NuScale Power™

RAIO-0618-60459

June 14, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 63 (eRAI No. 8882) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 63 (eRAI No. 8882)," dated June 20, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 63 (eRAI No.8882)," dated August 10, 2017

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

The Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 8882:

- 19-8

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 Paul Infanger at 541-452-7351 or at pinfanger@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8882

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8882

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

eRAI No.: 8882
Date of RAI Issue: 06/20/2017

NRC Question No.: 19-8

Regulatory Basis

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 design 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.

SRP 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."

Request for additional information

NuScale FSAR Chapter 19, page 19.1-81 states "Analysis shows that the offsite dose consequences of core damage in a horizontal module with a damaged containment vessel (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 applicant's analysis is described in ER_P060_7085_R1, "Dropped Module Consequence Analysis." The applicant used a MELCOR model of the module lying on its side and partially filled with nitrogen to simulate accident progression and fission product release from the containment. The applicant applied the scrubbing factors and iodine chemical forms for the fuel handling design basis accident in Appendix B of Regulatory Guide 1.183 to the MELCOR-predicted iodine release from the containment to estimate the iodine release from the pool.

Fission products other than iodine and noble gases were assumed to be retained in the pool.

Based on experimental and analytical studies (e.g., NUREG-1935, "State of the Art Reactor Consequence Analyses"), fission products are released from overheating fuel as vapors that nucleate to form aerosols or condense onto existing aerosols as they move from the overheating fuel to cooler regions of the RCS. The aerosols can then deposit onto RCS and containment surfaces or be released from the containment. For a module drop accident with overheating fuel, releases from the containment would be aerosols dissolved or suspended in water (when the containment water level is above the break) or aerosols suspended in gas bubbles composed of hydrogen, nitrogen, and steam (when the containment water level is below the break). For aerosols suspended in gas bubbles, the scrubbing mechanisms would be similar to a BWR sparger or downcomer.

Because the pool scrubbing factors in Appendix B of Regulatory Guide 1.183 are based on experiments bubbling nitrogen containing iodine vapor through a column of water, they do not appear to apply to a module drop accident with overheating fuel. The accident NuScale is analyzing appears to involve iodine aerosol and not iodine vapor. The applicant is requested to justify that the pool scrubbing factors based on iodine vapor apply to the accident that NuScale is analyzing.

NuScale Response:

NuScale is supplementing its response to RAI 8882 (Question 19-8) originally provided in letter RAIO-0817-55372, dated August 10, 2017. This supplemental response is provided as a result of discussions with the NRC during the PRA audit that began on March 06, 2018 (ML18053A216); this response replaces the original response in its entirety.

The module drop event (MDE) is a beyond design basis event unique to the NuScale design that is postulated to occur as a result of reactor building crane failure during module transport. In the analysis of this event, the module is conservatively assumed to fall over and lie nearly horizontal on the reactor pool floor. As a consequence, a radionuclide release may occur from either mechanical damage to the cladding or from overheating fuel as the core becomes partially uncovered in this orientation. The release from the fuel may result in a release from the module because failure of the containment vessel (CNV) is also conservatively assumed as a result of the drop impact. This release may occur in either an aqueous or gaseous form: liquid coolant contaminated with aqueous radionuclides expelled to the pool (through a CNV breach below the water line), or gases containing fission product vapors and aerosolized particulates vented to the pool (through a CNV breach above the water line). Consequently, the assumed configuration of the containment failure (i.e., location and size of breach) has a significant effect on the accident progression and ultimate consequences of the MDE.

In the analysis of the MDE, deposition mechanisms are credited for the retention of radionuclide vapors and particulates, which limits the magnitude of the release. The MELCOR deposition models account for the retention of radionuclides within the module. For both the gaseous and aqueous release from the module, pool scrubbing decontamination factors (DF) recommended in Regulatory Guide 1.183 for fuel handling accidents (FHA) are applied, including the prescribed treatment of particulates. Specifically, the component of the iodine release that is in the form of cesium iodide (CsI) is conservatively assumed to completely and instantaneously dissociate and re-evolve as elemental iodine vapor as it leaves the module and enters the reactor pool. A DF of 500 is applied to elemental iodine vapor (initialized vapor as well as re-evolved from CsI); a DF of 1 is applied for organic iodine and noble gases (no decontamination); and because of the approximately 50 feet of subcooled water in the reactor pool that overlies the release point, an effective DF of infinity is applied as a simplifying assumption for all other particulate radionuclides (i.e., complete retention in pool). The resulting mitigated release is assumed to directly enter the environment for the evaluation of offsite consequences (i.e., no credit for retention in the reactor building).

While the MDE and the FHA both involve pool scrubbing of a radionuclide release, the two accidents are not identical. Notably, the FHA does not involve overheating fuel while the MDE involves core overheating and fuel damage. As a result, greater quantities of aerosolized particulates (i.e., aerosols) are potentially released from the fuel during the MDE, so aerosols may contribute more significantly to the potential dose consequence. To assess the appropriateness of an infinite DF for aerosols as a simplifying assumption for the MDE, a sensitivity analysis has been performed to evaluate the aerosol contribution to the dose assuming a range of finite aerosol DFs. To establish an upper bound to the dose contribution from aerosols, the DF was assessed at “1”, i.e., no decontamination. Incrementally increasing decontamination rates were evaluated to assess the dose consequence as a function of aerosol DF.

The result of the sensitivity analysis demonstrated that, even in the bounding case in which no pool scrubbing occurs for aerosols (i.e., DF=1), the dose consequence of the MDE remains well below the large release criterion of 200 rem at the site boundary. The maximum dose consequence of the MDE is sensitive to the aerosol DF only when aerosol DFs are very low. As the assumed aerosol DF increases, the dose is dominated by re-evolved iodine vapor, noble gas, and organic iodine gas. This is because, for the containment failure configuration that provides the greatest dose consequence, very little aerosol remains suspended in the module atmosphere at the time the gaseous release from the module occurs. With an assumed aerosol DF of 200, the dose consequence of the MDE is indistinguishable from the analysis referred to in the RAI in which an infinite aerosol DF is assumed.

In summary, the simplifying assumption of an infinite DF for aerosols, as used in the MDE analysis referred to in the RAI, is reasonable because of the relatively small contribution of aerosols to the release from the module. These insights indicate that the pool scrubbing factors provided in Regulatory Guide 1.183 for the FHA are applicable to the analysis of the MDE.

Impact on DCA:

There are no impacts to the DCA as a result of this response.