September 17, 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-10266-P, REVISION 2, ADDENDUM 3, REVISION 1, "INCORPORATION OF THE LOCBART [LOSS-OF-COOLANT] (LOC), BEST ESTIMATE ANALYSIS OF REFLOOD TRANSIENTS (BART)] TRANSIENT EXTENSION METHOD INTO THE 1981 WESTINGHOUSE LARGE BREAK LOCA [LOSS-OF-COOLANT ACCIDENT] EVALUATION MODEL WITH BASH [BART AND SYSTEM HYDRAULICS] (BASH-EM)" (TAC NO. MB7485)

Dear Mr. Gresham:

By letter dated December 18, 2002, and supplemented by letters dated November 13, 2003, January 26, 2004, April 15, 2004, January 24, 2005, August 11, 2005, March 30, 2006, April 28, 2006, and April 13, 2007, Westinghouse submitted TR WCAP-10266-P, Revision 2, Addendum 3, to the U.S. Nuclear Regulatory Commission (NRC) staff for review. Revision 1 of TR WCAP-10266-P, Revision 2, Addendum 3, was submitted by letter dated June 29, 2007, and is an update to Addendum 3 requested by the NRC staff due to the changes in Addendum 3 that occurred over the course of the review.

By letter dated August 6, 2007, an NRC draft safety evaluation (SE) regarding our approval of TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1, was provided for your review and comments. By letter dated August 30, 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-10266-P, Revision 2, Addendum 3, Revision 1, is acceptable for referencing in licensing applications for Westinghouse-designed pressurized 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.

Sincerely,

/RA by MCase for/

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

requests for additional information and your responses. The accepted versions shall include an "-A" (designating accepted) following the TR identification symbol.

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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT (TR) WCAP-10266-P, REVISION 2, ADDENDUM 3, REVISION 1,

"INCORPORATION OF THE LOCBART [LOSS OF COOLANT (LOC), BEST ESTIMATE

ANALYSIS OF REFLOOD TRANSIENTS (BART)] TRANSIENT EXTENSION METHOD INTO

THE 1981 WESTINGHOUSE LARGE BREAK LOCA [LOSS-OF-COOLANT ACCIDENT]

EVALUATION MODEL WITH BASH [BART AND SYSTEM HYDRAULICS] (BASH-EM)"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION AND BACKGROUND

On November 2, 2000, the NRC staff informed Westinghouse Electric Company (Westinghouse) of its concern of the potential non-conservative modeling of downcomer boiling in the approved Westinghouse 1981 large-break LOCA (LBLOCA) evaluation model (EM) (Reference 1). Meetings were held to discuss the issue (References 2 and 3).

Westinghouse submitted for NRC staff review an addendum to the previously approved 1981 LBLOCA EM, WCAP-10266-P-A, Revision 2, to address the downcomer boiling issue (Reference 4), referred to as the LOCBART transient extension method. In response to NRC staff requests for additional information (RAIs), Westinghouse provided responses to the NRC staff's concerns in References 5, 6, and 7. A status meeting was held on January 25, 2005 (Reference 8). Westinghouse subsequently provided its response to an additional RAI in Reference 9.

On April 28, 2006, Westinghouse informed the NRC staff of its intent to phase out the use of the 1981 EM methodology and transition to the realistic LBLOCA analysis methodology (Reference 10). Westinghouse also identified limitations on the usage of 1981 LBLOCA EM until the transition is completed and committed to continue to work with the NRC staff to bring the concerns regarding the use of 1981 LBLOCA EM and the LOCBART transient extension method to closure.

The NRC staff requested additional clarification on the LOCBART transient extension method. Westinghouse provided responses in Reference 11, with a commitment to revise WCAP-10266-P, Revision 2, Addendum 3, accordingly.

ENCLOSURE

2.0 REGULATORY EVALUATION

The emergency core cooling system (ECCS) is designed to provide protection against postulated LOCAs caused by ruptures in the primary system piping. The functional requirements for the ECCS performance, under all LOCA conditions postulated in the design, must satisfy the requirements of Section 50.46 of Title 10 of the *Code of Federal Regulations* (10 CFR), "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors." The ECCS calculated cooling performance is based on an acceptable EM for which there is sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor coolant system during an LOCA or, in this case, an ECCS EM developed in conformance with Appendix K to 10 CFR Part 50.

The specific Appendix K requirements associated with this review are:

(1) 10 CFR Part 50, Appendix K, Section I.A.6, “Reactor Internals Heat Transfer,” states: “Heat transfer from piping, vessel walls, and non-fuel internal hardware shall be taken into account.”

