May 31, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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SUBJECT: NuScale Power, LLC Submittal of Turbine Missile Barrier Design Closure Plan Actions (Final Safety Analysis Report, Tier 2, Section 3.5.1.3)

REFERENCE: NuScale Letter to the NRC, "NuScale Power, LLC Submittal of Closure Plan for Turbine Missile Barrier Design Safety Review (Final Safety Analysis Report, Tier 2, Section 3.5.1.3)," dated May 3, 2019 (ML19123A321)

The purpose of this submittal is to address the actions identified in the referenced Turbine Missile Barrier Design Closure Plan. Specifically, NuScale committed to provide information sufficient for resolution of the following turbine missile related items:

- Turbine missile barriers described in detail and information added to the Final Safety Analysis Report (FSAR)
- Benchmarking and validation of the codes and calculations that support the turbine missile analysis
- Characteristics of the analyzed turbine missile and results of the impact analysis summarized
- Documentation and basis for the bounding turbine missile parameters

The Attachments and Enclosures to this letter provide the requested information.

Attachment 1 provides proprietary NuScale responses to the NRC Staff's Design Safety Review questions.

Attachment 2 provides security-related information figures showing the Turbine Missile barriers.

Attachment 3 provides the proprietary Finite Element Software Validation and Verification Tables.

Attachment 4 provides proprietary supplemental Verification and Validation information.

Attachment 5, Attachment 6, and Attachment 7 are the nonproprietary versions of Attachments 1,3, and 4, respectively.

Enclosure1 provides a markup of FSAR Section 1.8, "Interfaces with Certified Design," Section 3.5, "Missile Protection," and Section 10.2, "Turbine Generator," in redline/strikeout format. NuScale will include these changes as part of a future revision to the NuScale Design Certification Application.

Enclosure 2 provides the affidavit for withholding the proprietary information in Attachments 1, 3, and 4 to be withheld from public disclosure in accordance with the requirements of 10 CFR §2.390.

NuScale requests that the security-related information in Attachment 2 be withheld from public disclosure in accordance with the requirements of 10 CFR §2.390.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please contact Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

Michael Melton
Manager, Licensing
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Attachment 1: "Responses to NRC Staff Turbine Missile Barrier Design Safety Review," proprietary version
Attachment 2: "Figures Showing Turbine Missile Barriers," nonpublic
Attachment 3: "Finite Element Software Validation and Verification Tables," proprietary version
Attachment 4: "Supplemental Verification and Validation Information," proprietary version
Attachment 5: "Responses to NRC Staff Turbine Missile Barrier Design Safety Review," nonproprietary version
Attachment 6: "Finite Element Software Validation and Verification Tables," nonproprietary version
Attachment 7: "Supplemental Verification and Validation Information," nonproprietary version
Enclosure 1: Changes to NuScale Final Safety Analysis Report Section 1.8, "Interfaces with Certified Design," Section 3.5, "Missile Protection," and Section 10.2, "Turbine Generator"
Enclosure 2: Affidavit of Thomas A. Bergman, AF-0519-65738

SEB requested the following information to conduct its technical review on FSAR Section 3.5.3.

1. Turbine Missile Barriers
   - o Identify and describe specific structural barriers

     NuScale Response:

     A. Reactor Building (RXB)

        The exterior wall of the RXB is the barrier credited for protecting essential structures, systems and components (SSC) within the building.

        Detailed description of the RXB exterior walls:

        - The exterior walls of the RXB are five feet thick. FSAR Appendix 3B.2.2.5 provides a description of the exterior wall at grid line E on the south side of the RXB and Figure 3B-23 shows the reinforcement.
        - FSAR Table 3.8.4-10 provides the material properties of the concrete used.
        - FSAR Appendix 3B.2.1 provides the structural material requirements of the RXB.
        - FSAR Section 3.8.4.1.1 provides a description of the RXB with respect to its design category.
        - FSAR Figures 1.2-16 and 1.2-19 show the RXB layout at the grade level and elevation views.

     B. Control Building (CRB)

        The grade level floor and the exterior wall of the CRB are the barriers credited for protecting essential SSC within the building. Essential SSC in the CRB are located below grade.

        Detailed description of the CRB exterior walls and grade level floor:

        - The exterior walls of the CRB are three feet thick. FSAR Appendix 3B.3.2.2 provides a description of the exterior wall at grid line 4 on the east side of the CRB and Figure 3B-69 shows the reinforcement.
        - The grade level slab of the CRB is three feet thick. Appendix 3B.3.3.2 provides a description of the grade-level slab at elevation (EL) 100'-0."
        - FSAR Table 3.8.4-10 provides the material properties of the concrete used.
        - FSAR Appendix 3B.3.1 provides the structural material requirements of the CRB.
        - FSAR Section 3.8.4.1.2 provides a description of the CRB with respect to its design category.
        - FSAR Figures 1.2-24 and 1.2-26 show the CRB layout at the grade level and elevation views.

   - o Identify essential SSCs that the barrier protects

     NuScale Response:

     Systems and components defined as A1 and A2 in FSAR Table 3.2-1 are essential SSCs for the NuScale design. Components of these systems are located in either the RXB or CRB. As shown in Attachment 2, essential SSCs within the RXB are protected by the RXB exterior wall (Figures 1 and 2). Essential SSCs in the CRB are protected by the exterior wall and grade level floor (Figure 3).

   - o Acceptance criteria for the barrier design

NuScale Response:

There are three different design basis turbine missiles for the NuScale design: a turbine blade, a turbine blade with a fragment of the rotor, and half of the last stage of the turbine rotor. Due to their size and shape, the turbine blade and turbine blade with rotor fragment were evaluated for local damage. Global damage was assessed for the larger, more massive last stage of the turbine rotor.

A. Acceptance criteria for local damage

1. Penetration

   The acceptance criteria for turbine missile barriers delineated in subsection II.1.A of Standard Review Plan (SRP) 3.5.3 suggests the use of empirical equations such as the modified National Defense Research Council (NDRC) formula and “A Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects," by R.P. Kennedy. Although the methodologies referenced in these documents do not have definitive limits on size or mass, the research and tests that inform the methodology do not use missiles greater than 300 pounds or velocities greater than 500 feet per second. These methods were developed for a steel slug, a piece of steel pipe, and a wooden pole. These objects are relatively small and light when compared to a projectile the size of half of a turbine rotor. Additionally, the NRDC formula is limited with respect to penetration distance, particularly if the results of the penetration distance divided by the overall thickness are outside of certain values. When this occurs, the NDRC equation results become uncertain. Lastly, the NDRC equations are based on an essentially non-deformable missile and target, causing them to over-predict local effects for deformable missiles such as turbine blades.

   As an alternative, NuScale utilized a finite element analysis for predicting penetration in concrete instead of the NDRC formula suggested in the acceptance criteria of SRP 3.5.3. For both the turbine blade, and turbine blade with the rotor fragment, the finite element analysis determined the penetration distance to be less than the thickness of the barrier(s).

2. Spalling or Scabbing

   Protection from spalling and scabbing was considered. The Modified NDRC formula was used to determine the thickness necessary to prevent scabbing, based on the penetration thickness determined in the finite element analysis. Spalling is not a concern because it occurs on the face the missile impacts.

B. Acceptance criteria for overall damage and response of the barrier

   NuScale used the acceptance criteria delineated in subsection II.2 of SRP 3.5.3 to evaluate an equivalent static load concentrated at the impact area.

   An equivalent static load concentrated at the impact area was evaluated for both the RXB and CRB using the methodology described in Bechtel Corporation Topical Report BC-TOP-9A, “Design of Structures for Missile Impact.” This topical report was not specifically referenced in SRP 3.5.3. However, in NUREG-0979, Supplement 1, “Safety Evaluation Report Related to the Final Design Approval of the GESSAR II BWR/6 Nuclear Island Design,” Section 3.5.3, the NRC staff concluded that General Electric’s impact analysis for automobile impact on structures, which was largely based on the approach discussed in BC-TOP-9A, was acceptable. BC-TOP-9A provides the methodology for transforming an automobile impact into an equivalent force for analyzing structures for tornado loads. The weight of an

automobile and half of the last stage rotor are similar; a rotor fragment being similar to an automobile engine. The analyses were comparable to those of the document referenced in the SRP and the effects were within design limits for both the RXB and CRB.

