January 11, 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. 281 (eRAI No. 9082) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 281 (eRAI No. 9082)," dated November 14, 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. 9082:

- 05.04.07-4
- 05.04.07-5

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 Carrie Fosaaen at 541-452-7126 or at cfosaaen@nuscalepower.com.

Sincerely,

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

Distribution: Gregory Cranston, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Bruce Bavol, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9082

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9082

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

eRAI No.: 9082
Date of RAI Issue: 11/14/2017

NRC Question No.: 05.04.07-4

10 CFR Part 50, Appendix A, GDC 34 requires in part that a system have the capability to transfer decay heat and other residual heat from the reactor such that fuel and pressure boundary design limits are not exceeded. NuScale has proposed a PDC that is functionally equivalent to GDC 34 with the exception of the requirements associated with electrical power. For the NuScale design, the decay heat removal system (DHRS) serves the decay heat removal function.

In reviewing the NuScale detailed design documentation during an audit, staff discovered that the initial reactor pool conditions for the cases referred to in the FSAR (Figures 5.4-11 through 5.4-15) were 100F, rather than 140F (the maximum allowed reactor pool value in technical specifications). In FSAR section 5.4.3.3.4, these analyses are referred to as "assuming limiting off-normal conditions". This statement aligns with the staff's understanding that the single-train analyses documented are intended to represent bounding analyses for the DHRS performance. Although staff recognizes that NuScale has performed sensitivity studies that demonstrate the DHRS performance for higher reactor pool temperatures, these cases are currently not reflected in the licensing basis documentation. Staff requests that NuScale clarify the description of the limiting DHRS performance in the FSAR by either revising the calculations presented there or adding additional discussion related to the sensitivity cases and characterizing the effect of any conditions that were non-limiting in the cases presented in the FSAR.

NuScale Response:

The analyses in FSAR Section 5.4.3.3.4 are provided as the performance evaluation for the decay heat removal system (DHRS) consistent with Reg. Guide 1.206, Section C.I.5.4.7.3. The off-normal transient cases presented in FSAR Section 5.4.3.3.4 are intended to use initial conditions that are consistent with the DHRS design basis and provide the most limiting conditions for evaluating the ability of the DHRS to cool the reactor coolant system (RCS) to below 420°F in 36 hours. As identified in the question, the pool temperature of 100°F is not the most limiting for DHRS thermal performance.

FSAR Section 5.4.3.3.4 has been updated to include an off-normal high inventory case with an initial reactor pool temperature of 140°F. A pool temperature of 140°F is consistent with the upper temperature limit of Section 3.5.3 of the Technical Specifications. The results of this additional case are marginally more limiting when compared to the 100°F initial reactor pool temperature case in FSAR Figures 5.4-14 and 5.4-15. The average RCS temperature after 36 hours is 391°F for the 100°F initial pool temperature case and 392°F for the 140°F initial pool temperature case.

Impact on DCA:

FSAR Section 5.4.3.3.4 has been revised as described in the response above and as shown in the markup provided in this response.

To assess the impact of these factors, a thermal-hydraulic analysis of DHRS performance has been performed with NRELAP5 to calculate the DHRS heat transfer rate. The performance analysis is divided into three model categories:

- Steady State Model - Efficient model used to characterize the effect of the listed factors on the DHRS heat removal rate.
- Nominal Transient Models - Full transient models used to show that the DHRS cools the RCS for typical initiating events and conditions.
- Off-Normal Transient Models - Full transient models used to show that the DHRS provides adequate cooling even with the most limiting initiating events and conditions.

The analytical model used for the DHRS performance analysis and the basis for its validity is provided in Section 15.

Steady State Model

To determine the capability of the DHRS, a steady state model evaluates the DHRS with a constant primary side temperature, a constant primary side flow rate, a constant reactor pool temperature, and a constant mass of DHRS inventory. With these variables held constant, the steady state DHRS heat transfer rate is calculated.

An initial core power of 102 percent is assumed to account for uncertainty in the measurement of core power thereby producing a higher decay heat and a multiplier of 1.2 is applied to the core decay heat. A loss coefficient in the DHRS steam line is calculated to ensure acceptable system performance and relatively consistent heat transfer for a range of DHRS inventories. This loss coefficient is used to determine the diameter of the restriction orifice in the DHRS steam line.

