NuScaleDCRaisPEm Resource

From:	Chowdhury, Prosanta
Sent:	Friday, March 02, 2018 11:55 AM
To:	'RAI@nuscalepower.com'
Cc:	Lee, Samuel; Cranston, Gregory; Haider, Syed; Tabatabai, Omid; NuScaleDCRaisPEm Resource
Subject:	Request for Additional Information No. 377 eRAI No. 9380 (6.2.1.1)
Attachments:	Request for Additional Information No. 377 (eRAI No. 9380).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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Division of New Reactor Licensing
Office of New Reactors
U.S. Nuclear Regulatory Commission
301-415-1647

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Request for Additional Information No. 377 (eRAI No. 9380)

Issue Date: 03/02/2018
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: Section 6.2.1.1 Containment Structure

QUESTIONS

06.02.01.01.A-5

Liquid Water Temperature Stratification inside the Containment

To meet the General Design Criteria (GDCs) 16, 38, and 50 relevant to the containment design basis and guided by the Standard Review Plan (SRP), the staff is reviewing the applicant's analytical models and analysis results that are used for the licensing-basis safety analyses. Specifically, the staff needs to assess the licensing-basis models, constitutive/closure relations, and model input parameters used for the applicant's NPM design basis event (DBE) containment response analyses, in order to conclude that the results are valid over the applicable range of DBE conditions. The regulatory bases identified above are applicable to all questions in this RAI.

As shown in the NuScale Final Safety Analysis Report Table 6.2-2, Containment Analysis Response Results, the limiting transient for containment peak pressure is an inadvertent opening of a reactor recirculation valve (RRV). The NRELAP5 analysis of this transient shows that the pressurized RCS liquid flowing into the CNV will start flashing into steam. As the CNV pressure increases from approximately 2 psia at the start of the transient up to the peak containment pressure, a smaller fraction of the liquid would flash to steam since the degree of superheat is reduced as the containment pressure increases. The liquid falls to the lower bottom of the containment where the condensate from the flashed steam condensing on the cold containment wall also gets accumulated. The condensate eventually becomes subcooled due to CNV pressurization and the heat transfer from the liquid to reactor pool through the CNV wall. NRELAP5 is expected to calculate the flashing/separation of the steam and liquid entering the CNV and liquid water falling to the bottom of the CNV. As the liquid temperature of water entering the CNV increases with time, thermal stratification of this water accumulating in the CNV is expected.

NRELAP5 should be able to accurately calculate this potentially safety-significant, non-equilibrium thermodynamic process. This is important because overestimating the temperatures of the stratified subcooled water inventory in the lower CNV could lead to a lower calculated containment pressure – a non-conservative result. However, the NRELAP5 model of the NPM uses only a few large volume nodes to represent the portion of the CNV volume below the liquid steam interface, and it is not clear whether NRELAP5 accurately simulates the temperature stratification phenomenon in the liquid water accumulated in the CNV. The NRELAP5 peak CNV pressure will be under predicted if the NuScale NRELAP5 model overestimates the mixing and cooling of CNV steam by this relatively cool water in the lower CNV. Thus, a conservative

NRELAP5 model for temperature stratification that minimizes the steam cooling by the water accumulating in the CNV, and thus leads to a conservative distribution of energy in the CNV liquid and vapor phases, would be required in a conservative CNV peak pressure analysis.

The staff needs a greater understanding to assess the safety significance of the thermally stratified water in the CNV of the NPM during blowdown out to the time of peak containment pressure. NuScale is requested to provide additional information to enable the staff to assess the impact of liquid thermal stratification and nodalization in the CNV liquid region. For example, NuScale could provide (or make available) a revised nuclear power module (NPM) analysis for the limiting peak CNV pressure design basis event of inadvertent opening of an RRV with sufficiently fine hydrodynamic noding in the CNV liquid region. If additional analysis is performed, please provide (or make available) overlay plots that compare the impact of the revised nodalization on the computed liquid temperature and enthalpy versus time for the nodes up to the node where the liquid/steam interface occurs at the time of peak pressure. This will allow the staff to assess how NRELAP5 evaluates/treats the impact of subcooled water temperature stratification on the calculated CNV peak pressure.

06.02.01.01.A-6

NIST-1 HP-02 is a separate effects, high pressure steam condensation test. During the HP-02 test, steam is introduced into the NIST-1 containment vessel (CNV) resulting in a slowly increasing steam pressure. The steam condenses to liquid on the NIST-1 CNV wall at a temperature approximately equal to the saturation temperature at the time of condensation. Thus, the condensate temperature increases with time during the test as the NIST-1 CNV pressure increases. The staff's review of the HP-02 test data shows that this process {{

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a) While Staff recognizes that the temperature stratification in the NIST-1 HP-02 tests did not result from the same mechanism as discussed for the NPM, the staff requests to audit the NRELAP5 computer code calculations in order to gain better understanding of how NRELAP5 calculates the temperature stratification. Specifically, the applicant is requested to provide technical justification that the NRELAP5 code is capable of adequately representing thermal stratification in the CNV and justify the nodalization used in the model. For example, the applicant may use the standard NRELAP5 model for NIST-1 HP-02 tests to compute liquid temperature versus time at the same elevations as the temperature measurements made for HP-02 Runs 1, 2, and 3. If additional NRELAP5 analysis is performed, the applicant should consider modifying the standard NRELAP5 model with sufficiently fine hydrodynamic noding below the final liquid level occurring at the end of the HP-02 test runs to capture the thermally stratified distribution of subcooled water in the containment vessel. The applicant is requested to provide comparison plots to show the impact of node size on the computed temperature stratification of the liquid and CNV pressure vs. the HP-02 test data for any additional analyses performed. Provide an evaluation showing whether NRELAP5 correctly calculates the temperature stratification observed in the HP-02 tests and demonstrate that NRELAP5 does not allow the cooler stratified water to act as a heat sink and reduce the temperature and pressure of the steam.

b) Staff noticed that there was no pre-heating of NIST-1 containment wall in HP-02 test that suggests that condensation also took place on the containment wall besides the heat transfer plate (HTP). This would lead to a heat loss to the ambient air through the containment wall, in addition to the heat transfer across the HTP to the reactor cooling pool. Since the objective of the experiment is to validate the condensation heat transfer in a pressurized environment, failure to model the heat loss and the pool heat transfer will distort the pressure response inside the containment. {{

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06.02.01.01.A-7

Provide a discussion of the NIST-1 HP-06 tests results including an evaluation of the impact of preheating of the NIST-1 containment with regards to the ability of this test to show the impact of CNV liquid temperature stratification. Evaluate the NIST-1 HP-06 test data to show how the NRELAP5 code correctly calculates the temperature, enthalpy and mass fraction of vapor and liquid as the containment pressure increases with time.