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RAIO-0119-64247

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Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 340 (eRAI No. 9358) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 340 (eRAI No. 9358)," dated January 26, 2018
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 340 (eRAI No.9358)," dated March 27, 2018
3. NuScale Power, LLC Supplemental Response to "NRC Request for Additional Information No. 340 (eRAI No. 9358)" dated September 13, 2018
4. NuScale Power, LLC Supplemental Response to "NRC Request for Additional Information No. 340 (eRAI No. 9358)" dated November 15, 2018
5. NuScale Power, LLC Supplemental Response to "NRC Request for Additional Information No. 340 (eRAI No. 9358)" dated December 13, 2018

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

The Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 9358:

- 03.06.02-17

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

If you have any questions on this response, please contact Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9358

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9358

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

eRAI No.: 9358
Date of RAI Issue: 01/26/2018

NRC Question No.: 03.06.02-17

In response to RAI 9187, Question 03.06.02-16, NuScale stated that the configuration of the RVVs and RRVs had changed from a welded connection to a bolted connection.

In that response, NuScale also referred to its response to RAI 8776, Question 15.06.06-5, to support NuScale's position that high energy line breaks do not need to be postulated at the RVV and RRV connections to the RPV. Specifically, NuScale referred to Section III of the ASME BPV Code which defines "piping system" as "an assembly of piping, piping supports, components, and, if applicable, components supports." Further, NuScale stated that while a piping system may include non-piping components such as a valve, a piping system must at least include piping. Moreover, NuScale stated that in the NuScale design, there is no piping between the Reactor Pressure Vessel (RPV) nozzles and Reactor Vent Valves (RVVs)/Reactor Recirculation Valves (RRVs), but rather only two non-piping components welded together. Therefore, NuScale's position is that high energy line breaks do not need to be postulated at the RVV and RRV connections to the RPV.

The NRC staff disagreed with the above NuScale's interpretation of the piping system as defined in the ASME Code. The NRC staff's interpretation is that a piping system is a system that includes any of the following, piping, piping supports, components, or components supports. This NRC staff's interpretation is consistent with the definition and scope of vessel and pipe as described by the ASME Companion Guide. As described in RAI 9187, Question 03.06.02-16, Companion Guide to the ASME Boiler and Pressure Vessel Code states that Paragraph U-1(a)(2) of ASME Section VIII-1 scope addresses pressure vessels that are defined as containers for the containment of pressure, internal or external and if the primary function of the pressure container is to transfer fluid from one point in the system to another, then the component should be considered as piping. Further, Paragraph 21.3.1.2 of the

Companion Guide states that the vessel boundary ends at the face of the flange for bolted connections to piping, other pressure vessels, and mechanical equipment.

Accordingly, the NRC staff considers the boundary of the vessel to be at the [bolted flange connections between the RVV and RRV and the vessel]. Therefore, the staff's position is that RVV and RRV should be considered as part of the piping system and is the extremity of the affected piping system. As stated in BTP 3-4 Section 2A(iii) that breaks should be postulated at the terminal end of each piping run. Bolting the RVVs and RRVs to a flanged connect to the reactor vessel would be a terminal end connection.

For the NuScale RVV and RRV design, the NRC staff's key concern is that this bolted flange connection to the reactor vessel must not fail catastrophically, causing a loss-of-coolant accident. Operating experience from current reactors demonstrates that degradation and failure do occur at bolted connections in nuclear power plants. Electric Power Research Institute (EPRI) NP-5769, "Degradation and Failure of Bolting in Nuclear Power Plants," dated April 1988, discusses various causes of bolting degradations and failures. The contributing factors to these incidents include stress corrosion cracking, boric acid corrosion, flow-induced vibration, improper torque/preload, and steam cutting. NUREG-1339, "resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants," dated June 1990, discusses resolution of issues from this EPRI study. Specifically, it discusses NRC's evaluation of and exceptions to EPRI NP-5769. Further, Generic Letter (GL) 91-17, "Bolting Degradation or Failure in Nuclear Power Plants," provides information on the resolution of GSI 29.

