February 27, 2019

Docket: PROJ0769

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 9390 (eRAI No. 9390) on the NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 9390 (eRAI No. 9390)," dated June 15, 2018
2. NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0, dated December 2016
3. NuScale Power, LLC Response to NRC "Request for Additional Information No. 9390 (eRAI No. 9390)," dated January 29, 2019

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosures to this letter contain NuScale's response to the following RAI Questions from NRC eRAI No. 9390:

- 15.06.05-18
- 15.06.05-19

RAI Question 15.06.05-18 includes four parts, (a), (b), (c), and (d). The responses to parts (a), (b), and (c) were provided in Reference 3. This completes all responses to RAI 9390.

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 9390 (eRAI No. 9390). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The proprietary enclosures have been deemed to contain Export Controlled Information. This information must be protected from disclosure per the requirements of 10 CFR § 810. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the NuScale response.

This letter and the enclosed responses make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Paul Infanger at 541-452-7351 or at pinfanger@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8H12
Samuel Lee, NRC, OWFN-8H12
Rani Franovich, NRC, OWFN-8H12

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9390, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9390, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0219-64681

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9390, proprietary

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Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9390, nonproprietary

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9390

Date of RAI Issue: 06/15/2018

NRC Question No.: 15.06.05-18

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 50.43(e) (52 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 (RG) 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 that may be used to analyze transient and accident behavior that is within the design basis of a nuclear power plant. 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.

a. The NIST-1 facility was sized based on scaling the natural circulation phase at {{ }}$^{2(a),(c)}$, which the staff audited in support of the loss of coolant accident [LOCA] Topical Report [TR]). As the reactor will be in steady state for natural circulation, the two dominant phenomena, buoyancy and friction should match. {{ }}$^{2(a),(c)}$ steady state operation, as these two forces will be balanced as was shown in Section 4.4.1 {{ }}$^{2(a),(c)}$. Please explain this discrepancy.

b. Regarding depressurization equations for the system {{ }}$^{2(a),(c)}$, the staff is concerned that {{ }}$^{2(a),(c)}$ may not be properly preserved. Therefore, the current approach could average the effect of heat addition over the whole primary system. As a result, the depressurization rate could be distorted as the impact of heat addition might be diluted in the reactor pressure vessel (RPV) and similarly the pressurization rate in the containment could be also be altered. Please provide justifications to show this {{ }}$^{2(a),(c)}$ and approach does not adversely impact the blow-down phenomenon simulation in NIST.

c. The scaling report {{ }}$^{2(a),(c)}$ showed that there is distortion in {{ }}$^{2(a),(c)}$. At peak CNV pressure {{ }}$^{2(a),(c)}$. Also, at the peak pressure, all terms in the energy equation should be balanced, i.e, the energy input from the RPV and the energy lost to the containment wall surface should be equal. This is not evident from Table 6-20. Please explain. {{ }}$^{2(a),(c)}$ for CNV pressure indicates {{ }}$^{2(a),(c)}$. What are additional distortions that compensate for it?

d. Because the Section 8.3.2 only has a brief summary of the scaling analysis and distortion evaluation based on the actual scaling report and distortion analysis for NIST, however these evaluations form a large portion of the justification for the model, provide important findings and conclusions from the scaling analysis report and the distortion evaluation report with specific references (e.g. section/page/figure number) that support the conclusions in Section 8.3.2." These findings should also include distortions in power distribution, initial fluid and heat structure stored energy in the vessel, NIST CNV initial conditions; such as pressure, CNV wall temperature, HTP temperature, condensate liquid level, building pool temperature, and NIST initial vessel pressure, and the impact of these distortions on the test data for figures of merit. The accurate documentation of initial and boundary conditions are essential for NRELAP5 code validation.

NuScale Response:

eRAI 9390, Question 15.06.05-18 includes four parts, (a), (b), (c), and (d). This letter provides NuScale's response to part (d).

NuScale's response to parts (a), (b), and (c) were provided previously in NuScale Letter RAIO-0119-67307, "NuScale Power, LLC Response to NRC Request for Additional Information No. 9390 (eRAI No. 9390) on the NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0", dated January 29, 2019 (ML19029B559)

The Loss Of Coolant Accident Evaluation Model Topical Report (LOCA EM TR), TR-0516-49422, has been updated to include additional summary discussion of the scaling and distortion analyses used to develop its evaluation model.