2. Benchmark and Validation of Barrier Analysis Finite Element Modeling (FEM) Methodology
    - o Comparison of Test Missile parameters (mass, geometry, velocity) with turbine missile parameters

      NuScale Response:

      See Attachment 3 Table 1 of this response, “Comparison of Test Missile and NuScale Turbine Missile Parameters”
    - o Test Missile characteristic - Rigid and Deformable

      NuScale Response:

      See Attachment 3 Table 4 of this response, “Comparison of V&V Barrier and FEM Concrete Barrier Response”
    - o Design characteristics of test concrete barrier (strength, thickness, reinforcement configuration)

      NuScale Response:

      See Attachment 3 Table 2 of this response, “Comparison of Concrete Test Barrier and NuScale Barrier Parameters”
    - o Comparison of penetration depth and scabbing thickness from tests for Rigid and deformable missiles with the corresponding analytical results from FEM

      NuScale Response:

      See Attachment 3 Table 3 of this response, “Comparison of Test Missile and FEM Missile Parameters”
3. Summary of Barrier Analysis Results for NuScale Application
    - o Characteristics and parameters of turbine missiles evaluated in the barrier analysis

      NuScale Response:

        - Turbine blade: weight, 32.6 pounds; diameter, 1.41 inches; velocity, 1150 ft/s (at 120% overspeed)
        - Turbine blade with rotor fragment: weight: 52.6 pounds; width of rotor fragment, 4.5 inches; velocity, 1461 ft/s (at 160% overspeed)
        - Half of last stage of rotor fragment: weight: 3079 pounds; dimensions, 12 inches wide by 48 inches diameter; velocity, 512 ft/s (at 160% overspeed)
        - Blade material: ASTM A276-A403 steel
        - Rotor material: ASTM 470 CL 4 steel
    - o Barrier penetration depth and required scabbing thickness at various turbine speeds

      NuScale Response:

      The following barrier results were found using the 52.6 pound turbine blade with rotor fragment.

Summary of Barrier thickness for penetration:

Overspeed	Velocity (mph)	Penetration (inch)	Required Barrier Thickness (inch)
120%	747	17.0	20.4
140%	872	21.5	25.8
160%	996	24.0	28.8
180%	1121	26.0	31.2
190%	1183	25.5	30.6
200%	1245	26.0	31.2
210%	1308	28.5	34.2
220%	1370	28.5	34.2

Summary of barrier thickness for perforation:

Overspeed	x Penetration FEM results (inch)	d* Missile Diameter (inch)	x/d*	t_p (inch)	Required Barrier Thickness (inch)
120%	17.0	1.41	12.1	22.9	27.5
		3	5.7	25.0	30.3
140%	21.5	1.41	15.2	28.5	34.2
		3	7.2	30.6	36.7
160%	24.0	1.41	17.0	31.6	37.9
		3	8.0	33.7	40.5
180%	26.0	1.41	18.4	34.1	40.9
		3	8.7	36.2	43.4
190%	25.5	1.41	18.1	33.5	40.2
		3	8.5	35.6	42.7
200%	26.0	1.41	18.4	34.1	40.9
		3	8.7	36.2	43.4
210%	28.5	1.41	20.2	37.2	44.6
		3	9.5	39.3	47.2
220%	28.5	1.41	20.2	37.2	44.6
		3	9.5	39.3	47.2

d* = conservative equivalent diameter used in perforation and scabbing equations

Summary of barrier thickness for scabbing:

Overspeed	x Penetration FEM results (inch)	d* Missile Diameter (inch)	x/d*	t_s (inch)	Required Barrier Thickness (inch)
120%	17.0	1.41	12.1	26.1	31.3
		3	5.7	29.5	35.4
140%	21.5	1.41	15.2	32.2	38.7
		3	7.2	35.6	42.7
160%	24.0	1.41	17.0	35.6	42.8
		3	8.0	39.0	46.8
180%	26.0	1.41	18.4	38.3	46.0
		3	8.7	41.7	20.1
190%	25.5	1.41	18.1	37.7	45.2
		3	8.5	41.0	49.2
200%	26.0	1.41	18.4	38.3	46.0
		3	8.7	41.7	50.1
210%	28.5	1.41	20.2	41.7	50.1
		3	9.5	45.1	54.1
220%	28.5	1.41	20.2	41.7	50.1
		3	9.5	45.1	54.1

d* = conservative equivalent diameter used in perforation and scabbing equations

- Global damage analysis

  NuScale Response:

  RXB: Flexural Demand to capacity ratio (DCR) is 0.18, shear DCR is 0.16, and deflection is 0.02 inches.

  CRB: Flexural DCR is 0.81, shear DCR is 1.46, and deflection is 0.25 inches. Values are based on the exterior wall. The CRB exterior wall is not sufficient to prevent a shear failure that results from the impact of a turbine rotor missile. However, the resulting penetration opening is smaller than the size of a personnel door and, after impact, the normal operating loads redistribute to the redundant structural members adjacent to the impact location to prevent further damage. In addition, the exterior wall suffices to reduce the velocity by a significant margin. The remaining turbine missile is contained by the three foot thick concrete grade-level floor. This is due to the significant loss of energy in the missile, and the fact that the strike occurs at no less than a 45 degree angle (which has substantial influence on the penetration depth). The combination of the

exterior wall and grade level floor serve to protect essential SSC located below grade in the CRB.

In addition, the turbine rotor missile is similar to that of the automobile missile developed during a hurricane or tornado. Finite element analyses of this scenario shows that this missile has an insignificant effect on the global response of the structure. The base reactions, joint displacements, and deformed shape of both the RXB and CRB support this conclusion.

- o Sensitivity of penetration depth and scabbing thickness to the variation in FEM analysis input parameters

  NuScale Response:

  The table above provides a summary of the scabbing variation with overspeed and missile diameter. In addition, the models were run with design basis concrete strength and higher concrete strength (for aging and placed strength). The tables (shown above) are for the design basis concrete strength.

- o How is uncertainty in input parameters is considered?

  NuScale Response:

  As stated above, the finite element analysis varied input parameters included overspeed, missile diameter, and concrete strength. In addition, an evaluation was done for a deformable rod of 1.41 inch and 2.00 inch diameters, a rigid turbine blade, a rigid turbine blade with a confined wall, and a deformable blade. The table below summarizes the results of the penetration depths for the five different simulations. The required barrier thickness presented is calculated as 1.2 times the calculated penetration distance. Treating the blade as a rigid rod with an equivalent diameter is overly conservative. The analysis simulating the actual blade geometry shows the blade does not perforate the wall. Finally allowing the blade to deform reduces the penetration depth of the blade into the wall, and is the most realistic scenario.

Summary of various missile penetration using FEA:

Analysis Case	Simulation	Penetration (inch)	Required Barrier Thickness (inch)
1	Deformable Rod 1.41” Diameter*	>60	>60
2	Deformable Rod 2.00” Diameter*	42.3	50.8
3	Rigid Blade	54.6	65.5
4	Rigid Blade with Confined Wall	44.2	53.0
5	Deformable Blade*	20.0	24.0

* Rod and blade material is ASTM A416

MCB requests the following information to conduct its technical review on FSAR Section 3.5.1.3.

4. Documentation and basis for the bounding turbine missile parameters:

- Size and weight for the bounding turbine missile

  NuScale Response:

  Three turbine missiles were evaluated:

  - Turbine blade: weight, 32.6 pounds; diameter, 1.41 inches
  - Turbine blade with rotor fragment: weight, 52.6 pounds; rotor fragment width, 4.5 inches
  - Half of last stage rotor: weight, 3079 pounds; size, 12 inches wide by 48 inches in diameter

- Parameters such as turbine model, rotor material and processing, fracture toughness, preservice and in-service inspection and testing requirements (or analysis re-preformed using last stage rotor with blades attached)

  NuScale Response:

  An analysis was performed for both the RXB and CRB that assessed the structural adequacy for impact of the last stage of the turbine rotor. The calculation showed, among other things, that the rotor impact caused approximately 0.02 inches of deflection for the RXB wall, and 0.25 inches of deflection for the CRB wall.

- Parameters of turbine (including rotor size and weight)

  NuScale Response:

  The NuScale turbine is assumed to be an “off the shelf” turbine having 50 MWe output. The calculations were performed using a design with an integrally forged rotor made of ASTM 470 CL 4, and blades of ASTM A276-A403 steel. A schematic of the turbine geometry, and a cross section of the rotor is presented in Figure 1. Figure 2 shows the profile of the turbine rotor highlighting the last stage rotor disk that is about 10.5 inches wide (a 12 inch width was assumed in the analysis). The weight of the fragment evaluated in the analysis (half of this last stage rotor) is 3079 pounds.

Figure 1 - Rotor Cross-Section

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}}2(a),(c)

Figure 2 – Turbine Rotor Profile

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}}2(a),(c)

5. Questions/comments provided during NRC turbine missile barrier audit:
   a) Quantitative assessment of the control room building

      NuScale Response:

      As described above, the control building has been assessed for the larger missile as part of a global assessment of the structure. In addition, local effects were assessed for the control building. The combined thickness of the exterior wall and the grade level floor provide sufficient protection for penetration, perforation, and scabbing for essential SSC located in that building.
   b) NuScale stated that rigid case was run for comparison with hand calculation method such as NDRC. NuScale needs to provide this comparison.

