, conformance to GDC 50 is not necessary.

Additionally, various places in the FSAR appear to have conflicting statements as to compliance with this design criteria. For example, in FSAR Tier 2, Section 3.1.5.1, the applicant stated, "the NuScale Power Plant design conforms to GDC 50." Therefore, the staff requested clarification related to this discrepancy in **RAI 8788, Question 8.01-1**. Additionally, in **RAI 8788, Question 8.01-1**, the staff requested information on the description, design, and testing of the EPAs. In response to **RAI 8788, Question 8.01-1**, dated July 19, 2017 (ADAMS Accession No. ML17200D160), the applicant did not provide a complete response with respect to the EPA and its environmental qualification and testing. Subsequently, the applicant provided a supplemental response on November 3, 2017 (ADAMS Accession No. ML17310A296), and added new information on EPA safety classification and circuit protection related to EPAs. Based on this review of new information, the staff required additional clarifications related to the revision of certain EPA safety classifications and EPA circuit protection. The staff issued **RAI**

9308, Question 8.01-X, to obtain more detailed information on these issues.

Therefore, this item remains unresolved until the applicant provides proper clarification and verification **(OPEN ITEM 08.03.01-1)**.

8.3.1.4.22 Conformance to RG 1.63

RG 1.63 pertains 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 to meet the requirement of GDC 50. Mechanical integrity during and following a LOCA is addressed in SER Sections 3.11 and 6.2.1. External circuit protection was addressed in the applicant's response to **RAI 8788, Question 8.01-1**. The applicant revised FSAR, Table1.9-2, to state the following:

> *The portion of the RG 1.63 guidance that endorses IEEE-317-1983 is applicable. IEEE 741-1997 is used for external circuit protection of EPAs instead of IEEE 741-1986 as endorsed by RG 1.63. The 1997 version, including the additional design enhancements, is consistent with RG 1.63.*

However, this remains an open issue **(OPEN ITEM 08.03.01-1)**, pending resolution to the staff's question on the EPA, as discussed in SER Section 8.3.1.4.21, for GDC 50.

8.3.1.4.23 Compliance to 10 CFR 50.34(f)

The regulation at 10 CFR 50.34(f) pertains to additional TMI-related requirements, including the provision of electrical power to: the bypass and inoperable status indication of ac power systems, the pressurizer heaters, the pressurizer relief valves, block valves, and level indicators.

The regulations at 10 CFR 50.34(f)(2)(v), (f)(2)(xiii), and (f)(2)(xx) pertain to electrical systems. The regulation at 10 CFR 50.34(f)(2)(v) addresses bypass and inoperable status indications to be provided for safety systems. SER Section 7.2.4X addresses this item.

In DCA Part 7, Section 11 and Section 12, the applicant requested an exemption to 10 CFR 50.34(f)(2)(xx). In DCA, Part 7, Section 11.1.1, the applicant made the following statement:

> *The NuScale Power Plant design does not include pressurizer relief valves or pressurizer block valves; therefore, portions of the rule applicable to such valves are not technically relevant. The underlying purpose of the requirement is to enable natural circulation cooling in a loss of offsite power condition. The NuScale Power Plant design does not rely on pressurizer level indication to achieve and maintain natural circulation in a loss of electrical power condition, and therefore meets the underlying purpose of the rule. NuScale also requests an exemption from the portions of 10 CFR 50.34(f)(2)(xx) requiring power from vital buses and emergency power sources for pressurizer level indication.*

In regard to 10 CFR 50.34(f)(2)(xiii), the applicant made the following statement:

> *The NuScale Power requests an exemption from 10 CFR 50.34(f)(2)(xiii), which requires power supplies for pressurizer heaters and associated motive and control interfaces to establish and maintain natural circulation in hot shutdown conditions.*

The underlying purpose of the requirement is to enable natural circulation cooling in a loss of offsite power condition. The NuScale design does not rely on pressurizer heaters to achieve and maintain natural circulation in a loss of electrical power condition, and therefore meets the underlying purpose of the rule.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems."

The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the exemptions from the requirement of 10 CFR 50.34(f)(2)(xx) and 10 CFR 50.34(f)(2)(xiii) are also being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.1.4.24 Compliance with 10 CFR 50.55a(h)

Under 10 CFR 50.55a(h), the NRC requires compliance with the relevant positions for plant protection and safety systems for design, reliability, qualification, and testability of the power and instrumentation and control portions of the safety systems outlined in RG 1.153. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated with regard to 10 CFR 50.55a(h) that the onsite electrical ac power system equipment with respect to the design of instrumentation and control equipment and circuits is not a protection system and does not perform any safety-related functions. Therefore, the system is not required to conform to 10 CFR 50.55a(h) and IEEE Std. 603-1991. SER Subsection 7.2.13 addresses and provides the staff's evaluation of compliance with 10 CFR 50.55a(h) in regard to monitoring systems.

8.3.1.4.25 Compliance with 10 CFR 50.65(a)(4)

The regulation at 10 CFR 50.65(a)(4) pertains to the assessment and management of the increase in risk that may result from proposed maintenance activities before such activities are performed. SER Section 17.6 evaluates compliance with the Maintenance Rule.

8.3.1.4.26 Conformance to RG 1.218

RG 1.218, "Condition Monitoring Techniques for Electric Cables Used in Nuclear Power Plants," pertains to monitoring the condition of cables that have been determined to fall within the scope of the Maintenance Rule. SER Section 17.6 provides the staff's evaluation of this aspect of the design.

8.3.1.4.27 Conformance to Branch Technical Positions

SRP BTP 8-2 states that EDGs should not be used for peaking service. The intent of SRP BTP 8-2 is to ensure that the provision of GDC 17 is met with respect to minimizing the probability of concurrent loss of electrical power sources, which would preclude the use of onsite ac power sources for purposes other than supplying standby power when needed. In FSAR Tier 2, Section 8.3.1.2.7, the applicant stated that, with the NuScale design being nonreliant on ac power for the performance of safety-related functions, the concurrent loss of onsite and offsite ac power sources would have no significant adverse effect on plant safety.

DCA Part 7 discusses the exemption to GDC 17. DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the GDC 17 exemption and conformance to BTP 8-2 are being evaluated as part of **OPEN ITEM 8.3-1**.

The basis for SRP BTP 8-9 is to provide protection to safety-related ac loads in the event of an open phase condition on the high side of a UAT. SER Section 8.2 describes and evaluates SRP BTP 8-9.

8.3.1.5 Combined License Information Items

Table 8-2 below lists COL information item numbers and descriptions related to the onsite ac power system from FSAR Tier 2, Table 1.8-2.

Table 8-2 NuScale Combined License Information Items for FSAR Tier 2, Section 8.3.1

Item No.	Description	FSAR Tier 2 Section
8.3-1	A COL applicant will describe the site-specific location, type, and design of the AAPS.	8.3.1.1.2
8.3-2	A COL applicant will describe the site-specific heat tracing system.	8.3.1.2.3
8.3-3	A COL applicant will describe the design of the site-specific plant grounding grid and lightning protection network.	8.3.1.2.4

8.3.1.6 Conclusion

Because of the OPEN ITEMs associated with this section, the staff is unable to finalize its conclusions on whether the design of the NuScale onsite ac power system meets the appropriate regulatory requirements for onsite ac power systems as shown in the staff technical evaluation in SER Section 8.3.1.4.

8.3.2 Direct Current Power Systems

8.3.2.1 Introduction

The onsite direct current (dc) power systems include the highly reliable dc power system (EDSS) and the normal dc power system (EDNS). The EDSS is a non-Class 1E dc power system to which augmented design, qualification, and quality assurance (QA) provisions are applied. The EDSS comprises two dc subsystems: (1) the EDSS-common (EDSS-C) plant subsystem serves plant common loads that have functions that are not specific to any single NuScale Power Module (NPM). These plant common loads include main control room (MCR) emergency lighting and postaccident monitoring information displayed in the MCR. The EDSS-module-specific (EDSS-MS) plant subsystem consists of up to 12 separate and

independent dc electrical power supply systems, one for each NPM. The source of electrical supply to the EDSS-C and EDSS-MS battery chargers is the low-voltage alternating current (ac) electrical distribution system, through the backup diesel generator-backed distribution equipment.