Section 8.3.2 "NuScale Facility Scaling", and Section 8.3.4 "Evaluation of NuScale Integral Effects Tests Distortions and NRELAP5 Scalability" of TR-0516-49422 have been expanded by describing the evaluations and conclusions provided by NuScale's scaling reports and distortion analyses related to Section 8.3.2 of the topical report. These additional discussions provide the topical report with better support for the conclusions it provides to the reader, and the examples it provides in applying the NuScale LOCA EM.

Impact on Topical Report:

Topical Report TR-0516-49422, Loss-of-Coolant Accident Evaluation Model, has been revised as described in the response above and as shown in the markup provided with the response to question 15.06.5-19.

Response to Request for Additional Information

eRAI No.: 9390
Date of RAI Issue: 06/15/2018

NRC Question No.: 15.06.05-19

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 50.43(e) (52 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 (RG) 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 that may be used to analyze transient and accident behavior that is within the design basis of a nuclear power plant.

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 evaluation model (EM) ultimately determines whether the results are in compliance with applicable regulations. Therefore, the development, assessment, and review processes must consider the entire EM.

The purpose of the NIST-1 facility is to provide realistic data for evaluation model validation. As there are no other counterpart tests, the NIST-1 facility is critical for code validation. The validation with NIST-1 for a set of loss of coolant accident (LOCA) tests demonstrates the code's ability to predict NuScale Power Module (NPM) behaviors. However, for NIST-1, this requires an additional step of evaluating the scaling distortion. Significant distortion in initial conditions, boundary conditions and important scaling similarity groups (PI group) need to be assessed before the code is qualified to predict the figures of merit for the NPM, such as the containment peak pressure and the reactor vessel level that is a surrogate for clad temperature in a traditional pressurized water reactor (PWR).

In the scaling distortion report {{ }}2(a),(c), which the staff audited in support of the LOCA Topical Report (TR), the applicant attempts to quantify the effect of the scaling distortion by performing sensitivity calculations for the NPM and NIST-1 configuration. In the course of review, the staff identified several discrepancies and concerns, as listed below. These discrepancies were not adequately addressed in audit discussions with the applicant. Assessment of scaling distortions is essential to predicting the figures of merit for a NPM LOCA transient. One of the elements of review is the consistency of sensitivity calculations and their impact on predicted figures of merit in response to scaling distortions, which is not clearly shown based on the following observations. The staff needs to understand how these discrepancies and distortions contribute to the LOCA figures of merit (e.g. reactor level, containment pressure) quantitatively. An integral estimate of quantified uncertainty of figures of merit due to scaling distortions as identified below is also needed.

1. {{ }}2(a),(c) show primary side collapsed liquid level for HP-06. The timing of NPM emergency core cooling systems (ECCS) actuation and the level after ECCS starts varies among plots. Distortion of the time of ECCS actuation reflects a scaling distortion of several parameters which contribute to LOCA figures of merit. Evaluation of the HP06b test is essential since {{ }}2(a),(c). Provide a discussion regarding HP06b level behavior and the measured ECCS actuation timing.

2. {{ }}$^{2(a),(c)}$ shows pressure differentials at the break, and the NPM shows {{ }}$^{2(a),(c)}$ However, {{ }}$^{2(a),(c)}$. There exists {{ }}$^{2(a),(c)}$, which affects the vessel inventory prediction. The staff requests an explanation of this inconsistency and the implication to the vessel inventory prediction.

3. {{ }}$^{2(a),(c)}$ for test HP05 indicates that there is a better match for core flow data between the scaled NPM than NIST. It should be the other way around as NIST loss coefficients {{ }}$^{2(a),(c)}$ which the staff audited in support of the LOCA TR, describes {{ }}$^{2(a),(c)}$ This distortion is not explained sufficiently. The impact of this distortion is on stored energy in the vessel component, and its effects on the overall LOCA response. Provide quantitative justification to show that the distortion falls into the relevant PI number uncertainty range.

