RAIO-0318-59292

March 27, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 354 (eRAI No. 9359) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 354 (eRAI No. 9359)," dated January 29, 2018

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosure to this letter contains NuScale's response to the following RAI Question from NRC eRAI No. 9359:

- 01-1

This letter and the enclosed response make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9359

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9359

NuScale Power™

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9359
Date of RAI Issue: 01/29/2018

NRC Question No.: 01-1

In Section 4, "10 CFR 50, Appendix A, Electric Power Systems GDCs," of Part 7 of the NuScale Power, LLC (NuScale) Design Certification Application (DCA), NuScale requested an exemption from electrical power system general design criteria. As a partial basis for this exemption NuScale states the following in Section 4 of Part 7:

The NuScale Power Plant safety-related functions are achieved and maintained with no reliance on electrical power; therefore neither the AC power systems nor the DC power systems are required to be safety-related.

This statement is also made in the NuScale Final Safety Analysis Report (FSAR) Section 8.3, "Onsite Power Systems," and is supported with the following justification:

This conclusion is confirmed by the application of the evaluation methodology described in NuScale topical report TR-0815-16497-P.

NuScale FSAR Table 1.6-1, "NuScale Referenced Topical Reports," provides a list of TRs that are incorporated by reference in the NuScale FSAR. Specifically, NuScale FSAR, Chapter 8, "Electric Power," incorporates by reference TR-0815-16497, Revision 0. By letter dated December 13, 2017, the U.S. Nuclear Regulatory Commission (NRC) staff informed NuScale of the approval of topical report (TR)-0815-16497, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 1 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17340A524). This letter also informed NuScale that, when the report appears as a reference in applications, the NRC staff review will ensure that the material presented applies to the specific plant involved. In particular, the NRC staff needs to establish a finding that the NuScale DCA satisfies the conditions of applicability, provided in Table 3-1 of TR-0815-16497, and the five conditions identified by NRC staff in their safety evaluation (ADAMS Accession No. ML17340A524).

The NRC staff was not able to find the disposition of the conditions of applicability and the additional limitations and conditions in the NuScale DCA. In addition, there are several locations in the NuScale DCA (e.g., FSAR Table 1.6-1) that do not reference the approved version of TR-0815-16497. Accordingly, the staff requests the applicant to:

a. Document in the NuScale DCA the disposition of the conditions of applicability provided in Table 3-1 of TR-0815-16497, and the five conditions identified by NRC staff in their safety evaluation.

b. Add a table in the NuScale DCA to provide a cross reference of the conditions of applicability provided in Table 3-1 of TR- 0815-16497, and the five conditions identified by NRC staff in their safety evaluation, with the NuScale DCA sections in which the dispositions are specifically addressed.

c. Modify the NuScale DCA to change the revision number of TR-0815-16497 from “Revision 0” to the approved version.

NuScale Response:

Tables 8.3-9 and 8.3-10 have been added to FSAR Section 8.3 to include a cross reference for the disposition of the conditions of applicability provided in Table 3-1 of Topical Report TR-0815-16497-P-A and the five conditions identified by NRC staff in their associated safety evaluation. Additional conforming changes have been made to the following Tier 2 FSAR sections and tables:

- Section 1.2.1.3 Instrumentation, Controls, and Electrical Systems
- Table 1.9-2 Conformance with Regulatory Guides
- Section 6.4 Control Room Habitability
- Section 6.4.3.2 Off-Normal Operation
- Section 6.4.4 Design Evaluation
- Table 8.1-1 Acceptance Criteria and Guidelines for Electric Power Systems
- Section 8.3 Onsite Power Systems
- Section 8.3.2.1.1 Highly Reliable Direct Current Power System
- Section 8.3.2.2.2 Onsite Direct Current Power System Conformance with Regulatory Framework
- Section 8.3.2.2.3 Electrical Power System Calculations and Distribution System Studies for Direct Current Systems
- Section 8.3.2.3 Inspection and Testing
- Section 8.3.2.4 Instrumentation and Controls
- Section 14.2.7 Test Programs Conformance with Regulatory Guides
- Table 14.2-57 Highly Reliable DC Power System Test # 57
- Section 15.0.0.6.3 Engineered Safety Features Characteristics

FSAR Table 1.6-1, NuScale Referenced Topical Reports, and FSAR Section 8.3.3, References, were revised to reflect the approved version of Topical Report TR-0815-16497-P-A Rev. 1.

In addition, as part of the FSAR changes associated with the RAI response, certain paragraphs in FSAR Section 8.3.2.1.1 were rearranged and edited to align system description sections and topical report-related sections to improve clarity.

Impact on DCA:

The FSAR has been revised as described in the response above and as shown in the markup provided in this response.

1.2.1.3 Instrumentation, Controls, and Electrical Systems

The I&C architectural design philosophy incorporates clear interconnection interfaces, separation between safety and non-safety systems, and simplification of system functions. The I&C architecture primarily consists of the following systems, which are described in Section 7.0:

- module protection system (MPS) provides information from safety-related sensors monitoring temperature, flow, neutron flux, and pressure data on the NSSS.
- neutron monitoring system measures neutron flux as an indication of core power and provides safety inputs to the MPS.
- module control system (MCS) is a distributed control system that allows monitoring and control of module-specific plant components.
- plant control system supplies non-safety inputs to the human system interfaces in the MCR, the remote shutdown station, and other locations where necessary.
- fixed area radiation monitoring system continuously monitors in-plant radiation and airborne radioactivity levels.
- safety display and indication system provides visual display and indication in the MCR from the MPS and plant protection system.
- plant protection system monitors and controls systems that are common to all NPMs and are not specific to an individual NPM.
- health physics network provides the permanently installed communications infrastructure necessary to support a licensee-implemented radiation protection program.
- in-core instrumentation system monitors various parameters within the reactor core and RCS and sends the parameter values to the MCS for display and evaluation.

RAI 01-1

Under normal operating conditions the AC electrical power distribution system supplies continuous power to equipment required for startup, normal operation, and shutdown of the plant. As described in Section 8.3, ~~T~~the NuScale Power Plant does not require onsite or offsite AC electrical power to cope with design-basis events. Safety systems are not reliant on AC or DC electrical power for actuation.

The power systems within the plant are described below:

- The 13.8 KV and switchyard system provides power from the turbine generators and the auxiliary AC power source to the 13.8 kV AC buses and connects the onsite AC system to the switchyard.
- Medium voltage AC electrical distribution system provides power at 4,160V AC to buses servicing medium voltage loads.
- Low voltage AC electrical distribution system provides power at 120V AC and 480V AC to buses servicing low voltage loads.

RAI 01-1, RAI 07.0.DSRS-1, RAI 07.0.DSRS-2, RAI 07.0.DSRS-3, RAI 07.0.DSRS-4, RAI 07.0.DSRS-5, RAI 07.0.DSRS-6

Table 1.6-1: NuScale Referenced Topical Reports

Topical Report Number	Topical Report Title	Submittal Date	FSAR Section
NP-TR-1010-859-NP-A, Rev 3	NuScale Topical Report: Quality Assurance Program Description for the NuScale Power Plant	December 2016	17
TR-0515-13952-A, Rev 0	Risk Significance Determination	July 2015	17, 19
~~TR-0815-16497, Rev 0~~TR-0815-16497-P-A Rev. 1	Safety Classification of Passive Nuclear Power Plant Electrical Systems	~~October 2015~~February 2018	8, 15
TR-1015-18653-P-A, Rev 2	Design of the Highly Integrated Protection System Platform Topical Report	September 2017	7, 15
TR-0915-17565, Rev 2	Accident Source Term Methodology	September 2017	15
TR-0116-20825-P-A, Rev 1	Applicability of AREVA Fuel Methodology for the NuScale Design	February 2018	4
TR-0616-48793, Rev 0	Nuclear Analysis Codes and Methods Qualification	August 2016	4
TR-0516-49417, Rev 0	Evaluation Methodology for Stability Analysis of the NuScale Power Module	July 2016	4
TR-0516-49422, Rev 0	LOCA Evaluation Model	December 2016	15
TR-0915-17564, Rev 1	Subchannel Analysis Methodology	February 2017	4
TR-0516-49416, Rev 1	Non-LOCA Methodologies	August 2017	15
TR-0116-21012, Rev 1	NuScale Power Critical Heat Flux Correlations	November 2017	4
TR-0716-50350, Rev 0	Rod Ejection Analysis Methodology	December 2016	15
TR-0716-50351, Rev 0	NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces	September 2016	4
TR-0915-17772, Rev 0	Methodology for Establishing the Technical Basis for Plume Exposure Emergency Planning Zones at NuScale Small Modular Reactor Plant Site	December 2016	15

RAI 01-1, RAI 02.03.01-5, RAI 05.02.03-13, RAI 05.03.01-3, RAI 05.04.02.01-11, RAI 06.01.01-8, RAI 06.01.01-9, RAI 08.01-1, RAI 08.01-1S1, RAI 08.02-4, RAI 08.02-6, RAI 08.03.02-1, RAI 09.02.06-1