The EDNS is a non-Class 1E dc power system. The EDNS does not serve any safety-related loads, and it does not have any safety-related functional requirements during plant startup, normal operation, shutdown, or abnormal operation. Therefore, the EDNS is classified as non-safety-related and non-risk-significant. The EDNS is shared between the NPMs and provides both dc and ac power (through inverters) to non-safety-related loads that support functions related to investment protection and power generation (i.e., the loads that are part of the plant permanent nonsafety systems). The EDNS consists of batteries, battery chargers, inverters, voltage regulating transformers, ac panelboards, maintenance bypass switches, dc switchboards, fused transfer switch boxes, battery monitors, surge suppression, associated EDNS protective relays, instrumentation, and EDNS cabling and wiring. The EDNS battery chargers are supplied from the low-voltage ac electrical distribution system.

The objective of the NRC staff review is to determine that the onsite dc power system satisfies the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criteria (GDC) 2, 4, 5, 17, and 18 and will perform its design function during all plant operating and accident conditions.

8.3.2.2 Summary of Application

Final Safety Analysis Report (FSAR) Tier 1: None.

FSAR Tier 2: The applicant has provided a Tier 2 system description in Section 8.3.2 of the application, summarized here in part as follows.

The onsite dc power systems include the following:

- EDSS
- EDNS

Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC): There are no ITAAC associated with dc systems.

Plant Interfaces: None. There are no combined license (COL) items for FSAR Section 8.3.2.

Technical Specifications: None.

Topical Report: TR-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 1, issued February 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17048A459 (nonproprietary version)), as it relates to the augmented design, qualification, and QA provisions of the EDSS.

8.3.2.3 Regulatory Basis

Section 8.3.1 of the NuScale Power, LLC (NuScale), design-specific review standard (DSRS) gives the relevant requirements of the Commission's regulations for the onsite dc power system, and the associated acceptance criteria, as summarized below. Section 8.3.1 of the DSRS also gives the review interfaces with other DSRS sections.

- GDC 2, "Design Basis for Protection against Natural Phenomena," as it relates to structures, systems, and components (SSCs) of the dc power system being capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.

- GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to SSCs of the dc power system being able to protect against dynamic effects such as the effects of missiles and to accommodate the effects of environmental conditions and associated with normal operation, maintenance, testing, and postulated accidents.

- GDC 5, "Sharing of Structures, Systems, and Components," as it relates to sharing of the dc power system SSCs.

- GDC 17, "Electric Power Systems," as it relates to the onsite dc power system's (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

- GDC 18, "Inspection and Testing of Electric Power Systems," as it relates to inspection and testing of the onsite power systems.

- GDC 33, 34, 35, 38, 41, and 44, as they relate to GDC 17, to ensure that the safety functions so described are accomplished.

- GDC 50, "Containment Design Basis," as it relates to the design of containment electrical penetrations containing circuits of the ac and dc power system and the capability of electric penetration assemblies in containment structures to withstand a loss-of-coolant accident (LOCA) without loss of mechanical integrity and the external circuit protection for such penetrations.

- 10 CFR 50.34(f), as it relates to additional Three Mile Island-related requirements, including the provision of power to bypassed and inoperable status indication of dc power systems, pressurizer heaters, pressurizer relief valves, block valves, and level indicators.

- 10 CFR 50.55a(h), as it relates to the incorporation of IEEE Std. 603-1991, "Standard Criteria for Safety Systems for Nuclear Power Generating Stations" (including the correction sheet dated January 30, 1995).

- 10 CFR 50.65(a)(4), as it relates to assessment and management of the increase in

risk that may result from proposed maintenance activities before they are performed

The NRC has the following guidance and acceptance criteria for meeting the above regulatory requirements, per the DSRS:

- Regulatory Guide (RG) 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems," issued March 1971, Regulatory Positions D.1, D.3, and D.4, as they relate to the independence between redundant onsite dc power sources and between their distribution systems.

- RG 1.32, "Criteria for Power Systems for Nuclear Power Plants," Revision 3, issued March 2004, as it relates to the design, operation, and testing of the safety-related portions of the onsite dc power system.

- RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems," as it relates to the bypass and inoperable status of safety-related onsite power supplies.

- RG 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems," as it relates to the application of the single-failure criterion.

- RG 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants," Revision 3, issued February 1987, as it relates 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 (GDC 50).

- RG 1.75, "Criteria for Independence of Electrical Safety Systems," Revision 3, issued February 2005, as it relates to the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite ac and dc power systems.

- RG 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," as it relates to the sharing of SSCs (power sources) of the dc power system.

- RG 1.106, "Thermal Overload Protection for Electrical Motors on Motor-Operated Valves," as it relates to safety-related valves.

- RG 1.118, "Periodic Testing of Electric Power and Protection Systems," as it relates to the capability to periodically test the onsite ac and dc power systems (GDC 18).

- RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants," as it relates to criteria for vented lead-acid storage batteries.

- RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants," as it relates to criteria for vented lead-acid storage batteries.

- RG 1.153, "Criteria for Safety Systems," as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite dc power system.

- RG 1.155, “Station Blackout,” as it relates to the capability and the capacity of the onsite dc power system for a station blackout.

- RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” as it relates to methods that are acceptable for complying with the requirements of the Maintenance Rule (10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants”).

- RG 1.212, “Sizing of Large Lead-Acid Storage Batteries,” as it relates to guidance for defining the dc load and size of lead-acid batteries needed to supply the defined load for full-float stationary battery applications to support nuclear power plant operations.

- RG 1.218, “Condition Monitoring Techniques for Electric Cables Used in Nuclear Power Plants,” as it relates to monitoring the condition of cables that have been determined to fall within the scope of the Maintenance Rule.

- Branch Technical Position (BTP) 8-5, “Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems.”

8.3.2.4 Technical Evaluation

DSRS Section 8.3.2 (ADAMS Accession No. ML15356A552) discusses the relevant requirements of the Commission regulations for the onsite dc power system, and the associated acceptance criteria. The relevant requirements are discussed are discussed in Section 8.3.2.2 of this report. This section discusses how NuScale has met or addressed those regulatory requirements.

8.3.2.4.1 Compliance with GDC 2, “Design Basis for Protection against Natural Phenomena”

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 losing the capability to perform their intended safety functions.

With regard to the dc power system, this criterion requires that the capability for important-to-safety portions of the onsite dc power system to perform its functions must be retained during the most severe natural phenomena that historically have been reported for the site and surrounding area. Therefore, the important-to-safety portions of the dc power system and its components must normally be located in seismic Category (SC-) I structures that provide protection from the effects of tornadoes, tornado missiles, and floods.

In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to GDC 2:

> *The EDNS is not required to function in the event of natural phenomena events. The EDNS structures, systems, and components with the potential for adverse seismic interaction with Seismic Category I SSC are designed to Seismic Category II requirements so that their failure does not affect the ability of a safety-related SSC to perform its intended function. The EDSS structures, systems, and components are designed with augmented requirements for protection from the effects of natural phenomena for increased reliability and availability. The EDSS structures, systems, and components are <u>principally</u> [emphasis added] located in the CRB and RXB, which are designed to withstand*

the effects of and function following natural phenomena such as earthquakes, tornadoes, hurricanes, floods, and externally-generated missiles.

The EDSS structures, systems, and components are further augmented by applying design, qualification, and QA provisions typically applied to Class 1E DC power systems using a graded approach. The graded approach is reflected in the EDSS design, qualification, and QA provisions detailed in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P, Revision 0]. Specific to seismic phenomena, Reference 8.3-1 includes augmented seismic design and qualification provisions.

According to TR-0818-16497-P, the EDSS will meet the requirements for SC-I in accordance with IEEE Std. 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," as endorsed with clarification and exception by RG 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," Revision 3, issued September 2009, and as specified in Regulatory Position C.5 of RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants."