NuScale Response:

Response to Part 1:

> *{{ }}$^{2(a),(c)}$ show primary side collapsed liquid level for HP-06. The timing of NPM emergency core cooling systems (ECCS) actuation and the level after ECCS starts varies among plots. Distortion of the time of ECCS actuation reflects a scaling distortion of several parameters which contribute to LOCA figures of merit. Evaluation of the HP06b test is essential since {{ }}$^{2(a),(c)}$. Provide a discussion regarding HP06b level behavior and the measured ECCS actuation timing.*

The primary objective of the distortion analysis presented in NuScale's scaling distortion report is to identify and quantify the biases and scaling distortions in the as-performed NIST-1 integral effect tests (IET). The analysis was performed for NIST-1 tests HP-05, HP-06, HP-06b, HP-07, and HP-09. The NuScale Power Module (NPM) NRELAP5 model was systematically updated to account for selected biases and scaling distortions. By comparing the NPM NRELAP5 predictions and the NIST-1 IET data, it was demonstrated that the differences are reduced when the biases and distortions are taken into account. The scaling distortion report analysis has been updated. The updates include:

- {{
-
-
- }}2(a),(c)

{{

}}2(a),(c) Figures 1-1 and 1-2 below show the comparisons of RPV and CNV water levels in NPM and NIST-1 for the HP-06 test analysis. Table 1-1 shows the comparison of initial conditions between the NPM at 1650 psia and NIST-1 at the start of the test. Table 1-2 shows the comparison of event sequence timings between NPM and NIST-1 for the HP-06 test analysis. Similar results for the HP-06b test analysis are provided in Figures 1-4 and 1-5 and Tables 1-3 and 1-4.

It is observed from Figure 1-1 and 1-4 that {{

}}2(a),(c)

{{

}}2(a),(c),ECI

Figure 1-1. HP-06 Primary Liquid Level Comparison

{{

}}2(a),(c),ECI

Figure 1-2. HP-06 CNV Liquid Level Comparison

{{

}}2(a),(c),ECI

Figure 1-3. RPV and CNV liquid inventory comparison between NPM Distortions Case and NIST-HP-06 assessment

Table 1-1. Comparison of NPM CVCS discharge line break LOCA IC/BC and procedure case conditions at 1650 psia RCS pressure and initial conditions in NIST-1 HP-06 and HP-06b tests

{{

}} 2(a),(c),ECI

Table 1-2. Sequence of Events for NPM HP-06 Scenarios and NIST-1 HP-06 test

{{

}} 2(a),(c),ECI

{{

}}2(a),(c),ECI

Figure 1-4. HP-06b Primary Liquid Level Comparison

{{

}}2(a),(c),ECI

Figure 1-5. HP06b CNV Liquid Level Comparison

{{

}}2(a),(c),ECI

Figure 1-6. RPV and CNV liquid inventory comparison between NPM Distortions Case and NIST-HP-06 assessment

Table 1-3. Comparison of NPM CVCS discharge line break LOCA conditions at 1650 psia RCS pressure and initial conditions in HP-06b tests

{{

}} 2(a),(c),ECI

Table 1-4. Sequence of Events for NPM HP-06b Scenarios and NIST-1 HP-06b test

{{

}} 2(a),(c),ECI

Response to Part 2:

> *{{ }}$^{2(a),(c)}$ shows pressure differentials at the break, and the NPM shows {{ }}$^{2(a),(c)}$ However, {{ }}$^{2(a),(c)}$. There exists {{ }}$^{2(a),(c)}$, which affects the vessel inventory prediction. The staff requests an explanation of this inconsistency and the implication to the vessel inventory prediction.*

As summarized in the response to Part 1 of this RAI, the scaling distortion analysis has been updated. One of the updates implemented is to {{

}}$^{2(a),(c)}$

{{

}} 2(a),(c),ECI

{{

}}2(a),(c),ECI

Figure 2-1 HP06 Break Differential Pressure Comparison

{{

}}2(a),(c),ECI

Figure 2-2 HP06 NRELAP5 Break Flow Comparison

{{

}}2(a),(c),ECI

Figure 2-3 HP06 PZR Liquid Level Comparison

Response to Part 3:

> *{{ }}2(a),(c) for test HP05 indicates that there is a better match for core flow data between the scaled NPM than NIST. It should be the other way around as NIST loss coefficients {{*
>
> *}}2(a),(c) which the staff audited in support of the LOCA TR, describes {{*
>
> *}}2(a),(c) This distortion is not explained sufficiently. The impact of this distortion is on stored energy in the vessel component, and its effects on the overall LOCA response. Provide quantitative justification to show that the distortion falls into the relevant PI number uncertainty range.*

The response to Part 3 contains the following three sections. The first section discusses the original NPM and NIST-1 assessments referred to in this this RAI. The second section discusses the revised NPM and NIST-1 assessments. The third section discusses distortion on the reactor pressure vessel (RPV) stored energy and PI groups.

