RAIO-1118-62960

November 16, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 401 (eRAI No. 9447) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 401 (eRAI No. 9447)," dated March 28, 2018

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 Question from NRC eRAI No. 9447:

- 03.11-19

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 401 (eRAI No. 9447). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. 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 Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

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

Distribution: Gregory Cranston, NRC, OWFN-8G9A
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9447, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9447, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-1118-62961

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Enclosure 1:

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Enclosure 2:

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Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9447
Date of RAI Issue: 03/28/2018

NRC Question No.: 03.11-19

This is a follow-up RAI to eRAI 9160.

General Design Criterion 4, "Environmental and dynamic effects design bases," in part, requires that SSCs important to safety be designed to accommodate the effects of and be compatible with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss of coolant accidents.

In 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," the U.S. Nuclear Regulatory Commission (NRC) established specific requirements for the environmental qualification (EQ) of certain electric equipment important to safety located in a "harsh" environment (see DSRS 3.11).

NuScale's FSAR Tier 2, Chapter 3 analysis in part provides environmental conditions (e.g., pressure and temperature) during a design basis event (e.g., high energy line break (HELB)) used to qualify equipment that is required to perform a design function related to safety and could be subject to these environmental conditions. In particular, NuScale's FSAR Chapter 3 provides the environmental conditions during a HELB outside containment and under the bioshield (e.g., a harsh environment).

NuScale's FSAR Tier 2 Chapter 3 (e.g., Table 3.11-1) lists equipment in zone G (outside containment and under the bioshield) "…that will experience the environmental conditions of design basis accidents for which it must function to mitigate said accidents, and that will be qualified to demonstrate operability in the accident environment for the time required for accident mitigation with safety margin to failure." (EQ Category A). A similar equipment list can be found in FSAR Tier 1, Table 2.8-1. Safety-related equipment under the bioshield is associated with systems that are essential for emergency reactor shutdown, containment isolation, and decay heat removal. These systems are required to be environmentally qualified to meet their intended design function related to safety.

NuScale's FSAR Chapter 3 describes that the environmental conditions of design basis accidents under the bioshield are established assuming a vented bioshield (Appendix 3C and Figure 3C-3). In a response to RAI 9160, the applicant describes that the bioshield relieves (i.e., vents) the high pressure and temperature environment under the bioshield by opening relief panels. The panels are required to change position from normally closed to open in order to vent the atmosphere under the bioshield into the reactor building. The panels are hinged and provide one-way relief (venting) in response to a HELB under the bioshield.

NuScale's response to RAI 9160 describes in part that all the bioshield functions, including the venting function, are nonsafety-related. If the function of a component or part is nonsafety-related, the staff expects that its failure to function could not prevent the satisfactory performance of a safety-related function. As discussed above, NuScale's FSAR Chapter 3 safety analysis, which establishes the environmental conditions under the bioshield for items related to safety, currently assumes a vented bioshield (e.g., opening nonsafety-related relief panels discussed in response to RAI 9160). Therefore, the staff requests NuScale to assess the failure of the venting function (i.e., nonsafety-related bioshield relief panels do not open) and its impact on the performance of equipment important to safety (e.g., safety-related). As part of the response, because the FSAR Chapter 3 safety analysis currently assumes a vented bioshield and the bioshield vents (relief panels) are nonsafety-related, FSAR Chapter 3 safety analysis (e.g., under the bioshield HELB environmental conditions for pressure and temperature) should be revised assuming bioshield venting is not achieved by the relief panels. Otherwise, NuScale will need to provide additional information to justify reliance on the bioshield relief panels (vents) in its safety analysis.

NuScale Response:

Response to 9447:

The bioshield remains nonsafety-related, seismic category II, but no longer relies on hinged pressue relief panels to ensure equipment important to safety is not detrimentally impacted during abnormal or accident conditions, such as a high energy line break. The re-design of the bioshield now provides vent paths that allow venting without actuation of a relief panel, as shown below. No re-analysis of the environmental conditions under the bioshields was performed in the event of the failure of the relief panels; however, preliminary re-analysis of the environmental conditions remain acceptable under the bioshield using the current configuration.

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}} 2(a),(c)

Response to 8838:

Describe the method/mechanism for restraining a bioshield mounted on an adjacent bioshield and restraining the upper CNV on the module inspection rack during the refueling operations. Further, provide analysis and design criteria (consistent with DSRS Section 3.7.2.II.8) to ensure no adverse interactions occur between the seismic Category II bioshields and inspection racks with adjacent seismic Category I SSCs, during refueling operations (and during the transport of new modules, as applicable).

Response to RAI 8838 Question 1:

The bioshield is held in place by bolts securing the horizontal piece of the bioshield to the operating bay walls and pool wall of the RXB. The vertical portion of the bioshield is prevented from swinging (it is a hinged connection) by a bracket in the operating bay wall. For refueling, one bioshield is moved from its location to on top of another bioshield. The moved bioshield is secured to the bioshield below it by anchor bolts through the slab. The vertical piece of the bioshield is connected to the vertical piece behind it with bolts to prevent it from swinging. These configurations are analyzed with the loads described below to verify that no adverse reactions will cause the bioshield to impact safety related SSC. The bolts used for securing the horizontal portion of the bioshield to the operating bay and pool walls are safety related, and designed in accordance with ACI 349 as they anchor into a concrete structure. The bioshield is designed as a seismic category II structure, which is analyzed and designed to prevent its failure under SSE conditions such that the bioshield will not collapse or fail and strike or impair the integrity of the safety related and/or seismic category I SSC under it.

The following tables include demand over capacity (D/C) ratios of the bioshield design. The demands listed within the tables are from the load case which produced the highest loads on the bioshield. These loads included dead (x2 for refueling arrangement), live, seismic (SSE due to both CSDRS and CSDRS-HF), pressure (from HELB), and hydrodynamic (water sloshing). Temperatures seen in the pool area (i.e. main steam line break) were determined to have negligible effects on the steel assembly of the bioshield.

This table includes D/C ratios for the horizontal portion of the bioshield concrete slab and anchor bolts attaching it to the RXB.

Component	Capacity Check	Demand	Capacity	Unit	D/C Ratio
Concrete Slab	Out of Plane Bending	161.1	265.9	Kip-ft/ft	0.61
Concrete Slab	Out of Plane Shear	30.6	60.0	Kip/ft	0.51
Slab Anchor Bolt	Tension	274.8	531.0	Kip	0.52
Slab Anchor Bolt	Shear	352.1	637.2	Kip	0.55
Wall Anchor Bolt	Tension	627.8	1,062.0	Kip	0.59

This table includes D/C ratios for the horizontal and vertical bioshield connection.

Component	Capacity Check	Demand	Capacity	Unit	D-C Ratio
Bioshield Connection Between Horz. and Vert. Piece - Pin	Shear (double ended)	70.9	107.3	Kip	0.66
Bioshield Connection Between Horz. and Vert. Piece - Pin	Bearing	70.9	97.7	Kip	0.73
Bioshield Connection Between Horz. and Vert. Piece - Hinge Plate on Vert. Piece	Shear	70.9	166.5	Kip	0.43
Bioshield Connection Between Horz. and Vert. Piece - Hinge Plate on Vert. Piece	Tension	70.9	179.0	Kip	0.40
Bioshield Connection Between Horz. and Vert. Piece - Hinge Plate on Vert. Piece	Weld	70.9	133.5	Kip	0.53
Bioshield Connection Between Horz. and Vert. Piece - Hinge Plate on Horz. Piece	Area provided is 2" thick and acceptable since vertical hinge plate shown as acceptable and is 1.5" thick.				OK
Bioshield Connection Between Horz. and Vert. Piece - Hinge Plate on Horz. Piece	Weld	22.6	31.5	Ksi	0.72
Front Plate Assembly	Break-away	766.4	1,631	Kip-ft	0.47

This table includes the maximum stresses seen in the vertical portion of the bioshield steel support structure and and welded connections.

Component	Capacity Check	Demand	Capacity	Unit	D-C Ratio
Steel Structure Member	Extreme Load Case	70.0	96.6	Ksi	0.72
Steel Structure Member	Weld	20.7	31.5	Ksi	0.66

This table includes the lifting location D/C ratio for the highest stressed point on the lift assembly. It is noted that these lift locations and number are to be addressed by riggers at a later time as their expertise provides a better understanding on how to maneuver this large component.

Component	Capacity Check	Demand	Capacity	Unit	D-C Ratio
Lifting Plate	Highest Stress Point of Assembly	24.5	29.9	Ksi	0.82

Work performed on the CNV within the dry dock is based around the module support structure. The module support structure is what holds the upender during module import into the RXB and module inspection rack for CNV inspection. The analysis and design of the module support structure is in early stages, but the finite element analysis (performed in ANSYS) includes dead and seismic loads (SSE response spectra from 139'-8" El with 5% damping) of the structure, the component (either upender or inspection rack), and the module. There are no safe shutdown situations when the module or CNV is in the dry dock since they will not contain fuel at that time, therefore, these components are not considered safety related.

Responses to 9160:

The information provided below supersedes information provided in the original response to 9160.

RAI 9160 - 03.02.01-4

What is the exact function of the bioshield steel vertical faceplate: fire protection, radiation protection, prevention of foreign material deposition onto the NPMs, release of pressure and heat during normal ops and accident conditions?

The bioshield is designed to perform the following functions. The requirements listed below remained the same as the previous design, unless otherwise noted:

- provide ventilation in emergency conditions - The design of the bioshield to meet the requirement has changed. Prior design included one-way pressure relief panels on the vertical face of the bioshield that were hinged at the top so that they were self closing. The radiation panels now are arranged such that the vertical portion of the bioshield is "always open".