In FSAR Tier 2, Section 8.3.2.2, the applicant used the phrase "principally located"; however, the applicant did not define that phrase and the staff needed clarification on its meaning. In **RAI 9038, Question 08.03.02-7,** the staff asked the applicant to explain what is meant by "principally located" in the control room building (CRB) and reactor building (RXB), as stated in FSAR Tier 2, Section 8.3.2.2. In addition, In FSAR Tier 2, Section 8.3.3, Reference 8.3-1 is NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P, in which Table 3-2, "Augmented design, qualification, and quality assurance provisions," states that "[t]he highly reliable DC electrical systems (including the batteries) are housed in SC-I structures designed to provide protection from environmental hazards." Therefore, the staff also requested in **RAI 9038, Question 08.03.02-7,** that the applicant clarify whether any components of the EDSS will be located in buildings that are not environmentally qualified (i.e., outside the CRB and RXB).

In its response to **RAI 9038, Question 08.03.02-7,** dated October 18, 2017 (ADAMS Accession No. ML17291B312), the applicant explained that EDSS SSCs are located within the SC-1 portion of the CRB, which is below the 120-foot elevation, as well as in the RXB, also an SC-I structure. FSAR Tier 2, Table 3.2-1, "Classification of SSCs," states that the EDSS is identified as SC-I. The applicant revised FSAR Tier 2, Section 8.3.2.2.2, to remove the word "principally" and specify the areas in which EDSS SSCs are located.

The staff finds the response acceptable because the dc power system and its components are located in SC-I structures that provide protection from the effects of tornadoes, tornado missiles, and floods. Therefore, **RAI 9038, Question 08.03.02-7,** is **Confirmatory Item 08.03.02-4,** pending verification that the next FSAR revision incorporates the proposed changes.

For compliance with GDC 2, equipment and components composing the onsite dc power system must also generally be seismically designed, qualified, or both to perform their functions in the event of an earthquake.

The applicant stated in FSAR Tier 2, Section 8.3.2.2.2, that EDSS SSCs are augmented by applying design, qualification, and QA provisions typically applied to Class 1E dc power systems using a graded approach. The applicant further stated that Reference 8.3-1 in FSAR Tier 2, Section 8.3.3, has information on the graded approach and provisions for the EDSS design, qualification, and QA provisions. FSAR Tier 2, Table 3.2-1, "Classification of SSCs," states that the EDSS has augmented design requirements that include environmental qualification. The staff evaluates the graded approach in SER Section 3.2 of this report.

Pending the resolution of the confirmatory item, the staff finds that the EDSS complies with GDC 2 as the EDSS components are located in SC-I structures and the EDSS has augmented design requirements for environmental qualification.

8.3.2.4.2 Compliance with GDC 4, "Environmental and Dynamic Effects Design Bases"

Compliance with GDC 4 requires SSCs important to safety (1) to 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) to be appropriately protected against dynamic effects that may result from equipment failures, including missiles.

In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to GDC 4:

> *The EDSS design accommodates the effects of environmental conditions by applying augmented provisions for the design, qualification, and QA typically applied to Class 1E DC power systems using a graded approach. The graded approach is reflected in the EDSS design, qualification, and QA provisions detailed in Reference 8.3-1. The physical locations of the EDSS-MSs and EDSS-C within the Seismic Category I RXB and CRB, respectively, provide the EDSS with protection from dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids.*

According to NuScale's TR-0815-16497-P, the harsh environment is not applicable to the EDSS. The design would meet the same guidance governing environmental qualification for mild environments as that applied to a Class 1E electrical system. The augmented provisions assume that the EDSS will not be located in an area that would experience environmental conditions considered a harsh environment. These systems will be located in a "mild environment" as defined in 10 CFR 50.49(c), such that they would not be subject to the requirements of 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," for harsh environment.

Since the EDSS will be located in a mild environment, and in the SC-I RXB and CRB, the staff has reasonable assurance that the EDSS meets the requirements of GDC 4.

8.3.2.4.3 Compliance with GDC 5, "Sharing of Structures, Systems, and Components"

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

In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to GDC 5:

> *As shown on [FSAR Tier 2] Figure 8.3-7a and Figure 8.3-7b, the EDSS-MS is not shared between NPMs thus satisfying the intent of RG 1.81, Position C.1. Specifically, portions of the EDSS that supply electrical power to the MPS are not shared. This is achieved by providing each NPM with a dedicated EDSS-MS.*
>
> *Sharing of the EDSS-C is shown on [FSAR Tier 2] Figure 8.3-6. A postulated loss of or power fluctuation on the EDSS-C would not result in adverse interactions between NPMs, and would not impair the performance of safety-related functions necessary to achieve and maintain safe shutdown in all NPMs.*
>
> *As shown on [FSAR Tier 2] Figure 8.3-8a through Figure 8.3-8f, the EDNS consists of the EDNSs located throughout the NuScale Power Plant. A failure in these systems does not impair the ability to achieve and maintain safety-related functions for any NPM.*

Because (1) the EDSS-MS is not shared between NPMs and (2) the loss of the EDSS-C would not result in adverse interactions between NPMs, the staff finds that the EDSS meets the requirements of GDC 5.

8.3.2.4.4 Compliance with GDC 17, "Electric Power Systems"

GDC 17 states that dc onsite power shall be provided to permit the functioning of SSCs important to safety and electric power from the onsite ac electric power supplies to the onsite distribution system.

During the review of FSAR Tier 2, Section 8.3.2.1.1, the staff noted that the EDSS-C serves plant common loads, which are summarized in FSAR Tier 2, Table 8.3-4. A footnote to FSAR Tier 2, Table 8.3-4, states, "Charger-only loads are de-energized by MPS/PPS at the onset of the battery duty cycle." In **RAI 9038**, **Question 08.03.02-2,** the staff asked the applicant to clarify the phrase "charger-only loads." In its response dated October 18, 2017 (ADAMS Accession No. ML17291B312), the applicant clarified that "charger-only loads" are momentary loads, consistent with IEEE Std. 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications" (FSAR Tier 2, Reference 8.3-12). The applicant revised FSAR Tier 2, Section 8.3.2.2.1 and Table 8.3-4. IEEE Std. 485-1997, Section 4.2, designates noncontinuous loads lasting 1 minute or less as momentary loads. The applicant stated in its response that the additional minute to accommodate momentary loads has no significant impact on battery capacity margin. The staff finds the response acceptable because the applicant's usage of momentary loads is consistent with IEEE Std. 485-1997.

Therefore, **RAI 9038, Question 08.03.02-2,** is **Confirmatory Item 08.03.02-2,** pending verification that the next FSAR revision incorporates the proposed changes.

During the review of FSAR Tier 2, Section 8.3.2.1.1, the staff noted that the EDSS-MS for an NPM provides electrical power for the modular protection system (MPS), and other loads associated with that NPM. FSAR Tier 2, Table 8.3-5, provides these loads.

A footnote to FSAR Tier 2, Table 8.3-5, states that "Charger-only loads are de-energized by MPS/PPS at the onset of the battery duty cycle." In **RAI 9038, Question 08.03.02-3,** the staff asked the applicant to clarify the phrase "charger-only loads." In its response dated October 18, 2017 (ADAMS Accession No. ML17291B312), the applicant clarified that "charger-only loads" are momentary loads, consistent with IEEE Std. 485-1997 (FSAR Tier 2, Reference 8.3-12). The applicant revised FSAR Tier 2, Section 8.3.2.2.1 and Table 8.3-5. IEEE Std. 485-1997, Section 4.2, designates noncontinuous loads lasting 1 minute or less as momentary loads. The applicant stated in its response that the additional minute to accommodate momentary loads has no significant impact on battery capacity margin. The staff finds the response acceptable because the applicant's usage of momentary loads is consistent with IEEE Std. 485-1997. Therefore, **RAI 9038, Question 08.03.02-3,** is **Confirmatory Item 08.03.02-3,** pending verification that the next FSAR revision incorporates the proposed changes.

During the review of FSAR Tier 2, Section 8.3.2, the staff noted that the applicant stated that there is no safety-related ac or dc power. FSAR Tier 2, Table 8.3-7, "Highly Reliable Direct Current Power System Failure Modes and Effects Analysis (FMEA)," analyzes EDSS component failures. However, FSAR Tier 2, Section 8.3.2.1.1, states that "The results show that no failure prevents safety-related functions from being achieved and maintained [emphasis added]." **In RAI 9038, Question 08.03.02-4,** the staff asked the applicant to explain the meaning of the phrase "safety-related" functions.