Original NPM and NIST-1 assessments for HP-05 test:

In the original NIST-1 HP-05 assessment (in audited documents {{

}} 2(a),(c)), the loss coefficients along the RPV flow path {{

}} 2(a),(c) thus it is concluded that the pressure loss coefficients along the RPV flow path had been adequately characterized.

The main focus of the HP-05 assessment is {{

}} 2(a),(c),ECI

Revised NPM and NIST-1 assessments for HP-05 test:

Both the NPM and NIST-1 models for the HP-05 test have been revised {{

}}2(a),(c)

{{

}}2(a),(c)

{{

}} 2(a),(c)

Discussions on the distortions:

The RPV fluid stored energy depends on the RPV fluid mass and temperature. At the full power condition of the HP-05 test, a detailed calculation on the ratio of the NIST-1 RPV fluid mass to the NPM fluid mass is {{ }} 2(a),(c). Figure 3-2 and Figure 3-3 show {{

}} 2(a),(c)

Table 3-2 compares scaling similarity between NIST-1 and NPM models. The comparisons in Table 3-2 demonstrate that the NIST-1 facility is well scaled to the NPM in regards to natural circulation flow. {{

}}2(a),(c)

{{

}} 2(a),(c)

Table 3-1: Comparisons on the HP-05 Assessment Cases

{{

}} 2(a),(c)

{{

}}2(a),(c),ECI

Figure 3-1 HP05 RPV Flow Comparison to Test Data

{{

}}2(a),(c),ECI

Figure 3-2 HP05 Upper Riser Inlet Temperature Comparison to Test Data

{{

}}2(a),(c),ECI

Figure 3-3 HP05 Core Inlet Temperature Comparison to Test Data

Table 3-2 Comparison of Single-Phase Natural Circulation Similarity Criteria for the HP-05 Test (Full Power Only)

{{

}}2(a),(c)

{{

}} 2(a),(c)

Impact on Topical Report:

Topical Report TR-0516-49422, Loss-of-Coolant Accident Evaluation Model, has been revised as described in the response above and as shown in the markup provided with this response.

Adherence to the modeling requirements of RELAP5 assist in ensuring that the governing equations are well posed. Requirements for nodalization and time step sensitivity studies comply with 10 CFR 50 Appendix K requirements and ensure converged solutions. Solutions are examined to identify unstable or unphysical behavior.

8.3.2 NuScale Facility Scaling

The NIST-1 facility is designed to simulate the integral system behavior of a single NPM immersed in a single bay within the reactor pool. The scaling analysis was performed to determine the geometric dimensions and operating conditions for the NIST-1 facility. The purpose of the scaling analysis was to design an IET facility that can be used to obtain quality data for thermal-hydraulic system safety analysis code validation. The hierarchical two-tiered scaling (H2TS) (Reference 99) method was used to perform the RCS natural circulation scaling and the scaling of LOCA and ECCS. The scaling analysis generated the sets of dimensionless groups that needed to be preserved to accurately simulate the high-ranked phenomena identified in the NuScale LOCA PIRT. The figures of merit were the peak CNV pressure and the collapsed liquid level above the top of the core. The scaling analysis also documented the scaling distortions between the NIST-1 facility and the NPM design, and evaluated the effects of these distortions.

Detailed documentation of the NIST-1 scaling analysis is available in the NIST-1 Facility Scaling Reports. Section 8.3.2.1 summarizes the scaling objectives and methodology. The approaches for RCS scaling natural circulation scaling and the scaling of LOCA and ECCS are briefly presented in Sections 8.3.2.2 and 8.3.2.3, respectively.

8.3.2.1 Scaling Objectives and Methodology

The general objective of the scaling analysis was to obtain the physical dimensions and operating conditions of a reduced-scale test facility capable of simulating the important flow and heat transfer behavior of a NPM under the LOCA conditions. To develop a properly scaled test facility, the following specific objectives were met for each operational mode of interest.

