RAIO-0318-59309

March 27, 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 Response to NRC Request for Additional Information No. 340 (eRAI No. 9358) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 340 (eRAI No. 9358)," dated January 26, 2018

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

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

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

Distribution: Omid Tabatabai, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Prosanta Chowdhury NRC, OWFN-8G9A

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

Enclosure 1:

NuScale 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:

In the NuScale design, breaks are not postulated at the flanged connections of the reactor vent valves (RVV) or the reactor recirculation valves (RRV) to the reactor vessel (RPV) nozzles. Justification for requesting the classification of these flanged connections to the reactor vessel as break exclusion zones follows (in order of the requested considerations):

1. Quantitative assessment of the probability of gross failure for the bolted flange connection - A review of commercial nuclear power plant operating experience identified no catastrophic failures of primary system bolted flange connections; this is based on a literature and Licensee Event Report (LER) search that was performed and identified no catastrophic failures of non-pipe components of the primary reactor coolant pressure boundary in more than 3000 critical-years of U.S. nuclear power plant operating history. The robust NuScale ECCS bolted flange design takes advantage of lessons learned and benefits from design improvements associated with these many years of commercial nuclear power plant operating experience. As discussed below in the response to Consideration 3, these design and material changes eliminate many potential degradation mechanisms. Further, the NuScale module design includes a containment evacuation system (CES), that maintains the containment pressure at less than 1 psia and therefore provides the means of detecting RCS leaks inside containment (see Consideration 4 for additional information on leak detection). The CES, along with in-service inspections provide assurance that potential failure mechanisms are detected before the onset of a catastrophic failure. Based on operating experience in which only leaks have been observed for bolted flange connections (i.e., no catastrophic failures), the likelihood of a leak progressing undetected to the point of catastrophic failure is estimated to be less than 1E-7 per year (based on NUREG-1829 and NRC Industry Average Parameter Estimates). As such, catastrophic failure of an ECCS bolted flange connection is judged to be a negligible contributor to the frequency of a LOCA, and gross failure is not a credible challenge to RPV integrity over the life of a NuScale plant.

---

2. Specific design stress and fatigue limits used to analyze the bolted flange connections for the RVVs and RRVs - The components that comprise these connections (valves, bolts, and nozzles) are classified as ASME Code Class 1, and are designed, fabricated, constructed, tested, and inspected in accordance with the ASME Boiler and Pressure Vessel Code (BPVC), Section III, Subsection NB, 2013 Edition. As described in FSAR Section 3.9.3, ASME BPVC defines the design stress and fatigue limits. NuScale Power Module ITAAC 02.01.02 confirms that ASME Code requirements are met.

3. Comprehensive Bolting Integrity Program - Each of the RVVs are bolted to flanged nozzles in the upper RPV head by 8 sets of studs, nuts, washers, and threaded inserts. Both RRVs are bolted to flanged nozzles in the upper RPV section by 8 sets of studs, nuts, washers, and threaded inserts. In each case, the studs, nuts, and washers are fabricated from precipitation-hardenable nickel-base alloy SB-637 UNS N07718, also known as Alloy 718.

The Alloy 718 studs, nuts, and washers for the RVVs and RRVs are ASME BPVC Class 1 threaded fasteners, subject to the requirements in NuScale FSAR Section 3.13.

Generic Letter (GL) 91-17 provides the NRC resolution of Generic Safety Issue (GSI) 29, "Bolting Degradation or Failure in Nuclear-Power Plants," referencing NUREG-1339 and EPRI NP-5769. GL-91-17 offers the following guidelines in implementing NUREG-1339 and EPRI NP-5676:

> *The staff agrees that an effective means of ensuring bolting reliability, as recommended in EPRI NP-5769, would be to develop and implement plant-specific bolting integrity programs that encompass all safety-related bolting. NUREG-1339 includes recommendations and guidelines for the content of a comprehensive bolting integrity program. EPRI NP-5769 provides additional details on bolting integrity. The plant-specific bolting integrity program could incorporate licensee's commitments for continuing actions made in response to the previously issued NRC bulletins and generic letters listed in NUREG-1339.*

Per GL 91-17, any bolting integrity programs in accordance with NUREG-1339 are developed and implemented by licensees. The list below summarizes the recommendations and guidelines from NUREG-1339 (with additional detail provided by EPRI NP-5769, as referenced in NUREG-1339), as well as related NRC bulletins and generic letters related to Alloy 718 bolting for RVVs and RRVs.