(2) 10 CFR Part 50, Appendix K, Section I.D.3, “Calculation of Reflood Rate for Pressurized Water Reactors,” states: "The refilling of the reactor vessel and the time and rate of reflooding of the core shall be calculated by an acceptable model that takes into consideration the thermal and hydraulic characteristics of the core and of the reactor system. The primary system coolant pumps shall be assumed to have locked impellers if this assumption leads to the maximum calculated cladding temperature; otherwise the pump rotor shall be assumed to be running free. The ratio of the total fluid flow at the core exit plane to the total liquid flow at the core inlet plane (carryover fraction) shall be used to determine the core exit flow and shall be determined in accordance with applicable experimental data.... The effects on reflooding rate of the compressed gas in the accumulator which is discharged following accumulator water discharge shall also be taken into account."

(3) 10 CFR Part 50, Appendix K, Section I.D.4, “Steam Interaction with Emergency Core Cooling Water in Pressurized Water Reactors,” states: "The thermal-hydraulic interaction between steam and all emergency core cooling water shall be taken into account in calculating the core reflooding rate. During refill and reflood, the calculated steam flow in unbroken reactor coolant pipes shall be taken to be zero during the time that accumulators are discharging water into those pipes unless experimental evidence is available regarding the realistic thermal-hydraulic interaction between the steam and the liquid. In this case, the experimental data may be used to support an alternate assumption."

(4) 10 CFR Part 50, Appendix K, Section I.D.5, “Refill and Reflood Heat Transfer for Pressurized Water Reactors,” states: "a. For reflood rates of one inch per second or higher, reflood heat transfer coefficients shall be based on applicable experimental data for unblocked cores including Full Length Emergency Cooling Heat Transfer (FLECHT) results.... New correlations or modifications to the FLECHT heat transfer correlations are acceptable only after they are demonstrated to be conservative, by comparison with FLECHT data, for a range of parameters consistent with the transient to which they are applied. b. During refill and during reflood when reflood rates are less than one inch per second, heat transfer calculations shall be based on the assumption that cooling is only

by steam, and shall take into account any flow blockage calculated to occur as a result of cladding swelling or rupture as such blockage might affect both local steam flow and heat transfer."

(5) 10 CFR Part 50, Appendix K, Section II.2 states: "For each computer program, solution convergence shall be demonstrated by studies of system modeling or noding and calculational time steps."

(6) 10 CFR Part 50, Appendix K, Section II.3 states: "Appropriate sensitivity studies shall be performed for each evaluation model, to evaluate the effect on the calculated results of variations in noding, phenomena assumed in the calculation to predominate, including pump operation or locking, and values of parameters over their applicable ranges. For items to which results are shown to be sensitive, the choices made shall be justified."

(7) 10 CFR Part 50, Appendix K, Section II.4 states: "To the extent practicable, predictions of the evaluation model, or portions thereof, shall be compared with applicable experimental information."

3.0 TECHNICAL EVALUATION

The TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1 (Reference 12) describes the incorporation of the LOCBART transient extension method into the 1981 Westinghouse LBLOCA EM with BASH (BASH-EM). The LOCBART transient extension method was developed to extend the analysis of BASH-EM transients beyond the point at which downcomer boiling occurs in BASH. This was achieved by correlating the boiling-induced reduction in the downcomer driving head to a corresponding reduction in the core inlet flooding rate. This approach is to be used to ensure adequate termination of the fuel rod cladding temperature and oxidation transients as required to demonstrate compliance with the acceptance criteria of 10 CFR 50.46.

3.1 Description of the BASH-EM

The SATAN-VI computer program (Reference 13) is used to evaluate the blowdown thermal-hydraulic portion of the LBLOCA transient. The reactor core is modeled using a hot channel and an average channel, with radial flow paths simulating the crossflow between the channels. The fluid conditions in the hot channel are transferred to LOCBART and define the thermal-hydraulic boundary conditions for the fuel rod heatup during the blowdown phase of the transient.

The BASH computer program (Reference 14) is used to compute the refill and reflood thermal-hydraulic portions of the LBLOCA transient. The refill module models the transport of water from the ECCS injection points to the reactor vessel lower plenum. The reflood module models the integrated system response during reflood, including the core pressure, core inlet flooding rate, and core inlet enthalpy. These values are supplied to LOCBART as boundary conditions for the fuel rod heatup during this phase of the transient.

The minimum containment pressure transient is computed using the interactive Containment Pressure Analysis Code (COCO) module (Reference 15) for dry containment plants, or the stand-alone Long Term Ice Condenser Containment (LOTIC) computer program (Reference 16) for ice condenser containment plants. The minimum containment pressure defines the system pressure boundary condition for the refill and reflood portions of the thermal-hydraulic calculations.

The SMUUTH computer program (see Reference 14) is used to smooth the core inlet flooding rate and enthalpy during reflood. The smoothing procedure yields a core inlet flooding rate that is piecewise constant over three segments, and was designed to reduce the reflood oscillations predicted by BASH while preserving the net mass flow into the core.

