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February 27, 2019

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

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,

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

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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:

The following information supplements that provided in the earlier responses to RAI 9358 Question 03.06.02-17 as transmitted by NuScale letters RAIO-0318-59309, 3/27/2018 (initial response), RAIO-0918-61767, 9/13/2018 (Supplement 1), RAIO-1118-62971, 11/15/2018 (Supplement 2), RAIO-1218-63846, 12/13/18 (Supplement 3), and RAIO-0119-64247, 1/22/19 (Supplement 4).

A brief recap of the RAI 9358 Question 03.06.02-17 supplemental response history follows: Supplement 1 - During a May 1, 2018 public call the NRC stated that the ECCS valve flange bolts should be designed to more conservative stress and fatigue criteria than the ASME code, similar to the break postulation criteria of the BTP 3-4. NuScale agreed to supplement its response to address the application of more conservative design criteria.

Also during the call NRC expressed concern with NuScale not performing ultrasonic testing (UT) examination of removed flange bolts, because of industry experience with VT1 inspection missing bolting flaws. NuScale subsequently agreed to supplement its RAI response either with additional justification for the VT1 versus UT bolt examinations or to change the VT1 exam to a UT exam.

And, the NRC questioned whether potential leakage from the bolted flange connection could disrupt ECCS system operations, including if induced vibrations could cause damage. NuScale was asked if bolted flange leakage is categorized and controlled by the Technical Specifications. NuScale agreed to further supplement its RAI response to address these additional concerns.

Supplement 2 - During a public clarification call on 10/16/2018, the NRC indicated that ECCS valve actuation should be considered normal operation for the ECCS valves, and the associated dynamic load evaluated to service level A or service level B. NuScale agreed to evaluate the NRC position and provide more information in a supplemental response.

Supplement 3 - During an October 31, 2018 public call the NRC noted that the supplemental response to RAI 9358 Question 03.06.02-17 (Supplement 1 above) indicated that ‘RVVs and RRVs are within the scope of the NuScale CVAP.’ NuScale stated that RRVs were evaluated for susceptibility to acoustic resonance, and subsequently found to be acceptable. ‘Therefore, due to their inclusion in the CVAP, ECCS valves do not require additional margin in CUF limits to account for possible vibration loading.’ Given this conclusion, NRC requested that a discussion be added to the CVAP technical report relative to this ECCS valve evaluation to acoustic resonance.

Supplement 4 - During an January 3, 2019 public call the NRC noted that the revision made to Table 5.2-6 "Reactor Pressure Vessel Inspection Elements" for the Reactor Vent Valve (RVV) and the Reactor Recirculation Valve (RRV) flange threaded fasteners did not clearly enough specify that all of the flange bolts are subject to volumetric examination during the periodic inspection cycle. Additionally, the discussion in FSAR Section 3.6 describing the RRV and RVV attachment to the RPV as an integrated flange resulted in inconsistencies with FSAR Section 5.2.2.5 and FSAR Table 5.2-4 and Table 5.2-6. NuScale agreed to resolve these issues with a supplemental response.

Supplement 5 - On a public conference call with the NRC on February 6, 2019, NuScale and the NRC discussed including key technical justifications for the break exclusion at the RVV/RRV bolted connections to the FSAR consistent with the earlier responses to this RAI 9358 question (including supplements). NuScale agreed to this FSAR addition with a further supplemental response.

Response to Question 03.06.02-17 Supplement 5 -

The FSAR Section 3.6.2.7 subsection "Connection of Reactor Vent Valves and Reactor Recirculation Valves to the Reactor Vessel" has been replaced in its entirety by the following.

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

In the NuScale design, each of three RVVs and two RRVs bolt directly to reactor vessel nozzles. These five bolted-flange connections are classified as break exclusion areas because this configuration does not include a physical piping length, and therefore, a majority of the BTP 3-4 B.A (ii) criteria do not apply. However, these BTP 3-4 B.A (ii) criteria generically involve design stress and fatigue limits and in-service inspection (ISI) guidelines, which are addressed for these bolted connections below.

Additionally, discussion is provided regarding threaded fastener design and leakage detection, to demonstrate that the probability of gross rupture is extremely low. The leakage detection systems along with in-service 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, and therefore, that a break at this location need not be postulated.

