RAIO-1217-57723

December 18, 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. 240 (eRAI No. 8817) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 240 (eRAI No. 8817)," dated September 27, 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 Questions from NRC eRAI No. 8817:

- 14.03-1
- 14.03-2

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
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8817

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NuScale Response to NRC Request for Additional Information eRAI No. 8817

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

eRAI No.: 8817
Date of RAI Issue: 09/27/2017

NRC Question No.: 14.03-1

10 CFR Part 50, Appendix A, GDC 46 requires, in part, that the cooling water system shall be designed to permit appropriate pressure and functional testing to assure (1) the structural and leaktight integrity of its components, (2) the operability and the performance of the active components of the system, and (3) the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation for reactor shutdown and for loss-of-coolant accidents. For the NuScale design, the decay heat removal system (DHRS) functions as a cooling water system, as it is credited for certain transients as the system to transfer heat from structures, systems, and components important to safety, to an ultimate heat sink, and is therefore subject to both GDC 34 and 46.

In order to make a safety finding regarding the ability of the DHRS to meet GDC 46, staff needs to confirm that the proposed preoperational test program for the DHR function demonstrates the capability of all systems and components associated with the removal of decay heat (DSRS Section 5.4.7).

In the preoperational test program outlined in the FSAR, the acceptance criteria related to the DHRS contain no acceptance criteria related to the performance of the system: namely, to reduce temperature below 420F in 36 hours for any design basis transient. Test #63 (the module protection system test) contains a functional requirement to open the DHRS valves and includes provisions to go to "hot functional", while test #104 (reactor trip from 100 percent power) is stated to verify the ability of the DHRS to cool the RCS to mode 3 following a reactor trip. Before the DHRS is relied upon to perform ESF functions (test #104), system performance should be verified via test, or a combination of testing and analysis. ITAAC 02.08.08, an ITAAC related to equipment qualification, appears to partially perform this function; however, the level of detail is insufficient to determine how system performance as a whole is verified via a combination of testing and analyses. This combination may inlcude qualification testing on system components, as-installed testing conducted as part of the pre-operational test program, or other testing in conjunction with analysis to demonstrate that the totality of the DHRS will perform its safety function prior to fuel loading, and how these tests and analyses combine to demonstrate system performance should be clearly described as part of the response.

Provide additional acceptance criteria for the DHRS such that the DHRS testing performed as part of the ITAAC and initial test program are deemed to demonstrate adequate system performance for all transients via the combination of testing and analysis. Further, provide additional clarity, either in the ITAAC or FSAR Table 14.3-1, how the “combination of type test and analysis” will demonstrate system performance meets or exceeds that assumed in the safety analysis, given that system performance characteristics will not be as challenging during testing as they would be under a more limiting transient (i.e., describe the analyses that will reconcile the difference between the test conditions and the limiting transient conditions).

NuScale Response:

NuScale demonstrates that the decay heat removal system (DHRS) will perform its safety function, in accordance with GDC 46, prior to fuel loading, by means of the following analyses and tests:

1. NIST tests specifically designed to evaluate DHRS performance and used to validate the NRELAP5 model of the DHRS;
2. KAIST tests of high pressure condensation heat transfer;
3. NRELAP5 conservative analyses of DHRS cooldown of the RCS presented in the FSAR;
4. DHRS component and detector equipment environmental qualification;
5. Tier 1 ITAAC ; and
6. PRA risk insights.