Per the response to RAI No. 8785, Question 15.06.05-1 and based on our previous interactions with NuScale, the staff understands that NuScale is not assuming a break at this location. There is precedent for <u>not</u> postulating breaks in certain locations where additional design and operational criteria provide assurance that this approach is acceptable. GDC 4 explicitly allows exclusion of certain pipe ruptures when "the probability of fluid system piping rupture is extremely low"- the basis used for "leak-before-break" as described in SRP Section 3.6.3, "Leak-Before-Break Procedures." The specific guidelines included in SRP 3.6.3, are a deterministic fracture-mechanics-based approach. They are applicable for pipes only and cannot be directly applied to a bolted flange connection. However, the concept of demonstrating that leakage will be detected in time to ensure that the probability of gross failure is extremely low should be the same.

In addition, Section 2A(ii) of BTP 3-4 states that breaks need not be postulated in those portions of piping from containment wall to and including the inboard or outboard isolation valves (the "break exclusion zone"), provided they meet certain specific design criteria for stress and fatigue

limits, welding, pipe length, guard pipe assemblies, and full volumetric examination of welds. These existing break exclusion guidelines are for fluid system piping in the containment penetration area of current generation large light-water reactors and, therefore, are not directly applicable to NuScale.

If NuScale desires to treat the bolted connection of the RRVs and RVVs to a flange connected to the reactor vessel as a break exclusion area, then a justification for why this connection provides confidence that the probability of gross rupture is extremely low, must be provided for NRC staff review and acceptance. The justification will need to contain a discussion of the considerations outlined below.

1. Quantitative assessment of the probability of gross failure for the bolted flange connection

2. Specific design stress and fatigue limits

3. A comprehensive bolting integrity program in accordance with the recommendations and guidelines in NUREG-1339 (with additional detail provided in EPRI NP-5769, as referenced in NUREG-1339), as well as related NRC bulletins and generic letters

4. Local leakage detection (potentially similar in concept to leakage detection from reactor vessel heads) that will provide indication of leakage before gross bolt failure, such that the plant can shut down

5. Augmented inspection program requirements, which could include augmented procurement requirements for the bolting, ultrasonic in-service testing of the bolts of the bolted flange connection at some specific inspection frequency, periodic bolt replacement, etc.

The staff requests the applicant to clarify how they intend to treat the bolted connection as a break exclusion location and if so, provide justification with a discussion of the above considerations.

NuScale Response:

On a public conference call with the NRC on January 3, 2019, NuScale and the NRC discussed the following with regard to the NuScale response to request for additional information (RAI) 9358 - 03.06.02-17.

1. The supplemental response to Question 03.06.02-17S2, submitted by RAIO-1118-62971 dated November 15, 2018, revised the Table 5.2-6, "Reactor Pressure Vessel Inspection Elements" for the Reactor Vent Valve (RVV) and the Reactor Recirculation Valve (RRV) flange threaded fasteners to be Examination Category - B-G-2, augmented; the Examination Method - Volumetric; and the Notes - Augmented inspection to follow the guidance of B-G-1.

   The NRC indicated that this table revision does not clearly enough specify that all of the flange bolts are subject to volumetric examination during the periodic inspection cycle. The NRC identified that Note 3 of B-G-1 and Note 5 of B-G-2 allow the performance of a volumetric examination on only one or a representative sample of the flange bolt population. The NRC requested that NuScale clarify the RAI response and the Final Safety Analysis Report (FSAR) Table 5.2-6 to clearly specify that all of the RVV and RRV flange threaded fasteners are subject to volumetric examination during the specified inspection cycle.

2. The NRC discussed that FSAR Section 3.6, Revision 2, describes the RRV and RVV attachment to the RPV as an integrated flange. This description is inconsistent with the valve attachment arrangement discussed in FSAR Section 5.2.2.5 and in FSAR Table 5.2-4 and Table 5.2-6 (RVV flange only). NuScale was asked to resolve these inconsistencies with an additional supplement to this RAI 9358 Question 03.06.02-17 response.

Based on these discussions and further review, NuScale is providing the following clarifications:

1. The volumetric examination of the RVV and RRV flange bolts includes all of the threaded fasteners. NuScale has clarified the FSAR Table 5.2-6 line item for the RVV and RRV flange threaded fasteners to include an additional note which states that, "All threaded fasteners are subject to volumetric examination during the inspection period." See the attached markup of FSAR Table 5.2-6 for details.