The LOCBART computer program is used to compute the cladding temperature and oxidation transients for the highest-powered fuel rod in the core during the blowdown, refill, and reflood phases of the LBLOCA transient. LOCBART provides a mechanistic treatment of core heat transfer during reflood, which represents a significant improvement relative to prior application of the FLECHT correlation. The mechanistic models calculate the heat transfer coefficients appropriate to the flow and heat transfer regimes that develop axially in the hot channel, with a detailed spacer grid heat transfer model used to account for the effects of local flow acceleration and improved interfacial heat transfer.

3.2 LOCBART Transient Extension Model

BASH-EM uses a simple model to represent the downcomer and the calculation stops shortly after the downcomer fluid reaches saturation. However, downcomer boiling leads to a reduced driving head and subsequently a reduced reflood rate. BASH-EM cannot account for this reduction in the reflood rate.

A method has been proposed by Westinghouse to extend the LOCBART calculation beyond the point at which downcomer boiling is predicted to occur in BASH. This approach uses a void fraction correlation proposed by Sudo (References 17 and 18) to estimate the average void fraction in the downcomer during boiling, which is then converted to an equivalent void height. The corresponding reduction in downcomer driving head is used to calculate the core inlet flooding rate for use in the LOCBART calculation.

In response to the NRC staff's comments on the use of the proposed Sudo void fraction correlation, Westinghouse revised the proposed method to be consistent with the parameter definitions in the Sudo papers and to account for the uncertainty in the correlation. Westinghouse also revised the method used to calculate the void fraction during downcomer boiling. In addition, Westinghouse included the region below the bottom of the active core to the bottom of the downcomer in the determination of the core inlet reflood rate.

Sensitivity studies performed by Westinghouse (Reference 11) for a large, dry containment design showed the impact of reflooding rate, resulting from these changes, for the LOCBART transient extension method on the hot rod peak cladding temperature (PCT) and the maximum local oxidation. It was shown that the changes to the reflooding rate have a second order impact on these values for a large, dry containment design. Sensitivity studies for an ice-condenser containment design (Section 5.6, Reference 4) showed a measurable difference in the PCT and maximum local oxidation as a function of the reflooding rate. Ice-condenser designs typically have lower containment pressures than large, dry designs.

Westinghouse revised the method to address the containment back pressure, to be consistent with the guidance provided in Standard Review Plan 6.2.1.5, "Minimum Containment Pressure

Analysis for Emergency Core Cooling System Performance Capability Studies." The revised method includes running BASH past the point of downcomer boiling to calculate the lower containment pressure later in the transient. In addition, the revision includes a time-dependent calculation to capture the change in the wall heat release rate, the cold leg pressure, and the core collapsed liquid level.

Sensitivity studies performed by Westinghouse (Reference 11) for a large, dry containment design showed the impact of these changes on the LOCBART transient extension reflood rate and the resulting hot rod peak cladding temperature and the maximum local oxidation. It was shown that the impact from the reduced containment pressure change has an impact on these values for a large, dry containment design, with increases in both the hot rod PCT and the maximum local oxidation values.

The NRC staff finds the revised modeling method acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the PCT and local oxidation and addresses the downcomer boiling concern.

3.3 Validation of LOCBART Transient Extension Method

Westinghouse augmented the model validation to compare its implementation of the Sudo void fraction correlation to five Japan Atomic Energy Research Institute (JAERI) experiments (References 19 and 20). These tests modeled a 16 foot downcomer length and a width of 2 or 8 inches. With one exception, the initial conditions were representative of a pressurized water reactor (PWR) at the onset of downcomer boiling. The comparisons showed that the implementation adequately predicted the steady-state collapsed liquid level, which is representative of the conditions expected in the PWR downcomer.

3.4 Evaluation of 10 CFR Part 50, Appendix K, Requirements

3.4.1 10 CFR Part 50, Appendix K, Section I.A.6

The energy transfer between most of the metal structures in the primary system and the fluid has little effect on the system thermal-hydraulic transient, and a single metal node temperature is calculated using the slab heat transfer model described in Section 3.13 of Reference 14. However, for the lower plenum and downcomer, a detailed simulation is required for the resolution of internal temperature gradients, and a metal node temperature profile is calculated using the more detailed model.

The LOCBART transient extension method uses the downcomer metal-to-fluid heat flow rate at the onset of downcomer boiling to start the calculation of the reduction in the core inlet flooding rate. The NRC staff finds that there is reasonable assurance that Westinghouse has accounted for the effects of structures on the reflooding calculations after the onset of downcomer boiling, when coupled with the implementation of the Sudo void fraction correlation, in a conservative manner appropriate for an Appendix K-based EM.