A. EPRI NP-5769, Volume 1, Section 1 provides a summary of industry programs (19 tasks), whose recommendations are assessed for Alloy 718 bolting for RVVs and RRVs.

B. EPRI NP-5769, Volume 1, Section 2 provides additional details for the industry planned programs (19 tasks), whose recommendations are assessed for RVV and RRV bolting.

C. EPRI NP-5769, Volume 1, Section 3 and Section 5 provide the methodology and results, respectively, for leak-before-break (LBB) criteria for pressure-retaining bolted joints. LBB applicability for RVV and RRV bolted joints is discussed in response to Consideration 4.

D. EPRI NP-5769, Volume 1, Section 4 provides screening criteria for stress corrosion cracking (SCC). Specifically, bolting materials with yield strength exceeding 150 ksi are screened to be susceptible to SCC. The minimum required room temperature yield strength of SB-637 UNS N07718 is 150 ksi. However, EPRI NP-5769 screening criteria is based on operating experience of high-nickel maraging steels and low-alloy quenched and tempered (LAQT) steels. Maraging steels and LAQT steels are iron-base alloys. Therefore, the 150 ksi screening criterion is not applicable to Alloy 718 bolting for RVVs and RRVs.

E. EPRI NP-5769, Volume 1, Section 6 lists recommendations to modify ASME BPVC requirements for bolts and threaded fasteners. NuScale is designed to the 2013 edition of ASME BPVC Section III and Section XI endorsed by 10 CFR 50.55a. Therefore, recommendations adopted by ASME BPVC are already reflected in the current ASME code for threaded fasteners. Section 6 contains no additional recommendations for Alloy 718 bolting for RVVs and RRVs.

F. EPRI NP-5769, Volume 1, Section 7 summarizes new NDE techniques for bolting. It concludes that cylindrically guided wave UT is suitable for most studs or bolts over a size range of 16 to 112 inches in length and 1 to 4.5 inches in diameter. The technique can detect crack defects as small as 0.05 inch deep in the threaded region of the bolt. This bolt size range encompasses the Alloy 718 studs for NuScale RVVs and RRVs. Section 7 contains no specific recommendations other than considering alternate NDE techniques. Since SCC is unlikely to develop in Alloy 718 studs for RVVs and RRVs (see Item J.2 below), additional NDE beyond ASME BPVC requirements are unnecessary. Nonetheless, augmented ISI requirements have been applied to these bolts as described in Consideration 5.

G. EPRI NP-5769, Volume 1, Section 8 recommends against the use of lubricants containing molybdenum sulfide due to SCC concerns. As stated in NuScale FSAR Section 3.13, lubricants containing molybdenum sulfide are prohibited for NuScale ASME Class 1, 2, and 3 threaded

fasteners. Therefore, this recommendation has already been adopted for Alloy 718 bolting for RVVs and RRVs.

H. EPRI NP-5769, Volume 1, Section 9 evaluates alternative bolting materials for high-nickel maraging steels and LAQT steels, including stainless steels such as Alloy A286, 17-4PH, Type 410 and nickel-base alloys such as Alloy 625, Alloy X750, and Alloy 718. In selecting Alloy 718 for RVVs and RRVs, NuScale considered the alternative materials. Alloy 718 bolting was chosen due to its combination of design allowables and SCC resistance from available bolting materials permitted by ASME BPVC Section NB-2128.

