NuScaleDCRaisPEm Resource

From: Chowdhury, Prosanta
Sent: Friday, May 4, 2018 3:16 PM
To: Request for Additional Information
Cc: Lee, Samuel; Cranston, Gregory; Tabatabai, Omid; Jackson, Diane; Haider, Syed; NuScaleDCRaisPEm Resource
Subject: Request for Additional Information No. 465 eRAI No. 9494 (06.02.01.01.A)
Attachments: Request for Additional Information No. 465 (eRAI No. 9494).pdf

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

The NRC Staff recognizes that NuScale has preliminarily identified that the response to one or more questions in this RAI is likely to require greater than 60 days. NuScale is expected to provide a schedule for the RAI response by email within 14 days.

If you have any questions, please contact me.

Thank you.

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U.S. Nuclear Regulatory Commission
301-415-1647

Hearing Identifier: NuScale_SMR_DC_RAI_Public
Email Number: 496

Mail Envelope Properties (DM6PR09MB26181627659D935DF9CCC8569E860)

Subject: Request for Additional Information No. 465 eRAI No. 9494 (06.02.01.01.A)
Sent Date: 5/4/2018 3:15:34 PM
Received Date: 5/4/2018 3:15:38 PM
From: Chowdhury, Prosanta

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Tracking Status: None

Post Office: DM6PR09MB2618.namprd09.prod.outlook.com

Files	**Size**	**Date & Time**
MESSAGE	675	5/4/2018 3:15:38 PM
Request for Additional Information No. 465 (eRAI No. 9494).pdf	93779	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Request for Additional Information No. 465 (eRAI No. 9494)

Issue Date: 05/04/2018
Application Title: NuScale Standard Design Certification - 52-048
Operating Company: NuScale Power, LLC
Docket No. 52-048
Review Section: 06.02.01.01.A - PWR Dry Containments, Including Subatmospheric Containments
Application Section: FSAR Section 6.2.1.1 Containment Structure

QUESTIONS

06.02.01.01.A-16

NIST-1 Test Data Scaling Distortions Relevant to Containment Design & Applicability of the NIST-1 Validation to the Containment Response Analysis Methodology

Title 10, Part 52, of the Code of Federal Regulations (10 CFR Part 52), "Licenses, Certifications, and Approvals for Nuclear Power Plants," Section 52.47, "Contents of Applications; Technical Information" (10 CFR 52.47), specifies that an application for certification of a nuclear power reactor design that uses simplified, inherent, passive, or other innovative means to accomplish its safety functions must meet the requirements of 10 CFR Part 50.43(e) and 10 CFR Part 52.47(c)(2). 10 CFR 50.43(e) requires, in part, assessment of the analytical tools used for safety analyses over a sufficient range of normal operating conditions, transient conditions, and specified accident sequences. Regulatory Guide 1.203 describes a process that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in developing and assessing evaluation models (EMs) that may be used to analyze transient and accident behavior that is within the design basis of a nuclear power plant.

To make its safety findings, the staff must understand and assess the ability of the applicant's analytical tools used in the safety analyses to meet the aspects of the General Design Criteria (GDCs) 16, 38, and 50; and 10 CFR Part 52.47 and Part 50.43(e) relevant to the containment design basis. Specifically, the staff must assess the ability of the applicant's NRELAP5 models to predict the safety-significant phenomena in order to conclude that the evaluation model results are valid over the applicable range of design basis event (DBE) conditions. The thermal-hydraulic phenomena pertinent to NuScale FSAR Section 6.2 containment DBE analyses are the heat transfer from the containment vessel (CNV) to reactor pool (including condensation on the inner surface of the CNV), conduction through the CNV wall (represented by the heat transfer plate in the NIST-1 testing), and the convection to the reactor cooling pool. The staff needs to understand and assess the conservatism in the applicant's NPM DBE safety analyses, as well as the NIST-1 test data used to validate the DBE phenomenology.

The purpose of NIST-1 facility is to provide realistic test data for the NRELAP5 evaluation model validation. As there are no other counterpart tests, the NIST-1 testing is critical for NRELAP5 code validation. Validation of NRELAP5 with the set of NIST-1 DBE tests will bring confidence in the code's ability to predict the containment response to the mass and energy release events. However, this requires an additional step of scaling distortions evaluation of the NIST-1 test data that are presented by the applicant to support the LOCA evaluation models and containment response analysis methodology. Significant distortions in initial/boundary conditions and important scaling similarity groups (Pi group) need to be assessed before the code is qualified to predict the containment peak pressure and temperature. For regulatory purposes, the containment peak pressure prediction has to be realistic and should either show conservatism or should have a statement of uncertainty.

