September 14, 2018 Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Submittal of NRC Request to Provide Information on the Final Safety Analysis Report Section 14.2, "Initial Plant Test Program"

During an August 30, 2018, public teleconference between the NRC and NuScale Power, LLC (NuScale), NRC requested that NuScale provide, in writing, NuScale's expectations of the scope of the NRC staff review of FSAR Section 14.2, "Intial Plant Test Program," and that NuScale outline those parts of Section 14.2 that would be reviewed under that scope.

The purpose of this letter is to respond to the above requested information in Enclosure 1.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please contact Carrie Fosaaen at 541-360-0677 or at cfosaaen@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Samuel Lee, NRC, OWFN-8G9A
Gregory Cranston, NRC, OWFN-8G9A
Omid Tabatabai, NRC, OWFN-8G9A

Enclosure: NuScale Final Safety Analysis Report Section 14.2, "Initial Plant Test Program" Scope Outline

Enclosure:

"NuScale Final Safety Analysis Report, Tier 2, Section 14.2, 'Initial Plant Test Program' Scope Outline"

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

CONTENTS

TABLES

1.0 Introduction – Requested Review of NuScale FSAR Section 14.2, Initial Plant Test Program

On August 30, 2018, the NRC requested that NuScale Power, LLC restate, in writing, NuScale's expectations of the scope of the NRC staff review of Section 14.2, Initial Plant Test Program. NuScale's requested review scope was previously described in the August 1, 2018, presentation on Risk-Informed Review of the NuScale Initial Test Program (ML18213A157), and is reiterated herein.

NuScale's requested review scope is that NRC staff focus the FSAR Section 14.2 review on initial test program (ITP) abstracts for safety-related (SR) and risk-significant SSCs (A1 – safety-related, risk-significant; A2 – safety-related, not risk-significant; and B1 – nonsafety-related, risk-significant) in accordance with the guidance in NUREG-0800, Introduction Part 2, and DSRS Section 14.2 for DCA scope. Additionally, NuScale requests that the NRC staff's FSAR Section 14.2 review scope include test abstracts pertaining to ITAAC and first-of-a-kind (FOAK) design features. The reasons for including this review scope are: 1) some ITAAC require verification of design features of non-risk significant components through preoperational testing of the design; 2) FOAK tests verify design features that are new and unique and have not been tested previously; and 3) the need to achieve finality of these test abstracts at the DCA stage.

Review of the remaining B2 (NSR, non-risk significant) test abstracts would be out of scope of the DC and COL FSAR Section 14.2 review. The NRC would reach reasonable assurance for those based on the following:

- DCA review of test abstracts and the DCA/COLA review of administrative requirements provide sufficient review of the ITP.
- Review of programmatic aspects at COL stage does not impact the scope of test abstracts by risk-informing them.
- Programmatic requirements, including the COL holder quality assurance program, provide assurance that the COL holder develops and implements an effective ITP.
- The COL holder is required to develop adequate test procedures for the full RG 1.68, Rev. 4 scope, and make it available for NRC inspection.

The follow-on sections in this white paper describe how FSAR Section 14.2 was developed, including how Design Reliability Assurance Program (D-RAP) system functions were used and tied to test abstracts, the specific contents of FOAK tests and control system tests, COL items to the NuScale ITP, and the NRC-requested roadmap that explicitly ties classification of functions tested and ITAAC verified to its associated test abstract.

The following Table 1-1 provides the NuScale initial test program test abstracts that are the part of requested review of NuScale's initial test program.

Table 1-1 NRC Risk-Significant Review of NuScale Preoperational Tests and Startup Tests

Test Number	System Abb.	Test Abstract	A1	A2	B1	ITAAC
Preoperational Tests						
4	PSCS	Pool Surge Control System				X
9	ABS	Auxiliary Boiler System				X
18	CRHS	Control Room Habitability System				X
19	CRVS	Normal Control Room HVAC System				X
20	RBVS	Reactor Building HVAC System				X
24	BPDS	Balance-of-Plant Drains				X
25	FPS	Fire Protection System				X
35	LRWS	Liquid Radioactive Waste System				X
36	GRWS	Gaseous Radioactive Waste System				X
38	CVCS	Chemical and Volume Control System				X
41	CES	Containment Evacuation System				X
42	CFDS	Containment Flooding and Drain System				X
43	CNTS	Containment System	**X**			X
51	FHE	Fuel Handling Equipment System				X
52	RBC	Reactor Building Cranes			**X**	
60	PLS	Plant Lighting System				X
63	MPS	Module Protection System	**X**	**X**		X
66	SDIS	Safety Display and Indication				X
68	COMS	Communication System				X
73	N/A	Security Access Control				X
74	N/A	Security Detection and Alarm				X
Initial Fuel Loading Precritical Tests						
76	N/A	Initial Fuel Load				
77	N/A	Reactor Coolant System Flow Measurement				

78	N/A	NuScale Power Module Temperatures
79	N/A	Primary and Secondary System Chemistry
80	N/A	Control Rod Drive System-Manual Operation, Rod Speed, and Rod Position Indication
81	N/A	Control Rod Assembly Full-Height Drop Time
81A	N/A	Control Rod Assembly Ambient Temperature Full-Height Drop Time Test
82	N/A	Pressurizer Spray Bypass Flow
83	N/A	Initial Criticality
84	N/A	Post-Critical Reactivity Computer Checkout
Low Power Tests		
86	N/A	Determination of Zero-Power Physics Testing Range
87	N/A	All Rods Out Boron Endpoint Determination
88	N/A	Isothermal Temperature Coefficient Measurement
89	N/A	Bank Worth Measurement
Power-Ascension Tests		
91	N/A	Core Power Distribution Map
92	N/A	Nuclear Monitoring System Power Range Flux Calibration
93	N/A	Reactor Coolant System Temperature Instrument Calibration
94	N/A	Reactor Coolant System Flow Calibration
95	N/A	Radiation Shield Survey
96	N/A	Reactor Building Ventilation System Capability

97	N/A	Thermal Expansion
98	N/A	Control Rod Assembly Misalignment
99	N/A	Steam Generator Level Control
100	N/A	Ramp Change in Load Demand
101	N/A	Step Change in Load Demand
102	N/A	Loss of Feedwater Heater
103	N/A	100 Percent Load Rejection
104	N/A	Reactor Trip from 100 Percent Power
105	N/A	Island Mode Test for NuScale Power Module #1
106	N/A	Island Mode Test for Multiple NuScale Power Modules
107	N/A	Remote Shutdown Workstation
108	N/A	NuScale Power Module Vibration Test

2.0 Overview of Preoperational and Startup Testing

Regulatory Guide 1.68 defines the ITP as:

a) preoperational testing.
b) initial fuel loading testing.
c) pre-criticality testing.
d) initial criticality testing.
e) low power tests.
f) power ascension tests.

Also, RG 1.68 refers to the collection of tests b through f as *Startup Tests.*

In addition, RG 1.68 defines preoperational testing as those tests conducted following completion of construction inspections and tests, but before fuel loading, to demonstrate, to the extent practical, the capability of SSCs to meet the performance requirements to satisfy the design criteria. NuScale reflects this guidance in considering the RG 1.68 phrase “construction inspections and tests” as those activities completed by the COL holder’s Construction organization before the system care, custody, and control turnover from the COL holder’s Construction organization to the Startup organization. NuScale also considers “preoperational testing” as those tests conducted by Startup *after* the system care, custody, and control turnover from the COL holder’s Construction organization to the Startup organization and before the commencement of the initial fuel loading testing.

NuScale “preoperational tests” consists of (1) *generic component testing (*reference Section 4.0 of this document) completed on each system before the commencement of a system preoperational test, and (2) *system preoperational tests* listed in FSAR Table 14.2-109: List of Test Abstracts. NuScale preoperational tests are numbered test 1 through 74 in FSAR Table 14.2-109.

3.0 Organization of Preoperational and Startup Testing

Identification of NuScale Initial Test Program Preoperational Tests and Startup Tests

FSAR Table 14.2-109: List of Test Abstracts contains a listing of all preoperational and startup test abstracts. FSAR Table 14.2-109 has been duplicated in Appendix A of this document with the following additional information provided:

a) The Design Reliability Assurance Program (D-RAP) classification of each function tested by a preoperational test
b) The ITAAC number for each ITAAC associated with a preoperational test

Startup tests do not have references to D-RAP system functions because startup tests are integrated tests verifying multiple functions. Startup tests do not have any ITAAC references because ITAAC must be completed before fuel load.

Refer to Section 5.0 for a discussion of how system D-RAP functions were used to develop preoperational test abstracts.

Refer to FSAR Table 14.3-1: Module-Specific Structures, Systems, and Components Based Design Features and Inspections, Tests, Analyses, and Acceptance Criteria Cross Reference and FSAR Table 14.3-2: Shared/Common Structures, Systems, and Components and Non-Structures, Systems, and Components Based Design Features and Inspections, Tests, Analyses, and Acceptance Criteria Cross Reference for a discussion of how each NuScale ITAAC is verified. The tables are organized by ITAAC number. If the successful completion of a preoperational test is required to verify an ITAAC, the verifying preoperational test abstract number is provided in the discussion of the ITAAC. In addition, the preoperational test acceptance criteria column is annotated with the ITAAC number in the associated preoperational test abstract contained in FSAR Table 14.2.

