NuScale Power

June 12, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Submittal of Changes to Final Safety Analysis Report Tier 1 Section 2.1 and Tier 2 Sections 3.9, 4.5, and 4.6

REFERENCE: NuScale Power, LLC Letter to NRC "Submittal of the NuScale Standard Plant Design Certification Application (NRC Project No. 0769)," dated December 31, 2016 (ML17013A229).

During an April 21, 2017 public teleconference with Bruce Bavol and Matt Mitchell of the NRC staff, NuScale Power, LLC (NuScale) discussed potential updates to FSAR Section 4.5.1, Control Rod Drive System Structural Materials. The Enclosure to this letter provides a mark-up of the NuScale FSAR pages incorporating revisions to Tier 2 Section 4.5 and conforming revisions to Tier 1 Section 2.1 and Tier 2 Sections 3.9 and 4.6 in redline/strikeout format. NuScale will include these changes as part of a future revision to the NuScale Design Certification Application (reference).

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

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

Sincerely,

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Enclosure: Changes to NuScale Final Safety Analysis Report Tier 1 Section 2.1 and Tier 2 Sections 3.9, 4.5, and 4.6

Enclosure:

"Changes to NuScale Final Safety Analysis Report Tier 1 Section 2.1 and Tier 2 Sections 3.9, 4.5 and 4.6"

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2.1 NuScale Power Module

2.1.1 Design Description

System Description

The scope of this section is the NuScale Power Module (NPM) and its associated systems. The NPM is installed in the reactor pool in the Reactor Building (RXB). Up to 12 NPMs may be installed in the Reactor Building. The systems contained within the boundary of the NPM are the

- reactor coolant system (RCS), including the reactor pressure vessel (RPV), pressurizer, steam generator (SG), reactor vessel internals (RVI), and associated piping and valves.
- control rod drive system (CRDS), including the control rod drive mechanisms (CRDM) with embedded cooling water tubes, cables, and associated cooling water piping. The CRDS also includes instrumentation to provide control rod position indication information.
- containment system (CNTS), including the containment vessel (CNV) and containment isolation valves (CIVs) and associated piping.
- emergency core cooling system (ECCS) valves.
- decay heat removal system (DHRS), including associated piping and valves.

The NPM includes the pressure retaining structures of these systems because they are part of either the reactor coolant pressure boundary (RCPB) or the CNV pressure boundary. Therefore, the mechanical design and arrangement of the piping, CRDS, and NPM valves (emergency core cooling, reactor safety, and containment isolation) are included in this section.

The CRDM pressure housings form the pressure boundary between the environments inside the RPV and the CNV. The CRDM pressure housings consist of the latch housing ~~and the~~, rod travel housing, and rod travel housing plug.

The NPM performs the following ~~non~~safety-related, risk-significant functions that ~~is~~are verified by Inspections, Tests, Analyses, and Acceptance Criteria:

- The RCS supports the CNTS by supplying the RCPB and a fission product boundary via the RPV and other appurtenances.
- The CRDS supports the RCS by maintaining the pressure boundary of the RPV.
- The SG supports the RCS by suppling part of the RCPB.
- The ECCS supports the RCS by providing a portion of the RCPB for maintaining the RCPB integrity.
- The CNTS supports the RXB by providing a barrier to contain mass, energy, and fission product release from a degradation of the RCPB.
- The ECCS supports the CNTS by providing a portion of the containment boundary for maintaining containment integrity.

Table 2.1-2: NuScale Power Module Mechanical Equipment (Continued)

Equipment Name	Equipment Identifier	ASME Code Section III Class	Valve Actuator Type	Containment Isolation Valve
CRDM heat exchanger	CRDS-CRD-004	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-005	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-006	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-007	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-008	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-009	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-010	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-011	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-012	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-013	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-014	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-015	2	N/A	N/A
CRDM heat exchanger	CRDS-CRD-016	2	N/A	N/A
CRDM cooling water supply flex hose	CRDS-FHS-0101 thru CRDS-FHS-0116	2	N/A	N/A
CRDM cooling water return flex hose	CRDS-FHS-0201 thru CRDS-FHS-0216	2	N/A	N/A
CRDM latch housing	N/A	1	N/A	N/A
CRDM rod travel housing	N/A	1	N/A	N/A
CRDM rod travel housing plug	N/A	1	N/A	N/A
CNTS instrumentation and controls division I electrical penetration	CNV8	1	N/A	N/A
CNTS instrumentation and controls division II electrical penetration	CNV9	1	N/A	N/A
CNTS pressurizer heater power #1 electrical penetration	CNV15	1	N/A	N/A
CNTS pressurizer heater power #2 electrical penetration	CNV16	1	N/A	N/A
CNTS instrumentation and controls channel A electrical penetration	CNV17	1	N/A	N/A
CNTS instrumentation and controls channel B electrical penetration	CNV18	1	N/A	N/A
CNTS instrumentation and controls channel C electrical penetration	CNV19	1	N/A	N/A
CNTS instrumentation and controls channel D electrical penetration	CNV20	1	N/A	N/A
CNTS control rod drive system electrical penetration	CNV37	1	N/A	N/A
CNTS rod position indication group #1 electrical penetration	CNV38	1	N/A	N/A
CNTS rod position indication group #2 electrical penetration	CNV39	1	N/A	N/A
RCS instrumentation and controls channel A electrical penetration	RPV39	1	N/A	N/A
RCS instrumentation and controls channel B electrical penetration	RPV40	1	N/A	N/A

