September 29, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 116 (eRAI No. 8926) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 116 (eRAI No. 8926)," dated August 01, 2017

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. 8926:

- 19-23

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 116 (eRAI No. 8926). 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 Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com.

Sincerely,

Zackary W. Rad
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8926, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 8926, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0917-56323

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8926, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 8926, nonproprietary

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

eRAI No.: 8926
Date of RAI Issue: 08/01/2017

NRC Question No.: 19-23

10 CFR 52.47(a)(27) states that a design certification application (DCA) must contain a final safety analysis report (FSAR) that includes a description of the design-specific probabilistic risk assessment (PRA) and its results. 10 CFR 52.47(a)(2) states that the standard plant should reflect through its design, construction, and operation an extremely low probability for accidents that could result in the release of radioactive fission products. 10 CFR 52.47(a)(4) states that each DCA must contain an FSAR that includes an analysis and evaluation of the design and performance of systems, structures and components (SSCs). The objectives of the analysis and evaluation are to assess the risk to public health and safety resulting from operation of the facility and to determine the margins of safety during normal operations and transient conditions anticipated during the life of the facility. Standard Review Plan (SRP) Section 19.0, Revision 3, states, “Shutdown and refueling operations for small, modular reactor designs may be performed in ways that are new and completely different from those used at large traditional light water reactors (LWRs) either licensed or under review by the NRC. In these cases, a more in-depth review will be needed to ensure that the PRA model is of acceptable scope, level of detail, and technical adequacy.”

The staff reviewed FSAR Chapters 9 and 19 and ER-P060-7085, “Dropped Module Consequence Analysis,” Revision 1, dated 8/11/2016. The staff is requesting that the FSAR be updated with the following key assumptions and details regarding module drop and module movement, so the staff can make a reasonable assurance finding regarding the adequacy of the risk insights obtained from the dropped module risk analysis.

1. The Dropped Module Consequence Analysis report states that the reactor pressure vessel (RPV) and containment vessel (CNV) are pressurized with {{ }} 2(a),(c) psia of nitrogen gas, which is a design condition prior to transporting the module. The staff requests that the rationale for this design condition be discussed in the FSAR Section 19.1.6 and that this design condition be included as a key assumption for the low power and shutdown risk analysis.
2. The Dropped Module Consequence Analysis report states that the assessment is based on the module being shutdown for 48 hours. The staff requests the applicant to justify in the FSAR how this PRA assumption will be maintained by the combined license (COL) holder (e.g., by a Limiting Condition of Operation, a Condition of the License, or some other means).
3. Table 19.1-71, “Key Assumptions for the Low Power and Shutdown Probabilistic Risk

Assessment," states that the module is kept below the height that could damage the ultimate heat sink (UHS). The staff requests the applicant to define this height as a key assumption in the module drop analysis and justify in the FSAR how this PRA assumption will be maintained by the COL holder (e.g., by a Limiting Condition of Operation, a Condition of the License, or some other means). The staff is also requesting the applicant to justify the basis for this height in the FSAR.

4. Table 19.1-74, "External Flooding Susceptibility during Low Power and Shutdown Plant [(LPSD)]," states that operators are assumed not to move modules with the crane when forecasts indicate the potential for flooding hazards. Therefore, the external flooding effects were not considered for plant operating states (POSs) 3, 4, and 5. The staff finds that this assumption regarding the availability of forecasts to indicate a potential flooding hazard does not apply to all flooding mechanisms such as catastrophic dam breach. The staff requests that a COL information item be added to the FSAR requiring a COL applicant referencing the certified NuScale design to evaluate the risk of external flooding during POSs 3, 4, and 5.

5. The staff is requesting the applicant to clarify in FSAR Section 19.1.6 whether a module drop event (with the CNV intact or not) results in any automated signals or manual actions for the dropped module or any other modules such as reactor trip or main control room isolation.

6. The second type of module drop event, called "UPV," reflects the possibility of dropping the upper RPV section onto the stationary core, which remains in the reactor flange tool (RFT). The applicant states that "The radiological dose calculation of potential radionuclide release due to damaged fuel indicates that a large release does not occur due to this type of module drop. Thus, the UPV type of module drop is not considered further in the LPSD probabilistic risk assessment." The staff requests the applicant to (1) clarify what the acronym "UPV" stands for; and (2) justify in FSAR Section 19.1.6 why the source term from module drop events during refueling operations (with the containment open or breached) does not result in a large release.