In its response to **RAI 9038, Question 08.03.02-4,** dated October 18, 2017 (ADAMS Accession No. ML17291B312), the applicant stated that although the EDSS does not perform safety-related functions, EDSS provides power to safety-related loads that perform safety-related functions. The applicant further explained that in FSAR Tier 2, Table 8.3-7, the FMEA results demonstrate that EDSS component failures do not prevent safety-related functions from being achieved and maintained. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the classification of the EDSS is also being evaluated as part of **OPEN ITEM 8.3-1**.

In FSAR, Tier 2, Figure 8.3-8a, b, "Normal Direct Current Power System," Note 2 states, "Refer to FSAR Section 8.3.2, Tables 8.3-14a-h for a listing of loads on each EDNS subsystem." The staff could not find Tables 8.3-14a–h in the FSAR and in **RAI 9041, Question 08.03.02-1,** asked the applicant to address the omission. In its response to **RAI 9041, Question 08.03.02-1,** dated September 26, 2017 (ADAMS Accession No. ML17269A285), the applicant revised FSAR Tier 2, Figures 8.3-8a through 8.3-8f, to remove the Note 2. The applicant also stated that FSAR Tier 2, Section 8.3.2.2.1, lists the systems that receive EDNS power. The staff finds the response acceptable because the applicant removed the note and the FSAR contains information on the systems powered by the EDNS. Therefore, **RAI 9041, Question 08.03.02-1,** is **Confirmatory Item 08.03.02-1,** pending verification that the next FSAR revision incorporates the proposed changes.

Part 7 of the DCA discusses the exemption to GDC 17. In DCA Part 7, Section 4.2.1, "Technical Basis," states that safety-related functions are achieved and maintained with no reliance on electrical power.

Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the GDC 17 exemption is also being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.2.4.5 Compliance with GDC 18, "Inspection and Testing of Electric Power Systems"

Compliance with GDC 18 requires that electric power systems important to safety be designed to permit appropriate periodic inspection and testing of key areas and features to assess their continuity and the condition of their components. These systems shall be designed to test periodically (1) the operability and functional performance of the components of the systems, such as onsite dc 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 operation sequence that brings the systems into operation, including operation of applicable portions of the protection system and the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system.

In FSAR Section 8.3.2.2.2, "Onsite Direct Current Power System Conformance with Regulatory Framework," the applicant stated the following with regard to GDC 18:

> *[T]he NuScale design supports an exemption from the GDC 17 requirements. Accordingly, the NuScale design supports an exemption from the GDC 18 inspection and testing requirements.*

It is important to note that although the applicant states in its application that GDC 18 is not applicable, the applicant stated in DCA Part 7, Section 4.2.1, that the NuScale ac power systems are designed to permit periodic inspection and testing to assess the operability and functionality of the systems and the condition of their components for operational, commercial, and plant investment protection purposes.

Although not required as a formal GDC, NuScale stated that periodic inspection and testing is performed on the onsite ac power system for operational, commercial, and plant investment purposes. The staff finds the program as described in FSAR Tier 2, Section 8.3.2.3, "Inspection and Testing," to be acceptable since periodic inspection and testing are performed on the EDSS and EDNS systems.

In Part 7 of the DCA, the applicant stated that the electric power supply systems do not contain any safety-related or risk-significant SSCs that are required to meet GDC 18 and that the ac and dc power systems are non-safety-related and non-Class 1E. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, the GDC 18 exemption is being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.2.4.6 Compliance with 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"

The staff evaluated the FSAR with respect to the operation of the onsite electric power system. 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," identify plant safety-related functions, including electric power system requirements for those functions. The NuScale design accomplishes the safety-related functions addressed by these GDC via passive systems without reliance on power. The above GDC provisions for independence and redundancy of power systems do not apply because the safety-related functions are performed without electric power availability.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. The exemption from the requirements of GDC 33, 34, 35, 38, 41, and 44 is also being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.2.4.7 Compliance with GDC 50, "Containment Design Basis"

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. Containment electric penetrations must therefore be designed to accommodate, without exceeding their design leakage rate, the calculated pressure and temperature conditions resulting from a LOCA. This criterion applies specifically to ensuring the integrity of containment electrical penetrations in the event of design-basis LOCA conditions.

In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to GDC 50:

> *The only circuits that penetrate the CNVs are not within the scope of the NuScale plant electrical systems. These circuits are described in Section 7.0.4 for the Instrumentation & Control (I&C) systems.*
>
> *The CNV electrical penetration assemblies for the Class 1E and non-Class 1E circuits are included in the containment design and conform to GDC 50 as discussed in FSAR Tier 2, Section 6.2.1, "Containment Functional Design."*

In FSAR Tier 2, Section 8.1.4.3, the applicant stated that the ac and dc electrical power system circuits do not penetrate the containment vessels; therefore, conformance to GDC 50 is not necessary. Components requiring power inside containment are part of the instrumentation and controls systems. Section 8.3 of this report gives details on the staff's review and evaluation of compliance with GDC 50. In FSAR Tier 2, Section 3.1.5.1, the applicant stated that the NuScale design conforms to GDC 50.

Additionally, the applicant stated in FSAR Tier 2, Section 8.1.4.1, that "The AC and DC electrical power system circuits do not penetrate the containment vessels; therefore, conformance to GDC 50 is not necessary." However, in FSAR Section 3.1.5.1, the applicant also stated that "The NuScale Power Plant design conforms to GDC 50." Given the inconsistency between the above statements, the staff requested the clarification related to this nonconformance to GDC 50 in **RAI 8788, Question 8.01-1.** The staff also asked for more information in **RAI 8788, Question 8.01-1,** on the description, design, and testing of the EPAs. In its response to **RAI 8788, Question 8.01-1,** dated July 19, 2017 (ADAMS Accession No. ML17200D160), the applicant did not provide a complete response with respect to the EPAs and their environmental qualification and testing. Subsequently, the applicant provided a supplemental response on November 3, 2017 (ADAMS Accession No. ML17310A296). The staff evaluates this in Sections 8.3.1 and 3.11 of this report. The staff had additional questions as a result of the new information related to the revision of certain EPA safety classifications and EPA circuit protection and issued **RAI 9308, Question 8.01-X,** to obtain information on these issues. The staff describes and evaluates this in Sections 8.3.1 and 3.11 of this report.

8.3.2.4.8 Compliance with 10 CFR 50.34(f)(2)(v)

The regulation in 10 CFR 50.34(f)(2)(v) states that the applicant shall provide for automatic indication of the bypassed and operable status of safety systems. The staff evaluated the FSAR with respect to the automatic indication of the bypassed and operable status of safety systems. In the FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following about 10 CFR 50.34(f)(2)(v):

> *Bypassed or deliberately induced inoperability of the EDSS and EDNS batteries and battery chargers is automatically annunciated in the MCR to indicate the bypassed system or component. The EDSS and EDNS alarms are discussed in Chapter 18.*

By **RAI 9041, Question 08.03.02-1,** the staff asked the applicant to identify the location in the FSAR Tier 2, Chapter 18, of the discussion of EDSS and EDNS alarms to resolve this inconsistency. In its response to **RAI 9041, Question 08.03.02-1,** dated September 26, 2017 (ADAMS Accession No. ML17269A285), the applicant clarified that the reference to Chapter 18 in FSAR Tier 2, Section 8.3.2.2.2, is incorrect and revised FSAR Tier 2, Section 8.3.2.2.2, to remove the reference. In addition, the applicant stated that FSAR Tier 2, Chapter 8, incorrectly indicates that 10 CFR 50.34(f)(2)(v), RG 1.47, BTP 8-5, and NUREG-0718 apply to the onsite ac system and dc system (i.e., EDNS and EDSS). The applicant stated that 10 CFR 50.34(f)(2)(v) and associated guidance apply to safety-related systems and, because the onsite ac system, EDNS, and EDSS are non-safety-related systems, 10 CFR 50.34(f)(2)(v) and associated guidance are not applicable.

The staff finds the response acceptable as 10 CFR 50.34(f)(2)(v) and associated guidance only apply to safety systems and the design does not provide any safety-related ac or dc power systems. Therefore, **RAI 9041, Question 08.03.02-1,** is **Confirmatory Item 08.03.02-1,** pending verification that the next FSAR revision incorporates the proposed changes.