of the reactor vessel to allow the CRDM to raise, lower, or hold the CRA. The control rod drive shaft must also interact with the rod position indication sensor coils that communicate the elevation of the control rods. The control rod drive shaft allows for the release of the CRA for refueling purposes.

Drive Coil Assembly

The drive coil assembly has four main coils: the lift coil, the movable gripper coil, the stationary gripper coil, and the remote disconnect coil. The direct current generated by the control cabinets is sent through a coil which generates a magnetic field; this magnetic field engages the flat-face plunger magnet, which moves the latch arm to engage the control rod drive shaft. The rate at which the movable gripper coil, the stationary gripper coil, and the lift coil are energized determines the speed of the control rod drive shaft. The power from the direct current electrical and alternating current distribution system to the CRDM control cabinet can be interrupted if the reactor trip breakers open, causing the control rods to be inserted via gravity. Rod movement logic tracks the speed of the control rods, which utilizes direct rod position indication. The rod movement logic has a latching function for providing extra current to the coil(s) during initial movement (startup) to ensure the latch assembly is engaged positively to the control rod drive shaft. The remote disconnect mechanism coil and latches are capable of remotely connecting and disconnecting the drive shaft from the CRA, as the drive shafts are not accessible during reactor module disassembly, as customary for the current fleet of PWRs.

Pressure Housings

The pressure housings include all components of the CRDM that form the pressure boundary for the reactor coolant. The pressure housings are ASME BPVC Section III, Subsection NB components. The pressure housings consist of the latch housing (welded to the reactor vessel head nozzle) ~~and~~, the rod travel housing, and the rod travel housing plug. The rod travel housing is threaded into and seal welded to the top of the latch housing.

Latch Mechanism Assembly

The latch mechanism assembly consists of three separate latch assemblies that have the ability to grab and release the drive shaft in order to lift and lower the drive shaft in three-eighths-inch incremental steps and support operation of the remote disconnect mechanism. These motions are produced by electromagnetic forces generated by the drive coils. The latch mechanism assembly releases the control rod drive shaft during loss of power. The latch mechanism assembly is shown in Figure 4.6-5.

The latch assembly attaches to the bottom of the rod travel housing and is inserted into the latch housing.

Sensor Coil Assembly

4.5 Reactor Materials

4.5.1 Control Rod Drive System Structural Materials

The control rod drive system (CRDS) consists of the control rod drive mechanisms (CRDMs) and the related mechanical components that provide the means for control rod assembly insertion into the core as described in Section 4.6. Portions of the CRDS are a part of the reactor coolant pressure boundary (RCPB) as described in Section 5.2.

The CRDS materials discussed in this section include the CRDMs and extend to the coupling interface with the control rod assemblies (CRAs) in the reactor vessel. Figures 4.6-1, 4.6-5 and 4.6-6 are illustrations of the CRDM-to-CRA interface. Materials for the pressure-retaining components of the CRDMs are listed in Table 5.2-~~3~~4 and include the latch housing, the rod travel housing, and the rod travel housing plug.

Section 3.9.4 provides the details of the mechanical testing, seismic analysis of the CRDS, components life cycle testing, and mechanism functional tests. Operating experience of the CRDS design is discussed in Section 3.9.4 and Section 4.6.

4.5.1.1 Materials Specifications

The CRDMs are mounted above the pressurizer of the reactor pressure vessel and inside the containment vessel. The CRDM internal components can be exposed to primary coolant or saturated steam and non-condensable gases. Prior to module movement for refueling, the containment vessel is partially flooded with borated water, but the CRDMs are not normally submerged. However, the material design of the external surfaces of the CRDM include consideration of inadvertent submergence into borated water during module movement or refueling. The inside surface of the CRDM cooling tubes and cooling water connector is exposed to component cooling water. CRDM materials are selected to be compatible with the applicable fluid environments.

