RAIO-0218-58506

February 05, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 305 (eRAI No. 9194) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 305 (eRAI No. 9194)," dated December 19, 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. 9194:

- 09.03.04-8
- 09.03.04-9
- 09.03.04-10
- 09.03.04-11
- 09.03.04-12
- 09.03.04-13

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

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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9194

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9194

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

eRAI No.: 9194
Date of RAI Issue: 12/19/2017

NRC Question No.: 09.03.04-8

Regulatory Basis (applies to all questions in this RAI):

Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, General Design Criteria (GDC) 14 "Reactor Coolant Pressure Boundary," requires assurance that the reactor coolant pressure boundary (RCPB) have an extremely low probability of abnormal leakage, rapidly propagating failure, and of gross rupture. 10 CFR Part 52.47 requires that a standard design certification submitted for approval under 10 CFR Part 52 shall "contain a level of design information sufficient to enable the Commission … to reach a final conclusion on all safety questions associated with the design." As described below, additional information is needed in the NuScale application for the staff to reach a safety finding.

DCD Tier 2, FSAR section 9.3.4, "Chemical and Volume Control System [CVCS]," addresses how the CVCS controls reactor coolant purity levels. The RCPB materials, and the impact of the reactor coolant chemistry on the materials, are discussed in FSAR section 5.2.3.2.1, "Reactor Coolant Chemistry."

Design Specific Review Standard (DSRS) 9.3.4, "Chemical and Volume Control System," Section II, "Acceptance Criteria," discusses compliance with GDC 14 in item 4 under the "Technical Rationale." The DSRS states that meeting the requirements of GDC 14 provides assurance that the probability of corrosion-induced failure of the RCPB will be minimized. FSAR Section 3.1.2.5, "Criterion 14 – Reactor Coolant Pressure Boundary," states that the NuScale design conforms to GDC 14 and cites FSAR Section 9.3 as a relevant section. FSAR Section 9.3.4.3, "Safety Evaluation," states that the CVCS is not required to assure the integrity of the RCPB due to compliance with NuScale Principal Design Criterion (PDC) 27, "Combined Reactivity Control Systems Capability," GDC 28, "Reactivity Limits," and GDC 29, "Protection Against Anticipated Operational Occurrences." However, compliance with PDC 27, GDC 28, and GDC 29 does not address the possibility of the corrosion-induced failure of the RCPB. NuScale PDC 27 ensures that the combined capabilities of the reactivity controls systems can reliably control reactivity changes under postulated accident conditions. GDC 28 ensures that reactivity controls systems have appropriate limits on the potential amount and rate of reactivity increase to ensure that postulated reactivity accidents do not damage the RCPB. GDC 29 ensures that protection and reactivity control systems have an extremely high probability to accomplish their safety functions during an anticipated operational occurrence. None of these design criteria address the prevention of corrosion-induced failure. Therefore, the staff requests the applicant provide the basis for ensuring compliance with GDC 14 with respect to the possibility of corrosion-induced failure of the RCPB.

NuScale Response:

The GDC 14 paragraph in FSAR Section 9.3.4.1 indicates that the chemical and volume control system is provided with design features necessary to maintain reactor coolant chemistry within specified levels and thereby minimize the probability of corrosion-induced failure of reactor coolant pressure boundary components. The second paragraph of FSAR Section 9.3.4.3 has been revised to delete unnecessary text and the GDC 14 paragraph in FSAR Section 9.3.4.3 has been revised to provide a pointer to FSAR Section 3.1 for additional discussion of GDC 14.

Impact on DCA:

FSAR Section 9.3.4.3 has been revised as described in the response above and as shown in the markup provided in this response.

supply pump. This provides CVCS with the capability to supply high pressure makeup fluid to any one NPM at a time through the normal injection and spray paths if required for use in a beyond design basis event.

Boron Addition System Off-Normal Operations

Off-normal operation of the BAS is required when failure or maintenance of SSC disrupts normal system operations. The BAS is designed with features to provide operational flexibility when responding to off-normal events. These features include the BAST bypass line, the ability to manually control actuated components through the PCS, and manual valves to isolate components or direct flow in the system.

The BAST bypass line makes it possible for the boric acid supply pumps to supply borated water from the batch tank directly to CVCS or transfer it into the BAST via the storage tank recirculation line. The bypass line also allows mixture in the BAST to be pumped back into the batch tank, if needed.