      NuScale Response:

      This information, as well as an expanded discussion is provided in Attachment 4.
   c) NuScale stated that in both cases, rigid or deformable, the Reactor Building wall was shown to be an acceptable missile barrier. Table 5-3 in report ER-F010-6488, shows it otherwise. The required barrier thickness for scabbing for all other cases is greater than 5 feet, which exceeds the RXB wall thickness.

      NuScale Response:

The NuScale statement has been revised as follows: The reactor building wall thickness is greater than the thickness required for penetration, perforation, and scabbing when the turbine blade-only is assumed deformable. An assessment of a blade from a NuScale turbine has been shown to be deformable when impacting the reactor building, based on finite element analyses.

d) In Figure 5-10 of report ER-F010-6488, maximum penetration of about 23 inches is shown for the deformable blade (red curve), but it is reported as 16.5 inches in Table 5-3 of the same report.

<u>NuScale Response</u>:

Figure 5-10 shows the "average nodal displacement," which is the average displacement of all of the nodes in the turbine blade FEA. This is a different parameter than what is presented in Table 5-3, which is the maximum penetration of the most far penetrating node of the blade (frontal edge node). This maximum penetration is determined by evaluating the final deformed position of the blade and is reported to the nearest ½ inch increment.

e) Unexpected behavior is noticed in Figure 5-10 of report ER-F010-6520. The figure shows penetration depth versus initial velocity. The dip in the penetration depth shows that the penetration depth for the higher velocity (kinetic energy) impact is lower than that for the lower velocity (kinetic energy) impact within a velocity range from 1110 ft/sec to 1280 ft/sec. What is so unique about this velocity range? The staff's concern is whether the computer program is functioning properly for possible ranges of operational inputs. Has NuScale performed any analysis for any other velocity within this range to validate the unexpected behavior?

<u>NuScale Response</u>:

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Figure 5-10: Penetration Depth versus Initial Velocity

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Figure 5-7: Penetration Depth at 180% Overspeed

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Figure: Penetration Depth at 190% Overspeed

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Figure 5-8: Penetration Depth at 200% Overspeed

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Figure: Penetration Depth at 210% Overspeed

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}}2(a),(c)

Figure 5-9: Penetration Depth at 220% Overspeed

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}}2(a),(c)

f) Provide a report that shows how NuScale implemented the requirements in EPRI TR-1025243. EPRI TR-1025243 provides guidelines for accepting commercial grade computer programs for nuclear safety-related application.

NuScale Response:

The SIA Quality Procedure, QP07-03R5, "Dedication of Commercial Grade Items and Software," is available for NRC review. This quality procedure is based on EPRI TR-1025243 and has been audited and approved by NuScale Quality Assurance.

The information below provides a condensed version of the EPRI requirements for Commercial Grade Dedication (CGD) found in EPRI 1025243, and points the reader to where these elements can be found in the Structural Integrity Associates (SIA) Quality Assurance (QA) documents regarding the CGD and Verification and Validation (V&V) activities for the software, TeraGrande. TeraGrande is the Finite Element Analysis (FEA) software used to model the NuScale turbine missile impact against the reactor building concrete wall. EPRI 1025243 Method 1, "Special Tests, Inspections, and/or Analyses," was used to dedicate the software.

List of SIA Documentation of TeraGrande CGD and V&V:

1. 1800150.301, Revision 0, "Methodology for Commercial Grade Dedication of the TeraGrande Software Specific for NuScale Turbine Blade Missile Impact on Reactor Building (RBX) Wall Section Evaluation"
2. 1800150.302, Revision 0, "TeraGrande Verification Plan (ANA-R-10-0756R0)
3. 1800150.303.R0 Configuration Control of the TeraGrande Software Using CVS (ANA-R-10-0757R0)"

4. 1800150.304, Revision 0, “TeraGrande Functionality and Verification Problems, Part 1. Verification Problem Descriptions (ANA-R-10-0758R0)”
5. 1800150.305, Revision 0, “TeraGrande Functionality and Verification Problems, Part 2. Functionality Tests (ANA-R-10-0758R0)”
6. 1800150.306, Revision 0, “TeraGrande Verification Environment, (ANA-R-14-0927R0)”
7. 1800150.307, Revision 0, “Verification and Validation of TeraGrande Version 2.0-13905”
8. 1800150.109, Revision 1, “Commercial Grade Item Designation TeraGrande
9. 1800150.109.R1 Commercial Grade Classification and Characteristics Plan TeraGrande”
10. 1800150.109, Revision 1, “Software Requirement Specification QP07-03 TeraGrande”
11. QA-18-053,Revision 0, “SI QA letter to certify that verification and validation package in accordance with applicable requirements of SI QA Program and all requirements of the referenced Commercial Grade Classification and Characteristics Plan”
12. COMMERCIAL GRADE DEDICATION SUMMARY REPORT

Table 1 - EPRI 1025243 Requirement Crosswalk:

EPRI 1025243 Requirement	SIA Quality Procedure Reference	SIA Document Reference
Implement EPRI 1025243 into the SIA quality procedure for dedication of software	QP07-03, Rev. 5, 6.2.1	Specific dedication activities in items 1-6 below
1. Identification of the safety function(s) of the item being dedicated	QP07-03, Rev. 5, 6.2.1	1800150 F0703-02R4, Page 1 1800150 F0703-03R4, Page 1
2. A failure modes and effects analysis (FMEA) for the item being dedicated that postulates failure modes and/or mechanisms of the item that could affect its ability to perform its safety-related function(s)	QP07-03, Rev. 5, 6.2.4	1800150 F0703-02R4, Page 2
3. Identification of critical characteristics of the item that can be verified to obtain reasonable assurance that the item is capable of performing its intended safety-related function(s) (that is, the item will not succumb to the failure modes identified in the FMEA)	QP07-03, Rev. 5, 6.2.3	1800150.301, Section 2.0, Table 1 1800150 F0703-02R4, Page 3
4. Establishing acceptance criteria for each critical characteristic that will be verified	QP07-03, Rev. 5, 2.1.c & 6.3.2.d	1800150.301, Section 2.0, Table 1
5. Identification of the acceptance methods and/or activities that will be used to verify each critical characteristic	QP07-03, Rev. 5, 6.3.2.d	1800150.301, Section 2.0, Table 1
6. Documenting the technical evaluation and results of acceptance activities	QP07-03, Rev. 5, 2.1.d & 6.3	1800150.304 1800150.307

g) Address validation of computer program for Scabbing

<u>NuScale Response</u>:

The TeraGrande software was not validated for scabbing. It has only been validated for penetration depth. The NDRC formulas were used to determine the scabbing thickness.

h) Basis for some of the conservatisms is not appropriate. Examples:

- The conclusion, "Analysis shows that barrier is effective for a rigid missile and is acceptable even with a rigid missile" is not supported by data staff has reviewed in Table 5-3 of report ER-F010-6488.
- The NDRC equation for penetration is referenced as the basis of conservatism but this equation is not used. NuScale used FEM analysis.
- The 20% factor in the ACI 349-06 code, Appendix F7.2.1, is misinterpreted for the conservatism; per the code it accounts for uncertainty when penetration is based on formulas or test results.

ACI 349 code (Appendix F7.2.1) and its commentary states:

"The penetration depth and required concrete thickness to prevent perforation shall be based on applicable formulas or pertinent test data. This 20 percent factor is to account for uncertainty and is not considered to be an additional factor of safety."

NuScale Response:

NuScale agrees. These will be removed from the list of conservatisms. One conservatism omitted was that the turbine blade impacts the RXB wall directly in the center rebar curtains, such that the turbine blade does not impact the steel rebar. If the approximately 4 inch wide blade impacts over the curtain of bars it has less penetration depth than shown in the analysis with only concrete being impacted.

i) Global damage analysis per the guidance in SRP 3.5.3.

NuScale Response:

The global analysis has been performed for both the RXB and CRB as described above.