NuScale Response:

Item 1: The containment vessel (CNV) is pressurized during module transport. In the NuScale engineering report that is cited in Question 19-23, the CNV is described as being pressurized with nitrogen to a value such that the hydrostatic pressure on the inside and outside of the CNV flange is approximately equal when the vessel is upright. The intent of pressurizing the CNV is to limit the exchange of water when the CNV flange is opened. With this pressurization, an inflow of water that could submerge components near the top of the CNV is prevented due to the presence of the gas bubble; the pressurization is not high enough to cause an outflow of water which could lower the water level enough to release non-condensable gases into the refueling pool.

The level of CNV pressurization is not included as a key PRA assumption in the FSAR because it does not affect the assumed outcome of a module drop event or the associated potential dose consequences to the public. The low power and shutdown (LPSD) PRA assumes that a dropped module that comes to rest in a horizontal position will experience core damage with a damaged CNV, as discussed in FSAR Section 19.1.6.1.3. Conditions inside the module, such as CNV internal pressure, are not credited for preventing or mitigating core damage. As stated in FSAR Section 19.1.6.1.3, offsite dose consequences from core damage in a horizontal module with a damaged CNV result in a potential radionuclide release that is a small fraction of a large release, as defined in FSAR Section 19.1.4.2.1.4. The radionuclide release is limited because of the scrubbing effect of the reactor pool.

The PRA results are also not sensitive to the gas used for CNV pressurization. If air were used to pressurize the CNV, the presence of oxygen introduces the potential for hydrogen combustion, but the conclusion that a large release does not occur remains valid because (i) the containment is assumed to fail and is not credited with preventing the release of radionuclides, (ii) the source term is unaffected by combustion, and (iii) reactor pool water remains as a radionuclide scrubbing mechanism.

Item 2: The value of 48 hours was selected based on the anticipated time line for a refueling outage and corresponds approximately to the end of plant operating state 2, as summarized in FSAR Table 19.1-65. The assumption has been added to FSAR Table 19.1-71, and is maintained by the combined license holder, as required by COL Item 19.1-8.

Item 3: The PRA assumption stated in Table 19.1-71 is consistent with a functional requirement for the reactor building that the potential impact of a dropped module on the reactor building floor will not cause significant coolant leakage from the ultimate heat sink (UHS). The use of this assumption in the PRA provides the basis for not considering the loss of the UHS in the unlikely event of a dropped module.

The instrumentation and control system for the reactor building crane (RBC), described in FSAR Section 9.1.5.5, includes limit switches and interlocks to control the maximum lift height of the RBC, consistent with the cited PRA assumption. The maximum lift height is not, in itself, a key assumption. As indicated in FSAR Section 15.7.2, the RBC system design conforms to the single-failure-proof guidelines of NUREG-0612 so that any credible failure of a single component will not result in the loss of capability to stop and hold a critical load; thus, load drop evaluations are not performed to support the design basis. The PRA results are not sensitive to a specific lift height, but, as stated, depend only on the assumption that a dropped module in a hypothetical beyond-design-basis event will not result in significant leakage from the UHS. Thus, a specific lift height is not provided in the FSAR. For clarity, references to specific lift heights have been removed from the discussion in FSAR Section 19.1.6.1; additional textual clarifications have also been made in this section.

The PRA assumptions identified in Table 19.1-71 will be maintained by the COL applicant, as required by COL Item 19.1-8.

Item 4: The evaluation of the susceptibility of a module to external flooding provided in FSAR Table 19.1-74 for plant operating states POS3, POS4, and POS5 has been modified. The modification reflects the module response if warning of an external flood is not provided in sufficient time to implement operator action to suspend operations. The modification to FSAR Table 19.1-74 reflects the passive, fail-safe design of the RBC for controlling the module.

As identified in FSAR Table 19.1-55, a loss-of-offsite power is the initiating event that bounds the potential effects of an external flood. If the external flood does not cause a loss of external (AC) power, operator action can be taken to suspend operation and secure a load in a safe condition. If AC power is lost due to the external flood, the following summarizes the module response:

- The module enters POS3 when it is lifted by the RBC; POS3 includes transport to the refueling area and disassembly. In the event of loss of AC power, the RBC brakes will set and stop motion. The RBC is designed with redundant holding brakes so that if one set fails to engage, the other brake automatically holds the load. Because both brake systems are designed and rated to maintain a hoisted load at the maximum allowable crane load, a loss of power will halt operations, but not result in a load drop.
- In POS4, the RBC moves the upper vessels into the dry dock. The core is secured in the refueling area and there is no module movement in POS4. The RBC operates with the wet hoist in the vicinity of the core to remove reactor vessel internals, and the fuel handling machine moves fuel assemblies between the core and fuel storage racks in the spent fuel pool. A loss of AC power will set the brakes for both the wet hoist and fuel handling machine to stop all motion.
- In POS5, the upper vessels are moved out of dry dock, aligned with the reactor pressure vessel (RPV) lower head, moved to the containment flange tool (CFT), and the assembled module is transported back to the operating bay. Similar to POS3, an external flood that results in a loss of AC power will stop RBC motion and set the brakes to hold the load.