4.0 RG 1.68 Rev 4 Component Testing Guidance

Regulatory Guide 1.68 identifies types of components to be tested as part of the initial test program. Many of these listed component types are not applicable to NuScale design (reference Section 6.0 of this document). The component types listed in RG 1.68 that are applicable to NuScale design would be tested as part of the NuScale generic component testing. NuScale's generic component testing is largely completed after system care, custody, and control transfer of the system from Construction to Startup, and completed by Startup before the performance of the associated preoperational test. Generic component testing executes standardized tests for a family of related components, independent of the components' system assignment. Each generic component test procedure will be executed and approved before the component is required as a prerequisite to a preoperational test performance.

The completion of generic component testing is not listed as a prerequisite in NuScale's test abstracts. For a discussion of test prerequisites in the NuScale test abstracts see Section 9.2 of this document. However, each detailed preoperational test procedure will itemize the completed generic component tests as a prerequisite.

The component types described in RG 1.68 are listed below in Table 4-1. The RG 1.68 system reference is not included for each component, because the components may occur in multiple NuScale systems. The RG 1.68 component type list in Table 4-1 is a *subset* of components that will require testing as part of NuScale generic testing.

Table 4-1 RG 1.68 List of Components that Require a Generic Component Test

Component Type	Component
Mechanical components	Pumps Motors
Valves	Pressure relief Safety Isolation Turbine bypass
Electrical distribution components	Initiating devices Trip devices Heaters Breakers Motor controllers Switchgear Transformers Cables Batteries Battery chargers Transfer devices Converters Inverters Protective devices
Instruments	Instrumentation used to monitor system performance or perform permissive and prohibit interlock functions Instrument (instrument calibration)
Other components	Pressurizer heater Heat tracing for freeze protection Rotating machinery vibration testing Cathodic protection High-efficiency particulate air filters Charcoal adsorbers

5.0 NuScale D-RAP System Functions: Use in Initial Test Program Testing

FSAR Section 17.4.3 describes the NuScale process to evaluate and classify system functions and system components, called the Design Reliability Assurance Program. The scope of preoperational testing was determined using both RG 1.68 guidance and the functions identified in the NuScale D-RAP process.

The D-RAP SSC classification process uses a functional hierarchy concept in which each *system function* is classified and *components* required to support each system function are classified with respect to the associated system function they support. The defined standard functions are categorized as A1 (safety-related and risk-significant), A2 (safety-related, not risk-significant), B1 (nonsafety-related, risk-significant) or B2 (nonsafety-related, not risk-significant).

The functions identified by the D-RAP process have an inter-system dependence. The D-RAP system functions are of the form [the supporting system name] supports the [supported system name] by [identification of the method].

The functions identified by the D-RAP process were directly used in defining the scope of preoperational tests. The system functions for each system from the D-RAP results were analyzed to identify the testable functions for that system. The testable system functions were then recorded within the system's preoperational test abstract.

The FSAR Table 17.4-1, "D-RAP SSC Functions, Categorization, and Categorization Basis," lists the results of the D-RAP process for risk-significant functions only (function category A1 and B1). However, Appendix A, Table 7 provides all the D-RAP system function categories A1, A2, B1 and B2 for each preoperational test. RG 1.68 was used to verify that scope of system functions required to be tested by RG 1.68 guidance in a preoperational test were identified by the D-RAP system functions.

For the purpose of preoperational testing, there is no discrimination in the testing of A1 and A2 system functions. Preoperational test abstracts identify either A1 or A2 system functions as "safety-related" functions.

5.1 NuScale Initial Test Program Testing of NuScale Systems Containing A1, A2 and B1 System Functions

NuScale Systems Containing A1 System Functions

FSAR Table 17.4-1 lists safety-related, risk-significant (A1) system functions. The systems containing A1 functions are listed below. Each of the systems is a sub-system of the reactor module except the ultimate heat sink system.

a) Containment system (CNTS)
b) Steam generator system (SGS)
c) Reactor core (RXC) system
d) Control Rod Drive System (CRDS)
e) Reactor coolant system (RCS)
f) Emergency core cooling system (ECCS)
g) Decay heat removal system (DHRS)
h) Ultimate heat sink (UHS)

NuScale Systems Containing B1 System Functions

FSAR Table 17.4-1 lists nonsafety-related, risk-significant (B1) system functions. The systems containing B1 functions are listed below.

a) Containment system (CNTS)
b) Reactor Building crane (RBC)

5.2 Testable A1 System Functions

Not every A1 D-RAP system function is a testable function required to be tested by preoperational or startup testing. The preoperational testing includes both generic component testing and system preoperational testing.

NuScale system functions identified as “testable” are verified by NuScale preoperational and startup testing. NRC regulations and regulatory guidance does not contain a definition or explanation for “testable” system functions. It is easier to describe system functions that are not testable; the remaining system functions describe in the D-RAP process become the inventory of “testable system functions.” NuScale uses the following attributes to classify system functions as a “non-testable function.”

- The system function is related to providing structural or mechanical support of another system.
- The system function provides a portion of the RCPB or the containment pressure boundary.
- The system function provides transfer of thermal energy (heat).
- The system function provides housing or allows access to another system.
- The system function describes a system flow, drain, or vent path.
- The system function describes the supporting system providing effluent for chemistry analysis.

The following A1 system functions contained in FSAR Table 17.4-1 are not testable and thus are not addressed in a NuScale preoperational testing or startup testing.

Structural or mechanical support functions:

a) The CNTS supports the CRDS by providing structural support for the control rod drive mechanisms.
b) The CNTS supports the RCS by providing structural support for the reactor pressure vessel (RPV).
c) The CNTS supports the ECCS by providing structural support of the trip and reset valves for the ECCS reactor vent and recirculation valve.
d) The CNTS supports the neutron monitoring system (NMS) by providing structural support for the ex-core detectors.
e) The CNTS supports the ECCS by providing electrical penetration assemblies for reactor instrumentation cables through containment vessel (CNV).
f) The RXC system supports the control rod assembly (CRA) by providing control rod guide tubes to receive and align the CRA.
g) The RXC system supports the RCS by maintaining a coolable geometry
h) The RCS supports the CRDS by the RPV and the reactor vessel internals supporting and aligning the control rods.

i) The RCS supports the ECCS by providing mechanical support for the ECCS valves.
j) The RCS supports in-core instrumentation by providing structural support of the in-core instrumentation guide tubes.
k) The RCS supports the RXC system by the reactor vessel internals providing mechanical support to orient, position, and seat the fuel assemblies.
l) The RCS supports the SGS by providing physical support for the steam generator tube supports and for the integral steam and feed plenums.
m) The RXB supports the CNTS by housing and providing structural support.
n) The RXB supports the chemical and volume control system (CVCS) by housing, allowing access, and providing structural support.
o) The RXB supports the UHS by housing and providing structural support.
p) The RXB supports the module protection system (MPS) by housing and providing structural support.
q) The RXB supports the NMS by housing and providing structural support.
r) The CRB supports the MPS by housing and providing structural support.

Containment pressure boundary and reactor coolant pressure boundary system (RCPB) functions:

a) The SGS supports the RCS by supplying part of the RCPB.
b) ECCS supports the RCS by providing a portion of the RCPB for maintaining RCPB integrity.
c) The ECCS supports the CNTS by providing a portion of the containment boundary for maintaining containment integrity.

Heat transfer system functions:

a) The CNTS supports the RCS by transferring core heat from reactor coolant in containment to the UHS.
b) The RCS supports the RXC system by removing heat to ensure core thermal design limits are not exceeded.
c) The UHS supports the CNTS by providing heat removal via direct water contact with the containment vessel for the removal of core heat.
d) The UHS supports the spent fuel storage system by providing the removal of decay heat from spent fuel via direct water contact with spent fuel assemblies.
e) The UHS supports the DHRS by accepting heat from decay heat removal heat exchanger.
f) The UHS supports the RXC system by direct water contact with fuel assemblies during refueling to remove decay heat.

Radiation protection system functions to minimize contamination or provide radiation shielding

a) The RXC system supports the RCS by containing fission products and transuranics within the fuel rods to minimize contamination of the reactor coolant.
b) The UHS supports the spent fuel storage system by providing radiation shielding and iodine scrubbing for spent fuel via water surrounding the components.
c) The UHS supports the RXC system by providing radiation shielding and iodine scrubbing for fuel assemblies via the water surrounding the components.
d) The RCS supports RXC system by containing soluble neutron poison.

5.3 NuScale Testable A1 System Functions

Table 5-1 below is a list of A1 testable functions that were derived by eliminating the non-testable A1 functions contained in Section 5.2 of this document from the list of A1 functions in FSAR Table 17.4-1.

Table 5-1 identifies the preoperational test where the NuScale testable A1 system functions are tested.

