NuScaleDCRaisPEm Resource

From:	Cranston, Gregory
Sent:	Friday, May 25, 2018 9:21 AM
To:	NuScaleDCRaisPEm Resource
Cc:	Chowdhury, Prosanta
Subject:	Request for Additional Information No. 483 eRAI No. 9516 (15)
Attachments:	Request for Additional Information No. 483 (eRAI No. 9516)-np.pdf

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

Please submit your technically correct and complete 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.

Prosanta Chowdhury, Project Manager
Licensing Branch 1 (NuScale)
Division of New Reactor Licensing
Office of New Reactors
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301-415-1647

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Request for Additional Information No. 483 (eRAI No. 9516)

Issue Date: 05/25/2018
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Operating Company: NuScale Power, LLC
Docket No. 52-048
Review Section: 15 - Introduction - Transient and Accident Analyses
Application Section: 15

QUESTIONS

15-22

10 CFR 50 Appendix A, GDC 34, Residual heat removal, and NuScale's PDC 34, in FSAR Section 3.1.4.5, state,

> "A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded."

The long term cooling technical report (LTC-TR), TR-0916-51299, supports FSAR Section 15.0.5, Long Term Decay and Residual Heat Removal, when the ECCS is used for long term decay heat removal following either a non-LOCA or LOCA event up to 72 hours. The primary acceptance criteria for the analysis are 1) Collapsed liquid level is maintained above the active fuel and 2) fuel cladding temperature is maintained at an acceptable level such that the SAFDLs are preserved.

RG 1.203 describes the EMDAP, and provides guidance, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior, which in Element 4 discusses the process to Assess Evaluation Model Accuracy. Basic principle (4) of the EM development and assessment states:

> *"A key feature of the adequacy assessment is the ability of the EM or its component devices to predict appropriate experimental behavior. Once again, the focus should be on the ability to predict key phenomena, as described in the first principle. To a large degree, the calculational devices use collections of models and correlations that are empirical in nature. Therefore, it is important to ensure that they are used within the range of their assessment."*

The LTC report Executive Summary states:

"The LTC EM uses the proprietary NRELAP5 systems analysis computer code as the computational engine, derived from the Idaho National Laboratory RELAP5-3D© computer code. The models and correlations used by NRELAP5 were reviewed and, where appropriate, modified for use within the long-term cooling EM."

From a review of the LTC-TR, it is not clear which NRELAP5 models and correlations, if any, were modified for use within the LTC EM. In order to follow the RG 1.203 guidance, documentation of the models and correlations modified for use within the LTC EM should be provided in the report for the staff to reach a reasonable assurance finding that GDC 34/PDC-34 is met.

15-23

10 CFR 50 Appendix A, GDC 34, Residual heat removal, and NuScale's PDC 34, in FSAR Section 3.1.4.5, state,

"A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded."

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Section 4.2 of the LTC-TR discusses the validation and assessment of the LTC-EM using two NIST-1 facility tests, namely HP-19a and HP19b. The purpose of test HP-19a was to simulate the spurious opening of an RVV without DHRS activation.

Since the conditions at the time of ECCS actuation for tests HP-19a and HP-19b may be different for a non-LOCA event which transitions from the DHRS to the ECCS for LTC, the applicability of these tests to the LTC of non-LOCA events should be justified.

Justify the applicability of the NIST-1 HP-19a and HP-19b tests to validate the LTC EM used to simulate the non-LOCA transition from DHRS cooling to long term cooling with the ECCS and provide as discussion or reference to the scaling evaluation performed to show the applicability of these tests to the LTC for the non-LOCA events.

15-24

10 CFR 50 Appendix A, GDC 34, Residual heat removal, and NuScale's PDC 34, in FSAR Section 3.1.4.5, state,

"A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded."

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Section 4.2.3.3 describes the NRELAP5 simulation of the HP-19a test. The reactor vessel water level is outside the lower error band at 6,000 seconds, but climbs into the data band reaching the upper error band limit at approximately 7,200 seconds, while the containment water level is reasonably well predicted. It would be expected that the RPV and containment water level behaviors would be mirror images in terms of response. The containment and RPV pressures are very well predicted. However, the cooling pool water level and temperatures are poorly predicted. LTC-TR Section 4.2.3.3 stated the following:

"Figure 4-5 shows that the long-term cooling pool vessel level prediction with NRELAP5 over-predicts the test data by [ ]. NRELAP5 predicts a slight upward trend while the test data exhibits a slight downward trend. This differing trend is attributed to the increased temperatures predicted by NRELAP5 as shown in Figure 4-6 and Figure 4-7. The larger temperatures would increase the pool thermal swelling, resulting in a larger level prediction. As shown in Figure 4-8, near the top of the cooling pool, increased temperatures were measured. NRELAP5 underpredicts the measured temperatures at this elevation. This is considered to be a minimal agreement, which requires justification for acceptability and use in plant calculations. The justification is provided in the following paragraph."