Based on the RBC design, the results of the PRA evaluation are not dependent on a specific warning time for operator action in the event of external flood; thus, a COL item to evaluate the risk of external flooding in POSs 3, 4, and 5 is not needed. FSAR Table 19.1-74 has been modified to include the evaluation provided in this response. Further, the evaluation of susceptibility to high winds is not dependent on a specific warning time for operator action; thus, FSAR Table 19.1-75 has been modified in a similar manner.

<u>Item 5:</u> Automated signals are not generated by a dropped module. An automated signal is generated for an operating module only if the drop creates a condition that reaches a safety setpoint. Manual operator actions are not specified for the design certification, but it is anticipated that operators will monitor module movement and respond to off-normal conditions as the situation requires, such as by manually tripping an operating module(s).

FSAR Section 19.1.7.4 has been modified consistent with this discussion.

Item 6:

1. The acronym UPV refers to the “upper vessels” (i.e., the upper portions of the RPV and CNV) that are moved together after the RPV flange is detensioned in POS3. For clarity, the acronyms “UPV” and “RXM” in FSAR Section 19.1.6.1.2 have been deleted in favor of the description of the applicable configuration.
2. As stated in FSAR Section 19.1.6.1.3, “analysis shows that the offsite dose consequences of core damage in a horizontal module with a damaged CNV results in a radionuclide release that is a small fraction of that associated with a large release. The radionuclide release is limited because of the scrubbing effect of the reactor pool.”

The analysis, provided in the engineering report that is cited in Question 19-23, is available for audit. The analysis used the MELCOR severe accident simulation code as well as an evaluation of the offsite consequences employing the MELCOR Accident Consequence Code System (MACCS) offsite dose analysis code. Credit for pool scrubbing is discussed in the NuScale response to RAI 8882, Question 19-8, which was provided in NuScale letter RAIO-0817-55372, dated August 10, 2017.

Impact on DCA:

FSAR Section 19.1.6.1, Section 19.1.7.4 and Tables 19.1-71, 19.1-74, and 19.1-75 have been revised as described in the response above and as shown in the markup provided with this response.

allow the CNV to be flooded. The CFDS is used to fill the CNV with water from the reactor pool to approximately the level of the pressurizer baffle plate, establishing passive cooling by conducting heat through containment to the reactor pool.

RAI 19-23

If the module is to be refueled, disconnection begins after the RVVs and RRVs are open. Disconnection involves ~~isolating containment~~removing the bioshield, disconnecting all piping ~~connections and~~and instrumentation, installing material exclusion covers on pipe flanges, ~~transferring transport instrumentation to the connections on the RBC,~~ and connecting the RBC and module lifting adapter to the module.

RAI 19-23

Module transport involves using the RBC to lift the module ~~approximately 1 foot to allow it to be moved~~ out of its operating bay, transport it to the refueling area, and lift it into the containment flange tool (CFT).

RAI 19-23

Module disassembly begins after the module is placed into the CFT. With the module still connected to and supported by the RBC, the CNV flange bolts are detensioned and the RPV and upper CNV are lifted out of the CFT and moved to the reactor flange tool (RFT) while the lower portion of the CNV remains in the CFT. The RPV flange bolts are detensioned and the upper CNV and RPV, which includes the upper RPV internals, are moved to the dry dock area while the lower head of the RPV, which includes the core, remains in the RFT. After securing the upper vessels in the dry dock the RBC returns to the refueling area to remove the ~~lower portion of the RPV riser~~lower riser assembly and allow access to the fuel.

RAI 19-23

The fuel handling ~~crane~~machine is used to move fuel assemblies between the core and the fuel storage racks. Maintenance and inspections are carried out on the upper vessels and RPV internals in the dry dock area during this time, and remote inspections are performed on the lower RPV and CNV in the refueling area.

