October 22, 2007

Mr. James A. Gresham, Manager
Regulatory Compliance and Plant Licensing
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: FINAL SAFETY EVALUATION FOR WESTINGHOUSE ELECTRIC COMPANY (WESTINGHOUSE) TOPICAL REPORT (TR) WCAP-16606, REVISION 0, "SUPPLEMENT 2 TO BISON TOPICAL REPORT RPA 90-90-P" (TAC NO. MD2952)

Dear Mr. Gresham:

By letter dated August 15, 2006, Westinghouse submitted Topical Report (TR) WCAP-16606-P, Revision 0, "Supplement 2 to BISON Topical Report RPA 90-90-P," to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated September 5, 2007, an NRC draft safety evaluation (SE) regarding our approval of TR WCAP-16606-P, Revision 0, was provided for your review and comments. By letter dated September 13, 2007, Westinghouse commented on the draft SE. The NRC staff's disposition of Westinghouse's comments on the draft SE are discussed in the attachment to the final SE enclosed with this letter.

The NRC staff has found that TR WCAP-16606-P, Revision 0, is acceptable for referencing in licensing applications for boiling water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed final SE. The final SE defines the basis for our acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that Westinghouse publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed final SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The accepted versions shall include an "-A" (designating accepted) following the TR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, Westinghouse and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

If you have any questions, please contact Jon H. Thompson at (301) 415-1119.

Sincerely,

/RA/

Ho K. Nieh, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 700

Enclosure: Final SE

cc w/encl:
Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

October 22, 2007

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ADAMS ACCESSION NO.:ML072670542 *No major changes to SE input. NRR-043

OFFICE	PSPB/PM	PSPB/PM	PSPB/LA	Tech Branch*	PSPB/BC	DPR/DD
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DATE	10/8/07	10-9-07	10/8/07	8/23/07	10/11/07	10/22/07

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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT (TR) WCAP-16606, REVISION 0,

"SUPPLEMENT 2 TO BISON TOPICAL REPORT RPA 90-90-P"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION AND BACKGROUND

By letter dated August 15, 2006, Westinghouse Electric Company (Westinghouse) submitted TR WCAP-16606-P, Revision 0 (Reference 1), "Supplement 2 to BISON Topical Report RPA 90-90-P" (Supplement 2), which supplemented the BISON code to extend its capability to calculate the mass and energy releases to containment during an anticipated transient without scram (ATWS). No changes to the ATWS methodology were proposed. The containment response methodology is addressed in a separate TR.

The main purpose of Supplement 2 is to extend the applicability of the BISON code to the analysis of ATWS sequences beyond the time of the peak pressure to determine whether the mass and energy release to the containment during the boron injection phase of the accidents is acceptable.

Supplement 2 also proposed to extend the AA78 slip/void correlation to higher pressures. A similar proposal was previously submitted to the NRC staff as a license amendment request by letter dated June 15, 2005, by Exelon Generating Company, LLC (Exelon) (Reference 2). The U.S. Nuclear Regulatory Commission (NRC) staff approved this request by letter dated April 4, 2006 (Reference 3). The same material contained in Reference 2 was included in the TR WCAP-16606-P, Revision 0, so that it could be approved for generic application to all boiling water reactor plants.

The AA78 correlation was approved by the NRC staff in a letter dated October 24, 1989 (Reference 4). While the BISON description report was originally identified as TR WCAP-11236, it is also, and more commonly, identified as ABB Combustion Engineering Nuclear Operations TR RPA 90-90-P-A (Reference 5). Supplement 1 is identified as TR CENPD-292-P-A (Reference 6), and was approved for use by the NRC staff by letter dated October 16, 1995 (Reference 7). Supplement 2 is the subject of this safety evaluation (SE).

Westinghouse responded to a request for additional information by the NRC staff regarding Supplement 2 in letters dated May 14 and July 26, 2007 (References 8 and 12).

2.0 REGULATORY EVALUATION

Section 50.62 of Title 10 of the *Code of Federal Regulations* (10 CFR), "Requirements for reduction of risk from anticipated transients without scram (ATWS) events for light-water-cooled nuclear power plants," was considered during this review.

Standard Review Plan (SRP) Chapter 15, Section 8 (SRP 15.8), "Anticipated Transients Without Scram," was also considered during this review. Specifically, SRP 15.8 was used to examine this TR with respect to Appendix A of 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC)-38, as it relates to ensuring that the containment pressure and temperature are maintained at acceptably low levels following any accident that deposits reactor coolant in the containment, and GDC-50, as it relates to ensuring that the containment does not exceed the design leakage rate when subjected to the calculated pressure and temperature conditions resulting from any accident that deposits reactor coolant in the containment.