- provide ventilation during normal operations - The previous design of the bioshield used HVAC specific vents to provide for a pathway for normal ventilation. The new design uses a staggered radiation panel design to satisfy this.
- designed against adverse flow paths - The previous design aided in preventing objects and fire from entering the operating bay but was not specifically restrictive in preventing fire from getting out of the operating bay (discussed below). It relied on dampers to close in the event of pool room overpressure, fire, and pressure relief panels to relieve pressure inside the operating bay. Additional analysis has been performed and concluded that this requirement was not necessary. The new bioshield design aids in preventing objects and fire from entering the operating bay but is not specifically restrictive in preventing fire from getting out of the operating bay (discussed below).
- storage of the bioshield is on top of another bioshield - The previous and new design of the bioshield use the same method of securing the bioshield to the bioshield underneath it. Each bioshield contains a pattern of sleeves and embedded inserts that allow for bolts to pass through the top bioshield and tighten it to the bioshield underneath. The bioshields are aligned on top of each other the same, regardless of position, with a guide pin that is attached to the top face of the bottom bioshield to help align the bioshield resting on top.
- The bioshield is moved with the RXB crane - The prior and new design of the bioshield use the same method of securing the bioshield to the crane. The previous design of the bioshield used 4 anchor locations, but the new design uses 6. It is noted on the drawing that these locations are subject to review by a rigging group to verify the pick points are adequate.
- The bioshield shall serve as a 3-hour fire and smoke barrier - this requirement has changed since the previous revision of the bioshield. The original horizontal and vertical portion of the bioshield was subject to this requirement. The horizontal portion accomplished this due to the slab thickness, and the vertical portion was a walled off section except for the HVAC vents which were equipped with smoke/fire dampers. The new bioshield horizontal portion still accomplishes the requirement. The new vertical piece of the bioshield does not provide a 3-hour fire barrier or smoke. This is justified through the low fire load / combustibles identified in the pool area and operating bay as there is no plausible fire in the area during normal operations (DCA Section 9A.5.19 through 9A.5.30). In the unlikely event in which there is smoke in the pool room or operating bay, the design of the vertical portion of the bioshield allows for venting it out. In the unlikely event there is a fire, the design of the vertical piece of the bioshield prevents the spread of fire by maintaining a barrier around the the perimeter of the vertical piece so fire cannot travel along the top of the water surface, around the operating bay walls, or from the top of the bioshield down into the operating bay. The

vertical piece additionally provides a separation distance that aids in eliminating the spread of fire.

- The bioshield aids in protecting the module from manmade and external hazards. Both the previous and current bioshield design accomplish this requirement. Even though the new vertical bioshield design is "always open" for ventilation, there is no direct path from outside the operating bay that an item or projectile can take into the operating bay. The staggered panel design provides coverage to deflect the hazards.
- The bioshield is designed to accommodate environmental conditions for normal and accident conditions. The previous and new design accomplishes this requirement through construction material (concrete and steel components).
- prevent the buildup of gasses in the operating bay - the previous bioshield design provided a small opening at the top of the vertical piece of the bioshield to allow for this gas to escape. The new bioshield design allows for the gas to escape along the entire top of the vertical piece of the bioshield.
- prevent radiation streaming vertically - the bioshield slab in both designs accomplishes this requirement with the use of the 2 foot thick slab. Refined analysis of the vertical radiation stream has allowed for the removal of the HDPE in the horizontal slab.
- prevent radiation streaming horizontally - this is a new requirement. The previous vertical piece of the bioshield did not meet this requirement. The new design of the vertical piece of the bioshield accomplishes this requirement with HDPE panels built into the radiation panels on the front and rear face of the vertical piece.

What foreign material could be deposited onto the NPMs?

This is in reference to moving items over the NPMs (over the bioshields) during normal operations and for refueling. This response is unchanged from previous design.

Why does the design require a vertical face plate?

See responses to requirements question above.

Why does it need to go all the way into the water?

The vertical piece no longer is responsible for limiting the normal HVAC area to 25 sq ft. It still aids in preventing floating material from entering the operating bay.

Are any functions safety related?

- The functions of the bioshield are not safety related.

- The bolts that secure the bioshield to the operating bay and pool walls are safety related. The bolts are designed IAW ACI 349 as they anchor the bioshield to concrete walls.

Detailed drawings of the bioshield should be provided.

ED-F010-3661 Revision 3 can be made available for NRC audit.

RAI 9160 - 03.02.01-5

Are the vents in the bioshield vertical faceplate considered to provide a nuclear safety function (e.g., do they establish environmental conditions for safety-related components related to safe shutdown)?

The bioshield vents aid other SSC which perform a safety related function. If the vents are mechanical devices credited for heat and pressure relief in order to establish the environmental conditions for safety related components related to safe shutdown, explain how the current classification is appropriate?

The bioshield vents are no longer mechanical devices, the hinges have been removed. The ventilation is an always open path that relieves high temperature and pressure environments in the operating bay.

RAI 9160 - 03.02.01-6

What is the design of the vent(s)?

The design of the ventilation in the vertical piece of the bioshield has changed. The vents in the old design were hinged panels. The vents are now radiation panels arranged in a staggered pattern.

Is it a simple mechanical damper?

This vent system is a basic design that provides for all necessary requirements. In addition to those requirements, it is a better design to cool the environment in the operating bay post accident due to the chimney cooling effect provided by the different elevations of the vents.

What kind of maintenance will be applied to the vents?

Maintenance from a ventilation/mechanical viewpoint is not required. The radiation panels perform as radiation protection barriers, and it is expected that the HDPE inside the radiation panels will have an operating life dependent on calculated/tested absorption and require replacement. To allow for maintenance, the radiation panels are bolted to the vertical bioshield to allow for full replacement. Additionally, the radiation panels contain subcompartment panels which unbolt independently of the panel location, allowing the HPDE to be replaced one sheet at a time, and in place.

What kind of lubrication material will be used?

No lubrication required. The hardware for the bolts/nuts is a stainless steel which will not corrode in the pool room environment.

Wouldn't radiation affect the characteristics of the lubricant forcing it to be replaced at certain time intervals?

Not applicable. However, it is expected that aspects of the bioshield will be inspected and replaced during the life of the plant. These items have been designed accordingly such that they can be replaced as easily as practical.

RAI 9160 03.02.01-7

How will the vent(s) work when one bioshield is stacked on top of another?

The new vent arrangement allows for the flow of air to remain almost unhindered. In the stacked configuration, there is a slight difference in flow path, but this does not impact the functions of the vents.

and how, in this configuration, will the top bioshield be restrained in order to properly respond to seismic activity?

The horizontal portion of the bioshield is bolted to the bioshield underneath it. The vertical piece of the bioshield is bolted to the vertical piece behind it. The vertical piece in the pool walls is secured at the bottom to the pool wall with a revised design strike plate.

RAI 9160 03.02.01-8

What happens if the vent fails?

The vent does not have parts that can fail or cause failure of the vent function. The vents are designed as seismic category 2, and for high pressure and accident temperature events. In an event where a panel is knocked off, this will impact the radiation protection capability of the vertical piece, but will increase the venting characteristics. This event is considered outside design basis.

What happens if the temperature monitor (under the bioshield) fails? Are there supporting calculations?

The updated bioshield ventilation design will continue to aid in cooling the environment under the bioshield after a DBA.

RAI 9160 03.02.01-9

Identify and provide engineering documents which establish currently approved bioshield design. Does ED-F012-3661, rev 2, “BioShield General Arrangement and Details”, 13 Apr 2017, reflect the design?

ED-F012-3661 Revision 3 can be made available for NRC audit.

RAI 9160 03.02.01-10

If the recommended redesign to the bioshield is to add blowout panels to the vertical plates, at what differential pressure would these panels open? See DD-F010-4444, Rev 0, “Bioshield Re-Design to Support Environmental Qualification Profile”, 2 Sept 2016.

The bioshield design has changed to have the radiation panels arranged in a manner that makes the ventilation opening to be always open to satisfy normal and accident conditions. DD-F010-4444 is considered superseded in this aspect of the design.

Impact on DCA:

Tier 1 Section 3.11 and Tier 2 Sections 1.2, 3.7.2, 3.7.3, 3.8.4, 9.1.5, 9.5.1, 12.3 have been revised as described in the response above and as shown in the markup provided with this response.

RAI 03.11-19, RAI 12.03-17, RAI 12.03-27

Table 3.11-1: Reactor Building Shield Wall Geometry

Elev.	Room Name	North Wall (Note 1)	East Wall (Note 1)	South Wall (Note 1)	West Wall (Note 1)	Floor (Note 2)	Ceiling (Note 2)
24’	Module 1 CVCS ion exchanger sluice room	20” structural steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 2 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 3 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 4 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 5 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 6 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 7 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 8 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 9 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 10 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 11 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Module 12 CVCS ion exchanger sluice room	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	20" concrete/steel composite slab
24’	Degasifier room “A”	5’ concrete, RXB exterior wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	3’ concrete (floor of 50’ elevation)
24’	Degasifier room “B”	5’ concrete, RXB exterior wall	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	10’ concrete (ground floor)	3’ concrete (floor of 50’ elevation)
24’	Pool cleanup filter room “A”	5’ concrete, RXB wall	20” concrete/steel partition wall	20” concrete/steel partition wall	5’ concrete, RXB exterior wall	10’ concrete (ground floor)	3’ concrete (floor of 50’ elevation)
24’	Pool cleanup filter room “B”	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	5’ concrete, RXB exterior wall	10’ concrete (ground floor)	3’ concrete (floor of 50’ elevation)

Table 3.11-1: Reactor Building Shield Wall Geometry (Continued)

Elev.	Room Name	North Wall (Note 1)	East Wall (Note 1)	South Wall (Note 1)	West Wall (Note 1)	Floor (Note 2)	Ceiling (Note 2)
100’	Modules 1-6 CVCS vertical pipe chases	20” concrete/steel partition wall	20” concrete/steel partition wall	5’ concrete (reactor pool wall)	20” concrete/steel partition wall	N/A	N/A
100’	Modules 7-12 CVCS vertical pipe chases	5’ concrete (reactor pool wall)	20” concrete/steel partition wall	20” concrete/steel partition wall	20” concrete/steel partition wall	N/A	N/A
126’	Reactor pool area	5’ concrete wall	5’ concrete wall	5’ concrete wall	5’ concrete wall	~~21.5~~23.5” concrete, ~~2” high-density polyethylene,~~ 2 x 0.25” steel (Bioshield)	4’ concrete roof

Note 1: A 20” concrete/steel partition wall consists of two one-half inch steel plates with 19” of concrete in between.
Note 2: A 20” concrete/steel composite slab consists of two one-half inch steel plates with 19” of concrete in between.