The NRC staff finds the treatment of metal structures acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

3.4.2 10 CFR Part 50, Appendix K, Section I.D.3

Three issues need to be considered for the LOCBART transient extension method: (1) locked rotor assumption, (2) carryover fraction, and (3) accumulator nitrogen discharge.

Locked Rotor Assumption

The reactor coolant pump is modeled in BASH as a resistance in the cold leg based on a locked rotor assumption. This yields the maximum resistance through the pump, which was shown to reduce the flooding rate and increase the PCT (Reference 25). Westinghouse did not change the locked rotor assumption after the onset of downcomer boiling.

The NRC staff finds the locked rotor assumption acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

Carryover Fraction

Comparisons against experimental data were made directly against the measured flooding rate, the integral flooding rate, and the total carryover fraction (Reference 14). These comparisons showed that BASH provides a reasonable-to-conservative prediction of the carryover fraction, and conservatively predicts the flooding rate and integral flooding rate. The flooding rates directly influence the PCT and the flooding rates are supplied to LOCBART as a boundary condition.

The NRC staff finds the calculation of the carryover fraction acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

Accumulator Nitrogen Discharge

Previous studies performed by Westinghouse (Reference 22) showed that accumulator nitrogen discharge pressurizes the downcomer and increases the flooding rate. This behavior is supported by experimental results (e.g., Loss of Fluid Test (LOFT)), and was used to conclude that accumulator nitrogen discharge could be conservatively neglected in BASH. As discussed in Reference 21, Semiscale tests indicated a long-term increase in system pressure due to accumulator nitrogen discharge. This would produce an increase in the flooding rate, which is conservatively neglected, and a decrease in pumped injection flow, which is a very small effect over the pressure range of interest and is also neglected. There is no change to the treatment of accumulator nitrogen discharge after downcomer boiling.

The NRC staff finds treatment of the accumulator nitrogen discharge acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

3.4.3 10 CFR Part 50, Appendix K, Section I.D.4

BASH assumes equilibrium behavior in the reactor cold legs (Reference 14). This assumption maximizes the condensation of steam flowing from the intact cold legs to the downcomer, which minimizes the pressurization of the downcomer due to steam flowing through the broken nozzle and reduces the flooding rate. This assumption also minimizes the subcooling of the ECCS fluid entering the downcomer, which reduces the time required for the downcomer to reach saturation and leads to an earlier reduction of the flooding rate using the LOCBART transient extension method.

An additional pressure drop is applied in the cold legs to account for pressure oscillations during accumulator injection. As discussed in Reference 22, this pressure drop bounds the steam/water mixing data and was approved for licensing application as being sufficiently conservative. In a BASH-EM calculation, the accumulators are predicted to empty before the onset of downcomer boiling, and this requirement is not pertinent to the LOCBART transient extension method.

During the LOCBART transient extension, the effects of downcomer boiling and entrainment are considered in the calculation of the reduced flooding rate. Vertical entrainment effects due to steam escaping from the downcomer are reflected through use of the Sudo void fraction correlation.

The NRC staff finds the treatment of steam interaction with emergency core cooling water acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

3.4.4 10 CFR Part 50, Appendix K, Section I.D.5

Compliance of BASH-EM with Section I.D.5 of 10 CFR Part 50, Appendix K, was demonstrated in Section 11.0 of Reference 14, and was supplemented by the validation of the LOCBART reflood heat transfer models as described in Reference 23. When the flooding rate is less than or equal to 1 inch per second, direct heat transfer to liquid is ignored, and assembly blockage is modeled if the hot assembly average rod has been predicted to burst. There is no change to the modeling of reflood heat transfer during the LOCBART transient extension.

The NRC staff finds the treatment of refill and reflood heat transfer acceptable for use with the LOCBART transient extension method because no changes to the previously accepted models were needed.

3.4.5 10 CFR Part 50, Appendix K, Section II.2

Section II.2 requires that for each computer program, solution convergence be demonstrated by studies of system modeling or noding and calculational time steps.

The simplified modeling approach used in BASH was not intended to be used to perform evaluations past downcomer boiling. To address downcomer boiling, Westinghouse proposed the LOCBART transient extension method. The method uses conditions during downcomer boiling to obtain the reduced reflood rate resulting from the decreased pressure head in the downcomer. The revised method includes running BASH past the point of downcomer boiling to calculate the lower containment pressure later in the transient.

The previous nodal studies remain applicable to the LOCBART transient extension method. Solution convergence was demonstrated for BASH in Reference 14. Solution convergence for LOCBART was based on the axial node spacing and time step selection. The axial node spacing was determined by the maximum allowable value from Reference 24 (6"), the value required to adequately resolve the axial blockage profile (3"), and the minimum value implied by Section I.A.5 of 10 CFR Part 50, Appendix K (3").

