UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

April 28, 2020

Ms. Margaret M. Doane
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: NUSCALE COMBUSTIBLE GAS MONITORING

Dear Ms. Doane:

During the 672nd meeting of the Advisory Committee on Reactor Safeguards, April 8-10, 2020, we completed our review of the proposed NuScale combustible gas monitoring system to detect hydrogen (H_2) and oxygen (O_2) concentrations in containment during severe accident events. This letter addresses our recommendation from our letter of December 20, 2019. Our NuScale Subcommittee also reviewed this item on March 4, 2020. During these meetings, we had the benefit of discussions with NuScale and the staff. We also had the benefit of the referenced documents.

CONCLUSIONS

1. We concur with the staff position that the combustible gas monitoring system design not receive finality in the NuScale design certification because the staff is unable to evaluate dose implications.

2. We are concerned that to obtain a sample representative of the containment atmosphere, the proposed combustible gas monitoring system design will require establishing a sizeable flow through non-safety-grade piping outside containment. This may have implications on worker and off-site doses.

3. We expect to have the opportunity to review the final design updates submitted by Combined License (COL) applicants to ensure that our concerns have been addressed and are supported by analyses.

BACKGROUND

NuScale and the staff see a need for operators to monitor containment atmosphere for H_2 and O_2 concentrations sometime after 72 hours following a postulated severe core damage event. Continuous monitoring of combustible gases would allow operators to minimize the chance of a detonation that could challenge containment integrity. This core damage event is of very low probability because it requires failure of normal heat removal, failure of the passive decay heat removal system, and failure of the emergency core cooling system valves that provide another passive means to remove decay heat. NuScale has proposed to use the process sampling

system (PSS), which is used during normal operations, to monitor the containment atmosphere. The PSS is connected to the containment evacuation system (CES), which is a relatively large diameter pipe that is used to maintain containment vacuum during normal operation.

We issued a letter on December 20, 2019, where we raised our concerns. We stated that "[t]he risk tradeoff between unisolating the NuScale containment to enable long-term hydrogen and oxygen monitoring should be weighed against alternatives that may not require such monitoring."

The staff has proposed that the combustible gas monitoring system design not receive finality in the NuScale design certification because the design is not complete and, therefore, they are unable to estimate the dose implications of unisolating containment. This issue must be addressed by COL applicants.

DISCUSSION

We have several concerns with plans for using the PSS for monitoring of H_2 and O_2, as well as venting the containment via reactor building ventilation system or gaseous radioactive waste system , as suggested in the generic technical guidelines.

Although these systems have not yet been designed, Chapter 9, "Auxiliary Systems," of the Final Safety Analysis Report indicates that the PSS is aligned by setting up the proper flow path through the CES to the PSS and from PSS to the containment flooding and drain system return line to containment. The operators would then open the CES isolation valve and PSS return valve to the containment flooding and drain system pipe. From the expected relative sizes of CES piping and PSS piping along with the small capacity of the sample pump, it is not clear that the PSS will provide representative measurements in a reasonable time frame unless a significant flow of containment atmosphere is established through the CES.

The staff has concluded that the designer will ensure the ability of the system to provide representative measurements. NuScale stated that the final combustible gas monitoring system design must comply with ANSI N13.1-2011, which requires sampling to be representative. Because the CES piping is a relatively large diameter pipe, obtaining a representative containment sample at the PSS location would require establishing a non-negligible mass flow rate. This is likely to result in circulating large portions of containment volume through the non-safety-grade CES piping. Hydrogen stratification may be an issue. In addition, opening the isolation valves or operating the sampling pump may provide the energy to ignite the atmosphere if enough O_2 has been generated. We are concerned that deflagration/detonation on pipes outside containment may have more serious consequences than inside the containment.

The staff estimates that enough O_2 for ignition will be produced sometime after 72 hours following postulated core damage. The main source of O_2 is radiolysis (dissociation of H and O from water molecules interacting with ionizing radiation), and there is significant uncertainty on the rate of O_2 production. The assumed radiolysis correlations do not include the presence of a H_2-rich environment, which can suppress radiolysis. Thus, the credibility and timing of the accident progression is also called into question. The need for post-accident monitoring might be greatly reduced and an exemption might be possible based on the low risk (probability and consequence) of this type of scenario.

Before O_2 concentrations reach the point when combustion could occur, the generic technical guidelines suggest that the operators would vent containment via the reactor building ventilation system or the gaseous radioactive waste system. Both these systems would vent via the CES. If the path to reactor building ventilation system is selected, flow would pass through the filter bank on the exhaust of CES; there is no information supporting the ability of those filters to be effective on a fission product exhaust stream. For the gaseous radioactive waste system, no design information is available. Alternatively, the containment atmosphere could be inerted with nitrogen gas (N_2) via the chemical and volume control system. Again, details are unavailable, but inerting would avoid opening the containment to a larger piping system such as CES; however, it would not support monitoring concentrations of O_2 and H_2.

We would prefer that the combustible gas monitoring system design were complete enough at this time or that the performance requirements for this system were defined for the certified design. That is not the case. Therefore, we expect to have the opportunity to review the final design updates submitted by COL applicants.

SUMMARY

We concur with the staff position that the combustible gas monitoring system design not receive finality in the NuScale design certification because the staff is unable to evaluate dose implications. We are concerned that to obtain a sample representative of the containment atmosphere, the proposed combustible gas monitoring system design will require establishing a sizeable flow through non-safety-grade piping outside containment. This may have implications on worker and off-site doses. We expect to have the opportunity to review the final design updates submitted by COL applicants to ensure that our concerns have been addressed and are supported by analyses.

Sincerely,

Scott W. Moore
Digitally signed by Scott W. Moore
Date: 2020.04.28 21:17:33 -04'00'

Mathew W. Sunseri
Chairman

REFERENCES

1. Advisory Committee on Reactor Safeguards, "Safety Evaluation of the NuScale Power, LLC Topical Report TR-0915-17565, Revision 3, 'Accident Source Term Methodology,' and Source Term Area of Focus Review for the NuScale Small Modular Reactor," December 20, 2019 (ML19354A031).

2. Advisory Committee on Reactor Safeguards, "Proposed Focus Area Review Approach of the Advanced Safety Evaluation Report With No Open Items for the Design Certification Application of the NuScale Small Modular Reactor," September 25, 2019 (ML19269B682).

3. NuScale Power, Final Safety Analysis Report, Chapter 9, "Auxiliary Systems," Revision 4, January 16, 2020 (ML20036D448).

4. NuScale Power, "TR-1117-57216, NuScale Generic Technical Guidelines," Revision 1, May 31, 2019 (ML19151A810).

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