- The circulating water system is an open-loop system that provides a continuous supply of cooling water to the plant turbine condensers. Circulating water pumps draw water from a common basin to provide cooling water flow for up to six condensers in one TGB. Heated circulating water from the outlet of the condensers flows to a set of mechanical-draft cooling towers where excess heat is removed as the water gravity flows back to the common basin. (Section 10.4.5)
- The site cooling water system is an open-loop system that provides a continuous supply of cooling water to the chilled water system, the balance of plant component cooling water system, the spent fuel pool cooling system, the reactor pool cooling system, the RCCWS, and the condenser air removal system. Site cooling water pumps draw water from a common basin to provide cooling water flow to the systems serviced. Heated site cooling water from the outlet of the individual system heat exchangers continues to a dedicated set of mechanical-draft cooling towers where excess heat is removed as the water gravity flows back to the common basin. (Section 9.2.7)

1.2.1.7 Radioactive Waste Management System

The radioactive waste management system is discussed in detail in Chapter 11. Liquid, gaseous, and solid radioactive waste management systems are discussed in detail in Sections 11.2, 11.3, and 11.4, respectively. Process effluent radiation monitoring and sampling systems are discussed in Section 11.5.

1.2.2 General Arrangement of Major Structures and Equipment

Figure 1.2-2 presents the layout of a NuScale Power Plant. This figure includes an administration and training building and a warehouse that are outside the scope of the FSAR and not discussed further.

1.2.2.1 Reactor Building

As shown in Figure 1.2-2, the RXB is approximately central to the site. See Figure 1.2-5 and Figure 1.2-10 through Figure 1.2-20 for RXB drawings. Dimensions provided in Figure 1.2-5 are nominal or approximate values for illustrative purposes. The RXB houses the NPMs and systems and components required for plant operation and shutdown. The RXB is primarily a rectangular configuration that is approximately 350 ft long and 150 ft wide, and extends approximately 81 ft above nominal plant grade level. The bottom of the RXB foundation is 86 ft below grade except for the areas under the elevator pit and the refueling pool, which are approximately 92 ft below grade. The RXB is a Seismic Category I, reinforced concrete structure with design considerations for the effects of aircraft impact, environmental conditions, postulated design basis accidents (internal and external), and design basis threats. The RXB also provides radiation protection to plant operations and maintenance personnel.

RAI 03.11-19

Each NPM is located in the common reactor pool in its own three-walled bay with the open wall towards the center of the pool. The bays are arranged into two rows with six bays per row along the north and south walls of the reactor pool at the east end of the pool. A central channel is provided between the bays to allow for movement of the

NPMs between the bays and the refueling pool. The bays are approximately 20 ft wide by 20 ft long by 98 ft deep with a normal reactor pool water depth of approximately 69 ft (this correlates to an elevation of approximately 94'). Each bay has a concrete bioshield to reduce radiation levels in the RXB and to prevent deposition of foreign materials onto an NPM. The bioshield consists of a two foot thick horizontal slab comprised of reinforced concrete ~~and polyurethane~~ with a stainless steel surface and ~~steel vertical faceplate~~a vertical assembly comprised of a square stainless steel tube framing system and series of radiation panel assemblies that extends into the pool. The horizontal slab is bolted to the top of the bay. Nine radiation panels are attached on both sides of the vertical bioshield framing system to provide a radiation barrier and ventilation. The bioshields are designed to be removed to access the NPM. To accommodate the removed bioshield, each bioshield is designed to have another bioshield stacked on top of it to allow for NPM movement during refueling.

The NPM, reactor pool, and SFP are below grade. The surface of the reactor pool water is approximately 6 feet below grade. Also located below grade are most primary systems and some radioactive waste equipment. Hoisting and handling equipment is located above grade.

Pipe fittings and electrical connections are provided above the reactor pool water level to permit manual connection and disconnection during NPM installation, refueling outages, and during replacement or removal of NPMs.

There is no safety-related equipment on the 125'-0” elevation. With the exception of demineralized water isolation valves, which are located on the 50'-0" elevation, there is no safety-related equipment below the 75'-0” elevation. Table 3.2-1, Classification of Structures, Systems, and Components, provides the location and classification of systems, structures, and components.

1.2.2.1.1 Fuel Handling and Reactor Maintenance Areas

The fuel handling and reactor maintenance areas are located in the west end of the RXB and include space for the SFP, refueling pool, and dry dock. The pools are shown in Figure 1.2-16.

The operating areas at the west end, 100'-0" elevation of the RXB provide space for the operation of fuel handling equipment and accessing the upper portion of an NPM while the reactor core is being refueled.

The refueling pool is connected directly to the reactor pool accommodating transport of an NPM through the pool water using the Reactor Building crane (RBC). A weir between the refueling pool and SFP provides access for fuel assembly transport under water during the refueling process. The fuel handling and maintenance areas are designed to provide radiation protection for plant operations and maintenance personnel who are working in those areas.

The area west of the SFP contains a fuel receiving area and a jib crane for loading new fuel assemblies into the new fuel elevator. The area has pallet jack access to aid in new fuel receiving activities. Upon receipt, new fuel assemblies are inspected and temporarily stored in racks in the SFP before being placed in a reactor core.

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Table 3.7.2-34: SSC Seismic Analysis Identification Code Assignments

SSC	Description	Identification Code
CNTS	containment system	5
SGS	steam generator system	5
RXC	reactor core	5
CRDS	control rod drive system	5
CRA	control rod assembly	5
NSA	neutron source assembly	5
RCS	reactor coolant system	5
CVCS	chemical and volume control system	5
ECCS	emergency core cooling system	5
DHRS	decay heat removal system	5
CRHS	control room habitability system	6
CRVS	normal control room HVAC system	6
MAEB	Module Assembly Equipment - Bolting	3, 4
FHE	fuel handling equipment	3
SFSS	spent fuel storage system	3
RPCS	reactor pool cooling system	3, 4
UHS	ultimate heat sink	3, 4
CES	containment evacuation system	5
MSS	main steam system	5
FWS	feedwater system	5
EDSS	highly reliable DC power system	3[1], 4[1], 6[2]
MPS	module protection system	3[1], 4[1], 6[2]
NMS	neutron monitoring system	3, 4
SDIS	safety display and indication system	6
ICIS	in-core instrumentation system	5
PPS	plant protection system	3[1], 4[1], 6[2]
RMS	radiation monitoring system	3[1], 4[1], 6[2]
RXB	Reactor Building ~~(including Lug Support)~~	1, 2
RXB	Reactor Building - NPM Lug and Skirt Supports	5
RBC	Reactor Building crane	3
RBCM	Reactor Building Components - Pool Liner	1, 2
RBCM	Reactor Building Components - Bioshield	3~~, 4~~
CRB	Control Building	7, 8
SMS	seismic monitoring system	3[1], 4[1], 6[2]

[1]Design for SSC located in the Reactor Building

[2]Design for SSC located in the Control Building

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Table 3.7.2-35: Analysis Model Summary

No.	Analysis Model	Concrete Condition	Computer Program	SSI and SSSI Soil Types Considered	SSI and SSSI Time History Inputs Used	Purpose	Building Response	FSAR Explanation and Figures	FSAR Results
1	RXB stand-alone bldg	Uncracked & cracked	SAP2000	N/A	N/A	Static analysis	Member forces	Sections: 3.7.2.1.1.1, 3.7.2.1.2.1, 3.8.4.1.1, 3.8.4.3, 3.8.4.4.1, 3.8.5.4.1.2; Figures: 3.7.2-4, 3.8.4-15 through -20	Tables: 3B-2 through -25; Figures 3B-7 through -47
2	RXB stand-alone bldg	Uncracked & cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic SSI analysis using 7% material damping	Member forces	Sections: 3.7.2.1.1.3, 3.7.2.1.2.1, 3.7.2.1.2.4, 3.7.2.4, 3.7.2.11, 3.7.5.1.4, 3.8.4.3, 3.8.5.4.1.2; Figures 3.7.2-15 through -21 & -35 (SASSI Input); Table 3.7.2-8 (SASSI Input)	Tables: 3B-2 through -25; Figures 3B-7 through -47
3	RXB stand-alone bldg	Uncracked & cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic ISRS generation using 4% material damping	ISRS	Sections: 3.7.2.1.1.3, 3.7.2.1.2.1, 3.7.2.1.2.4, 3.7.2.4, 3.7.2.5, 3.7.2.5.3, 3.7.2.9, 3.7.5.1.4, 3.8.4.3; Figures 3.7.2-15 through -21 & -35 (SASSI Input); Table 3.7.2-8 (SASSI Input)	Figures: 3.7.2-99 through -103
4	RXB stand-alone bldg	Uncracked	ANSYS	Wall accelerations are based on soil types 7, 8, and 11 w CSDRS Input.	CSDRS: Capitola	Slosh heights in reactor pool and determine fluid-structure interaction effects of the RXB Pool	Accelerations, fluid pressures	Sections: 3.7.2.1.1.2, 3.7.2.1.2.4, 3.7.5.1.4, 3.8.4.3; Figures: 3.7.2-32 through -35, 3.8.5-8 through -14	Table 3.7.2-8; Figures 3.7.2-36 through -39

Table 3.7.2-35: Analysis Model Summary (Continued)

No.	Analysis Model	Concrete Condition	Computer Program	SSI and SSSI Soil Types Considered	SSI and SSSI Time History Inputs Used	Purpose	Building Response	FSAR Explanation and Figures	FSAR Results
26	Reactor Building crane (RBC)	N/A	ANSYS	Analysis based on RXB ISRS	Analysis based on RXB ISRS	Structural analysis of RBC	Member forces	Section 9.1.5	Not presented
27	RXB bioshield - partial model	Cracked & uncracked	SAP2000	Analysis based on RXB ISRS	Analysis based on RXB ISRS	Structural analysis of bioshield	Member forces	Sections: 3.7.3, 3.7.3.3.1~~2~~; Figures: 3.7.3-1~~ & -2~~; Tables 3.7.3-8 through -13~~2~~	Table 3.7.3-14

for the standard plant are normally composed of two SSE events, with 10 maximum stress-cycles each, for a total of 20 full cycles. This is considered equivalent to the cyclic load basis of one SSE and five OBEs.