A time step sensitivity analysis using the LOCBART transient extension method, performed by Westinghouse, showed the effect of reducing the maximum allowable time step value on the cladding temperature and oxidation. The calculation showed a minimal effect on the results for the sample case.

The NRC staff finds the nodal and time step sensitivity studies performed by Westinghouse acceptable to justify the LOCBART transient extension method.

3.4.6 10 CFR Part 50, Appendix K, Section II.3

Section II.3 requires that sensitivity studies be performed to evaluate the effect on results of "phenomena assumed in the calculation to predominate."

Sensitivity calculations were performed to demonstrate the effect of assembly blockage, maximum reflood time step size, and flooding rate after downcomer boiling on the hot rod PCT and the maximum local oxidation (Section 6.4 and 6.5, Reference 12). Additional sensitivity calculations were performed to demonstrate the effect of pumped safety injection flows and downcomer metal heat release on the hot rod peak cladding temperature and the maximum local oxidation.

Pumped Safety Injection Flows

The 1981 LBLOCA EM method (Reference 14) requires consideration of both minimum and maximum pumped safety injection (SI) flows. A sensitivity calculation was performed by Westinghouse for a 4-loop ice condenser plant using maximum pumped SI flows in BASH, to demonstrate how this change affected the calculated results when downcomer boiling was considered in the analysis. A comparison of the downcomer liquid temperature and containment pressure, for the BASH calculations modeling minimum and maximum pumped SI flows, showed the downcomer temperature was reduced for the maximum SI case which more than offset the small decrease in saturation temperature due to the reduced containment pressure, and produces a substantial delay in downcomer boiling.

The NRC staff finds the treatment of pumped SI flows acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

Downcomer Metal Heat

A sensitivity calculation was also performed by Westinghouse in which the downcomer heat links in BASH were turned off just prior to downcomer boiling. This caused the downcomer liquid temperature to remain just below saturation, and allowed the BASH calculation to be extended beyond the point at which downcomer boiling would otherwise have occurred. The results indicated that BASH was capable of extended simulations when downcomer boiling does not occur. However, the LOCBART transient extension method was developed to address the effects of the downcomer metal heat on the reflooding rate to conservatively evaluate the PCT and maximum local oxidation after downcomer boiling occurs. The downcomer is modeled with a sufficient number of nodes for use with the Sudo void fraction correlation to account for the decreased driving head following the onset of downcomer boiling.

The NRC staff finds the treatment of the downcomer metal heat acceptable for use with the LOCBART transient extension method because it results in a conservative evaluation of the reflooding rate.

3.4.7 10 CFR Part 50, Appendix K, Section II.4

Westinghouse provided comparisons of the LOCBART extension method to appropriate experimental data, as discussed in Section 3.3 of this safety evaluation (SE). The comparisons showed the implementation reasonably predicted the steady-state collapsed liquid level.

The NRC staff finds the model validation acceptable for use in justifying the LOCBART transient extension method.

3.4.8 Summary of 10 CFR Part 50, Appendix K, Requirements

Westinghouse has addressed the NRC staff concerns identified in Reference 1. The NRC staff finds there is reasonable assurance that the LOCBART transient extension method, incorporated into the 1981 LBLOCA EM, complies with the relevant requirements of 10 CFR Part 50, Appendix K and that the LOCBART transient extension method results in a conservative evaluation of the hot rod PCT and the maximum local oxidation.

4.0 LIMITATIONS AND CONDITIONS

The NRC staff's position is that BASH-EM may not adequately address some current plant configurations and that a realistic LBLOCA analysis will be required. These configurations include designs with large obstructions in the downcomer region, for example thermal shields, or designs with atypical ECCSs. In addition, Westinghouse, in correspondence regarding the review of TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1, has previously committed to limitations on the use of this TR (e.g. Reference 10). The limitations and conditions listed below do not remove the obligation of Westinghouse to abide by any previous statements made in correspondence to the NRC staff as part of the review for this TR.

Licensees referencing TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1, must ensure compliance with the following conditions and limitations:

1. Future usage of BASH-EM will be limited to (a) assessments pursuant to the reporting requirements of 10 CFR 50.46; and, (b) evaluations to support minor plant, fuel design, or other input changes that would normally be handled under 10 CFR 50.46 and/or 10 CFR 50.59.

2. BASH-EM shall not be used for any future LBLOCA evaluations for changes that would be expected to significantly exacerbate downcomer boiling (for example closure of the residual heat removal discharge crosstie valves, early initiation of the recirculation sprays, a significant increase in downcomer metal heat capacity, etc.).

In addition, for plants with large obstructions in the downcomer region, for example thermal shields, the downcomer cross sectional area used in the Sudo void fraction correlation should be justified.