The steady state model is varied to account for additional steam volume in the piping up to the non-safety steam isolation valve in the event of a failure of an MSIV to close. The model is also varied to evaluate the effects of DHRS and SG fouling and SG tube pugging. The steady state model is varied to include noncondensible gas in the DHRS steam piping. Additionally, the limiting mass of dissolved gas in the DHRS liquid that could be released during DHRS operation when the water is boiled in the SG is used in the DHRS performance analysis.

Nominal Transient Model

Nominal transients are analyzed to provide DHRS cooldown capability considering two category of cases: actuation of DHRS coincident with containment isolation and actuation of DHRS without containment isolation. The main difference in these two categories is the time required for pressurizer level to drop resulting in pressurizer heater isolation because containment isolation results in isolation of the CVCS lines.

RAI 05.04.07-4

Off-Normal Transient Model

Off-normal transients determine the capability of the DHRS to remove decay heat under limiting conditions. These transients include factors such as fouling of heat transfer surfaces, plugged SG tubes, reactor pool water temperature, and the presence of noncondensible gas to assess the limiting heat transfer capability of the system. To conservatively assess the heat removal capability of the system, the containment isolation valves and DHRS actuation valve timings are biased to result in the worst-case DHRS inventory conditions.

Decay Heat Removal System Performance Analysis

The analysis evaluated the DHRS capability of removing heat over a range of DHRS loop inventories with the steady state model. Sensitivity cases indicate that the DHRS is insensitive to a wide range of reactor pool temperatures and to the failure of an MSIV to close.

The base case was adjusted to determine the effect of DHRS performance over the DHRS loop inventory range at different RCS hot temperatures. Heat removal performance over the loop inventory range was shown to be similar for different RCS temperatures and overall DHRS performance decreases with decreasing RCS temperature due to the reduced driving temperature for heat transfer.

The base case was also adjusted to determine the effect of fouling of the heat transfer surfaces, SG tube plugging, and noncondensible gas accumulation on DHRS performance over the DHRS loop inventory range. The DHRS performance analysis assumes fouling factors of 0.0005 hr-ft^2-°F/BTU for the DHRS condenser and steam piping heat transfer surfaces and 0.0001 hr-ft^2-°F/BTU for the SG heat transfer surfaces, SG tube plugging of 10 percent, and a noncondensible gas mass of 0.422 kg. The performance analysis shows that fouling of the heat transfer surfaces and SG tube plugging has a moderate effect on DHRS performance, decreasing the peak heat removal capability, and the presence of noncondensible gas has less impact on DHRS performance.

The DHRS performance decreases with decreasing RCS temperature. As RCS temperature decreases, the driving temperature difference for DHRS heat transfer is reduced. The presence of noncondensible gas in the DHRS condenser further reduces system performance as RCS temperature decreases. A lower RCS temperature corresponds to a lower DHRS pressure allowing the noncondensible gas to expand and occupy a larger fraction of the internal volume of DHRS condenser resulting in reduced performance.

The likelihood of noncondensible gas accumulating down to the level sensors in the DHRS steam piping during the operating cycle was assessed and it was concluded that reaching the noncondensible gas limit in the DHRS steam piping is unlikely. In the event noncondensible gas reaches the limit, the affected DHRS train may no longer be capable of performing its intended safety function. Plant technical specifications provide requirements for the DHRS and associated remedial actions when the minimum requirements are not met.

Upon a loss of normal AC power with no backup power supply system available, DHRS actuates followed by opening of the RVVs and RRVs when DC power is no longer available to the associated pilot valves. However, the DHRS performance analysis does not include the synergistic RCS cooling effects associated with concurrent DHRS and ECCS operation.

Decay Heat Removal System Performance Results

The system performance analysis indicates the DHRS is capable of removing appreciable amounts of heat over a wide range of inventories and it is insensitive to a wide range of reactor pool temperatures and to the failure of an MSIV to close. The analysis also shows the ability to accommodate fouling and SG tube plugging. In addition, performance analysis indicates that the DHRS is capable of cooling the RCS below 420 degrees F in less than 36 hours with an accumulation of noncondensible gases, thus precluding the need for high-point vent capability.

Figure 5.4-11 shows RCS cooldown for 4 hours from full power conditions with two DHRS trains in operation assuming nominal system conditions and indicates that RCS temperatures decrease below 420 degrees F in less than 2 hours. For this nominal two DHRS train case, RCS average temperature stabilizes below 300 degrees F within 36 hours.