Alternatively, the number of fractional vibratory cycles equivalent to that of 20 full SSE vibratory cycles with an amplitude not less than one-third of the maximum SSE amplitude may be used when derived in accordance with IEEE 344 (Reference 3.7.3-8).

3.7.3.3 Procedures Used for Analytical Modeling

For the decoupling of the subsystem and the supporting system, the following criteria are used:

- if $R_m < 0.01$, decoupling can be done for any R_f
- if $0.01 \leq R_m \leq 0.1$, decoupling can be done if $0.8 \geq R_f \geq 1.25$
- if $R_m > 0.1$, a subsystem model should be included in the primary system model

where,

$$R_m = \frac{\text{total mass of supported subsystem}}{\text{total mass of supporting subsystem}}$$

$$R_f = \frac{\text{fundamental frequency of supported subsystem}}{\text{dominant frequency of support motion}}$$

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The Reactor Building (RXB) structural weight is greater than 500,000 kips (see Table 3.7.2-13). As such, a subsystem can be decoupled if the weight is less 5000 kips. The larger subsystems, the NPM and the RBC, have weights on the order of 2000 kips and could be uncoupled. However, they are both coupled in the RXB model. The fuel storage racks have a loaded weight less than 2000 kips, and each bioshield is less than ~~200~~220 kips. Therefore these SSC are decoupled.

Distributed systems (cable trays, piping, heating ventilation and air conditioning) and individual components will not have significant weights that would challenge the $R_m < 0.01$ criterion.

3.7.3.3.1 Bioshields

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The bioshields are nonsafety-related, not risk-significant, Seismic Category II components that are placed on top of each module bay at the 125-ft~~'~~ elevation to provide an additional radiological barrier to reduce dose rates in the RXB and support personnel access. Bioshields are removed while a NPM is being detached and refueled. During that time, the removed bioshield is placed on top of an in-place bioshield.

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Each bioshield is comprised of a horizontal slab supported by the bay walls and a hanging vertical ~~face plate~~assembly attached to the horizontal slab. The horizontal slab consists of ~~21.5~~23.5-in. thick reinforced 5000 psi concrete.~~ with a 2-in. layer of high-density polyethylene on the top.~~ The concrete is~~and high-density polyethylene are~~ encapsulated in 1/4-in. stainless steel plates for a total thickness of two feet. The vertical ~~plate~~assembly is constructed of a stainless steel tube framing system and ~~stainless steel face plates~~series of radiation panels. The radiation panels are comprised of 4-in. borated HDPE panels with 5 percent boron content encased within steel panels. The vertical ~~plate~~assembly is vented for heat removal during normal operation ~~via two fire and pressure rated louvered vents, and~~as well as heat and pressure mitigation in the event of a high energy line break and slow leak, high temperature event above the NPM~~ via hinged pressure relief panels providing one way ventilation~~. The vents are arranged on the vertical portion of the bioshield in a staggered manner, allowing for continuous ventilation of the operating bay~~for normal operation are located two feet off the surface of the pool, with one vent on the left and one on the right side of the front face of the vertical portion of the bioshield. The pressure relief panels cover the space between the vents for normal operation and all the way up the vertical face of the bioshield. A solid design is used as a representative weight for the structural analysis~~.

The bioshields are attached to the bay walls and outer pool wall using 1.5-in. diameter removable anchor bolts. Figure 3.7.3-1 shows six installed bioshields and Figure 3.7.3-2 shows a vertical faceplate.

Reinforced Concrete Properties and Slab Capacity

Table 3.7.3-8 contains the section dimensions used for the design of the bioshield. Table 3.7.3-9 shows the concrete and reinforcement design values used for capacity calculations. The values are obtained from ACI 349 (Reference 3.7.3-4). The minimum concrete cover for cast-in-place members is based on Section 7.7.1 of ACI 349.

The capacities for the bioshield slab are shown in Table 3.7.3-10 and are calculated based on the provisions of ACI 349. The individual equations used for out of plane moment and shear capacity are referenced in Table 3.7.3-10. The anchor bolt capacities for tension and shear are developed using the equations from Appendix D of ACI 349.

The welded connections between the vertical and horizontal component of the bioshield are designed based on the provisions of Chapter J of AISC 360 (Reference 3.7.3-5).

Structural Steel Material Properties

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~~The vertical component is constructed of ASTM A240 Type 304L stainless steel plates and tube steel in order to resist corrosion. The yield strength and tensile strength of Type 304L stainless steel is 25 ksi and 70 ksi respectively. Yield strength decreases due to increasing temperature. The operating environment underneath the bioshield is expected to be higher than the ambient building temperature. Therefore, a yield strength of 21.4 ksi, corresponding to a temperature of 200 °F, is used.~~The vertical assembly of the bioshield is constructed from steel tube members of HSS 5x5x1/2" in the horizontal and vertical directions. The tube steel material is SA-564 Type 630 condition H1150 high strength stainless steel with yield strength of 105 ksi and a tensile strength of 135 ksi. The stainless steel liner plate that protects the horizontal bioshield from corrosion and the radiation panel's ¼" closure plate is made from A240 Type 304. The framing members of the bioshield radiation panel are made from A276 stainless steel. The yield strength of A240 Type 304 is 25 ksi and the tensile strength is 70 ksi. A276 stainless steel has a yield strength of 25 ksi and a tensile strength of 70 ksi.

In-Structure Response Spectra

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In-structure response spectra were developed for multiple locations in the RXB in Section 3.7.2. Two nodes from that model were selected to use for the design of bioshields. These nodes are shown in Figure 3.7.3-3. Plots of the ISRS at these nodes are shown in ~~Figure 3.7.3-4~~Figure 3.7.3-4a, Figure 3.7.3-4b, and Figure 3.7.3-4c.

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The calculated natural frequency value is used to identify the maximum accelerations ~~in all three directions on the bioshield slab during an earthquake event. The acceleration obtained from these ISRS is used for the design~~in the vertical direction. In the East-West and North-South directions, it was assumed that the fundamental natural frequency is very high and the acceleration values based on ZPA were used. Those acceleration values were used for the design of the horizontal bioshield and the attachments to the walls.

3.7.3.3.1.1 Evaluation

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The self-weight of the bioshield was calculated using material densities and the dimensional properties. There are two structural components of the bioshield: the horizontal slab and vertical ~~face plate~~assembly. The horizontal slab rests on the interior pool walls as shown in Figure 3.7.3-1. The ~~face plate~~vertical assembly is ~~welded to the steel plate on the bottom of the slab~~attached to the side of the horizontal bioshield through eight pins. Table 3.7.3-11 summarizes the weight of the slab and Table 3.7.3-12 summarizes the weight of the face plate.

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The total weight of the bioshield used for design is twice the total calculated weight of each bioshield because they can be stacked on one another during refueling and maintenance. In addition, a 50 psf live load is included to account for the load due to plant personnel bolting and unbolting the bioshield during refueling and maintenance. The bioshield area is not expected to be a high traffic area during normal operation. ~~The total weight used for design is 383 kips.~~

The slab is treated as a simply supported beam for simplified design. The combined dead and live load are treated as a distributed load along the simplified beam. The slab will exhibit one-way bending due to the fact that it is mounted directly on the two opposite buttress walls. Therefore, the maximum shear and bending for the slab is obtained from Table 3-23 of AISC Steel Construction Manual (Reference 3.7.3-6).

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The frequency of the bioshield is based on two bioshields stacked one on top of the other. This is a conservative scenario for the seismic response. Using the parameters shown in Table 3.7.3-8 and Table 3.7.3-10, and the design weight of each bioshield, the natural vertical frequency is determined ~~to be 11.42 Hz~~. ~~This frequency is close to the peak of the ISRS, therefore the peak acceleration is used for the design. The natural north-south frequency of bioshield slab is 337.36 Hz. Therefore the acceleration at 100 Hz from the ISRS is used. The natural east-west frequency of the bioshield slab is 44.24 Hz and is used.~~ The accelerations used in the three directions are shown in Table 3.7.3-13.

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Load combination 9-6 from ACI 349 (this is load combination 10 in Table 3.8.4-1) is used to calculate maximum shear and moment in the horizontal slab. The bioshield slab is anchored to the NPM bay walls with four 1.5-in. vertical bolts on each wall and to the NPM pool wall with eight 1.5-in. bolts in the horizontal direction.

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~~In addition to the slab, the capacity of the anchor bolts is checked. The anchor bolt material is ASTM A193 Grade B7 due to its temperature and corrosion resistance. The ultimate tensile stress of ASTM A193 Grade B7 steel is 125 ksi. The bioshield slab is anchored to the NPM bay walls with four 1.5-in. vertical bolts on each wall and to the NPM pool wall with eight 1.5-in. bolts in the horizontal direction.~~

3.7.3.3.1.2 Demand to Capacity Ratios

Table 3.7.3-14 shows the summary of demand to capacity ratios for the bioshield.