Table 5-1 NuScale Testable A1 System Functions

System	Testable Function	Tested in Preoperational Test Number
CNTS	Supports the Reactor Building (RXB) by providing a barrier to contain mass, energy, and fission product release from a degradation of the RCPB.	CNTS Test #43-1
CNTS	Supports ECCS operations by providing a sealed containment and thermal conduction for the condensation of steam that provides makeup water to the RCS.	CNTS Test #43-1
CNTS	Supports the RXB by providing a barrier to contain mass, energy, and fission product release by closure of the containment isolation valves (CIVs) upon containment isolation signal.	MPS Test #63-6
CNTS	Supports the RCS by closing the CIVs for pressurizer spray, chemical and volume control system (CVCS) makeup, CVCS letdown, and RPV high point degas when actuated by the MPS for RCS Isolation.	MPS Test #63-6
SGS	None	
RXC	None	
CRDS	Supports the CRA by releasing control rod during a reactor trip.	MPS Test #63-5
RCS	Supports the MPS by providing instrument information signals for MPS actuation.	MPS Test #63-1
ECCS	Supports the RCS by opening ECCS reactor vent valves (RVVs) and reactor recirculation valves (RRVs) when their respective trip valve is actuated by the MPS.	MPS Test #63-6
DHRS	Supports by providing MPS actuation instrument information signals.	MPS Test #63-1
MPS	Supports low-voltage AC electrical distribution system (ELVS) by removing electrical power to the pressurizer on a pressurizer heater trip actuation signal.	MPS Test #63-4 MPS Test #63-6
MPS	Supports the ECCS by removing electrical power to the trip solenoids of the RVVs on an ECCS actuation signal.	MPS Test #63-4 MPS Test #63-6

System	Testable Function	Tested in Preoperational Test Number
MPS	Supports the DHRS by removing electrical power to the trip solenoids of the decay heat removal actuation valves on a DHRS actuation signal.	MPS Test #63-6
MPS	Supports the CNTS by removing electrical power to the trip solenoids of the main steam isolation valves, the main steam bypass isolation valves, and the feedwater isolation valves on a DHRS actuation signal.	MPS Test #63-4 MPS Test #63-6
MPS	Supports the CNTS by removing electrical power to the trip solenoids of the following CIVs on a CNTS isolation actuation signal: - RCS injection CIVs - RCS discharge CIVs - Pressurizer spray CIVs - RPV high point degasification CIVs - Feedwater isolation valves - Main steam isolation valves - Main steam bypass isolation valves - Containment evacuation isolation valves - Reactor component cooling water inlet and outlet CIVs - Containment flooding and drain CIVs	MPS Test #63-4 MPS Test #63-6
MPS	Supports the CNTS by removing electrical power to the trip solenoids of the following CIVs on a CVC isolation actuation signal: - RCS injection CIVs - RCS discharge CIVs - Pressurizer spray CIVs - RPV high point degasification CIVs	MPS Test #63-4 MPS Test #63-6
MPS	Supports the CVCS by removing electrical power to the trip solenoids of the demineralized water system isolation valves on a DWS isolation actuation signal.	MPS Test #63-4 MPS Test #63-6
MPS	Supports non-safety DC electrical and AC distribution system by removing electrical power to the CRDS for a reactor trip.	MPS Test #63-4 Test #63-5
MPS	Supports the CNTS by providing power to sensors.	CNT instrument calibration
MPS	Supports the DHRS by providing power to main steam pressure sensors.	DHR instrument calibration
MPS	Supports the RCS by providing power to sensors.	RCS instrument calibration

System	Testable Function	Tested in Preoperational Test Number
NMS	Supports the MPS by providing neutron flux data for various reactor trips, operating bypasses, and actuations. Testing of the NMS is limited before core load. NMS is also tested by the following power ascension tests: Test #91 Core Power Distribution Map Test Test #92 Neutron Monitoring System Power Range Flux Calibration Test Test #98 Control Rod Misalignment Test	MPS Test #63-4

5.4 NuScale Testable A2 Testable System Functions

In FSAR Table 17.4-1, safety-related, nonrisk-significant system functions are not identified. The D-RAP design information identifies four safety-related, nonrisk-significant (A2) system functions. Table 5-2 below identifies the A2 system functions and lists the preoperational test that verifies each function.

Table 5-2 NuScale Testable A2 System Functions

System	Testable Function	Tested in Preoperational Test #
DHRS	The DHRS supports the RCS by opening the DHRS actuation valves on a DHRS actuation signal.	MPS Test #63-6
ECCS	The ECCS supports RCS by providing low temperature over pressure protection for maintaining the RCPB integrity.	MPS Test #63-6
CVCS	The CVCS supports the RCS by isolating dilution sources.	MPS Test #63-6
RCS	The RCS supports the MPS by providing instrument information signals for low temperature overpressure protection actuation.	MPS Test #63-6

5.5 NuScale Testable B1 Testable System Functions

Table 5-3 below contains the two NuScale nonsafety-related, risk-significant (B1) system functions, which are both testable.

Table 5-3 NuScale Testable B1 System Functions

System	Testable Function	Tested in Preoperational Test #
CNTS	The CNTS supports the RBC by providing lifting attachment points that the RBC can connect to so that the module can be lifted.	RBC Test #52-1 RBC Test #52-2
RBC	The RBC supports the NPM by providing structural support and mobility while moving from refueling, inspection, and operating bay.	RBC Test #52-1 RBC Test #52-2

6.0 Type of RG 1.68 Rev 4 Testing Not Applicable to NuScale Design

Because of NuScale's simple passive design with fewer systems, many design features identified in RG 1.68 are not tested because the NuScale does not have the design feature. The following are examples of components and systems that are listed in RG 1.68, but are NOT contained in the NuScale design. The list is not comprehensive.

- Emergency AC power distribution system
- Emergency bus loading or sequencing
- Emergency diesel generator
- Emergency feedwater system
- Emergency boration system
- Emergency feedwater system
- Emergency cooling towers
- ECCS pumps
- ECCS tanks
- Safety-related UHS cooling towers and associated auxiliaries
- Load shedding of electrical busses
- Auxiliary feedwater system
- Refuel transfer canal
- Anticipated transients without scram system
- Automatic depressurization system
- Automatic reactor power control systems
- Traversing in-core probe system
- Failed fuel detection systems
- Loose parts monitoring system
- Steam generator blowdown
- Standby liquid control system
- Born recovery system
- Shield cooling system
- Pyrotechnic-actuated valves
- Containment:
  - Containment spray system
  - Combustible gas control system
  - Containment recirculation fans
  - Containment air locks
  - Containment inerting
  - Containment annulus
  - Containment penetration cooling
  - Containment sump
  - Post-accident hydrogen monitors
  - Containment cooling fans during normal operation
- RCS components:
  - Pumps, motors and associated power sources
  - Block valves and associated dump valves
  - Acoustic monitors for safety and relief valves
  - Jet pumps
  - Pyrotechnic-actuated squib valves
  - Rotating machinery
  - Reactor coolant pumps (which eliminates pump flow coast down requirements)

7.0 First-of-a-Kind Tests

The FSAR section 14.2.3.3 describes NuScale's first-of-a-kind (FOAK) testing. The following ITP test abstracts describe the Comprehensive Vibration Assessment Program testing of FOAK design features:

a) Table 14.2-44: Control Rod Drive System Flow-Induced Vibration Test #44
b) Table 14.2-45: Reactor Vessel Internals Flow-Induced Vibration Test #45
c) Table 14.2-75: Steam Generator Flow-Induced Vibration Test #72.
d) Table 14.2-108: NuScale Power Module Vibration Test #108

The FOAK tests #44, #45, and #72 are performed at the factory. Test #108 is performed on site at 100 percent power.

Only the vibration testing listed above is considered as NuScale FOAK testing. However, there are additional new design features in the NuScale design that will be verified for each plant, instead of the one time or three time verification required by FOAK testing.

FSAR Table 14.2-110: ITP Testing of New Design Features lists the new and unique design features that are subject to FOAK testing. FSAR Table 14.2-110 lists the associated test numbers for each new NuScale design features.

8.0 NuScale Control Systems

8.1 NuScale Control System Testing

In FSAR Section 7.0, an introduction and overview of instrumentation and controls (I&C) systems are provided, which includes safety-related and nonsafety-related systems. The control systems addressed in Section 7.0 include the following:

a) module protection system (MPS)
b) neutron monitoring system (NMS)
c) plant protection system (PPS)
d) safety display and indication system (SDIS)
e) module control system (MCS)
f) plant control system (PCS)
g) in-core instrumentation system (ICIS)
h) health physics network
i) fixed area radiation monitoring

Also, FSAR Section 14.2.1.1 describes how the testing of the above I&C systems will be completed before the care, custody, and control of the systems from Construction to Startup.

The successful testing of the digital I&C systems will not require Startup to re-perform the following type of testing in preoperational or startup tests:

a) control logic testing
b) parameter display tests
c) parameter alarm tests
d) trip settings
e) setpoint verification

The following list contains examples where RG 1.68 recommends testing of control system design features in the initial test program. These tests are not required in the NuScale initial test program, because the control system design features will be verified in the factory acceptance test and/or in the site acceptance test for the control system. The RG 1.68 examples below are not intended to be comprehensive, but, taken together, they describe the general scope of control system design features.

a) Verify operation of instrumentation, controls, interlocks, and alarms.
b) Verify proper operation in all combinations of logic; proper trip and alarm settings; proper operation of permissive, prohibit, and bypass functions; and operability of bypass switches.
c) Demonstrate proper operation of relaying and logic, permissives and prohibit interlocks, instrumentation and alarms.
d) Testing should include demonstrations of proper operation of associated alarms, indicators, controls.
e) Testing should include demonstrations of correct logic and set points, as well as proper operation of bypasses, permissive and prohibit interlocks,
f) Testing should also confirm the operation of local and remote alarm functions, including radioactivity or radiation levels above established set-points and tank content levels.

g) The following list illustrates the equipment and component tests that the program should include: high-radiation alarms and low-water-level alarms.
h) Demonstrate relaying and logic.
i) Verify proper trip and alarm settings; proper operation of permissive, prohibit, and bypass functions.