3.0 TECHNICAL EVALUATION

3.1 The Boron Injection Model

The boron concentration model calculates the boron concentration in the reactor vessel based on:

- a boron solution insertion flow rate,
- a boron mass fraction,
- total boron solution mass,
- a methodology penalty factor, and
- a core simulator correction factor to account for actual core contents and three-dimensional effects in the boron reactivity worth.

To obtain the concentration of boron in the reactor pressure vessel, Westinghouse assumes a conservative model denoted as the "perfect mixing" model. In this model the total core water volume is used to derive the concentration based on the total water mass in the reactor vessel, (Reference 1).

The BISON "perfect mixing" model generates a conservative boron concentration in the core. Details of the calculational method of the boron concentration model in BISON are provided in Section 4.1.2 of Reference 1.

The NRC staff requested additional information regarding the boron model concentration assumptions. Specifically, the NRC staff requested additional information regarding the boron settling model after injection, concentration levels, and time dependent projection of the SLCS function as a function of time. Westinghouse supplemented its response to the NRC staff by letters dated May 14, 2007 (Reference 8), and July 26, 2007 (Reference 12) and these addressed the NRC staff concerns regarding the boron model concentration assumptions.

3.2 The Neutron Kinetics Model

The neutron kinetics model provided in the BISON code is described in detail in Section 4 of Reference 1. The basis model was not changed for this submittal with respect to the basic analytical formulation and nuclear cross-section models. A brief description of the neutronic model in BISON is provided in the next section.

3.2.1 The Basic Model

The neutron kinetics model used in BISON is a time-dependent two-group diffusion model with one-dimensional (axial) space dependence. The neutron kinetics properties of the reactor core are calculated from local cross-sections and delayed neutron data. Boron in the core and bypass can be accounted for using a correction to the nuclear cross-sections derived according to the models and the methodology provided in Appendix A of Reference 5.

Prior to a transient calculation, a steady state is initialized by iterations between the neutron kinetics model and the thermal-hydraulics model until the power distribution and the void and temperature distributions correspond to each other. Nuclear cross-sections are provided as polynomial functions.

The Doppler correction includes the fuel temperature influence on k from all cross-sections represented in the model. These corrections are calculated by the interface program off-line. A complete set of polynomials are thus provided, accounting for fuel with no control rods present, and another set of polynomials with control rods fully inserted for each fuel type.

3.2.2 Accounting for Boron in Cross-Section Calculations

The inclusion of a boron model into the BISON code necessitated changes to the neutron kinetics model implemented in an earlier version of BISON.

The boron reactivity impact in BISON is assumed to be independent of the fuel or core as long as the ppm value is calculated properly. Modeling of the boron reactivity impact is documented in Reference 11.

To determine the impact of boron reactivity, the BISON model utilizes a separate set of nuclear cross-sections with different boron concentrations. The separate set of nuclear cross-sections is used in each axial core model cell generating nuclear cross-sections for zero boron and for the actual boron concentration in the model. This set of cross-sections is evaluated both with and without control rods.

The cross-section model consists of a set of tables with independent variations at each individual burnup, density parameters, coolant temperature, and boron concentration. These cross-sections are, like the base set of cross-sections, calculated with a two-dimensional lattice code at different burnups, varying core and bypass densities to generate dependencies of void and temperature in the core/bundle, and bypass in all combinations for the same voids. At all these combinations, the boron concentration is also varied.

Boron reactivity impact is only an impact from the water densities in the different parts of the core, since the boron is dissolved in the water. The more water is present, the more boron there is at a given concentration of boron in ppm. This impact varies between different fuel designs, different core loadings, and different operating points. Thus, the BISON boron model necessitates that a normalization of the boron reactivity worth is performed versus a three-dimensional core simulator (POLCA7) code, thus, ensuring boron reactivity accountability in the model.

3.3 Extension to the AA78 Slip/Void Correlation

The NRC staff imposed a limitation on the use of the AA78 correlation above 10 MPa when BISON was originally accepted in 1989 (Reference 4). This was identified as Condition 4 in the NRC staff SE for TR RPA 90-90-P-A (Reference 4).

Exelon provided justification for the use of the AA78 correlation above 10 MPa in its license amendment request for the transition to Westinghouse fuel at the Dresden Nuclear Power Station, Units 2 and 3, and the Quad Cities Nuclear Power Station, Units 1 and 2 (Reference 2).