Table 1.9-2: Conformance with Regulatory Guides

RG	Division Title	Rev.	Conformance Status	Comments	Section
1.3	Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors	2	Not Applicable	This guidance is only applicable to BWRs.	Not Applicable
1.4	Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors	2	Not Applicable	This RG pertains to existing reactors; RG 1.183 is specified in SRP Section 15.0.3 to be used for new reactors.	Not Applicable
1.5	Safety Guide 5 - Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors	-	Not Applicable	This guidance is only applicable to BWRs.	Not Applicable
1.6	Safety Guide 6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems	-	Partially Conforms	The onsite electrical AC power systems do not contain Class 1E distribution systems. The EDSS design conforms to the guidance for independence of standby power sources and their distribution systems.	8.3
1.7	Control of Combustible Gas Concentrations in Containment	3	Not Applicable	The containment vessel integrity does not rely on combustible gas control systems.	Not Applicable
1.8	Qualification and Training of Personnel for Nuclear Power Plants	3	Not Applicable	Site-specific programmatic and operational activities are the responsibility of the COL applicant.	Not Applicable
1.9	Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants	4	Not Applicable	The NuScale design does not require or include safety-related emergency diesel generators.	Not Applicable
1.11	Instrument Lines Penetrating the Primary Reactor Containment	1	Not Applicable	No lines penetrate the NPM containment.	Not Applicable

Table 1.9-2: Conformance with Regulatory Guides (Continued)

RG	Division Title	Rev.	Conformance Status	Comments	Section
1.35	Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containments	3	Not Applicable	The NuScale design uses a steel containment vessel (i.e., does not use concrete in its design).	Not Applicable
1.35.1	Determining Prestressing Forces for Inspection of Prestressed Concrete Containments	-	Not Applicable	The containment vessel is a steel containment (i.e., does not use in its design).	Not Applicable
1.36	Nonmetallic Thermal Insulation for Austenitic Stainless Steel	-	Not Applicable	The NuScale design does not use nonmetallic thermal insulation on RCPB or CNV components.	Not Applicable
1.40	Qualification of Continuous Duty Safety-Related Motors for Nuclear Power Plants	1	Not Applicable	The NuScale design does not use continuous duty Class 1E motors.	Not Applicable
1.41	Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments	-	~~Not Applicable~~Partially Conforms	~~This RG is not identified as an applicable RG in DSRS Section 8.1.~~Portions of this guide are applicable to preoperational testing of divisional EDSS load groups. It does not apply to NuScale AC power systems or the EDNS.	~~Not Applicable~~8.3
1.43	Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components	1	Conforms	None.	5.2 5.3 5.4 6.1
1.44	Control of the Processing and Use of Stainless Steel	1	Partially Conforms	This RG is applicable except for its specification of applying RG 1.37 for cleaning and flushing of finished surfaces. RG 1.37 has been withdrawn by the NRC.	4.5 5.2 5.3 5.4 6.1

Table 1.9-2: Conformance with Regulatory Guides (Continued)

RG	Division Title	Rev.	Conformance Status	Comments	Section
1.149	Nuclear Power Plant Simulation Facilities for Use in Operator Training, License Examinations, and Applicant Experience Requirements	4	Not Applicable	Simulation facilities and conduct of licensed operator training and qualification are the responsibility of the COL applicant.	Not Applicable
1.151	Instrument Sensing Lines	1	Partially Conforms	This RG governs design and installation of safety-related instrument sensing lines in nuclear power plants. The aspects of this RG regarding installation criteria are the responsibility of the COL applicant.	7.2
1.152	Criteria for Use of Computers in Safety Systems of Nuclear Power Plants	3	Partially Conforms	The NuScale I&C development lifecycle differs from the conceptual waterfall lifecycle in RG 1.152. The applicable tasks from the RG lifecycle model will be mapped to the I&C development lifecycle. Compliance with Clause 5.5 of IEEE 7-4.3.2-2003 is conditioned by the choice of field programmable gate array technology, which makes some tests not applicable (e.g., calculation tests, watchdog timer tests).	3.11 7.1 7.2 14.3
1.153	Criteria for Safety Systems	1	Conforms	Applicable to EDSS.	3.11 8.3
1.155	Station Blackout	1	Partially Conforms	The design conforms to the aspects of the RG as it pertains to passive plant designs.	5.4 6.2 8.3 8.4 9.3 9.5 10.3 14.2
1.156	Qualification of Connection Assemblies for Nuclear Power Plants	1	Conforms	None.	3.11

6.4 Control Room Habitability

Control room habitability refers to the conditions required for life support and safe, effective operation of the plant during normal conditions and following an accident. These conditions include adequate lighting, food, water, air, and climate control. Habitability functions are provided by systems and equipment to protect control room operators against postulated releases such as radioactive materials, toxic gases and smoke. Control room habitability functions include:

- missile protection (see Section 3.5.1)
- radiation shielding (see Chapter 12)
- normal pressurization, air filtration, and air-conditioning (see Section 9.4.1)
- fire protection (see Section 9.5.1)
- radiation monitoring (see Section 9.4.1 and Section 11.5)
- smoke detection (see Section 9.4.1)
- lighting (see Section 9.5.3)

RAI 01-1

This section describes the control room habitability system (CRHS) which provides breathable air to the control room during the first 72 hours following an accident without reliance on electrical power. After 72 hours, the normal control room HVAC system (CRVS), described in Section 9.4.1, is expected to be available to provide heating ventilation and air conditioning service to the control building (CRB) for the remainder of the accident recovery period.

6.4.1 Design Basis

This section identifies the CRHS required or credited functions, the regulatory requirements that govern the performance of those functions, and the controlling parameters and associated values that ensure that the functions are fulfilled. Together, this information represents the design bases, defined in 10 CFR 50.2, as required by 10 CFR 52.47(a) and (a)(3)(ii).

The CRHS is a nonsafety-related system designed to provide clean breathing air to the control room envelope and maintain a positive control room pressure for habitability and control of radioactivity when conditions prohibit the CRVS from fulfilling these functions.

GDC 2 was considered in the design of the CRHS. Natural phenomena, including earthquakes, do not prevent required components of the CRHS from performing their intended function.

GDC 4 was considered in the design of the CRHS. Failure of the CRHS or malfunction of the CRHS does not adversely affect other SSC that are located in the vicinity of CRHS components. Also, the CRHS components are located in the CRB, which provides protection from potential adverse environmental conditions.

GDC 5 was considered in the design of the CRHS. The CRHS services the control room that contains the controls of up to 12 NuScale Power Modules and is designed such that a

6.4.2.5 Interaction with Other Zones and Pressure-Containing Equipment

Other than the CRHS supply lines, the only pressurized lines that penetrate the CRE are the CRVS, fire protection, and potable water supply lines. Fire protection and potable water are not gas sources. CRVS isolation dampers, which form part of the CRE boundary, are closed while CRHS is in service, so no air infiltration is expected from CRVS duct work. There are no pressurized tanks in the CRE other than any self-contained breathing apparatus that may be required for protection against toxic gases.

6.4.2.6 Shielding Design

The CRE is surrounded by thick concrete walls that provide shielding from radiation that may be present in the atmosphere following an accident. The reactor building walls provide additional protection from radioactive sources.

The CRVS charcoal filters are located two floors above the control room so that any radiation emanating from that source will be attenuated by two thick concrete floors.

6.4.3 System Operation

6.4.3.1 Normal Operation

The CRHS is in standby mode during normal plant operation. Air bottles are maintained pressurized to provide breathing air and CRE pressurization when actuated.

6.4.3.2 Off-Normal Operation

RAI 01-1

In the event of a loss of alternating current power to both CRVS air handler units for ten minutes, or if high radiation is detected downstream of the CRVS air filtration unit, or if AC power is unavailable to all four of the EDSS-C battery chargers, the plant protection system generates a signal which automatically initiates the following actions:

- The isolation dampers in the CRVS ducts that penetrate the CRE close, isolating the CRE from its surroundings.
- The CRHS isolation valves open, providing the CRE with air from the emergency air storage bottles.
- The CRHS pressure relief isolation valves open, allowing air to discharge from the CRE to the surroundings.
- The CRVS outside air isolation dampers close

These actions provide CRE occupants with clean breathing air under conditions in which the normal air supply may be contaminated. The ten-minute delay provides an allowance for restoration of normal power so that an unnecessary initiation of the CRHS can be avoided.

RAI 01-1

A loss of DC power from EDSS-C to either division of the Plant Protection System (PPS) results in a CRHS actuation.

Operation of the CRHS can also be initiated by manual actuation, for example in response to a hazardous chemical spill.

After the CRHS isolation valves are opened, the air supply pressure is regulated by the self-contained regulating valves. These valves maintain a constant downstream pressure despite upstream pressure changes as the bottled air inventory is supplied to the CRE. A constant air flow rate is maintained by the orifice downstream of the pressure regulating valves.

In the event of insufficient or excessive flow in the main delivery line, the main delivery line is isolated and the alternate delivery line is manually actuated. The alternate delivery line contains the same components as the main delivery line with the exception of the remotely operated isolation valves, and thus is capable of supplying compressed air to the CRE pressure boundary at the required air flow rate.

The regulated breathing air flow rate from the CRHS air bottles is sufficient to maintain the CRE pressure boundary at one-eighth inch water column positive differential pressure with respect to the surroundings.