9.3.4.3 Safety Evaluation

The CVCS and BAS operate together to satisfy GDC 26 as the second reactivity control system capable of controlling the rate of reactivity changes resulting from planned, normal power changes (including xenon burnout) to assure acceptable fuel design limits are not exceeded. However, there is no design basis event for which boron addition via the CVCS and BAS is relied upon (in lieu of the safety-related control rods).

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~~When considered together with PDC 27 and GDCs 28 and 29 as discussed below, it is concluded that the CVCS, MHS and BAS are not required to assure:~~

- ~~the integrity of the reactor coolant pressure boundary~~
- ~~the capability to shut down the reactor and maintain it in a safe shutdown condition~~
- ~~the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in 10 CFR 50.34(a)(1) or 10 CFR 100.11~~

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~~Therefore the~~The CVCS, MHS, and BAS are nonsafety-related systems. However, the CVCS is equipped with two automatic, safety-related, fail-closed, demineralized water isolation valves to ensure CVCS operation does not inadvertently cause a dilution of the RCS boron concentration. See Section 4.3 for additional discussion of GDC 26.

Consistent with GDC 1, CVCS, MHS and BAS SSC are designed, fabricated, erected, and tested to appropriate quality standards such that their failure does not impact the function of other safety-related or risk significant systems. The safety-related CVCS demineralized water isolation valves and associated piping are Quality Group C per RG 1.26. The CVCS piping and components outboard of the CIVs up to the next valve that is normally closed or capable of automatic closure are also Quality Group C. Other SSC the MHS and BAS does not adversely affect an orderly shutdown and cooldown of the remaining NPMs.

Component or control system failures or improper operation could result in low boron concentration makeup water resulting in unintended dilution of the boron concentration in the RCS. This dilution event is classified as an AOO. Consistent with GDC 10 and GDC 21, the most probable dilution source of this AOO is isolated by two series, safety-related, fail-closed, single failure proof isolation valves located in the common demineralized water/LRWS water flow path to the CVCS makeup three way combining valve. Automatic closure of either demineralized water isolation valve via the MPS closes the supply of this inadvertent dilution source to the three way combining valve. MPS actuation occurs based on the capability of nuclear instrumentation to detect the effects of the dilution on the reactor. Under conditions of low RCS flow when the effects of the dilution are delayed and more difficult to detect, the demineralized water isolation valves are interlocked to prevent opening or by closing the valves if a low RCS flow condition develops when the valves are open. Also consistent with GDC 21, design of the CVCS supports full testing of the valves with the NPM at power.

GDC 13 was considered in the design of the CVCS, MHS, and BAS. These systems do not have safety-related instrumentation. MPS instrumentation closes the CVCS demineralized water isolation valves to prevent or terminate a dilution event.

RAI 09.03.04-8, RAI 09.03.04-11

GDC 14 was considered in the design of the CVCS. The CVCS maintains acceptable purity levels in the reactor coolant through the removal of insoluble corrosion products and dissolved ionic material by filtration and ion exchange. The CVCS provides an interface with the PSS to permit analysis of the chemistry conditions in the RCS. The CVCS is able to correct out of specification chemistry conditions that may over time challenge the material properties of the reactor coolant pressure boundary. See Section 3.1 for additional discussion of GDC 14. Out of specification chemistry in the RCS does not typically require immediate corrective actions except for severe out of specification chemistry conditions (Action level 3) in the Electric Power Research Institute (EPRI) 3002000505 Pressurized Water Reactor Primary Water Chemistry Guidelines, Reference 9.3.4-1. EPRI Action Level 2 and Action Level 1 conditions require correction within 24 hours and 7 days, respectively. A CVCS purification flow of 22 gpm is sufficient to allow correction of chemistry impurities from Action Level ~~3 thresholds~~2 concentrations to below the Action Level 2 ~~thresholds~~threshold within the 24 hour EPRI guidelines requirement.

PDC 27 was considered in the design of the CVCS and BAS. Due to the unique features of the NPM, the control rods alone, with no credit for boron from CVCS, have sufficient reactivity control capability under postulated accident conditions (with appropriate margin for stuck rods) to assure that the capability to cool the core is maintained. See Section 4.3 for additional discussion of PDC 27.