To demonstrate the applicability of the AA78 slip correlation, in combination with the Electric Power Research Institute (EPRI) boiling model (Reference 9), at pressures above 10 MPa, Exelon provided a comparison of these models extended to higher pressures and higher steam qualities than originally used to justify the AA78 correlation in TR RPA 90-90-P-A. The EPRI slip/boiling correlation has been verified for a wide range of pressures, and was developed to fit not only the rod bundle data which formed the basis of the AA78 correlation, but also other data including measurements in rectangular tubes. This comparison showed the AA78 void correlation does not have any discontinuity or threshold effect for pressures up to maximum value proposed in this request. The NRC staff approved the extended pressure range in 2006 in license amendments for the above mentioned Exelon plants (Reference 10).

High steam qualities are only expected to occur during pressure decrease transients. Experience indicates that pressurization transients, such as ATWS, do not lead to high qualities, especially if the transient is fast. Safety and relief valves would rapidly control the reactor pressure below nine MPa and in the verified AA78 correlation range. The upper limit on the steam quality for a steam dome pressure above nine MPa covers the expected conditions during a pressurization transient without scram. Additionally, for all foreseen ATWS applications, the ASME 120 percent maximum design pressure limit is below 10.5 MPa. Therefore, the NRC staff finds that there is reasonable assurance that the AA78 correlation will be used within the proposed limits for the expected range of applications, including ATWS.

4.0 LIMITATIONS AND CONDITIONS

4.1 AA78 Slip/Void Correlation

For reactor dome pressures less than 10 MPa, there are no limitations on the use of the AA78 correlation, as this correlation has been approved by the NRC staff previously. For pressures higher than 10 MPa during an ATWS event, if the quality exceeds the upper limit identified in TR WCAP-16606-P, Revision 0, then use of the TR is not approved.

5.0 CONCLUSION

The NRC staff concludes the inclusion of the boron model to the BISON code is acceptable for use by boiling water reactors. The boron injection model as described in TR WCAP-16606-P, Revision 0 (Reference 1), can be used to extend the applicability of the code to the analysis of ATWS sequences beyond the time of the peak pressure and to determine the mass and energy release to the containment during the boron injection phase of the accidents (Reference 12).

The NRC staff concludes that there is reasonable assurance that the AA78 correlation will be used within the proposed limits, subject to the limitation identified in Section 4.1 above, for the expected range of applications, including ATWS.

6.0 REFERENCES

1. J. A. Gresham, Westinghouse Electric Company, letter to the U.S. Nuclear Regulatory Commission,"Submittal of WCAP-16606-P/WCAP-16606-NP, "Supplement 2 to BISON Topical Report RPA 90-90-P-A" (Proprietary/Non-Proprietary)," August 15, 2006, LTR-NRC-06-48 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML062360486).

2. P. R. Simpson, Exelon Generation Company, LLC, letter to the U.S. Nuclear Regulatory Commission, "Request for License Amendment Regarding Transition to Westinghouse Fuel," June 15, 2005, RS-05-078 (ADAMS Accession No. ML060620352).

3. M. Banerjee, U.S. Nuclear Regulatory Commission, letter to C. M. Crane, Exelon Generating Company, LLC, April 4, 2006 (ADAMS Accession No. ML060750258).

4. A. C. Thadani, U.S. Nuclear Regulatory Commission, letter to W. J. Johnson, Westinghouse Electric Corporation, "Acceptance for Referencing of Licensing Topical Report WCAP-11236 Regarding the Westinghouse Boiling-Water Reactor Transient Analysis Code BISON," October 24, 1989 (ADAMS Legacy Library Accession No. 8911010136).

5. ABB Combustion Engineering Nuclear Operations, "BISON - A One Dimensional Dynamic Analysis Code for Boiling Water Reactors," RPA 90-90-P-A, Revision 0, December 1991.

6. ABB Combustion Engineering Nuclear Operations,"BISON - A One Dimensional Dynamic Analysis Code for Boiling Water Reactors: Supplement 1 to Code Description and Qualification," CENPD-292-P-A, July 1996.

7. R. C. Jones, U.S. Nuclear Regulatory Commission, letter to D. Ebeling-Koning, ABB CENO Fuel Operations, "CENPD-292-P, "BISON - One Dimensional Dynamic Analysis Code for Boiling Water Reactors: Supplement 1 to Code Description and Qualification (TAC NO. M90165)," October 16, 1995 (ADAMS Legacy Library Accession No. 9510230138).

