RAIO-0918-61767

Docket No. 52-048

September 13, 2018

U.S. Nuclear Regulatory Commission
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11555 Rockville Pike
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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
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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:

This information supplements the response to request for additional information (RAI) 9358 Question 03.06.02-17 provided by NuScale letter RAIO-0318-59309, dated March 27, 2018.

RAI 9358 question 03.06.02-17 states that the bolting for the reactor vent valve (RVV) and reactor recirculation valve (RRV) flanges is a piping terminal end, and that accordingly, per Branch Technical Position (BTP) 3-4, Section 2A(iii), breaks should be postulated at that location. The RAI further states that if the bolted connection of the RVVs and RRVs is to be considered a break exclusion area, then justification for why this connection provides an extremely low probability of gross rupture must also be provided for NRC staff review and acceptance. Because traditional methods used to demonstrate that the probability of gross rupture is extremely low are not directly applicable to bolts (e.g., leak before break (LBB) methodology, BTP 3-4 B.A(ii) break exclusion criteria), the NRC requested that NuScale develop a justification which would include a discussion of, among other things, specific design stress and fatigue limits and augmented test and inspection requirements. The response to this RAI addresses these items as follows:

- Design stress and fatigue limits for the bolts are in accordance with American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section III, Subsection NB, 2013 Edition, as these bolts are classified as ASME Code Class 1 components.

- Test and inspection requirements for the flange bolts are described. Augmented fabrication testing includes surface and volumetric inspections. Augmented in-service inspections include a requirement to perform volumetric inspection of the bolts if the connection is not planned to be disassembled during the inspection interval.

During a May 1, 2018 call the NRC stated that the 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.

Additionally, 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.

Each issue is addressed separately below.

Design and Fatigue Limits

BTP 3-4 B.A(ii)(1), gives the following stress and fatigue limits for ASME Class 1 piping in containment penetration areas:

- The maximum stress range between any two load sets should not exceed 2.4 S_m as calculated by Eq. (10) in ASME Code, Section III, NB-3653.
  - If the calculated maximum stress range of Eq. (10) exceeds 2.4 S_m, the stress ranges calculated by both Eq. (12) and Eq. (13) in NB-3653 should not exceed 2.4 S_m.
- The cumulative usage factor should be less than 0.1.

To determine the bases for the stress and fatigue limits presented in BTP 3-4, regulatory guidance that precedes BTP 3-4 was considered. Regulatory Guide 1.46, “Protection against Pipe Whip inside Containment,” which is now withdrawn, states the following bases:

> *The 'limits selected on this basis are elastically calculated primary plus secondary stress intensities of 2 S_m for ferritic steel and 2.4 S_m for austenitic steel. For stress intensity values calculated on an elastic basis that are 2 S_m or below in ferritic and 2.4 S_m or below in austenitic piping materials, the resulting strains in both materials are well within the 0.2% offset strain specified as the minimum yield strength by the applicable material specifications….*
>
> …
>
> *The limits on stress intensity and cumulative usage factor selected to determine piping break locations are based on the assumption that, despite the accepted conservatism in the ASME Code piping design rules, the system piping may suffer structural degradation of an unanticipated nature in service or may have its design margins unknowingly reduced by faulty design, improperly controlled fabrication, installation errors, or unexpected modes of operation. Therefore; the above limits provide additional margin over significant design basis stress cycles (for a 40-year plant life) which is available to account for these uncertainties*

From the discussion included in RG 1.46, the bases for the stress and cumulative usage factor limits can be summarized as:

- The stresses resulting from service loads (excluding those due to peak stresses) should be well within the material yield strength (i.e., elastic strains)
- The cumulative usage factor (CUF) should account for:

- Faulty design
- Improperly controlled fabrication and installation errors
- Unexpected modes of operation, vibration, and other structural degradation mechanisms

These bases are discussed separately below in relation to their applicability to the ECCS valve bolting configuration versus a typical piping system.

