NuScaleDCRaisPEm Resource

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Sent: Friday, June 02, 2017 9:04 AM
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Subject: Request for Additional Information No. 42, RAI 8836
Attachments: Request for Additional Information No. 42 (eRAI No. 8836).pdf

Attached please find NRC staff's request for additional information concerning review of the NuScale Design Certification Application.

Please submit your response within 60 days of the date of this RAI to the NRC Document Control Desk.

If you have any questions, please contact me.

Thank you.

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Request for Additional Information No. 42 (eRAI No. 8836)

Issue Date: 06/01/2017
Application Title: NuScale Standard Design Certification - 52-048
Operating Company: NuScale Power, LLC
Docket No. 52-048
Review Section: 03.06.02 - Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping
Application Section: 3.6.2

QUESTIONS

03.06.02-1

General Design Criteria (GDC) 4, "Environmental and Dynamic Effects Design Bases," requires, in part, that structures, systems, and components (SSCs) important to safety be designed to accommodate the effects of postulated accidents, including protection against the dynamic effects of postulated pipe ruptures. SRP 3.6.2 and its associated BTP 3-4 provides, in part, guidelines acceptable to the staff for meeting these GDC 4 requirements.

To address its compliance with GDC 4 requirements, in NuScale FSAR Tier 2, Section 3.6, the applicant describes the criteria and method used in the NuScale design to mitigate the dynamic effects of postulated pipe ruptures. NuScale FSAR Section 3.6.5, "Integral Jet Impingement Shield and Pipe Whip Restraint," states that one method used in the NuScale design to mitigate the dynamic effects of postulated pipe rupture is installation of an integral shield restraint (ISR). Based on its review of the information described in the FSAR Sections 3.6.5, 3.6.5.1, and 3.6.5.2, the staff determined that additional information for ISR design, CFD analysis, and confirmation testing as described below are needed to ensure that ISR performs its intended function to mitigate the dynamic effects of postulated high-energy pipe ruptures in the NuScale design.

a. A typical ISR is shown in FSAR Figure 3-6-33 and Figure 3-6-34. However, FSAR Section 3.6.5 states that the ISR designs will continue to be developed to be compatible with the various configurations of piping where breaks are postulated and with the types of break which must be postulated , including longitudinal breaks, as the detailed piping analyses indicate they are required. The applicant is requested to provide more ISR design details to ensure they are compatible with the various piping configurations and with the types of breaks postulated and to provide the locations where the ISRs will be used.

b. NuScale FSAR Section 3.6.5.1, "Integral Jet Impingement Shield and Pipe Whip Restraint Computational Fluid Dynamics Analysis," states that computational fluid dynamics (CFD) models were developed for the flow exiting the ISR following the pipe break and were used to determine the effect on nearby components resulting from jet impingement. It also included some information related to the CFD analysis performed as well as the analysis results. However, the NRC staff found that more detailed CFD analysis information (including, but not limited to, definition of problem, geometric configuration and physical modeling assumed, range of conditions in the specified scenario including initial condition and boundary condition, iteration convergence criteria, and discretization of special mesh and time step used) are needed for the NRC staff's review to ensure that representative and appropriate CFD analysis has been performed for the plant specific ISR application in the NuScale design. The applicant is requested to provide the information described above.

c. NuScale FSAR Section 3.6.5.2, "Integral Jet impingement Shield and Pipe Whip Restraint Confirmatory Test Program," states that proof of concept testing is being performed to validate the analytical model and to demonstrate that the ISR performs its intended function as the NuScale ISR is a first-of-a-kind application to mitigate the dynamic effects of postulated high-energy pipe rupture in the nuclear power plant design. It further describes the test objectives, parameters to be measured, and some information related to the facility design. However, the NRC staff found that more detailed information (including, but not limited to, test facility design/configuration, and the test repeatability which includes instrumentation accuracy and potential uncertainty of test results) are needed to ensure that the prototypic testing performed is representative for the NuScale ISR design and application. In addition, the recorded test parameters/results are needed by the NRC staff to validate the ISR analytical model and demonstrate that the ISR performs its intended function to mitigate the dynamic effects of postulated high-energy pipe ruptures in the NuScale design. The applicant is to provide the information described above and the schedule of performing the ISR confirmatory testing, development of reports, and when the NRC staff will have access for review.