Table 1: Comparison of Test Missile and NuScale Turbine Missile Parameters

Comparison of Test Missile and NuScale Turbine Missile Parameters

		ID #	Missile Mass (lbs)		Missile Velocity (mph)		Missile Kenetic Energy (lbm-in^2/s^2)		Missile Shape		Missile Diameter (in)		Missile Characteristic (Rigid / Deformable)	
			TEST	Turbine Missile	TEST	Turbine Missile	TEST	Turbine Missile	TEST	Turbine Missile (Bottom Half of Table)	TEST	Turbine Missile	TEST	Turbine Missile (Bottom Half of
Part A Test Parameters	Penetration Depth V&V [Ref 1, 2, 3]	1	{{	See Part B	{{	See Part B	{{	See Part B	3 Ogive Shape / Solid Bullet	See Part B	{{	See Part B	Deformable	See Part B
		2							3 Ogive Shape / Solid Bullet				Deformable	
		3							3 Ogive Shape / Solid Bullet				Deformable	
		4							4.25 Ogive Shape / Solid Bullet				Deformable	
		5							2 Ogive Shape / Solid Bullet				Deformable	
		6							2 Ogive Shape / Solid Bullet				Deformable	
		7							1.5 Ogive Shape / Solid Bullet				Deformable	
		8							1.5 Ogive Shape / Solid Bullet				Deformable	
		9							1.5 Ogive Shape / Solid Bullet				Deformable	
		10							1.5 Ogive Shape / Solid Bullet				Deformable	
		11							1.5 Ogive Shape / Solid Bullet				Deformable	
		12							1.5 Ogive Shape / Solid Bullet				Deformable	
		13							1.5 Ogive Shape / Solid Bullet				Deformable	
	Additional V&V (Bending / Punching)	14							Hollow Steel Pipe with Elliptical End Cap				Deformable	
		15							Blunt Nose Steel Tube with Concrete Fill				Deformable	
		16							Flat Nose Variable Thickness Steel Cylinder				Deformable	
		17							Flat Nose Variable Thickness Steel Cylinder				Deformable	
		18							Water Slug Cylindrical Impactor***				Deformable	
		19		}}2(a),(c)		}}2(a),(c)		}}2(a),(c)	Water Slug Cylindrical Impactor***			}}2(a),(c)	Deformable	
Part B Turbine Blade Param	Turbine Blade (120% Overspeed)	20	See Part A	32.6	See Part A	784	See Part A	3.10E+09	See Part A	Blade As 1.41" Diameter Rod	See Part A	1.41	See Part A	Deformable*
		21		32.6		784		3.10E+09		Blade As 2" Diameter Rod		2		Deformable*
		22		32.6		784		3.10E+09		Blade		NA		Rigid
		23		32.6		784		3.10E+09		Blade		NA		Rigid
		24		32.6		784		3.10E+09		Blade		NA		Deformable**
	Turbine Blade and Root (Variable Overspeed)	25		52.5		747		4.54E+09		Blade + Root		NA		Deformable**
		26		52.5		872		6.18E+09		Blade + Root		NA		Deformable**
		27		52.5		996		8.07E+09		Blade + Root		NA		Deformable**
		29		52.5		1121		1.02E+10		Blade + Root		NA		Deformable**
		29#		52.5		1183		1.14E+10		Blade + Root		NA		Deformable**
		30		52.5		1245		1.26E+10		Blade + Root		NA		Deformable**
		31#		52.5		1307		1.39E+10		Blade + Root		NA		Deformable**
		32		52.5		1370		1.53E+10		Blade + Root		NA		Deformable**

	Mass TEST	Mass Turbine Missile	Velocity TEST	Velocity Turbine Missile	Energy TEST	Energy Turbine Missile
MIN	0.1	32.6	220.0	747.0	1.30E+07	3.10E+09
MAX	14320.0	52.5	1377.0	1370.0	4.29E+11	1.53E+10

	Diameter TEST	Diameter Turbine Missile
MIN	0.51	1.41
MAX	48.5	2

*Deformable material includes strain rate effects and boundary symmetry conditions (Missile acts mostly rigid).
**Deformable material includes strain rate effects.
***Missile applied as time history forcing function.
#Analysis results included with comment response.

Ref [1] {{
Ref [2]
Ref [3] }}2(a),(c)

Table 2: Comparison of Concrete Test Barrier and NuScale Barrier Parameters

Comparison of Concrete Test Barrier and NuScale Barrier Parameters

Part	Group	ID #	Target Thickness (in) TEST	Target Thickness (in) Turbine Missile	Concrete Strength (psi) TEST	Concrete Strength (psi) Turbine Missile	Reinformenet Ratio TEST	Reinformenet Ratio Turbine Missile	
Part A Test Parameters	Penetration Depth V&V [Ref 1, 2, 3]	1	{{	See Part B	{{	See Part B	{{	See Part B	
		2							
		3							
		4							
		5							
		6							
		7							Strikes are Between Reinforcemnet
		8							
		9							
		10							
		11							
		12							
		13							
	Additional V&V (Bending / Punching)	14							
		15							
		16							
		17							
		18							
		19		}}2(a),(c)		}}2(a),(c)		}}2(a),(c)	
Part B Turbine Blade Param	Turbine Blade (120% Overspeed)	20	See Part A	60****	See Part A	7000	See Part A	None	
		21		60****		7000		None	
		22		60****		7000		None	
		23		60		7000		None	
		24		60****		7000		None	
	Turbine Blade and Root (Variable Overspeed)	25		60		7000		1.73%	Strikes are Between Reinforcemnet
		26		60		7000		1.73%	
		27		60		7000		1.73%	
		28		60		7000		1.73%	
		29#		60		7000		1.73%	
		30		60		7000		1.73%	
		31#		60		7000		1.73%	
		32		60		7000		1.73%	

	Target Thickness TEST	Target Thickness Turbine Missile	Concrete Strength TEST	Concrete Strength Turbine Missile	Reinforcement TEST	Reinforcement Turbine Missile
MIN	5.9	60.0	2030.0	7000.0	0.40%	1.73%
MAX	48.0	60.0	8470.0	7000.0	1.00%	1.73%

****Target is 4'x4' block with free sides allowing unconfined concrete.
#Analysis results included with comment response.

Ref [1] {{

Ref [2]

Ref [3]

}}2(a),(c)

Table 3: Comparison of Test Missile and FEM Missile Parameters

Comparison of Test Missile and FEM Missile Parameters

	ID #	Missile Mass (lbs)		Missile Velocity (mph)		Missile Kenetic Energy (lbm-in^2/s^2)		Missile Shape		Missile Diameter (in)		Missile Characteristic (Rigid / Deformable)	
		TEST	FEM	TEST	FEM	TEST	FEM	TEST	FEM	TEST	FEM	TEST	FEM
Penetration Depth V&V [Ref 1, 2, 3]	1	{{						3 Ogive Shape / Solid Bullet	Model of Shape	{{		Deformable	Deformable*
	2							3 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	3							3 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	4							4.25 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	5							2 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	6							2 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	7							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	8							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	9							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	10							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	11							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	12							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
	13							1.5 Ogive Shape / Solid Bullet	Model of Shape			Deformable	Deformable*
Additional V&V (Bending / Punching)	14							Hollow Steel Pipe with Elliptical End Cap	Model of Shape			Deformable	Deformable**
	15							Blunt Nose Steel Tube with Concrete Fill	Model of Shape			Deformable	Deformable**
	16							Flat Nose Variable Thickness Steel Cylinder	Model of Shape			Deformable	Deformable**
	17							Flat Nose Variable Thickness Steel Cylinder	Model of Shape			Deformable	Deformable**
	18							Water Slug Cylindrical Impactor***	Circular Area			Deformable	None***
	19							}}2(a),(c) Water Slug Cylindrical Impactor***	Circular Area			Deformable	None***

}}2(a),(c)

*Deformable material includes strain rate effects and boundary symmetry conditions (Missile acts mostly rigid).
**Deformable material includes strain rate effects.
***Missile applied as time history forcing function.

Ref [1] {{
Ref [2]
Ref [3] }}2(a),(c)

Table 4: Comparison of V&V Barrier and FEM Concrete Barrier Response

Comparison of V&V Barrier and FEM Concrete Barrier Response

		ID #	Barrier Penetration (in)		Scabbing Thickness (in)		Missile Characteristic (Rigid / Deformable)		NDRC Formula for rigid missile (SRP 3.5.3)	
			TEST	FEM	TEST	FEM	TEST	FEM	Penetration (in)	Scabbing (in)
Part A Test Parameters	Penetration Depth V&V [Ref 1, 2, 3]	1	{{				Deformable	Deformable*	{{	
		2					Deformable	Deformable*		
		3					Deformable	Deformable*		
		4					Deformable	Deformable*		
		5					Deformable	Deformable*		
		6					Deformable	Deformable*		
		7					Deformable	Deformable*		
		8					Deformable	Deformable*		
		9					Deformable	Deformable*		
		10					Deformable	Deformable*		
		11					Deformable	Deformable*		
		12					Deformable	Deformable*		
		13					Deformable	Deformable*		
	Additional V&V (Bending / Punching)	14					Deformable	Deformable*		
		15					Deformable	Deformable*		
		16					Deformable	Deformable*		
		17					Deformable	Deformable*		
		18					Deformable	None***		
		19				}}2(a),(c)	Deformable	None***		}}2(a),(c)
Part B Turbine Blade Parameters	Turbine Blade (120% Overspeed)	20		Perforation				Deformable*	36.4	52.5
		21		37.3		55		Deformable*	20.6	32.3
		22#*		43.3		62		Rigid	56.8	80.2
		23#*		39.8		57		Rigid	56.8	80.2
		24#*		16.5		25		Deformable**	56.8	80.2
	Turbine Blade and Root (Variable Overspeed)	25#*		15.5		24		Deformable**	83.2	116.1
		26#*		19.0		29		Deformable**	109.4	151.8
		27#*		22.0		33		Deformable**	138.6	191.5
		28#*		25.0		37		Deformable**	171.2	235.8
		29#,#*		25.0		37		Deformable**	188.5	259.3
		30#*		23.5		35		Deformable**	206.5	283.8
		31#,#*		27.0		40		Deformable**	225.2	309.3
		32#*		28.0		41		Deformable**	245.0	336.2

