



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

December 14, 2020

The Honorable Kristine L. Svinicki  
Chairman  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555-0001

SUBJECT: SUMMARY REPORT – 679<sup>th</sup> MEETING OF THE ADVISORY COMMITTEE  
ON REACTOR SAFEGUARDS, OCTOBER 8-9, 2020

Dear Chairman Svinicki:

During its 679<sup>th</sup> meeting, October 8-9, 2020, which was conducted virtually due to the COVID-19 pandemic, the Advisory Committee on Reactor Safeguards (ACRS) discussed several matters. The ACRS completed the following correspondence:

**LETTERS**

Letters to Margaret M. Doane, Executive Director for Operations (EDO), NRC, from Matthew W. Sunseri, Chairman, ACRS:

- ACRS Review of Staff Response to the Advisory Committee on Reactor Safeguards Letter on NuScale Power, LLC, Area of Focus – Boron Redistribution, dated November 4, 2020, ADAMS Accession No. ML20303A320
- Safety Evaluation for Framatome Inc., Topical Report ANP-10323P, Revision 1, "GALILEO Fuel Rod Thermal-mechanical Methodology for Pressurized Water Reactors," dated November 23, 2020, ADAMS Accession No. ML20324A744
- NuScale Topical Report, TR-0118-58005, Revision 1, "Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," dated November 23, 2020, ADAMS Accession No. ML20322A442

## MEMORANDA

Memoranda to Margaret M. Doane, EDO, NRC, from Scott W. Moore, Executive Director, ACRS:

- Documentation of Receipt of Applicable Official NRC Notices to the Advisory Committee on Reactor Safeguards for October 2020, dated November 2, 2020, ADAMS Accession No. ML20301A342
- Regulatory Guides, dated November 2, 2020, ADAMS Accession No. ML20301A353

## HIGHLIGHTS OF KEY ISSUES

1. ACRS Review of Staff Response to the Advisory Committee on Reactor Safeguards Letter on NuScale Power, LLC, Area of Focus – Boron Redistribution

In a letter dated August 25, 2020 (ML20231A598), the staff responded to the Committee's letter dated July 29, 2020, "NuScale Area of Focus – Boron Redistribution" (ML20210M890). The Committee reviewed the staff's letter and disagreed with the staff's response to Conclusions and Recommendations 4, 5, and 6. As stated in the Committee's July 29, 2020 letter, "Report on the Safety Aspects of the NuScale Small Modular Reactor," the Committee plans to address the boron redistribution area of focus as part of a future review of a potential license application that references the certified NuScale design or standard design approval.

2. Safety Evaluation for Framatome Inc., Topical Report ANP-10323P, Revision 1, "GALILEO Fuel Rod Thermal-Mechanical Methodology for Pressurized Water Reactors,"

Framatome requested in June 2018 that the NRC complete a review of ANP-10323P, Revision 1, "GALILEO Fuel Rod Thermal-Mechanical Methodology for Pressurized Water Reactors," which presents a methodology for the realistic evaluation of the performance of fuel rods for pressurized water reactors (PWRs). GALILEO consolidates features of modeling capability within approved Framatome codes, including COPENIC, RODEX, and CARO-3E, into a single methodology. Advances in modeling have also been incorporated, including new pellet mechanics models.

The GALILEO methodology models the following coupled physical phenomena: heat production and conduction in the fuel rod; fission gas release; mechanical behavior of the pellet and cladding structures; and growth of a corrosion layer at the cladding external surface. GALILEO includes the following models: thermal conductivity degradation; hydrogen pickup in the cladding; enhanced fission gas release for a range of burnups; high burnup structure on pellet rim, and cladding ridge formation; fuel pellet cracking, creep, dish filling, and hourglassing; and fuel pellet swelling. Framatome calibrated and validated their models using extensive experimental data, enabling them to apply the GALILEO methodology to their fuel types in the following bundle configurations: 14x14 Combustion Engineering; 15x15 Babcock & Wilcox; 17x17 Westinghouse; and 17x17 Framatome.

The staff safety evaluation (SE) defines the ranges of applicability for GALILEO fuel rod design and safety analyses to ensure that its use remains within the bounds of the database conditions. The SE also imposes several conditions and limitations, including: stipulation that fuel failure should be assumed when fuel temperature calculated by GALILEO exceeds the fuel melting

temperature; no methodology using GALILEO has been approved for providing initial data or conditions for emergency core cooling system (ECCS) calculations; future changes to both the mean and standard deviation of model parameter uncertainty input data values must be reviewed and approved by the staff; and Framatome responses to staff requests for additional information must be included with the final topical report. The Committee finds the range of applicability and these limitations and conditions appropriate.