03.06.02-2

To address its compliance with GDC 4 requirements, in NuScale FSAR Tier 2, Section 3.6, the applicant describes the criteria used in the NuScale design for determining the postulated rupture locations. In NuScale FSAR Tier 2, Sections 3.6.2.1.2 and 3.6.2.5, the applicant identifies at certain locations where some design and inspection criteria are employed to preclude the need for breaks to be postulated. Those locations as identified in the FSAR Section 3.6.2.1.2 include the welds between the valve and the safe-end for CVCS RCS injection, RCS discharge, pressurizer spray, high point vent line and two FW lines. The NuScale design provides two isolation valves in a single valve body outside of containment welded to a CNV nozzle safe-end. The applicant states that the benefits of this approach include eliminating piping between valves and between the vessel and the valve. The applicant also states that the piping and valves are designed to preclude a breach of containment integrity in conformance with SRP 3.6.2 and its associated BTP 3-4.

In FSAR Section 3.6.2.1.2, the applicant also states that breaks are not postulated in the ASME Class 1 piping (i.e., the four CVCS reactor coolant system lines) from the CNV head to the first isolation valve, and the ASME Class 2 FW piping from containment to the first isolation valve in accordance with the staff's guidelines delineated in BTP 3-4, Part B, Item A(ii). In the FSAR, the applicant describes its specific design and inspection provision for those piping segments. Similarly, in the FSAR Section 3.6.2.5, the applicant describes how the break exclusion criteria are applied to the segments of piping between the MS and FW lines from containment to the penetration at the reactor pool wall (including tees to the DHRS) and the DHRS piping outside containment.

It should be noted that the NRC staff guidance as delineated in BTP 3-4 is intended to present a means of compliance with the requirements of GDC 4 for the design of nuclear power plants SSCs. For the fluid system piping in containment penetration areas (i.e., those portions of piping from containment wall to and including the inboard or outboard isolation valves), the NRC staff guidance as described in BTP 3-4, Part B, Item A(ii) provides certain design and inspection provisions to ensure an extremely low probability of pipe failure in these areas and allow breaks and cracks to be excluded from the design basis for those portions of piping.

Based on its review of the FSAR information described above, the NRC staff determined that the applicant has not provided adequate justification for its application of the break exclusion in the areas described above. In certain cases, the applicant expands the break exclusion area beyond those portions of piping in containment penetration areas as delineated in BTP 3-4, Part B, Item A(ii). It should be noted that FSAR Sections 3.6.2.1.2 and 3.6.2.5 primarily address the NuScale design and inspection requirement for system piping within the break exclusion area. To support the NRC staff's safety determination on the acceptability of the NuScale break exclusion areas identified in the above FSAR sections, the applicant should provide the following information to justify the departure from the pertinent BTP 3-4 staff guidance, particularly, how the FSAR break exclusion area design provisions are considered and applied to the results of the design of these portions of system piping including any associated welds:

a) For those portions of system piping in the break exclusion area, the applicant is to provide a figure for the detailed geometric configuration including the approximate length, any bends in the piping, welds, valves, and welded features and discuss how overall length is minimized to reduce the size of the break exclusion area and how piping bends and piping welds are utilized/minimized to reduce piping stress.

b) For those portions of system piping in the break exclusion area, the applicant is to provide a detailed piping analysis to demonstrate that for the piping and the associated welds, the design stress and the cumulative usage factor (for ASME Class 1 piping only) do not exceed the relevant stress and fatigue limit as delineated in FSAR Sections 3.6.2.1.2 and 3.6.2.5.