8.2 NuScale Control System Testing/Field Testing Overlap

After a NuScale I&C system has completed its site acceptance test, the care, custody, and control of the system will be transferred from Construction to Startup. To place an I&C system in operation for a given system will require additional field activities to be completed. The following activities are performed on a preoperational test (generally a system) basis.

a) Instruments required for a preoperational test must be calibrated as a prerequisite to the preoperational test.
b) If the instrument calibration procedure did not require the instrument signal to be displayed on an MCS or a PCS workstation, then a preoperational test step will require this action to be taken in the preoperational test procedure. The completion of the following component-level test will ensure that all system variables are properly monitored by the associated control system.
c) The standard test abstract statement to verify an instrument signal is available on the MCS or the PCS is:
    - ***Component-level test objective***: Verify each [*tested system*] instrument is available on an MCS or a PCS display.
    - ***Test Method***: Initiate a single real or simulated instrument signal from each [tested system] transmitter.
    - ***Acceptance Criteria*****:** The instrument signal is displayed on an MCS or a PCS display, or is recorded by the applicable control system historian.
d) The remaining actions necessary to make a control system functional for a given system is to operate the system's remotely-operated equipment from the main control room. This is completed by executing component-level tests in the preoperational test that will open and close all valves and operate all equipment from the main control room which will require the speed of variable-speed equipment to be manually controlled from the main control room.

9.0 NuScale Test Abstract Attributes

9.1 Scope of Testing for Preoperational Tests

NuScale's scope of testing is defined by D-RAP system functions for the system under test. Each function was developed by NuScale using the process described in Section 5.0 of this document. A standardized method was used to describe each system function of the form "The [supporting system] supports the [supported system] by [description of the support method].

Regulatory Guide 1.68 was reviewed to ensure alignment of test scope defined by the NuScale system functions with NRC guidance. This result of the alignment check revealed conformity between developing the test scope using system functions and test guidance contained in RG 1.68. The check was performed by using several methods:

a) Regulatory Guide 1.68 was reviewed to determine the potential test scope of a DCA by identifying the test features described by RG 1.68 that are applicable to the NuScale design. An inventory of design features not applicable to NuScale was compiled. Section 6.0 of this document has examples of the design features not applicable to the NuScale design.
b) Table B-1 in Appendix B of this document was used to parse the RG 1.68 regulatory guidance applicable to the associated NuScale design features. Table B-1 cross references the applicable regulatory guidance to the NuScale testing that satisfies the guidance. Table B-1 also identifies the specific design feature contained in RG 1.68 guidance that is not contained in the NuScale design. In this way, the NuScale test abstracts could be measured against NRC test guidance.
c) NuScale reviewed RG 1.68 for references to component testing versus system testing. The instances where RG 1.68 referenced component tests were recorded in Table 1-1 in Section 4.0 of this document. This table allowed NuScale to differential between component-level test guidance and system-level test guidance.

9.2 NuScale Test Abstract Prerequisites

NuScale test abstracts provide only the essential prerequisites necessary to prepare a test procedure from the abstract.

a) Operating experience from the startups of operating U.S. commercial nuclear power plants identified numerous issues related to prerequisites contained in Chapter 14 test abstracts that required a change to the FSAR.
b) Prerequisites had to be revised, because the prerequisite was no longer valid at test conduct due to configuration changes made during detailed design after the PSAR was issued for a construction license. Some DCAs attempted to compensate for this unknown design condition by using phrases in the prerequisite such as "as necessary," "if required," or "to the extent possible."
c) The following are quotes (with emphasis added) from an approved DCA. Many DCAs have similar content.
    - "The following interfacing and support systems are available ***as necessary*** to support testing: component cooling water system; service water system; reactor coolant system; electrical power and distribution systems."
    - "Data collection is available ***as needed*** to support the specified testing and system configurations."

- **“**The cooled components are operational and operating ***to the extent possible.***”
- **“**Related system interfaces are available or simulated ***as necessary.”***
- The interfacing and support systems required for testing and data collection ***are available as needed*** to support the specified testing and system configurations.

d) NuScale included test prerequisites in NuScale preoperational and startup test abstracts to provide for unique prerequisite circumstances that would be required to ensure a successful test. These unique circumstances are:
   - The plant must be operated at plant conditions other than ambient conditions. For example, the plant may be required to operate at elevated temperatures, elevated pressures, specified power levels, specified boron concentrations, or the reactor must be critical.
   - Temporary test instrumentation is installed.
   - Temporary data collection equipment is available.
   - Specific tests that must be completed before test conduct to ensure the quality of preoperational or startup test data. For example, specific generic component tests for pump curves, calibrations, or a system flow balance must be completed.
   - Completion of factory acceptance test or a site acceptance test may be specified.

e) Regulatory Guide 1.68 does not provide guidance for test prerequisite content for *test abstracts* contained in FSAR Section 14.2

f) Regulatory Guide 1.68 has specific guidance in Appendix C-1 for test procedure prerequisites. This section states “Each test of the operation of a system normally requires that certain other activities be performed first (e.g., completion of construction, construction and/or preliminary tests, inspections, and certain other preoperational tests or operations). The *preoperational testing procedures* should include, as appropriate, these specific prerequisites.”

g) Section 10.0 Table 10-1: RG 1.68 Test Program Guidance describes how the NuScale test program addresses test procedure prerequisites**.**

9.3 Impact of Digital Control Systems versus Analog Control Systems on the NuScale Initial Test Program

Section 8.0 of this document describes how the NuScale digital systems are tested. As described in Section 8.0 the testing of digital systems is completed before the care, custody, and control transfer of the system from Construction to Startup. Therefore, Startup test abstracts and Startup test procedures are not required to address testing of displays, alarms, and controls. This is a significant decrease in scope for the NuScale test program as contrasted to traditional operating plants where displays, alarms, and control testing required the following test actions, and others, such as:

a) placement of electrical jumpers.
b) lifted leads.
c) manual operation of control relays.
d) injection of test signals.
e) manual actuation of analog bistables by signal injection.
f) testing of the ESF control system hardware.
g) manual operation of electrical protective relays.

As contrasted to operating U.S. nuclear power plants, the NuScale initial test program test abstract content, the NuScale initial test procedure content and volume and the NuScale test complexity have been reduced significantly compared to operating U.S nuclear power plant initial test programs.

Section 8.2 of this document describes the content of NuScale test abstracts and NuScale test procedures required to ensure proper test overlap with control systems testing.

10.0 RG 1.68 Test Program Guidance

The conformance to RG 1.68 test program guidance is described in the FSAR Sections listed in Table 10-1 below.

Table 10-1 Adherence to RG 1.68 Program Guidance

RG 1.68 Program Requirements	FSAR Section Containing a Description of the NuScale Test Program	Comment
Construction and installation	14.2.1.1	None
Testing of digital I&C systems	14.2.1.1	Logic testing of digital I&C systems is not repeated in the initial test program
Scope, conditions, and length of testing	14.2.1	Reference COL Item 14.2-2
Initial test program management and execution of the initial test program	14.2.2	Reference COL Item 14.2-1
FOAK features	14.2.3.3	Reference FSAR Table 14.2-44; Table 14.2-45; Table 14.2-75, Table 14.2-108; and Table 14.2-110
Test prerequisites	14.2.4 14.2.10.1	Reference COL Item 14.2-2
Test Conduct	14.2.4	Reference COL Item 14.2-2
Test procedures	14.2.3.1 14.2.5 14.2.11	Reference COL Item 14.2-2
Test Results/ Test Reports	14.2.5	Reference COL Item 14.2-2
Test Records	14.2.6	Reference COL Item 14.2-2
Graded approach: Standardized component – level tests in preoperational tests	14.2.3.2	None
Utilization operating experience	14.2.8	None
Trial Testing of Plant Emergency, Operating, and Surveillance Test Procedures	14.2.9	None
Test Schedule	14.2.11	Reference COL Item 14.2-4
Milestones and Power Hold Points	14.2.10.5 14.2.11	Reference COL Item 14.2-4

11.0 COL Items related to the NuScale Initial Test Program

COL Item 14.2-1: A COL applicant that references the NuScale Power Plant design certification will describe the site-specific organizations that manage, supervise, or execute the Initial Test Program, including the associated training requirements.

COL Item 14.2-2: A COL applicant that references the NuScale Power Plant design certification is responsible for the development of the Startup Administration Manual that will contain the administrative procedures and requirements that control the activities associated with the Initial Test Program. The COL applicant will provide a milestone for completing the Startup Administrative Manual and making it available for NRC inspection.

COL Item 14.2-3: A COL applicant that references the NuScale Power Plant design certification will identify the specific operator training to be conducted during low-power testing related to the resolution of TMI Action Plan Item I.G.1, as described in NUREG-0660, NUREG-0694, and NUREG-0737.