*Deformable material includes strain rate effects and boundary symmetry conditions (Missile acts mostly rigid).
**Deformable material includes strain rate effects.
***Missile applied as time history forcing function.
#Analysis results included with comment response.
#*Calculation of Penetration and Scabbing based on 1.41 idealized diameter

Ref [1] {{

Ref [2]

Ref [3]

}}2(a),(c)

Validation and Verification Results Summary

The following table is a summary of results preformed for the verification and validation of penetration depth measurements. The results were obtained from a finite element simulation in comparison to test data results obtained from three sources; {{ }}2(a),(c) as Ref [1], {{ }}2(a),(c) as Ref [2], and {{ }}2(a),(c) as Ref [3].

Shot-ID#	Velocity (mph)	Experimental Penetration Depth (in)	FE Analysis Penetration Depth (in)	Ratio
1	{{			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				}}2(a),(c)
Average Ratio Between Analysis and Test				{{ }}2(a),(c)
Standard Deviation				{{ }}2(a),(c)
Coefficient of Variation				{{ }}2(a),(c)}

The following plot displays all the data available for the three sources with an overlay of the analysis results. All experimental results from the paper are presented as colored dots. Finite Element (FE) analysis results validates a subset of experimental results. FE analysis results are shown with a square box. The analysis focused on velocities closer to the targeted overspeed of the blade. The second plot scales the plot to better focus on verification and validation ranges.

{{

}}2(a),(c)

The following two plots group the same set of data showing the dimensionless (X/d) versus diameter and mass, respectively.

{{

}}2(a),(c)

The following discussion is provided to better understand the verification and validation penetration data, the relationship to finite element analysis, and theoretical equations regarding penetration. The finite element models developed for Report 1800154.402 (ER-F010-6488), based on defining the blade as an equivalent rod, can be used to investigate the penetration depth for a range of initial velocities and compare to the most common industry standard penetration formulae (Modified NDRC, Army Corps of Engineers, and Ammann & Whitney, Reference 5 Kennedy 1976). The initial velocity for the 1.41 inch diameter rod was analyzed at 200, 300, 400, 500, 600, and 700 mph and the penetration depth was recorded for each FE analysis. The initial velocity for the 2 inch diameter equivalent rod used the same velocities as the 1.41 inch rod with additional points at the 120% overspeed case (784 mph) and 900 mph.

The data from the FE analysis is plotted against three formula for penetration depth; the modified NDRC (NDRC in plots) formula defined by equations 1 and 2, Ammann and Whitney (A&W in plots) formula defined by equation 3, and the Army Corp of Engineers (Army in plots) formula defined by equation 4 from Kennedy (Reference 5). Aside from the experimental V&V results and references already provided to the NRC (References 1-4) there are limited published results from small diameter high velocity ballistics experiments due to the classified nature of experiments. Thus, it is necessary to compare our FEA results with empirical formulae that were based on the original experimental results and not directly against individual experimental results (except as already provided). The reasons for selecting these three empirical formulae is fully explained in the paper by Kennedy (Reference 5). Modified NDRC is endorsed by the Standard Review Plan NUREG-0800, 3.5.3 and is applicable to a wide variety of missile diameters and speeds. However, the NuScale turbine missile problem is outside of the x/D penetration depth range 3<x/D<18 (x/D = 60"/1.41" = 42 >> 18) for the Modified NDRC. The Army Corps of Engineers formula is also not valid for the NuScale penetration depth to missile diameter range. From Reference 5, "The Ammann and Whitney formula is intended to predict the penetration of small explosively generated fragments travelling over 1000 ft/sec (682 mph)." Thus, it is our conclusion that NuScale turbine missile results for a blade idealized as a rigid rod with circular diameter (D = 1.4" to 2") should fall somewhere between the Army and Ammann and Whitney formulae.

$$G_{(x/d)} = KNd^{0.2}D(V/1000)^{1.80} \quad (1)$$

$$G_{(x/d)} = \begin{cases} (x/2d)^2, for\ x/d \le 2.0 \\ [(x/d) - 1], for\ x/d \ge 2.0 \end{cases} \quad (2)$$

$$\left(x/d\right) = \frac{282NDd^{0.2}}{\sqrt{f_c'}}(V/1000)^{1.8} \quad (3)$$

$$\left(x/d\right) = \frac{282Dd^{0.215}}{\sqrt{f_c'}}(V/1000)^{1.5} + 0.5 \quad (4)$$

Where *d* is the diameter on the projectile in inches, f_c' is the concrete compressive strength in psi, *V* is the velocity of the projectile in ft/sec, *N* is a missile shape factor equal to 0.72 for flat

nosed, D is defined in equation 5 with W equal to the weight of the projectile in pounds, and K is defined by equation 6. The theoretical equations can be solved for penetration depth, X, and plotted with FE analysis results versus velocity.

$$D = W/d^3 \tag{5}$$

$$K = 180/\sqrt{f_c'} \tag{6}$$

Work by {{ }}[2(a),(c)] (Reference 4) provide a dimensionless value of penetration based on an impact function (I) expressed as equation (7), (8), and (9) where M is the mass of the projectile and V_o is initial velocity. The parameter S is dimensionless when f_c' is in MPa. The dimensionless penetration is then plotted versus the impact function and is used as a comparison between all data sets. This allows us to compare our FEA results with a large data set of experimental results.

$$I = \frac{I^*}{S} \tag{7}$$

$$I^* = \frac{M{V_o}^2}{d^3 {f'}_c} \tag{8}$$

$$S = 82.6{f'}_c^{-0.544} \tag{9}$$

In the following plots the FE analysis results are marked with a black “X” and the theoretical equations are the colored solid lines. The following set of figures shows the penetration depth versus velocity for the blade represented as a 1.41 inch and a 2.0 inch diameter rod respectively. The penetration depths calculated by analysis (FE analysis results) overestimate penetration when compared to the modified NDRC formula and the Ammann and Whitney formula. The Army formula is closer to the analysis data at lower speed. As the velocity is increased the penetration depth begins trending towards the Ammann and Whitney theoretical equation.

{{

}}2(a),(c)

FE Analysis of 1.41Inch Diameter Rod and Theoretical Equation

{{

}}2(a),(c)

FE Analysis of 2.0 Inch Diameter Rod and Theoretical Equation

The results data is plotted as dimensionless parameters for penetration and the impact function. The subsequent set of plots represent the data for the blade as a 1.41 inch and a 2.0 inch diameter rod, respectively. The plots also include the validation and verification test data (colored dots), the validation and verification analysis results (black squares), and the additional FE analysis results (black “X”). All are plotted for comparison. Plotting of the theoretical equations (colored lines) in the two plots show the sensitivity to diameter. The upper limit of velocity used in the theoretical equations is set at 1300 mph. This corresponds to a drop-in impact factor (I) from 217 for the 1.41 inch diameter rod to 76 for the 2 inch diameter rod. Additionally, the modified NDRC equation does not maintain correlation to the data sets when moving higher along the impact function axis. The principle driver for a larger impact factor is a smaller diameter ($1/d^3$ component in formula) followed by a larger velocity (V^2 component in formula) when mass and concrete strength are fixed. Note, on the plots for dimensionless penetration versus impact function, the axis scales are held constant for comparison between each plot.

{{

}}2(a),(c)

Dimensionless Visualization of FE Analysis of 1.41 Inch Diameter Rod and Theoretical Equation

{{

}}2(a),(c)

Dimensionless Visualization of FE Analysis of 2.0 Inch Diameter Rod and Theoretical Equation

The theoretical equation can also be compared to the validation and verification data set. The following plots isolate the smallest diameter projectile and largest diameter projectile data, which correlate to Reference 2 (with projectiles at 0.5-inch diameter) and Reference 3 (with projectiles at 3.0-inch diameter), respectively. The reference data is plotted as both penetration depth versus velocity in the first plot and then as dimensionless parameters for penetration and impact function. These plots illustrate that the modified NDRC formula is better at predicting large diameter projectile penetrations while the Ammann and Whitney equations are better for small diameter projectile penetrations.