RAI 19-23

The module is reassembled after maintenance activities are completed and proper fuel loading is verified. The RBC replaces the reactor vessel internals, then aligns the upper vessels for reassembly in the RFT. The RPV flange bolts are tensioned~~, the flange is pressure tested,~~ and the assembly is lifted out of the RFT and moved to the CFT. The RBC aligns the CNV for reassembly~~,~~ and the CNV flange bolts are tensioned~~, and the flange is pressure tested~~.

Module transport involves using the RBC to lift the module out of the CFT, transport it to the operating bay, and lower it into the seismic restraints. The crane is disconnected from the module and returned to its storage location.

RAI 19-23

Module reconnection involves ~~transferring transport instrumentation to normal instrumentation connections, reconnecting all normal~~restoring instrumentation and power connections, and reconnecting ~~and leak testing~~ all piping.

Restart begins with steam generator cleanup by establishing flow through the steam generators using the feedwater, main steam, and condensate systems. The RVVs and RRVs are closed, the RPV pressurized with nitrogen to ensure net positive suction head for the CVCS pumps, and flow is established through the CVCS to begin coolant cleanup and boron dilution. The CNV is drained and RPV heatup begins as direct heat conduction to the reactor pool is reduced. Heat is added primarily by passing CVCS flow through the startup heater, with some assistance from the pressurizer heaters. Feedwater flow is adjusted to establish coolant circulation within the RPV, and control rods are withdrawn to establish criticality. When the power level reaches the minimum turbine load, the turbine is brought online and heatup continues. When the turbine is synchronized with the electrical grid, the module exits the scope of the LPSD probabilistic risk assessment and enters that of the full-power PRA.

The nominal refueling outage is modeled as a series of seven plant operating states (POSs) that cover each arrangement of the module between shutdown and start-up. In addition to module arrangement, POSs are defined based on the activity being performed and availability of systems which can cause or be used to mitigate an initiating event. Each POS is described in detail below.

POS1: Shutdown and Initial Cooling: The module enters POS1 when the control rods are inserted and the module becomes subcritical. Normal secondary cooling through the turbine bypass is used to reduce the temperature of the primary coolant to a level that allows the CNV to be flooded, and the CVCS functions to both borate and cleanup coolant chemistry. Containment flood begins and the main steam and feedwater systems are removed from service. The module exits POS1 when CNV flood is complete.

POS2: Cooling Through Containment: The module enters POS2 when the CNV flood is complete. Decay heat is passively conducted through the flooded CNV to the reactor pool, and cooling remains passive for the duration of the outage. If the module is not being transported, the module can be maintained in POS2 indefinitely without electric power or operator action. If the module is being transported, it exits POS2 when it is lifted by the RBC, and if it is not being transported it exits POS2 when the CNV drain begins in preparation for restart.

POS3: Transport and Disassembly: The module enters POS3 when the module is lifted by the RBC. This POS includes transport to the refueling area and disassembly and ends when the crane moves the upper RPV and CNV into the dry dock area.

POS4: Refueling and Maintenance: The module enters POS4 when the RBC moves the upper RPV and CNV into the dry dock. While in POS4, the core remains in the RPV lower head while the upper vessels are far enough from the refueling area that the core is not affected by an RBC failure. The module exits POS4 when the upper vessels are brought out of the dry dock in preparation for module reassembly.

drop initiating event, an event tree is developed to account for potential mitigating features (e.g., detection capability, emergency stops) which could prevent the initiating event from progressing to a module drop. Two types of drops were initially considered, based on the assembled configuration of the module during crane movements:

RAI 19-23

- The first type of module drop~~, "RXM,"~~ reflects the possibility of dropping an assembled module. For this type of module drop, the module is fully assembled and the CNV is intact. (A portion of the refueling operation involves movement of a module without the bottom portion of the CNV attached, which introduces the possibility of a "partial module drop." However, in this configuration, control rods are inserted and primary coolant in the RPV can communicate with the water in the reactor pool through the open RVVs and RRVs, allowing pool water to enter and cover the fuel, assuring adequate heat removal if the partial module were dropped. Thus, this configuration is not included as a potential contributor to CDF in the LPSD PRA).

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- The second type of module drop~~, "UPV,"~~ reflects the possibility of dropping the ~~upper RPV section, when the upper RPV is~~ upper vessels (i.e., the upper portion of the RPV and CNV) as they are moved to or from the dry dock area. The primary hazard in this situation is the physical impact of the crane dropping the upper RPV onto the stationary core which remains in the RFT. ~~The~~While this configuration is not included as a potential contributor to CDF (because it involves potential mechanical fuel damage rather than inadequate heat removal), the radiological dose calculation of potential radionuclide release due to damaged fuel indicates that a large release does not occur due to this type of module drop. Thus, ~~the UPV~~ this type of module drop is not considered further in the LPSD probabilistic risk assessment.

