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

February 22, 2019

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

SUBJECT: SAFETY EVALUATION FOR ANP-10332P, REVISION 0, AURORA-B: AN EVALUATION MODEL FOR BOILING WATER REACTORS; APPLICATION TO LOSS-OF-COOLANT ACCIDENT SCENARIOS

Dear Ms. Doane:

During the 660th meeting of the Advisory Committee on Reactor Safeguards, February 6-8, 2019, we completed our review of report ANP-10332P, Revision 0, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios," and the associated NRC staff draft safety evaluation (SE). Our Subcommittee on Thermal-Hydraulic Phenomena also reviewed this matter on December 18, 2018. During these reviews, we benefitted from discussions with representatives of the staff, their contractors, and Framatome. We also benefitted from the referenced documents.

CONCLUSION AND RECOMMENDATION

1. The AURORA-B loss-of-coolant accident evaluation model provides an acceptable methodology to estimate safety margins for boiling-water reactors during loss-of-coolant events in accordance with Appendix K to 10 CFR Part 50.

2. The staff's safety evaluation provides a comprehensive evaluation of this methodology and imposes limitations and conditions to ensure its appropriate application. It should be published.

BACKGROUND

AURORA-B is a multi-physics, multi-code package developed for predicting the dynamic response of boiling-water reactors (BWRs) during a variety of transient and accident scenarios. We completed our review of applications of AURORA-B for anticipated operational occurrences in October 2017 and control rod drop accidents in March 2018. Together, these applications cover most of the transient and accident events described in Chapter 15 of the NRC's Standard Review Plan (NUREG-0800). The only exceptions are stability events, which will continue to use the RAMONA-5FA methodology, and the latter stages of anticipated transient without scram scenarios, which are not normally evaluated for each fuel reload.

The latest topical report, ANP-10332P, extends AURORA-B applicability to loss-of-coolant accident (LOCA) analysis to demonstrate compliance with the criteria in 10 CFR 50.46. Framatome has chosen to license AURORA-B only for conservative Appendix K LOCA analyses instead of best estimate plus uncertainty calculations, which simplified the review. Framatome has requested NRC approval of the AURORA-B LOCA methodology for operating BWRs, including power uprate and extended flow window conditions.

DISCUSSION

Codes and Methods

AURORA-B is based on four independent computer codes: MICROBURN-B2, a steady-state core simulator; RODEX4, a fuel thermal-mechanical code; S-RELAP5, a thermal-hydraulic system code; and MB2-K, a 3D transient neutron-kinetics code.

For LOCA applications, AURORA-B uses the point kinetics model built into S-RELAP5, instead of the MB2-K 3D neutronics. The staff finds this approach acceptable because neutron kinetics play a limited role in LOCA, which is mostly controlled by decay heat after scram.

These codes have individually received prior review and approval by the NRC for different applications. In particular, the RODEX4 fuel thermal-mechanical models address explicitly fuel thermal conductivity degradation and have been approved for use with all current Framatome fuels, including ATRIUM 11™ with chromium-doped fuel pellets.

The staff concentrated its review on the areas where modifications to the codes were made to accommodate the AURORA-B application to BWR LOCAs. These areas include: upper plenum mixing and spray condensation model; incorporation of BWR-specific fluid correlations; and code modifications to enforce Appendix K conservatisms. The staff performed TRACE confirmatory calculations to verify a number of AURORA-B assumptions and complete their review. The staff imposed additional conservatisms and limitations that are documented in the proprietary SE to ensure the code is applied appropriately within its validated ranges.

The staff concluded that, with the proposed limitations and conditions, the code modifications and methodology are acceptable. We concur with the staff evaluation of the AURORA-B LOCA methodology.

Qualification

Framatome has qualified the AURORA-B evaluation model using a large database of experimental data, including: five component effects tests, fifteen separate effects tests, and nine integral effects tests from three facilities with representative BWR conditions.

Framatome developed a phenomena identification and ranking table (PIRT) for BWR LOCA events. All the highly ranked phenomena were verified against the qualification database and AURORA-B provided conservative results.

Framatome did not address AURORA-B qualification for evaluation of long-term cooling. Instead, Framatome intends to use the existing generic evaluation of record by the reactor vendor. Consequently, the staff did not approve AURORA-B for long-term cooling evaluations.

Limitations and Conditions

The staff SE specifies 28 limitations and conditions to the applicability of the AURORA-B LOCA methodology. Most of them enforce limitations to use the methodology within the validated range of applicability using the agreed conservatisms. However, a number of limitations impose requirements for future licensees to justify the acceptability of a number of AURORA-B models on a plant-specific basis. The staff has informed us that they are exploring change-process guidelines that would apply to all vendors and would facilitate resolving these limitations on a generic basis. This is a good example of efforts by the staff to make the NRC more efficient while not losing focus on safety, and we encourage it. We look forward to interacting with the staff as these efforts mature.

SUMMARY

The staff's SE provides a comprehensive evaluation of this methodology and imposes limitations and conditions to ensure its appropriate application. It should be published.

Sincerely,

/RA/

Peter C. Riccardella
Chairman

REFERENCES

1. AREVA, ANP-10332P, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios,” Revision 0, February 2014 (ML14091A220).

2. U.S. Nuclear Regulatory Commission, “Audit Report for the May 16 to May 18, 2017, Audit in Support of the Review of ANP 10332P, Revision 0, ‘AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios’,” December 5, 2017 (ML17262B138).

3. Framatome, ANP-10300P-A, “AURORA-B: An Evaluation Mode for Boiling Water Reactors; Application to Transient and Accident Scenarios,” Revision 1, January 2018 (ML18186A440 (Non-Public)/ ML18186A181 (Public)).

4. Framatome, ANP-10340P-A, “Incorporation of Chromia-Doped Fuel Properties in AREVA Approved Methods,” Revision 0, May 2018 (ML18171A107).

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