2. NuScale acknowledges the inconsistency of the RVV and RRV attachment descriptions between FSAR Section 5.2.2.5 (including FSAR Table 5.2-4 and Table 5.2-6) and FSAR Section 3.6.2.7. Based on this, NuScale has revised FSAR Section 5.2.2.5, FSAR Table 5.2-4 and Table 5.2-6 to provide a description of the RVV and RRV attachment that is consistent with FSAR Section 3.6.2.7.

   One exception to the NRC requested changes was identified. The RVV flange identified in Table 5.2-6 was not removed as this flange is still connected to the pressurizer and thus subject to the identified inspection. Also note that the Reactor Safety Valves (RSVs) were also modified to remove statements that indicated they are connected to a safe-end. See the attached markup for details.

Impact on DCA:

FSAR Section 5.2.2.5, Table 5.2-4 and Table 5.2-6 have been revised as described in the response above and as shown in the markup provided in this response.

active failure assuming the most limiting allowable operating condition and system configuration.

Further description of the design and operation of the RVVs is covered in Section 6.3.2. Environmental qualification information associated with the RVVs is provided in Section 3.11.

5.2.2.5 Mounting of Pressure-Relief Devices

RAI 03.06.02-17S4

~~The RSVs and RVVs are mounted to the RPV head via nozzle safe ends.~~ The RSVs~~, RVVs and RRVs~~ are bolted to flanges mounted on the RPV head, ~~which are welded to nozzle safe ends,~~ to allow for periodic removal for inspection and testing. Access to the RSVs is provided by a manway on the containment upper head.

RAI 03.06.02-17S4

The RRVs and RVVs are bolted directly to the reactor vessel nozzles. Further description of the design of the RRVs and RVVs is covered in Section 6.3.2.

5.2.2.6 Applicable Codes and Classification

The RSVs and RVVs are designed in accordance with ASME BPVC, Section III, Subarticle NB-3500 and function to satisfy the overpressure protection criteria described in ASME BPVC Section III, Article NB-7000. The applicable design code edition is described in Section 5.2.1 and Section 3.2 describes the classifications applicable to overpressurization equipment and components.

5.2.2.7 Material Specifications

Material specifications for the RSVs and the RVVs are addressed in Section 6.1.

5.2.2.8 Process Instrumentation

Direct position indication for each RSV and RVV is provided in the control room pursuant to the requirement of 10 CFR 50.34(f)(2)(xi) promulgating Three Mile Island action plan recommendation Item II.D.3. Due to the design of the NPM, RCS leakage into the containment atmosphere is conservatively classified as unidentified leakage, including the leakage from these valves.

Detection of leakage from the reactor vessel to the containment vessel is discussed in Section 9.3.6.3.

5.2.2.9 System Reliability

RAI 03.09.06-10, RAI 03.09.06-11

The RSVs and RVVs are designed, tested and inspected to ASME BPVC, Sections III and XI criteria. ASME BPVC safety and relief valves have demonstrated a high degree of reliability over their many years of service in the nuclear industry. Functional

RAI 03.06.02-17S4, RAI 05.02.03-1, RAI 05.02.03-9, RAI 05.02.03-12, RAI 05.02.03-18, RAI 05.03.01-3, RAI 05.04.02.01-6, RAI 06.01.01-1S1, RAI 06.01.01-3, RAI 08.01-2

Table 5.2-4: Reactor Coolant Pressure Boundary Component and Support Materials Including Reactor Vessel, Attachments, and Appurtenances