The explanation for the poor level prediction would seem plausible considering the over prediction of temperature in the lower regions leading to a fluid higher specific volume. However, the under prediction in the upper region would have the opposite effect. Since no quantitative assessment of the level poor prediction of the level was performed, the temperature basis for the poor prediction is not validated. The LTC-TR goes on to state:

"In the NRELAP5 models of the NIST-1 facility and the NPM, a [ ] is used to model the reactor pool. This model cannot capture natural circulation patterns within the pool, nor evaporation at the pool surface. However, in spite of these limitations, the results show that thermal stratification in this test is reasonably predicted by the [ ] nodalization of the pool. The pool level and temperature conditions at the outside of the CNV have a relative role in the heat removal capability of the containment, together with conduction across the CNV wall (or heat transfer plate at NIST-1) and condensation/convection on the inner surface. The limitations of modeling the long term pool heatup with a [ ], the pool temperature and level are bounded in the LTC calculations as described in Section 5.0 by performing sensitivity calculations with large variations in important parameters [ ] and demonstrating the results meet the acceptance criteria. Thus, minimal match of the cooling pool vessel temperature at the upper elevation is acceptable."

The test simulation shows that NRELAP5 is able to predict thermal stratification, although not accurately, because although the staff noted that both RPV and containment vessel pressures are well predicted, while level in the cooling pool is not well predicted. The applicant stated that the pool level and temperature conditions have a "relative role" in the heat removal from the containment. However, the heat removal by the containment has a direct effect on the pressure and level within the containment which directly affect the level and pressure within the RPV. If the heat removal to the pool is not correctly calculated, the heat remove from the containment cannot be calculated correctly. If the containment level and pressure are well predicted some compensating error in the heat transfer either from the containment to the CNV or from the CNV to the pool is likely responsible. The applicant did not described an evaluation of the heat transfer coefficients to provide an explanation of the simulation results. While it is understood that the cooling pool temperatures may be set to bounding temperature and level values to assess which condition may be worse for an aspect of LTC, it does not assess the integrated long term effect of miscalculated heat transfer, nor quantify the uncertainty associated with the miscalculation of the heat transfer or explain potentially compensating error lead to accurate predictions of some results.

Provide additional information as to the basis for the prediction of the reactor vessel water level in relation to the containment water level. Explain the physical basis for the good predictions of RPV and containment vessel pressures, while the observed thermal stratification and level in the cooling pool is not accurately predicted. Identify any areas of uncertainty which could lead to an accurate prediction of reactor vessel and containment pressures while other key phenomena are not predicted well.

15-25

10 CFR 50 Appendix A, GDC 34, Residual heat removal, and NuScale's PDC 34, in FSAR Section 3.1.4.5, state,

"A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded."

The long term cooling technical report (LTC-TR), TR-0916-51299, supports FSAR Section 15.0.5, Long Term Decay and Residual Heat Removal, when the ECCS is used for long term decay heat removal following either a non-LOCA or LOCA event up to 72 hours. The primary acceptance criteria for the analysis are 1) Collapsed liquid level is maintained above the active fuel and 2) fuel cladding temperature is maintained at an acceptable level such that the SAFDLs are preserved.

LTC-TR Section 4.2.4 discusses the prediction of NIST-1 test HP-19b. The only difference between tests HP-19a and HP19b was the containment pressure initial condition.   The initial conditions at 6,000 seconds were different from those in HP-19a, indicating that the initial containment backpressure at atmospheric conditions had some effect on the transient progression from 0 – 6,000 seconds. The LTC TR did not discuss how the effect of initial containment atmosphere condition had on the test response or how it would affect the predicted level response.