Consistent with GDC 28, the potential rate and amount of reactivity insertion due to a CVCS dilution event is limited by the maximum CVCS injection rate and the demineralizer water supply isolation valve closure based on analytical limits. This

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eRAI No.: 9194
Date of RAI Issue: 12/19/2017

NRC Question No.: 09.03.04-9

The supplement dated August 3, 2017 (ADAMS Accession No.ML17215A977), stated that the NuScale Primary Water Chemistry Program would be “based on” the EPRI Primary Water Chemistry Guidelines (EPRI Guidelines). The staff requests additional information on the phrase “based on.” Specifically, the applicant should provide a discussion to clarify whether a primary water chemistry program that is “based on” the EPRI guidelines meets the “Mandatory” and “Shall” elements of the EPRI Guidelines. In order to clarify the licensing basis for the Nuscale design, the staff requests the following information:

1. Confirm that the NuScale Primary Water Chemistry Program will follow the “Shall” and “Mandatory” elements as described in the EPRI Guidelines, and revise the FSAR to reflect this. If the “Shall” and “Mandatory” elements of the EPRI Guidelines will not be met, provide the technical basis for not following these parts of the EPRI Guidelines and how RCPB integrity will be ensured with respect to corrosion-induced failure.
2. The supplement did not add any detail on the diagnostic parameters as described in the EPRI Guidelines. State the parameters and associated limits to be monitored, or reference the appropriate tables from the EPRI Guidelines. In addition, update the relevant tables in the FSAR to reflect the information provided in this response.
3. The NuScale FSAR states that the Combined License (COL) Applicant will be responsible for developing a site-specific pH Control Program. Confirm that this program must follow the guidance provided in Table 3-1 of the EPRI Guidelines and provide a pH and lithium range for all operational modes, and add a COL Item that specifies the COL Applicant must develop a pH Control Program that follows the latest revision of the EPRI Guidelines, and fuel vendor recommendations. In addition, update the relevant section(s) of the FSAR to reflect the information provided in this response.

NuScale Response:

Question (1):

The supplement dated August 3, 2017 (ADAMS Accession No. ML17215A977) provided FSAR changes including changes to FSAR Section 5.2.3.2.1, "Reactor Coolant Chemistry." FSAR Section 5.2.3.2.1 states, “The water chemistry program is based on industry guidelines as described in Electric Power Research Institute Technical Report 3002000505, Pressurized Water Reactor Primary Water Chemistry Guidelines, (Reference 5.2-3).” The EPRI PWR Primary Water Chemistry Guidelines describes the framework for developing an optimized chemistry program in Chapter 4, Methodology for Plant-Specific Optimization. Chapter 4 contains underlined statements which read, “This section outlines the documentation which each utility must develop to define a Strategic Water Chemistry Plan. Development and maintenance of the Strategic Water Chemistry Plan is a mandatory requirement of these Guidelines per NEI 03-08 and NEI 97-06."

COL Item 5.2-4 requires that, ”A COL applicant that references the NuScale Power Plant design certification will develop and implement a Strategic Water Chemistry Plan. The Strategic Water Chemistry Plan will provide the optimization strategy for maintaining primary coolant chemistry and provide the basis for requirements for sampling and analysis frequencies, and corrective actions for control of primary water chemistry consistent with the latest version of the Electric Power Research Institute Pressurized Water Reactor Primary Water Chemistry Guidelines.”

The optimization strategy described in the EPRI Guidelines requires plants to adopt the “site-specific chemistry limits within the bounds established in Table 3-1 (the Principles table) and Table 3-3, Table 3-7, and Table 3-8 (the Control tables), as well as the Action Level 1, 2 and 3 responses in Chapter 3” to ensure RCPB and fuel cladding integrity. If a plant decides not to implement a shall parameter and its associated action levels as described in the EPRI Guidelines, then a deviation “shall be handled in accordance with the guidance in the current revision of the Steam Generator Management Program (SGMP) Administrative Procedures” as directed by Chapter 1, Introduction and Management Responsibilities, of the EPRI Guidelines. A NuScale plant will follow the “mandatory” and “shall” elements as described in the EPRI guidelines or process a deviation to the element as described by the EPRI Guidelines.

