RAIO-0817-55372

August 10, 2017

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. 63 (eRAI No. 8882) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 63 (eRAI No. 8882)," dated June 20, 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 Enclosure to this letter contains NuScale's 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 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. 8882

Enclosure 1:

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

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NuScale Power

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:

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 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 since failure of the containment vessel (CNV) is also conservatively assumed as a result of the drop impact. This release may occur in two ways: liquid coolant contaminated with aqueous radionuclides is expelled to the pool (through a CNV breach below the water line), or gases containing fission product vapors and aerosolized particulates are vented to the pool (through a CNV breach above the water line).

In the analysis of the MDE, deposition mechanisms are credited for the retention of radionuclide vapors and particulates, which results in effective scrubbing 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 (RG) 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 assumed to completely and instantaneously dissociate in the pool water and re-evolve as elemental iodine vapor due to the low pH of the 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 an effective DF of infinity is applied for all other particulate radionuclides (complete retention in pool). The resulting mitigated release is assumed to enter the environment for the evaluation of offsite consequences without credit for retention in the reactor building.

The release from the MDE shares the same components of the release from the FHA as described in RG 1.183. Namely, the release consists of noncondensible gases, vapors, and particulates. While this suggests that the recommended treatment of the FHA is likewise appropriate for the MDE, a distinction can conceivably be drawn between the particulates associated with the FHA and the aerosolized particulates of the MDE when the release path is at the high point of the vessel. Although not incorporated in the results of the original MDE analysis supporting the FSAR discussion, the SPARC aerosol decontamination model integral to MELCOR can calculate DFs for aerosol scrubbing in the pool. Employing the SPARC model, a supplementary analysis has been performed by NuScale that demonstrates that the cumulative DF for aerosols over the duration of the release is calculated to be at least an order of magnitude higher than the RG 1.183 effective DF for CsI particulates. This result suggests that the decontamination rates of aerosols are sufficiently great to approximate as infinity for the MDE, as recommended in RG 1.183 for the FHA.

Furthermore, an additional sensitivity analysis indicates that the limiting dose result of the MDE analysis is insensitive to the effective DFs applied for aerosols suspended in bubbles. The limiting dose consequence is dominated by the release of noble gases and organic iodine gas for which no decontamination is applied, as well as the aqueous release of CsI where the iodine is assumed to entirely re-evolve into vapor as soon as it leaves the module, which is a conservative treatment. The case that involves a gaseous release of aerosols from the high point in the vessel is non-limiting, even when very low aerosol DFs are assumed, because the core is recovered by reactor pool water flooding in the vessel before extensive aerosol generation occurs.

The deterministic treatment of RG 1.183 provides a clear approach for crediting pool scrubbing that NuScale considers to be applicable and conservative for the analysis of the MDE. A large majority of the particulate release from the MDE is expected to be retained in the water just as it is in the FHA. Furthermore, the maximum offsite consequence of the MDE is insensitive to the scrubbing DFs employed for aerosols.

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