NuScaleTRRaisPEm Resource

From: Chowdhury, Prosanta
Sent: Wednesday, May 9, 2018 4:14 PM
To: Request for Additional Information
Cc: Lee, Samuel; Cranston, Gregory; Karas, Rebecca; Burja, Alexandra; Franovich, Rani; NuScaleTRRaisPEm Resource
Subject: Request for Additional Information Letter No. 9374 (eRAI No. 9374) Topical Report, Non-LOCA Analysis Methodology, 15.00.02, SRSB
Attachments: Request for Additional Information No. 9374 (eRAI No. 9374).pdf

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

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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Request for Additional Information No. 9374 (eRAI No. 9374)

Issue Date: 05/09/2018
Application Title: NuScale Topical Report
Operating Company: NuScale
Docket No. PROJ0769
Review Section: 15.00.02 - Review of Transient and Accident Analysis Methods 01/2006
Application Section: TR-0516-49416-P, Non-LOCA Analysis Methodology

QUESTIONS

15.00.02-22

TR-0516-49416-P, "Non-Loss-of-Coolant Accident [Non-LOCA] Analysis Methodology," supports the conclusions in the NuScale Final Safety Analysis Report (FSAR), which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. Regulatory Guide (RG) 1.203, "Transient and Accident Analysis Methods," describes a process that the NRC staff considers acceptable for use in developing and assessing evaluation models (EMs) used to analyze transient and accident behavior, known as the evaluation model development and assessment process (EMDAP). Step 7 of the EMDAP discusses the identification and performance of separate effects tests (SETs) and integral effect tests (IETs) and states: "The effects of distortions should be evaluated in the context of the experimental objectives."

TR-0516-49416-P, Section 5.3.2.3 describes the NRELAP5 model of the NIST facility and states:

[[ ]]

However, TR-0516-49416-P does not describe other model scaling aspects that are applicable and that could affect the conclusions of the assessment studies.

Information Requested:

Demonstrate that the nodalization scheme of the facility and NPM preserve the fluid and structural time constants by providing representative time constants for NIST-1 and the NPM for the nodalization selected. Update TR-0516-49416-P as appropriate.

15.00.02-23

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. RG 1.203 describes the EMDAP, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. RG 1.203 discusses that the EM should be capable of predicting experimental data, and wherever calculated results disagree with experimental data, causes for the discrepancy and the importance of the deficiency should be explained. RG 1.203 also states:

Because compensating errors in the code can unintentionally lead to correct answers, additional performance measures serve as physical tracking points and additional proof of accuracy. While the code may calculate the correct peak cladding temperature (PCT), for example, incorrect or physically impossible parameter values could evolve in other areas of the calculation.

Furthermore, NUREG-0800, Standard Review Plan (SRP) Section 15.0.2, "Review of Transient and Accident Analysis Methods," provides the staff guidance on reviewing analytical models and computer codes used to analyze transient and accident behavior. SRP Section 15.0.2 states:

If the evaluation model is to be accepted, it must be clearly demonstrated that the model is getting the right answer for the right reasons. There must be no evidence of compensating errors or arbitrary code tuning that produces the desired result for a single parameter.

The staff notes that several of the NIST tests discussed and assessed in TR-0516-49416-P do not predict one or more physical quantities well, yet the total energy removal (the enthalpy flow) in the decay heat removal system (DHRS) or heat transfer from the primary side to secondary side appears to be acceptable. Examples include:

- TR Section 5.3.2.5.1 (HP-03-01 Run): the predicted DHRS collapsed water level (Figure 5-12) and the predicted DHRS tube internal temperature (Figure 5-13) are outside of the measurement uncertainty bands. In addition, the predicted DHRS collapsed water level showed significant changes, especially between 100 to 200 seconds, that were not observed experimentally. However, the DHRS enthalpy flow (Figure 5-11) is in good agreement.