8. B. F. Maurer, Westinghouse Electric Company, letter to U.S. Nuclear Regulatory Commission, "Response to NRC's Request for Additional Information by the Office of Nuclear Reactor Regulation for Topical Report (TR) WCAP- 16606-P, Revision 0, "Supplement 2 to BISON Topical Report RPA 90-90-P-A" (TAC No. MD2925) (Proprietary/Non-proprietary)," May 14, 2007, LTR-NRC-07-15 (ADAMS Accession No. ML071440450).

9. Electric Power Research Institute (G. S. Lellouche, B. A. Zolotar), "A Mechanistic Model for Predicting Two-Phase Void Fraction for Water in Vertical Tubes, Channels, and Rod Bundles," EPRI NP-2246-SR, 1982.

10. M. Banerjee, U.S. Nuclear Regulatory Commission, letter to C. M. Crane, Exelon Generation Company, LLC, "Dresden Nuclear Power Station, Units 2 and 3, and Quad Cities Nuclear Power Station, Units 1 and 2 - Issuance of Amendments Re: Transition to Westinghouse Fuel and Minimum Critical Power Ratio Safety Limits (TAC No. MC7323, MC7324, MC7325 and MC7326," April 4, 2006 (ADAMS Accession No. ML060750258).

11. ABB Combustion Engineering, "The Advanced PHOENIX and POLCA Codes for Nuclear Design of Boiling Water Reactors," CENPD-390-P-A, December 2000.

12. J. A. Gresham, Westinghouse Electric Company, letter to U.S. Nuclear Regulatory Commission, "Clarification Response to NRC's Request for Additional Information By the Office of Nuclear Reactor Regulation for Topical Report (TR) WCAP-16606-P, Revision 0, "Supplement 2 to BISON Topical Report RPA 90-90-P-A" (TAC No. MD2952) (Proprietary/Non-proprietary)," July 26, 2007, LTR-NRC-07-34 (ADAMS Accession No. ML072270094).

Attachment: Resolution of Comments

Principal Contributors: A. Attard
E. Throm

Date: October 22, 2007

RESOLUTION OF WESTINGHOUSE ELECTRIC COMPANY (WESTINGHOUSE)

COMMENTS ON DRAFT SAFETY EVALUATION FOR TOPICAL REPORT (TR)

WCAP-16606, REVISION 0, "SUPPLEMENT 2 TO BISON TOPICAL REPORT RPA 90-90-P"

(TAC NO. MD2952)

By letter dated September 13, 2007, Westinghouse provided five comments on the draft safety evaluation (SE) for TR WCAP-16606-P-A, Revision 0, “Supplement 2 to BISON Topical Report RPA 90-90-P.” Some information in the draft SE for this TR was identified as proprietary; therefore, the draft of this SE will not be made publicly available. The following are the NRC staff’s resolution of these comments:

Draft SE comments for TR WCAP-16606, Revision 0:

1. Proprietary Statement – Recommendation: Suggest either bracketing the following: [proprietary statement deleted] or delete the sentence (Page 1, Line 15).

   NRC Resolution for Comment 1 on Draft SE:

   The sentence will be changed to read: “Supplement 2 also proposed to extend the AA78 slip/void correlation to higher pressures.”

2. Proprietary Statement - Recommendation: Suggest either bracketing the following: [proprietary statement deleted] or delete the sentence (Page 2, Lines 36-42).

   NRC Resolution for Comment 2 on Draft SE:

   The paragraph will be changed to read: “The BISON "perfect mixing" model generates a conservative boron concentration in the core. Details of the calculational method of the boron concentration model in BISON are provided in Section 4.1.2 of Reference 1.”

3. Proprietary Statement – Recommendation: Suggest either bracketing the following: [proprietary statement deleted] or delete the sentence (Page 3, Line 3[5]-3[6]).

   NRC Resolution for Comment 3 on Draft SE:

   The sentence will be changed to read: “Modeling of the boron reactivity impact is documented in Reference 11.”

4. Proprietary Statement – Recommendation: Suggest either bracketing the following: [proprietary statement deleted] or delete the sentence (Page 4, Line [1-7]).

   NRC Resolution for Comment 4 on Draft SE:

   The paragraph will be deleted.

ATTACHMENT

5. Proprietary Statement - Recommendation: Suggest either bracketing the following: [proprietary statement deleted] or delete the sentence (Page 4, Line [9-11]).

NRC Resolution for Comment 5 on Draft SE:

The sentence will be deleted.