   NuScale FSAR Section 3.12 states that complete piping analyses have been performed for the class 1 RCS discharge line (NPS 2) and the class 2 FW (NPS 5) line up to the first 6-way rigid restraint beyond the containment isolation valve. FSAR 3.12 also implies that preliminary analyses have only been performed for the Class 1 RCS injection (NPS 2), the Class 2 MS (NPS 12) up to the first 6-way rigid restraint beyond the containment isolation valve and the DHRS lines. The applicant's preliminary analyses consider only deadweight, thermal expansion and seismic loads and does not consider the occasional loads including plant system operating transient loads. It should be noted that one of the design criteria for piping in the break exclusion area as described in FSAR Sections 3.6.2.1.2 and 3.6.2.5 is that calculated stresses due to sustained, occasional load, and thermal expansion, including an OBE event (if applicable) should not exceed 80% of allowable value per ASME Section III, NC Eqs. (9) + (10) which is consistent with the pertinent staff guidance delineated in BTP 3-4. With respect to the seismic loads, for NuScale design, the OBE is 1/3 of the SSE and therefore, the OBE is not included as design loading in ASME Section III, NC Eq. 9. With the elimination of OBE load, the applicable loads in NC Eq. 9 are pressure, dead weight, and any applicable occasional loads including plant system operating transient loads while the applicable loads in NC Eq. 10 are due to thermal expansion. The applicant is to justify why performing only preliminary piping analysis with the consideration of dead weight and thermal expansion (i.e., not considering any applicable occasional loads) is consistent with the NuScale FSAR break exclusion criteria as delineated in FSAR Sections 3.6.2.1.2 and 3.6.2.5.

c) NuScale FSAR Section 3.6.2.1.2 Item 1(c) states that for ASME Class 1 piping, the maximum stress, as calculated by Eq. 9 in Section III of the ASME NB-3652 under the loading resulting from a postulated piping rupture beyond these portions of piping, does not exceed 2.25 Sm and 1.8 Sy. This is consistent with the pertinent staff guidance delineated in BTP 3-4, Part B.A(ii)(1)(c), except that the FSAR criteria do not address the potential impact on the valve . For those portions of system piping in the break exclusion area, the applicant is to perform a detailed piping analysis to demonstrate that the piping design meets FSAR Section 3.6.2.1.2 Item 1(c) and the applicable valve design requirement is met in accordance with the criteria specified in SRP Section 3.9.3. Similarly, the applicant is to provide a detailed piping analysis for ASME Class 2 system piping identified in FSAR Sections 3.6.2.1.2, and 3.6.2.5

d) NuScale FSAR Sections 3.6.2.1.2 and 3.6.2.5 Item 7 refer to the ISI program for the weld inspection in the break exclusion area. However, it is not clear whether access provisions are made in the NuScale design to permit a 100% volumetric inservice examination of all the welds in the break exclusion area conducted during each inspection interval as defined in ASME Section XI, IWA-2400 as delineated in BTP 3-4, Part B, Item A(ii)(7). The applicant is to describe and clarify the access provision for the applicable weld examination as described above.

e) The applicant is to provide a discussion to clarify whether the break exclusion only applies to the pertinent main piping (i.e., breaks are postulated for its associated branch piping, if any). If branch piping is included in the break exclusion area, then items (a) through (d) above should be addressed for these piping segments as well.

03.06.02-3

NuScale FSAR Tier 2, Section 3.6.1.3, “Protection Methods,” states that as the piping analysis is finalized other protection methods (i.e., other than ISR) may be employed to protect against pipe whip and jet impingement. NuScale FSAR Tier 2, Section 3.6.1.3, “Protection Methods,” states that as the piping analysis is finalized other protection methods (i.e., other than ISR) may be employed to protect against pipe whip and jet impingement. The FSAR further states that these other protection methods may include equipment shields, barriers, and pipe whip restraints utilizing energy-absorbing structures. Moreover, it states that pipe whip and jet protection methods are developed when postulated breaks are identified that cannot utilize an ISR. However, the NRC staff found that the design criteria for the equipment shields, barriers, and pipe whip restraints utilizing energy-absorbing structures are not currently included in the FSAR Section 3.6. The applicant is requested to provide the information as described.