- TR Section 5.3.2.5.2 (HP-03-02c Run): the staff observes considerable differences in magnitudes of predicted vs. measured fluctuations in the DHRS collapsed level (Figure 5-17) and DHRS internal fluid temperature (Figure 5-18); disagreement in the predicted vs. measured average value of the DHRS internal fluid temperature (Figure 5-18); thermal stratification in the cooling pool near the heat exchanger tubes not predicted by NRELAP5 (Figure 5-19); yet it is concluded that the DHRS flow enthalpy (Figure 5-16) is in good agreement.

- TR Section 5.3.2.5.3 (HP-03-03 Part 1 Run): the staff observes disagreement in the predicted vs. measured average value of the DHRS internal fluid temperature (Figure 5-23), yet average values of DHRS flow enthalpy (Figure 5-21) are in good agreement.

- TR Sections 5.3.2.7.1 (HP-04-02 Run) and 5.3.2.7.2 (HP-04-03 Run): DHRS condensate temperature (Figures 5-27 and 5-33) agrees for only a short time out of the 18,000-second test run; the predicted DHRS internal collapsed level (Figures 5-28 and 5-34) appears to start dropping earlier than the measured level; and cooling pool vessel temperature is not well predicted (Figures 5-30 and 5-36), yet it is concluded that NRELAP5 predicts the correct net energy transfer to the cooling pool vessel (CPV).

- TR Sections 5.3.3.7 through 5.3.3.10 (NLT-2b Phase 1 through Phase 4 Test Results): predicted DHRS condensate temperature is significantly higher than measured (Figures 5-65, 5-82, 5-100, and 5-119); predicted cooling pool temperatures are higher than measured (Figures 5-69, 5-70, 5-87, 5-88, 5-105, 5-106, 5-124, and 5-

125); yet it is concluded that heat transfer from the primary side to the steam generator and from the DHRS to the CPV are well predicted.

Information Requested:

Given the discrepancies in such quantities as the DHRS collapsed level, cooling pool axial temperature distribution, and DHRS condensate temperature, demonstrate that the acceptability of overall DHRS heat removal (enthalpy flow) and heat transfer from the primary to secondary side in the NIST-1 experiments is not due to compensating errors in the NRELAP5 models and correlations. Such demonstration may include additional explanation of existing results, comparisons of additional relevant parameters for the listed NIST tests, and/or additional assessment studies. Update TR-0516-49416-P as appropriate.

15.00.02-24

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. RG 1.203 describes the EMDAP, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. Element 1 of the EMDAP guides an applicant to establish its requirements for the EM capability, including identification of systems, components, phases, geometries, fields, and processes that should be modeled. Furthermore, Step 11 of the EMDAP discusses establishment of the EM structure:

> *The special concerns related to integrating the component calculational devices into a complete EM are frequently referred to collectively as the EM methodology. The way in which the devices are connected spatially and temporally should be described.*

TR-0516-49416-P, Section 6.1.5 describes the NRELAP5 model of the DHRS in the NPM plant model:

> *Although in the actual NPM the DHRS heat exchanger is located in the reactor cooling pool,* ***[[ ]]*** *.*

This statement implies that **[[ ]]** . NIST-1 tests discussed in TR Section 5.3 show that thermal stratification in the cooling pool is an important aspect of the coolant dynamics, and the staff is concerned about its effects on overall DHRS heat removal.

During an audit discussion (Round 2, Issue 7), the applicant stated that there are no significant effects due to thermal stratification and natural circulation in the cooling pool since the surface of the DHRS is hot enough for boiling heat transfer to occur; therefore, the saturation temperature of the pool is more important than the bulk temperature. TR Section 6.1.5 discusses that **[[ ]]** . Based upon the dominant bulk boiling heat transfer mode, the applicant's conclusion was that the DHRS performance would not be sensitive to temperature gradients; the surface of the tube is insensitive to the bulk fluid condition and drives itself to a superheated condition to result in as much boiling as necessary. Furthermore, the applicant stated that cooler liquid near the bottom of the DHRS should enhance the DHRS performance, and **[[ ]]** . However, the staff needs justification for these statements.