Table 19.1-68 summarizes the module drop initiating events associated with an RBC failure and the mitigating features. Figure 19.1-30 is a representative event tree for evaluating potential RXM drops. The representative event tree is used to evaluate a full module drop based on the overload module drop initiating event (OL) (Item 7 in Table 19.1-68), in which the load exceeds the rated capacity of the crane. As indicated on the event tree, a module drop occurs based on combinations of detection and safety system features, e.g., Sequence 6 involves failure of the weigh circuit in the hoist control system to detect the overload (DET-OL) and failure of the motor overload protection to stop the motor (OL-PROT), which results in a module drop (MD) end state. The top events of the event trees are evaluated using fault trees. Quantification of the event trees associated with the module drop initiators identified in Table 19.1-68, and accounting for the time that a module is being moved in either the refueling area and operating area, produced probabilities of module drop in each of these areas for POS3 and POS5 as summarized in Table 19.1-69, as well as the determination of the initiating event frequencies that are used in the LPSD probabilistic risk assessment.

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A module dropped in the operating area is dropped from a maximum height of one foot; a drop from this low height leaves a possibility that the containment support skirt may not fail and the module may remain upright. Due to uncertainty in the parameters of such a module drop, the probability of the module remaining upright is assigned by engineering judgment. A module dropped in the refueling area~~, where it is lifted to a height of as much as 30 feet,~~ is assumed to have no probability of remaining upright. The transfer event trees provided as Figure 19.1-32 through Figure 19.1-35 are used to link the module drop initiating event frequencies provided in Table 19.1-69 to the event trees used to evaluate the end state of a module drop event; these event trees are provided as Figure 19.1-36 and Figure 19.1-37.

Figure 19.1-36 depicts the possibility of a module drop in the operating area. The initiating event shown in the figure, IE-RBC-DROP-OP-FTS, is a placeholder, and the initiating event frequency is added through the POS-specific transfer event trees shown in Figure 19.1-32 and Figure 19.1-33. The top event RBC-T01 depicts the possibility of the module tipping if dropped. If the module remains upright, cooling from natural circulation and conduction through the flooded CNV is unaffected and the module remains cooled. If the module remains upright, no core damage occurs and the sequence results in an "OK" end state. If the module falls over, core damage occurs, and the sequence is assigned the end state "MD-CD." It is further conservatively assumed that the CNV is damaged in a manner that provides a radionuclide release path, but does not allow inflow of water that would prevent core damage. Analysis shows that the offsite dose consequences of core damage in a horizontal module with a damaged CNV results in a radionuclide release that is a small fraction of that associated with a large release. The radionuclide release is limited because of the scrubbing effect of the reactor pool.

Figure 19.1-37 illustrates the possibility of a module drop in the refueling area. The initiating event shown in the figure, IE-RBC-DROP-OP-FTS, is a placeholder, and the initiating event frequency is added through the POS-specific transfer event trees shown in Figure 19.1-34 and Figure 19.1-35. Module drops in the refueling area are assumed to result in core damage because the module is dropped from a height greater than one foot.

19.1.6.1.4 Low Power and Shutdown Data Sources and Analysis

Data sources used in the LPSD probabilistic risk assessment are similar to those discussed for the full power PRA. Differences from the full power PRA are:

- The initiating event frequency from the full-power PRA is adjusted to account for the duration and frequency for each POS.

  The equation used to adjust the frequency is

$$f_{\mathrm{LP}} = f_0 f_{\mathrm{RF}} \frac{t}{8760}$$

modules with a demand to respond. A review of mitigating systems shows that there is no indication of any coupling mechanisms that would affect the ability of multiple modules to safely shutdown in response to a high-wind event. Specifically, a high-wind event would create the demand for all modules to shutdown, but given the fail-safe design of the decay heat removal system, ECCS, and CIVs, there are no multi-module dependencies in the design that result in an elevated conditional probability of core damage or large release given core damage in the first module.

19.1.7.4 Insights Regarding Low Power and Shutdown for Multi-module Operation

Evaluation of full-power multiple module operation provides insights into the risk associated with LPSD. The full-power evaluations of internal and external initiating events indicate that modules are largely independent. In a twelve-module configuration, and a two-year fuel cycle, one module enters a LPSD configuration for refueling every two months. As discussed in Section 19.1.6.1, the module being refueled is moved to the refueling area of the reactor pool and the personnel and equipment involved in the refueling (and maintenance activities that are not performed on-line) do not interfere with the operation of other modules.

