June 19, 2020 Docket No. PROJ0769

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC "Submittal of Errata to Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 2

REFERENCE: Letter from NuScale to NRC, NuScale Power, LLC Submittal of the "Loss-of-Coolant Accident Evaluation Model, TR-0516-49422, Revision 2," dated May 27, 2020 (ML201448T471)

During an audit teleconference with NRC Staff, NuScale Power, LLC (NuScale) discussed potential updates to the "Loss-of-Coolant Accident (LOCA) Evaluation Model," TR-0516-49422, Revision 2. As a result of this discussion, NuScale provides this errata to the topical report. The Enclosure to this letter provides a mark-up of the report pages incorporating revisions in redline/strikeout format. NuScale will include this change as part of finalization of the approved topical report.

Enclosure 1 is the proprietary version of the "Submittal of Errata to 'Loss-of-Coolant Accident Evaluation Model,' TR-0516-49422, Revision 2." NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the revised pages of the topical report.

The topical report TR-0516-49422, "Loss-of-Coolant Accident Evaluation Model" contains export controlled information. The markup pages in the enclosure are therefore labeled "Export Controlled," although these markups pages do not contain any export controlled information.

This letter makes no regulatory commitments or revisions to any existing regulatory commitments.

If you have any questions, please feel free to contact Rebecca Norris at 541-452-7539 or at RNorris@nuscalepower.com.

Sincerely,

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

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Enclosure 1: "Revised pages for Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 2, proprietary version
Enclosure 2: "Revised pages for Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 2, nonproprietary version
Enclosure 3: Affidavit of Zackary W. Rad, AF-0620-70501

Enclosure 1:

"Revised pages for Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 2, proprietary version

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Enclosure 2:

"Revised pages for Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 2, nonproprietary version

The secondary side is operated such that the SGs remove the heat generated by the reactor core. The DHRS heat exchangers are isolated from the steam line and do not remove heat during normal operation.

The containment is evacuated during normal operation to provide an insulated barrier between the reactor and containment; no physical RPV insulation is present inside containment.

3.3 Safety-Related System Operation

The NuScale Module Protection System (MPS) is composed primarily of the reactor trip system and the engineered safety features actuation system. The MPS protection functions are limited to automated safety responses to off-normal conditions. The MPS functional response to an initiating event is a reactor trip; isolation (as necessary) of main feedwater, main steam, CVCS, and containment; followed by an integrated safety actuation of one or more of the passive safety-related systems (DHRS and ECCS). Containment isolation is achieved by closing of the following containment isolation valves:

- CVCS isolation valves
  - CVCS makeup line
  - CVCS letdown line
  - CVCS pressurizer spray supply line
  - CVCS high point degasification line,
- reactor component cooling water system isolation valves
- main steam system isolation valves
- feedwater system isolation valves
- containment flood and drain system isolation valves
- containment evacuation system isolation valves

Dual safety-related isolation valves are installed on piping for the CVCS, containment evacuation system, containment flood and drain system, and reactor component cooling water system. There is one safety-related containment isolation valve in the main steam and feedwater piping penetrating containment with a redundant nonsafety-related isolation valve for each safety-related valve.

The reactor trip system consists of four independent separation groups with independent measurement channels to monitor plant parameters that can generate a reactor trip. Each measurement channel trips when the parameter exceeds a predetermined setpoint.

The engineered safety features actuation system also consists of four independent separation groups with independent measurement channels that monitor plant parameters that activate the operation of the engineered safety features.

ECCS is actuated by MPS on high CNV level (interlocked with RCS hot temperature and pressurizer level) or low RCS pressure (interlocked with RCS hot temperature and CNV pressure). High CNV level or low RCS pressure are primary indications of a LOCA event. Interlocks are designed to prevent ECCS actuations for expected operational conditions or non-LOCA transients.

3.3.1 Emergency Core Cooling System

The ECCS is a two-phase natural circulation system that maintains a liquid water supply to the core during its operation in a LOCA scenario. This results in a collapsed liquid level in the RPV that is above the top of the core.

The ECCS consists of three independent RVVs and two independent RRVs. It is initiated by simultaneously actuating the RVVs on the top of the RPV in the pressurizer region and the RRVs on the side of the RPV in the downcomer region. The RRVs are designed to provide a low-resistance flow path for coolant to flow from the CNV into the RPV. The RVVs are designed to equalize pressure between the two vessels allowing steam from the reactor to vent to the containment and to provide hydrostatic equalization that allows coolant flow through the RRVs back into the reactor.

The ECCS actuation creates a steam flow path from the pressurizer to the containment and an RPV downcomer flow path to and from containment.