Information Requested:

The staff notes that the heat flux is much higher in the bulk boiling regime (i.e., nucleate pool boiling) than under subcooled conditions. The heat flux limit will determine the heat transfer mode. It may be possible to exceed the critical heat flux, resulting in film boiling, depending upon the surface temperature conditions. Demonstrate that the potential for dryout (vapor blanketing) which would reduce DHRS performance, and progressively shift the thermal center downward in the DHRS, does not exist or is negligible, for instance by comparing the calculated local heat flux to the CHF for various elevations along the DHRS tubes.

15.00.02-25

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. SRP Section 15.0.2 provides the staff guidance on reviewing analytical models and computer codes used to analyze transient and accident behavior. SRP Section 15.0.2 states that the EM documentation must include a user manual that provides clear and unambiguous guidance, including:

- detailed instructions about how the computer code is used,
- a description of how to choose model input parameters and appropriate code options,
- guidance about code limitations and options that should be avoided for particular accidents, components, or reactor types, and
- documented procedures for ensuring complete and accurate transfer of information between different elements of the EM.

As discussed during the non-LOCA audit, NuScale-specific modeling guidance for non-LOCA events is provided in document SwUM-0304-15495, "NRELAP5 Version 1.3 Input Data Requirements," and relevant parts of the non-LOCA and LOCA topical reports. TR-0516-49416-P, Table 7-1 provides a typical list of initial conditions that are applicable for non-LOCA transient analysis. The list includes a number of parameters that are either redundant or would result in an over-specification of initial steady-state conditions for the plant. This over-specification may cause unacceptable results (i.e., failure to achieve a unique converged steady-state solution). Examples include:

- Volume-weighted core average fuel temperature – Fuel temperatures are calculated from the power distribution and the state of the reactor coolant system. The volume-weighted core average fuel temperature is a calculated outcome, not an initial condition.
- RCS fluid temperature – Given the pressurizer pressure, feedwater flow, feedwater temperature, and reactor power level, the RCS fluid temperature is a calculated outcome, not an initial condition.
- Turbine governor valve flow rate – Given the feedwater flow rate, steam generator level, and steam header pressure, the steam flow to the turbine is a calculated outcome, not an initial condition.

During an audit discussion (Round 2, Issue 8), the applicant stated that Table 7-1 is intended to list all parameters that could be set for an analysis and that an analyst would identify items to cut from the list. However, TR-0516-49416-P is not clear about the purpose of Table 7-1 and does not provide clear and unambiguous guidance regarding initial condition specification.

Information Requested:

Clearly state the purpose of Table 7-1 in TR-0516-49416-P as discussed during the audit, and revise Table 7-1 and the associated text in TR Section 7.1.1.2 accordingly. The discussions should include the specific constraints under nominal operating conditions and the technical basis to demonstrate that (a) the specified constraints would not result in an over- or under-specification, (b) changes to specified conditions to bias the calculations also fulfill the conditions under part (a), and (c) the specified constraints result in unique initial conditions.

15.00.02-26

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. RG 1.203 describes the EMDAP, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. Step 16 of the EMDAP describes, in part, determining the ability of numeric solutions to approximate equation sets:

> *The numeric solution evaluation considers convergence, property conservation, and stability of code calculations to solve the original equations when applied to the target application. The objective of this evaluation is to summarize information regarding the domain of applicability of the numerical techniques and user options that may impact the accuracy, stability, and convergence features of each component code.*

TR-0516-49416-P, Section 7.1.1.4 describes the typical initialization process and states:

