



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

November 26, 2019

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

**SUBJECT: SAFETY EVALUATION FOR BRUNSWICK STEAM ELECTRIC PLANT  
UNITS 1 AND 2 TO SUPPORT REVIEW OF THE LICENSE  
AMENDMENT REQUEST REGARDING APPLICATION OF  
FRAMATOME METHODOLOGIES FOR TRANSITION TO ATRIUM 11  
FUEL**

Dear Ms. Doane:

During the 668<sup>th</sup> meeting of the Advisory Committee on Reactor Safeguards (ACRS), November 6-8, 2019, we completed our review of the staff's safety evaluation (SE) of Brunswick Steam Electric Plant (BSEP) Units 1 and 2 license amendment request (LAR) to allow application of the Framatome analysis methodologies necessary to support a planned transition to ATRIUM™ 11 fuel. Our Thermal-Hydraulic Subcommittee also reviewed this LAR on November 5, 2019. As part of our review, we met with the Nuclear Regulatory Commission (NRC) staff and representatives from Framatome and Duke Energy. We also had the benefit of the referenced documents.

**CONCLUSION AND RECOMMENDATION**

1. The Framatome core reload analysis methodology is acceptable for use in BSEP Units 1 and 2 licensing applications that incorporate ATRIUM™ 11 fuel in their currently approved extended power-flow operating domain.
2. The LAR should be approved, and the SE should be issued.

**BACKGROUND**

BSEP Units 1 and 2 are of the BWR/4 design with Mark I containments. These units began commercial operation with a thermal power of 2436 MWt in 1975 (Unit 2) and in 1976 (Unit 1). In May 2002, NRC granted these units an extended power uprate (EPU) to increase to the current licensed thermal power of 2923 MWt, and in September 2018, NRC approved BSEP to operate in the Maximum Extended Load Line Limit Analysis Plus domain with Framatome ATRIUM™ 10XM fuel. Currently, BSEP uses a mixture of Framatome and General Electric Hitachi methods to demonstrate that safety margins are maintained for each new core reload. In October 2018, Duke Energy submitted an LAR to adopt advanced Framatome methods for

fuel and thermal-hydraulic performance to the latest generation ATRIUM™ 11 fuel. Duke Power indicated that they plan to start loading this new fuel type during the 2020 BSEP outage.

## DISCUSSION

This LAR is the first application of eight new analysis methodologies. Of these eight, five were approved on a generic basis at the time of submittal:

- AURORA-B methodology for anticipated operational occurrences (AOO) and anticipated transients without scram (ATWS) over-pressure events.
- Control rod drop accident (CRDA) method.
- AREVA-approved methods with incorporation of Chromia-doped fuel properties.
- Realistic thermal-mechanical fuel rod methodology.
- ACE/ATRIUM™ 11 critical power correlation method.

Two of the eight methodologies were not approved when this BSEP LAR was submitted, but have since been approved:

- AURORA-B loss of coolant accident (LOCA).
- ATWS with instability (ATWS-I).

One methodology is currently under review by the staff for generic use, and the applicant requested that it be approved for use in BSEP as part of this LAR:

- Best-estimate Enhanced Option III with Confirmation Density Algorithm (BEO-III/CDA) stability solution.

The BSEP LAR contains several changes to the technical specifications and core operating limits report (COLR), primarily by incorporating references to these new Framatome methods. Therefore, future core reload analyses can properly reference these methods as approved.

The staff review concludes that the LAR provides an acceptable implementation of the previously approved generic analysis methods, including: the fuel assembly design and chromia-doped fuel property correlations; AOOs; ATWS overpressure; and control rod drop accidents. In their review, the staff confirmed that limitations and conditions for these methods were addressed appropriately in the LAR application.

Generic SEs of the ATWS-I and LOCA methods had not been completed at the time of LAR submittal; therefore, the staff conducted a detailed review to confirm that their use for BSEP was acceptable. In the case of ATWS-I methods, the staff also performed confirmatory calculations to verify that these methods yielded acceptable results. Recently, we have completed reviews of the generic methods for LOCA, AOO, and ATWS-I and concurred with the staff that these generic methods should be approved. The BSEP-specific version of these methods in the LAR is essentially identical to the generic version that we reviewed and should also be approved.

The staff review of the generic BEO-III stability methodology is currently underway, and this section of the LAR was approved on a plant-specific basis with six licensing conditions. BEO-III is implemented by performing calculations at a sufficient number of cycle exposure points. The

goal of BEO-III is to determine the value of the operating limit minimum critical power ratio (OLMCPR) that guarantees that, even if an instability occurs, the safety limit is not challenged. The methodology calculates a best-estimate OLMCPR plus its uncertainty using non-parametric statistical analyses. The typical reload application will perform many separate calculations, which should cover any expected instability scenario. The staff has reviewed the BSEP-specific implementation of BEO-III and found it acceptable.

Framatome provided an example application for Cycle 23 of BSEP Unit 1 showing that the BEO-III OLMCPR value is not limiting. Other AOOs (e.g., load rejection or feedwater controller failure) require larger OLMCPR values to ensure the safety limit is not challenged.