Differential pressure between the CRE and the surrounding area is monitored to ensure that a positive pressure is maintained in the control room with respect to its surroundings. The wall separating the MCR area from the vestibule contains two pressure relief lines with balancing valves which discharge air from the CRE general area into the CRE vestibule. This air movement maintains the vestibule at a higher pressure than the CRB corridor pressure, reducing the potential for radioactive material being transported into the CRE when operators enter. Two vestibule discharge openings provide a purge flow path from the vestibule to the corridor.

6.4.4 Design Evaluation

As noted in Section 15.0.0, no operator actions are required or credited to mitigate the consequences of design basis events. As such, the operators perform no safety-related functions, consistent with the definition in 10CFR50.2. Therefore, although a habitable control room is provided for the operators, consistent with GDC 19, to perform other important non-safety related functions, the control room envelope and supporting habitability systems and components, including the CRHS, are not safety-related.

GDC 2 was considered in the design of the CRHS. Natural phenomena, including earthquakes, do not prevent regulatory required components of the CRHS from performing their intended function. The CRHS is designed and constructed to Seismic Category I specifications except for the compressor and the piping up to the first isolation valve between the compressor and the air bottles. The compressor is not located in the same space as the air bottles. The CRHS is located within the CRB, a Seismic Category I concrete building protecting its contents from the effects of severe weather.

GDC 4 was considered in the design of the CRHS. CRHS components are not subject to pipe whipping or fluids discharging from nearby systems that could degrade their performance.

CRHS materials are compatible with the expected environmental conditions encountered during all phases of plant operation.

Although the CRHS is a shared system for 12 NPMs, its use during an accident on one unit does not affect the ability to safely shutdown and cooldown the remaining units, as it provides air to the control room common to all units. Thus, in compliance with GDC 5, the CRHS design does not create conditions that would cause an accident in one unit to propagate to other units.

The CRHS, in conjunction with the CRVS, provides compliance with GDC 19, as it relates to maintaining the control room in a safe condition under accident conditions and providing adequate radiation protection. The CRVS has radiation monitors, toxic gas monitors, and smoke detectors located in the outside air intake as described in Section 9.4.1. Upon detection of smoke or toxic gas in the outside air duct, the outside air isolation dampers are closed to isolate the CRB from the environment. The CRB will not be pressurized under these conditions.

RAI 01-1

Upon a detection of a high radiation level in the outside air intake, the normal outside air flow path is isolated with isolation dampers and 100 percent of the outside air is routed through the CRVS air filtration unit, which includes charcoal and HEPA filters. If high levels of radiation are detected downstream of the air filtration unit or if normal AC power is not available to the CRVS air handlers or the EDSS-C battery chargers, the CRVS provides isolation of the CRE from the surrounding areas and outside environment via the CRE isolation dampers. A loss of DC power from EDSS-C to the PPS also results in a CRHS actuation. The CRHS is then relied upon to maintain a habitable environment in the CRE. The CRHS air bottles have sufficient capacity to pressurize the CRE for 72 hours. The thermal mass of the CRB provides passive cooling, maintaining CRE temperatures suitable for equipment and personnel for 72 hours.

After 72 hours, backup power is expected to be available and the CRVS will then be used to provide air conditioning and building pressurization. The CRHS also includes an external air supply connection so that the air bottles can be replenished from an offsite source if needed.

The TSC is not served by the CRHS and therefore does not receive pressurization air in the event the CRVS is unavailable. If the CRVS is not able to provide air of acceptable quality for pressurization of the TSC, the TSC is determined to be uninhabitable and is evacuated. The TSC function is then transferred to another location in accordance with the emergency plan.

The design of the CRHS satisfies CFR 50.34(f)(2)(xxviii) in that it provides assurance that, in the event of an accident, radiation doses to operators will not exceed acceptable limits and consequently will not prevent operators from performing required functions. The CRHS does not interface with other systems that would provide a potential pathway for radioactive materials. The CRHS consists of pressurized air bottles that are charged with breathing quality air. There is an external air connection point that will allow the

RAI 01-1, RAI 08.01-1, RAI 08.01-1S1, RAI 08.02-2, RAI 08.02-4, RAI 08.02-6, RAI 08.02-8, RAI 08.03.02-1

Table 8.1-1: Acceptance Criteria and Guidelines for Electric Power Systems

Criteria	Title	Applicable Section (Note 1)				Remarks
		8.2 Offsite Power System	8.3.1 Onsite AC Power System	8.3.2 Onsite DC Power System	8.4 Station Blackout	
1. 10 CFR 50, Appendix A, General Design Criteria for Nuclear Plants						
a. GDC 2	Design bases for protection against natural phenomena		A	A		§8.2 - ADAMS Accession No. ML090260039
b. GDC 4	Environmental and dynamic effects design bases		A	A		§8.2 - ADAMS Accession No. ML090260039
c. GDC 5	Sharing of structures, systems, and components		A	A		§8.2 - ADAMS Accession Nos. ML11133A334 and ML090260039
d. GDC 17	Electric power systems					The NuScale design supports an exemption from GDC 17.
e. GDC 18	Inspection and testing of electric power systems					The NuScale design supports an exemption from GDC 18.
f. GDC 33	Reactor coolant makeup					The NuScale design supports an exemption from GDC 33.
g. GDCs 34, 35, 38, 41, 44	Residual heat removal, emergency core cooling, containment heat removal, containment atmosphere cleanup, cooling water					The plant design complies with a set of principal design in lieu of these GDC, as described in Section 3.1.4.
h. GDC 50	Containment design basis		A	A		The electrical design requirements for electrical penetration assemblies are included in Section 8.3.1.
2. Regulations (10 CFR 50 and 10 CFR 52)						
a. 10 CFR 50.34	Contents of applications; technical information					
i. 10 CFR 50.34(f)(2)(v)	Additional Three Mile Island (TMI)-related requirements (Item I.D.3)					This requirement is not applicable to the NuScale electric power systems, which are not safety-related.
ii. 10 CFR 50.34(f)(2)(xiii)	Additional TMI-related requirements (Item II.E.3.1)					The NuScale design supports an exemption from 10CFR50.34(f)(2)(xiii).

Table 8.1-1: Acceptance Criteria and Guidelines for Electric Power Systems (Continued)

Criteria	Title	Applicable Section (Note 1)				Remarks
		8.2 Offsite Power System	8.3.1 Onsite AC Power System	8.3.2 Onsite DC Power System	8.4 Station Blackout	
iii. 10 CFR 50.34(f)(2)(xx)	Additional TMI-related requirements (Item II.G.1)					The NuScale design does not include pressurizer relief valves or block valves, and the the design supports an exemption from the pressurizer level indicator portion of 10CFR50.34(f)(2)(xx).
b. 10 CFR 50.55a(h)	Codes and standards		A	A		
c. 10 CFR 50.63	Loss of all alternating current power		G		A	
d. 10 CFR 50.65(a)(4)	Requirements for monitoring the effectiveness of maintenance at nuclear power plants	A	A	A		Development and implementation of the Maintenance Rule program is discussed in Section 17.6.
e. 10 CFR 52.47(b)(1)	Contents of applications; technical information	A	A	A	A	Paragraph (b)(1), as it relates to ITAAC (for design certification) sufficient to assure that the SSC in this area of review will operate in accordance with the certification.
f. 10 CFR 52.80(a)	Contents of applications; additional technical information					N/A for NuScale, this rule pertains to applications referencing an early site permit or a standard design certification.
3. Regulatory Guides (RGs)						
a. Regulatory Guide 1.6 - March 1971	Safety Guide 6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems		G	G		
b. Regulatory Guide 1.32 - Revision 3, March 2004	Criteria for Power Systems for Nuclear Power Plants			G		As it relates to the EDSS; see Section 8.3.2
c. Regulatory Guide 1.41 - March 1973	Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments			G		As it relates to EDSS; see Section 8.3.2
~~c~~d. Regulatory Guide 1.47 - Revision 1, February 2010	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems					This guidance does not apply to the NuScale electric power systems, which are not safety-related.

Table 8.1-1: Acceptance Criteria and Guidelines for Electric Power Systems (Continued)

Criteria	Title	Applicable Section (Note 1)				Remarks
		8.2 Offsite Power System	8.3.1 Onsite AC Power System	8.3.2 Onsite DC Power System	8.4 Station Blackout	
~~d~~e.Regulatory Guide 1.53 - Revision 2, November 2003	Application of the Single-Failure Criterion to Safety Systems		G	G		As it relates to the EDSS; see Section 8.3.2
~~e~~f. Regulatory Guide 1.63 - Revision 3, February 1987	Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants		G	G		The electrical design requirements for electrical penetration assemblies (EPAs) with respect to RG 1.63 are included in Section 8.3.
~~f~~g. Regulatory Guide 1.68 - Revision 4, June 2013	Initial Test Programs for water-Cooled Nuclear Power Plants	G	G	G		As it relates to the EDSS; see Section 8.3.2. See Section 8.2 as it relates to the offsite power system.
~~g~~h.Regulatory Guide 1.75 - Revision 3, February 2005	Criteria for Independence of Electrical Safety Systems		G	G		As it relates to the EDSS; see Section 8.3.2
~~h~~i. Regulatory Guide 1.81 - Revision 1, January 1975	Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants		G	G		EDSS-MS is not shared; sharing of EDSS-C meets the intent of the guidance; see Section 8.3.2
~~i~~j. Regulatory Guide 1.106 - Revision 2, February 2012	Thermal Overload Protection for Electric Motors on Motor-Operated Valves					Not applicable; the design does not include safety-related MOVs
~~j~~k. Regulatory Guide 1.118 - Revision 3, April 1995	Periodic Testing of Electric Power and Protection Systems		G	G		As it relates to the EDSS; see Section 8.3.2
~~k~~l. Regulatory Guide 1.128 Revision 2, February 2007	Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants			G		Applicability as described in Reference 8.3-1 and Section 8.3.2
~~l~~m.Regulatory Guide 1.129 - Revision 3, September 2013	Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants			G		Applicability as described in Reference 8.3-1 and ~~S~~Section 8.3.2
~~m~~n.Regulatory Guide 1.153 - Revision 1, June 1996	Criteria for Safety Systems		G	G		§8.3.2 - Applies to EDSS to the extent described in Reference 8.3-1
~~n~~o.Regulatory Guide 1.155 - August 1988	Station Blackout		G	G	G	Limited to portions relevant to passive plant designs; see Section 8.4
~~o~~p.Regulatory Guide 1.160 - Revision 3, May 2012	Monitoring the Effectiveness of Maintenance at Nuclear Power Plants		G	G		