Design Stress and Fatigue Limits

BTP 3-4 B.A(ii)(1) specifies more conservative stress and fatigue limits for ASME Class 1 piping in containment penetration areas than those required for piping by ASME Code, Section III, NB-3653. The bases for these is a desire to limit the stresses resulting from service loads (excluding those due to peak stresses) to within the material yield strength (i.e., elastic strains), and a concern that the cumulative usage factor calculation account for the possibility of a faulty design, improperly controlled fabrication, installation errors, and unexpected modes of operation, vibration, and other structural degradation mechanisms.

The RVV and RRV bolted connections are not classified as piping by their design specifications, and instead are classified as components designed to the rules of NB-3200. For the RVV and RRV bolt material (SB-637 UNS N07718), the design criteria given in NB-3230 for bolting provides greater margin against yielding due to service loads than do the rules of NB-3653 for typical piping system materials, even when considering the more restrictive limits of BTP 3-4 B.A(ii)(1). Therefore, the imposition of more conservative stress limits are not justified.

Additional limits on CUF are not justified because the risk of a faulty design and fabrication and installation errors for a flanged connection is low compared to that of a piping system. The possible degradation mechanisms applicable to Class 1 piping systems do not apply to the ECCS valve bolts. These considerations are addressed further below.

Faulty design is not a concern for the RVV and RRV flanges as the design features for these flanged connections that affect the stresses in the bolts are the number and size of the bolts used, which are selected based on industry standards (ASME B16.5). The RVV and RRV flanged connections consist of Class 2500 NPS 5 and NPS 2 B16.5 flange configurations, respectively. ASME B16.5, “Pipe Flanges and Flanged Fittings,” has a history of reliability. In addition to conforming to an industry standard design, detailed analysis is required to validate the design per ASME BPVC Section III, NB-3230, including a fatigue evaluation. The fatigue evaluation for these bolts utilizes the fatigue curve from ASME Section III, Division I, Mandatory Appendix I, Figure I-9.7. Figure I-9.7 was generated specifically for small diameter bolting made of SB-637 UNS N07718. Also, as required by NB-3230.3(c) for high strength bolting, a fatigue strength reduction factor of no less than 4.0 is applied to the bolts. The fatigue strength reduction factor specified for bolting further reduces the risk of a faulty design for the RVV and RRV bolting, as compared to ASME Class 1 piping systems.

To address fabrication concerns, additional surface and UT examinations, beyond the ASME code requirements for these components, have been specified to properly control fabrication. Bolts analyzed using NB-3232.3(b) have further requirements as stated in NB-3232.3(b)(2) and

(3) that place controls on fabrication, by specifying both a minimum thread root radius and minimum radius between the head and shank, thus ensuring that the specified fatigue strength reduction factor used in the calculation of CUF is sufficiently conservative.

Unexpected modes of operation for piping systems in the nuclear industry generally involve thermal stratification, cycling, and striping. These situations do not apply to the valve locations. Unexpected vibration is another common concern, however, the RVVs and RRVs are within the scope of the NuScale Comprehensive Vibration Assessment Program (CVAP). As described in TR-0716-50439, “NuScale Comprehensive Vibration Assessment Program Technical Report,” the CVAP ensures that the structural components of the NPM exposed to fluid flow are precluded from the detrimental effects of flow induced vibration (FIV).

Other degradation mechanisms that have contributed to past piping failures and not already discussed are addressed below. Included is an explanation as to why these mechanisms are less likely to occur in the RVV and RRV valves than in a typical piping system.

- Corrosion - Not applicable as suitable materials have been selected and the bolts are not exposed to fluid.
- Erosion/ Flow Assisted Corrosion - Not applicable as there is no flow through these valves during normal operation and the bolts themselves are not exposed to fluid.
- Stress Corrosion Cracking (SCC) - Not applicable as suitable materials have been selected and the bolts themselves are not exposed to fluid.
- Water Hammer - Water hammer is not credible because there is no downstream piping and the valves discharge into a vacuum. Additionally, functional testing is performed for these valves including the dynamic effects of blowdown. Blowdown is classified as a service level B load in the ASME loading combinations for the valves, and therefore is included in the fatigue evaluations of the bolts.

<u>In-Service Inspection</u>

BTP 3-4 B.A(ii)(1) states that a 100% volumetric in-service examination of all pipe welds should be conducted during each inspection interval as defined in ASME Code, Section XI, IWA-2400. This requirement is addressed for the RVV and RRV bolting by providing augmented ISI requirements for these bolts that address the Code requirements. For in-service inspection, if the connection is disassembled during the interval, a UT inspection is performed on the bolts (Section 3.13.2). If the connection is not disassembled during the inspection interval, a volumetric inspection of the connection is performed in-place. Additionally, exceptions in the ASME code for flanged connections that allow only a sample of bolting to be inspected are not

followed, and instead all flange bolts for all RVVs and RRVs are inspected at each inspection interval.