03.06.02-4

NuScale FSAR Tier 2, Section 3.6.2.1.3, “Pipe Breaks in the Reactor Building (outside the Reactor Pool Bay),” states that as fluid jets have the potential to impact SSC further away than pipe whip, a conservative approach is to evaluate ruptures of high- or moderate-energy piping located within 25 pipe diameters of the target SSC and refers to Appendix A of SRP 3.6.2, Revision 3 Draft. NuScale FSAR Tier 2, Section 3.6.2.1.3, “Pipe Breaks in the Reactor Building (outside the Reactor Pool Bay),” states that as fluid jets have the potential to impact SSC further away than pipe whip, a conservative approach is to evaluate ruptures of high- or moderate-energy piping located within 25 pipe diameters of the target SSC and refers to Appendix A of SRP 3.6.2, Revision 3 Draft. However, it should be noted that the 25 pipe diameters identified in Appendix A of SRP 3.6.2 is to describe that tests in a German test facility showed that significant damage from the dynamic effects of steam jets can occur as far as 25 pipe diameters from a postulated high-energy pipe rupture. It should be noted that as described in FSAR Section 3.6.1.2, for moderate-energy pipe failure, only the environmental effects (e.g., flooding, spray wetting, increased temperature, pressure, and etc.,) are considered. Since the dynamic fluid jet is not a consideration for moderate-energy pipe failure, the applicant is to justify why it is a conservative approach by applying the 25 pipe diameters (for the dynamic fluid jet) to the evaluation of potential environmental impact for moderate- energy pipe failures.

03.06.02-5

NuScale FSAR Tier 2, Section 3.6.2.1.3 refers to Appendix A of SRP 3.6.2, Revision 3. In that referred Appendix A of the SRP 3.6.2, the NRC staff discusses some potential non-conservatism of the jet modeling described in ANSI/ANS 58.2-1988 (also referred to as ANS 58.2). These potential non-conservatisms include the assessments of the dynamic blast wave effect, the jet plume expansion and zone of influence, distribution of the pressure within the jet plume, and jet dynamic loading including potential feedback amplification and resonance effects. The applicant is requested to address those issues when using ANS 58.2 methodology for assessing the dynamic effects resulting from postulated high-energy piping rupture.

03.06.02-6

NuScale FSAR Tier 2, Section 3.6.2.1.3, “Pipe Breaks in the Reactor Building outside the reactor Pool Bay,” states that evaluation of the unrestrained pipe whip may also be performed to show that the effects of the rupture are acceptable without mitigation. However, the staff found that no information (or pointer) related to the design criteria/methodologies for assessing the dynamic effects of unrestrained pipe whip included in the FSAR Tier 2, Section 3.6. The applicant is requested to provide the information for the NRC staff’s review.

03.06.02-7

NuScale FSAR Tier 2, Section 3.6.2.1.3, “Pipe Breaks in the Reactor Building outside the reactor Pool Bay,” outlines the information which will be included in the summary of the NuScale pipe rupture hazards analysis for the balance-of-plant high- and moderate-energy pipe ruptures. However, it is not clear that the described pipe rupture hazards analysis report is also applicable to all other areas in the NuScale plant design (e.g., pipe breaks inside the containment vessel, pipe breaks in the reactor pool bay outside containment, etc.). The applicant is requested to clarify/identify if the information as outlined in FSAR Section 3.6.2.1.3 is also to be provided in the pipe rupture hazards analysis report for other areas of the plant design where breaks and/or cracks are assumed.