Table 8.1-1: Acceptance Criteria and Guidelines for Electric Power Systems (Continued)

Criteria	Title	Applicable Section (Note 1)				Remarks
		8.2 Offsite Power System	8.3.1 Onsite AC Power System	8.3.2 Onsite DC Power System	8.4 Station Blackout	
~~p~~q. Regulatory Guide 1.204 - November 2005	Guidelines for Lightning Protection of Nuclear Power Plants		G			
~~q~~r. Regulatory Guide 1.206 - June 2007	Combined License Applications for Nuclear Power Plants (LWR Edition)	G	G	G	G	
~~r~~s. Regulatory Guide 1.212 - November 2008	Sizing of Large Lead-Acid Storage Batteries			G		As it relates to sizing VRLA batteries; see Section 8.3.2
~~s~~t. Regulatory Guide 1.218 - April 2012	Condition-Monitoring Techniques for Electric Cables Used in Nuclear Power Plants	G	G	G		Limited to cables determined to be within the scope of 10 CFR 50.65
4. Branch Technical Positions (BTPs)						
a. SRP BTP 8-1	Requirements on Motor-Operated Valves in the ECCS Accumulator Lines					Not applicable; the design does not include safety-related MOVs or ECCS accumulator lines
b. SRP BTP 8-2	Use of Onsite AC Power Sources for Peaking		G			As it relates to the non-Class 1E BDGs; see Section 8.3.1
c. SRP BTP 8-3	Stability of Offsite Power Systems	G				
d. SRP BTP 8-4	Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves					Not applicable; see Section 8.3.1 and Section 8.3.2
e. SRP BTP 8-5	Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems					This BTP does not apply to NuScale electric power systems as these systems are not engineered safety features and are not relied on to support engineered safety features.
f. SRP BTP 8-6	Adequacy of Station Electric Distribution System Voltages					Not applicable; See Section 8.2.3 and Section 8.3.1
g. SRP BTP 8-7	Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status					Not applicable; no Class 1E emergency diesel generators
h. SRP BTP 8-8	Onsite (emergency diesel generators) and offsite power sources allowed outage time extensions					Not applicable; with non-reliance on AC power, no technical specification operating restrictions for inoperable AC power sources

8.3 Onsite Power Systems

RAI 01-1

The onsite power systems provide power to the plant loads during all modes of plant operation. The onsite power systems include alternating current (AC) power systems and direct current (DC) power systems. The plant safety-related functions are achieved and maintained without reliance on electrical power; therefore, neither the AC power systems nor the DC power systems are required to be safety-related (Class1E). This conclusion is confirmed by the application of the evaluation methodology described in NuScale topical report TR-0815-16497-P-A (Reference 8.3-1). Table 8.3-9 provides a cross reference of the FSAR sections that demonstrate compliance with the conditions of applicability and the additional limitations in the NRC Safety Evaluation Report (SER) associated with this topical report.

The nonsafety-related onsite AC power systems are described in Section 8.3.1. The nonsafety-related DC power systems are described in Section 8.3.2. Structures, systems, and components (SSC) classification information for the onsite power systems is provided in Section 3.2.

8.3.1 Alternating Current Power Systems

8.3.1.1 System Description

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 NuScale Power Plant does not use nor include an emergency onsite AC power system. The onsite AC power systems are shared between the NuScale Power Modules (NPMs), and include the following:

- normal power system (Section 8.3.1.1.1)
  - 13.8 kV and switchyard system (EHVS) with nominal bus voltage of 13.8 kV
  - medium voltage AC electrical distribution system (EMVS) with nominal bus voltage of 4.16 kV
  - low voltage AC electrical distribution system (ELVS) with nominal bus voltages of 480 V and 120 V
- backup power supply system (BPSS) (Section 8.3.1.1.2)
  - backup diesel generators (BDGs) with nominal output voltage of 480 V
  - auxiliary AC power source (AAPS) with nominal output voltage of 13.8 kV

The normal source of onsite AC electrical power is from the operating NPM turbine generators (see Figure 8.3-2a and Figure 8.3-2b) through the EHVS generator buses. The EHVS supplies the plant loads through the unit auxiliary transformers (UATs). The EHVS also supplies the switchyard through the main power transformers (MPTs), which are connected to the offsite transmission grid, a micro-grid (if the plant is not connected to a transmission grid), or both, as described in Section 8.2. Each NPM is designed to sustain a loss of external electrical load from full power while its associated

8.3.1.3 Inspection and Testing

As described in Section 8.3.1.2.7, the NuScale design supports an exemption from GDC 18. However, periodic inspection and testing is performed on the AC power system for operational, commercial, and plant investment protection purposes. Accordingly, the onsite AC power system is designed to permit periodic inspection and testing to assess the operability and functionality of the systems and the condition of their components.

Specifically, the design described in Section 8.3.1.1 allows for removing portions of the AC power system from operation without affecting continued operation of the plant. Protection devices are capable of being tested, calibrated, and inspected. Additionally, the interfaces between the BPSS and the other portions of the AC power system allow periodic testing of the BDGs and AAPS to verify their capability to start and accept load.

Preoperational tests are conducted to verify proper operation of the AC power system. These tests are within the scope of the initial test program described in Section 14.2.

8.3.1.4 Instrumentation and Controls

The onsite AC power systems are provided with monitoring and control capability in the MCR and locally.

The power to I&C systems and protective relays is provided by the plant DC power systems, as described in Section 8.3.2.

8.3.2 Direct Current Power Systems

8.3.2.1 System Description

The onsite DC power systems include the EDSS and the EDNS. These systems are described in the following subsections.

8.3.2.1.1 Highly Reliable Direct Current Power System

RAI 01-1

~~The EDSS is a non-Class1E DC power system to which augmented design, qualification, and quality assurance (QA) provisions are applied as described in Reference 8.3-1.~~

The EDSS is composed of two DC subsystems that provide a continuous, failure-tolerant source of 125 Vdc power to assigned plant loads during normal plant operation and for a specified minimum duty cycle following a loss of AC power. The EDSS-common (EDSS-C) plant subsystem serves plant common loads that have functions that are not specific to a single NPM. These include MCR emergency lighting and PAM information displayed in the MCR. The EDSS-module-specific (EDSS-MS) plant subsystem consists of up to12 separate and independent DC electrical power supply systems, one for each NPM.

RAI 01-1

The EDSS-MS consists of four power channels and EDSS-C consists of two power divisions. EDSS-MS and EDSS-C are capable of providing uninterrupted power to their loads. EDSS-MS Channels A and D have a specified minimum battery duty cycle of 24 hours, and EDSS-MS Channels B and C have a specified minimum battery duty cycle of 72 hours. The EDSS-C power divisions have a specified minimum battery duty cycle of 72 hours. The 24-hour battery duty cycle of EDSS-MS Channels A and D is specified to preclude unnecessary ECCS valve actuation for a minimum of 24 hours following a postulated loss of AC power, unless a valid ECCS actuation signal is received (see Section 6.3.2 for additional information on ECCS operation). The 72-hour battery duty cycle for EDSS-MS Channels B and C and EDSS-C provides a minimum of 72 hours of DC electrical power for MCR emergency lighting and certain equipment supporting PAM. These EDSS-MS and EDSS-C systems are not credited to meet the acceptance criteria for accident analyses in Chapter 15.

Figure 8.3-6, Figure 8.3-7a, and Figure 8.3-7b provide the simplified one-line diagrams of the EDSS-C and EDSS-MS systems, respectively, and show the demarcation between the EDSS and the Class 1E I&C equipment served by the EDSS-MS.

The source of electrical supply to the EDSS-C and EDSS-MS battery chargers is the ELVS, through the BDG-backed distribution equipment, described above in Section 8.3.1.1.2.

The EDSS-C serves plant common loads as summarized in Table 8.3-4. There are a total of four 125 Vdc batteries and four battery chargers (two batteries and chargers in Division I and two batteries and chargers in Division II) in the EDSS-C subsystem for a NuScale Power Plant containing 1 to 12 NPMs. Each EDSS-C battery consists of 60 cells, sized for a 72-hour duty cycle to provide power to the plant common 125 Vdc loads.