COL Item 14.2-4: A COL applicant that references the NuScale Power Plant design certification will provide a schedule for the Initial Test Program.

Appendix A.

Appendix A Table A-1 data reveal that the only NuScale Preoperational Tests that verify safety-related (A1 or A2) functions are:

a) Test #43 Containment System
b) Test #63 Module Protection System

Appendix A Table A-1 data also reveal that the only NuScale Preoperational Test that verifies B1 functions is

c) Test #52 Reactor Building Cranes

Table A-1 NuScale Initial Test Program Tests

Test Number	System Abb.	Test Abstract	Classification of Functions Tested for Each Preoperational Test				ITAAC Verified for Each Preoperational Test
			A1	A2	B1	B2	
1	SFPCS	Spent Fuel Pool Cooling System				X	
2	PCUS	Pool Cleanup System				X	
3	RPCS	Reactor Pool Cooling System				X	
4	PSCS	Pool Surge Control System				X	03.09.10 (B2) (1)
5	UHS	Ultimate Heat Sink				X	
6	PLDS	Pool Leakage Detection System				X	
7	RCCWS	Reactor Component Cooling Water System				X	
8	CHW	Chilled Water System				X	
9	ABS	Auxiliary Boiler System				X	03.09.08 (B2) (1) 03.09.09 (B2) (1)
10	CWS	Circulating Water System				X	
11	SCW	Site Cooling Water System				X	
12	PWS	Potable Water System				X	
13	UWS	Utility Water System				X	
14	DWS	Demineralized Water System				X	
15	NDS	Nitrogen Distribution System				X	
16	SAS	Service Air System				X	
17	IAS	Instrument Air System				X	
18	CRHS	Control Room Habitability System				X	03.01.01 (B2) (2) 03.01.02 (B2) (2) 03.01.03 (B2) (2) 03.01.05 (B2) (2) 03.09.02 (B2) (1)
19	CRVS	Normal Control Room HVAC System				X	03.02.01 (B2) (3) 03.02.02 (B2) (3) 03.02.03 (B2) (3) 03.09.01 (B2) (3)

Test Number	System Abb.	Test Abstract	Classification of Functions Tested for Each Preoperational Test				ITAAC Verified for Each Preoperational Test
			A1	A2	B1	B2	
20	RBVS	Reactor Building HVAC System				X	03.03.01 (B2) (4) 03.03.02 (B2) (4) 03.03.03 (B2) (4) 03.09.03 (B2) (1)
21	RWBVS	Radioactive Waste Building HVAC System				X	
22	TBVS	Turbine Building Ventilation				X	
23	RWDS	Radioactive Waste Drain System				X	
24	BPDS	Balance-of-Plant Drains				X	03.17.02 (B2) (1) 03.17.03 (B2) (1) 03.17.04 (B2) (1) 03.18.02 (B2) (1) 03.18.03 (B2) (1)
25	FPS	Fire Protection System				X	03.07.02 (B2) (6)
26	FDS	Fire Detection				X	
27	MSS	Main Steam				X	
28	CFWS	Feedwater System				X	
29	FWTS	Feedwater Treatment				X	
30	CPS	Condensate Polisher Resin Regeneration System				X	
31	HVD	Heater Vents and Drains				X	
32	CARS	Condenser Air Removal System				X	
33	TGS	Turbine Generator				X	
34	TLOS	Turbine Lube Oil System				X	
35	LRWS	Liquid Radioactive Waste System				X	03.09.07 (B2) (1)
36	GRWS	Gaseous Radioactive Waste System				X	03.09.04 (B2) (1) 03.09.05 (B2) (1) 03.09.06 (B2) (1)
37	SRWS	Solid Radioactive Waste System				X	
38	CVCS	Chemical and Volume Control System				X	02.02.03 (B2) (7) 02.02.04 (B2) (7) 02.02.05 (B2) (7) 02.07.02 (B2) (1) 02.07.03 (B2) (1) 02.07.04 (B2) (1)
39	BAS	Boron Addition System				X	
40	MHS	Module Heatup System				X	
41	CES	Containment Evacuation System				X	02.03.01(B2) (5) 02.03.02(B2) (5) 02.07.01(B2) (1)
42	CFDS	Containment Flooding and Drain System				X	03.17.01 (B2) (1) 03.18.01 (B2) (1)
43	**CNTS**	**Containment System**	**X**				02.01.07 (A1) (8) 02.01.21 (A1) (9)

Test Number	System Abb.	Test Abstract	Classification of Functions Tested for Each Preoperational Test				ITAAC Verified for Each Preoperational Test
			A1	A2	B1	B2	
44	CRDS	Control Rod Drive System Flow-Induced Vibration	Factory Acceptance Test				
45	RVI	Reactor Vessel Internals Flow-Induced Vibration	Factory Acceptance Test				
46	RCS	Reactor Coolant System					
47	ECCS	Emergency Core Cooling System					
48	DHRS	Decay Heat Removal System					
49	ICIS	In-core Instrumentation				X	
50	MAE	Module Assembly Equipment	There are no preoperational tests for module assembly equipment. MAE testing will be performed by Construction.				
51	FHE	Fuel Handling Equipment System					03.04.05 (B2) (11) 03.04.06 (B2) (12)
52	**RBC**	**Reactor Building Cranes**			**X**	X	
53	PSS	Process Sampling System				X	
54	EHVS	13.8 kV and Switchyard System				X	
55	EMVS	Medium Voltage AC Electrical Distribution System				X	
56	ELVS	Low Voltage AC Electrical Distribution System				X	
57	EDSS	Highly Reliable DC Power System				X	
58	EDNS	Normal DC Power System				X	
59	BPSS	Backup Power Supply				X	
60	PLS	Plant Lighting System				X	03.08.01 (B2) (13) 03.08.02 (B2) (13) 03.08.03 (B2) (13)
61	MCS	Module Control System				X	
62	PCS	Plant Control System				X	

Test Number	System Abb.	Test Abstract	Classification of Functions Tested for Each Preoperational Test				ITAAC Verified for Each Preoperational Test
			A1	A2	B1	B2	
63	**MPS**	**Module Protection System**	**X**	**X**		X	02.01.08 (15) 02.01.13 (16) 02.01.14 (17) 02.01.15 (18) 02.01.18 (19) 02.01.19 (20) 02.01.20 (21) 02.02.03 (22) 02.02.05 (23) 02.05.02 (24) 02.05.08 (24) 02.05.09 (24) 02.05.10 (24) 02.05.11 (24) 02.05.12 (25 02.05.13 (26) 02.05.14 (24) 02.05.15 (24) 02.05.16 (27) 02.05.17 (28) 02.05.18 (24) 02.05.19 (24) 02.05.20 (24) 02.05.21 (24) 02.05.22 (24) 02.05.23 (24) 02.05.26 (29)
64	PPS	Plant Protection System				X	
65	NMS	Neutron Monitoring System					
66	SDIS	Safety Display and Indication				X	02.05.25 (B2) (14)
67	RMS	Fixed Area Radiation Monitoring System				X	
68	COMS	Communication System				X	03.16.11 (B2) 03.16.12 (B2) 03.16.13 (B2)
69	SMS	Seismic Monitoring System	Test provided by COL (COL item 3.7-1)				
70	HFT	Hot Functional Testing	The Test #70 abstract list all hot functional tests. The Test #70 abstract also provides the associated test objectives and classification of the systems functions associated the hot functional tests.				
71	MAEB	Module Assembly Equipment Bolting				X	
72	SG	Steam Generator Flow-Induced Vibration	Separate affects tests using prototype.				
73	N/A	Security Access Control					03.16.04 (B2)
74	N/A	Security Detection and Alarm					03.16.05 (B2) 03.16.07 (B2) 03.16.08 (B2) 03.16.09 (B2) 03.16.10 (B2)

Test Number	System Abb.	Test Abstract	Classification of Functions Tested for Each Preoperational Test				ITAAC Verified for Each Preoperational Test
			A1	A2	B1	B2	
75	N/A	Initial Fuel Loading Precritical Test	The Test #75 abstract lists all precritical tests. The COL will provide the sequence and schedule of testing for precritical tests (COL Item 14.2-4).				
76	N/A	Initial Fuel Load	System functions are not provided for precritical tests. The precritical tests have no associated ITAAC.				
77	N/A	Reactor Coolant System Flow Measurement					
78	N/A	NuScale Power Module Temperatures					
79	N/A	Primary and Secondary System Chemistry					
80	N/A	Control Rod Drive System-Manual Operation, Rod Speed, and Rod Position Indication					
81	N/A	Control Rod Assembly Full-Height Drop Time					
81A	N/A	Control Rod Assembly Ambient Temperature Full-Height Drop Time Test					
82	N/A	Pressurizer Spray Bypass Flow					
83	N/A	Initial Criticality					
84	N/A	Post-Critical Reactivity Computer Checkout					
85	N/A	Low Power Test Sequence	Test #85 abstract lists all low power tests (test #86 though test #89). The COL will provide the sequence and schedule of testing for low power tests (COL Item 14.2-4).				
86	N/A	Determination of Zero-Power Physics Testing Range	System functions are not provided for low power tests. The low power tests have no associated ITAAC.				
87	N/A	All Rods Out Boron Endpoint Determination					
88	N/A	Isothermal Temperature Coefficient Measurement					
89	N/A	Bank Worth Measurement					
90	N/A	Power-Ascension	Test #90 abstract lists all power-ascension tests (test #91 though test #108). The COL will provide the sequence and schedule of testing for power-ascension tests (COL Item 14.2-4)				