> *Prior to the initialization process, certain parameters critical to establishing the correct steady state for the event of interest are identified. Once the parameters of interest achieve steady state target values within acceptable tolerances, on the basis of engineering judgement,* ***[[ ]]*** *. A steady state solution has been achieved when the change in the target value during the loop transits is within the variance band described for each parameter.*

During audit discussions, the applicant stated that there are two ways to achieve the biased conditions: 1) changing the control target values or 2) combinations of biasing variables to obtain a desired target value. The applicant also stated that part of the null transient evaluation is to examine the primary and secondary conditions to ensure that they are correct for the biased conditions. In addition, the nominal operating conditions are calculated for a given power level, as described in document EC-A030-2713, “Primary and Secondary Steady State Parameters.” However, based on the staff’s audit of EC-A030-2713, the document did not demonstrate that the conditions shown for secondary side level, superheat, primary RCS flow, and RCS temperature correspond to the unique and correct steady-state conditions. If a unique and correct steady state is not achieved, the results of the transient calculation will be unreliable.

Information Requested:

Provide a document that describes the process of obtaining a unique and correct steady-state initialization for non-LOCA transients or update TR-0516-49416-P to include such information. The document or update should list the constraints imposed on the steady-state initialization (e.g., reactor power, inlet temperature, outlet temperature, feedwater flow rate, feedwater temperature, etc.).

15.00.02-27

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. RG 1.203 describes the EMDAP, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. Step 11 of the EMDAP describes the EM structure, and Item (6), Additional Features, addresses the code capability to model boundary conditions and control systems.

TR-0516-49416-P, Section 7.1.2 discusses the treatment of plant control systems based on their impact on the calculated consequences relative to the acceptance criteria and states:

> *The effect of various plant controls on the response to a specific acceptance criterion is assessed for each non-LOCA transient… (Emphasis added)*
>
> *When considering operation of the various plant controls, the approach is based on the event consequences for a given acceptance criterion.* ***[[ ]]*** *.*

For the PCS functions of controlling pressurizer pressure, pressurizer level, core average coolant temperature, steam pressure, turbine load, and containment pressure, the initial limiting bias condition is determined for the transient analysis (i.e., the limiting condition in the band of operation of the PCS is determined for the associated function). However, for the most part, there is no discussion for each specific event and associated acceptance criteria of how the operation of the PCS during the event affects the transient response (i.e., the effect of the PCS operation attempting to maintain a control parameter within the operating band during the transient). The staff notes that control systems treatment could have a significant effect on the severity of a transient.

Furthermore, the following statement in TR-0516-49416-P, Section 7.1.2, seems to indicate that credit may be taken for operation of the PCS or operator action. This would contradict the previous statement and Section 7.1.7 of the TR, which states that operator action is not credited for non-LOCA analyses:

> ***[[ ]]*** *.*

Information Requested:

a. Specify for which events PCS operation during the event is considered, and describe how operation of the PCS affects the transient response.

b. Explain for which non-LOCA analyses PCS operation or operator actions, such as **[[ ]]**, are credited.

c. Update TR-0516-49416-P to clarify the discussion of plant controls and operator actions, including the second quoted statement above, as appropriate.

15.00.02-28

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole.

RG 1.203 describes the EMDAP, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. Step 18 of the EMDAP discusses the preparation of input and performing of calculations to assess system interactions:

> *The ability of the EM to model system interactions should also be evaluated in this step, and plant input decks should be prepared for the target applications. Sufficient analyses should be performed to determine parameter ranges expected in the nuclear power plant.*

TR-0516-49416-P, Table 7-29 provides the NRELAP5 MCHFR results of parametric sensitivity studies for the loss of containment vacuum and containment flooding events:

- Rows 1 and 2 present the loss of containment vacuum sensitivity to initial containment pressure, **[[ ]]** . Row 3 presents a containment flooding case that was performed for many of the same conditions as the loss of containment vacuum cases. Differences in the initial containment pressure and pool temperature for the Row 3 case preclude concluding that the loss of containment vacuum is not limiting.