Section 8.3.1.4.23 of this report evaluates other requirements related to the accident at Three Mile Island.

8.3.2.4.9 Compliance with 10 CFR 50.55a(h)

The staff evaluated the FSAR with respect to the incorporation of IEEE Std. 603-1991 (including the correction sheet dated January 30, 1995). In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to 10 CFR 50.55a(h) that the onsite electrical dc power system equipment is not a protection system and does not perform any safety-related functions. The staff evaluates compliance with 10 CFR 50.55a(h) with respect to monitoring systems in Chapter 7 of this report.

8.3.2.4.10 Compliance with 10 CFR 50.65(a)(4)

The regulations in 10 CFR 50.65(a)(h) relate to the assessment and management of the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. FSAR Tier 2, Section 8.3.2.2.2, states with regard to 10 CFR 50.65(a)(4) that FSAR Tier 2, Section 17.6, discusses the development and implementation of the Maintenance Rule program, including the identification of SSCs that require assessment in accordance with 10 CFR 50.65(a)(4). The staff evaluates the FSAR in terms of the Maintenance Rule in SER Chapter 17.

8.3.2.4.11 Conformance to Regulatory Guide 1.6

RG 1.6 describes an acceptable degree of independence between redundant standby (onsite) power sources and between their distribution systems, as part of compliance with GDC 17. The staff evaluated the FSAR with respect to RG 1.6 as it relates to the independence between redundant onsite dc power sources and between their distribution systems. In the FSAR Tier 2, Section 8.3.2.2.2, NuScale stated with regard to RG 1.6 that the EDSS design conforms to the guidance for independence of standby power sources and their distribution systems provided in RG 1.6.

FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, RG 1.6 and the GDC 17 exemption are being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.2.4.12 Conformance to Regulatory Guide 1.32

The staff evaluated the FSAR with respect to RG 1.32, as it relates to the design, operation, and testing of the safety-related portions of the onsite dc power system. RG 1.32 endorses IEEE Std. 308-2001, "IEEE Standard Criteria for Class IE Power Systems for Nuclear Power Generating Stations." In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to RG 1.32 that the EDSS conforms to RG 1.32 and IEEE Std. 308-2001 to the extent described in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P].

RG 1.32 is applicable to the electrical power portions of safety-related systems. The applicant stated in FSAR Tier 2, Section 8.3.2.1.1, that the EDSS is a non-Class 1E system. Part 7 of the DCA discusses the exemption to GDC 17. DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power.

Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, RG 1.32 conformance is also being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.2.4.13 Conformance to Regulatory Guide 1.47

The staff evaluated the FSAR with respect to RG 1.47 as it relates to the bypass and inoperable status of the onsite power supply. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to RG 1.47 that the onsite dc power systems conform to RG 1.47 to the extent described in the discussion of compliance with 10 CFR 50.34(f)(2)(v). The staff evaluates Section 8.3.2.2.2 on conformance to RG 1.47 in SER Chapter 7.

8.3.2.4.14 Conformance to Regulatory Guide 1.53

The staff evaluated the FSAR with respect to RG 1.53, as it relates to the application of the single-failure criterion to electrical power portions of plant safety systems. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to RG 1.53 that the EDSS conforms to RG 1.53 and IEEE Std. 379-2000, "IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems," to the extent described in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P]. In Reference 8.3-1, the applicant described that the requirement of IEEE Std. 308-2001, as endorsed by RG 1.32, will be met to the extent as follows:

> *The single failure criterion is applied to the highly reliable DC electrical system(s) using the same guidance and standards as those applied to a Class 1E electrical system. The standards and guidance governing single failure include consideration for common-cause failures.*

RG 1.53 is applicable to the electrical power portions of safety-related systems. Part 7 of the DCA discusses the exemption to GDC 17. DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. Therefore, RG 1.53 conformance is also being evaluated as part of **OPEN ITEM 8.3-1**.

8.3.2.4.15 Conformance to Regulatory Guide 1.63

The staff evaluated the FSAR with respect to RG 1.63 as it relates to the capability of electric penetration assemblies in containment structures to withstand a loss-of-coolant accident without loss of mechanical integrity and the external circuit protection for such penetrations. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to RG 1.63 that FSAR Tier 2, Section 8.1.4.3, gives details on compliance with GDC 50 and RG 1.63. The staff evaluates the applicant's conformance to RG 1.63 in SER Section 8.3.1.4.22.

8.3.2.4.16 Conformance to Regulatory Guide 1.75

The staff evaluated the FSAR with respect to RG 1.75 as it relates to the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite dc power system. RG 1.75 discusses independence of the electrical circuits and does not differentiate between ac and dc power systems. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to Regulatory Guide 1.75 that the EDSS conforms to RG 1.75 and IEEE Std. 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," to the extent described in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P]. In Reference 8.3-1, the applicant stated that IEEE Std. 384-1992, as endorsed by RG 1.75, will be met substantially equivalent to Class 1E, with clarifications. Although the onsite power system neither contains nor supports safety-related SSCs, the applicant stated that the separation criteria contained in RG 1.75 will be used to maintain separation between the non-Class 1E power system and the Class 1E circuits within the MPS. The staff finds this acceptable for the onsite dc power system. The staff evaluates electrical isolation with respect to the MPS in SER Section 7.1.2.4.1.

8.3.2.4.17 Conformance to Regulatory Guide 1.81

The staff evaluated the FSAR with respect to RG 1.81 as it relates to the sharing of SSCs of the dc power system. Regulatory Position C.1 of RG 1.81 states that multiunit sites should not share dc systems. The staff discusses the applicability of RG 1.81 to the dc systems in SER Section 8.3.2.3.3, with regard to GDC 5.

8.3.2.4.18 Conformance to Regulatory Guide 1.106

RG 1.106 provides guidance with respect to thermal overload protection for Class 1E motor-operated valves. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated that the NuScale design does not include safety-related, motor-operated valves. Therefore, the staff determined that RG 1.106 does not apply to the onsite dc power system, as it has no safety-related motor-operated valves.

8.3.2.4.19 Conformance to Regulatory Guide 1.118

The staff evaluated the FSAR with respect to RG 1.118 as it relates to the capability to periodically test the onsite dc power system. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to RG 1.118 that the EDSS conforms to RG 1.118 and IEEE Std. 338-1987, "IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems," to the extent described in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P].

In Part 7 of the DCA, the applicant stated that the electric power supply systems do not contain any safety-related or risk-significant SSCs that are required to meet GDC 18 and that the ac and dc power systems are non-safety-related and non-Class 1E systems. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. NRC staff is evaluating the exemption to GDC 18 and conformance to RG 1.118 as part of **OPEN ITEM 8.3-1**.

8.3.2.4.20 Conformance to Regulatory Guide 1.128

The staff evaluated the FSAR with respect to RG 1.128 as it relates to the installation of vented lead-acid storage batteries in the onsite dc power system. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to RG 1.128:

> *Regulatory Guide 1.128 endorses IEEE Standard 484-2002 as an acceptable method of demonstrating compliance with NRC regulations relevant to installation design and installation of vented lead-acid (VLA) batteries. As described in [FSAR Tier 2], Section 8.3.2.1, "System Description," the EDSS uses VRLA batteries. Thus, IEEE Standard 1187-2013 is applied rather than IEEE Standard 484-2002. However, the regulatory positions of RG 1.128, although directed toward VLA battery installations, are appropriately considered in the installation design of the VRLA batteries, with exceptions and clarifications described in Reference 8.3-1.*

The staff finds RG 1.128 not applicable to the EDSS system because RG 1.128 relates to VLA batteries and the NuScale design uses valve-regulated lead-acid (VRLA) batteries.

8.3.2.4.21 Conformance to Regulatory Guide 1.129

The staff evaluated the FSAR with respect to RG 1.129 as it relates to maintenance, testing, and replacement of vented lead-acid storage batteries in the onsite dc power system. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to RG 1.129:

> *Regulatory Guide 1.129 endorses IEEE Standard 450-2010 as an acceptable method of demonstrating compliance with NRC regulations relevant to maintenance, testing, and replacement of VLA batteries.*
>
> *The EDSS uses VRLA batteries and, thus, applies IEEE Standard 1188-2005 with the 2014 amendment rather than IEEE Standard 450-2010. However, the regulatory positions of RG 1.129, although directed toward VLA battery installations, are appropriately considered for the VRLA batteries, with clarification described in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P].*

The staff finds RG 1.129 not applicable to the EDSS system because RG 1.129 relates to VLA batteries and the NuScale design uses VRLA batteries.