Each EDSS-C battery charger is designed to supply electrical power to its connected loads while simultaneously recharging its associated battery from the design minimum charge state to 95 percent of full charge within 24 hours.

When a battery or charger is not functional or is taken out of service for maintenance, the redundant battery or charger is capable of serving the full load of the affected EDSS-C division.

During normal plant operations, the 480 Vac power source to the EDSS-C battery chargers is the ELVS. The chargers normally supply power to their connected loads in addition to maintaining the batteries fully charged. Therefore, upon a loss of power to all battery chargers, both the Division I and Division II EDSS-C batteries are capable of supplying their connected plant loads for 72 hours. The batteries are described further below.

The EDSS-MS for an NPM provides electrical power for the MPS, other loads associated with that NPM, and the electrical loads shown in Table 8.3-5. There are eight 125 Vdc batteries and eight 125 Vdc battery chargers in each EDSS-MS subsystem (two batteries and chargers in each of redundant Channels A and D, and redundant Channels B and C). Each battery consists of 60 cells connected in series to produce 125 Vdc.

During normal operations, the 480 Vac ELVS provides power to the EDSS-MS battery chargers from the BDG-backed ELVS motor control centers. The chargers normally supply power to plant loads in addition to maintaining the batteries fully charged. Upon a loss of power to all battery chargers, the bus and connected loads remain energized directly from the parallel connection with the batteries. Either the primary or redundant standby batteries are capable of providing the necessary power to the loads. The Channel A and Channel D EDSS-MS batteries have sufficient capacity to supply assigned plant loads for 24 hours, while the Channel B and Channel C EDSS-MS batteries have sufficient capacity to supply assigned plant loads for 24 or 72 hours (as indicated in Table 8.3-5).

The BDGs provide additional capability to preserve battery capacity during the time when normal AC power to the battery chargers is not available by supplying 480 Vac input power to the battery chargers to supply the connected loads and recharge the batteries.

RAI 01-1

The EDSS is a non-Class 1E DC power system. Augmented design, qualification, and quality assurance (QA) provisions are applied to the EDSS as described in Reference 8.3-1. Table 8.3-10 provides a cross reference of the FSAR sections that demonstrate compliance with the augmented provisions. The EDSS conforms to the design, manufacture, installation, testing, and surveillance provisions of IEEE Standard 308 (Reference 8.3-15) and RG 1.32 as described in the safety classification section of Reference 8.3-1. Consistent with the augmented provisions, the EDSS is designed to provide independent and redundant power to certain load groups arranged by channel (EDSS-MS) or division (EDSS-C). The EDSS design also includes augmented provisions for single and common-cause failures and conforms to IEEE-308 (Reference 8.3-15) and IEEE-379 (Reference 8.3-20) to the extent described in Reference 8.3-1.

RAI 01-1

An evaluation of EDSS component failures is provided in Table 8.3-7. The evaluation conservatively assumed that each component single failure occurs concurrently with the unavailability of the redundant EDSS channel (EDSS-MS) or EDSS Division (EDSS-C). The results show that even with this conservative assumption, failures do not prevent safety-related functions from being achieved and maintained. Additionally, under normal operating conditions wherein all EDSS channels and divisions are available, a single failure does not result in inadvertent actuation of safety-related functions. An evaluation of the EDSS reliability was performed using the methodology described in Condition of Applicability II.2 of

Reference 8.3-1. Using the generic failure probabilities from Section 19.1.4.1.1.5, the EDSS supports the mission requirements with high reliability.

RAI 01-1

During or following a postulated DBE concurrent with a loss of AC electrical power, the EDSS-MS provides power to the MPS for a minimum of 24 hours and PAM equipment for 72 hours. The EDSS-C provides power to equipment needed for PAM and MCR emergency lighting for a minimum of 72 hours. This capability is not credited to meet the acceptance criteria for accident analyses in Chapter 15 (per Section 15.0.0).

The EDSS and equipment is designed to allow operability testing online or offline during normal operation. The batteries and battery chargers can be isolated from the rest of the subsystem for testing. Local and remote indications in the control room ensure the ability for continuously monitoring the batteries, battery chargers, and DC buses during test conditions.

RAI 01-1

The 24-hour battery duty cycle of EDSS-MS Channels A and D is specified to provide power to the MPS to preclude unnecessary emergency core cooling system (ECCS) valve actuation for a minimum of 24 hours following a postulated loss of AC power, unless a valid ECCS actuation signal is received (see Section 6.3.2 for additional information on ECCS operation). The 72-hour battery duty cycle for EDSS-MS Channels B and C and the EDSS-C provides a minimum of 72 hours of DC electrical power for equipment supporting PAM and MCR emergency lighting.

Battery monitors provide continuous monitoring of EDSS battery performance.

The EDSS provides DC power only to DC loads. Therefore, inverters are not required or included in the EDSS design.

The EDSS operates ungrounded. Therefore, there are no connections to ground from either the positive or negative legs of the EDSS batteries or chargers. An ungrounded DC system ensures system reliability and availability in the event one of the system legs becomes grounded. The EDSS includes ground fault detection devices and relays consistent with the recommendations of IEEE Standard 946-2004 (Reference 8.3-13).

The EDSS does not contain safety-related cables.

Physical separation is achieved by installing equipment in different rooms that are separated by 3-hour fire barriers. The EDSS-MS Division I cables (Channels A and C) and raceways are routed separately from EDSS-MS Division II cables (Channels B and D) and raceways. Similarly EDSS-C Division I cables and raceways are routed separately from EDSS-C Division II cables and raceways. Although EDSS electrical power is not required to achieve a safe shutdown, this separation ensures that equipment in one fire area rendered inoperable by fire, smoke, hot gases, or fire suppressant, does not affect the availability of the redundant equipment located in another fire area. The fire protection features and analyses are described in Section 9.5.1.

The EDSS-MS batteries (A, B, C, D) and EDSS transfer switches are located in separate rooms on the 75-foot elevation of the RXB. The EDSS-MS switchgear rooms are located on the 86-foot elevation (immediately above the batteries) and house the EDSS switchgear assemblies, battery chargers, and interconnecting system cabling.

The EDSS-C batteries (Division I, Division II) are located on the 50-foot elevation of the CRB. The EDSS-C switchgear rooms are also located on the 50-foot elevation (immediately adjacent) and contain EDSS-C switchgear assemblies, transfer switches, battery chargers, and interconnecting system cabling.

The location of the chargers and switchgear assemblies associated with each battery are located as close as practical to the battery to minimize voltage drops from the battery to the load under high discharge currents from the battery.

See Table 8.3-3 for EDSS equipment locations. The EDSS equipment rooms are separated by 3-hour fire barriers and interconnecting system cabling is routed such that a complete loss of equipment in one fire area does not challenge the EDSS-MS or EDSS-C capability to provide DC electrical power for the applicable 24-hour or 72-hour mission time.

The EDSS-MS equipment is shown on Figure 8.3-7a and Figure 8.3-7b.

RAI 01-1

All EDSS equipment is designed to Seismic Category I standards as discussed in Section 3.7. and Section 3.10. The EDSS design includes augmented provisions for seismic qualification. The codes and standards that implement these provisions are described in Reference 8.3-1.

RAI 01-1

The design of the EDSS includes augmented provisions for component identification and access control. The codes and standards that are used to implement these provisions are described in Reference 8.3-1.

Highly Reliable Direct Current Power System Batteries

RAI 01-1

The EDSS includes augmented design provisions for batteries. The codes and standards that are used to implement these provisions are described in Reference 8.3-1. Each EDSS battery is composed of 60 valve-regulated lead-acid (VRLA) type cells connected in series to generate 125 Vdc. The VRLA battery cells are sealed, with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a preselected amount. The VRLA cells provide a means for recombining internally generated

- EDNS battery room ventilation systems
- post-accident type E variable control and instrumentation loads
- turbine generator system emergency DC lube oil pumps

8.3.2.2.2 Onsite Direct Current Power System Conformance with Regulatory Framework

This section describes the extent to which the design of the onsite DC power systems, including the EDSS and the EDNS electrical equipment, conforms to NRC requirements and guidance. As such, the information in this section provides clarification for the associated entries in Table 8.1-1 of Section 8.1.

RAI 08.03.02-7

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 located in the RXB and in areas of the CRB below the 120 ft elevation, 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 Class1E 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. Specific to seismic phenomena, Reference 8.3-1 includes augmented seismic design and qualification provisions.

GDC 4

RAI 01-1

The EDSS design accommodates the effects of environmental conditions by applying augmented provisions for the design, qualification, and QA typically applied to Class1E 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 codes and standards that are used to implement the EDSS environmental qualifications are described 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.

GDC 5

As shown on 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.

RAI 01-1

The EDSS includes augmented design provisions for multiple NPMs that prevent sharing of DC power equipment between NPMs that has the potential to result in adverse interactions. The codes and standards that are used to implement these provisions are described in Reference 8.3-1. Sharing of the EDSS-C is shown on 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 of the NPMs.

As shown on 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 NPM safety-related functions.

GDC 17

The NuScale design supports an exemption from GDC 17. The NuScale Power Plant is designed with passive safety-related systems for safe shutdown, core and spent fuel assembly cooling, containment isolation and integrity, and RCPB integrity. Electrical power is not relied upon to meet specified acceptable fuel design limits nor to protect the RCPB as a result of anticipated operational occurrences or postulated accidents.