Test Number	System Abb.	Test Abstract	Classification of Functions Tested for Each Preoperational Test				ITAAC Verified for Each Preoperational Test
			A1	A2	B1	B2	
91	N/A	Core Power Distribution Map	System functions are not provided for power-ascension tests (test #91 though test #108. The power-ascension tests have no associated ITAAC.				
92	N/A	Nuclear Monitoring System Power Range Flux Calibration					
93	N/A	Reactor Coolant System Temperature Instrument Calibration					
94	N/A	Reactor Coolant System Flow Calibration					
95	N/A	Radiation Shield Survey					
96	N/A	Reactor Building Ventilation System Capability					
97	N/A	Thermal Expansion					
98	N/A	Control Rod Assembly Misalignment					
99	N/A	Steam Generator Level Control					
100	N/A	Ramp Change in Load Demand					
101	N/A	Step Change in Load Demand					
102	N/A	Loss of Feedwater Heater					
103	N/A	100 Percent Load Rejection					
104	N/A	Reactor Trip from 100 Percent Power					
105	N/A	Island Mode Test for NuScale Power Module #1					
106	N/A	Island Mode Test for Multiple NuScale Power Modules					
107	N/A	Remote Shutdown Workstation					
108	N/A	NuScale Power Module Vibration Test					

Table A-1 Notes:

(1) System response to a high-radiation signal (radiation protection)
(2) Control room habitability system performance
(3) Normal control room HVAC System performance (radiation protection)
(4) Reactor Building HVAC system performance (radiation protection)
(5) Containment evacuation system performance (RCS leakage detection)
(6) Fire protection system pump performance
(7) ASME Code Class 3 air-operated valves and check valve performance
(8) Containment vessel Type B and Type C local leak rate test
(9) CNTS safety-related check valve performance.
(10) NOT USED
(11) Fuel handling machine travel limitation

(12) New fuel jib crane travel limitation
(13) Normal and emergency illumination of workstations in the MCR and the RSS; emergency illumination for post-fire activities outside control room
(14) SDIS displays of PAM Type B and Type C displays in the main control room
(15) Containment isolation valve stroke time
(16) Containment isolation valve stroke from main control room
(17) ECCS safety-related valve stroke from main control room
(18) DHRS safety-related valve stroke from main control room
(19) CNTS safety-related hydraulic-operated valve fail position on loss of power
(20) ECCS RRVs and RVVs safety-related hydraulic-operated valve fail position on loss of power
(21) DHRS safety-related hydraulic-operated valve fail position on loss of power
(22) CVCS ASME Code Class 3 air-operated valves stroke from main control room
(23) CVCS ASME Code Class 3 air-operated valve fail position on loss of power
(24) MPS logic testing
(25) MPS manual reactor trip
(26) MPS manual ESF actuations
(27) Completion of safety-related protective actions
(28) Response times for safety-related MPS reactor trip functions and safety-related MPS ESF functions
(29) The controls located on the operator workstations in the MCR operate to perform important human actions (IHAs).

Appendix B.

RG 1.68 Rev 4 Preoperational System Testing Guidance

Regulatory Guide 1.68 Appendix A-1 makes reference to specific systems or design features that should be tested during an initial test program. The following Table B-1 contains extracts from RG 1.68 Appendix A-1 that provide NRC guidance for the scope of testing. The table identifies the NuScale initial test program tests that satisfy the Appendix A-1 guidance applicable to the NuScale design.

Section 6.0 of this document discusses examples of design features discussed in RG 1.68 that are not contained in the NuScale design.

Table B-1 RG 1.68 Rev 4 Preoperational Testing Guidance versus NuScale Preoperational Tests

RG 1.68 Test Guidance	**NuScale Initial Test Program Test**
A-1.a. Reactor Coolant System Tests	
Section A-1.a contains items that are RCS design features. The RCS design features that are not applicable to the NuScale design are: 1; 2.b.; 2.c.; 2.d. (block valves and dump tank); 2.f.; 2.h.; 2.i (acoustic monitoring); 2.j.; 2.l; 3 (rotating machinery)	
A-1.a. item 2.a Pressurizer spray and throttle valves	***Initial Fuel Loading Precritical Test*** Test #82: Pressurizer Spray Bypass Flow Test
A-1.a. item 3. Vibrations tests	***Power Ascension Test*** Test #108: NuScale Module Vibration Test
A-1.a. item 4. RCS pressure boundary integrity test	Performed by vendor
A-1.b.1. Control Rod System Tests	
Section A-1.b.1 contains items that are CRDS design features. The CRDS design features that are not applicable to the NuScale design are: 1.b.; 1.c. (CRDS interaction with other design features such as automatic reactor power and refueling equipment);	
A-1.b. item 1.a Normal operation of the CRDS	***Initial Fuel Loading Precritical Test*** Test #80: Control Rod Drive System-Manual Operation, Rod Speed, and Rod Position Indication
A-1.b. item 1.a Reactor trip	MPS Test #63-5
A-1.b item 1.c Rod position indication	***Initial Fuel Loading Precritical Test*** Test #80: Control Rod Drive System-Manual Operation, Rod Speed, and Rod Position Indication

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.b. item 1.d Operation of CRDS on loss of power	MPS Test #63-2
A-1.b.2. Chemical Control System Tests	
Section A-1.b.2 contains items that are CVCS design features. The CVCS design features that are not applicable to the NuScale design are: 2.b, 2.c (redundancy, electrical independence)	
A-1.b. item 2.a Proper blending of boron solution and water; uniform mixing	***Preoperational Test*** Chemical and Volume Control System Test # 38-3
A-1.b. item 2.c Correct failure mode on loss of power to system components	***Preoperational Test*** Chemical and Volume Control System Test # 38 component level test ii.
A-1.c. Reactor Protection and Engineered Safety Features Actuation Systems Tests	
Time response	MPS Test #63-7
Redundancy, electrical independence, coincidence, and safe failure on loss of power	EDSS Test #57-1, #57-2 and #57-3 (RG 1.41 Independence Test)
A-1.d. Decay Heat Removal System Tests	
Section A-1.d contains items that are DHRS design features. The DHRS design features that are not applicable to the NuScale design are: 3. (Redundancy, electrical independence); 3.f; 3.h; 3.i.; 3.j; 3.k.; and 3.l. Items 3.b; 3.c. 3.d. and 3.g are components tested by the generic component testing program.	
A-1.d. item 1. Verify design features provided or relied on to dissipate or channel thermal energy from the reactor to the atmosphere or to the main condenser following off-normal conditions or anticipated transients, including reactor scram.	***Power Ascension Test*** Test #103: 100% Load Rejection Test
A-1.d. item 2. Verify design features provided for makeup of coolant, to dissipate residual heat, to cool the reactor down to a cold-shutdown condition, and to maintain long-term cooling.	***Power Ascension Test*** Test #103: 100% Load Rejection Test
A-1.d. item 3.a Turbine bypass valves	***Power Ascension Test*** Test #103: 100% Load Rejection Test Test #106 Island Mode Test Test #33 TG Test (HFT)

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.e. Power Conversion System Tests	
Section A-1.e contains items that are power conversion system design features. Items 3, 4, and 6 are components tested by the generic component testing program.	
A-1.e. item 1 Steam generators	**None**
A-1.e. item 2 Main steam system	***Preoperational Test*** Test #27 Main Steam Test Test #33-2 TG Test
A-1.e. item 3 Main steam isolation valves	Generic component tests
A-1.e. item 4 Steam generator pressure relief and safety valves	Generic component tests
A-1.e. item 5 Steam extraction system	***Preoperational Test*** Test #27 Main Steam Test
A-1.e. item 6 Turbine stop, control, bypass, and intercept valves	Generic component tests
A-1.e. item 7 Main condenser hotwell level control system	MCS control system factory acceptance testing (FAT) and site acceptance testing (SAT)
A-1.e. item 8 Condensate system	***Preoperational Test*** Test #28 Feedwater Test Test #33-1,-2 TG Test
A-1.e. item 9 Feedwater system	***Preoperational Test*** Test #28 Feedwater Test Test #33-1,-2 TG Test
A-1.e. item 10 Feedwater heater and drain systems	***Preoperational Test*** Test #31 Heater Vents and Drains Test ***Power Ascension Test*** Test #102 Loss of FW Heater Test (50 and 90% power)
A-1.e. item 11 Makeup water and chemical treatment systems	***Preoperational Test*** Test #38 CVCS Test (makeup: pressurizer level control)
A-1.e. item 12 Main condenser off gas system used to maintain condenser vacuum main condenser off gas system used to maintain condenser vacuum	***Preoperational Test*** Test #32 Condenser Air Removal Test