Bolting Design

The 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. Of the degradation mechanisms listed in NUREG-1339, only SCC could potentially affect RVV and RRV bolted joints. Alloy 718 is highly resistant to SCC 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. Additionally, the RRV bolting is submerged in borated water only 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. Bolting design is discussed further in DCD Section 3.13.

Leakage Detection

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, the change in pressure within the CNV and collected condensate from the containment evaluation system. Even under a scenario where leakage occurs due to one or more postulated bolt breaks, containment leakage monitoring systems are sensitive to a leak rate as low as 0.01 lbm per minute (or ~0.001 gallon per minute). This is because the containment is a relatively small closed volume 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 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. High containment pressure is also a safety actuation signal that initiates a reactor trip.

Impact on DCA:

The FSAR Tier 2, Section 3.6.2.7 has 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.

RAI 03.06.02-6

Breaks are not postulated in this segment of piping because it meets the design criteria for break exclusion in a containment penetration area (see Section 3.6.2.1.2). Although the DHRS condenser is manufactured from piping products, it is considered a major component and not a piping system, thus breaks are not postulated.

RAI 03.06.02-6, RAI 03.06.02-17, RAI 03.06.02-17S2

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

RAI 03.06.02-17S5

~~In the NuScale design, each of three RVVs and each of two reactor recirculation valves 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 (Section 3.13.2).~~In the NuScale design, each of three RVVs and two RRVs bolt directly to reactor vessel nozzles. These five bolted-flange connections are classified as break exclusion areas. Because this configuration does not include a physical piping length, a majority of the BTP 3-4 B.A (ii) criteria do not apply. However, these BTP 3-4 B.A (ii) criteria generically involve design stress and fatigue limits and in-service inspection (ISI) guidelines, which are addressed for these bolted connections below.

RAI 03.06.02-17S5

Additionally, discussion is provided regarding threaded fastener design and leakage detection, to demonstrate that the probability of gross rupture is extremely low. The leakage detection systems along with in-service 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, and therefore, that a break at this location need not be postulated.

RAI 03.06.02-17S5

Design Stress and Fatigue Limits

RAI 03.06.02-17S5

BTP 3-4 B.A(ii)(1) specifies more conservative stress and fatigue limits for ASME Class 1 piping in containment penetration areas than those required for piping by ASME Code, Section III, NB-3653. The bases for these is a desire to limit the stresses resulting from service loads (excluding those due to peak stresses) to within the material yield strength (i.e., elastic strains), and a concern that the cumulative usage factor calculation account for the possibility of a faulty design, improperly controlled fabrication, installation errors, and unexpected modes of operation, vibration, and other structural degradation mechanisms.

RAI 03.06.02-17S5

The RVV and RRV bolted connections are not classified as piping by their design specifications, and instead are classified as components designed to the rules of NB-3200. For the RVV and RRV bolt material (SB-637 UNS N07718), the design criteria given in NB-3230 for bolting provides greater margin against yielding due to service loads than do the rules of NB-3653 for typical piping system materials, even when considering the more restrictive limits of BTP 3-4 B.A(ii)(1). Therefore, the imposition of more conservative stress limits are not justified.

RAI 03.06.02-17S5

Additional limits on CUF are not justified because the risk of a faulty design and fabrication and installation errors for a flanged connection is low compared to that of a piping system. The possible degradation mechanisms applicable to Class 1 piping systems do not apply to the ECCS valve bolts. These considerations are addressed further below.

RAI 03.06.02-17S5

Faulty design is not a concern for the RVV and RRV flanges as the design features for these flanged connections that affect the stresses in the bolts are primarily the number and size of the bolts used, which are selected based on industry standards (ASME B16.5). The RVV and RRV flanged connections consist of Class 2500 NPS 5 and NPS 2 B16.5 flange configurations, respectively. ASME B16.5, "Pipe Flanges and Flanged Fittings," has a history of reliability. In addition to conforming to an industry standard design, detailed analysis is required to validate the design per ASME BPVC Section III, NB-3230, including a fatigue evaluation. The fatigue evaluation for these bolts utilizes the fatigue curve from ASME Section III, Division I, Mandatory Appendix I, Figure I-9.7. Figure I-9.7 was generated specifically for small diameter bolting made of SB-637 UNS N07718. Also, as required by NB-3230.3(c) for high strength bolting, a fatigue strength reduction factor of no less than 4.0 is applied to the bolts. The fatigue strength reduction factor specified for bolting further reduces the risk of a faulty design for the RVV and RRV bolting, as compared to ASME Class 1 piping systems.