8.3.2.4.22 Conformance to Regulatory Guide 1.153

The staff evaluated the FSAR with respect to RG 1.153 as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite dc power system. As endorsed by RG 1.153, IEEE Std. 603-1991 provides a method acceptable to the staff to evaluate all aspects of the electrical portions of the safety-related systems, including basic criteria for addressing single failures.

In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to RG 1.153:

> *The EDSS conforms to 10 CFR 50.55a(h) and IEEE Standard 603-1991 (and hence RG 1.153) to the extent described in Reference 8.3-1 [NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P].*

The staff evaluates the FSAR with regard to IEEE Std. 603-1991 and 10 CFR 50.55a(h) in Chapter 7 of this report.

Part 7 of the DCA discusses the exemption to GDC 17. DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. NRC staff is tracking the conformance to RG 1.153 as part of **OPEN ITEM 8.3-1.**

8.3.2.4.23 Conformance to Regulatory Guide 1.155

RG 1.155 relates to the capability and the capacity of the onsite dc power system for a station blackout. The staff evaluates conformance to RG 1.155 in SER Section 8.4.

8.3.2.4.24 Conformance to Regulatory Guide 1.160

The staff evaluated the FSAR with respect to RG 1.160 as it relates to the effectiveness of maintenance activities for dc power systems, including compliance with the Maintenance Rule and verification that appropriate maintenance activities are covered therein.

In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to RG 1.160:

> *Regulatory Guide 1.160 provides guidance for monitoring the effectiveness of maintenance at nuclear power plants. The development and implementation of the maintenance rule (10 CFR 50.65) program, including the identification of SSC that require assessment per 10 CFR 50.65(a)(4), is stated in [FSAR Tier 2,] Section 17.6.*

FSAR Tier 2, Section 17.6, states that a COL applicant that references the NuScale Power Plant design certification will describe the program for monitoring the effectiveness of maintenance required by 10 CFR 50.65. Because the applicant provided COL Item 17.6-1 to monitor the effectiveness of maintenance as required by 10 CFR 50.65, the staff finds that the design conforms to RG 1.160.

8.3.2.4.25 Conformance to Regulatory Guide 1.212

The staff evaluated the FSAR with respect to RG 1.212 as it relates to the sizing of large lead-acid storage batteries. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to RG 1.212 that the EDSS and EDNS batteries are sized in accordance with IEEE Std. 485-1997, as endorsed by RG 1.212. Although the NuScale design uses VRLA batteries, the staff finds that defining the dc load and size of lead-acid batteries is applicable to VRLA batteries, and thus RG 1.212 can be

used.

The staff finds the application of IEEE Std. 485-1997 and RG 1.212 for sizing EDSS and EDNS batteries to be acceptable. However, because of the **OPEN ITEM 8.3-1** associated with GDC 17, the staff is unable to finalize its conclusions on conformance to RG 1.212.

8.3.2.4.26 Conformance to Regulatory Guide 1.218

The staff evaluated the FSAR with respect to RG 1.218 as it relates to the condition monitoring techniques of electric cables within the scope of the Maintenance Rule. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated the following with regard to RG 1.218:

> *Regulatory Guide 1.218 provides guidance for monitoring the condition of cables that have been determined to fall within the scope of the maintenance rule (10 CFR 50.65). The development and implementation of the maintenance rule program, including the identification of SSC that require assessment per 10 CFR 50.65(a)(4), is stated in Section 17.6.*

The staff reviewed the methodology for implementing of the Maintenance Rule program (10 CFR 50.65) described in FSAR Tier 2, Section 17.6. COL Item 17.6-1 states, "A COL applicant that references the NuScale Power Plant design certification will describe the program for monitoring the effectiveness of maintenance required by 10 CFR 50.65." Because the applicant has a COL information item to address plant-specific provisions related to the Maintenance Rule (10 CFR 50.65), and given that the description of a Maintenance Rule program is the COL applicant's responsibility, the staff finds that the design conforms to RG 1.218.

8.3.2.4.27 Conformance to Branch Technical Position 8-5

The staff evaluated the FSAR with respect to BTP 8-5, which is applicable to dc systems as it relates to bypass or inoperable status of dc systems important to safety. In FSAR Tier 2, Section 8.3.2.2.2, the applicant stated with regard to BTP 8-5 that "The onsite DC power systems conform to BTP 8-5 to the extent described in the discussion of compliance with 10 CFR 50.34(f)(2)(v)."

The staff evaluates compliance with 10 CFR 50.34(f)(2)(v) in Section 8.3.2.3.8 of this report.

8.3.2.5 Combined License Information Items

There are no COL items for FSAR Tier 2, Section 8.3.2.

8.3.2.6 Conclusion

Because of the OPEN ITEM associated with this section, the staff is unable to finalize its conclusions for the onsite dc power systems to meet the requirements of GDCs 17, 18, 33, 34, 35, 38, 41, 44, and 50, 10 CFR 50.34(f), RG 1.6 RG 1.32, RG 1.53, RG 1.118, and RG 1.153. The staff finds that the design complies with GDC 2, GDC 4, GDC 5, RG 1.81, RG 1.106, and RG 1.218, as discussed above.

8.4 Station Blackout

8.4.1 Introduction

10 CFR 50.2, "Definitions," defines an SBO as a complete loss of ac electric power to the essential and nonessential switchgear buses in the nuclear power plant. An SBO involves a loss of the offsite electric power system (preferred power system) concurrent with a turbine trip and failure of the onsite emergency ac power system. An SBO does not include loss of available ac power to buses fed by station batteries through inverters or by AAC sources specifically provided for SBO mitigation. The staff's review is to verify that the plant is capable of withstanding and recovering from a complete loss of ac electric power for a minimum of 72 hours, as described in the FSAR. The staff reviewed and evaluated the application to determine its compliance with the requirements of 10 CFR 50.63; 10 CFR 50.65; and 10 CFR Part 50, Appendix A, GDC 17 and 18, and conformance to the applicable guidance.

8.4.2 Summary of Application

FSAR Tier 1: There is no Tier 1 information for this area of review.

FSAR Tier 2: The applicant has provided a Tier 2 system description in Section 8.4, summarized, in part, as follows:

> *The NPM design does not rely on the use of onsite or offsite ac power for the performance of safety-related functions for any DBE. As a result, emergency onsite ac power is not included in the design. The SBO duration for passive plant designs is 72 hours, which is consistent with the NRC's policy provided in SECY-94-084 and SECY-95-132 and the associated staff requirements memorandums. The aforementioned SECY documents provide guidance for passive plants to demonstrate that safety-related functions can be performed without reliance on ac power for 72 hours after the initiating event. The relevant guidelines of RG 1.155 are applied as they pertain to compliance with 10 CFR 50.63 for the passive NuScale design.*

ITAAC: There are no ITAAC associated with SBO.

Technical Specifications: There are no technical specifications for this area of review.

CDIs: There are no certified design interfaces for this area of review.

8.4.3 Regulatory Basis

DSRS Section 8.4 provides the relevant NRC requirements for this area of review and the associated acceptance criteria for NuScale's plant design, as summarized below. DSRS Section 8.4 also provides review interfaces with other SRP sections.

The following acceptance criteria are adequate to meet the above requirements:

- 10 CFR 50.63, as it relates to the capability to withstand and recover from an SBO.
- 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 such activities are performed.

These activities include, but are not limited to, surveillances, postmaintenance testing, and corrective and preventive maintenance. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17.

- GDC 17, as it relates to the onsite ac power system's (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.

- GDC 18, as it relates to the inspection and testing of the offsite and onsite power systems

The following documents also provide additional criteria or guidance in support of the DSRS Section 8.4 acceptance criteria to meet the above requirements:

- RG 1.155, as it relates to compliance with 10 CFR 50.63.