3.7.3.4 Basis for Selection of Frequencies

When practical, components are designed (or specified) so that the fundamental frequencies of the component are less than one half or more than twice the dominant frequencies of the support structure. However, equipment will be tested or analyzed to

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Table 3.7.3-10: Moment and Shear Capacity of Horizontal Slab

Description	Parameters	Value
Out-of-plane moment capacity $\phi M_N = \phi_M M_N$	ϕM_N (kip-ft/ft)	~~206~~265.9
Shear capacity provided by concrete $\phi V_c = \phi_v 2bd\sqrt{(fc')}$	$\phi_v V_c$ (kip/ft)	~~21~~26.1
Shear capacity provided by stirrups[1] $\phi V_s = \phi_v((A_{st(s)} f_y d)/s_s)$	$\phi_v V_s$ (kip/ft)	~~27~~33.9
In-plane shear capacity by concrete[2] $\phi V_{conc} = \phi A_{cv}(\alpha_c \sqrt{(f_c')})$	$\phi_v V_{conc}$(kip/ft)	~~27~~29.9
In-plane shear capacity[2] $\phi V_{in\text{-}plane}$=minimum of $\phi A_{cv}(\alpha_c \sqrt{(f_c')} + \rho_t f_y)$ or $\phi_v 8 A_{cv} \sqrt{(f_c')}$	$\phi_v V_{in\text{-}plane}$ (kip/ft)	~~109~~119.4

Note:
1. Section 11.5.7.2 of ACI 349 (Reference 3.7.3-4)
2. Section 21.7.4.1 of ACI 349 (Reference 3.7.3-4)

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Table 3.7.3-11: Bioshield Slab Self-Weight

Material	Density	Material Thickness	Section Width	Section Length	Section Area	Total Weight
	lb/ft^3	in	ft	ft	ft^2	kip
Steel	490.75	2 x 1/4	24.5	20.5	502.25	~~[1]10.35[1]~~
Concrete	150	~~21.5~~23.5				~~135.00~~
~~HDPE~~	~~60.56~~	~~2~~				~~5.08~~
					Total	~~150.44~~157.9

~~Notes:~~

~~[1]Total weight of steel is the weight of two plates (top and bottom of slab)~~

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Table 3.7.3-12: Bioshield Face Plate Self-Weight

~~Material~~	~~Density~~	~~Material Thickness~~	~~Section Width~~	~~Section Height~~	~~Section Area~~	~~Total Weight~~
	~~lb/ft^3~~	~~in~~	~~ft~~	~~ft~~	~~ft^2~~	~~kip~~
~~Plate~~	~~490.75~~	~~¼~~	~~21.5~~	~~30~~	~~645~~	~~13.29[1]~~
~~Member~~	~~Linear Weight~~	~~Horizontal Members~~	~~Section Width~~	~~Vertical Members~~	~~Section Height~~	~~Total Weight~~
	~~lb/ft~~	~~qty~~	~~ft~~	~~qty~~	~~ft~~	~~kip~~
~~HSS4X4X1/2~~	~~21.63~~	~~16[±]~~	~~22~~	~~12~~	~~30~~	~~15.4~~
					~~Total~~	~~28.69~~

~~Notes:~~

~~[1]Total weight of plate steel is the weight of two plates (front and back of vertical component)~~

Component	**Quantity**	**Weight (lbs)**	**Total (lbs)**
radiation panels	9	4700	42300
frame weldment	1	16132	16132
-	-	**Total**	**58432 (60,000 used)**

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Table 3.7.3-13: Horizontal Bioshield Accelerations

Node	Excitation Direction	Frequency	Acceleration @ 4% Damping
		Hz	G
~~26191~~25826	East-west	100.00~~44.28~~	~~0.737~~0.688
	North-south	100.00	~~1.305~~1.362
	Vertical	10.26~~14.45~~	~~2.077~~1.660
~~26674~~26345	East-west	100.00~~44.28~~	~~0.813~~0.764
	North-south	100.00	~~0.842~~0.833
	Vertical	10.26~~9.20~~	~~2.027~~2.159

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Table 3.7.3-14: Summary of Bioshield Demand to Capacity Ratios

Component	Capacity Check	Demand	Capacity	Unit	D/C Ratio
~~Slab reinforcement~~Concrete slab	out-of-plane bending	161.1~~124.54~~	~~206~~265.9	kip-ft/ft	0.61~~0~~
	out-of-plane shear	30.6~~23.62~~	~~48~~60.0	kip/ft	~~0.49~~0.51
Slab anchor bolt	Tension	274.8~~198.52~~	~~663.75~~531.0	kip	~~0.30~~0.52
	Shear	352.1~~467.53~~	~~796.5~~637.2	kip	~~0.59~~0.55
Wall anchor bolt	Tension	627.8~~486.16~~	~~922.5~~1062.0	kip	~~0.53~~0.59
	~~Shear~~	~~385.85~~	~~796.5~~	~~kip~~	~~0.48~~
~~Bent plate fillet weld~~Front plate assembly (structure embedded in horizontal portion to anchor vertical portion)	~~Tension~~Break-away	766.4~~37.6~~	~~59.39~~1631.0	kip	~~0.63~~0.47
~~Hoist ring anchorage~~Lifting plate	~~Interaction tension + shear~~Highest stress point of assembly	24.5~~-~~	~~-~~29.9		~~0.78~~0.82
~~Vertical component slot weld~~Vertical steel structure member	~~Weld capacity~~Extreme load case stress	70.0~~23.28~~	96.6~~47.25~~	kip	~~0.49~~0.72
Vertical steel structure member	Weld	20.7	31.5	kip	0.66

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Figure 3.7.3-1: Cutoff View of Reactor Building to Depict Bioshields

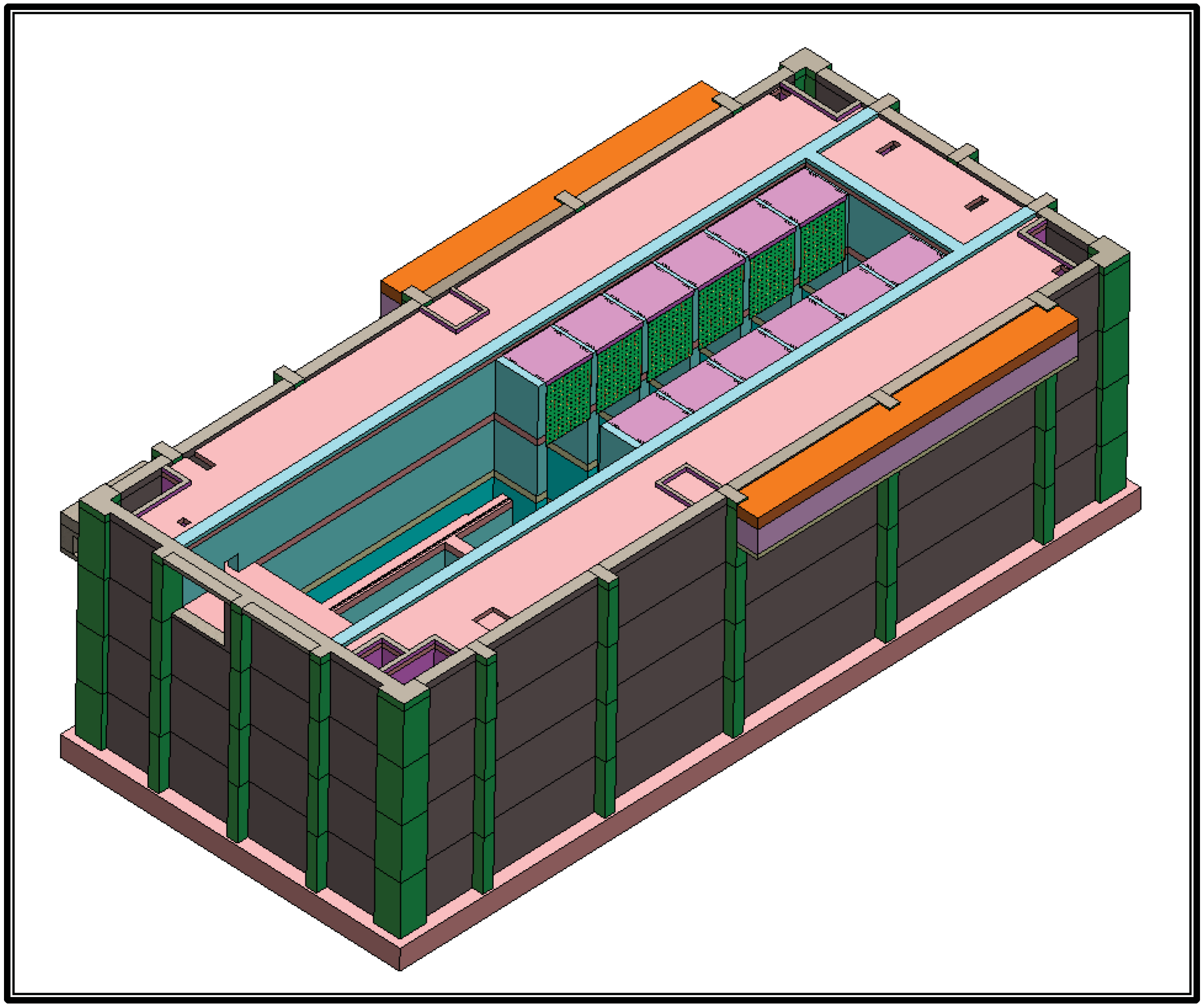

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Figure 3.7.3-2: ~~Conceptual Bioshield Vertical Face Plate~~Not Used