- The thermal-hydraulic processes that should be modeled were identified.
- The similarity criteria that should be preserved between the test facility and the full-scale prototype were obtained.
- The priorities for preserving the similarity criteria were established.
- Specifications for the test facility design were established.
- Biases due to scaling distortions were quantified.
- The critical attributes of the test facility that must be preserved to meet testing requirements were identified.

Different similarity criteria were obtained for the different modes of system operation. These criteria depend on the geometry of the components, the scaling level required to

Table 8-12. Scaling factors for NIST-1 facility

{{

}}2(a),(c)

The NIST-1 tests start from steady-state natural circulation conditions. {{

}}2(a),(c).~~The initial conditions in the NIST-1 facility have been scaled to simulate single-phase natural circulation flow in a single NPM operating at 50 percent of full power with all heat rejection through one SG.~~ The test facility operates near prototypic pressures and temperatures and operates with the same working fluid: water. Therefore, fluid property similitude is invoked. This means that the fluid property ratios are near to unity in all of the scale ratios, thereby simplifying the analysis.

8.3.2.2 Reactor Coolant System Natural Circulation Scaling

Figure 8-10 provides a flow diagram that describes the scaling analysis process for the RCS natural circulation operational mode. First, a top-down scaling analysis was performed. This included an analysis at the system level (integrated loop behavior) for normal operating conditions. {{

}}2(a),(c) Further details are available in the NIST-1 facility scaling reports.

8.3.2.4 As-Built NuScale Facility Scaling Summary

The top-down portion of the NIST-1 scaling analysis presented in Section 8.3.2.3 was expanded to perform an additional quantitative evaluation of the distortions in the as-built NIST-1 facility. The mass/energy balance equations were re-defined to include additional terms that better quantify the distortion in various phenomena seen in the RCS and CNV during a typical LOCA. The control volume balance equations derived for the RCS and CNV include

- {{

}}2(a),(c)

For quantifying the distortions, the following terms in the energy balance equations were explicitly accounted for in the top-down scaling analysis

- {{

}}2(a),(c)

The dimensionless forms of the mass/energy balance equations were derived by identifying the characteristic scales appearing in the balance equations. π groups characterizing the ratio of characteristic times for each process were defined based on the dimensionless equations.

Table 8-13, Table 8-14, and Table 8-15 summarize the mass flow paths and heat flow paths for the RCS and CNV considered in the top-down scaling analysis. The heat and mass flows into the control volume have a positive sign; whereas the negative sign represents heat and mass flow out of the control volume. Three mass flow rates are identified for both NPM and NIST-1 and are symmetric between the RCS and CNV. The same number of heat flow paths are identified for the RCS in NPM and NIST-1. {{

}}2(a),(c) Two major heat transfer paths are identified for the CNV: the first path is the heat transfer on the inner surface of the containment wall, the second is the heat transfer from the outer surface of the reactor pressure vessel. {{

}}2(a),(c)

{{

}}2(a),(c)

A summary of π groups in the dimensionless mass/energy balance equations is given in Table 8-16 and Table 8-17. As depicted in Table 8-16 and Table 8-17, {{

}}2(a),(c)

Table 8-13 Mass Flow Paths for NPM and NIST-1 (RCS and CNV)

Flow Path No	Description
{{	}}2(a),(c)

Table 8-14 Heat Flow Paths for RCS in NPM and NIST-1

Heat Flow Path No	Description
{{	}}2(a),(c)

Table 8-15 Heat Flow Paths for Containment in NPM and NIST-1

Heat Flow Path No	Description
{{	}}2(a),(c)

Table 8-16 Description of π Groups for the RCS Mass/Energy Balance

Π Group	Description
{{	
	}}2(a),(c)

Table 8-17 Description of π Groups for the Containment Mass/Energy Balance

Π Group	Description
{{	
	}}2(a),(c)

Π Group	Description
{{	
	}}2(a),(c)

These π groups were evaluated based on NRELAP5 simulations of the NPM and as-built NIST-1 facility for the following events:

- 100 percent discharge line break on the CVCS line (similar to NIST-1 HP-06 test)
- 100 percent high point vent line break (Similar to NIST-1 HP-07 test)
- Inadvertent opening of a single RVV (Similar to NIST-1 HP-09 test)

{{

}}2(a),(c) The key conclusions of this analysis are summarized below.