I. EPRI NP-5769, Volume 1, Section 10 lists the EPRI training packages for generic recommended bolting practice in accordance with EPRI TR-104213 and NUREG-1801 Rev. 2, Section XI.M18 Bolting Integrity Aging Management Program. The EPRI recommended bolting practice is to be implemented by licensees for pressure-retaining bolting including Alloy 718 for RVVs and RRVs, if it is not already implemented by the licensees.

J. EPRI NP-5769, Volume 1, Section 11 lists specific conclusions and recommendations from the aforementioned industry programs (19 tasks). Applicability to the Alloy 718 bolting for the NuScale RVVs and RRVs is addressed below.

a. Borated Water Corrosion (BWC): BWC is not a concern for nickel-base alloys. Alloy 718 bolting for RVVs and RRVs is not susceptible to BWC.

b. SCC: EPRI NP-6908-M summarizes SCC test results for Alloy X-750, Alloy 718, and Alloy A286 in BWR water at 550°F and PWR water at 650°F. Alloy 718 is resistant to SCC in both PWR and BWR water. To further improve SCC resistance, NuScale tightened the solution treatment temperature range prior to precipitation hardening to 1800°F to 1850°F. In addition, the RRV bolting will only be submerged in borated water during refueling at a much lower temperature than RCS operating temperature. The RVV bolting materials are not submerged in borated water as part of any normal operating condition. As stated in FSAR Section 3.13, lubricants containing molybdenum sulfide are prohibited from NuScale ASME Class 1, 2, and 3 threaded fasteners. Although limited SCC has been observed inside reactor vessel internals, SCC is unlikely for Alloy 718 bolting for the RVVs and RRVs.

c. Support and Embedded Bolting Degradation due to SCC: The 150 ksi specified yield strength screening criterion is for maraging steels and LAQT steels. It is not applicable to nickel-base Alloy 718 bolting for the RVVs and RRVs.

d. Pressure Boundary Bolting Integrity: LBB applicability for RVV and RRV bolted joints is discussed in response to Consideration 4.

e. Bolting Practice: EPRI recommended bolting practice in accordance with EPRI TR-104213 and NUREG-1801 Rev. 2, Section XI.M18 Bolting Integrity Aging Management Program is to be implemented by licensees if it is not already implemented for pressure-retaining bolting, including Alloy 718 for RVVs and RRVs.

f. Material Considerations: The use of Alloy 718 prevents boric acid corrosion when the bolting is submerged in borated water during plant startup and shutdown. Alloy 718 is not susceptible to thermal aging at RVV and RRV operating temperatures. As discussed above, SCC is unlikely for Alloy 718 studs for the RVVs and RRVs. Because Alloy 718 is a nonferrous material, impact and fracture toughness is not an issue for Alloy 718.

A review of the information bulletins in NUREG-1339 indicates that the affected bolting materials are related to maraging steels, LAQT steels, and Type 410 stainless steels. None of the incidents involved nickel-base alloys including Alloy 718. Therefore, the listed information bulletins in NUREG-1339 are not relevant to Alloy 718 bolting for the RVVs and RRVs.

In summary, this assessment shows that applicable guidelines and recommendations in NUREG-1339 have been adopted by NuScale. Lubricants containing molybdenum sulfide are prohibited for pressure-retaining bolted joints including the RVV and RRV joints. EPRI recommended bolting practice is to be implemented for pressure-retaining bolted joints including RVV and RRV joints if it is not already implemented by the licensees. Of the degradation mechanisms listed in NUREG-1339, only SCC could affect RVV and RRV bolted joints. Alloy 718 was selected due to its SCC resistance in borated water. To further improve Alloy 718 SCC resistance, the solution treatment temperature range prior to precipitation hardening treatment is restricted to 1800°F to 1850°F. In addition, the RRV bolting will only be submerged in borated water during refueling at a much lower temperature than RCS operating temperature, further reducing SCC susceptibility. The RVV bolting materials are not submerged in borated water as part of any normal operating condition. Based on these considerations, SCC is unlikely for Alloy 718 studs for RVVs and RRVs. Therefore, a further comprehensive bolting integrity program beyond that defined by FSAR Section 3.13 requirements, including

applicable inservice requirements for threaded fasteners, is not necessary for the RVVs and RRV bolted joints. Nonetheless, augmented ISI requirements have been applied to these bolts as described in Consideration 5.