5.0 CONCLUSION

Westinghouse provided the revised version of Addendum 3 of the TR on June 29, 2007 (Reference 12). The LOCBART transient extension model is based on experimental data, the Sudo correlation, and conservatively adjusts the reflooding rate during downcomer boiling to account for the reduced downcomer driving head. The LOCBART transient extension method results in a conservative evaluation of the hot rod PCT and the maximum local oxidation. Future analyses based on the 1981 LBLOCA BASH-EM should be conducted with the accepted LOCBART transient extension method to account for downcomer boiling, subject to the limitations discussed in Section 4.0 of this SE. The NRC staff concludes that the LOCBART transient extension method developed to account for downcomer boiling, and incorporated into the 1981 LBLOCA EM, complies with the relevant requirements of 10 CFR Part 50, Appendix K, as discussed in Section 3.4 of this SE.

6.0 REFERENCES

1. S. Dembek, US NRC, letter to H. A. Sepp, Westinghouse Electric Company, "Potential Non-Conservative Modeling in Approved Evaluation Models," November 2, 2000 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML003765667).

2. J. S. Galembush, Westinghouse Electric Company, letter to S. Dembek, US NRC, "Proprietary Presentation Material for March 6, 2001 Meeting to Discuss Downcomer Boiling," March 1, 2001 (ADAMS Package No. ML010640233).

3. H. A. Sepp, Westinghouse Electric Company, letter to J. S. Wermiel, US NRC, "Proprietary Presentation Material for July 11th Meeting to Discuss Downcomer Boiling," July 10, 2002 (ADAMS Package No. ML022130129).

4. Westinghouse Electric Company, "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)," WCAP-10266-P, Revision 2, Addendum 3, December 2002 (ADAMS Package No. ML050060358).

5. J. S. Galembush, Westinghouse Electric Company, letter to US NRC, "Response to NRC Request for Additional Information on Addendum 3 to WCAP-10266-P, Rev. 2 (Proprietary) and WCAP-11524-A, Rev. 2 (Non-Proprietary), "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)," [Responses to RAIs 2d, 3a, 3b, 3c, 4a, 4b, 4c, 4d, and 4f] November 13, 2003, LTR-NRC-03-66 (ADAMS Package No. ML033230526).

6. J. A. Gresham, Westinghouse Electric Company, letter to US NRC, “Response to NRC Request for Additional Information on Addendum 3 to WCAP-10266-P-A, Rev. 2 (Proprietary) and WCAP-11524-A, Rev. 2 (Non-Proprietary), "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)," [Responses to RAIs: 1b, 2a, 2b, 2c and 4c] January 26, 2004, LTR-NRC-04-4 (ADAMS Package No. ML040330189).

7. J. A. Gresham, Westinghouse Electric Company, letter to US NRC, “Response to NRC Request for Additional Information on Addendum 3 to WCAP-10266-P-A, Rev. 2 (Proprietary) and WCAP-1 1524-A, Rev. 2 (Non-Proprietary),” April 15, 2004, LTR-NRC-04-20 (ADAMS Accession No. ML041130209).

8. J. A. Gresham, Westinghouse Electric Company, letter to US NRC, “Presentation Material for January 25, 2005 Meeting Regarding WCAP-10266-P, Revision 2, Addendum 3 (Proprietary/Non-Proprietary),” January 24, 2005, LTR-NRC-05-2 (ADAMS Package No. ML050330489).

9. J. A. Gresham, Westinghouse Electric Company, letter to US NRC, “Response to NRC Request for Additional Information on WCAP-10266-P, Revision 2, Addendum 3, "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)" (Proprietary/Non-Proprietary),” August 11, 2005, LTR-NRC-05-45 (ADAMS Package No. ML052300278).

10. B. F. Maurer, Westinghouse Electric Company, letter to US NRC, “Response to NRC Request for Additional Information on WCAP-10266-P, Revision 2, Addendum 3, "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)", and Transmittal of Slide Package Entitled "Update on Large Break LOCA Evaluation Model Issue" (Proprietary/Non-Proprietary),” April 28, 2006, LTR-NRC-06-23 (ADAMS Accession No. ML061290471).

11. B. F. Maurer, Westinghouse Electric Company, letter to US NRC, “Response to NRC Request for Additional Information on WCAP-10266-P, Revision 2, Addendum 3, "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)" (Proprietary/Non-Proprietary),” April 13, 2007, LTR-NRC-07-21 (ADAMS Accession No. ML071140206).

12. J. A. Gresham, Westinghouse Electric Company, letter to US NRC, “Submittal of WCAP-10266-P, Revision 2, Addendum 3, Revision 1 (Proprietary) and WCAP-11524, Revision 2, Addendum 3, Revision 1 (Non-Proprietary), "Incorporation of the LOCBART Transient Extension Method into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)" June 29, 2007, LTR-NRC-07-32 (ADAMS Package No. ML071840041).