Although not relied on to ensure plant safety-related functions are achieved, the onsite electric power systems are designed with reliability considerations, including independence, redundancy, and testability. The onsite electrical systems are classified as non-Class1E.

GDC 18

As described above, the 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.

GDC 33

The NuScale design supports an exemption from GDC 33, as described in Section 3.1.4.

GDC 34, 35, 38, 41 and 44

The EDSS design conforms to the guidance for independence of standby power sources and their distribution systems provided in RG 1.6.

Regulatory Guide 1.32, Rev. 3

The EDSS conforms to RG 1.32 and IEEE Standard 308-2001 to the extent described in Reference 8.3-1.

RAI 01-1

Regulatory Guide 1.41 (March 1973)

RAI 01-1

The EDSS conforms to RG 1.41 to the extent described in Reference 8.3-1. Section 14.2 includes preoperational testing to verify the independence of certain EDSS load groups arranged by channel or division. The load groups are associated with EDSS functions that would typically be provided by a Class 1E power supply. These groups include type B & C post-accident monitoring variables and the associated MCR displays (SDIS), ECCS valves, and MCR emergency lighting.

Regulatory Guide 1.53, Rev. 2

The EDSS conforms to RG 1.53 and IEEE Standard 379-2000 (Reference 8.3-20) to the extent described in Reference 8.3-1.

RAI 08.01-1

Regulatory Guide 1.63, Rev. 3

The electrical design requirements for electrical penetration assemblies (EPAs) satisfy RG 1.63 as described in Section 8.3.1.2.5.

Regulatory Guide 1.68, Rev. 4

RAI 01-1

Initial testing of the EDSS conforms to RG 1.68 with clarifications described in Reference 8.3-1. Per RG 1.68 in that, preoperational testing is implemented using a graded approach to testing in order to provide reasonable assurance, considering the importance to safety of the item, that the item performs satisfactorily while, at the same time, accomplishing the testing in a cost-effective manner. The EDSS preoperational testing is performed as part of the Initial test program described in Section 14.2.12.

Regulatory Guide 1.75, Rev. 3

The EDSS conforms to RG 1.75 and IEEE Standard 384-1992 to the extent described in Reference 8.3-1.

Regulatory Guide 1.81, Rev. 1

The EDSS conforms to RG 1.81 to the extent described in the discussion of conformance to GDC 5 above and Reference 8.3-1.

Regulatory Guide 1.106, Rev. 2

The NuScale Power Plant design does not include safety-related, motor-operated valves and; therefore, RG 1.106 is not applicable.

Regulatory Guide 1.118, Rev. 3

The EDSS conforms to RG 1.118 and IEEE Standard 338-1987 (Reference 8.3-21) to the extent described in Reference 8.3-1. Periodic testing of the EDSS and EDNS equipment is discussed in Section 8.3.2.3.

Regulatory Guide 1.128, Rev. 2

Regulatory Guide 1.128 endorses IEEE Standard 484-2002 (Reference 8.3-22) 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 Section 8.3.2.1, the EDSS uses VRLA batteries. Thus, IEEE Standard 1187-2013 (Reference 8.3-17) 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.

Regulatory Guide 1.129, Rev. 3

Regulatory Guide 1.129 endorses IEEE Standard 450-2010 (Reference 8.3-6) 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 (Reference 8.3-18) 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.

Regulatory Guide 1.153, Rev. 1

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.

Regulatory Guide 1.155 (August 1998)

Regulatory Guide 1.155 provides guidance for implementing the station blackout requirements of 10 CFR 50.63. The extent to which the NuScale Power Plant design conforms to RG 1.155 is described in Section 8.4.

RAI 01-1

As described in Reference 8.3-1, an augmented quality assurance (QA) program is applied to the EDSS. The program meets the QA provisions of RG 1.155 Appendix A.

Regulatory Guide 1.160, Rev. 3

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 Section 17.6.

Regulatory Guide 1.212

The EDSS and EDNS batteries are sized per IEEE Standard 485-1997 as endorsed by Regulatory Guide 1.212 (November 2008).

Regulatory Guide 1.218 (April 2012)

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.

Branch Technical Position 8-4, Rev. 3

Branch Technical Position 8-4 establishes the acceptability of disconnecting power to electrical components of a fluid system as one means of designing against a single failure that might cause an undesirable component action. Removal of electric power from safety-related valves is not used in the NuScale Power Plant design as a means of satisfying the single failure criterion. Therefore, this BTP is not applicable to the NuScale design.

RAI 08.02-9

SECY 94-084 and SECY 95-132

FSAR Section 17.4.3 describes the NuScale methodology to establish risk significance of SSC. The NuScale process for evaluating SSC against the RTNSS criteria is described in FSAR Section 19.3. This process did not identify safety-related or risk-significant functions for the onsite DC power systems.

8.3.2.2.3 Electrical Power System Calculations and Distribution System Studies for Direct Current Systems

The following subsections describe the calculations and studies that were developed for the DC power systems. The calculations were performed using the ETAP computer software (Reference 8.3-11).

Load-Flow and Voltage-Regulation Studies, and Undervoltage and Overvoltage Protection

The DC load-flow analyses were performed for both the EDNS and EDSS to confirm equipment assumptions and select equipment ratings. The margins for load growth were included in the analyses.

The operating voltage range for the EDSS and EDNS was determined by calculation and accommodates equalize charging the batteries at a specified low temperature. The operating voltage range for the EDSS-MS and the EDSS-C 125 Vdc batteries is 105 Vdc to 140 Vdc. The operating voltage range for the EDNS 250 Vdc batteries is 200 Vdc to 280 Vdc, and the operating range for the EDNS 125 Vdc batteries is 100 Vdc to 140 Vdc.

Short-Circuit Studies

Short-circuit analyses are performed for the EDSS-MS, EDSS-C, and the EDNS DC subsystems. These analyses are performed in accordance with IEEE Standard 946-2004 (Reference 8.3-13) methodology and the available short-circuit currents from each battery and connected charger are determined under a worst case short circuit at the battery terminals.

Equipment Sizing Studies

The DC equipment sizing was developed from a load list and was verified using the ETAP load-flow and short-circuit analysis results. Worst-case loading was determined and the power supply equipment was selected that enveloped the loading requirements. The ratings for the major DC equipment are listed in Table 8.3-3 and Table 8.3-8.

The acceptance criteria for the major DC system components are that the equipment ratings are not exceeded when load-flow, voltage-drop, and short-circuit analyses are performed. The equipment sizing includes additional design margin for future load growth.

The EDSS switchgear DC buses are sized based on the calculated loading, which includes an additional margin of 25 percent (1.25 factor) applied to the highest battery charger current during operation in the current-limit mode (i.e., 150 percent of the battery charger rated full-load current).

The EDNS switchgear DC buses are sized by applying a factor of 120 percent to the highest ampere demand on the battery charger while operating in the current-limit mode and selecting the next higher standard-current value for DC buses. The EDNS switchgear AC buses are sized based on the rating of the inverter rounded off to the next higher standard rating in amperes. See Table 8.3-8 for EDNS bus ratings per subsystem.

Equipment Protection and Coordination Studies

RAI 01-1

The EDSS includes augmented design provisions for equipment protection. The codes and standards that are used to implement these provisions are described in Reference 8.3-1.

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. This results in the fault being localized to the smallest possible area without causing interruption or damage to other portions of the systems.

The minimum interrupting rating for the EDSS equipment is greater than the worst-case, short-circuit contribution from the batteries and battery chargers.

The minimum interrupting rating for the EDNS equipment is greater than the worst-case, short-circuit currents from the batteries, battery chargers, and DC motors (as applicable.)

Power Quality Limits

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The EDSS battery chargers supplied by the ELVS provide electrical isolation between the AC power system and the EDSS. Power quality is a design provision that relies on IEEE Standard 308-2001 (Reference 8.3-15) as endorsed by RG 1.32 and IEEE Standard 741-1997 (Reference 8.3-26) as described in Reference 8.3-1. The NMS and MPS Class 1E isolation devices ensure that a power fluctuation on either the AC or DC power system does not adversely affect safety-related functions.

8.3.2.2.4 Grounding

The EDNS and EDSS power supply systems are operated ungrounded. Neither the positive nor the negative leg is grounded during normal operation. Therefore, a connection to ground on either the positive or negative leg does not change the DC system voltage; it is only referenced to ground at that point. However, structures and components of the EDSS and EDNS are connected to the station ground grid to provide personnel and equipment protection.

The EDSS and EDNS designs incorporate ground detection features to identify when a connection to ground occurs on either the positive or negative leg of a DC system.

8.3.2.3 Inspection and Testing

Highly Reliable Direct Current Power System

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The surveillance~~inspection~~ and testing of the EDSS structures, systems, and components are based on the augmented provisions in Reference 8.3-1. Periodic temperature deviations, discharges, and voltage excursions that exceed predefined tolerances.

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The EDSS includes augmented design provisions for the location of indicators and controls that conform to IEEE Standard 308-2001 (Reference 8.3-15) as described in Reference 8.3-1.