Chapter 1 of the EPRI Guidelines also states that, "With respect to the advanced nuclear technology designs, the current guidelines are being evaluated for applicability to new plants. Any changes identified based on this evaluation will be issued as Interim Guidance and incorporated in the next revision to these guidelines.” This review for the NuScale design has not been performed yet. NuScale expects that their SMR design differences (i.e., lack of a SG blowdown system, lack of reactor coolant pumps) will require changes to the current EPRI guidelines to address these differences. In the event that this evaluation has not been performed at the time of a NuScale plant licensing, the SGMP administrative procedures for processing a deviation will drive the change to the EPRI Guidelines.

Question (2):

The site specific strategic water chemistry plan will evaluate the diagnostic parameters contained in the current revision of the EPRI PWR Primary Water Chemistry Guidelines at the time of the COL application for inclusion into the optimized chemistry program. Diagnostic parameter tables are listed in Chapter 3 and identified in Chapter 5 (Section 5.2.3) of the current revision of the EPRI PWR Primary Water Chemistry Guidelines referenced in the DCA (Reference 5.2-3). The plant specific chemistry control procedures will implement those diagnostic parameters including recommended limits and sampling frequencies as well as any additional diagnostic parameters recommended by the fuel vendor. Any exceptions (deviations) to implementing the diagnostic parameters listed in the EPRI Guidelines will be identified and documented in the plant specific strategic water chemistry plan as directed by the EPRI PWR Primary Water Chemistry Guidelines.

Question (3):

Development of a plant specific pH control program consistent with the requirements of EPRI Guidelines Table 3-1 including fuel vendor recommendations defining lithium and pH_T limitations is a “shall” parameter as defined by the EPRI Guidelines and is required by the COL applicant per existing COL Item 5.2-4. Development of a program outside the “Principles” specified in Table 3-1 will be a deviation to a control parameter and will require that the plant provide a technical justification for the deviation and process that deviation “…in accordance with the guidance in the current revision of the Steam Generator Management Program (SGMP) Administrative Procedures” as directed by Chapter 1 of the EPRI Guidelines.

Impact on DCA:

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

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Response to Request for Additional Information
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eRAI No.: 9194
Date of RAI Issue: 12/19/2017

NRC Question No.: 09.03.04-10

DCD Tier 2, FSAR Section 9.3.4 addresses the chemical volume and control system (CVCS) which controls reactor coolant purity levels. DCD Tier 2, FSAR section 5.2.3.2.1 addresses reactor coolant chemistry. In Figure 9.3.4-1, “Chemical and Volume Control System Diagram,” it appears that there is piping that can connect the CVCSs for up to 6 NuScale Power Modules (NPMs) via the module heatup system.

What physical measures, or other controls, are in place to prevent impurities in the reactor coolant from one module from impacting the chemistry of the reactor coolant in a different module?

Additionally, if the CVCSs can be interconnected via other means not shown in Figure 9.3.4-1, describe the interconnections and address how impurities in one NPM may impact the reactor coolant chemistry in a different NPM.

Revise the DCD Tier 2 FSAR, as necessary, to reflect any ways the CVCSs may be interconnected and the controls in place to prevent impurities in the reactor coolant from one module from impacting the reactor coolant in a different module.

NuScale Response:

The module heatup system (MHS) interface with the chemical volume and control system (CVCS) is the only interface in which reactor coolant could be potentially passed from one NuScale Power Modules (NPM) to another. As described in FSAR 9.3.4.2.2, each MHS to CVCS interface is provided with double isolation valves with pressure indication and a drain valve in between to detect and troubleshoot CVCS to MHS intersystem leakage. As described in FSAR 9.3.4.2.3, the normal operating mode of the MHS is reactor startup. During times when the MHS is not required for service the system is isolated from the CVCS by the two isolation valves on each supply and return line and monitored for leakage. FSAR 9.3.4.2.3 has been revised to indicate that the fail-closed double isolation valves between each MHS to CVCS interface are de-energized when the MHS is not in use for a NPM.

Impact on DCA:

FSAR Section 9.3.4.2.3 has been revised as described in the response above and as shown in the markup provided in this response.

The BAS boric acid batch tank is used to produce borated water from dry boric acid powder delivered by the hopper and demineralized water. The tank is outfitted with a tank mixer, discussed below, to facilitate complete dissolution of the acid, and instrumentation for control and monitoring of tank level. Viewing ports are provided near the bottom of the batch tank to allow visual inspection of the bottom of the tank and the screen.