The staff reviewed the Reload Safety Analysis Report (RSAR) for Cycle 23 of BSEP Unit 1. The cycle-specific results in the RSAR confirmed all limits were met for the full range of operating conditions.

## SUMMARY

The Framatome core reload analysis methodology is acceptable for use in BSEP Units 1 and 2 licensing applications that incorporate ATRIUM™ 11 fuel. The LAR should be approved, and the SE should be issued.

We are not requesting a formal response from the staff to this letter report.

Sincerely,

**/RA/**

Peter Riccardella  
Chairman

## REFERENCES

1. U.S. Nuclear Regulatory Commission (NRC), "Draft Safety Evaluation for Brunswick Steam Electric Plant, Units 1 and 2 to Support Review of the License Amendment Request Regarding Application of Framatome Methodologies for Transition to Atrium 11 Fuel," October 29, 2019 (ADAMS Accession No. ML19255H826).
2. U.S. NRC, Advisory Committee on Reactor Safeguards, "Safety Evaluation for Topical Report ANP-10300P, Revision 0, 'Aurora-B: an Evaluation Model for Boiling Water Reactors; Application to Transient And Accident Scenarios,'" October 19, 2017 (ADAMS Accession No. ML17290B212).
3. U.S. NRC, Advisory Committee on Reactor Safeguards, "Safety Evaluation for ANP-10333P, Revision 0, & Aurora-B: an Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA)," March 26, 2018 (ADAMS Accession No. ML18081A291).
4. U.S. NRC, Advisory Committee on Reactor Safeguards, "Safety Evaluation for ANP-10332P, Revision 0, Aurora-B: An Evaluation Model for Boiling Water Reactors; Application to Loss-of-Coolant Accident Scenarios," February 22, 2019 (ADAMS Accession No. ML19057A018).

5. U.S. NRC, Advisory Committee on Reactor Safeguards, "Safety Evaluation of Topical Report ANP-10346P, Revision 0, 'ATWS-I Analysis Methodology for BWRs Using RAMONA5-FA,'" November 4, 2019 (ADAMS Accession No. ML19308A004).
6. Duke Energy, "Brunswick, Units 1 and 2, Request for License Amendment Regarding Application of Advanced Framatome Methodologies," October 11, 2018 (ADAMS Accession No. ML18284A394).
7. Duke Energy, "Brunswick, Units 1 and 2 - Update to Request for License Amendment Regarding Application of Advanced Framatome Methodologies," November 28, 2018 (ADAMS Accession No. ML18333A028 Proprietary).
8. Duke Energy, ANP-3772P, Revision 0, "CR Supplement Report on Brunswick LAR Analyses," May 14, 2019 (ADAMS Accession No. ML19135A030 Proprietary).
9. Duke Energy, "Brunswick, Units 1 and 2, Supplement to Request for License Amendment Regarding Application of Advanced Framatome Methodologies," May 23, 2019 (ADAMS Accession No. ML19143A397).
10. Duke Energy, ANP-3782P, Revision 1, "Brunswick ATRIUM 11 Advanced Methods Response to Request for Additional Information," May 29, 2019 (ADAMS Accession No. ML19149A320 Proprietary).
11. Duke Energy, ANP-3782NP, Revision 2, "Brunswick, Units 1 and 2, Response to Request for Additional Information Regarding Advanced Framatome Methodologies License Amendment Request," June 18, 2019 (ADAMS Accession No. ML19169A032).
12. Duke Energy, "Supplement to Request for License Amendment Regarding Application of Advanced Framatome Methodologies," July 2, 2019 (ADAMS Accession No. ML19183A107).
13. Framatome Inc., ANP-2637P, Revision 7, "Boiling Water Reactor Licensing Methodology Compendium," September 30, 2018 (ADAMS Accession No. ML18264A016 Proprietary).
14. Advanced Nuclear Fuels Corporation, ANF-89-98(P)(A), "Revision 1 and Supplement 1 - "Generic Mechanical Design Criteria for BWR Fuel Designs"," May 1, 1995 (ADAMS Accession No. ML081350281 Proprietary).
15. Duke Energy, "Brunswick Steam Electric Plant, Units 1 and 2, Updated Final Safety Analysis Report, Revision 26," August 13, 2008 (ADAMS Accession No. ML18249A165).
16. Framatome Inc., ANP-3702P Revision 0, "Brunswick ATRIUM 11 Transient Demonstration", August 2018 (ADAMS Accession No. ML18284A394, Attachment 12.a, Proprietary).
17. Framatome Inc., ANP-3703P Revision 0, "Best Estimate Option-III Analysis Methodology for Brunswick Using RAMONA5-FA," August 2018 (ADAMS Accession No. ML18284A394, Attachment 15.a, Proprietary).
18. Framatome Inc., ANP-3705P Revision 0, "Applicability of Framatome BWR Methods to Brunswick with ATRIUM 11 Fuel," September 2018 (ADAMS Accession No. ML18284A394, Attachment 5.a, Proprietary).
19. Framatome Inc., ANP-3674P Revision 1, "Brunswick Units 1 and 2 LOCA Analysis for ATRIUM 11 Fuel," October 2018 (ADAMS Accession No. ML18284A394, Attachment 13.a Proprietary).

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