03.06.02-8

NuScale FSAR Tier 2, Section 3.6.2.1.1 states that a terminal end is defined as an extremity of a piping run that connect to structures, components (e.g., vessels, pumps, valves), or pipe anchors, which act as rigid constraints to piping motion and thermal expansion. Are other piping geometric configurations (e.g., a branch connection to a main piping run) as identified in Footnote 3 of BTP 3-4 also applicable to the NuScale design? If yes, have those other configurations been considered as terminal ends for postulating pipe ruptures? In addition, is the same "terminal end" definition applicable to other FSAR Tier 2, 3.6 subsections (e.g., Section 3.6.4.1) where terminal end is referred to?

03.06.02-9

BTP 3-4, Part B, Item A(iii)(4) states that if a structure separates a high-energy line from an essential component, the separating structure should be designed to withstand the consequences of the pipe break in the high-energy line that produces the greatest effect at the structure, irrespective of the fact that the criteria identified in BTP 3-4, Part B, Item A(iii)(1), (2), and (3) might not lead to postulating a break at this location. The staff found that no information (or pointer) related to the design criteria of the separating structure are currently included in the FSAR Tier 2, Section 3.6. The applicant is requested to clarify whether the NuScale design criteria for structures that separate high-energy from essential components, if applicable are consistent with the NRC staff guideline described in BTP 3-4, Part B, Item A(iii)(4).

03.06.02-10

NuScale FSAR Tier 2, Section 3.6.4.1 provides the criteria for postulating ASME Section III, Class 1, 2, and 3 high-energy pipe breaks in areas other than the containment penetration. Specifically, it states that those criteria are used to determine the pipe break locations in each piping and branch run with the exception of those portions of piping identified in FSAR Section 3.6.2.1.1. It implies that the criteria for postulating breaks described in FSAR Section 3.6.4.1 are applicable to those portions of piping outside containment and outside containment penetration. However, there are portions of piping which are outside of containment and outside of containment penetration (e.g., those portions of piping described in FSAR Section 3.6.2.5) for which breaks are not postulated and therefore, the FSAR Section 3.6.4.1 break postulation criteria should not be applied. This is not consistent with the FSAR Section 3.6.4.1 statement. The applicant is requested to address this inconsistency regarding the applicability of the pipe break criteria described in the FSAR Tier 2, Section 3.6.4.1.

03.06.02-11

NuScale FSAR Tier 2, Section 3.6.4.1 states that high-energy pipe breaks in seismically analyzed non-ASME Class piping are addressed in Section 3.6.2.1.3. Is there non-ASME Class piping which is not seismically analyzed? If yes, how are the break locations selected?

03.06.02-12

NuScale FSAR Tier 2, Section 3.6.1.2 states that moderate-energy piping is evaluated for through wall leakage cracks and analyzed for flooding and environmental effects. It also states that through wall leakage cracks are as defined in BTP 3-4, Revision 2. However, it is not clear whether the applicant's criteria for postulating through wall leakage in moderate-energy piping are consistent with the NRC staff's guidelines delineated in BTP 3-4 Part B Item, B(ii), B(iii), and B(iv). Although an allowable stress of 0.4(1.8Sh + Sa) is listed in the last column of FSAR Table 3.6-7, which is the stress limit specified in BTP 3-4 Part B, Item B(iii) for determining the location of leakage cracks in moderate-energy piping, the NRC staff found no other discussion (pointer) in FSAR Section 3.6 which discusses this stress limit. In addition, it is not clear whether the applicant's criteria for evaluating moderate-energy fluid systems in proximity to high-energy fluid systems are consistent with the BTP 3-4 guidelines such that leakage cracks need not be postulated in moderate-energy fluid system piping located in an area in which a break in high-energy fluid system piping is postulated, provided such leakage cracks would not result in more limiting environmental conditions than the high-energy pipe break. The applicant is requested to provide the above information/clarification.