Boron Addition System Boric Acid Batch Tank Mixer

A motor driven BAS boric acid batch tank impeller mixer is mounted to the batch tank to completely and uniformly dissolve boric acid in demineralized water.

Boron Addition System Boric Acid Transfer Pump

The BAS boric acid transfer pump recirculates the solution of borated water in the batch tank to facilitate mixing and accurate sampling and transfers mixed solutions of borated water from the batch tank to the storage tank.

Boron Addition System Boric Acid Storage Tank

One BAST is provided to store borated water for use by the CVCS and SFPCS. The BAST and batch tank capacities are conservatively sized and include sufficient quantity to support a 12 NPM shutdown with conservative RCS boron concentration requirements.

Boron Addition System Boric Acid Supply Pumps

Two BAS boric acid supply pumps are provided to supply borated water to the CVCS and SFPCS. The pumps normally supply borated water from the BAST; however the system is designed to allow the pumps to draw from either the BAST or the batch tank. The pumps can also be used to recirculate the inventory of the BAST or transfer inventory from the batch tank to the BAST.

9.3.4.2.3 System Operation

The CVCS is used during normal operations except for refueling when the NPM is disconnected from the CVCS. The CVCS is used to establish the boron concentration necessary to make mode changes and to modulate reactor power. The CVCS has sufficient makeup and letdown capacity to supply borated water to the RCS and maintain RCS water inventory within the allowable pressurizer level range for normal modes of operation.

RAI 09.03.04-10

The MHS design precludes boron dilution via intersystem leakage by providing double isolation valves with drains and pressure monitoring between the isolation valves. The normal operating mode of the MHS is reactor startup. During times when the MHS is not required for service the system is isolated from the CVCS by the two isolation valves on each supply and return line and monitored for leakage.

The fail-closed double isolation valves between each MHS to CVCS interface are de-energized when the MHS is not in use for a NPM.

Borated water supply from the BAS to the CVCS, then into the RCS, can be used to add negative reactivity to the core during normal operations. The boron concentration is increased by discharging reactor coolant to the LRWS while making up coolant with borated water from the BAS.

Chemical and Volume Control System Normal Operations

The normal modes of operation for the CVCS are as follows:

- reactor startup using MHS
- coolant purification
- chemistry control
- chemical shim adjustment
- volume control
- pressurizer spray
- pressurizer venting

These CVCS normal operating modes can be summarized as reactor startup mode and chemical and volume control mode. Reactor startup mode using the CVCS and MHS is utilized when the decay heat from the core is inadequate to heat the coolant to startup temperatures or inadequate to generate the minimum required RCS flow. The chemical and volume control mode is responsible for purifying the reactor coolant, adjusting reactor coolant chemistry (including boron concentration), providing makeup and letdown for coolant volume changes, and providing pressurizer spray flow.

Reactor Startup Using Module Heatup System

CVCS startup requires that valves are properly aligned and lines and equipment are water solid. The pressurizer is pressurized with nitrogen using the RPV high point degasification line to provide the necessary net positive suction head for the recirculation pumps.

To start the MHS, one or both CVCS recirculation pumps must be operating. The MHS is placed in service by opening the two supply and return isolation valves which normally separate the MHS from the CVCS and by closing the MHS diverting isolation valve. Auxiliary boiler system steam is supplied to the module heatup heat exchangers at pressure less than or equal to CVCS pressure.

The MHS heats the RCS to assist in developing natural circulation through the core prior to nuclear heat addition. The action of injecting high temperature water into the riser compared to the cooler water in the downcomer of the RPV initiates RCS flow. The heat addition of the module heatup heat exchangers is also sufficient to

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Date of RAI Issue: 12/19/2017

NRC Question No.: 09.03.04-11

DCD Tier 2, FSAR Section 9.3.4.3, "Safety Evaluation," discusses the GDCs, their applicability to the NuScale design, and how the GDCs are met by the NuScale design.

In the discussion for GDC 14, the applicant stated that the CVCS provides the ability to correct the reactor coolant system (RCS) water chemistry from the EPRI Guidelines "…Action Level 3 thresholds to Action Level 2 thresholds within the 24 hour EPRI guidelines."

The statement in FSAR Section 9.3.4.3 seems inconsistent with the EPRI Guidelines. Therefore, NRC staff requests that the applicant verify:

1. That the CVCS has the capacity to reduce water chemistry values exceeding Action Level 2 limits to below the Action Level 2 threshold within 24 hours; and
2. That if a parameter exceeds an Action Level 3 value, that the licensee shall immediately initiate an orderly unit shutdown.

