August 21, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Submittal of Responses to ECCS Valve FMEA Audit Follow-Up Items

REFERENCES:

1. U.S. Nuclear Regulatory Commission Staff Report of Regulatory Audit Failure Modes and Effects Analysis and Other Supporting Documents for Emergency Core Cooling System Valves in the NuScale Power, LLC, Design Certification Application, dated August 14, 2018 (ML18219B634).

2. NuScale Power, LLC Submittal of Resolution Plans and Classification for ECCS Valve FMEA Audit Follow-Up Items, dated September 21, 2018 (ML18264A312).

During an August 15, 2018 public teleconference with Ms. Marieliz Vera, Mr. Tim Lupold, and Mr. Tom Scarbrough of the NRC staff, NuScale Power, LLC (NuScale) discussed a proposed path forward for resolution of follow-up items from the Reference 1 audit report. As a result of this discussion, NuScale submitted the proposed closure plan, Reference 2, for these follow-up items.

The purpose of this letter is to provide responses to the following items in Reference 2, discussed during an August 7, 2019 teleconference: 28, 37, 39, 43, 46, 47, 53, 57, 62, 64, 102 and 104. Enclosure 1 provides the responses to the aforementioned follow-up items.

If you have any questions, please contact Rebecca Norris at 541-602-1260 or at RNorris@nuscalepower.com.

Sincerely,

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Attachment: Responses to ECCS Valve FMEA Audit Follow-Up Items

<u>NRC ML18219B634 Item Description(s):</u>

Initial: NuScale stated that the ongoing detailed design evaluation of the IAB valve will provide reasonable assurance of the sealing requirements for the vent port to prevent leakage from the main chamber prior to the differential pressure between the RPV and CNV being reduced to the assumed value for main valve opening. NuScale Drawing Document NP12-00-B020-M-GA-5679, "Inadvertent Actuation Block Drawing," identifies the IAB valve assembly as a Category A valve in accordance with the IST program requirements in the ASME "Code for Operation and Maintenance of Nuclear Power Plants" (OM Code). NuScale stated that it will evaluate the IAB valve categorization in the NuScale IST Program to satisfy the ASME OM Code regarding leakage requirements. The NRC staff will review the final design of the ECCS valve (including the IAB valve) to support its IST categorization.

> Update: During the onsite audit, the NRC staff discussed the sealing requirements of the IAB valve with NuScale and Target Rock personnel. The most recent design drawing of the IAB valve assembly has downgraded the leakage categorization of the IAB valve. Upon completion of the final design of the IAB valve, NuScale should confirm that the leakage categorization of the IAB valve is consistent with its performance requirements.

Index No. (NuScale letter LO-0918-61910)**: 102**

<u>Response:</u>

The OM category is no longer called out on the current revision of the IAB drawing (ED-B020-5679). The IST requirements for the ECCS valves are described in FSAR Chapter 3.9.6. The IAB is an actuation subcomponent of the main valve and is therefore not categorized separately from the main valve in Table 3.9-16, in turn the leakage performance of the IAB is not explicitly categorized. In FSAR Table 3.9-16, Note 12, the following statement is added: the IAB is a subcomponent of the ECCS valve and is subject to performance assessment testing. For IST, the ECCS valves are categorized as BC in Table 3.9-16, they are self-actuating and seat leakage in the closed position is inconsequential for fulfillment of their safety function in the NuScale plant. The IST performance assessment testing for the ECCS valves is described in FSAR 3.9.6.3.2. This content of FSAR 3.9.6 was updated by RAI 8955 03.09.06-16S1 (response submitted 2/19/18). The IAB does not have a specific maximum leakage limit in order to fulfill its safety function and is therefore not a Category A valve. The IAB function is to prevent the main valve from opening above the threshold pressure and permit the main valve to open below the release pressure which are not dependent on specific leakage limits.
This response addresses IST information contained in NuScale component drawings. IST requirements for the ECCS valves as described in the DCA are still being reviewed in the scope of the in-progress ECCS valve design audit (see audit plan ML19067A143).