Portions of the CRDM that establish the RCPB are classified as Quality Group A and are designed, fabricated, constructed, tested, and inspected as Class 1 in accordance with Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME BPV Code) and the applicable conditions promulgated in 10 CFR 50.55a.(b). The CRDM materials, including weld materials, conform to fabrication, construction, and testing requirements of ASME BPV Code, Section III, Subsection NB. The materials selected for fabrication conform to the applicable material specifications provided in ASME BPV Code, Section II and meet the requirements of ASME BPV Code, Section III, Article NB-2000.

As a conservative measure to minimize the potential for leakage of the fluid system inside containment, the CRDM coil heat exchangers, cooling tubes, and cooling water connectors are classified as Quality Group B (Section 3.2) and are designed, fabricated, constructed, tested, and inspected as Class 2 in accordance with Section III of the ASME BPV Code and the applicable conditions promulgated in 10 CFR 50.55a.(d). The CRDM coil heat exchanger, cooling tubes, and cooling water connector materials, including weld materials, conform to fabrication, construction, and testing requirements of ASME BPV Code, Section III, Subsection NC. The materials selected for fabrication conform to

4.5.1.3 Other Materials

The use of martensitic stainless steel is limited to Type 410 with a minimum tempering temperature of 1050°F to prevent temper embrittlement and stress-corrosion cracking.

Nickel-chromium based alloy X-750 is used for the CRDM springs and cobalt-based alloys Haynes 25 and Stellite 6 are used for wear-resistant parts as identified in Table 4.5-1. These materials have been used in existing pressurized water reactor (PWR) CRDMs for the same function with satisfactory performance. The material of the rod drive expansion plug and pins associated with gripper components is Haynes 25. Stellite 6 material is limited to hardfacing of the CRDM gripper latch arm tips. To minimize the possibility of stress-corrosion cracking failures, the CRDM springs and wear-resistant parts are procured in the same heat treatment condition as previously used in the industry. Alloy X-750 spring material and heat treatment conform to the requirements of AMS 5698 or AMS 5699. For Alloy X-750, the cobalt impurity is maintained as low as possible and does not exceed 1%. To minimize cobalt intrusion into the reactor coolant, low-cobalt or cobalt-free alloys may be used for wear-resistant CRDM parts if their wear and corrosion resistance are qualified by testing.

4.5.1.4 Material Cleaning and Cleanliness Control

Cleaning of CRDMs complies with the ASME NQA-1 requirements (Reference 4.5-2). The final surface cleanness meets the requirements for "Class B" of Subpart 2.1.

Handling, storage, and shipping of CRDMs comply with ASME NQA-1-2008, Part 1, Requirement 13. Packaging, shipment, handling, and storage of CRDMs meet the requirements of "Level B" of ASME NQA-1a-2009, Part II, Subpart 2.2 (Reference 4.5-2).

4.5.2 Reactor Internals and Core Support Structure Materials

Figures 3.9-1 through 3.9-5 show the reactor vessel internals (RVI) subassemblies with components that comprise the RVI. The RVI consist of core support assembly, lower riser assembly, upper riser assembly, flow diverter, and pressurizer spray nozzles.

4.5.2.1 Materials Specifications

Table 4.5-2 lists the RVI materials and associated specifications, including the material grade, class, or type as applicable. The portions of the RVI performing a core support function are classified as Quality Group B and are designed and fabricated as Class CS in accordance with ASME BPV Code, Section III, Subsection NG. The materials for core support structures and threaded structural fasteners conform to the requirements of ASME BPV Code, Section III, Subsubarticle NG-2120, and the applicable requirements of ASME BPV Code, Section II, Part D, Tables 2A, 2B, and 4. The remaining portions of the RVI are designated as internal structures and are designed to conform to ASME BPV Code, Section III, Article NG-3000 considering the requirements of Paragraph NG-1122(c).