4. Local leakage detection to provide indication of leakage before gross bolt failure, such that the plant can shut down - Bolted flange leakage quantification through numerical analysis is complicated because it is affected by many parameters, such as the number of bolts, bolt dimensions, bolt material, bolt preload, internal pressure, gasket geometry, gasket material nonlinearity, flange stiffness, flange geometry, contained fluid conditions, and etc.

EPRI NP-5769, Section III Volume 1, Section 3 proposes a leak-before-break approach to ensure integrity of a bolted closure, because “carbon steel fasteners can become degraded as a result of prolonged contact with primary coolant water at elevated temperatures.” This approach has been applied to primary manway covers with 16/20 studs, reactor coolant pump main flanges with 16 studs, and check valves with 12/16 studs. Finite Element Analysis (FEA) has been used to predict the amount of flange cover separation due to bolt failure. Henry-Fauske’s critical flow model has been used to predict the leak rate. It was concluded that "integrity can be assured by monitoring closure leakage in excess of operational limits." Adequate safety margins can be demonstrated provided that the closure damage is localized.

NuScale RRV and RVV bolting material is SB-637, N07718 which is SCC resistant and, as stated in Consideration 3, fracture toughness is not an issue for Alloy 718. Additionally, the bolts do not experience prolonged contact with primary coolant water at elevated temperatures. The flange bolting is sized with safety margins as required by the ASME BVPC Appendix E. FSAR Section 3.6.3 and FSAR Section 5.2.5 describe how the reactor coolant pressure boundary leakage detection systems conform to the sensitivity and response time recommended in Regulatory Guide 1.45, Revision 1. Leakage monitoring is provided by two means, change in pressure within the CNV and collected condensate from the containment evaluation system. Even under a scenario that leakage occurs due to one or more postulated bolt breaks, NuScale containment leakage monitoring systems are sensitive to a leak rate as low as 0.01 lbm per minute (or ~0.001 gallon per minute) because the containment is a relatively small closed volume compared to large plants and is maintained at a pressure of less than 1 psia during normal operation. Compared to LBB leakage through other postulated cracks, the flange opening slit (if any) has a smoother flow surface (lower surface roughness compared to the crack morphology of fatigue cracks), and a straighter flow path that causes much less pressure loss through the flow path in the Henry-Fauske’s flow model. Therefore it is expected to result in a higher leak rate than through other postulated LBB fatigue cracks, when other conditions are similar.

5. Augmented fabrication and in-service bolting inspections - These have been

added for the flange bolts of the RRVs and the RVVs. The augmented fabrication inspections include surface and volumetric inspections for the RRV and RVV flange bolts. For in-service inspection, if the connection is disassembled during the interval, a VT-1 inspection is performed on the bolts. If the connection is not planned to be disassembled during the inspection interval, a volumetric inspection of the connection is performed. This augmented ISI requirement ensures that the flange bolts are examined at least once an interval without requiring disassembly. Changes to the RRV and RVV bolt inspection requirements are shown in the attached revision to FSAR Section 3.13.2, FSAR Table 3.13-1, and FSAR Table 5.2-6.

In summary, as discussed in FSAR Section 6.3.2, the ECCS bolted flange connection meets applicable industry codes and standards, and regulatory requirements commensurate with its safety functions. The components of the ECCS valves are Quality Group A, Seismic Category I designed to the requirements of ASME BPVC, Section III, Subsection NB, 2013 Edition. The design takes advantage of lessons learned and benefits from design improvements associated with many years of commercial nuclear power plant operating experience. Consideration 4 describes how the reactor coolant pressure boundary leakage detection systems conform to the sensitivity and response time recommended in Regulatory Guide 1.45, Revision 1. The pressure in the CNV is continually monitored by operators. High containment pressure is also a safety actuation signal that initiates a reactor trip. Leak detection systems along with inservice inspections provide assurance that potential failure mechanisms are detected before the onset of a catastrophic failure involving the fasteners of the bolted flange connections for the RRVs and RVVs.