{{

}}2(a),(c)

Reference 2 – 0.5 Inch Diameter and Theoretical Equation Comparison

{{

}}2(a),(c)

Reference 2 – 0.5 Inch Diameter and Theoretical Equation Dimensionless Comparison

{{

}}2(a),(c)

Reference 3 – 3 Inch Diameter and Theoretical Equation Comparison

{{

}}2(a),(c)

Reference 3 – 3 Inch Diameter and Theoretical Equation Dimensionless Comparison

References:

{{

}}2(a),(c)

Reference 5 Kennedy, "A Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects," Nuclear Engineering & Design 37, pp183-203 (1976)

Enclosure 1:

Changes to NuScale Final Safety Analysis Report Section 1.8, “Interfaces with Certified Design,” Section 3.5, “Missile Protection,” and Section 10.2, “Turbine Generator”

Table 1.8-2: Combined License Information Items (Continued)

Item No.	Description of COL Information Item	Section
COL Item 2.5-1:	A COL applicant that references the NuScale Power Plant design certification will describe the site-specific geology, seismology, and geotechnical characteristics for Section 2.5.1 through Section 2.5.5, below.	2.5
COL Item 3.2-1:	A COL applicant that references the NuScale Power Plant design certification will update Table 3.2-1 to identify the classification of site-specific structures, systems, and components.	3.2
COL Item 3.3-1:	A COL applicant that references the NuScale Power Plant design will confirm that nearby structures exposed to severe and extreme (tornado and hurricane) wind loads will not collapse and adversely affect the Reactor Building or Seismic Category I portion of the Control Building.	3.3
COL Item 3.4-1:	A COL applicant that references the NuScale Power plant design certification will confirm the final location of structures, systems, and components subject to flood protection and final routing of piping.	3.4
COL Item 3.4-2:	A COL applicant that references the NuScale Power plant design certification will develop the on-site program addressing the key points of flood mitigation. The key points to this program include the procedures for mitigating internal flooding events; the equipment list of structures, systems, and components subject to flood protection in each plant area; and providing assurance that the program reliably mitigates flooding to the identified structures, systems, and components.	3.4
COL Item 3.4-3:	A COL applicant that references the NuScale Power plant design certification will develop an inspection and maintenance program to ensure that each water-tight door, penetration seal, or other "degradable" measure remains capable of performing its intended function.	3.4
COL Item 3.4-4:	A COL applicant that references the NuScale Power plant design certification will confirm that site-specific tanks or water sources are placed in locations where they cannot cause flooding in the Reactor Building or Control Building.	3.4
COL Item 3.4-5:	A COL applicant that references the NuScale Power Plant design certification will determine the extent of waterproofing and dampproofing needed for the underground portion of the Reactor Building and Control Building based on site-specific conditions. Additionally, a COL applicant will provide the specified design life for waterstops, waterproofing, damp proofing, and watertight seals. If the design life is less than the operating life of the plant, the COL applicant will describe how continued protection will be ensured.	3.4
COL Item 3.4-6:	A COL applicant that references the NuScale Power Plant design certification will confirm that nearby structures exposed to external flooding will not collapse and adversely affect the Reactor Building or Seismic Category I portion of the Control Building.	3.4
COL Item 3.4-7:	A COL applicant that references the NuScale Power Plant design certification will determine the extent of waterproofing and damp proofing needed to prevent groundwater and foreign material intrusion into the expansion gap between the end of the tunnel between the Reactor Building and the Control Building, and the corresponding Reactor Building connecting walls.	3.4
COL Item 3.5-1:	~~A COL applicant that references the NuScale Power Plant certified design will provide a missile analysis for the turbine generator which demonstrates that protection from turbine missiles is accomplished by using barriers.~~A COL applicant that references the NuScale Power Plant design certification will demonstrate that the site-specific turbine missile parameters are bounded by the DC analysis, or provide a missile analysis using the site-specific turbine generator parameters to demonstrate that barriers adequately protect essential SSC from turbine missiles.	3.5
COL Item 3.5-2:	A COL applicant that references the NuScale Power Plant design certification will address the effect of turbine missiles from nearby or co-located facilities.~~Not Used.~~	3.5
COL Item 3.5-3:	A COL applicant that references the NuScale Power Plant ~~certified design~~design certification will confirm that automobile missiles cannot be generated within a 0.5-mile radius of safety-related structures, systems, and components and risk-significant structures, systems, and components requiring missile protection that would lead to impact higher than 30 feet above plant grade. Additionally, if automobile missiles impact at higher than 30 feet above plant grade, the COL applicant will evaluate and show that the missiles will not compromise safety-related and risk-significant structures, systems, and components.	3.5

are ASME Class 1 or 2 and therefore not credible missile sources as discussed in Section 3.5.1.1.1.

A control rod drive mechanism (CRDM) housing failure, sufficient to create a missile from a piece of the housing or to allow a control rod to be ejected rapidly from the core, is non-credible. The CRDM housing is a Class 1 appurtenance per ASME Section III.

3.5.1.3 Turbine Missiles

RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

The turbine generator building layout in relation to the overall site layout is shown on Figure 1.2-2. The turbine generator rotor shafts are physically oriented such that the RXB, CRB, and RWB are within the turbine trajectory hazard, thereby making the turbines zone and considered to be unfavorably oriented with respect to the NPMs, as defined by RG 1.115, Revision 2. Appendix A of RG 1.115, Rev. 2 identifies SSC requiring protection from turbine missiles. The SSC that require protection from turbine missiles (high-trajectory and low-trajectory turbine rotor and blade fragments) are located in either the RXB, or the CRB, the RWB, or underground. The SSC located in the RXB and below grade in the CRB are classified as A1 or A2 (per Section 3.2) and are considered essential SSC as defined in Appendix A of RG 1.115. Table 3.2-1 provides a complete listing of these SSC.

Section 10.2.2 and Table 10.2-1 provide details regarding the type of turbine to be used in the NuScale design. Using the design and material specifications that appear in Section 10.2.2 and Table 10.2-1, the turbine missiles selected for evaluation included:

- A turbine blade weighing 32.6 lbs with an equivalent diameter of 1.41 inches, and a velocity of 1150 ft/s.
- A turbine blade with a rotor fragment weighing 52.6 lbs with a rotor width of 4.5 inches, and a velocity of 1461 ft/s.
- Half of the last stage of the turbine rotor weighing 3079 lbs that is 48 inches in diameter by 12 inches wide, and a velocity of 512 ft/s.

RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

Protection from turbine missiles is accomplished by using barriers instead of the statistical significance criteria outlined in Section 3.5.1. The Seismic Category I RXB and CRB provide protection from turbine missiles for SSC located within each building. The SSC located underground are protected by their depth below grade. The SSC located in the Seismic Category II RWB are not protected from the effects turbine missiles. However, any radioactive release that might result from the effects of a turbine missile is bounded by the failure of the gaseous radioactive waste system postulated in Section 11.3.3 and the resultant doses presented in Table 11.3-9.

RAI 03.05.03-4, RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

COL Item 3.5-1: A COL applicant that references the NuScale Power Plant certified design will provide a missile analysis for the turbine generator which demonstrates that protection from turbine missiles is accomplished by using barriers.A COL applicant that references the NuScale Power Plant design certification will demonstrate that

the site-specific turbine missile parameters are bounded by the DC analysis, or provide a missile analysis using the site-specific turbine generator parameters to demonstrate that barriers adequately protect essential SSC from turbine missiles.

RAI 03.05.01.03-1, RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

COL Item 3.5-2: A COL applicant that references the NuScale Power Plant design certification will address the effect of turbine missiles from nearby or co-located facilities.~~Not used.~~

3.5.1.4 Missiles Generated by Tornadoes and Extreme Winds

Hurricane and tornado generated missiles are evaluated in the design of safety-related structures and risk-significant SSC outside those structures. The missiles used in the evaluation are assumed to be capable of striking in all directions and conform to the Region I missile spectrums presented in Table 2 of RG 1.76, Rev. 1, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants" for tornado missiles and Table 1 and Table 2 of RG 1.221, Rev. 0, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," for hurricane missiles. These spectra are based on the design basis tornado and hurricane defined in Section 3.3.2 and represent probability of exceedance events of 1 x 10^{-7} per year for most potential sites.

The selected missiles include

- A massive high-kinetic-energy missile that deforms on impact, such as an automobile.

  The "automobile" missile is 16.4 feet by 6.6 feet by 4.3 feet with a weight of 4000 lbs. and a C_DA/m (drag coefficient x projected area/mass) of 0.0343 ft^2/lb.