Revise the DCD Tier 2 FSAR, as necessary, to reflect the information provided in the response to the questions above.

NuScale Response:

Question (1):

The Chemical and Volume Control System has the capacity to reduce reactor coolant chemistry impurity values from Action level 2 concentrations to below the Action Level 2 threshold concentration in 24 hours as required by the EPRI PWR Primary Water Chemistry Guidelines in order to maintain full power operation. The GDC 14 paragraph of FSAR Section 9.3.4.3 has been revised to provide the required clarification.

Question (2):

Entry into Action Level 3 parameter values will require a unit shutdown as directed by the EPRI PWR Primary Water Chemistry Guidelines. The GDC 14 paragraph of FSAR Section 9.3.4.3

states that, “Out of specification chemistry in the RCS does not typically require immediate corrective actions except for severe out of specification chemistry conditions (Action level 3) in the Electric Power Research Institute (EPRI) 3002000505 Pressurized Water Reactor Primary Water Chemistry Guidelines, Reference 9.3.4-1.”

Impact on DCA:

FSAR Section 9.3.4.3 has been revised as described in the response above and as shown in the markup provided in this response.

the MHS and BAS does not adversely affect an orderly shutdown and cooldown of the remaining NPMs.

Component or control system failures or improper operation could result in low boron concentration makeup water resulting in unintended dilution of the boron concentration in the RCS. This dilution event is classified as an AOO. Consistent with GDC 10 and GDC 21, the most probable dilution source of this AOO is isolated by two series, safety-related, fail-closed, single failure proof isolation valves located in the common demineralized water/LRWS water flow path to the CVCS makeup three way combining valve. Automatic closure of either demineralized water isolation valve via the MPS closes the supply of this inadvertent dilution source to the three way combining valve. MPS actuation occurs based on the capability of nuclear instrumentation to detect the effects of the dilution on the reactor. Under conditions of low RCS flow when the effects of the dilution are delayed and more difficult to detect, the demineralized water isolation valves are interlocked to prevent opening or by closing the valves if a low RCS flow condition develops when the valves are open. Also consistent with GDC 21, design of the CVCS supports full testing of the valves with the NPM at power.

GDC 13 was considered in the design of the CVCS, MHS, and BAS. These systems do not have safety-related instrumentation. MPS instrumentation closes the CVCS demineralized water isolation valves to prevent or terminate a dilution event.

RAI 09.03.04-8, RAI 09.03.04-11

GDC 14 was considered in the design of the CVCS. The CVCS maintains acceptable purity levels in the reactor coolant through the removal of insoluble corrosion products and dissolved ionic material by filtration and ion exchange. The CVCS provides an interface with the PSS to permit analysis of the chemistry conditions in the RCS. The CVCS is able to correct out of specification chemistry conditions that may over time challenge the material properties of the reactor coolant pressure boundary. See Section 3.1 for additional discussion of GDC 14. Out of specification chemistry in the RCS does not typically require immediate corrective actions except for severe out of specification chemistry conditions (Action level 3) in the Electric Power Research Institute (EPRI) 3002000505 Pressurized Water Reactor Primary Water Chemistry Guidelines, Reference 9.3.4-1. EPRI Action Level 2 and Action Level 1 conditions require correction within 24 hours and 7 days, respectively. A CVCS purification flow of 22 gpm is sufficient to allow correction of chemistry impurities from Action Level ~~3 thresholds~~2 concentrations to below the Action Level 2 ~~thresholds~~threshold within the 24 hour EPRI guidelines requirement.

PDC 27 was considered in the design of the CVCS and BAS. Due to the unique features of the NPM, the control rods alone, with no credit for boron from CVCS, have sufficient reactivity control capability under postulated accident conditions (with appropriate margin for stuck rods) to assure that the capability to cool the core is maintained. See Section 4.3 for additional discussion of PDC 27.

Consistent with GDC 28, the potential rate and amount of reactivity insertion due to a CVCS dilution event is limited by the maximum CVCS injection rate and the demineralizer water supply isolation valve closure based on analytical limits. This

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eRAI No.: 9194
Date of RAI Issue: 12/19/2017

NRC Question No.: 09.03.04-12

In DCD Tier 2, FSAR Section 9.3.4.2.1, “Chemical Volume and Control System,” the applicant discusses the CVCS ion exchangers and their operation. In order for the NRC staff to determine if the CVCS has adequate capacity to maintain primary water purity, the following information is requested.

