RAIO-0318-58992

March 05, 2018

Docket No. 52-048

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

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 331 (eRAI No. 9283) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 331 (eRAI No. 9283)," dated January 08, 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 Enclosure to this letter contains NuScale's response to the following RAI Question from NRC eRAI No. 9283:

- 12.02-23

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

If you have any questions on this response, please contact Steven Mirsky at 240-833-3001 or at smirsky@nuscalepower.com.

Sincerely,

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

Distribution: Samuel Lee, NRC, OWFN-8G9A
Anthony Markley, NRC, OWFN-8G9A
Prosanta Chowdhury NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9283

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NuScale Response to NRC Request for Additional Information eRAI No. 9283

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

eRAI No.: 9283
Date of RAI Issue: 01/08/2018

NRC Question No.: 12.02-23

Regulatory Basis

10 CFR 52.47(a)(5) requires applicants to identify the kinds and quantities of radioactive materials expected to be produced in the operation and the means for controlling and limiting radiation exposures within the limits of 10 CFR Part 20. 10 CFR Part 20 requires the use of engineering features to control and minimize the amount of radiation exposure to occupational workers and members of the public, from both internal and external sources. Appendix A to Part 50—General Design Criteria (GDC) for Nuclear Power Plants, Criterion 61—"Fuel storage and handling and radioactivity control," requires systems which may contain radioactivity to be designed with suitable shielding for radiation protection and with appropriate containment, confinement, and filtering systems. NuScale DSRS 12.2 DSRS Acceptance Criteria states that the applicant should describe the radiation fields in sufficient detail for evaluating the inputs to shielding codes, and determination of radiation doses.

Background

NuScale DCD, Tier 2 Revision 0, Subsection 12.2.1.8, "Reactor Pool Water," states that the neutron flux at the outside edge of the containment vessel was calculated to be approximately six orders of magnitude less than the average neutron flux in the core, and continues to quickly decrease in the reactor pool's borated water. DCD Tier 2, Revision 0, Table 4.3-12, "Typical Neutron Flux Levels (n/cm2-sec) in the Reactor Core and Reactor Pressure Vessel at Full Power," indicates that the core average neutron flux exceeds 1E14 (n/cm2-sec). There is no information on the flux and spectrum at the outside edge of the containment vessel in DCD Subsection 12.2. In addition, NuScale Technical Report TR-0116-20781-P Rev. 0, "Fluence Calculation Methodology and Results," does not appear to provide a calculation, or the associated results, that support the statement in DCD subsection 12.2.1.8. Based on assessment performed by the staff, given the limited information provided by the applicant, the dose rate outside of the containment vessel may be as high as approximately 21,000 Rem/h just due to neutrons. While this dose rate is only present underwater, utilities frequently use divers to perform underwater maintenance activities. Also, the neutron flux and spectral data is used by the staff to assess applicant estimates of activated material, including the production of isotopes (e.g., deuterium) that are precursors to radioactive species.

The neutron spectrum and flux information evaluated during the staff review under NuScale DSRS 12.2 are used as inputs to the evaluation performed by the staff for NuScale DSRS 12.3-12.4, related to the acceptability of the facility design, the establishment of radiation zones, the impact on systems, structures and components, and the activation of material. The inclusion of this type of information is consistent with NuScale DSRS 12.2 Acceptance Criteria, which states that the source descriptions should include all pertinent information required for input to shielding codes used in the design process, establishment of related facility design features, and determination of radiation dose rates, as well as the controlling radiation exposure to workers and members of the public, consistent with 10 CFR Part 20 and GDC 61. DSRS 12.2 also states that unless described within other sections of the FSAR, source descriptions should include the methods, models, and assumptions used as the bases for all values provided in FSAR Section 12.2. These acceptance criteria are consistent with the relevant requirements of 10 CFR Part 50 and 10 CFR Part 52. Based on information made available to the staff during the RPAC Chapter 12 Audit, the staff was unable to identify the neutron flux and spectrum outside of the containment vessel near the reactor core.

Key Issue: It is unclear from the DCD document what the neutron flux and energy spectrum are external to the CV and how they were derived. The staff needs to know the neutron flux, energy spectrum and sufficient information about the methods, models and assumptions, used to justify the assumed values. The staff uses the stated neutron flux and energy to assess the impact on a variety of topics considered in the review, including; the generation of tritium from activation of Deuterium, and neutron capture in boron; the generation of radioactive argon; the generation of Deuterium from Hydrogen; and the activation of the containment structural materials. These radioisotopes contribute to the occupational radiation exposure of workers, and in some cases are related to the amount of effluent releases, which are important aspects of staff's review.

Key Issue: It is unclear what methods, models, and assumptions were used to derive the stated neutron flux and energy spectrum. The neutron flux and energy spectrum along with sufficient supporting information provide a basis for justifying the assumed values used in calculating the generation of tritium from activation of Deuterium, and neutron capture in boron; the generation of radioactive argon; the generation of Deuterium from Hydrogen; and the activation of the containment structural materials. These radioisotopes contribute to the occupational radiation exposure of workers, and in some cases are related to the amount of effluent releases, which are important aspects of staff's review.