NRC ML18219B634 Item Description(s):

Initial: Section 3.10 states that the IAB valve setpoint is adjusted by bellows rod adjustment in the IAB disc and by shimming the spring. How and when can these adjustments be made?

> Update: During the onsite audit discussions, NuScale personnel stated that these adjustments can only be made during the manufacturing process. NuScale should confirm that the ECCS valve design can accommodate appropriate adjustments during the manufacturing process for applicability to the reactor conditions.

Initial: NuScale stated that the four ECCS valve subcomponents will not be designed to allow adjustments following installation. NuScale stated that shims will be installed in the ECCS valve to adjust its performance during pre-installation testing. NuScale Drawing Document NP12-00- B020-M-GA-5679 specifies that shims will be installed between the spring and disc to achieve the IAB threshold and IAB release pressures within the specification requirements. NP12-00- B020-M-GA-5679 specifies that the IAB threshold pressure will be set between [[-]] and [[-]] psid, and that the IAB release pressure will be set between [[-]] and [[-]] psid, at the factory. The NRC staff will review the design of the ECCS valves (including shims and their precision) to account for variations between pre-installation testing and normal operating conditions.

> Update: During the onsite audit, the NRC staff discussed the shim to be included in each IAB valve with NuScale and Target Rock personnel. As part of the final design of the ECCS valves, NuScale should demonstrate that the shims are capable of accounting for variations between pre-installation testing and normal operating conditions.

Index No. (NuScale letter LO-0918-61910)**: 62, 104**

Response:

There is a washer component on the IAB, which in combination with the spring and bellows assembly creates the differential force against which pressure acts to close and open at the designated threshold and release pressures. This component is a custom piece and its geometry is set by valve supplier design calculations. This washer component thickness is set at the factory to meet the required threshold and release pressure range. It is possible to uninstall an IAB and replace the washer component with one of a different thickness to accommodate performance variations but any evaluation and modification should be performed by the valve designer to ensure that all components in the force balance are still within acceptable design limits. Note that a pressure range is specified for IAB threshold and release performance requirements in ECCS design documents. Therefore the specification of a pressure range provides some margins to accommodate variation in performance without requiring physical adjustment. Qualification and setting testing procedures will account for reactor operating conditions (e.g. temperature) which could affect the performance of the valve in the operating condition.

<u>**NRC ML18219B634 Item Description(s):**</u>

Initial: Table 5-2 does not discuss potential failures related to the loss of power to the trip and reset valves.

> Update: During the onsite audit discussions, Target Rock personnel indicated that the FMEA did not address loss of power or tubing performance because these aspects of the ECCS valve design are within the specific NuScale technical areas. NuScale should supplement the FMEA as necessary to address potential failure modes in technical areas not addressed by Target Rock (such as loss of power and tubing performance).

Initial: The FMEA report addresses a potential tubing break, but does not discuss other potential failure modes of the tubing, such as binding or crimping.

> Update: During the onsite audit, the NRC staff discussed with NuScale and Target Rock personnel the potential failure modes related to binding or crimping of the tubing. This issue was identified as a NuScale evaluation item. NuScale should describe its plans to demonstrate the design of the ECCS valves to avoid adverse effects of binding or crimping of the valve tubing to support the DC application.

Initial: Section 4.2.2 states that the TRV, TV, and main valve tubing is NuScale equipment. What are NuScale's plans to demonstrate the performance of this tubing?

> Update During the onsite audit discussions, NuScale personnel stated that the ECCS valve tubing will be 304 Stainless Steel seamless piping of Class 1 category similar to reactor sample lines. NuScale personnel stated that tubing supports will be addressed later during the design process. NuScale should demonstrate the performance of the connecting tubing and supports for the ECCS valves to support the DC application.