The RPV depressurizes due to liquid and steam exiting the ECCS valves. Steam entering containment is condensed on the containment wall, which in turn is cooled by the reactor pool. Initially, the containment pressure will increase to a peak, and then decrease as flow from the RPV decreases and heat is transferred from the CNV to the reactor pool. The RPV water inventory decreases while the containment level increases due to inventory transferred from the RPV.

As the pressure between the two vessels reach a near-equilibrium condition, the collapsed liquid level in the containment rises to a level higher than the RRV elevation, creating enough static head to overcome the pressure difference between the RPV and CNV. At this point, the condensed liquid in containment enters the RPV through the RRVs while steam exits the RPV through the RVVs. This stable process continues maintaining a collapsed water level above the top of the active fuel.

All ECCS valves are equipped with an inadvertent actuation block (IAB), the feature that prevents spurious opening of the ECCS valves at full operating pressure. The IAB prevents the valves from opening when the differential pressure between the RPV and CNV is greater than the IAB threshold pressure setpoint. After the IAB has blocked a spurious opening of the ECCS valve, it allows the valve to open only after the differential pressure between the RPV and CNV has decreased below the IAB release pressure setpoint.

The ECCS valves will also open on low differential pressure between the RPV and CNV, independent of an ECCS actuation signal. This action is a function of the mechanical design of the valves, where the valve spring will cause the valves to open if the pressure

The PIRT panel divided the NPM LOCA scenarios into two phases for the phenomena identification:

LOCA blowdown (Phase 1a)

Phase 1a begins with a postulated breach in the RCS pressure boundary that initiates the blowdown of the RCS into the CNV and ends when the MPS actuates ECCS to open the RVVs and RRVs.

ECCS actuation (Phase 1b)

Phase 1b begins when the MPS actuates ECCS to open the RVVs and RRVs and ends when the recirculation flow is established. The pressures and levels in containment and RPV approach a stable condition (i.e., initiation of long-term cooling).

Example calculations are performed for both steam space and liquid space LOCAs. Steam space breaks depressurize more quickly and generally actuate ECCS on low RCS pressure. Some liquid space breaks also actuate ECCS on low RCS pressure; however, the majority of the liquid space break spectrum actuates ECCS on high CNV level. The progression of the steam and liquid space LOCA events are similar, with the exception of different timing of the sequence of events and the liquid/steam composition of the break flow. The example calculations in this report were completed before the ECCS signal on low RCS pressure was added. The events that actuate earlier on low RCS pressure are less limiting with respect to the acceptance criteria. Therefore, the example calculations in this report are still representative and have conservative results.

4.3 Figures of Merit

The safe operation of the NPM was considered in the primary design phase. This produced a reactor system that protects the fuel using simple passive safety features. The NPM retains sufficient water in the RPV that the core will not be uncovered. For such a system, the LOCA PCT occurs at time zero (normal operating temperature). There is no heatup due to CHF or uncovering the core after event initiation; PCT remains below the 10 CFR 50.46 acceptance criterion of 2,200 degrees Fahrenheit (1,204 degrees Celsius) throughout the event. Hence, PCT is not an FOM for the NuScale PIRT process.

The critical heat flux ratio (CHFR) is an important FOM as it demonstrates there is no significant heatup of the cladding. One of the primary design fundamentals of the NPM is to protect the fuel from a CHF event. Therefore, an assessment of CHF becomes important.

Collapsed liquid level above the core is an additional FOM as it demonstrates there is an adequate supply of liquid water available to the core. Heatup of the fuel will not occur under LOCA conditions as long as the core is covered with coolant and CHF conditions do not exist.

summarized in Section 4. The model describes the key components of the NPM participating in a LOCA, as follows:

- RPV with internals
  - LP
  - reactor core
  - riser including the riser upper plenum
  - upper and lower downcomer
  - pressurizer
- CNV
- SG secondary side with DHRS condensers
- reactor pool
- ECCS valves
- postulated break locations
- RPV internal heat structures and heat structures between components (i.e., RPV to CNV to reactor pool)
- riser holes - this feature location is approximately at the midpoint of the SG but is not included in the noding diagram. Evaluations determined riser holes do not significantly impact LOCA analysis results.

The nodalization diagram of these key components is shown in Figure 5-1. The details of the NRELAP5 NPM model are described in the following sections.

11 precursor groups, and no explicit reactor trip is applied. Instead the model predicts precursor concentrations from the prompt and delayed fissions rate, and so naturally follows fission power.

Sensitivities have determined that the ANS71 option requires careful selection of an additional delay time beyond a reactor trip before activating the power decay to account for post-trip prompt and delayed fissions. This delay time, which depends on control rod insertion speed and reactivity, can be more than {{ }}2(a),(c) seconds. Once the delay is accounted for, both options are consistent for short term LOCA through the first 1000 seconds. Considering the correct response of the ANS73 option without any special evaluation of delay times, the ANS73 option was chosen as the standard choice in the LOCA guideline.

