NuScaleTRRaisPEm Resource

From: Cranston, Gregory
Sent: Tuesday, September 19, 2017 2:19 PM
To: NuScaleTRRaisPEm Resource
Cc: Chowdhury, Prosanta
Subject: Request for Additional Information Letter No. 8990 (eRAI No. 8990) Topical Report LOCA Piping Breaks
Attachments: Request for Additional Information No. 8990 (eRAI. No. 8990)P.pdf

Hearing Identifier: NuScale_SMR_DC_TR_Public
Email Number: 60

Mail Envelope Properties (7c6cbc29627f4259aeb1fd97ccd8e555)

Subject: Request for Additional Information Letter No. 8990 (eRAI No. 8990) Topical Report LOCA Piping Breaks
Sent Date: 9/19/2017 2:19:19 PM
Received Date: 9/19/2017 2:19:20 PM
From: Cranston, Gregory

Created By: Gregory.Cranston@nrc.gov

Recipients:
"Chowdhury, Prosanta" <Prosanta.Chowdhury@nrc.gov>
Tracking Status: None
"NuScaleTRRaisPEm Resource" <NuScaleTRRaisPEm.Resource@nrc.gov>
Tracking Status: None

Post Office: HQPWMSMRS07.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	3	9/19/2017 2:19:20 PM
Request for Additional Information No. 8990 (eRAI. No. 8990)P.pdf	194110	

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

Request for Additional Information No. 8990 (eRAI. No. 8990) P

Issue Date: 09/19/2017
Application Title: NuScale Topical Report
Operating Company: NuScale
Docket No. PROJ0769
Review Section: 15.06.05 - Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary
Application Section: 15.6

QUESTIONS

15.06.05-7

Title 10 of the Code of Federal Regulations (10 CFR) Part 52, Section 47 (a)(2) states, "A description and analysis of the structures, systems, and components (SSCs) of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which these requirements have been established, and the evaluations required to show that safety functions will be accomplished." Likewise, 10 CFR Part 50, Appendix K, II.4 – Required Documentation, requires that, "To the extent practicable, predictions of the evaluation model, or portions thereof, shall be compared with applicable experimental information."

As stated in RG 1.203, an evaluation model (EM) is the calculational framework for evaluating the behavior of the reactor system during a postulated transient or design-basis accident. As such, the EM may include one or more computer programs, special models, and all other information needed to apply the calculational framework to a specific event, as illustrated by the following examples:
(1) Procedures for treating the input and output information (particularly the code input arising from the plant geometry and the assumed plant state at transient initiation).
(2) Specification of those portions of the analysis not included in the computer programs for which alternative approaches are used.
(3) All other information needed to specify the calculational procedure.

The entirety of an EM ultimately determines whether the results are in compliance with applicable regulations. Therefore, the development, assessment, and review processes must consider the entire EM.

During a Loss of Coolant Accident, the primary heat transfer processes include condensation heat transfer to the containment vessel (CNV) inside wall, conductive heat transfer though the CNV wall and convective heat transfer from the CNV outside wall to the reactor cooling pool. These heat transfer capabilities are critical to cool the reactor core and remove decay heat. The Loss-of-Coolant Accident (LOCA) Evaluation Model topical report did not clearly define how each of these heat transfer processes are calculated in the NRELAP5 code models and did not clearly describe the impact of uncertainty in these models and processes on ability of the CNV to function and provide emergency core cooling system (ECCS) condensate flow back to the reactor pressure vessel (RPV).

During any RPV liquid space LOCA, part of the high energy fluid released from the RPV will flash to steam and expand into the CNV volume. During any RPV steam space LOCA, the high pressure RPV steam will expand into the CNV volume. Regardless of the break location, blowdown ensues and when the differential pressure difference between the RPV and CNV reaches the design blocking pressure, the Reactor Recirculation Valves (RRV) and Reactor Vent Valves (RVV) are all designed to open to equalize the pressure and initiate the ECCS function of the CNV. After these valves open, the added rapid liquid volume flows from the RRVs and steam volume flows from the RVVs, causing the pressures between these two volumes to equalize in a short time {15-20 seconds}.