The unique LPSD activity that potentially affects multiple modules is associated with module movement. Section 19.1.6.1.2 provides the initiating event frequencies applied to a potential module drop during LPSD operation. To consider the possibility that a dropped module could affect multiple modules, potential drop scenarios were evaluated; a dropped module may strike no other modules or may strike up to two operating modules, as indicated:

- Single module accident -- The dropped module falls toward the centerline of the reactor pool and comes to rest horizontally on the floor without striking any operating modules, pool walls, or other obstructions.
- Two-module accident -- The dropped module strikes an operating module, bioshield, or bay wall at an angle such that it is deflected toward the center of the reactor pool and falls horizontally to the floor of the reactor pool. The operating module is struck near its top.
- Three-module accident -- The dropped module falls toward an operating module, striking it near the top. The bottom of the dropped module then slides across the floor and strike another module on the other side of the reactor pool.

A three-module accident, illustrated by Figure 19.1-41, is realistic only when the dropped module falls directly toward an operating module (i.e., into Module 3). The other operating bays present a smaller visible angle and make it less likely that the bottom of the dropped module is able to slide into a module across the pool. Additionally, a three-module accident is not likely if the module drop occurs in the refueling area, because its base is angled away from the operating area and would slide farther from the operating modules.

If the dropped module remains partially upright, such as if it is supported by another module or RXB structure, it is assumed that core damage is avoided; conversely, if it is not supported and falls to the floor core damage is assumed to occur.

RAI 19-23

The effects of a module being struck by a dropped module are determined by engineering judgment. ~~The most likely initiating event for a struck, operating, module is a general reactor trip.~~ Automated signals are not generated by a dropped module. An automated signal is generated for an operating module only if the drop creates a condition that reaches a safety setpoint. It is ~~reasonable to expect that operators are closely monitoring~~anticipated that operators will monitor a module transport~~,~~ and ~~manually trip nearby modules following a crane failure.~~respond to the effects of a dropped module by ensuring that the appropriate automatic functions occur for the conditions and taking follow up manual actions, as needed (e.g., tripping an operating module).

If the module is struck near the top, the DHRS piping or heat exchangers may be damaged, rendering one or both trains unavailable. If the module is struck near the bottom, as in a three-module accident, the low speed of the impact and distance from important components allow safety systems to be nominally available. In both cases, the CNV is unlikely to be breached due to the relatively low velocity of impact, caused by the dropped module falling only a short distance through a resistive medium (i.e., the water in the reactor pool).

A struck module being dislodged from its operating bay is not considered credible as the seismic restraints limit horizontal motion, and the weight of the module and downward angle at which it is struck prevents it from being lifted high enough to escape its bay.

Thus, it is assumed that a dropped module event could result in the dropped module incurring a core damage and the struck modules incurring an initiating event at full power. The dropped module is assumed to also incur damage which fails its CNV. In such an occurrence, a radionuclide release is assumed. However, as the event occurs under a minimum of 50 feet of water in the reactor pool, a large release would not occur due to the scrubbing effect of the reactor pool water.

19.1.8 Probabilistic Risk Assessment-Related Input to Other Programs and Processes

The PRA supporting the design certification has been used to support the NuScale design and provides a basis for COL applicant development of a site-specific PRA. The following sections summarize the uses of the PRA.

19.1.8.1 Probabilistic Risk Assessment Input to Design Programs and Processes

As discussed in Section 19.1.1.1 the uses of the PRA during the design phase are summarized in Table 19.1-1, which also indicates the applicable section in which the PRA application is discussed. The following sections address specific applications of the PRA, several of which rely on the updated site-specific PRA.

19.1.8.2 Probabilistic Risk Assessment Input to the Maintenance Rule Implementation

The Maintenance Rule, prescribed by 10 CFR 50.65, is implemented by the licensee, who will describe the use of the site-specific PRA in supporting the Maintenance Rule as indicated in Section 17.6.