Index No. (NuScale letter LO-0918-61910)**: 28, 39, 64**

<u>**Response:**</u>

<u>Tubing Design</u>: Per FSAR Table 3.2-1 the ECCS hydraulic lines are Quality Group A, and Seismic Category I. As described by FSAR 3.2.2.1, Quality Group A SCC are designed to the requirements for Class 1 components in Section III, Div. 1 of ASME BPVC. FSAR 3.12 identifies the design and analyses requirements for Class 1 piping systems, piping components, and associated supports. These analyses evaluate stress and strain due to the specified loads and acceptance criteria are based on component function requirements in the specified plant events. The approach of defining and using functional capability as acceptance criteria for analyses of ASME Class 1 lines are described in FSAR 3.12.510; this ensures the ECCS tubing is designed to withstand loads associated with events in which ECCS is required to operate. As discussed in Pipe Rupture Hazards Analysis (TR-0818-61384, Rev.1) Section 4.3.1 for postulated pipe breaks in containment, pipe whip effects on the trip/reset lines are considered to fully sever the tubing which has the same effect as opening the trip valve and allows the ECCS main valve to open once below the IAB release pressure.

<u>Tubing Installation</u>: There is also an ITAAC (Tier 1, Table 2.1-4, No. 26) which identifies that inspections will be performed for each ECCS valve and associated hydraulic lines. This inspection will confirm that the hydraulic lines are installed in accordance with their associated installation specifications.

Tubing Performance: With respect to DCA review, the ECCS valve DCA Demonstration test program demonstrates performance of the ECCS valve hydraulic lines. The test configuration uses tubing size, length, and arrangement which is representative of the ECCS hydraulic lines in the NPM design. With respect to plant performance, the tubing performance will be verified by the required ASME QME-1 functional qualification testing. Tubing between ECCS valve components will be included in qualification testing.

Electrical Power: Loss of power to the ECCS valves is not a failure mode. With respect to ECCS operation the safety position of the ECCS valves is the de-energized position. When the Module Protection System (MPS) actuates ECCS, DC power is removed from the ECCS trip solenoid valves. Therefore, loss of power to the to the ECCS trip solenoid valves has the same effect as an MPS actuation of ECCS. Within this context, the following paragraph is a discussion about design of the systems which provide continuous power to the ECCS trip solenoid valves.

During normal power operations the Module Protection System (MPS) supplies continuous power to the ECCS trip solenoid valves via the Highly Reliable DC Power System (EDSS) to hold them in the closed position. The MPS class 1E AC-DC converters isolate the class 1E MPS system from the nonsafety EDSS power supply when an ECCS actuation signal is generated. The MPS supplied class 1E power ensures a regulated DC current and voltage is provided to the ECCS solenoid valves during all modes of normal and abnormal operation preventing damage to the solenoids from electrical transients. This regulated power maintains the integrity and capability of the solenoids to satisfy their safety function of opening the ECCS valves, when power is removed from the solenoids, by either an MPS protective action of loss of power (failsafe operation). Following a loss of all AC the nonsafety EDSS system provides adequate DC current and voltage to support the MPS ECCS hold mode period for a period of 24 hours to maintain the ECCS valves shut preventing unwanted valve actuation. The power supplied to the ECCS trip valves is provided via redundant power channels with each power channel battery sized to provide the necessary battery capacity to provide 24 hours of ECCS hold mode operation.

<u>NRC ML18219B634 Item Description(s):</u>

Initial: The FMEA report does not address the potential impact of the reverse flow from the diffuser upon actuation of the RVV.

> Update: As indicated in the comments on the RVV Diffuser report, NuScale should describe its plans to demonstrate the performance of the RVVs in response to the reaction flow from the diffuser to support the DC application.

Index No. (NuScale letter LO-0918-61910)**: 37**

<u>Response:</u>

When an RVV actuates to the open position there is a sudden increase in pressure in the diffuser region when steam fills the region. However, throughout an RVV actuation event, pressure is always higher immediately upstream of the main disc than downstream of the disc in the diffuser region. Therefore there is no mechanism for flow to move in the reverse direction (from lower pressure to higher pressure). There is also no mechanism for any significant reflected pressure wave (i.e. water hammer) because the fluid is saturated steam which is compressible. Thrust reaction loads on the RVVs due to jet flow out of the valves upon ECCS actuation are specified and evaluated to ASME service level B limits (FSAR Table 3.9-11). Specification and development of reaction loads on reactor safety valves and ECCS valves is described in FSAR 3.12.5.3. Final ASME design reports for the ECCS valves will show that the valves withstand these reaction loads according to service level B allowable stress limits (and all other specified load combinations), refer to FSAR Tier 1 ITAAC, Table 2.1-4.