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.f. Waste Heat Rejections Systems	
Section A-1.f contains items that are waste heat rejection systems design features. The waste heat rejection systems design feature that is not applicable to the NuScale design is Item 2.	
A-1.f. item 1 Circulating water system	***Preoperational Test*** Test #10 Circulating Water System Test
A-1.f. item 3 Raw water system	***Preoperational Test*** Test #13 Utility Water System
A-1.f. item 3 Service cooling water cooling	***Preoperational Test*** Test #7 Reactor Component Cooling Water System Test
A-1.f. item 3 Ultimate heat sink system	***Preoperational Test*** Test #11 Site Cooling Water System Test
A-1.g. Electrical Systems	
Section A-1.g contains items that are electrical systems design features. The electrical systems design features that are not applicable to the NuScale design are: Item 1.f. (load shedding features); items 2 and 3 (emergency AC power distribution system). Items 1.a; 1.b.; 1.c (trip devices) and f.a. through f.e. are components tested by the generic component testing program.	
Normal AC Power Distribution System: Tests should demonstrate that the integrated system will perform as designed in response to simulated partial and full losses of offsite power sources. Tests also should demonstrate degraded protection systems designed to transfer from offsite to onsite power sources during degraded voltage conditions.	***Power Ascension Tests*** Test #105 Island Mode Test for NPM #1 Test #106 Island Mode Test for Multiple NPMs
DC System: Demonstrate the design capability of the emergency lighting systems.	***Preoperational Test*** PLS Test #60 component level tests ii. and iii.
DC System: Demonstrate redundancy and electrical independence) and show that actual total system amperage loads are in agreement with design loads.	***Preoperational Test*** EDSS Test #57-1, #57-2 and #57-3 (RG 1.41 Independence Test)
A-1.h. Engineered Safety Features	
Emergency Core Cooling System: expansion and restraint tests	***Power Ascension Test #97*** Thermal Expansion Test #97

RG 1.68 Test Guidance	NuScale Initial Test Program Test
Cold Water Interlocks (including logic, circuitry, and final control devices used to prevent cold water injection into the reactor vessel)	***Preoperational Test*** MPS Test #63-6
A-1.i. Primary and Secondary Containments	
Section A-1.i contains items that are primary and secondary containment design features. The primary and secondary containment design features that are not applicable to the NuScale design are: Items 1 (vacuum tests), 3 (in-leakage tests), 5, 6, 7, and 9 through 21.	
A-1.i. item 1 Containment design overpressure structural tests	Performed by vendor
A-1.i. item 2 Containment isolation valve functional test	***Preoperational Test*** MPS Test #63-6
A-1.i. item 2 Containment isolation valve closure timing tests	***Preoperational Test*** MPS Test #63-7
A-1.i. item 3 Containment isolation valve leakage tests	***Preoperational Test*** CNT Test #43-1
A-1.i. item 4 Containment penetration leakage tests	***Preoperational Test*** CNT Test #43-1
A-1.j. Instrumentation and Control Systems	
I&C system testing is completed before the I&C system's care, custody, and control turnover from Construction to Startup.	
Section A-1.i contains the following statement: "The following list illustrates instrumentation and control systems that should be included in the test program (some of these tests can be conducted in conjunction with the appropriate system level tests)…." The list contains descriptions of *control features or a system name, but* does **NOT** list I&C systems.	
Section A-1.i has 31 line items. The following items are *design features* that are not applicable to the NuScale design: 2, 4, 6-9, 11, 12, 14, 15, 16, 18, 20, 21	
Section A-1.j The list contains items that are descriptions of control design features. The following control design features are applicable to the NuScale design: 1, 3, 17, 19, 22 and 24	
A-1.j. Item 1: Pressurizer pressure and level control systems including transient response for pressurizer in-surge and out-surge	***Power Ascension Test*** Test #101 Step Change in Load Demand Test (25, 50, 75, 100% power)

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.j. Item 3: Secondary system steam pressure control system	***Power Ascension Test*** Test #101 Step Change in Load Demand Test (25, 50, 75, 100% power) Test #99 SG Level Control Test
A-1.j. Item 17: Feedwater heater temperature, level, and bypass control systems	***Preoperational Test*** Test #27 Main Steam Test, component level test #iv
A-1.j. Item 19: Instrumentation and controls used for shutdown from outside the control room	***Preoperational Test*** Test #107 Remote Shutdown Workstation Test
A-1.j. Item 22: Instrumentation that can be used to track the course of postulated accidents (such as containment wide range pressure indicators and reactor vessel water level monitors)	***Preoperational Test*** Test #66-2 Safety Display and Indication Test
A-1.j. Item 22: Instrumentation that can be used to track the course of postulated accidents (such as high radiation devices)	***Preoperational Test*** Test # 67 Fixed Area Radiation Monitoring System Test #9, 19, 24, 35, 36, 38, 41, and 42 valve or damper close on high radiation signal.
A-1.j. Item 24: Annunciators for reactor control and engineered safety features	Annunciators for reactor control and engineered safety features are contained in the MPS system which is tested before the MPS care, custody, and control transfer to Startup
Section A-1.j The list contains items that are names to describe systems. The following systems are applicable to the NuScale design: 5, 10, 13, 26, 28, and 31	
A-1.j. Item 5: Reactor coolant system leak detection systems	***Preoperational Test*** Test #41-3 Containment Evacuation System
A-1.j. Item 10: Seismic instrumentation	***Preoperational Test*** Test #69 Seismic Monitoring System (provided by COL)

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.j. Item 13: In-core and ex-core neutron instrumentation	***Preoperational Test*** Test #63-4 NMS neutron flux data to MPS ***Low Power Test*** Test # 86 Determination of Zero-Power Physics Testing Range Test ***Power Ascension Test*** Test #91 Core Power Distribution Map Test Test #92 Neutron Monitoring System Power Range Flux Calibration Test Test #98 Control Rod Misalignment Test
A-1.j. Item 26: Component cooling water Chilled water Ultimate heat sink	***Preoperational Test*** Test #7 Reactor Component Cooling Water System Test # 11 Site Cooling Water System Test #8 Chilled Water System (no test for ultimate heat sink)
A-1.j. Item 28: Fire water system	***Preoperational Test*** Test #25 Fire Protection System Test
A-1.j. Item 31: Process computers	Process computers are tested before the computer's care, custody, and control transfer to Startup
Section A-1.j The list contains items that are tests applicable to the NuScale design: 7	
A-1.j. Item 7: Leak detection test used to detect failures in the ECCS and containment	***Preoperational Test*** Test #43-1 Containment System Test
A-1.k. Radiation Protection Systems	
Appropriate tests should be conducted to demonstrate the proper operation of the following types of systems and components used to monitor or measure radiation levels, provide for personnel protection, or control or limit the release of radioactivity:	
A-1.k. Item 1: Test process, criticality, effluent, and area radiation monitors.	***Preoperational Test*** Test #67 Fixed Area Radiation Monitor System Test #9, 19, 24, 35, 36, 38, 41, and 42 Valve or damper close on high radiation signal.
A-1.k. Item 2: Test personnel monitors and radiation survey instruments.	COL responsibility

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.k. Item 3: Test laboratory equipment used to analyze or measure radiation levels and radioactivity concentrations.	COL responsibility
A-1.k. Item 4: Test high-efficiency particulate air filters and charcoal adsorbers.	Commodity item. Component test
A-1.k. Item 5: Test leakage detection system sensitivity and capability meets TS leakage detection guidance in Regulatory Guide 1.45 (Ref. 25). This may include leakage detection system sensitivity and capability to detect RCS leakage from Steam Generators within the guidance in Nuclear Energy Institute (NEI) 97-06, “Steam Generator Program Guidelines,” (Ref. 26) and in Electric Power Research Institute (EPRI) TR-1008219, “PWR Primary-to-Secondary Leak Guidelines,” (Ref. 27) (e.g., radiation monitor detection sensitivity is 30 gallons per day or 1.25 gallons per hour).	***Preoperational Test*** Test #41-3 Containment Evacuation System Reference COL Item 5.4-1.
A-1.k. Item 6: Test radiation monitor computer system.	COL responsibility
A-1.k. Item 7: Test radiation data transmission to the emergency response data system.	COL responsibility
A-1.l. Integrity of Systems Outside of Containment that Contain Radioactive Materials	
In accordance with the requirement in §50.34(f)(2)(xxvi), applicants shall provide for a leakage control and detection program in the design of systems outside containment that could contain radioactive material following an accident. As part of the initial test program, applicants shall submit a leakage control program, a schedule for retesting the systems, and actions taken to minimize leakage from these systems. The tests should include leak rate test results and a discussion of actions to reduce leakage from systems outside containment that could contain radioactive fluids or gases during or following a serious transient or accident.	COL Responsibility Reference COL Item 9.3-1.