Stress Criteria

The limits on primary and secondary stress given in BTP 3-4 ensure that, after "shake down," the strains in the break exclusion area (excluding the effects of stress concentrations) are within the elastic limit. This is accomplished by the requirement that the stress as calculated by Eq. (10), or Eq. (12) and Eq. (13), in NB-3653 not exceed 2.4 Sm (i.e., 80% of the Code allowable). The majority of NuScale ASME Section III piping is SA-312 TP304, which at room temperature has S_y=30.0 ksi and S_m=20.0 ksi. Therefore, imposing a limit on the primary plus secondary stress range of 2.4 S_m allows a limit of 48.0 ksi, or 1.6 S_y. Alternating loads that remain below 2.0 S_y allow "shake down" to elastic action (i.e., after repetitive loading, a state is reached where plastic action is no longer produced), therefore an imposed limit of 1.6 S_y provides ample margin to non-recoverable yielding. Note that NB-3653.6 allows this limit to be applied separately to thermal loads and non-thermal primary and secondary stresses.

The stress limits for Class 1 bolts are contained in NB-3230 and include a limit on the maximum stress resulting from direct tension plus bending primary and secondary loads of 3.0 S_m. The RVV and RRV bolting material is SB-637 UNS N07718, which at room temperature has S_y=150.0 ksi and S_m=50.0 ksi. Imposing a limit on the primary plus secondary stress range of 3.0 S_m for this material allows a limit of 150.0 ksi, or 1.0 S_y. Therefore, for the RVV and RRV bolt material, the design criteria given in NB-3230 provides more margin against yielding 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).

The embedded margin against yielding in the bolting rules is implicit as there is no option given for simplified elastic-plastic analysis (i.e., no K_e factor). Additionally, the bolting criteria in NB-3230 do not allow for qualifying the thermal and non-thermal stresses separately (the calculated stresses for the 3.0 S_m limit must include loads due to preload, pressure, and differential thermal expansion), as is allowed for piping in NB-3653.6. Consequently, it is NuScale's position that the primary plus secondary stress limits as specified by ASME NB-3230 are sufficient for the RVV and RRV bolting and meet the intent of the guidance provided in BTP 3-4 for typical piping systems.

Effect of faulty design on CUF

The layout of piping involves the routing of complex systems of straight and curved pipe, tees, and other fittings. Additionally, piping systems are often supported by multiple structures with a variety of restraint types. Considerations that are made when designing a piping system include internal pressure, thermal expansion of long and complex piping runs, thermal movement of the supporting structures and the supporting structure flexibility characteristics. Mistreatment of one of these factors may lead to a faulty design. EPRI TR-110102, "Nuclear Reactor Piping Failures at US Commercial LWRs: 1961 - 1997," gives an example where the thermal expansion of a reactor vessel was neglected during the design of piping, leading to failure at the vessel nozzle due to interference between downstream piping and other structures. EPRI TR-110102 additionally discusses material selection and consideration of dynamic loads as being potential design errors that could lead to failure.

These concerns are related to a piping layout design and are not applicable to the design of the RVV and RRV as there is no piping attached to the downstream side of these valves. The design features for these flanged connections that affect the stresses in 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 particular for higher pressure classes for the range of flange sizes specified for the RVV and RRV.

In addition to conforming to a reliable 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, which 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.

Other design considerations involve material selection and consideration of dynamic loads. The material selection for these bolts has been discussed in the initial RAI response and is not in question. The only dynamic load applicable to this valve is ECCS actuation, which is included in the design load combinations for the bolting. However, as this load is classified as service level C, it does not contribute to fatigue usage. Additionally, the ECCS valves undergo qualification testing, which includes functional testing of the dynamic effects of valve blowdown, ensuring that this loading condition is characterized and the risk of faulty design is low.

Effect of improperly controlled fabrication and installation errors on CUF

As discussed in the initial RAI response, additional surface and UT examinations, beyond the ASME code requirements for these components, have been specified in order to properly control fabrication. Additionally, bolts analyzed using NB-3232.3(b) have further requirements as stated in NB-3232.3(b)(2) and (3) that place additional 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 conservative.

Installation errors in the context of typical piping systems can include misplaced supports and improperly adjusted snubbers and spring hangers, all of which can contribute to increased fatigue usage. These situations are not applicable to the RVV and RRVs as no physical piping segments or supports are required. Installation errors for the ECCS valve flanged connections are more likely incorrect gasket installation or misapplication of bolting torque. The incorrect installation of a gasket or insufficient bolt torque would likely result in immediate leakage during plant start-up. Conservatisms added to CUF limits do not preclude this type of failure. Leakage of this nature is detectable as discussed in the initial RAI response. As discussed in more detail in a subsequent section, 'Effects Due to Leakage at the Flanged Joint,' this type of leakage is acceptable and does not impair ECCS operation. Over-torque of the flange bolts is an installation error that could shorten their fatigue life. However, administrative controls, training of personnel and QC verifications ensure that procedures for torqueing are implemented correctly.