ASME QME-1 qualification testing requires qualification of the safety-related ECCS valve functions including valve stroke and capacity of the RVV (including diffuser).

<u>NRC ML18219B634 Item Description(s):</u>

Initial: Failure mode 6-1-4 relates to the potential failure of the trip valve to open. The mitigating factors are specified as redundant RVVs and RRVs, and opening of the main valve by spring force when the pressure differential between the RPV and CNV reaches [[-]] psid.

> Update: During the onsite audit, the NRC staff discussed with NuScale and Target Rock personnel the design of the main valve to open with low differential pressure when the IAB valve blocks depressurization of the main valve control chamber. NuScale should describe its reliance on the main valve spring to support the safety function of the ECCS valves.

Index No. (NuScale letter LO-0918-61910)**: 43**

<u>Response:</u>

In safety analyses there is no reliance on the low pressure ECCS main valve spring to actuate the valves to the open position. The safety function that the main valve spring is credited with is to hold the ECCS main valves in the open position after an actuation in which differential pressure is used to initially open the valves. Eventually after an ECCS actuation, the pressure between the reactor vessel and containment approach near equilibrium and large differential pressures are no longer present, therefore the spring ensures that the valve disc stays in the open position.

<u>NRC ML18219B634 Item Description(s):</u>

Initial: Table 6-5 lists potential failure modes caused by boric acid. NuScale should provide justification that the lessons learned from the Davis Besse RPV degradation, such as described in NRC NUREG/BR-0353 (Revision 1), “Davis-Besse Reactor Pressure Vessel Head Degradation,” or documents prepared by the Institute of Nuclear Power Operations (INPO), have been addressed in the design of the ECCS valves, such as related to materials in failure mode 6-5-1.

> Update: During the onsite audit, NuScale personnel indicated that the lessons learned related to boric acid effects from the Davis Besse event have been considered in its design of the ECCS valves. NuScale should include its consideration of the Davis Besse lessons learned as part of its final design documentation.

Index No. (NuScale letter LO-0918-61910)**: 46**

<u>Response:</u>

The Davis-Besse reactor vessel experienced wastage of carbon steel material due to boric acid exposure via a through-wall crack in a CRDM penetration (nickel-based alloy, Alloy 600) and exposure to boric acid via external flange leakage onto the reactor vessel. The Davis-Besse reactor vessel shell consists of a thick carbon steel shell with a thin internal stainless steel cladding. The stainless steel cladding did not experience degradation on the Davis-Besse reactor vessel. The ECCS valve (main valves, trip/reset valves, and IABs) reactor pressure retaining materials are stainless steel base materials and therefore not subject to corrosion by boric acid solutions, refer to FSAR 6.1.1.2 and Table 6.1-1. The external surfaces of the ECCS valves are also stainless steel base material except for the non-pressure boundary solenoid enclosure of the trip/reset valves which is nickel plated carbon steel to support performance of the magnet and coil solenoid assembly. Therefore the ECCS valve component internal and external surfaces are inherently protected from boric acid corrosion. The ECCS main valves are bolted to RPV flanges, therefore mid-shell corrosion cracking of the welded CRDM alloy 600 reactor vessel penetration on the Davis-Besse reactor vessel is not an applicable failure mechanism for the NuScale ECCS valve attachment design. The reactor vessel ECCS valve flanges and the containment vessel trip/reset valve connections using shell component forging and safe-end full penetration welds (see FSAR Figure 3.8.2-10). The carbon steel portions of the NuScale reactor vessel and containment vessel shell have stainless steel cladding on both internal and external surface compared to the Davis-Besse reactor vessel which only had cladding on the interior surface. Therefore the exterior surfaces of both vessel shells are protected from boric acid corrosion.

<u>NRC ML18219B634 Item Description(s):</u>

Initial: Failure mode 6-5-13 relates to the main valve filter being blocked by boric acid precipitation and crystallization. The FMEA categorizes this potential failure mode as remote.