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.m. Radioactive Waste Handling and Storage Systems	
Section A-1.m has 12 line items. Items #3, #5 and #6 are *design features* that are not applicable to the NuScale design.	
A-1.m. The following list illustrates the systems, components, and features for which the test program should demonstrate operability:	
A-1.m. item 1 Liquid radioactive waste handling systems	***Preoperational Test*** Test #35 Liquid Radwaste System
A-1.m. item 2 Gaseous radioactive waste handling systems	***Preoperational Test*** Test #36 Gaseous Radwaste System
A-1.m. item 4 Solid waste handling systems and resulting waste products complying with waste classification and characteristic requirements	***Preoperational Test*** Test #37 Solid Radwaste System
A-1.m. item 7 Isolation features for ventilation systems and diversion of exhaust flows to HEPA/charcoal filtration subsystems	***Preoperational Test*** CRVS Test #19-4 GRWS Test #36-vii and viii CFDS Test 42-4 and 42-55
A-1.m. item 8 Isolation features for liquid radioactive waste effluent systems and diversion of effluent flows to appropriate subsystems	***Preoperational Test*** LRWS Test 35-vi
A-1.m. item 9 Isolation features (process interlocks, backflow preventers, differential pressures, etc.) of waste processing subsystems, as equipped, in preventing the cross contamination of nonradioactive systems and avoiding unmonitored and uncontrolled radioactive releases	Generic component testing
A-1.m. item 10 Operability of plant process and effluent sampling systems for expected types of media	***Preoperational Test*** PSS Test #53

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.m. item 11 Testing of liquid and wet waste solidification subsystems in verifying that residual amounts of free liquid present in process packaged wastes conform with regulatory requirements and waste acceptance criteria	COL operating procedures
A-1.m. item 11 For waste processing system supplemented with mobile skid-mounted processing equipment, as equipped, testing should include the hydraulic integrity of connections carrying radioactive fluids between mobile processing equipment and permanently installed plant subsystems.	COL operating procedures
A-1.n. Fuel Storage and Handling Systems	
Appropriate tests should be conducted to demonstrate that equipment and components used to handle or cool irradiated and non-irradiated fuel will operate in accordance with design.	
The following list illustrates the equipment and component tests that the program should include:	
A-1.n. item 1 Spent fuel pool cooling system tests	***Preoperational Test*** SFPC Test #1
A-1.n. item 1 Spent fuel pool cooling system high radiation alarms, and low-water-level alarms	Spent fuel pool cooling system alarms are tested by the PCS FAT and SAT before care, custody, and control of the system from Construction to Startup.
A-1.n. item 1 Spent fuel pool water makeup	Manual operator action performed with operating procedure.
A-1.n. item 2 Refueling equipment tests, including hand tools, power equipment, bridge and overhead cranes, and grapples.	Generic component testing
A-1.n. item 3 Operability and leak tests of sectionalizing devices and drains and leak tests of gaskets or bellows in the refueling canal and fuel storage pool.	The PLDS is described in Section 9.1.3.2.5 Leakage from the UHS liner gravity drains to the radiation waste drain system (RWDS). RWDS Test #23-2 tests the MCR alarm when the RWDS sump fill rate exceeds the PLDS leakage rate setpoint.

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.n. item 4 Static and dynamic load testing of cranes, hoists	***Preoperational Test*** FHE Test #51
A-1.n. item 4 Static and dynamic load testing of lifting and rigging equipment	Generic component testing
Static and dynamic load testing of fuel cask	Not applicable to DCA
A-1.n. item 5 Fuel transfer devices	***Preoperational Test*** FHE Test #51
A-1.n. item 6 Irradiated fuel pool or building ventilation system tests	***Preoperational Test*** RBVS Test #20
A-1.n. item 7 Computerized automated fuel handling systems, programming, indexing, data base controls for fuel storage information and interlocks should be tested for proper operation.	***Preoperational Test*** FHE Test #51
A-1.n. item 8 Equipment in the fuel cavity, including reactor vessel seals, vessel seal leakage detection, refueling cavity fuel storage handling equipment including temporary fuel storage racks and weir gates should be tested for proper operation.	Generic component testing
A-1.n. no item # Refueling equipment testing should demonstrate the operability of protective interlocks and devices.	***Preoperational Test*** FHE Test #51
A-1.n. no item # Static testing of cranes, hoists, and associated lifting and rigging equipment should be at 125 percent of rated load, and full operational testing should be at 100 percent of rated load.	RBC Test #52
A-1.o. Auxiliary and Miscellaneous Systems	
The following list illustrates the types of systems and features for which performance should be demonstrated by testing:	
Section A-1.o has 26 numbered line items. Items 8, 12, 14b, 14g, 15, 16, 17, 21, 22, 23, 24 and 26 are *design features* that are not applicable to the NuScale design.	

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.o. item 1 Service and raw water cooling ultimate heat sink systems	*Preoperational Test* SCWS Test #11
A-1.o. item 2 Closed-loop cooling water systems	*Preoperational Test* RCCWS Test #7 CHW Test #8
A-1.o. item 3 Component cooling water and chilled water systems	*Preoperational Test* SCWS Test #11 RCCWS Test #7 CHW Test #8
A-1.o. item 4 Reactor coolant makeup system	*Preoperational Test* CVCS Test #20
A-1.o. item 5 Reactor coolant and secondary sampling systems	*Preoperational Test* PSS Test #53
A-1.o. item 6 Chemistry control systems for the reactor coolant and secondary coolant systems	*Preoperational Test* CVCS Test #20 FWT Test #29 Power Ascension Test Test #79 Primary and Secondary System Chemistry Test
A-1.o. item 7 Fire protection systems (including demonstrations of proper manual and automatic operation of fire detection, alarm, suppression, and smoke control systems	*Preoperational Test* FPS Test #25
A-1.o. item 9 Vent and drain systems (for contaminated or potentially contaminated systems and areas), and drain and pumping systems serving essential areas (e.g., spaces housing diesel generators, essential electrical equipment, and essential pumps);	
A-1.o. item 10 Purification and cleanup systems for the reactor coolant system	*Preoperational Test* CVCS Test #20

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.o. item 11 Compressed gas system supplying pneumatic equipment, components, or instrumentation that are required to function to support the normal operation of the facility	
A-1.o. item 13 Communication systems	*Preoperational Test* COMS Test #68
A-1.o. item 14 Heating, cooling, and ventilation systems serving the following areas should meet the guidance in RG 1.140:	
A-1.o. item 14.a Spaces housing engineered safety features	*Preoperational Test* RBVS Test #20 CRVS Test #19
A-1.o. item 14.c Battery rooms	*Preoperational Test* RBVS Test #20 CRVS Test #19 TBVS Test #22
A-1.o. item 14.d Diesel generator buildings	COL Item
A-1.o. item 14.e Auxiliary building	COL Item
A-1.o. item 14.e Reactor building	*Preoperational Test* RBVS Test #20
A-1.o. item 14.e Turbine building	*Preoperational Test* TBVS Test #22
A-1.o. item 14.e Radioactive waste handling building	*Preoperational Test* RWBVS Test #22
A-1.o. item 14.f Control room habitability systems	*Preoperational Test* CRHS Test #18
A-1.o. item 14.h Fuel storage and handling area ventilation system	*Preoperational Test* RBVS Test #20
A-1.o. item 18 Heat tracing for freeze protection	Generic component testing
A-1.o. item 19 Emergency lighting for safe egress, post accident vital areas, and emergency facilities	*Preoperational Test* RBVS Test #20

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.o. item 20 Cathodic protection system for corrosion control of underground and submerged metallic surfaces (i.e., buried carbon steel pipes and tanks)	Generic component testing
A-1.o. item 25 Leakage detection from the spent fuel pool, refueling cavity	The PLDS is described in Section 9.1.3.2.5 Leakage from the UHS liner gravity drains to the radiation waste drain system (RWDS). RWDS Test #23-2 tests the MCR alarm when the RWDS sump fill rate exceeds the PLDS leakage rate setpoint.
A-1.o. no item # Communication system tests should include demonstrations of the proper operation of evacuation and other alarms, the public address system within the plant, systems that may be used if the plant is required to be shut down from outside the control room, and communication systems required by the facility's emergency plan. This testing may include a check for frequency interferences from emergency communication devices used at multi-unit sites or other communication devices.	*Preoperational Test* COMS Test #68
A-1.o. no item # Control room habitability system testing should include, as appropriate, demonstrations of the proper operation of smoke and toxic chemical detection systems and ventilation shutdown devices, including leak-tightness of ducts and flow rates, proper direction of airflows, and proper control of space temperatures.	*Preoperational Test* CRVS Test #19 CRHS Test #18 Leak-tightness of ducts is tested by Construction.
A-1.p. Reactor Component Handling Systems	
Include the following activities:	
A-1.p. item 1 Conduct dynamic and static load tests (see footnote 14) of cranes, hoists, and associated lifting and rigging equipment (e.g., slings and strong backs used during refueling or the preparation for refueling).	*Preoperational Test* RBC Test #52

RG 1.68 Test Guidance	NuScale Initial Test Program Test
A-1.p. item 2 Conduct full operational testing of cranes, hoists, and associated lifting and rigging equipment at 100 percent of rated load.	*Preoperational Test* RBC Test #52
A-1.p. item 3 Conduct static testing of cranes, hoists, and associated lifting and rigging equipment at 125 percent of rated load	*Preoperational Test* RBC Test #52
A-1.p. item 4 Demonstrate operability of protective devices and interlocks.	*Preoperational Test* RBC Test #52
A-1.p. item 5 Demonstrate operability of safety devices on equipment.	*Preoperational Test* RBC Test #52
A-1.p. item 6 Demonstrate clearance for safe movement of heavy loads through designated paths.	*Preoperational Test* RBC Test #52
A-1.p. item 7 Demonstrate operability of reactor component handling equipment in the refueling cavity and the spent fuel pool.	*Preoperational Test* RBC Test #52