The staff's determination of applicability ranges and limitations was based on the ability of GALILEO to accurately simulate currently available test data. Their review and comparisons were supplemented by confirmatory calculations performed with the independent NRC code FRAPCON. The review approach was thorough, and the results were convincing.

The methodology documented in ANP-10323P, Revision 1, when applied within the staff-imposed limitations and conditions, is acceptable for the calculation of PWR fuel rod thermal-mechanical performance.

#### Committee Action

The Committee issued a letter on November 23, 2020, with the following conclusion and recommendation:

- The methodology documented in ANP-10323P, Revision 1, when applied within the staff-imposed limitations and conditions, is acceptable for the calculation of PWR fuel rod thermal-mechanical performance.
  - The SE should be issued
3. NuScale Topical Report, TR-0118-58005, Revision 1, "Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," [Note that this Topical Report is not referenced in the current NuScale design certification application]

Regulations require that Structures, Systems and Components (SCCs) important to safety be designed to withstand earthquakes. The analyses must address soil structure interaction (SSI). Seismic analysis of the NuScale plant is more complex than conventional PWRs and boiling water reactors because of the large reactor building (RXB) pool in which up to twelve NuScale Power Modules (NPMs) may be immersed and which is also interconnected with the refueling bay and the spent fuel pool. The combined mass of the RXB, NPMs and pool are sufficient to potentially feed back into the SSI analysis, creating a combined SSI/fluid-structure interaction (FSI) analysis problem.

NuScale has developed a novel approach in which an industry-standard SSI code (SASSI) is used to develop dynamic soil impedances and seismic load vectors for a site and include them directly in a large-scale ANSYS finite element analysis (FEA) model of the plant. This permits an integrated single-step analysis that addresses SSI/FSI with more accurate modelling of the SSCs, including the RXB pool, in the analysis, without iterating between the SASSI and ANSYS codes.

The topical report (TR) includes four sample problems ranging from a simplified PWR model that was an original SASSI code demonstration problem, to a small-scale model of a reactor building, with and without a large water pool, and ultimately to a detailed model of a 12-module NuScale reactor building. In each case, the analysis was performed using both the

conventional, multi-step process and the integrated single-step process described in the TR. The results were compared and showed excellent agreement between the two methods.

The NuScale approach incorporates the following assumptions:

1. Material properties are linear elastic during the analysis.
2. The behavior of boundary conditions and constraints is linear.
3. The seismic load is represented by vertically propagating shear and compression waves.

The staff reviewed the NuScale approach, observing that it conforms to established mathematical principles of the dynamics of structures and fluids and that its validity is demonstrated through the example problems presented in the TR. The SE concludes that the methodology is acceptable for seismic analysis of complex NPP structures involving soil-structure-fluid interactive behaviors, such as the NuScale reactor building, in accordance with the applicable regulations. The SE imposed conditions and limitations that basically consist of demonstrating the applicability of the above three assumptions.

#### Committee Action

The Committee issued a letter on November 23, 2020, with the following conclusion and recommendation:

- NuScale has developed a new seismic analysis approach that addresses SSI and FSI that improves the analysis process and its accuracy.
- The SE approves the methodology with conditions and limitations. It should be issued.

#### SIGNIFICANT ACTIONS/DISCUSSIONS AT THE PLANNING AND PROCEDURES SESSION

The Committee discussed the conduct of virtual meetings at least through March 2021 with the caveat to discuss at future meetings as the situation evolves. This is due to the pandemic response and the renovations activities being undertaken in the ACRS conference rooms.

The Committee also discussed and approved Member Petti's recommendation following a Subcommittee meeting to not write a letter on the subject of the Kairos topical report on performance-based licensing basis development methodology.

The Committee discussed and approved Member March-Leuba's recommendation for the Full Committee not to review the Framatome topical report on the BEO-III, following a Subcommittee meeting that heard a presentation on the report.

Vice Chairman Rempe led a discussion of a proposal for the Office of Nuclear Regulatory Research to brief the Committee on relevant issues including plans post-Halden.

#### SCHEDULED TOPICS FOR THE 680<sup>th</sup> ACRS MEETING

The following topics are on the agenda for the 680<sup>th</sup> special ACRS meeting scheduled for November 4-7, 2020:

- Review of latest revision of Branch Technical Position 7-19 regarding guidance for evaluation of diversity and defense-in-depth in digital and computer-based instrumentation and control systems
- Regulatory Guide 1.200 revision of review and approval of new methods for light water reactors (probabilistic risk assessment)
- Commission meeting preparations

Sincerely,

Matthew W. Sunseri,  
Chairman

December 14, 2020

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