The NuScale topical report “Non-Loss-of-Coolant Accident Analysis Methodology”, TR-0516-49416-P, which was submitted in January 2017 to the NRC as part of the DCA, presents a detailed analysis of NRELAP5 DHR performance calculations in comparison to 10 NuScale integrated systems test (NIST) tests and to Korea Advanced Institute of Science and Technology (KAIST) tests. The NIST tests (seven under HP-03, two under HP-04, and NIST-NLT-02b) and KAIST tests were designed to specifically evaluate DHRS behavior and performance with respect to RCS cooldown and heat transfer to the pool. Collectively, the 10 NIST tests and KAIST tests were used to validate the ability of the NRELAP code to model all the heat transfer mechanisms associated with DHRS heat exchangers including condensation within the DHR heat exchanger tubes, conduction heat transfer through the walls of the heat exchanger tubes, and heat transfer from the heat exchanger tube exterior surfaces to the pool. In addition, these tests validated NRELAP’s ability to model the overall heat transfer from the RCS through the steam generators and DHRS to the pool during changes in core power. A detailed presentation of test data and comparison to NRELAP5 calculations is presented in Section 5.3 of the aforementioned topical report.

FSAR Section 5.4.3.3.4 presents the results of NRELAP analyses of DHRS performance under a range of limiting conditions. The base case with nominal DHRS conditions and both DHRS trains operating showed that the RCS temperature decreases below 420 degrees Fahrenheit in less than 2 hours. The most limiting case assumes limiting DHR heat exchanger fouling factors, 10 percent steam generator tube plugging, and the presence of noncondensible gas with only one of the two DHRS trains available. The most limiting case results were that the RCS temperature decreases below 420 degrees Fahrenheit in less than 18 hours as compared to the design basis value of 36 hours.

FSAR Section 3.11 provides information on the environmental qualification of DHRS components. FSAR Table 3.11-1 specifies a harsh environment for qualification of the DHRS actuation valves, DHRS condenser outlet temperature and pressure detectors, DHRS valve position indicators, and steam generator steam pressure indicators. Specific environmental qualification regulatory requirements and industry standard commitments are also described in FSAR Section 3.11. The environmental qualification methodology is presented in FSAR Appendix 3C.

As discussed in FSAR Section 5.4.3, the DHRS is classified as ASME BPVC Section III Class 2 and Seismic Category I. As such, the DHRS is subject to the following ITAAC that are delineated in FSAR Tier 1, Table 2.1-4:

1. No. 1 Piping systems compliance with ASME Code Section III requirements
2. No. 2 Components conforming to the ASME Code Section III construction rules
3. No. 4 Protection from pipe break dynamic and environmental effects
4. No. 5 Leak before break evaluation
5. No. 15 DHRS valves change position under design differential pressure
6. No. 20 DHRS valves fail to their safety related position on the loss of electrical power

In addition, the following equipment qualification ITAAC in FSAR Tier 1, Table 2.8-2 are directly applicable to the DHRS:

1. No. 1 Equipment, supports, and anchorages withstand design basis seismic loads without loss of safety function
2. No. 2 Class 1E electrical equipment environmental qualification
3. No. 3 Safety-related mechanical equipment non-metallic parts, materials, and lubricant environmental qualification
4. No. 6 Safety-related valves perform under the full range of conditions including DBA
5. No. 8 DHRS condensers have the capacity to transfer their design heat loads

The aforementioned 11 ITAAC have acceptance criteria that include:

- ASME Code Section III Design Report
- ASME Code Section III Data Report
- As-built Pipe Break Hazard Analysis Report
- As-built LBB analysis
- Seismic qualification records,
- EQ records,
- Qualification reports of safety-related valves,
- ASME Code Section III design reports,
- Type tests, and
- Analyses.

Three pre-operational tests that are directly related to DHRS functional performance are in FSAR Section 14.2, Tables 14.2-48, 14.2-63, and 14.2-66. These tests encompass hot functional testing of the DHRS actuation valves response to a MPS actuation signal and response time testing of DHR actuation valves, The module heatup system (MHS) is not designed to provide full power input to the reactor coolant system. Therefore, it is not physically possible to conduct a pre-operational test of DHRS cooldown to less than 420 degrees Fahrenheit from full power conditions.