In the scaling distortion report (Calculations to Support NIST-1 Distortion Analysis and Modeling of Containment and Pool heat Transfer, {{ }}), the applicant quantifies the effect of the scaling distortions by performing sensitivity calculations for NPM and NIST-1 configuration. Section 4.1 of the "Containment Response Analysis Methodology" Technical Report (CRAM TeR) (TR-0516-49084-P Rev. 0) addresses some scaling distortions for the primary and secondary system releases. In the course of review, the staff identified several additional distortions and discrepancies that affect peak containment pressure, and some of them were not adequately addressed in audit discussions with the applicant. The staff needs to assess how these outstanding distortions and discrepancies contribute to the peak containment pressure. Assessment of test data scaling distortions is essential to the peak containment pressure prediction due to the small margin available in the NuScale design. The staff needs to ensure consistency of sensitivity calculations with the predicted containment pressure in response to scaling distortions. The staff has also issued RAI 9208 under LOCA EM topical report (TR-0516-49422-P) that involves additional containment aspects of the scaling analysis report relevant to CRAM (especially RAI 9208, Question 30890, Parts c and d) that need further clarification. The current RAI is closely related to RAI 9208 in terms of the phenomena in the LOCA transient. Therefore, the applicant is requested to provide an integral estimate of the uncertainty of peak containment pressure in the NuScale design, and address the concerns identified in the following seven questions in addition to RAI 9208. The regulatory bases and the SRP acceptance criteria identified above are applicable to all questions in this RAI.

a) The distortion report ({{ }}) shows NIST-1 predictions and NPM base calculation, and lists the differences between the NIST-1 and NPM initial and boundary conditions and procedures. There are differences in the timing of ECCS actuation as the conditions in the NPM calculations are changed. The timings of ECCS in NPM base calculation and NIST-1 are close as shown in Figure 5-10. Figure 5-17 (page 57) shows CNV pressures for NIST-1 and NPM, after corrections were made in the NPM reactor power and pool temperature to match with NIST-1 testing. If NIST-1 scales the NPM initial conditions correctly, the CNV pressure curves should be closer after correction. However, the ECCS actuation timing got worse. Figure 5-29 (Pg. 67) presents the results of another calculation in which conditions in NPM are made even closer to NIST-1. There is improvement seen in the prediction of ECCS actuation timing, which depends on conditions in the CNV and RPV, and will affect the DBE response afterwards. There was no NPM calculation to match initial pressure conditions in NIST-1 and it may have additional effect on ECCS actuation timing. It seems different distortions produce compensating effects. NuScale is requested to explain and quantify the consequences of different distortions on the timing of ECCS actuation.

b) In the distortion report ({{ }}), Figures 5-10, 5-17 and 5-29 show CNV pressure history. The NPM calculation results in Figure 5-29 are the closest to NIST-1 conditions. However, the figure shows {{ }} for CNV before ECCS actuation compared to NIST-1. No clear explanation of the impact of different distortions on the initial CNV pressurization rate is provided in the report. As the purpose of the NIST-1 facility is to provide integral data to validate the NRELAP5 code to model the phenomena involved in the range of NIST-1 operation, NuScale is requested to provide explanation for this discrepancy in early CNV pressurization in terms of distortions in the NIST-1 design or code's scaling-up toward NPM.

c) The NIST-1 tests were not initiated from the steady conditions expected in NPM. The NIST-1 initial pressure conditions were obtained from NPM blowdown calculation. At the time when NPM RPV is depressurized to {{ }}, the CNV pressure is increased to {{ }}. These pressure conditions were used to initialize RPV and CNV in NIST-1 testing due to the limitation of the NIST-1 facility upper bound operating pressure. The distortion report does not address this distortion and other initial condition distortions for the NIST-1 testing. Therefore, NuScale is requested to provide an evaluation to quantify the impact on CNV peak pressure, should the corresponding scaled NPM initial conditions had been used for all NIST-1 test cases.

d) The distortion report ({{ }}) Section 5.1.3 shows analyses of another distortion case. NPM is modeled in the same way as NIST-1 was operated except for initial CNV and RPV pressures. From Figures 5-28 (Pg. 67) and 5-29 (Pg. 67), the CNV pressure of {{ }} and RPV pressure of {{ }} occur at similar times in the modified NPM calculation and at NIST-1. With the time history matching, the peak CNV pressure is still higher in NPM than at NIST-1 by {{ }}. The cause of this over prediction of CNV peak pressure is not discussed adequately in the report. NuScale is requested to provide explanation for this over prediction.