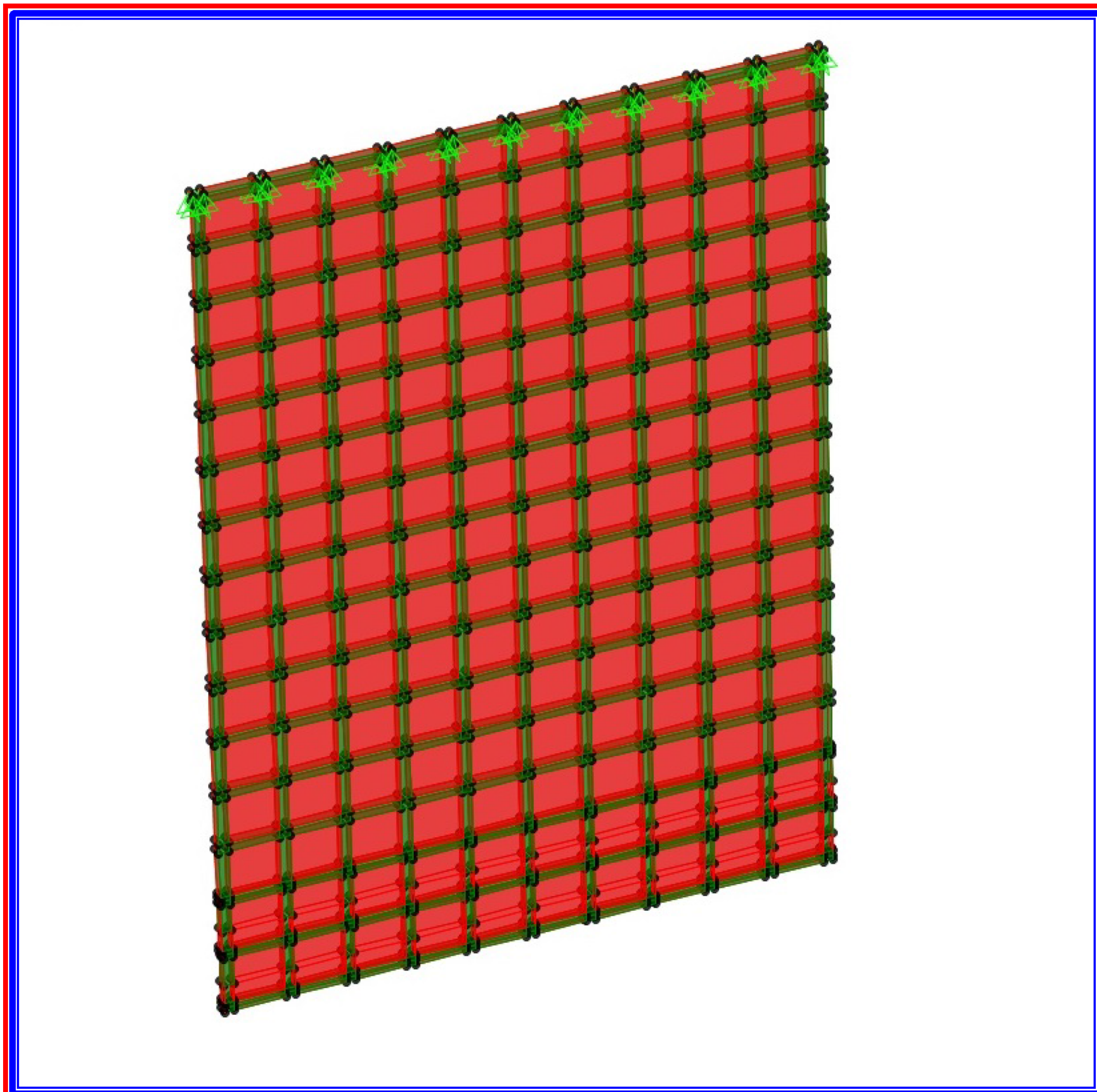

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Figure 3.7.3-3: Location In-structure Response Spectra Nodes for Design of Bioshields

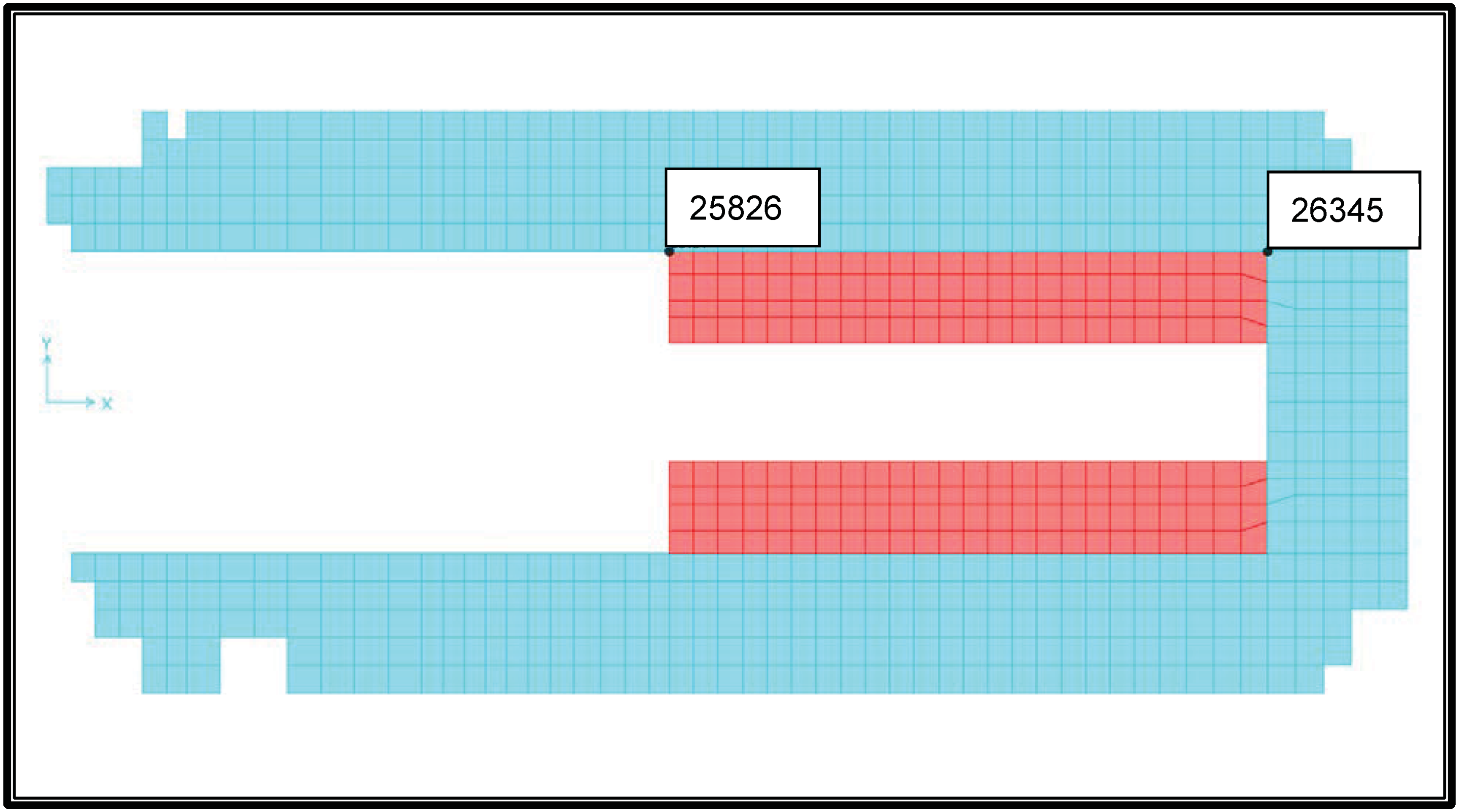

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Figure 3.7.3-4: ~~In-structure Response Spectra Used for the Evaluation of the Bioshield~~Not Used

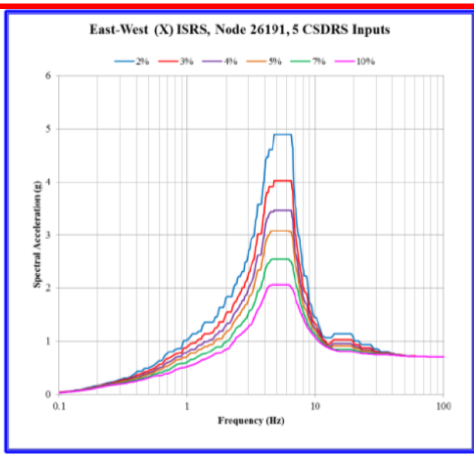

Figure A-190. RXB - East-West (X) ISRS, Node 26191, Northwest Corner of Bio Shield, 5 CSDRS Inputs.

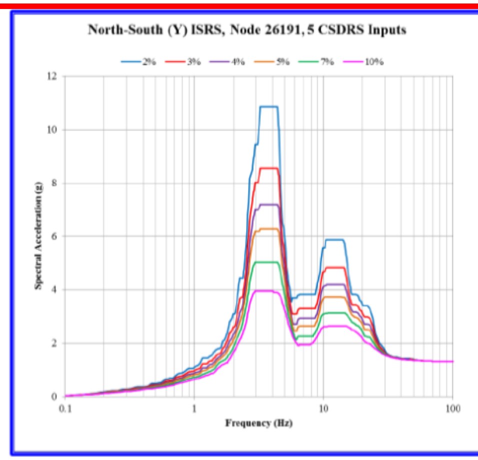

Figure A-191. RXB - North-South (Y) ISRS, Node 26191, Northwest Corner of Bio Shield, 5 CSDRS Inputs.

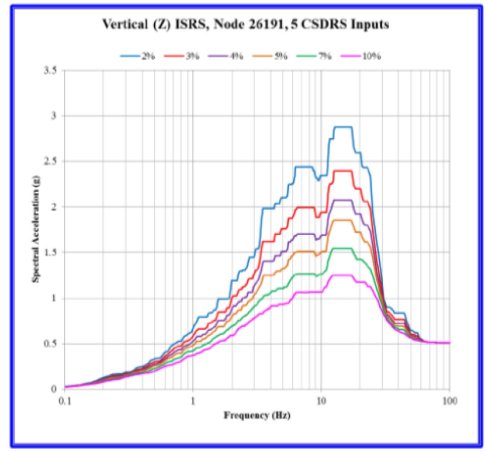

Figure A-192. RXB - Vertical (Z) ISRS, Node 26191, Northwest Corner of Bio Shield, 5 CSDRS Inputs.