Component	Specification	Alloy Designation (Grade, Class, or Type)[1]
Reactor Vessel		
Lower RPV section flange shell RPV bottom head Core support blocks	SA-508	Grade 3, Class 1
RPV top head PZR Shell Integral steam plenum Upper RPV flanged transition shell Steam plenum access ports Upper RPV SG shell Lower RPV SG shell Feed plenum access ports	SA-508	Grade 3, Class 2
RPV support gussets RPV support plates	SA-533	Type B, Class 2
Core barrel guides	SA-479 or SA-240	Type 304 with 0.03% max carbon
Pressure instrument tap swagelok reducers Threaded inserts for: RSV flanges RPV instrument seal assemblies PZR heater access ports Steam plenum access ports Feed plenum access ports	SA-479	Type 304/304L
RPV instrument seal assemblies	SA-240	Type 304/304L
RPV instrument seal assemblies set screws	SA-193	B8, Class 1
RPV instrument seal assemblies swagelok male connectors	SA-479	Type 316/316L
RPV flange leak detection tube	SA-312	Type 316L; Seamless
Threaded fasteners, nuts, and washers for: Main RPV flange RSV flanges RPV instrument seal assemblies PZR heater access ports Steam plenum access ports Feed plenum access ports	SB-637	Alloy 718 (UNS N07718)[3]
PZR pressure taps Thermowell nozzles	SB-166	Alloy 690 (UNS N06690)

Table 5.2-4: Reactor Coolant Pressure Boundary Component and Support Materials Including Reactor Vessel, Attachments, and Appurtenances (Continued)

Component	Specification	Alloy Designation (Grade, Class, or Type)[1]
Safe ends for: • ~~RRV~~ • CVCS charging and letdown nozzles • CRDM nozzles • ~~RVV~~ • High point degasification nozzle • Pressurizer Spray nozzle	SB-166 or SB-167[5]	Alloy 690 (UNS N06690)
PZR heater closure flange	SB-168	Alloy 690 (UNS N06690)
Ultrasonic testing sensor nozzles	SA-182	Grade F304/F304L
Low alloy steel weld filler material[4]	SFA 5.5 SFA 5.23 SFA-5.28 SFA-5.29	Weld filler metal classifications compatible with low alloy steel base metal
Stainless steel weld filler material (includes filler material for cladding)	SFA 5.4 SFA 5.9 SFA-5.22	E308, E308L, E309, E309L, E316, E316L ER308, ER308L, ER309, ER309L ER316, ER316L, EQ308L, EQ309L E308, E308L, E309, E309L, E316, E316L
Nickel-based alloy weld filler material	SFA-5.11 SFA-5.14	ENiCrFe-7 ERNiCrFe-7, ERNiCrFe-7A, EQNiCrFe-7, EQNiCrFe-7A
Steam Generators		
SG tubes	See Section 5.4.1.5	
SG tube supports	SA-240	Type 304/304L
Upper and Lower SG supports	SA-240	Type 304/304L
Integral steam plenum cap	SB-564	Alloy 690 (UNS N06690)
Nickel-based alloy weld filler material	SFA-5.11 SFA-5.14	ENiCrFe-7 ERNiCrFe-7, ERNiCrFe-7A, EQNiCrFe-7, EQNiCrFe-7A
Piping	See Table 5.4-3	
Piping supports		
Piping reducers and elbows		
RVVs and RRVs		
Refer to Table 6.1-3		
RCS Piping		
RCS injection line, CNV to RPV RCS discharge line, RPV to CNV RPV high point degasification line, RPV to CNV PZR spray supply line, CNV to RPV	SA-312	Grade TP304/304L
Stainless steel weld filler materials[2]	SFA 5.4 SFA 5.9	E308, E308L, E316, E316L ER308, ER308L, ER316, ER316L
RCS piping reducers and elbows	SA-479	Type 304/304L
Tee connection to ECCS reset valves	SA-182	Grade F304/F304L
Reactor Safety Valves		
Refer to Table 6.1-3		
RCS Piping Supports		