The design of RVI has considered peak neutron fluence in the materials surrounding the core. Neutron irradiation-induced degradations such as irradiation-assisted stress corrosion cracking, void-swelling, stress-relaxation, and irradiation embrittlement have

Table 4.5-1: Control Rod Drive Mechanism Materials

Component	Material Designation (Grade, Class, or Type)
Latch Mechanism Assembly	
Magnetic parts: plungers, poles, keys	Type 410
Springs	Alloy X-750 (UNS N07750), AMS 5698 or AMS 5699
Wear parts: latch pins, pivot pins, plunger pin, key pins	Haynes Alloy 25
Latch links Latch arms Lock plungers Guide tubes, support tubes Shims and lock cups	Type 304
Hardfacing for latch arm tips	Stellite 6 or Low cobalt or cobalt-free material
Lock screws	Type 316
Water-Cooled Coil Stacks	
Magnetic parts: housings and flux rings Cooling tube Housing through bolts	Type 410
Non-magnetic parts	Type 304
Wire	Class N insulated copper
Drive Rod & Remote Disconnect Assembly	
Drive rod Drive rod coupling, coupling sleeve Remote disconnect rod Remote disconnect button and button insert	Type 410
Drive rod lower spring retainer Remote disconnect coupling expansion nut Drive rod collar dowel Remote disconnect rod union Remote disconnect upper spring retaining collar Remote disconnect shoulder nut	Type 304
Remote disconnect lower and upper springs	Alloy X-750 (UNS N07750), AMS 5698 or AMS 5699
Remote disconnect expansion plug	Haynes Alloy 25
Latch Housing Assembly	
Flux rings, shield rings	Type 410
Housing thermal shield	Type 304
CRDM Weld Filler Metals (Note 2)	
Welding electrode materials	E308, E308L, E316, E316L
Welding rod materials	ER308, ER308L, ER316, ER316L
CRDM RCPB Components	**Refer to Section 5.2**

Note 1: All listed materials, except the water-cooled coil stacks, are exposed to RCS coolant.
Note 2: 0.03% maximum carbon

GDC 23 requires that the protection system be designed to fail into a safe state in the event of adverse conditions or environments. The CRDM provides positive core reactivity control through the use of movable CRAs. The movable CRAs provide reactivity control for all modes of operation, including all plant conditions from the cold shutdown condition to the full-load condition. The CRDM, in conjunction with the module protection system, actuate the control rods to perform safety-related functions when necessary to provide core protection during normal operation, AOOs, and accidents. The CRDM is designed to fail in a safe condition, even under adverse conditions, that prevents damage to the fuel cladding and excessive reactivity changes during failure. Loss of electrical power to the reactor trip breaker will initiate a reactor scram, causing rods to drop into the core to shut down the reactor.

GDC 25 requires that the protection system be designed to ensure that specified acceptable fuel design limits are not exceeded for any single malfunction of the reactivity control systems. Chapter 15 safety analyses demonstrate that the CRDS with any assumed credible failure of any single active component is capable of performing a reactor trip when plant parameters exceed the reactor trip setpoint, in accordance with GDC 25.

GDC 26 is applicable to the CRDS design, as the CRDS is one of the independent reactivity control systems. It is designed with appropriate margin to assure its reactivity control function under conditions of normal operation including AOOs. The CRDS facilitates reliable operator control by performing a safe shutdown (i.e., reactor scram) via gravity-dropping of the CRAs on a reactor trip signal or loss of power. The CRDS is designed such that core reactivity can be safely controlled and that sufficient negative reactivity exists to maintain the core subcritical under cold conditions.

PDC 27 requires that the two independent reactivity control systems (control rods and soluble boron system) are capable of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained. The analyses in Chapter 15 demonstrate that, with a stuck rod, the capability to cool the core is maintained. The insertion of all CRAs is required to hold the reactor core subcritical under cold conditions.

GDC 28 requires that the effects of postulated reactivity insertion accidents neither result in damage to the reactor coolant pressure boundary, nor cause sufficient damage to impair the capability to cool the core. A postulated failure of the CRDS causing a rod ejection has the potential to result in a relatively high rate of positive reactivity insertion, which could challenge specified acceptable fuel design limits. The rod ejection accident is not analyzed as a loss-of-coolant accident event. To prevent a mechanical failure of the CRDM housings, the ~~housings~~CRDM nozzles are designed to be an integral part of the RPV. The CRDM pressure housings are full penetration welded to the safe ends of the ~~RPV head~~CRDM nozzles. The safe-end-to-CRDM nozzle welds and safe-end-to-CRDM pressure housing welds are inspected to ASME Class 1 requirements. However, a failure of the CRDM pressure housing is postulated to provide a limiting reactivity insertion event in Section 15.4. The REA analysis presented in Section 15.4 demonstrates that GDC 28 is met by ensuring that the effects of a postulated rod ejection event meet the acceptance criteria in the SRP.

GDC 29 is applicable to the CRDS design, as the CRDS, in conjunction with reactor protection systems, is designed to assure an extremely high probability of accomplishing its safety-related functions in the event of AOOs. The CRDS fulfills its safety-related