- SECY-90-016 and SECY-94-084, as they relate to the use of AAC power sources and the RTNSS process at plants that have passive safety systems.

- RG 1.75, as it relates to the independence of SBO-related power sources and distribution systems between the onsite and offsite ac power systems, especially the isolation capability of the battery chargers for the dc system.

8.4.4 Technical Evaluation

The staff reviewed FSAR Tier 2 Section 8.4, to determine whether the design is capable of withstanding and recovering from an SBO as required by 10 CFR 50.63. The SBO duration for passive plant designs is 72 hours, which is consistent with the NRC's policy in SECY-94-084 and SECY-95-132 and the associated staff requirements memorandums.

8.4.4.1 Compliance with 10 CFR 50.63 and Conformance to RG 1.155

Under 10 CFR 50.63, the NRC requires that each NPP be capable of withstanding or coping with, and recovering from, an SBO of a specified duration (known as coping duration) and of maintaining adequate core cooling and appropriate containment integrity for the SBO coping duration. RG 1.155 provides guidance for implementing the SBO requirements of 10 CFR 50.63. DSRS Section 8.4 states that, for new ALWR applications, such as the NuScale application, that use passive safety systems and do not include a spare, full-capacity AAC power source for coping with an SBO, (1) all safety-related functions should be performed without relying on ac power for 72 hours after the initiating event and (2) the applicant has implemented, as appropriate, an RTNSS process that conforms to RG 1.206, Section C.IV.9, "Regulatory Treatment of Nonsafety Systems." For COL applicants who reference the NuScale certified design, that application will address the implementation of the RTNSS process. RG 1.155 and DSRS Section 8.4 describe guidance acceptable to the staff for meeting the requirements of 10 CFR 50.63 that will be applied to the NuScale design. Aspects of the staff's review for compliance with 10 CFR 50.63 are discussed below.

In FSAR Tier 2, Section 8.4.3, the applicant stated that it evaluated the design adequacy and capability of equipment needed to cope with an SBO for the 72-hour duration of the event and that the evaluation provides reasonable assurance that the required SBO equipment remains operable and that no special equipment provisions or operator actions are necessary to ensure the operability of SBO mitigation equipment for the 72-hour duration.

RG 1.155, Regulatory Position C.3.2, states that each NPP should be evaluated to determine its capability to withstand and recover from an SBO of the acceptable duration determined for that plant. In order to establish the plant's capability for mitigating an SBO, the staff requested additional information on the evaluation referenced in FSAR Tier 2, Section 8.4.3.

In **RAI 8824, Question 08.04-1, Part 1**, dated May 26, 2017 (ADAMS Accession No. ML17146B298), the staff asked the applicant to provide the assumptions and a summary of the above evaluation and to discuss its conformance to RG 1.155, Regulatory Position C.3.2, as it relates to the plant's capability to cope with an SBO. In addition, the staff requested that the COL applicant should outline its responsibility to cope with an SBO, if applicable.

In its response to **RAI 8824, Question 08.04-1, Part 1,** dated June 28, 2017 (ADAMS Accession No. ML17179A979), the applicant stated that the SBO coping analysis assumption is described in FSAR Tier 2, Sections 8.4.1 and 8.4.2, and provided a summary of conformance with RG 1.155, Regulatory Position C.3.2, for the NuScale design. The applicant also stated that the coping analysis did not identify any responsibilities for the COL applicant to cope with an SBO.

The staff's review of RG 1.155 conformance is summarized below.

RG 1.155, Regulatory Position C.3.2.1, states that the SBO evaluation should be performed under the assumption that the SBO event occurs while the reactor is operating at 100-percent rated thermal power and has been at this power level for at least 100 days. The applicant stated in its response and in FSAR Tier 2, Section 8.4.1, that the SBO analysis assumes that a total of 12 NPMs and supporting equipment are initially operating normally at a minimum of 100-percent rated thermal power for 100 days. Therefore, the staff finds that the design conforms to RG 1.155, Regulatory Position C.3.2.1, because the initial assumptions for the SBO analysis include operation at 100-percent power for 100 days.

RG 1.155, Regulatory Position C.3.2.2, states that the capability of all systems and components necessary to provide core cooling and decay heat removal should be determined. RG 1.155, Position C.3.2.3, states that the ability to maintain an adequate reactor coolant system inventory to ensure that the core is cooled should be evaluated. SER Chapter 15 evaluates the capability of systems required to perform core cooling and decay heat removal and control the reactor coolant system inventory, including the pump seal.

RG 1.155, Regulatory Position C.3.2.4, states that the design adequacy and capability of equipment needed to cope with an SBO for the required duration and recovery period should be addressed and evaluated as appropriate for the associated environmental conditions. The applicant stated in its response to **RAI 8824, Question 08.04-1, Part 1,** that "an evaluation of the environmental conditions for the actual installed SBO support equipment in its final configuration will be done as part of the detailed design phase using the guidance of NUMARC 87-00 Revision 1, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors."

Based on the above response, in **RAI 9155, Question 08.04-2, Part A,** dated September 27, 2017 (ADAMS Accession No. ML17318A816), the staff asked the applicant to provide an evaluation of the environmental conditions for installed SBO equipment or a COL item that will require the COL applicant to complete the evaluation.

In its response to **RAI 9155, Question 08.04-2, Part A,** dated November 14, 2017, the applicant stated that the SBO mitigation equipment that is relied on to meet 10 CFR 50.63 (e.g., decay heat removal system, emergency core cooling system) is passive, safety-related, and already required to be environmentally qualified and meet design basis accident conditions that bound the SBO environment. Therefore, the staff finds that the design conforms to RG 1.155, Regulatory Position C.3.2.4, because the environmental conditions for installed SBO equipment are bounded by the design-basis accident conditions.

RG 1.155, Regulatory Position C.3.2.4, Subpart 1, states that the potential failures of equipment necessary to cope with the SBO should be considered. The applicant stated in its response that the SBO event does not impose a new or different failure mode on SBO mitigation equipment and that the coping analysis did not identify any failures of SBO mitigation or support equipment. Therefore, the staff finds that the design conforms to RG 1.155, Regulatory Position C.3.2.1, because the potential failures of equipment necessary to cope with the SBO have been considered and the coping analysis did not identify any failures of SBO mitigation or support equipment.

RG 1.155, Regulatory Position C.3.2.4, Subpart 2, states that potential environmental effects on the operability and reliability of equipment necessary to cope with SBO, including fire protection systems, should be considered. SER Section 8.3.2.3.2 reviews the effects of environmental conditions, and SER Chapter 9 evaluates the effects of fire protection systems.

RG 1.155, Regulatory Position C.3.2.4, Subpart 3, states that potential effects of other hazards, such as weather, on SBO response equipment should be considered. SER Chapter 18 evaluates the effects of other hazards on SBO response equipment.

RG 1.155, Regulatory Position C.3.2.4, Subpart 4, states that potential habitability concerns for areas requiring operator access should be considered. SER Chapter 18 reviews this subpart.

RG 1.155, Regulatory Position 3.2.5, states that available non-safety-related equipment should be considered to cope with an SBO as long as such equipment meets the recommendations of RG 1.155, Regulatory Positions 3.3.3 and 3.3.4. The staff evaluates this in SER Section 8.3.2.

RG 1.155, Regulatory Position 3.2.6, states that consideration should be given to timely operator actions inside or outside the control room that would increase the length of time that the plant can cope with an SBO as long as the applicant can be demonstrate that it can carry out these actions in a timely fashion. SER Chapter 18 evaluates timely operator actions.

RG 1.155, Regulatory Position 3.2.7, states that the ability to maintain “appropriate containment integrity” should be addressed. SER Chapter 6 evaluates containment integrity.

Based on the above review of the electrical systems, conformance to RG 1.155, Regulatory Position C.3.2, the staff finds that the NuScale design is acceptable because the applicant demonstrated that safety-related functions are assured for a minimum of 72 hours following an SBO event in accordance with RG 1.155, Regulatory Position C.3.2, as required by 10 CFR 50.63.

