NON-PROPRIETARY FINAL SAFETY EVALUATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

AREVA NP, INC. (AREVA) TOPICAL REPORTS

EMF-2209(P), REVISION 2, ADDENDUM 1

"SPCB ADDITIVE CONSTANTS FOR ATRIUM-10 FUEL," AND

ANP-10249 (P), REVISION 0, SUPPLEMENT 1

"ACE ADDITIVE CONSTANTS FOR ATRIUM-10 FUEL"

AREVA NP, INC.

PROJECT NO. 728

1.0 INTRODUCTION AND BACKGROUND

AREVA NP, INC. (AREVA) submitted, by letters dated, May 1, 2008, and July 31, 2008, the following topical reports (TRs): EMF-2209(P), Revision 2, Addendum 1, "SPCB Additive Constants for ATRIUM-10 Fuel" and ANP-10249 (P), Revision 0, Supplement 1, "ACE Additive Constants for ATRIUM-10 Fuel," for U.S. Nuclear Regulatory Commission (NRC) staff review and approval. These submittals are in response to the Title 10 of the *Code of Federal Regulations* (10 CFR) Part 21 notification, dated October 8, 2007.

The above stated AREVA submittals document revisions made to the ACE and SPCB critical power correlations additive constants for ATRIUM-10 fuel for boiling water reactors (BWRs). The additive constants were revised in response to an error discovered in the evaluation of the laboratory data when accounting for the power distribution and the power contained in the part-length fuel rods. Evaluations have confirmed that the SPCB critical power correlation coefficients do not require revision as a result of the error.

The SPCB correlation was developed for two fuel types, the ATRIUM-10 and the ATRIUM-9 fuel designs. However, application of the SPCB correlation to ATRIUM-9 fuel does not require revision as this fuel design does not contain part-length fuel rods. AREVA also noted that the error discussed in these reports is restricted to critical heat flux (CHF) testing of the ATRIUM-10 fuel. Application of the ACE and SPCB additive constant correlation to co-resident BWR fuel containing part-length fuel rods using the NRC approved method described in References 1 and 2, do not require revision.

ENCLOSURE 1

2.0 REGULATORY EVALUATION

In its review of EMF-2209 (P), Addendum 1, and ANP-10249 (P) Revision 0, Supplement 1, the NRC staff utilized the guidance of Standard Review Plan (SRP) 4.4 "Thermal and Hydraulic Design." SRP 4.4 implements the requirements of General Design Criterion (GDC) 10 which is found in Appendix A to 10 CFR 50 to the Commissions regulations. GDC-10 states the following:

> The reactor core and associated coolant, control, and protection systems shall be designed with the appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

The guidance from SRP 4.4 which is applicable to the review of EMF-2209 (P), Addendum 1, and ANP-10249 (P) Revision 0, Supplement 1, is Acceptance Criterion 1.b, which states that for correlations used to predict critical power, the limiting (minimum) value should be established so that at least 99.9% of the fuel rods in the core will not be expected to experience departure from nucleate boiling or boiling transition during normal operation or anticipated operational occupations.

3.0 TECHNICAL EVALUATION

3.1 Test Data Modifications

The AREVA test facility uses electrically heated rods to simulate the behavior of the fuel bundle in the reactor core. The electrical power generated in the individual rods is readily calculated by knowing the voltage, current, and/or the resistance of the various components. The surface of the simulated rods serves as the electrical conductor for the full length rods. The part-length rods carry the current on the surface of the rod in one direction and then through an inner copper conductor in the other direction. Consequently, the power for the part-length rods should account for the power associated with current at the surface of the rod and in the portion of the inner copper conductor that is contained within the heated length. The initial method for determining the power distribution within the bundle did not properly account for the power of the inner copper conductor of the part-length rods in the test bundle. The test data power distributions and the total power generated in a bundle were modified to properly account for the power present in the inner copper conductor in the part-length rods.

3.2 Power Distributions

AREVA assessed the impact of the modified additive constants on all the pertinent power distributions. AREVA recalculated lattice peaking powers and noted that, when the power carried in the inner copper conductor of the part-length rods is included, the relative power delivered by the part-length rods in the lower end of the lattice (in the fully rodded region below the end of the part-length rods) of the bundle, increased compared to the previously reported powers. Consequently, on a normalized relative power basis, the radial peaking factors of the part-length rods increase, and the radial peaking factors of the full-length rods decrease in the fully rodded region of the bundle. See Figures 3.1 and 3.2 of References 1 and 2.

The inclusion of the power associated with the inner copper conductor of the part-length heater rods impacts the axial power shape of the part-length rods, and consequently impacts the bundle average axial power. However, because the power associated with the inner copper conductor is such a small fraction of the overall bundle power (much less than 1 percent), the impact is small.

The development of the ACE and SPCB correlations was based on selected axial power shapes. The adjustment to the additive constants included the axial power shapes from measurements of the individual rod axial shapes for both, full-length rods and part-length rods. The part-length heater rods accounted for the incorporation of the inner copper conductor. An example comparing the bundle average axial power shape for the bundle STS 17.1 is shown in Figure 3.3 of References 1 and 2. The calculations show that the impact is small, and that the impact on the bundle axial power shape was included in the revised additive constant calculations.

3.3 Additive Constants

Having corrected the respective power distributions, both the lattice power and the bundle power, AREVA performed calculations to determine the boiling transition values of f-effective (SPCB), and the K-factors (ACE), respectively, for each test in the data base. The boiling transition values of f-effective are those values that result in a critical power ratio of 1.0 at the measured operating condition. **[**

] A detailed description of the determination of the new additive constants is provided in responses to requests for additional information (RAIs) in Reference 3. The newly derived additive constants supersede the additive constants that were presented in References 4 and 5.