  This missile has a horizontal velocity of 135 ft/s and a vertical velocity of 91 ft/s in a tornado; and corresponding velocities of 307 ft/s and 85 ft/s, respectively, in a hurricane.

  The automobile missile is considered capable of impact at all altitudes less than 30 ft above all grade levels within 1/2 mile of the plant structures.

- A rigid missile that tests penetration resistance, such as a six-inch diameter Schedule 40 pipe.

  The "pipe" missile is 6.625 inch diameter by 15 feet long with a weight of 287 lbs. and a C_DA/m of 0.0212 ft^2/lb.

  This missile has a horizontal velocity of 135 ft/s and a vertical velocity of 91 ft/s in a tornado; and corresponding velocities of 251 ft/s and 85 ft/s, respectively, in a hurricane.

- A one-inch diameter solid steel sphere to test the configuration of openings in protective barriers.

The "sphere" missile is 1 inch in diameter with a weight of 0.147 lbs. and a C_DA/m of 0.0166 ft^2/lb.

This missile has a horizontal velocity of 26 ft/s and a vertical velocity of 18 ft/s in a tornado; and corresponding velocities of 225 ft/s and 85 ft/s, respectively, in a hurricane.

These missile parameters are key design parameters and are provided in Table 2.0-1.

3.5.1.5 Site Proximity Missiles (Except Aircraft)

As described in Section 2.2, the NuScale Power Plant certified design does not postulate any hazards from nearby industrial, transportation or military facilities. Therefore, there are no proximity missiles.

3.5.1.6 Aircraft Hazards

As described in Section 2.2, the NuScale Power Plant certified design does not postulate any hazards from nearby industrial, transportation or military facilities. Therefore, there are no design basis Aircraft Hazards. Discussion of the beyond design basis Aircraft Impact Assessment is provided in Section 19.5.

3.5.2 Structures, Systems, and Components to be Protected from External Missiles

RAI 03.05.01.04-1, RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

All safety-related and risk-significant SSC that must be protected from external missiles are located inside the seismic Category I RXB and Seismic Category I portions of the CRB. The concrete walls and roof of the RXB and the CRB below the 30 ft above plant grade threshold are designed to withstand all design basis missiles discussed in Section 3.5.1.3 and Section 3.5.1.4. The portions of the RXB and the CRB that are above 30 ft plant elevation have not been analyzed to withstand the design basis automobile missile, but are resistant to the other design basis missiles discussed in Section 3.5.1.4. Section 3.8 provides additional information for the design of RXB and CRB.

RAI 03.05.01.04-1

COL Item 3.5-3: A COL applicant that references the NuScale Power Plant ~~certified~~ design certification will confirm that automobile missiles cannot be generated within a 0.5-mile radius of safety-related structures, systems, and components and risk-significant structures, systems, and components requiring missile protection that would lead to impact higher than 30 feet above plant grade. Additionally, if automobile missiles impact at higher than 30 feet above plant grade, the COL applicant will evaluate and show that the missiles will not compromise safety-related and risk-significant structures, systems, and components.

The RXB and CRB meet the requirements of the RG 1.13, Rev. 2, "Spent Fuel Storage Facility Design Basis", RG 1.117, Rev. 2, "Protection Against Extreme Wind Events and Missiles for Nuclear Power Plants," and RG 1.221, Revision 0, "Design-Basis Hurricane and Hurricane

Missiles for Nuclear Power Plants" for protection of SSC from wind, tornado and hurricane missiles.

RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

The RXB and CRB have been credited to withstand turbine missiles.

RAI 03.05.02-02

COL Item 3.5-4: A COL Applicant that references the NuScale Power Plant design certification will evaluate site-specific hazards for external events that may produce more energetic missiles than the design basis missiles defined in FSAR Tier 2, Section 3.5.1.4.

3.5.3 Barrier Design Procedures

In the design, there are a limited number of potential internal missiles and a limited number of targets. If a missile/target combination is determined to be statistically significant (i.e., the product of (P_1), (P_2) and (P_3) is greater than 10^{-7} per year), barriers are installed.

Safety-related and risk-significant SSC are protected from missiles by ensuring the barriers have sufficient thickness to prevent penetration and spalling, perforation, and scabbing that could challenge the SSC. Missile barriers are designed to withstand local and overall effects of missile impact loadings. The barrier design procedures discussed below may be used for both internal and external missiles.

3.5.3.1 Local Damage Prediction

The prediction of local damage in the impact area depends on the basic material of construction of the structure or barrier (i.e., concrete, steel, or composite). The analysis approach for each basic type of material is presented separately. It is assumed that the missile impacts normal to the plane of the wall on a minimum impact area.

3.5.3.1.1 Concrete Barriers

Concrete missile barriers are evaluated for the effects of missile impact resulting in penetration, perforation, and scabbing of the concrete using the Modified National Defense Research Committee (NDRC) formulas discussed in "A Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects," (Reference 3.5-3) as described in the following paragraphs. Concrete barrier thicknesses calculated using the equations in this section for perforation and scabbing are increased by 20 percent~~%~~. The NDRC formulas were not used for determining penetration distance for the design basis turbine blade and blade with rotor fragment missiles. Instead, a finite element analysis was used because the Modified NDRC equations are based on the assumption that the missile and target are essentially non-deformable, which is not appropriate for a turbine blade which will deform. Using NDRC equations for deformable missiles over-predicts the penetration distance. After the penetration distance is determined with the finite element model, the Modified NDRC formulas are used to determine perforation and scabbing thicknesses.

RAI 03.05.03-1

Concrete thicknesses to preclude perforation or scabbing from the design basis hurricane and tornado pipe and sphere missiles have been calculated for the 5000 psi and 7000 psi concrete used for the RXB, CRB and RWB external walls and roof using the below equations. The design basis hurricane and tornado automobile missile is incapable of producing significant local damage; therefore, it is not considered. The same is true for the design basis turbine missile of half of the last stage of the turbine rotor. The wind and tornado missile results are tabulated in Table 3.5-1. The RXB has five foot thick outer walls and a four foot thick roof. The missile protected portions of the CRB have three foot thick exterior walls and roof, consisting of a concrete slab with a steel cover, and the RWB has exterior walls that are two feet thick above grade and has a one foot thick roof. The local results for the design basis turbine missile are presented in Table 3.5-2 through Table 3.5-4.

RAI 19.05 Aircraft Impact Assessment (APR1400)-1

Additional design characteristics of the RXB and the CRB are provided in Section 3B.2. The RWB exterior walls are 5000 psi concrete reinforced with a minimum of #8 reinforcing bars on 12-inch centers.

3.5.3.1.1.1 Penetration and Spalling Equations

The depth of missile penetration, x, is calculated using the following formulas:

$$x = \left[4KNWd\left\langle\frac{V}{1000d}\right\rangle^{1.8}\right]^{0.5} \text{ for } \frac{x}{d} \leq 2.0 \qquad \text{Eq. 3.5-1}$$

$$x = KNW\left(\frac{V}{1000d}\right)^{1.8} + d \text{ for } \frac{x}{d} \geq 2.0 \qquad \text{Eq. 3.5-2}$$

where,

x = penetration depth, in,

W = missile weight, lb,

d = effective missile diameter, in,

N = Missile shape factor:

- flat nosed bodies = 0.72,
- blunt nosed bodies = 0.84,
- average bullet nose (spherical end) = 1.00,
- very sharp nosed bodies = 1.14,

V = Velocity, ft/sec,

$K = 180/(\sqrt{f'_c})$, and

f'_c = concrete compressive strength (lb/in2).

3.5.3.1.1.2 Perforation Equations

The relationship for perforation thickness, t_p (inches), and penetration depth, x, is determined from the following formulas:

$$t_p/d = 3.19(x/d) - 0.718(x/d)^2 \text{ for } (x/d) < 1.35$$

$$t_p/d = 1.32 + 1.24(x/d) \text{ for } 1.35 \leq (x/d) \leq 13.5$$

3.5.3.1.1.3 Scabbing Equations

The relationship for scabbing thickness, t_s (inches), and penetration depth, x, is determined from the following formulas:

$$t_s/d = 7.91(x/d) - 5.06(x/d)^2 \text{ for } (x/d) < 0.65$$

$$t_s/d = 2.12 + 1.36(x/d) \text{ for } 0.65 \leq (x/d) \leq 11.7$$

3.5.3.1.2 Steel Barriers

RAI 03.05.03-2S1

There are no steel missile barriers used in the design.

3.5.3.1.3 Composite Barriers

The design does not use composite barriers.

3.5.3.2 Overall Damage Prediction

For predicting overall damage, a dynamic impulse load concentrated at the impact area is determined and applied as a forcing function to determine the structural response.