RAI 03.06.02-17S5

To address fabrication concerns, additional surface and UT examinations, beyond the ASME code requirements for these components, have been specified to properly control fabrication. Bolts analyzed using NB-3232.3(b) have further requirements as stated in NB-3232.3(b)(2) and (3) that place controls on fabrication, by specifying both a minimum thread root radius and minimum radius between the head and shank, thus ensuring that the specified fatigue strength reduction factor used in the calculation of CUF is sufficiently conservative.

RAI 03.06.02-17S5

Unexpected modes of operation for piping systems in the nuclear industry generally involve thermal stratification, cycling, and striping. These situations do not apply to these valves. Unexpected vibration is another common concern, however, the RVVs and RRVs are within the scope of the NuScale Comprehensive Vibration Assessment Program (CVAP). As described in TR-0716-50439, "NuScale Comprehensive Vibration

Assessment Program Technical Report," the CVAP ensures that the structural components of the NPM exposed to fluid flow are precluded from the detrimental effects of flow induced vibration (FIV).

RAI 03.06.02-17S5

Other degradation mechanisms that have contributed to past piping failures and not already discussed are addressed below. Included is an explanation as to why these mechanisms are less likely to occur in the RVV and RRV valves than in a typical piping system.

RAI 03.06.02-17S5

- Corrosion - Not applicable as suitable materials have been selected and the bolts are not exposed to fluid.

RAI 03.06.02-17S5

- Erosion/ Flow Assisted Corrosion - Not applicable as there is no flow through these valves during normal operation and the bolts themselves are not exposed to fluid.

RAI 03.06.02-17S5

- Stress Corrosion Cracking (SCC) - Not applicable as suitable materials have been selected and the bolts themselves are not exposed to fluid.

RAI 03.06.02-17S5

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RAI 03.06.02-17S5

In-Service Inspection

RAI 03.06.02-17S5

BTP 3-4 B.A(ii)(1) states that a 100% volumetric in-service examination of all pipe welds should be conducted during each inspection interval as defined in ASME Code, Section XI, IWA-2400. This requirement is addressed for the RVV and RRV bolting by providing augmented ISI requirements for these bolts that exceed the Code requirements. For in-service inspection, if the connection is disassembled during the interval, a UT inspection is performed on the bolts (Section 3.13.2). If the connection is not disassembled during the inspection interval, a volumetric inspection of the connection is performed in-place. Additionally, exceptions in the ASME code for flanged connections that allow only a sample of bolting to be inspected are not followed, and instead all flange bolts for all RVVs and RRVs are inspected during each inspection interval.

RAI 03.06.02-17S5

Threaded Fastener Design

RAI 03.06.02-17S5

The 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. Of the degradation mechanisms listed in NUREG-1339, only SCC could potentially affect RVV and RRV bolted joints. Alloy 718 is highly resistant to SCC 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. Additionally, the RRV bolting is submerged in borated water only 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. Threaded fastener design is discussed further in DCD Section 3.13.

RAI 03.06.02-17S5

Leakage Detection

RAI 03.06.02-17S5

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, the change in pressure within the CNV and collected condensate from the containment evacuation system. Even under a scenario where leakage occurs due to one or more postulated bolt breaks, containment leakage monitoring systems are sensitive to a leak rate as low as 0.01 lbm per minute (or ~0.001 gallon per minute). This is because the containment is a relatively small closed volume 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 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. High containment pressure is also a safety actuation signal that initiates a reactor trip.

3.6.3 Leak-Before-Break Evaluation Procedures

RAI 03.06.02-6

General Design Criterion 4 includes a provision that the dynamic effects associated with postulated pipe ruptures may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping. This analysis is called LBB. The LBB concept is based on the plant's ability to detect a leak in the piping components well before the onset of unstable crack growth.

For the NuScale Power Plant, the application of LBB is limited to the ASME Class 2 main steam and feedwater piping systems inside the CNV. The FWS piping analysis addresses significant feedwater cyclic transients and produces bounding loads for the ASME Class 2 piping with respect to LBB.

The methods and criteria to evaluate LBB are consistent with the guidance in Standard Review Plan 3.6.3 and NUREG-1061, Volume 3. Potential degradation mechanisms are