Provide the capacity of the ion exchangers (i.e., will the resin last days/weeks/months) and the amount of flow each ion exchanger can handle relative to total RCS flow.

Revise the DCD Tier 2 FSAR as necessary to reflect the information provided in the response to the questions above.

NuScale Response:

As listed in FSAR Table 9.3.4-1, the resin volume of each of the CVCS ion exchangers is a minimum of 8.8 ft^3. Ionic purification through the resin beds is effective from 1-5 gpm/ft^3 based on industry water treatment literature [Crittenden, et. Al. Water treatment Principles and Design, 2nd Edition, 2005] and resin vendor data. Therefore, the service flow rate capacity of the CVCS ion exchangers with 8.8 ft^3 resin is at least 44 gpm. As stated in Section 9.3.4.3, in the discussion of GDC 14, a flow of 22 gpm is sufficient to reduce reactor coolant chemistry impurities from Action Level 2 concentrations to below the Action Level 2 threshold within 24 hours (see the response to RAI 9194, Question 09.03.04-11).

This CVCS ion exchanger flow capacity (based on resin volume) in combination with the reactor coolant system (RCS) volume and flow rates provided in FSAR Table 5.1-1 and Table 5.1-2 can be used to determine the reactor coolant purification turnover time and ratio of CVCS purification flow to reactor coolant core flow. The CVCS ion exchanger flow capacity ratio compared to RCS flow and RCS total volume is consistent with industry PWR designs. The resin capacity, the resin flow capacity, and the quantity of CVCS ion exchangers provide operational flexibility with respect to resin life.

No additional FSAR change is required as a result of this response as sufficient information is provided in the FSAR Section and FSAR Tables cited to determine that the CVCS has adequate capacity to maintain primary water purity.

Impact on DCA:

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

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eRAI No.: 9194
Date of RAI Issue: 12/19/2017

NRC Question No.: 09.03.04-13

In DCD Tier 2, FSAR section 9.3.4.2.1, “Chemical Volume and Control System,” the applicant discusses the water chemistry parameters that are required to be controlled as per the EPRI Guidelines. FSAR Table 9.3.2-1, “Primary Sampling System Normal and Post-Accident Sample Points,” lists the primary water chemistry parameters that will be monitored. However, the NRC staff notes that there are discrepancies between the primary water chemistry control parameters and the parameters that will be monitored. In order for the primary water chemistry parameters to be controlled within the acceptable limits these parameters will need to be monitored on the appropriate frequency. Therefore, the staff requests that the applicant either add the control parameters and testing frequency required by the EPRI Guidelines to FSAR Table 9.3.2-1, or address the discrepancy between FSAR section 9.3.4.2.1 and FSAR Table 9.3.2-1.

NuScale Response:

FSAR Table 9.3.2-1 has been revised to include additional RCS control parameters (chloride, fluoride, sulfate, and lithium) from the EPRI PWR Primary Water Chemistry Guidelines. FSAR Table 9.3.2-1, Note 1, indicates that monitoring frequencies will be specified in plant procedures. These plant procedures are developed by the COL applicant per COL Item 5.2-4.

Impact on DCA:

FSAR Table 9.3.2-1 has been revised as described in the response above and as shown in the markup provided in this response.

RAI 09.03.04-13

Table 9.3.2-1: Primary Sampling System Normal and Post-Accident Sample Points

Sample Points	System	Process Fluid Type	Sampling Methods	Analysis[1]
Chemical and volume control system (CVCS) suction line from RCS, upstream of CVCS purification equipment	CVCS	liquid	continuous semi-continuous[2] grab[3]	dissolved hydrogen, dissolved oxygen, conductivity chloride, fluoride, sulfate lithium
CVCS sample point downstream of purification equipment	CVCS	liquid	grab	
CVCS injection line to RCS	CVCS	liquid	grab	

Notes:

1. Specific analyses, limits, and monitoring frequencies will be specified in plant procedures.
2. Semi-continuous (i.e., intermittent) analyses are performed by the applicable ion chromatography analysis unit provided in the hot lab.
3. Normal and post-accident sampling.