Effect of unexpected modes of operation, vibration and other degradation mechanisms on CUF

Unexpected modes of operation include thermal stratification, cycling, and striping. Historically, these have been known to cause failures in nuclear power plant piping. BTP 3-4 accounts for these types of occurrences with additional margin in CUF limits. These modes of operation are sufficiently considered in the NuScale design, as described in NuScale FSAR Sections 3.12.5.7 through 3.12.5.9. NuScale has determined that the RVVs and RRVs are not susceptible to these types of phenomena as they would be considered up-horizontal or horizontal pipes with no potential for in-leakage. The bolts are not in contact with the process fluid, therefore these types of phenomena, or any other unexpected fluid transients, do not produce severe nonlinear (i.e., peak) thermal gradients in the bolts, and the resultant increased fatigue usage.

Industry experience has shown that other degradation mechanisms are more likely to result in piping failures than the thermal fatigue scenarios described above, even though thermal fatigue is the primary contributor to CUF in ASME code calculations. One of the more prominent failure mechanisms, often unexpected and not included in ASME code piping calculations, is vibration fatigue. In the NuScale design, 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). The RVVs are located in the pressurizer steam space and are not exposed to flow, except during ECCS operation, and therefore have been screened out of the CVAP evaluation. Potential vibrations occurring during ECCS operation are addressed in a subsequent section of this response, ‘Effects Due to Leakage at the Flanged Joint.’ The RRVs, located off of the downcomer in the RCS, 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.

Other degradation mechanisms identified in EPRI TR-110102 and EPRI TR-1022873 that have contributed to past piping failures and not already discussed are addressed below. Included is an explanation as to why these mechanisms, as with thermal and vibration fatigue, 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 attached and the valves discharge into a vacuum. Additionally, functional testing is performed for these valves which includes the dynamic effects of blowdown.

Acceptability of Surface Exams for Small Bolting

The bolts for the RRVs and the RVVs are less than 2 inches in diameter and require a VT-1 exam once per interval only if bolting is removed, per ASME BPVC Section XI IWB-2500-1 B-G-2.

NuScale has stated that the bolting inspection will follow the ASME BPVC Section XI requirement that threaded fasteners for RRVs and RVVs require a VT-1 exam every interval if the connection is removed, and has added the augmented inspection requirement that 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 (See FSAR Table 5.2-6). NuScale has also committed to an augmented volumetric exam during fabrication per ASME BPVC Section III NB-2586 after threading (See FSAR Table 3.13-1).

The current ASME inspection requirements are sufficient for the bolting for the RRVs and the RVVs. NuScale Class 1 small bolt design includes use of materials that are corrosion resistant and have high resistance to fast fracture. Additionally, the NuScale design implements a sensitive containment leak detection system. These design features are addressed in the NuScale FSAR. Also, the bolts for the RRVs and RVVs are not located in primary or secondary coolant, and therefore, are not subject to degradation mechanisms such as primary water stress corrosion cracking or intergranular stress corrosion cracking. The primary failure mechanism of these bolts is excessive mechanical loading (e.g., mechanical service loads, overtorqueing). Any signs of degradation from excess mechanical loads (e.g. necking down, stripped threads, etc.) can be found with a VT-1 examination.

The inspection requirement for bolts greater than 2 inches in diameter is volumetric examination at each interval per ASME BPVC Section XI IWB-2500-1 B-G-1, or surface examination if the bolt is removed (See table B-G-1 note 7). Small sized components have fewer testing requirements because they have increased quality due to a higher degree of hot working, resulting in higher fracture toughness, fewer and smaller defects, and greater homogeneity. The ASME BPVC typically identifies that smaller products have a higher minimum yield strength than larger components. Smaller components are less likely to suffer from catastrophic brittle failures due to lower geometric constraints (i.e. plane stress vs. plane strain). Conversely, this indicates that the increased requirements (i.e. testing, examination, etc.) for large components by ASME BPVC are designed to compensate for the higher potential for defects and brittle failure. Compliance with the ASME BPVC, 10 CFR 50.55a and 10 CFR 50 Appendix A assures a high degree of quality and integrity for the structures, systems and components designed to these standards. Nonetheless, augmented inspection requirements have been added as described above. A more detailed discussion on small components is included in the NuScale response to RAI 9109, Question 06.06-1, as submitted by RAIO-1117-57257, November 17, 2017 and supplemented by RAIO-0618-60409, dated June 12, 2018.