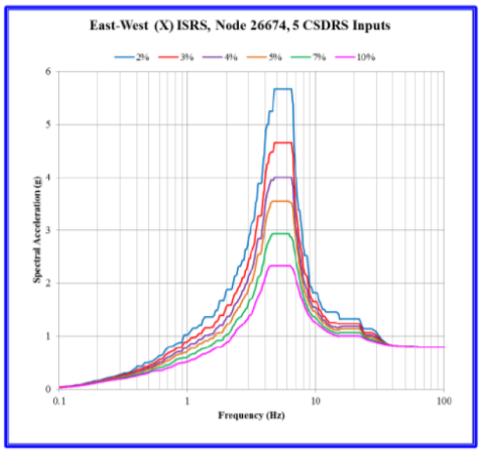

Figure A-202. RXB - East-West (X) ISRS, Node 26674, Northeast Corner of Bio Shield, 5 CSDRS Inputs.

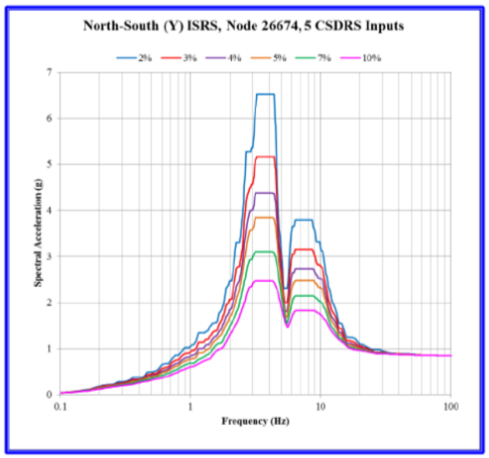

Figure A-203. RXB - North-South (Y) ISRS, Node 26674, Northeast Corner of Bio Shield, 5 CSDRS Inputs.

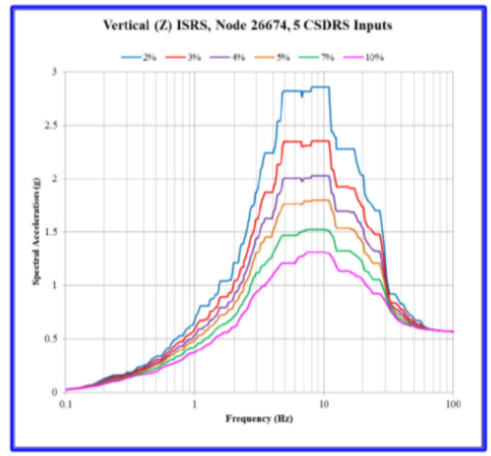

Figure A-204. RXB - Vertical (Z) ISRS, Node 26674, Northeast Corner of Bio Shield, 5 CSDRS Inputs.

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Figure 3.7.3-4a: ISRS in X-Direction for Nodes 25826 and 26345 and the Enveloped ISRS

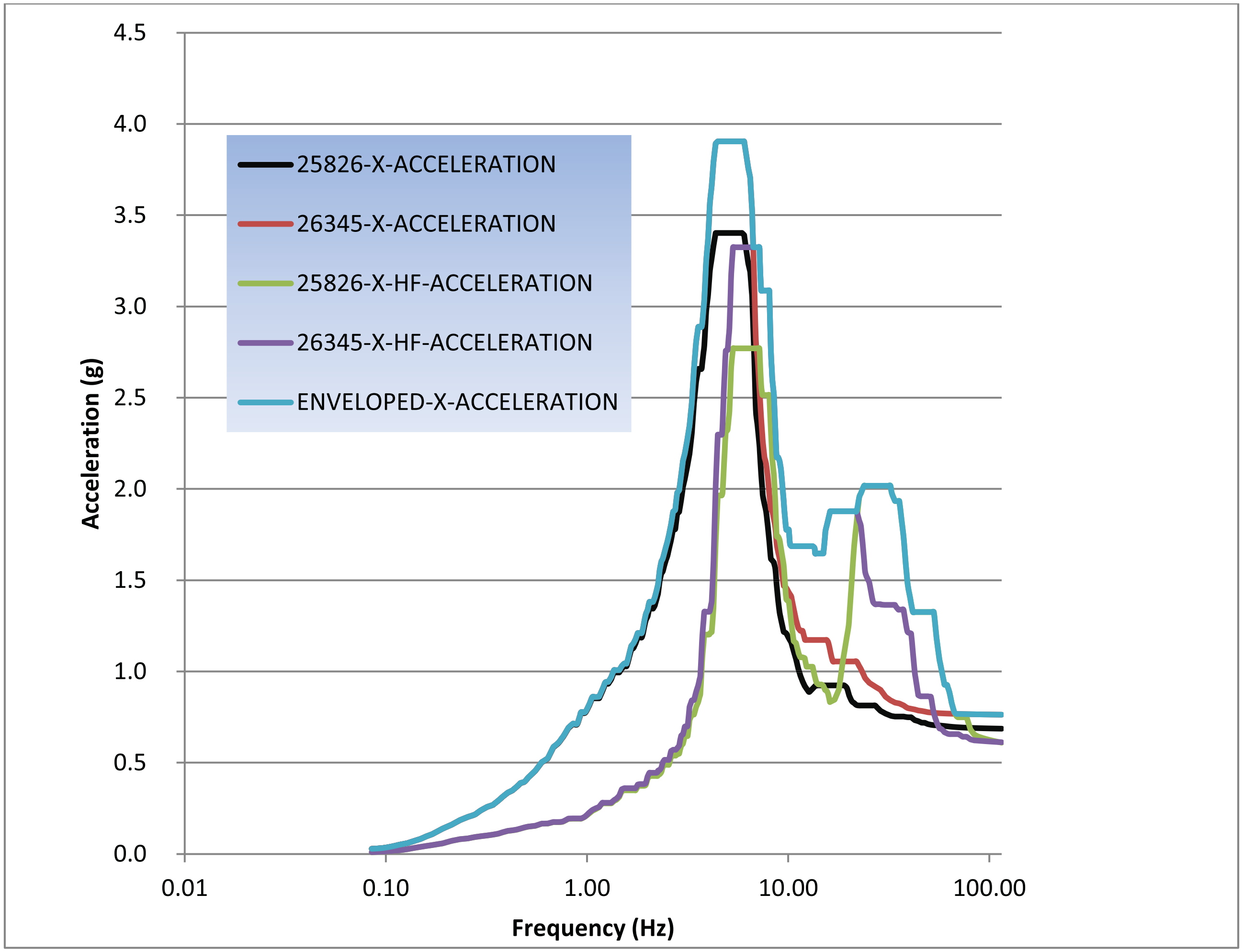

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Figure 3.7.3-4b: ISRS in Y-Direction for Nodes 25826 and 26345 and the Enveloped ISRS