1. {{

}}2(a),(c)

{{

}}2(a),(c)

8. {{

}}2(a),(c) The scaling and distortion analysis methodology presented above is used to analyze the impact of biases in initial and boundary conditions and differences in operating procedures of the final NIST-1 IET data used in Section 8.3.4.

~~The scaling analysis showed that the NIST-1 facility is well scaled for single-phase natural circulation during operating conditions.~~

~~The distortions during the RCS depressurization, CNV pressurization, long-term recirculation cooling, and Reactor Building pool heat-up periods of the LOCA were analyzed in the scaling analyses for CVCS discharge line break LOCA. The scaling analysis indicated that none of the distortions have an impact on peak CNV pressure~~

- ~~{{~~

~~}}2(a),(c)~~

~~– {{~~

~~}}2(a),(c)~~

~~In addition to the distortions identified in the scaling analysis the IET data may get affected by the differences in initial conditions, boundary conditions, and operating procedures, as well as distortions due to changes to the NPM design.~~

~~The differences in initial/boundary conditions include the differences in initial CPV temperature, decay heat, break configuration, etc. The differences in operating procedure include the differences in SG secondary-side operation, pressurizer heat operation, etc. {{~~

~~}}2(a),(c)~~

~~The scaling distortions as well as the differences identified above are evaluated to determine their impact in Section 8.3.4. It is shown that NRELAP5 is capable of accounting for these distortions/differences, thereby establishing the scalability of NRELAP5 to model the phenomena in NPM.~~

8.3.3 Assessment of NuScale Facility Integral Effects Test Data

The NIST-1 IET data that supports the validation of NRELAP5 for NPM LOCA analysis includes the following tests.

- {{

}}2(a),(c)

{{

}}2(a),(c)

As shown in Sections 7.5.5 to 7.5.8, in general, NRELAP5 predicted the NIST-1 IET data with excellent agreement. This shows that NRELAP5 is capable of predicting the phenomena and process occurring in the NIST-1 facility including system interactions. Further, evaluations of these assessments for each high-ranked PIRT phenomenon are summarized in Table 8-19~~4~~.

8.3.4 Evaluation of NuScale Integral Effects Tests~~Facility~~ Distortions and NRELAP5 Scalability

The scaling and distortion analysis summarized in Section 8.3.2.4 identified and quantified scaling distortions in the as-built NIST-1 facility {{

}}2(a),(c)

The NuScale NRELAP5 LOCA EM was updated to simulate NIST-1 IETs HP-05, HP-06, HP-06b, HP-07, and HP-09 in the NPM. {{

}}2(a),(c)

{{

}}2(a),(c)

The results showed that the biases, differences, and distortions between the NPM design and the NIST-1 facility can be accounted for using NRELAP5, and NRELAP5 is scalable to model phenomena and process in the NPM during LOCA events.

8.3.4.1 NuScale Facility Powered Natural Circulation Test (HP-05)

The NPM relies on natural circulation flow as the primary mechanism to remove energy produced in the core and to deposit that energy in the SG tubes. The core power provides the driving force, with resistance to the flow caused by form and friction losses along the primary coolant path. The NIST-1 test facility is a scaled model of the NPM that uses the same natural circulation mechanism to move energy from the core heater rods to the model SG tubes. Scaling factors for the NIST-1 facility are as shown in Table 8-12.

Test NIST-1 HP-05 was conducted to characterize the natural circulation flow rate and pressure drop in the NIST-1 test facility at various core power levels. As shown in Section 7.5.5 NRELAP5 predicted the HP-05 test data for the primary loop flow rate, core inlet temperature, and ~~core outlet~~upper riser inlet temperature with reasonable-to-excellent agreement (see Figure 7-88 to Figure 7-90). These results demonstrate the applicability of NRELAP5 to predict the natural circulation flow in the NIST-1 facility over a range of power levels.