The best-estimate ANS79 actinides model is used to account for heat deposition from actinide decay. The actinide model includes the decay energies from the production and decay of ^{239}U, ^{239}Np, and ^{239}Pu.

5.1.2.3 Riser

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}}2(a),(c)

5.1.2.4 Downcomer

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}}2(a),(c)

Table 5-3. NuScale Power Module safety-related system measurement parameters

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}}2(a),(c)

- Section B.8.1 briefly presents a typical sequence of events for both the inadvertent RVV and RRV opening cases. The RVV event sequence assumes no loss of electrical power, while the RRV event sequence assumes a loss of normal AC and DC power at event initiation. The event sequences show how the availability of normal electric power affects the ECCS timing. The addition of ECCS actuation on low RCS pressure would result in earlier actuation of the remaining ECCS valves for an inadvertent opening of an RVV with power available. For an inadvertent opening of an RRV with power available, the remaining ECCS valves would still open on the high CNV level actuation signal. IORV cases with a loss of all power are unaffected by the addition of the low RCS pressure signal (remaining ECCS valves open at IAB threshold).
- Section B.8.2 presents the matrix of initial condition biases applied to the IORV calculations, the results of which are shown in Sections B.8.3 through B.8.5, and support development of methodology guidance for biasing the initial conditions for IORV analysis cases.
- Section B.8.3 presents analysis results for inadvertent RVV opening for the 17 initial condition biases with no loss of electrical power.
- Section B.8.4 presents analysis results for inadvertent RRV opening for the 17 initial condition biases with no loss of electrical power.
- Section B.8.5 presents analysis results for inadvertent RSV opening for the 17 initial condition biases with no loss of electrical power.
- Section B.8.6 presents analysis results for sensitivity cases on model parameters, including:
  - Fuel rod gap conductance
  - Axial power shape
  - ECCS valve sizing
  - ECCS valve opening rate
  - DHRS availability/credit
  - Assumed single active failures
- Section B.8.7 presents analysis results from applying the single active failure assumptions listed in Section B.6.2 to the limiting RVV and RRV base cases.
- Section B.8.8 presents analysis results from applying the three electrical power availability assumptions listed in Section B.6.1 to the limiting RVV and RRV base cases.
- Section B.8.9 presents plots of parameters of interest for the typical RVV opening and RRV opening cases presented in Sections B.8.1 and B.8.2.

Table B-8. IORV analysis initial conditions

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}}2(a),(c)

RCS Initial Temperature: Analyses are performed with a highest operationally allowed RCS average temperature which places the RCS closer to saturated conditions at the time of transient initiation. Analyses are also performed at the coldest operationally allowed RCS average temperature which reduces level swell following inadvertent valve opening and lengthens the time before two-phase choking conditions exist at the open valve.

RCS Initial Flow: Analyses are performed for both minimum and maximum initial RCS flow rates. The low RCS flow condition minimizes the CHFR at transient initiation. The high flow initial condition reduces the temperature difference across the core, thereby raising the core inlet temperature when the RCS average temperature is held fixed. The values for minimum and maximum RCS initial flow are not affected by the addition of the riser diverse flow holes.

RCS Initial Pressure: Analyses are performed for both low and high RCS initial pressure conditions. The high initial pressure maximizes the initial RCS energy and results in a higher flow rate on initial RPV opening. A low initial pressure places the RCS closer to saturation at transient initiation, which increases void generation and swell while the core power is still high.

Pressurizer Initial Level: Analyses are performed to vary the initial pressurizer level between the programmed operational setpoint plus or minus instrument error. A high

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0620-70501

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AFFIDAVIT of Zackary W. Rad

I, Zackary W. Rad, state as follows:

(1) I am the Director of Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale

(2) I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:

(a) The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.

(b) The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.

(c) Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

(d) The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.

(e) The information requested to be withheld consists of patentable ideas.

(3) Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying revised topical report pages reveal distinguishing aspects about the method by which NuScale develops its Loss-of-Coolant Accident Evaluation Model.

NuScale has performed significant research and evaluation to develop a basis for this methodology and has invested significant resources, including the expenditure of a considerable sum of money.

The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

(4) The information sought to be withheld is in the enclosed submittal entitled "Submittal of Errata to Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 2. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.

(5) The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).

(6) Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:

(a) The information sought to be withheld is owned and has been held in confidence by NuScale.

(b) The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.

(c) The information is being transmitted to and received by the NRC in confidence.

(d) No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.

(e) Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on June 19, 2020.

Zackary W. Rad