In FSAR, Tier 2, Section 8.4.3, the applicant stated that an SBO transient sensitivity case that considered a simultaneous loss of all ac and dc power was evaluated and demonstrated that the NuScale power plant design does not rely on dc power from the EDSS to meet the requirements of 10 CFR 50.63. Because the SBO transient analysis assumes operation of the EDSS during the event to comply with 10 CFR 50.63 and because the applicant stated in FSAR Tier 2, Section 8.4.3, that dc power from the EDSS is not relied on for the NuScale power plant design to meet the requirements of 10 CFR 50.63, the staff requested a summary of the cited sensitivity case in **RAI 8824, Question 08.04-1, Part 2**, dated May 26, 2017 (ADAMS Accession No. ML17146B298). In its response dated June 28, 2017, to **RAI 8824, Question 08.04-1, Part 2** (ADAMS Accession No. ML17179A979), the applicant stated that the SBO transient analysis, the analysis of record, assumes operation of the EDSS during the event, which, in part, forms the basis for compliance with 10 CFR 50.63. The applicant further stated that the sensitivity case assumptions are the same as the base case except that there is immediate loss of the EDSS at the outset of the event. The applicant also stated that this sensitivity case represents an additional failure that is outside of the SBO event; is not used to show compliance to 10 CFR 50.63; and, therefore, does not need to be included in the FSAR but should be available for audit upon request. The staff requested a regulatory audit to seek clarification on (1) NuScale's assumptions and methodology on the SBO transient analysis and (2) the SBO sensitivity case, which demonstrates that the NuScale design does not rely on dc power from the EDSS to meet the requirements of 10 CFR 50.63, as discussed in the audit plan, dated September 27, 2017 (ADAMS Accession No. ML17264A677).

During the audit, the staff verified the methodology, assumptions, and results of the SBO transient sensitivity case as discussed in the audit report, dated January 5, 2018, (ADAMS Accession No. ML18004A046). The staff verified (1) the acceptance criteria of an SBO in all 12 modules, (2) the assumptions and methodology used for the evaluation, and (3) the results of the base case and the sensitivity case. The staff accepts the methodology and the assumptions of the SBO transient sensitivity case. Based on the above, staff finds that the applicant has adequately addressed the NuScale design's nonreliance on the EDSS during an SBO, although it is not needed to meet 10 CFR 50.63 requirements.

In summary, the staff determined that the applicant demonstrates the capability to achieve and maintain safe shutdown for a minimum of 72 hours. Therefore, the staff finds that the design conforms to the guidance in RG 1.155, Regulatory Position C.3.2, as required by 10 CFR 50.63.

The staff also reviewed the FSAR information on procedures and training to cope with and recover from an SBO. DSRS Section I, Item 3 (page 8.4-2), states that the review should determine that procedures and training conform to the guidance in RG 1.155, Regulatory Position C.3.4, as they pertain to passive plants. RG 1.155 provides guidance on procedures and training for coping with an SBO for the coping duration and for restoring normal long-term cooling. FSAR Tier 2, Section 8.4.4, "Station Blackout Procedures and Training," states that the SBO procedures and training consider the relevant guidance of RG 1.155 as it pertains to passive plants, and training and procedures to mitigate an SBO event are implemented in accordance with FSAR Tier 2, Section 13.2, "Training," and Section 13.5, "Plant Procedures." The applicant has COL items for developing (1) the procedures to cope with and recover from an SBO in accordance with COL Item 13.5-2 and (2) the training to cope with an SBO in accordance with COL Item 13.2-1. Therefore, the staff determined that the design conforms to RG 1.155, Regulatory Position C.3.4, because the applicant provided COL items for developing procedures and training and is, therefore, acceptable.

Additionally, the staff reviewed the FSAR information on quality assurance (QA) and specification guidance for non-safety-related equipment required to meet 10 CFR 50.63. DSRS Section I, Item 4 (page 8.4-2), states that the review should determine that QA activities and specifications for non-safety-related equipment used to meet the requirements of 10 CFR 50.63 conform to the recommendations in RG 1.155, Regulatory Position C.3.5, Appendix A.

FSAR Tier 2, Section 8.4.3, states that non-safety-related equipment is not relied on to mitigate an SBO and that there is no SBO mitigation equipment that requires regulatory oversight under the RTNSSs process, which is described in FSAR Tier 2, Section 8.1.4.3 and Section 19.3, "Regulatory Treatment of Non-Safety Systems."

The staff determined that QA activities and specifications for non-safety-related equipment, required to meet 10 CFR 50.63 and conform to the recommendations in RG 1.155, Regulatory Position C.3.5, and Appendix A to RG 1.155, is not applicable because non-safety-related equipment is not relied on to mitigate an SBO.

8.4.4.2 Compliance with 10 CFR 50.65

SER Sections 8.2 and 8.3 discuss compliance with 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 such activities are performed. Because the applicant provided COL Item 17.6-1 to monitor the effectiveness of maintenance as required by 10 CFR 50.65, the staff finds it acceptable for compliance with 10 CFR 50.65.

8.4.4.3 Compliance with GDC 17

GDC 17 states that ac onsite power shall be provided to permit functioning of SSCs important to safety and electric power from the onsite ac electric power supplies to the onsite distribution system.

DCA Part 7 discusses the exemption to GDC 17. DCA Part 7, Section 4.2.1, states that safety-related functions are achieved and maintained with no reliance on electrical power. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. NRC staff is evaluating the exemption to GDC 17 as part of **OPEN ITEM 8.3-1**.

8.4.4.4 Compliance with GDC 18

GDC 18 discusses the inspection and testing of electric power systems important to safety.

In DCA Part 7, the applicant stated that the electric power supply systems do not contain any safety-related or risk-significant SSCs that are required to meet GDC 18 and that the ac and dc power systems are non-safety-related and non-Class 1E. Furthermore, FSAR, Tier 2, Section 8.3 states that the design does not rely on AC or DC power systems, and that this position is supported by the application of the evaluation methodology described in NuScale topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems."

The applicability of TR-0815-16497 to the NuScale DCA is discussed in Section 8.3.1.4 of this SER and is being evaluated as **OPEN ITEM 8.3-1**. NRC staff is evaluating the exemption to GDC 18 as part of **OPEN ITEM 8.3-1**.

Although the applicant requested an exemption to GDC 18, DCA Part 7, Section 4.2.1, states that the NuScale ac power systems are designed to permit periodic inspection and testing to assess the operability and functionality of the systems and the condition of their components for operational, commercial, and plant investment protection purposes.

8.4.4.5 Conformance to the Guidelines of SECY-90-016 and SECY-94-084

The guidelines and criteria of SECY-90-016, as they relate to the use of AAC power sources, pertain to evolutionary ALWR designs and do not directly apply to passive plant designs.

For meeting the guidelines and criteria of SECY-94-084 as they relate to the RTNSS at plants provided with passive safety systems, the applicant stated in FSAR Tier 2, Section 8.4.3, that non-safety-related equipment is not relied on to mitigate an SBO and that there is no SBO mitigation equipment that requires regulatory oversight under the RTNSSs process, which is described in FSAR Tier 2, Section 8.1.4.3, and FSAR Tier 2, Section 19.3. The staff considers this acceptable because the non-safety-related equipment is not relied on to mitigate an SBO; therefore, SECY-90-016 and SECY-94-084 do not apply to the NuScale design for an SBO. The staff further discusses and evaluates this in SER Section 19.3.

8.4.4.6 Conformance to RG 1.75.

The guidance in RG 1.75 pertains to the independence of SBO-related power sources and distribution systems between the onsite and offsite ac power systems. In FSAR Tier 2, Section 8.4, the applicant stated that the NPM design does not rely on the use of onsite or offsite ac power for the performance of safety-related functions for any DBE. Although the SBO-related power sources and distribution systems neither contain nor support safety-related SSCs, the applicant has stated that it will use the separation criteria in RG 1.75 to maintain separation between the non-Class 1E power system and the Class 1E circuits within the MPS. The staff finds this acceptable for the SBO-related power sources. SER Section 7.1.2.4.2 evaluates electrical isolation with respect to the MPS.

8.4.5 Combined License Information Items

There are no COL items provided for this section.

8.4.6 Conclusion

Because of the OPEN ITEM associated with this section, the staff is unable to finalize its conclusions whether no installed non-safety-related SSCs are relied on to meet the requirements of 10 CFR 50.63 and RG 1.155.