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14. Westinghouse Electric Company, "The 1981 Version of the Westinghouse ECCS Evaluation Model Using the BASH Code," WCAP-10266-P-A, Revision 2, March 1987.

15. Westinghouse Electric Company,"Containment Pressure Analysis Code (COCO)," WCAP-8327, July 1974. (Approved in WCAP-8471-P-A, "The Westinghouse ECCS Evaluation Model: Supplementary Information," April 1975).

16. Westinghouse Electric Company, "Long Term Ice Condenser Containment Code - LOTIC Code," WCAP-8354-P-A, Supplement 1, April 1976.

17. Y. Sudo, "Estimation of Average Void Fraction in Vertical two-phase Flow Channel Under Low Liquid Velocity," *Journal of Nuclear Science and Technology*, 17(1), pp 1-15, January 1980.

18. Y. Sudo and H. Akimoto, "Downcomer Effective Water Head During Reflood in Postulated PWR LOCA," *Journal of Nuclear Science and Technology*, 19(1), pp 34-45, January 1982.

19. Y. Sudo and Y. Murao, "Experiment of the Downcomer Effective Water Head During a Reflood Phase of PWR LOCA," JAERI-M 7978, October 27, 1978.

20. Y. Sudo, Y. Murao, and H. Akimoto, "Experimental Results of the Effective Water Head in Downcomer During Reflood Phase of a PWR LOCA (2^{nd} report, 50 mm Gap Size)," JAERI-M 8978, July 7, 1980.

21. US NRC, "Summary of the Semiscale Program (1965-1986)," NUREG/CR-4945, EGG-2509, July 1987.

22. Westinghouse Electric Company, "The Westinghouse ECCS Evaluation Model: Supplementary Information," WCAP-8471-P-A, April 1975.

23. Westinghouse Electric Company, "Spacer Grid Heat Transfer Effects During Reflood," WCAP-10484-P-A, Addendum 1, September 1993.

24. Westinghouse Electric Company, "BART-A1: A Computer Code for the Best Estimate Analysis of Reflood Transients," WCAP-9561-P-A, March 1984.

25. Westinghouse Electric Company, "Calculational Model for Core Reflooding After a Loss of Coolant Accident (WREFLOOD Code)," WCAP-8170, June 1974.

Principle Contributor: E. Throm

Date: September 17, 2007

RESOLUTION OF WESTINGHOUSE ELECTRIC COMPANY (WESTINGHOUSE) COMMENTS ON DRAFT SAFETY EVALUATION (SE) FOR TOPICAL REPORT (TR) WCAP-10266-P, REVISION 2, ADDENDUM 3, REVISION 1, "INCORPORATION OF THE LOCBART [LOSS-OF-COOLANT (LOC), BEST ESTIMATE ANALYSIS OF REFLOOD TRANSIENTS (BART)] TRANSIENT EXTENSION METHOD INTO THE 1981 WESTINGHOUSE LARGE BREAK LOCA [LOSS-OF-COOLANT ACCIDENT] EVALUATION MODEL WITH BASH [BART AND SYSTEM HYDRAULICS] (BASH-EM)"

(TAC NO. MB7485)

By letter dated August 30, 2007, Westinghouse provided seventeen comments on the draft SE for TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1, “Incorporation of the LOCBART Transient Extension Method Into the 1981 Westinghouse Large Break LOCA Evaluation Model with BASH (BASH-EM)” and three comments on the cover letter associated with this draft SE. No information in the draft SE for this TR was identified as proprietary; therefore, the draft SE will be made publicly available. The following are the U.S. Nuclear Regulatory Commission (NRC) staff’s resolution of these comments:

Cover Letter comments for TR WCAP-10266, Revision 2, Addendum 3, Revision 1:

1. Add “-A” following “WCAP-10266-P” (3 places).

   NRC Resolution for Comment 1 on Cover Letter:

   The cover letter cites TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1, which is the subject of this SE and for which a “-A” version has not yet been issued. Therefore, the title of the TR in the cover letter (3 places) should not include the “-A.” In general, whenever the subject is a previously approved and published TR (e.g., TR WCAP-10266-P-A, Revision 2) the “-A” is appropriate.

2. Change “Best Estimate Analysis Reflood Transient” to “Best Estimate Analysis of Reflood Transients” and BART System Hydraulics” to “BART and System Hydraulics” (Page 1, Subject line).

   NRC Resolution for Comment 2 on Cover Letter:

   The proposed change is adopted.

3. Add November 13, 2004, and April 13, 2007, to the list of supplemental letter dates (Page 1, 1st paragraph, 1st sentence).

   NRC Resolution for Comment 3 on Cover Letter:

   The proposed change is adopted.