Normal Direct Current Power System

Each EDNS subsystem includes indications for DC bus voltage, battery charging and discharging current, battery charger output current, and battery charger output voltage. Similarly, each primary and standby battery and battery charger (where provided) provides alarms and indications for high and low battery voltage, high and low DC bus voltage, battery charger undervoltage, battery discharge alarm, battery charger input and output breaker open alarms, and a high impedance ground fault detector.

8.3.3 References

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8.3-1 NuScale Power, LLC, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," TR-0815-16497-P-A, Rev. 1~~0~~.

8.3-2 Insulated Cable Engineers Association, "Ampacities of Cables Installed in Cable Trays," ICEA P-54-440 (NEMA WC 51) - 2009, Carrollton, GA.

8.3-3 National Fire Protection Association, "National Electric Code," NFPA 70-2014, Quincy, MA.

8.3-4 Institute of Electrical and Electronics Engineers, "IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)," IEEE Standard 242-2001, Piscataway, NJ.

8.3-5 Institute of Electrical and Electronics Engineers, "IEEE Design Guide for Electric Power Service Systems for Generating Stations," IEEE Standard 666-2007, Piscataway, NJ.

8.3-6 Institute of Electrical and Electronics Engineers, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," IEEE Standard 450-2010, Piscataway, NJ.

8.3-7 Institute of Electrical and Electronics Engineers, "IEEE Guide for Generating Station Grounding," IEEE Standard 665-1995, Piscataway, NJ.

8.3-8 Institute of Electrical and Electronics Engineers, "IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations," IEEE Standard 1050-2004, New York, NY.

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Table 8.3-9: FSAR Cross Reference for the Conditions of Applicability and NRC SER Limitations and Conditions for TR-0815-16497-P-A

Table 3-1 Section I Condition Number	FSAR Sections that Demonstrate Condition is Satisfied
1.	Design Basis Event Assumptions • 15.0.0.6.4 and 15.0.4 (72 hour stabilized condition DBE end state without operator actions required) • 15.0.0.6.5 (DBE analysis includes loss of electrical power) • 8.4.2 (SBO Loss of AC and DC power for 72 hour duration)
1.a .	• 3.9.4 (CRDS does not rely on electrical power) • 8.4.2 (SBO reactor trip)
1.b.	• 4.3.1.5 (Shutdown capability does not rely on electrical power) • 15.6 (Decrease in inventory event analyses do not rely on electrical power or credit active injection sources) • 8.4.2 (SBO does not rely on electrical power for shutdown or inventory control)
1.c.	• 5.4.3.1 (DHRS function does not rely on electrical power) • 6.3.1 (ECCS function does not rely on electrical power) • 15.0.0.6.3 (DBE analysis does not credit electrical power for DHRS or ECCS functions) • Table 15.0-2, Table 15.0-3, Table 15.0-4 (Fuel and core acceptance criteria confirm core cooling) • 8.4.2 (SBO core cooling relies on DHRS and ECCS)
1.d.	• 6.2.4.2.1 (CNV isolation function does not rely on electrical power) • 8.4.3 (SBO containment integrity does not rely on electrical power)
1.e.	• 6.2.1, 6.2.2, and 6.2.5.1. (Passive CNTS and UHS design does not include active ESF heat removal and combustible gas control systems) • Table 15.0-2 (DBE thermal hydraulic acceptance criteria confirm containment peak pressure margin) • 8.4.3 (No credit for active ESF heat removal for containment integrity in SBO analysis)
1.f.	• 6.5.3 (Active fission product removal systems are not required) • Table 15.0-12 (DBA radiological consequences show guidelines maintained)
1.g.	• 5.2.2. 1 (Overpressure protection system does not rely on electrical power) • 8.4.2 (SBO RPV pressure margin) • Table 15.0-2 (DBE thermal hydraulic analyses confirm margin to RCS pressure acceptance criteria)
2.	• See associated PAM FSAR references in items 2a-2c below.
2.a	• 7.1.1.2.2 (PAM design) • 8.4.2 (No credit for manual actions in SBO analysis)
2.b	• 7.1.1.2.2 (PAM design)
2.c	• 7.1.1.2.2 (PAM design)
3.	• 9.1.3, 9.2.5.2 (UHS and SFP integrated passive cooling function does not rely on electrical power) • 9.2.5.2.1 (SFP weir design maintains 10 feet in SFP above racks without active systems)
4.	• 9.1.3, 9.2.5.2 (UHS and SFP integrated passive cooling function does not rely on electrical power) • 9.2.5.2.1 (SFP weir design maintains 10 feet in SFP above racks without active systems) • 9.1.4.2, 9.2.5.3 (UHS provides a minimum of 10 feet for shielding available during fuel handling)
5.	• 6.4 (CRHS does not rely on electrical power) • 8.4.3 (Main control room habitable during SBO without relying on electrical power)

Table 8.3-9: FSAR Cross Reference for the Conditions of Applicability and NRC SER Limitations and Conditions for TR-0815-16497-P-A (Continued)

Table 3-1 Section I Condition Number	FSAR Sections that Demonstrate Condition is Satisfied
6.	• 3.11.2.1 (PAM environmental qualification) • 3.11.4 (72 hour loss of ventilation) • Table 3C-3 (EDSS environment environment) • 8.4.2, 8.4.3 (SBO mitigation equipment for 10 CFR 50.63 (DHRS and ECCS) is operable in SBO environment)
7.	Active Fission Product Removal Systems • 6.5.3 (Active fission product removal systems are not required to meet regulatory requirements) Active Ventilation Systems Not Required to Mitigate the Consequences of Design Basis Accidents • 9.4.2.3 (RBVS) • 9.4.5 (No ESF ventilation in NuScale design) Dose Analyses • 15.0.3, Table 15.0-12 (No active ventilation systems are required to maintain offsite doses within applicable guidelines)
Table 3-1 Section II Condition Number	**FSAR Sections Which Demonstrate Condition is Satisfied**
1. Augmented Provisions	• Table 8.3-10
2. Comparative EDSS Reliability	• 8.3.2.1.1 (EDSS reliability evaluation)
3. Emergency Lighting Capability	• 8.4.3 (SBO emergency lighting) • 9.5.1.2 (Fire protection) • 9.5.3.2 (Emergency lighting design)
SER Condition Number	**FSAR Sections Which Demonstrate Condition is Satisfied**
4.1 RG 1.155	• 8.3.2.2.2 (RG 1.155 part)
4.2 Seismic	• Table 3.2-1 (EDSS seismic classification) • 8.3.2.1.1 (EDSS seismic design) • 8.3.2.2.2 (EDSS GDC 2)
4.3 Operator Actions	• 7.1.1.2.2 (PAM design) • 15.0.0.6.4, 18.6.2.2 (Operator actions not needed to support DBE analysis)
4.4 AOO with ECCS actuation	• 15.0.0.6.3 (Condition 4.4)
4.5 Stuck rod safe shutdown	• 4.3.1.5 (Shutdown capability) • 9.3.4.3 (CVCS safety evaluation) • 15.0.6 (Return to power)

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Table 8.3-10: FSAR Cross Reference for the EDSS Augmented Provisions in TR-0815-16497-P-A

Augmented Provision (Table 3-2 of Reference 8.3-1)	FSAR Sections Which Demonstrate that Condition is Satisfied
Compliance with 10 CFR 50.55a(1) and IEEE Standard 603-1991	• 8.3.2.2.2 (10 CFR 50.55a(h))
Safety Classification	• 8.3.2.1.1 • 8.3.2.2.2 (RG 1.32)
Quality Assurance	• 8.3.2.2.2 (RG 1.155)
Seismic Qualification	• 8.3.2.1.1 (EDSS seismic design) • 8.3.2.2.2 (GDC 2)
Environmental Qualification	• 8.3.2.2.2 (GDC 4) • 3.11.2.1 (mild environments) • Appendix 3C and Table 3C-3 (EDSS rooms)
Batteries	• 8.3.2.2.1 (Battery design)
Onsite Standby Power Sources	• 8.3.1.2.7 (SECY 94-084 and SECY 95-132)
Identification	• 8.3.2.1.1 • 8.3.2.2.2 (RG 1.32 and RG 1.75)
Independence	• 8.3.2.1.1 • 8.3.2.2.2 (10 CFR 50.55a(h), RG 1.32, RG 1.75, and RG 1.128)
Single Failure Criterion	• 8.3.2.1.1 • 8.3.2.2.22 (RG 1.32 and RG 1.53)
Common Cause Failure	• 8.3.2.1.1 • 8.3.2.2.2 (RG 1.32 and RG 1.53)
Control of Access	• 8.3.2.1.1 • 8.3.2.2.2 (RG 1.232)
Protection	• 8.3.2.2.3 (Equipment Protection)
Power Quality	• 8.3.2.2.3 (Power Quality)
Location of Indicators and Controls	• 8.3.2.2.2 (RG 1.32) • 8.3.2.4
Surveillance and Testing	• 8.3.2.2.2 (RG 1.32, RG 1.41, RG 1.68, RG 1.118, RG 1.129, and Section 14.2) 8.3.2.3
Multi-Unit Station Considerations	• 8.3.2.2.2 (RG 1.32 and 1.81, GDC 5)

- RG 1.20 - Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing, Rev. 3
- RG 1.29 - Seismic Design Classification for Nuclear Power Plants, Rev. 5

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- RG 1.41 - Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments, March 1973
- RG 1.45 - Guidance on Monitoring and Responding to Reactor Coolant System Leakage, Rev. 1
- RG 1.68.1 - Initial Test Program of Condensate and Feedwater Systems for Light-Water Reactors, Rev. 2
- RG 1.68.2 - Initial Startup Test Program to Demonstrate Remote Shutdown Capability for Water- Cooled Nuclear Power Plants, Rev 2
- RG 1.68.3 - Preoperational Testing of Instrument and Control Air Systems, Rev.1
- RG 1.69 - Concrete Radiation Shields and Generic Shield Testing for Nuclear Power Plants, Rev. 1
- RG 1.79 - Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors, Rev. 2
- RG 1.118 - Periodic Testing of Electric Power and Protection Systems, Rev. 3
- RG 1.128 - Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants Rev. 2
- RG 1.140 - Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water- Cooled Nuclear Power Plants, Rev. 2
- RG 1.155 - Station Blackout, Rev.1
- RG 8.38 - Control of Access to High and Very High Radiation Areas of Nuclear Power Plants, Rev. 1

14.2.8 Utilization of Reactor Operating and Testing Experience in Test Program Development

The operational experience gained from pressurized-water and other reactor designs is factored into the design and testing.