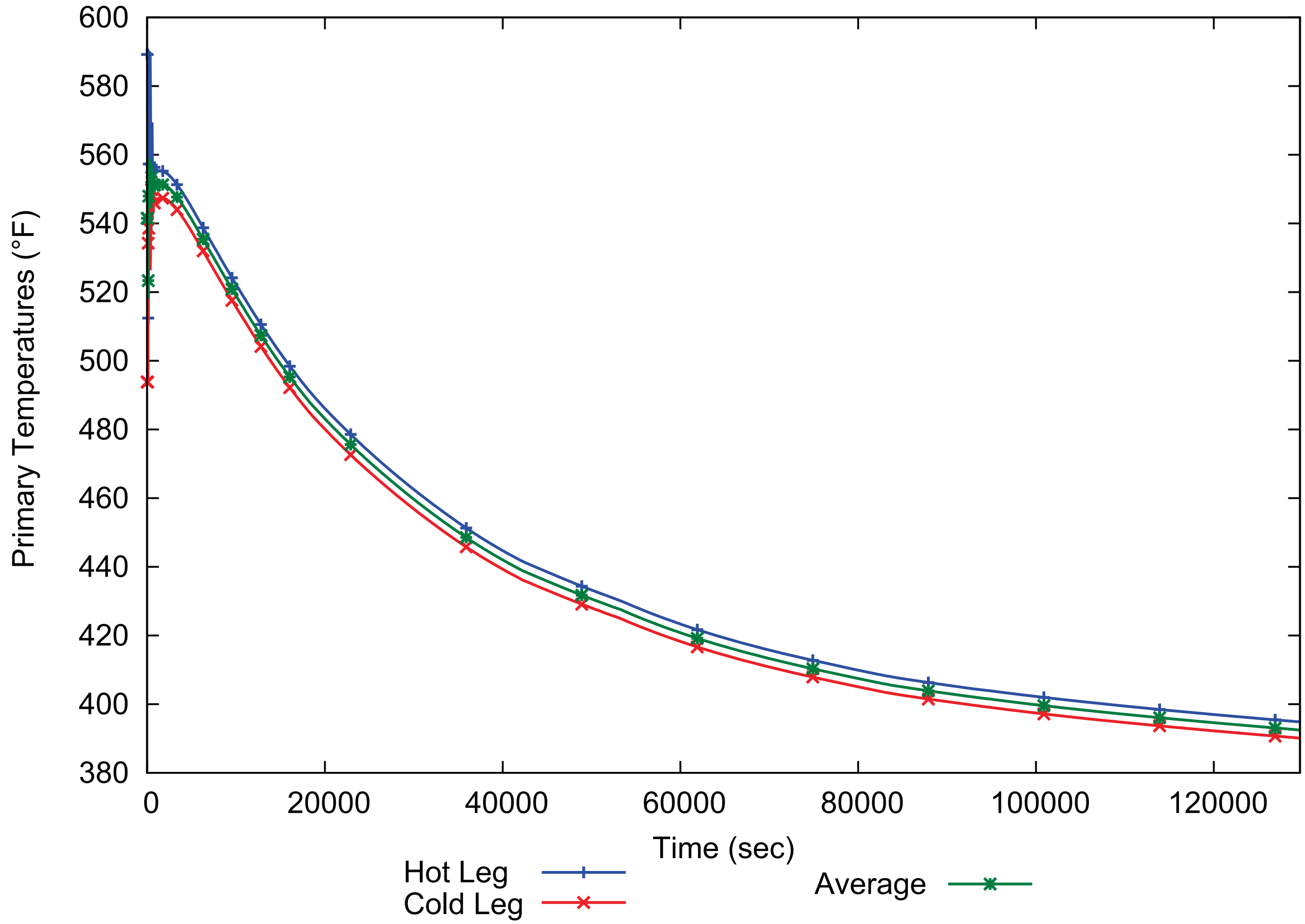
RAI 05.04.07-4

Figure 5.4-12 through Figure 5.4-15 show the RCS cooldown response during transient cases with one DHRS train in operation assuming low and high DHRS inventories. These off-normal transient cases assume ~~the~~an initial reactor pool temperature of 100 degrees F and reduced heat removal capability due to fouling, SG tube plugging, and accumulation of noncondensible gases. Figure 5.4-12 and Figure 5.4-14 show the RCS cooldown over 4 hours and Figure 5.4-13 and Figure 5.4-15 show the RCS cooldown over 36 hours. The low DHRS inventory case indicates that RCS average temperature stabilizes below 350 degrees F within 36 hours and the limiting high DHRS inventory case indicates that RCS average temperature stabilizes below 400 degrees F within 36 hours. An additional high DHRS inventory case is run using an initial reactor pool temperature of 140 degrees F. This pool temperature is consistent with the upper limit temperature in Section 3.5.3 of the Technical Specifications. The results in Figure 5.4-16 show that the limiting reactor pool temperature of 140 degrees F has a small effect on the RCS temperature after 36 hours compared to the 100 degrees F initial condition. Based on these results, the DHRS design is capable of cooling the RCS to below a safe shutdown temperature of 420 degrees F in less than 36 hours with one DHRS train in operation assuming limiting off-normal conditions and a single active failure of the associated MSIV to close.

Figure 5.4-11 and Figure 5.4-13 show the hot and cold leg temperatures difference increase as the water level in the RPV drops to near the top of the riser. When the liquid level is near the top of the riser, the reduced flow area causes more losses and impedes RCS natural circulation that increases the temperature difference. Oscillations in natural circulation of the RCS could occur once the level drops to near the top of the riser due to vapor build up in the top of the core and lower riser.

RAI 05.04.07-4

Figure 5.4-16: Primary Coolant Temperature Cooldown with Decay Heat Removal System One Train Operation: High System Inventory, 140°F Initial Pool Temperature - 36 Hours



NuScale Power

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

eRAI No.: 9082
Date of RAI Issue: 11/14/2017

NRC Question No.: 05.04.07-5

10 CFR Part 50, Appendix A, GDC 34 requires in part that a system have the capability to transfer decay heat and other residual heat from the reactor such that fuel and pressure boundary design limits are not exceeded, with suitable redundancy in components and features, to assure that the system safety function can be accomplished, assuming a single failure. NuScale has proposed a PDC that is functionally equivalent to GDC 34 with the exception of the requirements associated with electrical power. For the NuScale design, the decay heat removal system (DHRS) serves the decay heat removal function.