3.4 Evaluation of Transient Critical Power Data

AREVA re-analyzed the transient critical power tests presented in References 4 and 5 using the revised initial bundle powers, axial power shapes, f-effective and K-factors values. The repeated analysis was performed consistent with References 4 and 5. The calculated time of boiling transition of each test for the repeat analysis are presented in Table 6.1 of References 1 and 2, and Table 7.1 in Reference 2.

Table 7.1 of Reference 2 indicates that two of the tests listed in 7.1 are slightly non-conservative. The explanation for the minor non-conservatisms provided by AREVA is that in one of the tests (Test STS-17.8-u6.2), simulating a flow decay event along with a correspondent power decay, the power decay was delayed by nearly a full second after the initiation of the flow decay. Typically, an event of this kind experiences an instantaneous power decrease during a flow decay transient. Consequently, the test is considered "atypical," and thus is not a true representation of a realistic plant event. The other test that indicates a minor non-conservatism is Test STS-29.5-H100.1. For this test, AREVA pointed out that Test STS-29.5-H100.4 had very similar initial boundary conditions, but that Test STS-29.5-H100.4 had a lower bundle power, and is representative of how the transient calculation is performed in a licensing procedure. But, in Test STS-29.5-H100.1, the initial bundle power was too high and thus not representative of realistic licensing event. Also, the higher power case would not be analyzed because boiling transition is to happen at a lower bundle power.

The analysis conducted by AREVA in support of this issue indicated that the changes to initial bundle powers, axial power shapes, f-effective and K-factors values, did not impact conclusions in References 4 and 5. The repeated analysis for each of these parameters demonstrated that the ACE and SPCB steady-state "Dry-out" correlations continue to be appropriate for use in evaluating transient events.

4.0 CONCLUSION

The NRC staff finds that the revisions AREVA provided in the submittal regarding the uncertainties associated with the additive constants are acceptable. The revised additive constants will supersede the additive constants for the ATRIUM-10 that is presented in References 4 and 5.

The additive constants were revised in response to an error discovered in the evaluation of the laboratory data when accounting for the power distribution and the power contained in the part-length fuel rods.

Application of SPCB to ATRIUM-9 fuel does not require revision, as this fuel design does not contain part-length fuel rods. Since the error discussed in this report is restricted to CHF testing of the ATRIUM-10 fuel, applications of ACE and SPCB to co-resident BWR fuel containing part-length fuel rods using the NRC approved method described in Reference 1 do not require revision.

The NRC staff acknowledges that AREVA will combine this safety evaluation with the previously approved TRs, to issue Revision 3 of TR EMF-2209, and Revision 1 of TR ANP-10249 . All parts of the latest revisions have been approved by the NRC staff. Therefore, Revision 3 of TR EMF-2209, and Revision 1 of TR ANP-10249, can be submitted as the approved versions of the TRs. This will allow use of current plant technical specification (TS) references without modifications to the standard TSs.

5.0 REFERENCES

1. Letter, Ronnie L. Gardner, Manager, Site operations and Corporate Regulatory Affairs, AREVA, to the U.S. Nuclear Regulatory Commission, requesting review and approval of EMF-2209 (P), Addendum 1, "SPVB Additive Constants for Atrium-10 Fuel," dated May 1, 2008.

2. Letter, Ronnie L. Gardner, Manager, Site operations and Corporate Regulatory Affairs, AERVA, to the U.S. Nuclear Regulatory Commission, requesting review and approval of ANP-10249 (P), Revision 0, Supplement 1, Revision 0, ACE Additive Constants for ATRIUM-10 Fuel," dated July 31, 2008.

3. Responses to Request for Additional Information Regarding adjustments to Additive Constants for ATRIUM-10 fuel design, EMF-2209 (P), Revision 2, Addendum 1, Revision 0, dated October 2008.

4. EMF-2209 (P)(A), Revision 2, "SPC Critical Power Correlations," September 2003.

5. ANP-10249 (P)(A), Revision 0, "ACE/ATRIUM-10 Critical Power Correlation," August 2007.

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Date: September 23, 2009

RESOLUTION OF AREVA NP, INC. (AREVA)

COMMENTS ON DRAFT SAFETY EVALUATION FOR TOPICAL REPORTS (TRs)

EMF-2209(P), REVISION 2, ADDENDUM 1

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By letter dated July 24, 2009 (ADAMS Accession No. ML092120299), AREVA provided two (2) corrections to references listed in the draft safety evaluation (SE) for TRs: EMF-2209(P), Revision 2, Addendum 1, "SPCB Additive Constants for ATRIUM-10 Fuel" and ANP-10249 (P), Revision 0, Supplement 1, "ACE Additive Constants for ATRIUM-10 Fuel." The following are the NRC staff's resolution of these corrections:

Draft SE comments for EMF-2209(P), Revision 2, Addendum 1, and ANP-10249 (P), Revision 0, Supplement 1:

1. Page 4, Line 36: date of the reference revised to May 1, 2008.

   NRC Resolution for Comment 1 on Draft SE:

   The staff reviewed the AREVA recommendation and found it acceptable.

2. Page 4, Line 41: date of the reference revised to July 31, 2008.

   NRC Resolution for Comment 2 on Draft SE:

   The staff reviewed the AREVA recommendation and found it acceptable.

ATTACHMENT