ATTACHMENT

Draft SE comments for TR WCAP-10266, Revision 2, Addendum 3, Revision 1:

1. Add "-A" following "WCAP-10266-P" (Multiple Pages).

   NRC Resolution for Comment 1 on Draft SE:

   The proposed change is adopted in all instances where TR WCAP-10266-P, Revision 2, or earlier approved versions of TR WCAP-10266-P, are cited. The instance where TR WCAP-10266-P, Revision 2, Addendum 3, is cited is not adopted because TR WCAP-10266-P, Revision 2, Addendum 3, was never approved by the NRC staff. In addition, the proposed change is not adopted in instances where TR WCAP-10266-P, Revision 2, Addendum 3, Revision 1, is cited, because Westinghouse has not yet published the "-A" version.

2. Change "Best Estimate Analysis Reflood Transient" to "Best Estimate Analysis of Reflood Transients" and "BART System Hydraulics" to "BART and System Hydraulics" (Title).

   NRC Resolution for Comment 2 on Draft SE:

   The proposed change is adopted.

3. Add "Revision 2," after "WCAP-10266-P-A," (Page 1, line 9).

   NRC Resolution for Comment 3 on Draft SE:

   The proposed change is adopted.

4. Change "References 5 and 6" to "References 5, 6 and X", where X is the reference number for LTR-NRC-04-20 (Page 1, line 12).

   NRC Resolution for Comment 4 on Draft SE:

   The proposed change is adopted. However, "Reference X" is "Reference 7" in the Final SE.

5. Change to "Westinghouse subsequently provided its response to an additional request for information in Reference 8 (Page 1, lines 13-15).

   NRC Resolution for Comment 5 on Draft SE:

   The proposed change is adopted. However, "Reference 8" of the Draft SE is "Reference 9" in the Final SE.

6. Delete "in Reference 10" and the corresponding citation (not applicable to TR Revision 1) (Page 1, lines 24-25, and page 11, lines 39-44).

<u>NRC Resolution for Comment 6 on Draft SE</u>:

The proposed change is adopted.

7. Delete the following sentence for consistency with the original BASH-EM methodology: "At that point the reflood rate, from SMUUTH, is used to continue the hot rod heat up calculation in LOCBART" (Page 4, lines 25-26).

<u>NRC Resolution for Comment 7 on Draft SE</u>:

The proposed change is adopted.

8. Change "at the onset of" to "during" for consistency with TR Revision 1 (Page 4, line 40; Page 8, line 3; Page 10, line 23).

<u>NRC Resolution for Comment 8 on Draft SE</u>:

The proposed change is adopted.

9. Change "range of widths, from 2 to 8 inches" to "width of 2 or 8 inches" (Page 5, lines 28-29).

<u>NRC Resolution for Comment 9 on Draft SE</u>:

The proposed change is adopted.

10. Delete Reference 21 (repeated reference) and replace with Reference 14 (Page 5, line 40; Page 6, line 27; Page 7, lines 7 and 34; Page 8, line 9; Page 12, lines 42-43).

<u>NRC Resolution for Comment 10 on Draft SE</u>:

The proposed change is adopted.

11. Replace Reference 21 with a reference for WCAP-8170 (Reference 6-4 of TR Revision 1) (Page 6, line 17).

<u>NRC Resolution for Comment 11 on Draft SE</u>:

The proposed change is adopted. The reference for WCAP-8170 is Reference 25.

12. Replace Reference 21 with Reference 23 (Page 6, line 39).

<u>NRC Resolution for Comment 12 on Draft SE</u>:

The proposed change is adopted. Reference 23 in the Draft SE is Reference 22 in the Final SE.

13. Delete the first sentence and the word "also" from the second sentence (corresponding sensitivities removed in TR Revision 1), and change (Section 5.4 and 5.5, Reference 4)" to "(Sections 6.4 and 6.5, Reference 12)" (Page 8, line 28-33).

    NRC Resolution for Comment 13 on Draft SE:

    The proposed change is adopted.

14. Change "As such" to "In addition" to distinguish between the affected/unaffected plant designations provided in Reference 9 and the configurations identified in lines 42-44 (Page 9, line 44).

    NRC Resolution for Comment 14 on Draft SE:

    The proposed change is adopted.

15. Change "March 6" to "March 1" (Page 10, line 42).

    NRC Resolution for Comment 15 on Draft SE:

    The proposed change is adopted.

16. Change the title of Reference 20 to "Experimental Results of the Effective Water Head in Downcomer During Reflood Phase of a PWR LOCA (2^{nd} report, 50 mm Gap Size)" (Page 12, lines 39-40).

    NRC Resolution for Comment 16 on Draft SE:

    The proposed change is adopted.

17. Change "BART-AI" to "BART-A1" (Page 13, line 7).

    NRC Resolution for Comment 17 on Draft SE:

    The proposed change is adopted.