{{

}}2(a),(c)

Figure 8-15 shows that the scaled NPM feedwater flow compares well with the test data. ~~The oscillations in the NPM feedwater flow are damped over the course of each power step and the flow approaches the experimental flow rate near the end of each step.~~{{

}}2(a),(c)

{{

}}2(a),(c)

Figure 8-16 shows comparison of scaled NPM natural circulation flow to the test data. {{

}}2(a),(c) ~~The excellent agreement between the scaled NPM predicted mass flow rate and the NIST-1 test data demonstrates that NRELAP5 is applicable for predicting the magnitude of the NPM natural circulation flow over a range of power levels.~~

{{

}}2(a),(c),ECI

Figure 8-15. Comparison of HP-05 feedwater flow to test data

{{

}}2(a),(c),ECI

Figure 8-16. Comparison of HP-05 reactor pressure vessel flow to test data

~~The predicted core exit subcooling is compared to test data in Figure 8-17. {{~~

~~}}2(a),(c),~~

~~Bands at ±5 degrees F (±2.8 degrees C) of the target subcooling are shown on the figure. While there is considerable variation in the subcooling, the NPM prediction is comparable to the test data in this regard. The oscillations in subcooling are to some extent driven by the oscillations in feedwater flow shown in Figure 8-15. This is further evidenced by the oscillations in core inlet temperature shown in Figure 8-18. It is apparent that the oscillations are initiated when the feedwater flow is ramped from one level to the next and that they are damped out when the feedwater flow demand is held constant. This trend is shown in both the predictions and in the test data. The predicted temperatures are in excellent agreement with the test data, thus demonstrating that NRELAP5 is applicable for predicting temperature response in NPM during changes in natural circulation flow.~~The upper riser inlet temperature comparison to test data is shown in Figure 8-17. {{

}}2(a),(c)

{{

}}2(a),(c)

In summary, the comparisons of scaled NRELAP5 calculations of the NPM RPV flow and fluid temperatures to NIST-1 NRELAP5 calculations and the test data indicate that the NIST facility is well scaled. {{

}}2(a),(c)

{{

}}2(a),(c),ECI

Figure 8-17. Comparison of HP-05 ~~core exit subcooling~~upper riser inlet temperature to test data

{{

}}2(a),(c),ECI

Figure 8-18. Comparison of HP-05 core inlet temperature to test data

8.3.4.2 NuScale Facility Loss-of-Coolant Accident and ~~Spurious~~Inadvertent Reactor Vent Valve Opening Integral Effects Tests (HP-06, HP-07, and HP-09)

This section summarizes the ~~comparisons~~results of the distortion analysis performed for ~~of the scaled NPM NRELAP5 predictions to~~ the NIST-1 LOCA and ~~spurious~~inadvertent RVV opening IETs. The following initial/boundary condition biases, differences and scaling distortions between NPM and the as performed NIST-1 IETs have been identified to have a noticeable impact on the important LOCA parameters (i.e., RPV/CNV pressures and levels):

Initial Conditions:

The NIST-1 tests start from the steady-state natural circulation conditions. {{

}}2(a),(c)

{{

}}2(a),(c)

The impact of bias in some of the initial conditions is summarized below:

Initial core power:

{{

}}2(a),(c)

Initial RCS temperature/subcooling distribution:

{{

}}2(a),(c)

{{

}}2(a),(c)

Initial reactor pool temperature:

{{

}}2(a),(c)

Reactor Core Power following Reactor Trip:

{{

}}2(a),(c)

CNV Wall Thickness and Material:

{{

}}2(a),(c)

{{

}}2(a),(c)

Steam Generator Secondary Side Operation and Quantity of Steam Generators:

{{

}}2(a),(c)

NIST-1 CNV Shell:

{{

}}2(a),(c)

RPV Outside Surface Heat Transfer:

{{

}}2(a),(c)

RPV stored energy:

{{

}}2(a),(c)~~Two NPM NRELAP5 predictions are presented to show the calculated phenomena prior {{~~

~~}}2(a),(c) The predictions for the NuScale facility NRELAP5 model are shown for comparison.~~

~~The primary (or RCS) and CNV pressure comparisons to the test data are shown in Figure 8-19 and Figure 8-20, respectively, for the HP-06 IET. The primary and CNV liquid level comparisons to the test data are shown in Figure 8-21 and Figure 8-22, respectively, for the HP-06 IET. Similar results were obtained for the comparison against the HP-07 and HP-09 IETs.~~

~~The figures show that the NRELAP5 predictions for the NPM are very close to the experimental data {{~~