- Rows 4 and 5 demonstrate the effect of different RCCW leakage flow rates on the MCHFR, **[[ ]]** . It would be expected that a higher leakage rate would alter the containment atmosphere sufficiently to result in an increased magnitude of energy removal from the RCS compared to the lower leakage rate. TR Section 7.2.5.1 states: *The potential CNV flooding sources considered are pipe ruptures inside the CNV.* ***[[ ]]*** *.*

  It is not clear how different the reactor trip time would be for the higher leakage rate. At the higher leakage rate with the higher energy transfer, even with an earlier reactor trip time, it is not clear why **[[ ]]** .

- Rows 7 and 8 present the effect of a change in the pressurizer pressure bias from HIGH to LOW, **[[ ]]** . Rows 8 and 9 show the effect of a loss of power at reactor trip, **[[ ]]** .

Based upon the results presented, the initial conditions and limiting bias conditions are not clear.

Information Requested:

a. Describe how the results in Row 3 of Table 7-29 would change with the initial CNV pressure and pool temperature biased LOW.

b. Provide a physical description of the transient difference between the low and high leakage rate cases (Table 7-29, Rows 4 and 5), explaining **[[ ]]** .

c. Explain what physical transient response contributes to **[[ ]]** for the higher RCCW temperature (Table 7-29, Rows 5 and 6), and discuss how the reactor trip times and the integrated RCS energy transfer to the containment atmosphere at reactor trip differs for cases with lower RCCW temperatures.

d. Explain the transient response that contributes to **[[ ]]** for a lower pool temperature, and discuss how the reactor trip times and the integrated RCS energy transfer from the containment to the pool at reactor trip would differ for cases with a higher pool temperature.

e. Describe why the MCHFR for a containment flooding case similar to case 6 in TR Table 7-29, but with pressurizer pressure biased LOW, would not be more limiting.

f. While the loss of containment vacuum cases (rows 1 and 2) which used the minimum containment pressure **[[ ]]**, justify using the nominal containment pressure **[[ ]]** instead of the minimum for the containment flooding cases.

g. Update TR-0516-49416-P as necessary.

15.00.02-29

TR-0516-49416-P supports the conclusions in the NuScale FSAR, which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole. RG 1.203 describes the EMDAP, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. Step 18 of the EMDAP discusses preparation of input and performing of calculations to assess system interactions:

> *The ability of the EM to model system interactions should also be evaluated in this step, and plant input decks should be prepared for the target applications. Sufficient analyses should be performed to determine parameter ranges expected in the nuclear power plant.*

The system response to a loss of normal feedwater described in TR-0516-49416-P, Section 8.2.1, and the response to a feedwater line break described in TR-0516-49416-P, Section 8.2.3, are difficult to discern due to the scale of the figures. In particular, the time scales extend to 2500 to 3500 seconds. In order for the staff to understand the transient behavior, figures on different time scales are necessary.

Information Requested:

a. Provide Figures 8-29 through 8-36 on a 0 to 100 second time scale.
b. Provide Figures 8-38 through 8-46 on a 700 to 900 second time scale.
c. Provide Figures 8-55, 8-56, 8-59, and 8-61 on a 0 to 500 second time scale.

15.00.02-30

SRP Section 15.0.2 provides the staff guidance on reviewing analytical models and computer codes used to analyze transient and accident behavior. SRP Section 15.0.2 states that the evaluation model documentation must be scrutable, complete, unambiguous, accurate, and reasonably self-contained.

During an audit discussion (Round 2, Issue 13), the applicant stated that an error was found in the loss of condenser vacuum (LOCV) calculation described in TR-0516-49416-P, Section 7.2.7. The peak pressure case did not include **[[ ]]** .

Information Requested:

To ensure accurate documentation, please provide a revised LOCV analysis, and incorporate the results in a revision of TR-0516-49416-P.