Operations and technical staff review the following documents for information that can be included in the ITP:

- NRC licensee event reports
- NRC generic communications (i.e., inspection and enforcement bulletins, circulars, generic letters, administrative letters, information notices, and regulatory issue summaries)
- Institute of Nuclear Power Operations issuances

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Table 14.2-57: Highly Reliable DC Power System Test # 57

~~Preoperational test is required to be performed for each NPM.~~ Component level tests are required to be performed for each NPM. System Level Test #57-1 and Test #57-2 are required to be performed once. System Level Test #57-1 and Test #57-2 may be performed concurrently. System Level Test #57-3 is required to be performed once for each NPM.		
The EDSS is described in Sections 8.1.2.2, 8.1.4.2 and 8.3.2.1.1, and the functions verified by this test are:		
System Function	**System Function Categorization**	**Function Verified by Test #**
The highly reliable DC power system (EDSS) supports the following systems by providing DC electrical power. • MPS • neutron monitoring system (NMS) • fixed area radiation monitoring system (RMS) • plant lighting system (PLS) • PPS • safety display information system • CRVS	nonsafety-related	The Site Acceptance Test criteria in the prerequisites satisfies the functional verification.
EDS system functions verified by other tests are:		
System Function	**System Function Categorization**	**Function Verified by Test #**
1. EDSS supports the MPS by providing EDSS module-specific operating parameter information signals.	nonsafety-related	Reference 14.2-66 Component level test
2. EDSS supports the PPS by providing EDSS common operating parameter information signals.	nonsafety-related	Reference 14.2-66 Component level test
Prerequisites i. Verify an instrument calibration has been completed, with approved records and within all calibration due dates, for all instruments required to perform this test. ii. Verify a valve-regulated lead-acid battery acceptance tests has been performed on all EDSS batteries to confirm battery capacity in accordance with IEEE Standard 1188 Sections 6 and 7. iii. Verify battery charger performance testing has been completed by the manufacturer or a site acceptance test has been completed in accordance with manufacturer instructions.		
Component Level Tests		
Test Objective	**Test Method**	**Acceptance Criteria**
i. Verify on loss of power each EDSS battery charger ELVS input breaker automatically opens.	De-energize the ELVS motor control center feed to a EDSS battery charger. Repeat test for remaining EDSS battery chargers.	The battery charger ELVS input breaker is open.

Table 14.2-57: Highly Reliable DC Power System Test # 57 (Continued)

ii. Verify each EDSS instrument is monitored in the MCR and the RSS, if the signal is designed to be displayed in the RSS. (Test not required if the instrument calibration verified the MCR and RSS display.)	Initiate a single real or simulated instrument signal from each EDSS transmitter.	i. The instrument signal is displayed on an MCR workstation or recorded by the applicable control system historian. ii. The instrument signal is displayed on an RSS workstation or recorded by the applicable control system historian if the instrument signal is designed to be displayed in the RSS. iii. The instrument signal is displayed on an MCR module-specific safety display instrument monitor or an MCR common safety display instrument monitor if the instrument signal is designed to be displayed on a safety display instrument monitor.
System Level Tests		
~~None~~**System Level Test #57-1**		
Test Objective	**Test Method**	**Acceptance Criteria**
Verify the EDSS common buses provide independent power to the main control room (MCR) emergency lighting. (RG 1.41 Independence Test)	i. With both EDSS common buses energized and providing power to MCR emergency lighting, de-energize the EDSS Division I common bus. ii. With both EDSS common buses energized and providing power to MCR emergency lighting, de-energize the EDSS Division II common bus.	i. The MCR lighting designed to be powered by the EDSS Division I common bus is de-energized, and the MCR emergency lighting designed to be powered by the EDSS Division II common bus is energized. ii. The MCR emergency lighting designed to be powered by the EDSS Division II common bus is de-energized, and the MCR emergency lighting designed to be powered by the EDSS Division I common bus is energized
System Level Test #57-2		
Test Objective	**Test Method**	**Acceptance Criteria**
Verify the EDSS common buses provide independent power to all SDIS MCR displays. (RG 1.41 Independence Test)	i. With EDSS Division I and Division II common buses energized verify power is available in the MCR for all SDIS displays. ii. De-energize the EDSS Division I common bus. iii. Re-energize the EDSS Division I common bus and de-energize the EDSS Division II common bus.	i. Power is available in the MCR for all SDIS displays. ii.a. Power is not available in the MCR for any SDIS Division I displays. ii.b. Power is available in the MCR for all SDIS Division II displays. iii.a. Power is not available in the MCR for any SDIS Division II displays. iii.b. Power is available in the MCR for all SDIS Division I displays.

Table 14.2-57: Highly Reliable DC Power System Test # 57 (Continued)

System Level Test #57-3		
Test Objective	**Test Method**	**Acceptance Criteria**
Verify EDSS module-specific channels provide independent and redundant power to the ECCS trip valve solenoids and PAM Type B and C variables. (RG 1.41 Independence Test)	i. With all EDSS module-specific channels de-energized for the NPM under test, energize EDSS module-specific channel A. ii. With all EDSS module-specific channels de-energized for the NPM under test, energize EDSS module-specific channel C. iii. With all EDSS module-specific channels de-energized for the NPM under test, energize EDSS module-specific channel B. iv. With all EDSS module-specific channels de-energized for the NPM under test, energize EDSS module-specific channel D.	i. Power is available to the Division I ECCS trip valve solenoids. ii.a. Power is available to the Division I ECCS trip valve solenoids. ii.b. All PAM Type B and C variables shown on Figure 7.1-2 are displayed on an SDIS display for the NPM under test. iii.a. Power is available to the Division II ECCS trip valve solenoids. iii.b. All PAM Type B and C variables shown on Figure 7.1-2 are displayed on an SDIS display for the NPM under test. iv. Power is available to the Division II ECCS trip valve solenoids.

actuation, the RVVs and the RRVs open creating a steam flow path from the pressurizer to the containment, and an RPV downcomer flow path to and from containment. Water that is vaporized in the core leaves as steam through the RVVs, is condensed and collected in the CNV, and is returned to the downcomer region inside the RPV through the RRVs. The CNV is sized such that the displacement of liquid from the RPV into containment establishes a liquid level above the RRVs, establishing the natural circulation loop. The natural circulation loop removes decay and residual heat from the core and RPV into the containment. Heat in the containment is then transferred by conduction and convection to the water in the reactor pool. Because the ECCS does not replace or add inventory after a LOCA, it does not require boron addition to maintain reactivity control caused by the addition of an external source of water. Section 15.6.5 provides additional information on the NPM response during a LOCA.

The ECCS valves and the DHRS do not rely on electrical power or on nonsafety-related support systems for actuation. After actuation, the valves do not require a subsequent change of state or continuous availability of power to maintain their intended safety functions. The RVVs and RRVs are the only active components in the ECCS. No single failure prevents the ECCS from performing its safety function, including single failures in electrical power (single failures in onsite power and offsite power, busses, electrical and mechanical parts, cabinets and wiring), initiation logic, and single active or passive component failure. One RRV and two RVVs are required for successful ECCS operation. If the redundant direct current (DC) power to the MPS or the ECCS and DHRS valve actuators is lost, the valves actuate. The ECCS valves open once RCS pressure goes below the inadvertent actuation block (IAB) pressure locking threshold.

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An ECCS actuation would occur in the event of an AOO or IE such as an inadvertent opening of an RSV, and inadvertent opening of an ECCS valve, or a loss of AC power for more than 24 hours. An ECCS actuation would also occur during an AOO that includes an assumption of a loss of DC power. An analysis of these events was conducted and consistent with Condition 4.4 of Reference 8.3-1, ECCS actuation in response to an AOO or IE is expected to occur much less than once in the lifetime of an NPM.

Long-term cooling requirements that call for the removal of decay heat by the passive containment heat removal are discussed in Section 6.2.

15.0.0.6.4 Required Operator Actions

There are no operator actions credited in the evaluation of NuScale DBEs. After a DBE, automated actions place the NPM in a safe-state and it remains in the safe-state condition for at least 72 hours without operator action, even with assumed failures.