Effects Due to Leakage at the Flanged Joint

The ECCS valves undergo qualification conducted by the COL applicant. This qualification is to include functional testing that includes the dynamic effects of valve blowdown (i.e., thrust loads from discharge). These dynamic effects bound the dynamic effects that occur during low differential pressure recirculation, such as vibration from a small gasket leak. The RRV and RVV bodies are rigid structures with natural frequencies greater than 100 Hz. Flow induced vibration effects with high frequency also have low amplitude, so excitation of the main valve body natural frequency is not significant relative to blowdown thrust loads.

During normal operation, leakage from an ECCS valve that develops during plant operation is classified as unidentified leakage. The containment leakage detection system has limited capabilities of identifying the specific source of leakage from a gasket during plant operation. The technical specifications ensure that the plant is not operated with significant leakage occurring from an RVV or RRV. Flow through the valve plus the gasket with a leak is similar to flow through the valve, since the flow through an open valve is several orders of magnitude greater than the parallel flow through a gasket leak. The small leakage that may be present during normal operation cannot significantly affect the pressures, velocities, and flows of ECCS operation.

A larger gasket leak could develop during normal operation, leading to a plant shutdown. This event is unlikely to result in ECCS actuation. However, if ECCS operation did occur with a larger gasket leak it would not be detrimental to long term performance of the ECCS system. A gasket leak acts as an additional parallel flow path at the same location of the ECCS valve. This provides additional ECCS flow, improving the recirculation performance of the system. Plant depressurization from a large gasket leak is bounded by FSAR Tier 2, Chapter 15 LOCA analyses. CVCS LOCAs have higher flowrates than are possible from a gasket leak at an ECCS valve. Injection line LOCAs are at a similar location to the RRVs, while highpoint degasification line LOCAs are at a similar location to the RVVs. Gasket leaks from the ECCS valves, RSVs, vessel flanges, or RPV manway flanges are not, and need not be, directly considered in Chapter 15. However, the plant impacts of such gasket leaks are bounded by the plant impacts of LOCAs, and operation of the plant with large gasket leaks is precluded by the technical specification limits on unidentified leakage.

Conclusions

More conservative stress and fatigue criteria, similar to that given for typical piping systems in BTP 3-4 B.A(ii)(1), are not required for the ECCS valve bolts, as the ASME code already contains conservative stress limits. The intent of the more conservative stress limits, to ensure margin to excessive yielding, is accomplished by compliance with the stress rules for bolting and the materials specified for the bolts. Additional limits on CUF are not required because the risk of a faulty design is low and the possible degradation mechanisms applicable to Class 1 piping systems do not apply to the ECCS valve bolts. Adding a factor of safety of ten to the CUF criteria (i.e., designing to 0.1 instead of 1.0 similar to the guidance of BTP 3-4 B.A.ii.1), would be overly restrictive for the analysis of bolts, which already includes a conservative fatigue strength reduction factor of 4.

As discussed in the initial RAI response, additional surface and UT examinations, beyond the code requirements for these components, have been specified in order to properly control fabrication and to ensure the bolts undergo in-service inspection during their inspection interval even if they are not removed. A VT-1 examination is acceptable based on the size of the ECCS valve bolting. Any signs of degradation from excess mechanical loads (e.g. necking down, stripped threads, etc.) would be found with a VT-1 examination.

In summary, the probability of gross rupture at the ECCS valve bolting locations is extremely low, given the lack of applicable bolt degradation mechanisms, sufficiently conservative design criteria, and the addition of augmented fabrication and in-service inspection requirements. In addition, the consequences of flange leakage, for any reason, are demonstrated to be insignificant.

References

1. Regulatory Guides 1.46, "Protection Against Pipe Whip Inside Containment," May 1973 (Withdrawn March 1985)
2. EPRI TR-110102, “Nuclear Reactor Piping Failures at US Commercial LWRs: 1961 - 1997,” December 1998
3. ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection NB, 2013 Edition
4. NUREG/CR-6260, “Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components”
5. EPRI TR-1022873, “Improved Basis and Requirements for Break Location Postulation,” October 2011

Impact on DCA:

There are no impacts to the DCA as a result of this response.