RAI 03.05.03-3

The forcing functions to determine the structural responses are derived using EPRI NP440, "Full Scale Tornado Missile Impact Tests," (Reference 3.5-9) for the triangular impulse formulation of the design basis steel pipe missile. BC-TOP-9A, Rev. 2, "Design of Structures for Missile Impact," (Reference 3.5-8) is used for the design basis automobile missile and design basis half of the last stage turbine rotor. The solid sphere missile ~~is~~and turbine blades are too small to affect the structural response of the

RXB and the CRB and ~~was~~were not evaluated for ~~its~~their contribution to overall structural response.

The automobile missile forcing functions are applied to the building models in selected locations using the horizontal impact loads since they are higher than the vertical loads. The results are addressed in Section 3.8.4.

The weights and velocity of an automobile missile and half of the last stage rotor are similar. Equating the turbine rotor to an equivalent static force resulted in the following:

For the RXB, the flexural demand to capacity ratio (DCR) is 0.18, shear DCR is 0.16, and wall deflection is 0.02 inches.

For the CRB, the flexural DCR is 0.81, shear DCR is 1.46, and deflection is 0.25 inches. All values are based on the exterior wall only. It is observed that the CRB exterior wall is not sufficient to prevent a shear failure that results from the impact of a turbine rotor missile. However, the penetration opening that could be developed is smaller than the size of a personnel door and after impact the normal operating loads will redistribute to the redundant structural members adjacent to the impact location to prevent further damage. In addition, it is anticipated that the exterior wall will suffice to reduce the velocity by a significant margin. The remaining turbine missile will then be contained by the three-foot-thick concrete grade-level floor; this conclusion is determined by inspection due to the significant loss of energy in the missile, and the fact that the strike will occur at not less than a 45 degree angle (which has a substantial influence on the penetration depth). The combination of the exterior wall and grade-level floor serve adequately to protect essential SSCs, which are located below grade in the CRB.

Finite element analyses of the automobile missile has shown to have an insignificant effect on the global response of either structure. Given the similarity of the turbine missile to the automobile missile, the analysis is considered valid for evaluating the effect from the turbine missile. The base reactions, joint displacements, and deformed shape of both the RXB and CRB support this conclusion.

Design for impulsive and impactive loads is in accordance with ACI 349 "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary," (Reference 3.5-6) for concrete structures and AISC N690 "Specification for Safety-Related Steel Structures for Nuclear Facilities," (Reference 3.5-7) for steel structures except for the modifications listed below.

Stress and strain limits for the missile impact equivalent static load comply with applicable codes and RG 1.142, Rev. 2 "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)," and the limits on ductility of steel structures are given as noted below.

Table 3.5-2: Summary of Barrier Thickness for Turbine Missile Penetration

Overspeed	Velocity (mph)	Penetration (inch)	Required Barrier Thickness (inch)
120%	747	17.0	20.4
140%	872	21.5	25.8
160%	996	24.0	28.8
180%	1121	26.0	31.2
190%	1183	25.5	30.6
200%	1245	26.0	31.2
210%	1308	28.5	34.2
220%	1370	28.5	34.2

Table 3.5-3: Summary of Barrier Thickness for Turbine Missile Perforation

Overspeed	x Penetration FEA results (inch)	d* Missile Diameter (inch)	x/d*	t_p (inch)	Required Barrier Thickness (inch)
120%	17.0	1.41	12.1	22.9	27.5
		3	5.7	25.	30.3
140%	21.5	1.41	15.2	28.5	34.2
		3	7.2	30.6	36.7
160%	24.0	1.41	17.0	31.6	37.9
		3	8.0	33.7	40.5
180%	26.0	1.41	18.4	34.1	40.9
		3	8.7	36.2	43.4
190%	25.5	1.41	18.1	33.5	40.2
		3	8.5	35.6	42.7
200%	26.0	1.41	18.4	34.1	40.9
		3	8.7	36.2	43.4
210%	28.5	1.41	20.2	37.2	44.6
		3	9.5	39.3	47.2
220%	28.5	1.41	20.2	37.2	44.6
		3	9.5	39.3	47.2

d* = conservative equivalent diameter used in perforation and scabbing equations

Table 3.5-4: Summary of Barrier Thickness for Turbine Missile Scabbing

Overspeed	x Penetration FEA results (inch)	d* Missile Diameter (inch)	x/d*	t_p (inch)	Required Barrier Thickness (inch)
120%	17.0	1.41	12.1	26.1	31.3
		3	5.7	29.5	35.4
140%	21.5	1.41	15.2	32.2	38.7
		3	7.2	35.6	42.7
160%	24.0	1.41	17.0	35.6	42.8
		3	8.0	39.0	46.8
180%	26.0	1.41	18.4	38.3	46.0
		3	8.7	41.7	20.1
190%	25.5	1.41	18.1	37.7	45.2
		3	8.5	41.0	49.2
200%	26.0	1.41	18.4	38.3	46.0
		3	8.7	41.7	50.1
210%	28.5	1.41	20.2	41.7	50.1
		3	9.5	45.1	54.1
220%	28.5	1.41	20.2	41.7	50.1
		3	9.5	45.1	54.1

d* = conservative equivalent diameter used in perforation and scabbing equations

- turbine rotor grounding device
- turbine to generator shaft coupling

The boundary between the main steam system and TGS is the upstream side of the turbine generator vendor package interface, the upstream side of the gland steam condenser connection point, and downstream of the extraction line connection points. See Figure 10.2-1 and Section 10.3 for additional information.

~~The turbine generator design utilizes a~~The turbine generators employed in the NuScale design utilize an "off the shelf" condensing steam turbine with uncontrolled extractions. The turbine is a single inlet design with one stop valve and a steam chest with multiple inlet control valves.

RAI 10.02-3, RAI 10.02.03-1, RAI 10.02.03-2

The turbine shaft journal bearings are lubricated by the lube oil subsystem. The turbine is also restrained via a thrust bearing to absorb the axial thrust of the turbine.

The turbine generator design includes a spray system which provides cooling to the turbine exhaust hood upon sensing a high temperature condition.

The gland seal steam control skid (Section 10.4.3) is also a part of the turbine subsystem. The gland seal steam control skid performs the following functions:

- prevents air leakage into the turbine under vacuum and prevents steam leakage out of the turbine under pressure for anticipated load conditions
- provides for the use of redundant steam supplies and controlling devices

Areas of the turbine requiring attention during operation are accessible during expected plant operating conditions.

10.2.2.1.2 Generator Subsystem Description

The generator takes the rotational mechanical energy from the turbine and converts it into electricity by spinning the generator rotor through a magnetic field. The magnetic field is produced by self-excitation of the stator coils. The frequency is synchronized with the offsite transmission system and power is transferred to the grid. The generator is directly coupled to the turbine, and is air cooled. Cooling water for the generator air cooling is provided by the site cooling water system. Components of the generator subsystem include the

- generator stator
- generator air coolers
- generator rotor
- brushless or static exciter
- shaft grounding devices
- high voltage bushings

Table 10.2-1: Turbine Generator Design Parameters

Component	Parameter	Value
Turbine	Rotor	• Single Turbine • ~~,~~10 stage condensing • ~~, u~~Uncontrolled extraction • Integrally forged • ASTM 470 CL 4 or equal
	Blades	ASTM A276 - A403 or equal
	RPM	3600 rpm
Generator	Generator power output	50MWe
	Apparent Power	Greater than 57,000 kVA
	Active Power	Greater than 48,000 kWe
	Power Factor	0.85 p.f
	Phase/Frequency/Voltage	3PH/60Hz/13.8kV
	Cooling Type	Air (TEWAC - Totally Enclosed Water to Air Cooling)
Lube Oil	Oil Type	ISO VG 32
	Normal Power	3/60/460 VAC
	Emergency Power	250 VDC
Valves	Turbine control valves	Multiple standard globe valves, with internal spring and yoke
	Stop valve	One hydraulically operated positionable trip valve with throttling pilot for startup operation

Enclosure 2:

Affidavit of Thomas A. Bergman, AF-0519-65738

NuScale Power, LLC

AFFIDAVIT of Thomas A. Bergman

I, Thomas A. Bergman, state as follows:

(1) I am the Vice President of 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 letter reveals distinguishing aspects about the finite element analysis by which NuScale develops its approach for protecting essential structures, systems and components from the effects of turbine missiles.

NuScale has performed significant research and evaluation to develop a basis for this approach for protecting essential structures, systems and components from the effects of turbine missiles 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 letter entitled “NuScale Power, LLC Submittal of Turbine Missile Barrier Design Closure Plan Actions (Final Safety Analysis Report, Tier 1, Section 3.5.1.3).” The attachments contain the designation “Proprietary" at the bottom 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 May 31, 2019.

Thomas A. Bergman