Question

To facilitate staff understanding of the application information sufficient to make appropriate regulatory conclusions, with respect to the kinds and quantities of radioactive materials and radiation fields within the facility, the staff requests that the applicant:

1. Explain/Justify the aforementioned statements made in DCD subsection 12.2.1.8 and DCD Table 4.3-12.
2. Identify and describe the methods, models and assumptions used to calculate the neutron spectrum and flux outside of the containment vessel near the elevation of the core.

3. As necessary, revise and update NuScale DCD, Tier 2, Revision 0, Section 12.2 to include information describing the neutron spectra and flux, at the area identified above, and the assumptions and input parameters used.

OR

Provide the specific alternative approaches used and the associated justification.

NuScale Response:

The neutron flux at the outer edge of the CNV is many orders of magnitude less than the neutron flux in the core. NuScale has performed calculations of water activation from neutrons escaping the core and entering the ultimate heat sink (UHS) water. The neutron energy spectrum used for neutron activation of UHS water is based on the identical three energy grouping used to describe the neutron flux in the core, as shown in FSAR Table 4.3-12. The neutron flux calculation for regions inside the NPM and outside the core uses the MCNP computer code to calculate the fast neutron flux. In order to estimate the epithermal and thermal neutron flux to the UHS, the distribution of the core average was applied. The calculated fast neutron flux at the outer edge of the CNV, at the core beltline, is 6.34E+8 neutrons/cm^2/second, (Table 5-1 of TR-0116-20781). Using the average core distribution of neutron energy spectra, the thermal neutron flux to the UHS is 3.65E+8 neutrons/cm^2/second, and the epithermal neutron flux to the UHS is 1.78E+9 neutrons/cm^2/second.

The thermal neutron flux energy spectra was further distributed using a Maxwell-Boltzmann distribution. The epithermal neutron flux energy was further distributed using a relationship of 1/E. The fast neutron flux energy spectrum was further distributed using the watt fission spectra for U235.

This approximation of the neutron flux spectrum is not intended to rigorously represent the actual flux outside the CNV, but rather to ascertain the neutron flux's relative importance in radionuclide generation through the neutron activation of pool water components. Because the amount of radionuclides generated by this neutron flux was determined to be negligible compared to other mechanisms, further refinement of this mechanism was considered unnecessary.

During the generation of this RAI response, it was discovered that the description in FSAR Section 12.2.1.8 was not accurate. The magnitude of the neutron flux on the outside of the CNV is actually determined to be closer to five orders of magnitude less than the average neutron flux in the core, therefore the wording in the FSAR was revised.

Impact on DCA:

Section 12.2.1.8 has been revised as described in the response above and as shown in the markup provided in this response.

RAI 12.02-23

The radionuclide contribution resulting from neutron activation of the reactor pool water contents is not significant due to the reduced neutron flux in the reactor pool water. The neutron flux at the outside edge of the containment vessel ~~was calculated~~is many ~~to be approximately six~~ orders of magnitude less than the average neutron flux in the core, and continues to quickly decrease in the reactor pool's borated water. The small amount of neutron activation products in the reactor pool water was calculated to be insignificant compared to the amount of primary coolant radionuclides released to the reactor pool water during refueling outages. The reactor pool and RCS water chemistry limits (when the temperature of the RCS is less than 250 degrees F) are in conformance with the Electric Power Research Institute primary water chemistry guidelines (Reference 12.2-3). The reactor pool water volume dilutes inadvertently introduced impurities that could result from component failures and, because the chemistry limits in both the reactor pool and each NPM are monitored, impurities in either of the two water sources are minimized.

Between refueling outages, the radionuclides in the reactor pool water are treated by the PCUS demineralizers and filters to reduce the radionuclide content. The pool water has a negligible neutron activation source term. The major input assumptions are listed in Table 12.2-9.

The pool surge control system (PSCS) storage tank is designed to temporarily store pool water that is displaced during drydock operations. The PSCS storage tank is modeled as a vertical cylindrical tank with the characteristics listed in Table 12.2-9.

The source terms and the source strengths for the pool water and the PSCS storage tank are provided in Table 12.2-10 and Table 12.2-11, respectively.

12.2.1.9 Spent Fuel

Spent fuel stored in the spent fuel racks presents a radiation source that is shielded by the water in the spent fuel pool as well as by the pool's concrete walls. The same methodology used to determine the maximum core isotopic source term in Section 11.1 is used to develop the spent fuel source term, resulting in the bounding assumption that the spent fuel racks are filled with freshly-discharged, irradiated fuel assemblies. Spent fuel gamma ray and neutron source strengths are considered in the evaluation of radiation levels for fuel handling and spent fuel storage.

Spent fuel gamma ray source strengths are presented in Table 12.2-21 for a spent fuel rack full of freshly discharged fuel assemblies. Spent fuel neutron source strengths are given in Table 12.2-22 for the same spent fuel rack.

12.2.1.10 In-Core Instruments

There are 12 fuel assemblies distributed in the reactor core that are instrumented with in-core instruments. Each of the 12 instruments contains self-powered neutron detectors and thermocouples. During reactor operations, the in-core instruments are irradiated, resulting in activation. The major inputs assumptions are listed in Table 12.2-23. The gamma spectra are provided in Table 12.2-24.