RAI 19-23

Table 19.1-71: Key Assumptions for the Low Power and Shutdown Probabilistic Risk Assessment

Assumption	Applicable POS	Basis
The refueling cycle of a module is two years, giving a frequency of 0.5 refueling outages per year.	All	Design characteristic
Only the refueling outage is analyzed quantitatively in the LPSD PRA; evolutions such as turbine bypass and controlled shutdown are only discussed qualitatively. Seven POSs are identified for LPSD conditions.	All	Common engineering practice
No credit is taken for heat transfer through containment during containment flooding (i.e., POS1-shutdown and initial cooling) or containment draining (POS6 - heatup).	POS1, POS6	Bounding assumption
Control rod withdrawal and reactivity insertion is not credible during LPSD.	POS1, POS2, POS3, POS4, POS5, POS6	Control rods are disconnected from their drive mechanisms after insertion to prevent premature withdrawal.
Spurious closure of the ECCS valves is not credible after they are opened.	POS2, POS5	Spurious closure is precluded by valve design; separate actions are required to pressurize the control chamber and close the pilot valve. Closure of the valves is also not possible when CVCS is not in service because CVCS flow is required to close the valves.
The inadvertent actuation block (IAB) of the ECCS valves is not credited for reducing the frequency of a spurious valve opening when the module is subcritical (i.e., POS1 and POS6).	POS1, POS6	The IAB is active when the RPV pressure is near operating pressure (i.e., POS7).
Scheduled testing and maintenance on module-specific components (i.e., CVCS pumps) is performed during a POS in which the component is not required.	POS1, POS6	Common engineering practice
The module is transported by the RBC to the refueling area in POS3 and back to the operating bay in POS5; postulated module drops are only considered in the operating area or refueling area of the reactor pool.	POS3, POS5	Bounding assumption that gives the greatest probability of striking another module and tipping horizontally. Also gives the lowest probability that a dropped module lands upright.
If dropped from a height of one foot or less, the probability that the module tips is 0.5, with uncertainty uniformly distributed between 0 and 1. When dropped from greater than one foot, the module is assumed to tip.	POS3, POS5	Engineering judgment based on the design of the CNV support skirt and seismic amplification margin.
A dropped module that tips, falls horizontally to the reactor pool floor and experiences core damage. The CNV is assumed to be damaged and is not credited with preventing the release of radionuclides. The resulting source term is evaluated 48 hours after shutdown, which is approximately the beginning of POS3.	POS3, POS5	Conservative analysis
After the bottom of the CNV is removed, primary coolant communicates with water in the reactor pool through the open RVVs and RRVs and keeps the core covered and cooled.	POS3, POS4, POS5	Engineering judgment
During an RBC lift, the module is kept below the height that could damage the UHS if dropped.	POS3, POS5	~~Engineering judgment~~Design characteristic

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Table 19.1-74: External Flooding Susceptibility During Low Power and Shutdown Plant Operating States

Plant Operating State	External Flooding Susceptibility
POS1, Shutdown and initial cooling	Although this POS is similar in terms of plant response to the full-power PRA, because the time in this POS is limited, the module can be cooled down and in POS2 before any equipment is susceptible to a flood-induced failure. In the event flood levels exceed expectations, secondary cooling can be provided by the passive DHRS to reach POS2. Therefore, external flooding effects were not ~~considered~~evaluated for this POS.
POS2, Cooling through containment and module disconnection	Because the module can be maintained in POS2 indefinitely without electric power or operator action, there is no effect from an external flood during this POS.
POS3, Transport and disassembly	~~The module enters POS3 when the module is lifted by the RBC. This POS includes transport to the refueling area and disassembly, and ends when the crane moves the upper vessels into the dry dock area.~~ ~~Operators are not assumed not to move modules with the crane when forecasts indicate the potential for flooding hazards. Therefore, external flooding effects were not considered for this POS.~~ Operators are anticipated to suspend module movements if external flooding is predicted. In the event of loss of AC power, the RBC brakes will set and stop motion. The RBC is designed with redundant holding brakes so that if one set fails to engage, the other brake automatically holds the load. Because both brake systems are designed and rated to maintain a hoisted load at the maximum allowable crane load, a loss of power will halt operations but not result in a load drop. The module can be maintained in position suspended by the RBC until power is restored and the lift can resume; therefore, external flooding effects were not evaluated for this POS.
POS4, Refueling and maintenance	~~Operators are assumed not to move fuel or the upper vessels when forecasts indicate the potential for flooding hazards. Therefore, external flooding effects were not considered for this POS.~~Operators are anticipated to suspend fuel and upper vessels movements if external flooding is predicted. The RBC operates with the wet hoist in the vicinity of the core to remove reactor vessel internals, and the fuel handling machine moves fuel assemblies between the core and fuel storage racks in the spent fuel pool. Both have fail-safe redundant brakes so that in the event of loss of AC power, the brakes set and hold the load. The load can be maintained in position suspended by the RBC and wet hoist or fuel handling machine until power is restored and refueling operations can resume; therefore, external flooding effects were not evaluated for this POS.
POS5, Reassembly, transport, and reconnection	~~Operators are assumed not to move upper vessels or modules when forecasts indicate the potential for flooding hazards. Therefore, external flooding effects were not considered for this POS.~~Operators are anticipated to suspend upper vessels and module movements if external flooding is predicted. In the event of loss of AC power, the RBC brakes will set and stop motion. The RBC is designed with redundant holding brakes so that if one set fails to engage, the other brake automatically holds the load. Because both brake systems are designed and rated to maintain a hoisted load at the maximum allowable crane load, a loss of power will halt operations, but not result in a load drop. The module can be maintained in position suspended by the RBC until power is restored and the lift can resume; therefore, external flooding effects were not evaluated for this POS.
POS6, Heatup	Operators are ~~assumed~~anticipated not to initiate plant heatup when forecasts indicate the potential for flooding hazards. ~~Therefore, external flooding effects were not considered for this POS.~~Based on the limited duration of this POS, and the fail-safe nature of the passive NuScale design, external flooding effects were not evaluated for this POS.
POS7, Low power operation	Operators are ~~assumed~~anticipated not to enter low power operation when forecasts indicate the potential for flooding hazards. ~~Therefore, external flooding effects were not considered for this POS.~~Based on the limited duration of this POS, and the fail-safe nature of the passive NuScale design, external flooding effects were not evaluated for this POS.