Impact on DCA:

The FSAR Tier 2, Section 3.6.2.5, Section 3.13.2, Table 3.13-1, Table 5.2-6 and Table 5.2-8 have been revised as described in the response above and as shown in the markup provided in this response.

chosen because the DHRS cannot be isolated from the CNV as there are no isolation valves.

In accordance with BTP 3-4 Section B.A.(ii), breaks are not postulated in this segment of piping because it meets the design criteria of the Section III of the ASME Boiler and Pressure Vessel Code, Subarticle NE-1120 and the following seven criteria:

1) The DHRS lines do not exceed the following design stress and fatigue limits:

   a) The maximum stress ranges as calculated by the sum of equations (9) and (10) in Paragraph NC-3653, Section III of the ASME Boiler and Pressure Vessel Code, do not exceed $0.8(1.8\ S_h + S_A)$.

   b) The maximum stress, as calculated by Section III of the ASME Boiler and Pressure Vessel Code, paragraph NC-3653 equation (9) under the loadings resulting from a postulated piping rupture of fluid system piping beyond these portions of piping, does not exceed $2.25\ S_h$ and $1.8\ S_y$.

2) There are no welded attachments for pipe supports. Other welded features (thermowells, branch lines) within the piping segment have been minimized and are qualified using detailed stress analysis.

3) There are no longitudinal welds in this piping. Circumferential welds have been minimized to the extent possible. Piping bends are used in place of welded fittings where space allows.

4) The length of the piping is the minimum practical, considering that bends and jogs have been added to reduce the thermal stresses in the system.

5) There are no pipe anchors or restraints welded to the surface of the pipe.

6) Guard pipes are not used.

7) The welds are included in the ISI program as described in Section 6.6.

RAI 03.06.02-17

Connection of Reactor Vent Valves and Reactor Recirculation Valves to the Reactor Vessel

In the NuScale design, each of three Reactor Vent Valves (RVVs) and each of two Reactor Recirculation Valves (RRVs) bolt directly to Reactor Vessel nozzles. These five bolted flange connections are classified as break exclusion areas. Because this break exclusion area does not include a physical piping length, a majority of the BTP 3-4 B.A.(ii) criteria do not apply. However, similar to the augmented ISI requirements given for piping welds in BTP 3-4 B.A.(ii), augmented ISI requirements are specified for the bolts of these flanged connections to ensure they are inspected at least once per interval (Section3.13.2).

respectively. CMTRs for ASME Section III Class 1, 2, and 3 threaded fasteners will be retained in accordance with 10 CFR 50.71.

3.13.2 Inservice Inspection Requirements

RAI 03.06.02-17

Inservice Inspection for ASME Class 1, 2, and 3 threaded fasteners is in accordance with the ASME BPVC, Section XI (Reference 3.13-5) (see Table 3.13-2), as required by 10 CFR 50.55a, except where specific written relief has been granted by the NRC. Inservice inspection requirements for bolting associated with the RPV are provided in Table 5.2-6.

RAI 03.13-3

COL Item 3.13-1: A COL applicant that references the NuScale Power Plant design certification will provide an in-service inspection program for ASME Class 1, 2 and 3 threaded fasteners. The program will identify the applicable edition and addenda of ASME Boiler and Pressure Vessel Code, Section XI and ensure compliance with 10 CFR 50.55a.

3.13.3 References

3.13-1 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, 2013 Edition, Section III, "Rules for Construction of Nuclear Facility Components," American Society of Mechanical Engineers.