~~}}2(a),(c)~~

~~{{~~

~~}}2(a),(c)~~

~~In summary, the evaluations show that the differences and distortions between the NIST-1 facility and the NPM design can be accounted for using NRELAP5. The comparison of the NPM NRELAP5 predictions against the NIST-1 IET data for the LOCAs and a spurious RVV opening shows reasonable-to-excellent agreement once the 10 CFR 50 Appendix K assumptions are removed, initial and boundary conditions as well as operating procedures are consistent, and the scaling distortions are accommodated. The remaining differences between the NRELAP5 NPM calculation and the experimental~~

~~data are likely justified by the minor distortion due to the thermal inertia in the CNV shell heat structure which was not specifically examined.~~

{{

}}~~2(a),(c)ECI~~

~~Figure 8-19. Comparison of HP-06 primary pressure to test data~~

{{

}}2(a),(c)ECI

~~Figure 8-20. Comparison of HP-06 containment vessel pressure to test data~~

{{

}}~~2(a),(c)ECI~~

~~Figure 8-21. Comparison to HP-06 primary liquid level to test data~~

{{

}}~~2(a),(c)ECI~~

~~Figure 8-22. Comparison of HP-06 containment vessel liquid level to test data~~

8.4 Summary of Adequacy Findings

8.4.1 Findings from Bottom-Up Evaluation

The bottom-up evaluation focused on determining the pedigree, applicability, fidelity to SET data, and scalability of the NRELAP5 closure relations and correlations that model the high-ranked phenomena as determined by the PIRT panel.

The pedigree of the identified closure relations and correlations was first established based on their historical development and subsequent assessment in the literature. Assessment cases were then identified to demonstrate the capability of NRELAP5 to predict the experimental data responses with reasonable-to-excellent agreement. Applicability of NRELAP5 to model the subject phenomena is established by demonstrating that the assessment cases cover the range of parameters that approximates the NPM range. The scalability evaluation was limited to whether the specific model or correlation is applicable for the NPM configuration over the range of conditions encountered in LOCA events.

Results of the bottom up evaluation are summarized in Table 8-18~~3~~.

Table 8-18. Summary of bottom-up evaluation of NRELAP5 models and correlations

{{

}}2(a),(c)

8.4.2 Findings from Top-Down Evaluation

Results of the adequacy evaluation based on the NIST-1 IETs are summarized in Table 8-19~~4~~ below. All high-ranked phenomena are included in the table. Where the NIST-1 IETs do not provide information, or provide limited information, regarding NRELAP5 applicability to model the phenomenon an explanation is provided. Areas not covered, or partly covered, by the IETs are addressed by SETs or other means, e.g., sensitivity studies, bounding assumptions, component test data.

Table 8-19. Applicability summary for high-ranked phenomena

{{

}}2(a),(c)

{{

}}2(a),(c)

8.4.3 Summary of Biases and Uncertainties

The NRELAP5 based LOCA EM was evaluated for applicability to analyzing LOCA events in the NPM. The applicability evaluation confirmed that the models and correlations in the NuScale LOCA EM are acceptable for simulating the important, i.e., high ranked, phenomena that determine the NPM response. Results of the LOCA EM applicability evaluation based on the bottom-up approach are summarized in Table 8-18~~3~~. The overall evaluation of NRELAP5 applicability based on the top down approach is summarized in Table 8-19~~4~~. The summaries in these tables show that the code is applicable for predicting LOCA response for the high-ranked phenomena that govern LOCA response in the NPM. A key element of the applicability confirmation is provided by SET and IET assessments that demonstrate reasonable-to-excellent agreement between NRELAP5 predictions and relevant experimental data.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0219-64681

NuScale Power, LLC

AFFIDAVIT of Zackary W. Rad

I, Zackary W. Rad, state as follows:

1. I am the Director, Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.
2. I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:
    a. The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.
    b. The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.
    c. Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.
    d. The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.
    e. The information requested to be withheld consists of patentable ideas.
3. Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying Request for Additional Information response reveals distinguishing aspects about the method by which NuScale develops its loss of coolant accident analysis.

    NuScale has performed significant research and evaluation to develop a basis for this method and has invested significant resources, including the expenditure of a considerable sum of money.

    The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

    If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

4. The information sought to be withheld is in the enclosed response to NRC Request for Additional Information No. 9390, eRAI No. 9390. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.
5. The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).
6. Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:
   a. The information sought to be withheld is owned and has been held in confidence by NuScale.
   b. The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.
   c. The information is being transmitted to and received by the NRC in confidence.
   d. No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.
   e. Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 27, 2019.

Zackary W. Rad