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Table 19.1-75: High-Wind Susceptibility during Low Power and Shutdown Plant Operating States

Plant Operating State (POS)	Tornado and Hurricane Susceptibility
POS1 Shutdown and Cooling	High-winds events are ~~considered~~evaluated in POS1.
POS 2: Cooling through containment	Because the module can be maintained in POS2 indefinitely without electric power or operator action, no SSC are susceptible to high winds in this POS.
POS 3: Transport and disassembly	~~Operators are assumed to not transport a module under a hurricane warning or conditions where a tornado strike is likely. Therefore, high-winds events are not considered in this POS.~~Operators are anticipated to suspend module movements if high winds are predicted. In the event of loss of AC power, the RBC brakes will set and stop motion. The RBC is designed with redundant holding brakes so that if one set fails to engage, the other brake automatically holds the load. Because both brake systems are designed and rated to maintain a hoisted load at the maximum allowable crane load, a loss of power will halt operations, but not result in a load drop. The module can be maintained in position suspended by the RBC until power is restored and the lift can resume; therefore, high wind effects were not evaluated for this POS.
POS 4: Refueling and maintenance	~~Operators are assumed to not move fuel or the upper vessels under a hurricane warning or conditions where a tornado strike is likely. Therefore, high-winds events are not considered in this POS.~~ Operators are anticipated to suspend fuel and upper vessels movements if high winds are predicted. The RBC operates with the wet hoist in the vicinity of the core to remove reactor vessel internals, and the fuel handling machine moves fuel assemblies between the core and fuel storage racks in the spent fuel pool. Both have fail-safe redundant brakes so that in the event of loss of AC power, the brakes set and hold the load. The load can be maintained in position suspended by the RBC and wet hoist or fuel handling machine until power is restored and refueling operations can resume; therefore, high wind effects were not evaluated for this POS.
POS 5: Reassembly, transport, and reconnection	~~Operators are assumed to not move upper vessels or the module under a hurricane warning or conditions where a tornado strike is likely. Therefore, high-winds events are not considered in this POS.~~Operators are anticipated to suspend upper vessels and module movements if high winds are predicted. In the event of loss of AC power, the RBC brakes will set and stop motion. The RBC is designed with redundant holding brakes so that if one set fails to engage, the other brake automatically holds the load. Because both brake systems are designed and rated to maintain a hoisted load at the maximum allowable crane load, a loss of power will halt operations, but not result in a load drop. The module can be maintained in position suspended by the RBC until power is restored and the lift can resume; therefore, high wind effects were not evaluated for this POS.
POS 6: Heatup	Operators are ~~assumed~~anticipated to not initiate plant heatup under a hurricane warning or conditions where a tornado strike is likely. ~~Therefore, high-winds events are not considered in this POS.~~Based on the limited duration of this POS, and the fail-safe nature of the passive NuScale design, high wind effects were not evaluated for this POS.
POS 7: Low power operation	High-winds events are ~~considered~~evaluated in POS7.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0917-56323

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
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 reveals distinguishing aspects about specific values used in NuScale operational processes.

    NuScale has performed significant research and evaluation to develop a basis for this process 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. 116, eRAI No. 8926. 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 9/29/2017.

Zackary W. Rad