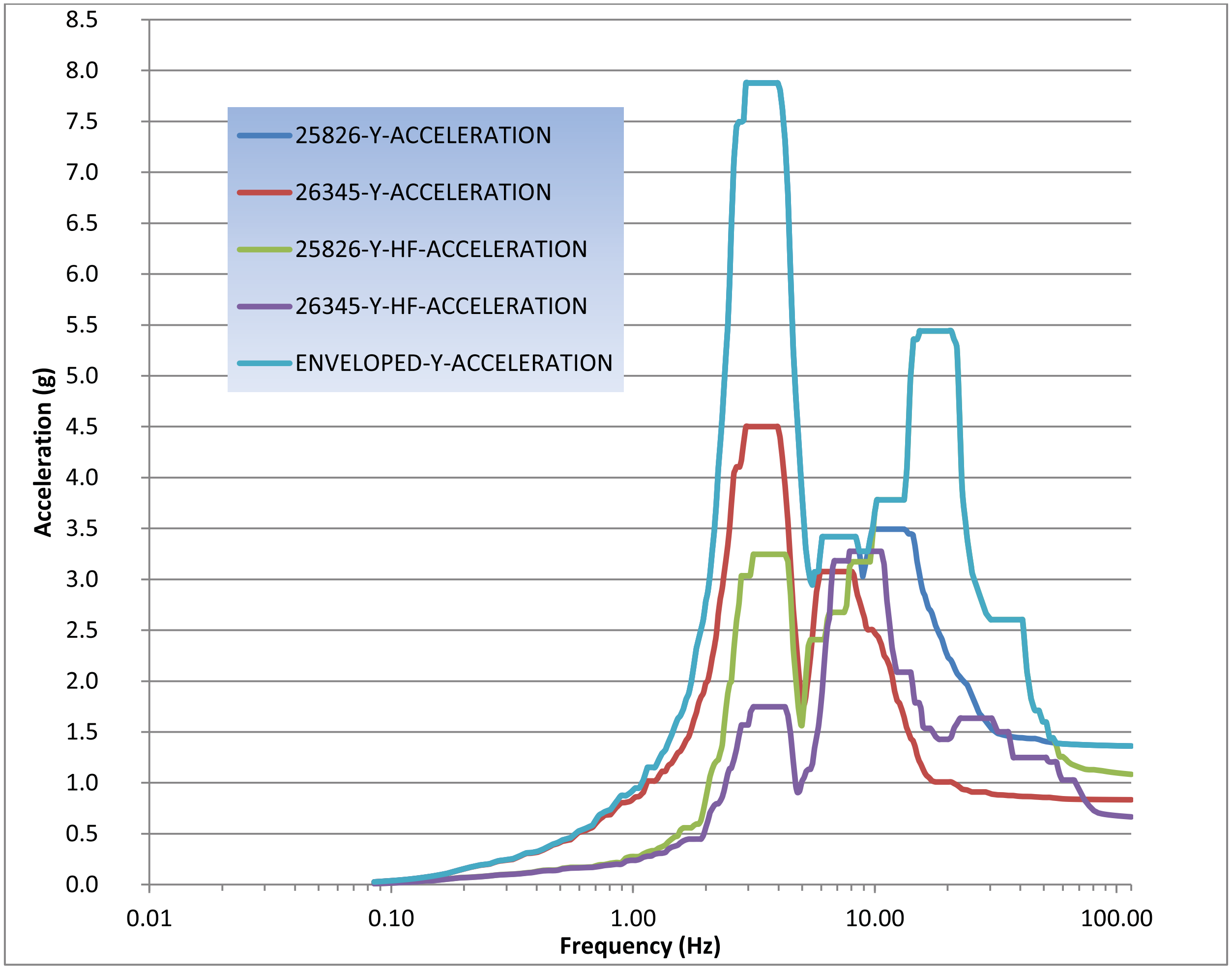

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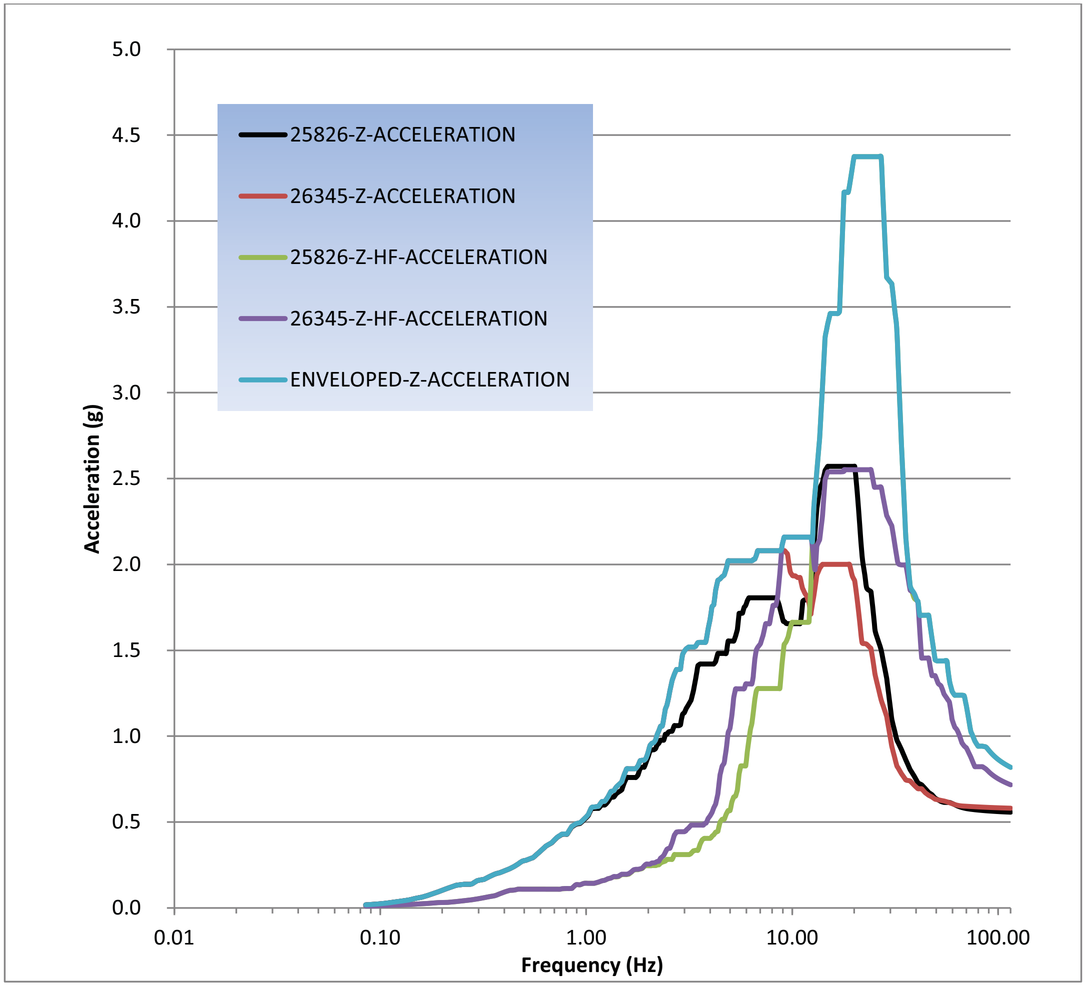
Figure 3.7.3-4c: ISRS in Z-Direction for Nodes 25826 and 26345 and the Enveloped ISRS



Fire suppression or detection is also not necessary during refueling outages. During a plant shutdown for refueling, the containment is flooded at essentially the same time containment pressure is being increased to atmospheric. The reactor core is then separated from the containment and moved to the refueling area of the pool. Significant maintenance including hotwork inside a containment vessel cannot be practically accomplished without removal of the reactor core and in any case would be accomplished with the reactor already shutdown, cooled down, and submerged for passive decay heat removal to the UHS pool.

The area inside containment is recognized by RG 1.189 as one in which divisional separation of safe shutdown components is not practicable and this is evaluated as a special case by the fire hazards analysis in Appendix 9A.

Containment Dome Enclosed by the Bioshield

The single reactor building houses the NPMs and maintains them partially immersed in the same UHS pool.

RAI 03.11-19

The exposed dome of each NPM containment is entirely enclosed by 3-hour rated fire barriers or a fire barrier that will perform as a 3-hour fire barrier; at the back by the structural pool wall, at either side by the integral, structural "wing" walls, and at the front and over the top by non-structural, removable bioshields. This configuration creates a separate fire area enclosing the top of each module thereby providing separation from other modules.

The fire area enclosed by the bioshield is a small area which cannot be practicably divided into multiple fire areas. This area must accommodate the mechanical and electrical penetrations, containment isolation valves and other valves required for safe shutdown. This area is therefore similar to the annulus area of a conventional reactor building in that it contains safe shutdown equipment for more than a single division. The arrangement of plant equipment and routing of conductors is such that redundant safe shutdown equipment cannot be divisionally separated by a 3 hour rated fire barrier. Practicable measures are taken under the bioshield to ensure that one division of safe shutdown equipment remains available to perform safe shutdown functions. Measures taken include:

- Divisional separation is provided to the extent practicable given the physical restraints of the area. Safe shutdown SSC are safety related; as a minimum, the separation guidance of RG 1.75 is followed.
- Minimal combustibles and no intervening combustibles are used. Cable is routed in suitable conduit or is of noncombustible construction.
- The use of redundant, hydraulically operated valves for safe shutdown are not dependent on power cables in the bioshield fire area.
- Divisionally separated hydraulic control units for the hydraulic valves are located outside of the bioshield fire area in separate 3-hour rated structural fire areas. The hydraulic fluid utilized is noncombustible.

RAI 03.11-19, RAI 12.03-17, RAI 12.03-23

Table 12.3-6: Reactor Building Shield Wall Geometry

Elev.	Room # (Note 1)	Room Name	North Wall (Note 2)	East Wall (Note 2)	South Wall (Note 2)	West Wall (Note 2)	Floor (Note 3)	Ceiling (Note 3)	Source Term
24′	010-040	Module 1 CVCS ion exchanger sluice room	20″ Structural steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-041	Module 2 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-042	Module 3 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-043	Module 4 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-044	Module 5 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-045	Module 6 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-051	Module 7 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-050	Module 8 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-049	Module 9 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-048	Module 10 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed
24′	010-047	Module 11 CVCS ion exchanger sluice room	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	10′ Concrete (ground floor)	20″ Concrete/steel composite slab	CVCS mixed bed and CVCS cation bed

Table 12.3-6: Reactor Building Shield Wall Geometry (Continued)

Elev.	Room # (Note 1)	Room Name	North Wall (Note 2)	East Wall (Note 2)	South Wall (Note 2)	West Wall (Note 2)	Floor (Note 3)	Ceiling (Note 3)	Source Term
75′	N/A	Modules 1-6 CVCS vertical pipe chases	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	5′ Concrete (reactor pool wall)	20″ Concrete/steel partition wall	N/A	N/A	CVCS pipe
75′	N/A	Modules 7-12 CVCS vertical pipe chases	5′ Concrete (reactor pool wall)	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	N/A	N/A	CVCS pipe
86′	N/A	Modules 1-6 CVCS vertical pipe chases	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	5′ Concrete (reactor pool wall)	20″ Concrete/steel partition wall	N/A	N/A	CVCS pipe
86′	N/A	Modules 7-12 CVCS vertical pipe chases	5′ Concrete (reactor pool wall)	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	N/A	N/A	CVCS pipe
100′	N/A	Modules 1-6 CVCS vertical pipe chases	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	5′ Concrete (reactor pool wall)	20″Concrete/steel partition wall	N/A	N/A	CVCS pipe
100′	N/A	Modules 7-12 CVCS vertical pipe chases	5′ Concrete (reactor pool wall)	20″ Concrete/steel partition wall	20″ Concrete/steel partition wall	20″Concrete/steel partition wall	N/A	N/A	CVCS pipe
126	010-022	Reactor pool area	5' Concrete wall, 4" HDPE, 5% boron content (Bioshield vertical portion in front of operating bay)	5' Concrete wall	5' Concrete wall, 4" HDPE, 5% boron content (Bioshield vertical portion in front of operating bay)	5' Concrete wall	23.5~~21.5~~" Concrete ~~2" High-density polyethylene~~ 2 x 0.25" Steel (Bioshield)	4' Concrete roof	NPM

Note 1: Refer to Figure 1.2-10 through Figure 1.2-18 for room locations.

Note 2: A 20" concrete/steel partition wall consists of two one-half inch steel plates with 19" of concrete in between.

Note 3: A 20" concrete/steel composite slab consists of two one-half inch steel plates with 19" of concrete in between.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-1118-62961

NuScale Power, LLC
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www.nuscalepower.com

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 NuScale bioshield design.

    NuScale has performed significant research and evaluation to develop a basis for this design 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. 401, eRAI No. 9447. 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 November 16, 2018.

Zackary W. Rad