3.13-2 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, 2013 Edition, Section II, "Materials," American Society of Mechanical Engineers.

3.13-3 A. R. McIlree, "Degradation of High Strength Austenitic Alloys X-750, 718 and A286 in Nuclear Power Systems," 1st International Symposium on Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors, NACE, 1984.

3.13-4 U.S. Nuclear Regulatory Commission, “Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants,” NUREG-1339, June 1990.

3.13-5 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, 2013 Edition, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," American Society of Mechanical Engineers.

3.13-6 Electric Power Research Institute, “Boric Acid Corrosion Evaluation (BACE) Program, Phase - Task 1 Report,” TR-101108, Palo Alto, CA, December 1993.

3.13-7 Electric Power Research Institute, “Boric Acid Corrosion of Carbon and Low Alloy Steel Pressure Boundary Components in PWRs,” NP- 5985, Palo Alto, CA., August 1988.

RAI 03.06.02-17

Table 3.13-1: ASME BPV Code Section III Criteria for Selection and Testing of Bolted Materials

Code Category		ASME Class 1 Criteria	ASME Class 2 Criteria	ASME Class 3 Criteria
Material Selection		NCA-1220 and NB-2128	NCA-1220 and NC-2128	NCA-1220 and ND-2128
Material test coupons and specimens for ferritic steel material (tensile test criteria)	Heat Treatment Criteria	NB-2210	NC-2210	ND-2210
	Test coupons requirements bolting and studing materials	NB-2221 NB-2224	NC-2221 NC-2224.3	ND-2221 ND-2224.3
Fracture toughness requirements	Materials to be impact tested	NB-2311	NC-2311	ND-2311
	Types of impact test	NB-2321	NC-2321	ND-2321
	Test coupons	NB-2322	NC-2322	ND-2322
	Acceptance standards	NB-2333	NC-2332.3	ND-2333
	Number of impact tests necessary	NB-2345	NC-2345	ND-2345
	Retesting	NB-2350	NC-2352	ND-2352
	Calibration of test equipment	NB-2360	NC-2360	ND-2360
Examination criteria for bolts, studs, and nuts		NB-2580	NC-2580	ND-2580
Certified material test report criteria		NCA-3860	NCA-3860	NCA-3860

Note 1: Section III paragraphs listed in this table represent those specified in the 2013 Edition of Section III.

Note 2: The threaded fasteners for the RVV and RRV connections shall be inspected per NB-2581 and NB-2583 or NB-2584. Additionally the threaded fasteners shall be inspected as per NB-2586 after threading.

RAI 03.06.02-17, 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
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 threaded fasteners	B-G-2	VT-1	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.
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.

RAI 03.06.02-17, RAI 03.08.02-14

Table 5.2-8: American Society of Mechanical Engineers Class 1 Piping Inspection Elements

Description	Examination Category	Examination Method	Notes
Dual valve, single body isolation valve to safe-end	B-J	Surface and Volumetric	Refer to Section 5.2.4.1 for discussion on welds between the containment and the dual valve, single body CIVs.
CRDM nozzles	B-J	Surface or Volumetric	
RCS discharge piping and RPV nozzle safe end to piping RCS discharge piping to excess flow check valve and containment safe end (inside containment) RCS injection piping and RPV nozzle safe end to piping RCS injection piping to excess flow check valve and containment safe end (inside containment) PZR spray piping and RPV nozzle safe end to piping PZR spray piping to excess flow check valve and containment safe end (inside containment) RPV high point degasification piping and RPV nozzle safe end to piping RPV high point degasification to excess flow check valve and containment safe end (inside containment)	B-J	Surface	
RRV and RVV trip-reset actuators to safe ends RRV and RVV trip-reset actuators piping and fitting welds	B-J	None	Exempted by ASME BPVC Section XI, Paragraph IWB-1220 due to small size of piping and fittings.
~~RRV and RVV bolts~~	~~B-G-2~~	~~VT-1~~	~~Inspection is only required when disassembled.~~