e) The distortion report ({{ }}) shows the sensitivity study of reducing condensation heat transfer (Figure 5-145, Pg. 164). The figure shows that it has significant effect on {{ }} for steam space LOCA (HP-09). Same effect could occur in a liquid space LOCA, e.g. HP-06b. However, this observation appears inconsistent with the conclusion drawn in Section 5.6.1.1 of the distortion report based on Figure 5-139 that the condensation heat transfer coefficient does not affect the overall heat transfer coefficient much, it only affects by {{ }}. The staff also noticed that Figure 5-139 is based on Butterworth correlation for condensation, and not the extended Shah correlation. Therefore, the following information is needed for the staff to evaluate the detailed phenomena: (1) An expanded figure of CNV pressure for first 500 seconds to see the effect of condensation heat transfer on early blowdown and ECCS phase in a liquid space LOCA such as HP-06b, (2) Verify the conclusion drawn in Section 5.6.1.1 by providing a similar plot of Figure 5.139 based on the extended Shah correlation as implemented in NRELAP5 code, (3) Similar sensitivity study of condensation heat transfer for NIST-1 calculation, and (4) Non-condensibles effects on condensation based on NIST-1 test results. NuScale is requested to provide the abovementioned information and explain why the NIST-1 containment layout did not adversely affect its capability to produce quality data for containment peak pressure estimation for NPM.

f) In the distortion report ({{ }}), Figure 5-29 (Pg. 67, HP-06 test) and Figure 5-50 (Pg. 84, HP-06b test) compare CNV pressures from data and calculations for NIST-1. The predicted NIST-1 CNV pressure shows good match with data in Figure 5-29 for HP-06 test but not as good in Figure 5-50 for HP-06b test, for pressurization phase prior to ECCS initiation. While differences are small, the increase in under prediction of CNV pressure is of concern. NuScale is requested to explain the difference with respect to code validation for peak containment pressure evaluation.

g) In the distortion report ({{ }}), Figure 5-44 shows the effect of {{ }} on predicted NPM CNV pressure, for the HP-06 test scenario. It shows there is only a small effect on CNV peak pressure. However, Figure 5-95 (Page 122) shows the effect of {{ }} on predicted NPM CNV pressure for HP-07 scenario (pressurizer spray line break). The figure indicates that for slower transient like HP-07 scenario, the wall conditions and heat transfer effect on CNV peak pressure are significant. It implies that conclusions from the scaling study for HP-06 test, a fast transient, are not valid for HP-07 test which is a slower transient. There is a need for a scaling study for slow transient like HP-07 test. The discrepancy indicates that distortions exist in the scaling of {{ }}. In the scaling report ({{ }}) only one LOCA event – the CVCS discharge line break is analyzed. There are other locations of coolant discharge for design basis event. Some of these design basis events may reveal other distortions such in HP-7 that becomes limiting for safety. An evaluation of non-dimensional similarity groups (PI groups) for slower LOCA transients is requested for NuScale to justify the CVCS line LOCA distortion bounds all other coolant discharge points.

06.02.01.01.A-17

The "Containment Response Analysis Methodology" Technical Report (CRAM TeR) (TR-0516-49084-P Rev. 0), in Section 2.0, states that the qualification of the LOCA and non-LOCA methodologies presented in both LOCA and Non-LOCA topical reports (TR-0516-49422-P, Rev. 0, and TR-0516-49416-P, Rev. 0, respectively) and in particular the comparisons to separate effects tests and integral effects tests, are applicable for the containment response analysis methodology. It appears to the staff that NuScale is relying on the qualification documented in these two topical reports as part of its containment response analysis methodology (CRAM). However, the LOCA topical report (TR) states that "NuScale is requesting Nuclear Regulatory Commission (NRC) review and approval to use the LOCA evaluation model (EM) described in this report for analyses of *design-basis LOCA events* in the NPM." Therefore, the staff is concerned about the applicability of the NIST-1 separate/integral effects tests results, validation, and distortion analysis presented in the LOCA TR, to the NRELAP5 safety analysis models used in the CRAM TeR to evaluate containment peak pressure/temperature for the design-basis events. The staff has the same concern about the stated scope for the non-LOCA TR and its applicability to the CRAM. Likewise, the scaling distortion report (Calculations to Support NIST-1 Distortion Analysis and Modeling of Containment and Pool heat Transfer, {{ }}) that is used to analyze the scaling distortions of the NIST-1 testing for both LOCA EM and CRAM, is only discussed in the LOCA TR. Sections 4.1.1 and 4.1.2 of the CRAM TeR state that no additional qualification activities were performed for the LOCA and non-LOCA models relative to applicability to the CRAM, and that these qualification activities were adequate. However, a clear and complete basis for that conclusion was not provided. NuScale is therefore requested to address the following questions, and update the FSAR and the reports involved, accordingly:

a) Clarify the intended applicability of the LOCA and non-LOCA TRs to the CRAM, including specification of the portions of those two TRs considered applicable to the CRAM,

b) Make any necessary associated changes to the scope of the LOCA TR and the non-LOCA TR, and

c) Demonstrate the applicability of those portions of the LOCA and non-LOCA TRs to the CRAM, and justify that the qualification activities in those TRs were adequate.