PRA of the DHRS provides the following insights:

1. DHRS is not a PRA candidate for system-level risk significance;
2. DHRS heat transfer performance is not a candidate for basic event risk significance;
3. DHRS actuation valves are candidates for component level risk significance;
4. Although not classified as a risk significant system, the DHRS was classified as risk significant in the DRAP process as discussed in FSAR Table 17.4-1 due its importance as a passive safety-related core cooling system

In summary, the DHRS meets GDC 46 by demonstrating that the integrated DHRS and its components are capable of removing decay heat under all anticipated normal, transient, and design basis accident conditions using a combination of tests, inspections, reports and analyses as delineated below.

1. The tests include 11 different NRELAP validation separate effects and integral tests that were specifically used to evaluate DHRS behavior and performance.

2. Additional tests will be performed for equipment qualification of DHRS components in a harsh and seismic category I environment. This encompasses the DBA environment.
3. A specific type test of the DHR heat exchanger will be performed to confirm its design heat loads capacity in accordance with an ITAAC.
4. ITAAC confirm DHRS valve actuation and fail safe positioning upon a loss of power.
5. ITAAC confirm as-built fabrication of the DHRS by design report and construction associated with this system.
6. Conservative NRELAP analyses of limiting (tube fouling, SG tube plugging, presence of non-condensible gases, and only one of the two DHRS functioning) cooldown scenarios are documented in the FSAR and confirm the ability of the DHRS to reduce RCS temperature to below 420 degrees Fahrenheit in less than 36 hours with an 18-hour margin.
7. Preoperational tests confirm module protection system operability of the DHRS as well as safety display/indication functions.

Impact on DCA:

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

Response to Request for Additional Information
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eRAI No.: 8817
Date of RAI Issue: 09/27/2017

NRC Question No.: 14.03-2

10 CFR Part 50, Appendix A, GDC 46 requires, in part, that the cooling water system shall be designed to permit appropriate pressure and functional testing to assure (1) the structural and leaktight integrity of its components, (2) the operability and the performance of the active components of the system, and (3) the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation for reactor shutdown and for loss-of-coolant accidents. For the NuScale design, the decay heat removal system (DHRS) functions as a cooling water system, as it is credited for certain transients as the system to transfer heat from structures, systems, and components important to safety, to an ultimate heat sink, and is therefore subject to both GDC 34 and 46.

The DHRS piping layout and DHRS level sensor locations represent important design considerations in evaluating the performance of the DHRS. In reviewing the supporting calculations as part of an audit, staff found that both piping layout and slope were important in order to ensure that the natural circulation pathway remains uninterrupted and DHRS inventory is maintained. Additionally, considerations related to these design details revealed that the presence of additional non-condensable gases in the DHRS could adversely impact the heat transfer. Staff reviewed the FSAR and existing ITAAC and could not determine how these values were verified for the as-built design. Discrepancies in these values compared to the thermal-hydraulic analyses have the potential to invalidate the analyses and result in impaired system operation compared to that assumed in the licensing basis.
Staff requests the applicant update the ITAAC or provide another appropriate verification mechanism to clarify that DHRS piping layout, slope, and level sensor location for considerations related to non-condensable gases such that the conditions laid out in the DHRS thermal-hydraulic analysis are verified in the as-built design.

NuScale Response:

The decay heat removal system (DHRS) consists of structures, systems and components (SSCs) which are designed and constructed to ASME Section III, Class 2 rules. As such, the ASME Design Report will be utilized as a verification mechanism to reconcile the as-built piping arrangement to the piping arrangement that was assumed in thermal-hydraulic analyses and documented in the construction drawings as required by ASME BPVC Section III Paragraph NCA-3551.1. The considerations specific to non-condensable gases within the DHRS such as the slope of pipe and dimensions required to verify the volume between the DHRS level sensor and the DHRS actuation valve are specified by the piping design drawings which are verified by the ASME Design Report.

The ASME Design Report is identified in ITAAC No. 02.01.01 which states an ITAAC inspection is performed on the NuScale Power Module ASME Code Class 1, 2, and 3 as-built piping systems to verify that the requirements of ASME Code Section III are met.

Impact on DCA:

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