> Update: During the onsite audit, the NRC staff discussed with NuScale and Target Rock personnel the potential for the main valve filter to be blocked by debris. Target Rock personnel considered that such blockage would not have a significant effect on the capability of the main valve to open. NuScale should demonstrate that the blocking of the main valve filter is not credible for the ECCS valve to support the DC application.

Initial: Failure mode 6-8-17 relates to the potential clogging of the filter assembly with debris that could cause inadvertent main valve opening. The FMEA specifies this failure mode as low significance.

> Update: During the onsite audit, the NRC staff discussed the potential clogging of the filter assembly with NuScale and Target Rock personnel. NuScale should demonstrate the performance of the control orifice and filter for the safety function of the ECCS valves to support the DC application.

Initial: Section 3.7.1 states that the main disc feed orifice filter has a large area to mitigate debris. What are the plans to demonstrate that the filter design is adequate?

> Update: During the onsite audit discussions, NuScale personnel stated that the orifice filter for the main valve will be sized based on Target Rock experience with filters in nuclear service. NuScale personnel considered the RCS to be sufficiently pure to avoid filter problems. With respect to boron precipitation, NuScale personnel stated that the filter will be above the melting temperature of boron (approximately 330°F) such that boron will not block the filter. NuScale personnel discussed the plan to flush the main valve orifice filter with the chemical volume and control system (CVCS) prior to plant startup with reliance on the purity of the CVCS fluid to avoid filter problems. Based on the onsite audit discussions, NuScale should document its justification for the performance of the main valve orifice filter to support the NuScale DC application.

Index No. (NuScale letter LO-0918-61910)**: 47, 53, 57**

<u>Response:</u>

As a precaution, a filter is provided on the ECCS main valve disc which prevents foreign material from entering the main valve control chamber, trip line, and trip valves. The control orifice allows the ECCS valves to accommodate low levels of trip valve leakage during plant operations as fluid low through the trip valve can be made up through the control orifice however the control orifice is sufficiently small the main valve chamber depressurizes when the trip valve is opened enabling the main valve to actuate to the open position. Filter performance does not affect the ability of the ECCS valves to actuate to the open position when demanded. A clogged filter does not prevent or degrade actuation of the ECCS valves to the open position when demanded, the hydraulic opening forces do not rely on flow through the main valve disc port. A clogged filter would limit the amount of trip valve leakage that could be accommodated. The filter surface area is many times greater than the flow area of the control orifice, therefore a significant amount of blockage can be accommodated before flow through the control orifice would be affected.

The fluid which interfaces with the ECCS valves is reactor coolant which has chemistry controls as described in FSAR 5.2.3.2.1. Reactor coolant is sampled routinely and impurities are measured and controlled. NuScale's primary chemistry control program will be based on the EPRI Primary Water Chemistry Guidelines (COL Item 5.2-4). Revision 7 of the EPRI Primary Water Chemistry Guidelines recommends that suspended solids should be less than 350 ppb during startup and less than 10 ppb is typically observed during normal power operation. In NuScale engineering documents, the valve orifice filter is specified to be a micron filter and reactor coolant is purified by the NuScale chemical and volume control system filters to 0.1-15 microns. Although the ECCS DCA demonstration testing to be performed in May-June 2019 does not address filter performance, it addresses performance of the ECCS valve system in a boric acid solution environment.

The ECCS valve hydraulic lines are discharged during each shutdown of the reactor when the ECCS valves are opened once containment is flooded in preparation for refueling. The ECCS valve hydraulic lines are filled with CVCS supplied coolant during the startup process when the ECCS valves are closed to establish the reactor coolant pressure boundary. The hydraulic lines can be further flushed with purified coolant from CVCS once the ECCS valve are closed by opening the reset solenoid valve to send CVCS supplied fluid to the ECCS main valve where the flow exits the main valve control orifice into the reactor coolant system. See RAI 9189, question 09.03.04-7 (response submitted 2/8/18) for additional information on chemistry of fluid in the ECCS hydraulic lines and reactor coolant chemistry control requirements which are applicable to fluid in the ECCS hydraulic lines.