RAI 03.06.02-17, RAI 03.06.02-17S2, RAI 03.06.02-17S4, RAI 05.02.04-3, RAI 05.03.01-3, RAI 05.04.02.01-6, RAI 06.06-3

Table 5.2-6: Reactor Pressure Vessel Inspection Elements

Description	Examination Category	Examination Method	Notes
RPV Shell and Head Welds			
Lower RPV flange shell to RPV bottom head Upper RPV flanged transition shell to lower SG shell Lower SG shell to upper SG shell Upper SG shell to integral steam plenum Integral steam plenum to PZR shell PZR shell to RPV top head Steam plenum cap to integral steam plenum	B-A	Volumetric	
RPV Internal Welds			
Core support block to RPV bottom head Core support block to latch Core barrel guide to lower RPV flange shell Upper SG support to lower RPV integral steam plenum Lower SG support to upper RPV	B-N-2	VT-3	
Instrumentation and Controls Sleeve Welds	None	None	These welds are part of the cladding.
Flow diverter to RPV lower head RPV interior surfaces and attachment welds	B-N-1	VT-3	B-N-1 is for the space above and below the core made accessible by removal of components during a normal refueling outage
RPV External Welds			
RPV support plate to RPV support gussets RPV support plate to upper RPV SG shell 1-4	F-A	VT-3	
RPV support plate to upper RPV SG shell RPV support gussets to upper RPV SG shell RPV lateral support lug	B-K	Surface or Volumetric	
RPV Nozzle to Shell and Head Welds			
Reactor recirc valve flange Feedwater nozzles RCS discharge	B-D	Volumetric	Inside corner. All welds examination requirement IWB-2500-7(d).
Main steam nozzles	B-D	Volumetric	Examination requirement IWB-2500-7(d)
RCS injection PZR spray supply lines	B-D	N/A	No inside corner

Table 5.2-6: Reactor Pressure Vessel Inspection Elements (Continued)

Description	Examination Category	Examination Method	Notes
Reactor vent valve flange Reactor safety valves RPV high point degasification CRDM nozzles	B-D	None	Inside corner region examinations are not required for pressurizer nozzles by ASME BPV-C, Section XI. Therefore, these nozzles are exempted from inspection given the nozzles have the same functionality and consequences as traditional pressurizer nozzles region of the vessel.
PZR heater access ports I&C - Channels	B-D	Not required	See ASME BPVC, Section XI, Table IWB-2500-1 (B-D) Note 1.
Feedwater plenum access ports Main steam plenum access ports	B-D	Volumetric	Examination requirement IWB-2500-7(b) Examination requirement IWB-2500-7(c) All welds, no inside corner
PZR pressure taps T-Hot thermowells PZR liquid temp thermowells PZR T-Hot thermowells Ultrasonic testing sensor nozzles	B-D	Volumetric	Examination requirement IWB-2500-7(a) Examination requirement IWB-2500-7(a) Examination requirement IWB-2500-7(a) Examination requirement IWB-2500-7(a) Examination requirement IWB-2500-7(b) All welds, no inside corner, shell side exam only
Nozzle-to-Safe End Dissimilar Metal Welds			
Feedwater nozzle safe ends Main steam nozzle safe ends	B-F	Surface and Volumetric	
RCS injection safe end (inner and outer) RCS discharge safe end PZR spray supply safe end (outer) RPV high point degasification safe end	B-F	Surface	
PZR spray supply safe end (inner)	None	None	Open ended pipe
CRDM nozzle safe ends	B-O	Volumetric or Surface	
Threaded Fastener Threaded Inserts and Threaded Insert Welds			
RSV flanges I&C access ports PZR heater access ports Steam plenum access ports Feed plenum access ports RVV flanges RRV flanges	None	VT-1	No inspection requirement. Augmented to VT-1 when bolts are removed.

Table 5.2-6: Reactor Pressure Vessel Inspection Elements (Continued)

Description	Examination Category	Examination Method	Notes
Bolting			
RPV main flange bolts	B-G-1	See note	Per Note 1 of B-G-1, surface examination is permitted when bolts are removed.
RVV and RRV flange threaded fasteners	B-G-2, augmented	~~VT-1~~Volumetric	~~This inspection is required to be completed once every inspection interval. If the connection is not planned to be removed during the interval, a volumetric exam is required to be completed at least once per interval.~~Augmented inspection to follow the guidance of B-G-1. No sampling permitted. All threaded fasteners are subject to volumetric examination during the inspection interval.
RPV bolting two inches or less in diameter	B-G-2	VT-1	Examined if removed.
Assembled RPV			
RPV- assembled after refueling outage	B-P	VT-2	Per Section XI IWA-5241(c), leakage is continuously monitored in the CNV and constitutes a VT-2 examination.