The staff notes that Figure 4-10 shows the predicted RPV water level is well below the lower bound of the measurements until approximately 12,000 seconds, and it approaches the measured value at approximately

18,000 seconds. On the other hand, the Figure 4-9 shows the water level in the containment is close to the upper bound of the measurements, which is consistent with the lower RPV level, however, it reaches values that are between the measured level and the lower bound values. It is expected that good agreement over the long-term in the RPV water level would also result in good agreement in containment water level, unless, the heat removal by the containment cooling pool is under predicted by NRELAP5. As the expected agreement between the RPV and containment level is not demonstrated the staff is seeking to understand if model limitations exists which could require code modification or additional code validation.   In addition, the prediction of the cooling pool temperature in the upper region in Figure 4-16, which remains well below the data error bands, showed an inflection at approximately 50,000 seconds and upward trend toward the data.

The staff is requesting the applicant describe how: 1) the containment atmospheric initial condition affected the test transient response in comparison to the HP-19a test, 2) why the containment level (Figure 4-9) is within the upper test bound while the predicted RPV level (Figure 4-10) is outside the lower test bound and 3) and the change in the NRELAP5 cooling pool simulation of the upper temperature prediction at approximately 50,000 seconds in Figure 4-16.

15-26

10 CFR 50 Appendix A, GDC 34, Residual heat removal, and NuScale's PDC 34, in FSAR Section 3.1.4.5, state,

"A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded."

The long term cooling technical report (LTC-TR), TR-0916-51299, supports FSAR Section 15.0.5, Long Term Decay and Residual Heat Removal, when the ECCS is used for long term decay heat removal following either a non-LOCA or LOCA event up to 72 hours. The primary acceptance criteria for the analysis are 1) Collapsed liquid level is maintained above the active fuel and 2) fuel cladding temperature is maintained at an acceptable level such that the SAFDLs are preserved.

RG 1.203 describes the EMDAP, and provides guidance, which the NRC staff considers acceptable for use in developing and assessing EMs used to analyze transient and accident behavior. RG 1.203 provides guidance regarding the content of assessment reports:

"With respect to a calculational device input model and the related sensitivity studies, assessment reports must achieve the following additional purposes:

> *(10) Provide a nodalization diagram, along with a discussion of the nodalization rationale.*
>
> *(11) Specify and discuss the boundary and initial conditions, as well as the operational conditions for the calculations.*
>
> *(13) Discuss modifications to the input model (nodalization, boundary, initial or operational conditions) resulting from sensitivity studies."*

In LTC-TR Section 4.3, the Applicant describes the studies performed to assess the difference in the NRELAP5 nodalization for the LTC-EM and the NRELAP5 nodalization for the LOCA-EM, and stated that both nodalization schemes preserve the code validation pedigree. However, the LTC-TR did not explain what was different. LTC-TR Section 4.3 stated:

"In order to evaluate the effect of the nodalization differences on the LTC results, a normal letdown line break LTC calculation was performed using the nodalization documented in the NuScale LOCA topical report. For this comparison, the following conditions were modeled:

- *Minimum flow area and flow coefficient (Cv) for the ECCS valves*
- *The ECCS valve IAB release pressure was assumed to be 900 psi*
- *100 percent of the 1973 ANS standard decay heat, accounting for actinides*
- *Nominal initial reactor pool temperature (100 degrees F) and level (69 feet)"*

In addition, the changes described in Section 4.1 of the LTC TR were included in the LOCA EM nodalization calculation. The background, bases, and justification for these changed conditions is not discussed in the LTC-TR. In Figure 4-18 through Figure 4-23 of The TR, the applicant describes the differences in the results between the calculations. However, there is no explanation relating the differences in the nodalization to the differences in the results. The applicant concluded that the lower RCS temperatures and lower core inlet and exit temperatures in the LTC-EM nodalization is conservative for the boron precipitation analysis. Nevertheless, there is a significant difference in the time at which comparable pressures and temperature are achieved between the two calculations Without a firm understanding of the reasons for the differences in the calculations, it is not clear how it may be concluded that the differences in the pressures and temperatures would not affect the flows through the RVVs, RRVs, flow within the RPV, the natural circulation of coolant flow within the CNV and the heat transfer response during the long- term cooling calculation.

Discuss the analysis differences between the LTC-EM nodalization of the letdown line break and the LOCA-EM nodalization of the letdown line break, including the basis and justification for the changes to the LOCA-EM model for the conditions noted. Describe how the differences between the model nodalization resulted in the differences between the calculated results. Alternately, the applicant may provide a detailed technical basis justifying the LTC EM nodalization based on adequately capturing the uncertainity assoicated with the high ranked phenomena identified by the PIRT.