NuScale uses their version of RELAP5-3D (NRELAP5) to evaluate the single and two phase liquid flows between the RPV and CNV. However, the application of RELAP5 to the unique NuScale design, which incorporates a high pressure CNV space that functions as both a containment and ECCS, is a new application of RELAP5 that requires detailed and complete descriptions of the models, equations and methods used to calculate (1) steam temperature and pressure in the CNV, and (2) heat transfer from the CNV steam space via condensation to the CNV wall.

In the LOCA evaluation model topical report and the NRELAP5 theory manual (SwUM-0304-17023, Revision 4), the application of the condensation heat transfer correlations is not sufficiently clear. The staff needs more information on the NRELAP5 wall heat transfer computation processes. An initial list of items needed is as follows:

1. NuScale has indicated that the {Shah Condensation correlation 1979 and 2009 forms the basis for the NRELAP5 wall condensation modeling. NuScale has also acknowledged that the correlations are being used beyond stated applicability (per p. 2-392 and 2-394 of the theory manual) and points to the distortion analysis (EC-0000-3853, rev 1) as justification} of application to the NuScale power module (NPM). Please provide detailed numerical calculation procedures on how the Shah and {Nusselt correlations} are actually used in the NRELAP5 code. Please provide Re#, film thickness, Nu#, condensation heat transfer correlation (HTC), and overall HTC calculations for three consecutive nodes in the top, middle, and bottom portions of the CNV where steam is condensing on the CNV wall and then flowing down the CNV wall as a thin film.

2. Please identify the specific CNV nodes in the LOCA results where the majority of the condensation is occurring (i.e., for nodes 500-22, 500-21, and 500-20, which are linked with heat structures (HSs) 5104-014, 5014-013, and 5014-012, respectively) and provide the following for those nodes:

    a. Describe the method used to calculate the Reynolds number for the node as an input for the determination of the steam condensation heat transfer coefficient;

    b. Provide equations used to calculate the heat transfer coefficient, film flow and thickness, and total steam condensation rate from the top to the bottom and the node average heat removal based on the dimensionless vapor velocity parameter, J_g;

    c. Provide boundary conditions used to ensure that the correct film flow rate per unit periphery is determined at each node interface and is then transferred to the next node down the CNV;

    d. Specify any limits imposed on steam condensation heat transfer or heat removal rate; and

    e. Describe how NRELAP5 calculates heat convection and conduction to the CNV wall surfaces below the liquid water level inside the CNV.

3. The staff needs to better understand event progression during the period just after ECCS opens and peak CNV pressure is reached for a liquid space LOCA (e.g., chemical volume and control system [CVCS] 100% break). For the three CNV nodes and associated HSs identified in Item 2, list key calculation steps used in the NRELAP5 code with results and show how computations are implemented for equations in Section 2.6.2.5 of the theory manual for condensation heat transfer.

4. Describe the equations, models and methods used in NRELAP5 to calculate the transient heat flow from the inside surface of the CNV to the ultimate heat sink pool outside the CNV. Describe the initial boundary conditions applied to solving the transient heat conduction equation for the

CNV. For the heat structures referenced above, describe how heat energy is conducted through the CNV wall to the pool and provide an assessment of the number of mesh points used.

5. Repeat the process (items 1-4) for a similar location of the NIST-1 heat transfer plate (HTP) with three corresponding nodes from the representative test, HP-06b "CVCS discharge pipe break," where condensation heat transfer is highest.

6. Since the {Shah Correlation has been used beyond the applicability of the original correlation}, please provide an uncertainty band based on the uncertainty analysis using NuScale-specific experimental data or any other applicable and credible separate effects test data.

7. The {sensitivity study of condensation heat transfer coefficient presented in the distortion report (EC-0000-3853)} did not have enough resolution for NRC staff to reach a conclusion. In particular the NRC staff seeks a better understanding of the period before the peak CNV pressure is reached for a liquid space LOCA (CVCS 100% break). Please demonstrate the relative effects of heat transfer mechanisms on the peak containment pressure {at a minimum for Figures 5.140 to 5.145} with better resolution.