FSAR Section 5.4.3.2 states that “the DHRS function is dependent on the closure of the associated safety relief MSIVs and FWIVs.” Staff’s understanding of this statement is that any single failure in the DHRS can render only one train of DHRS inoperable (while secondary isolation valves exist as stated in Section 5.4.3.2, they are not safety related and therefore are not relied on in the application of single failure when evaluating the system itself). Based on the information available, a single train appears to be sufficient for all events where DHRS is credited save for a steam generator tube rupture, which could result in the initiating event (the tube rupture) rendering one train of DHRS inoperable while a single failure of an isolation valve renders the other train inoperable. Clarify, in the FSAR, the description in Section 5.4.3.2 as applicable to the steam generator tube rupture event and clearly state which, if any, non-safety related valves are being credited for isolation.

NuScale Response:

FSAR Section 5.4.3.2 states that “*the DHRS function is dependent on the closure of the associated safety-related* [Main Steam Isolation Valves] *MSIVs and* [Feedwater Isolation Valves] *FWIVs*.” The NuScale design maintains that any single failure in the DHRS can render only one train of DHRS inoperable. This is accomplished through use of the secondary (backup) MSIVs and Feedwater Regulating Valves (FWRVs) as described in FSAR Section 15.0.0.6.6. FSAR Table 15.0-9 identifies the events in which nonsafety-related equipment is credited for accident mitigation.

With regard to the Steam Generator Tube Failure (SGTF) event, FSAR Section 15.6.3.3.2 states that failure of the primary (safety-related) MSIV is the assumed single failure as closure of the secondary MSIV yields the limiting mass release scenario and extends the time before the faulted SG is isolated. Whereas, closure of the primary MSIV yields a higher pressure in the event analysis. See FSAR Section 15.6.3 for a fuller discussion of the SGTF event and isolation assumptions.

Table 3.2-1 provides the classification information for the secondary MSIVs and FWRVs.

FSAR section 5.4.3.2 already discusses use of the secondary (backup) MSIVs and FWRVs as isolation devices to support DHRS functions. Therefore, no update to this section is necessary.

Impact on DCA:

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