November 5, 2004

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

SUBJECT: FINAL SAFETY EVALUATION FOR WCAP-16009-P, REVISION 0, "REALISTIC LARGE BREAK LOCA EVALUATION METHODOLOGY USING AUTOMATED STATISTICAL TREATMENT OF UNCERTAINTY METHOD (ASTRUM)" (TAC NO. MB9483)

Dear Mr. Gresham:

On June 2, 2003, Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16009-P, Revision 0, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)," to the staff for review. On October 5, 2004, an NRC draft safety evaluation (SE) regarding our approval of WCAP-16009-P was provided for your review and comments. By e-mail dated October 25, 2004, Mr. Mitch Nissley of Westinghouse commented on the draft SE. The 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 staff has found that WCAP-16009-P is acceptable for referencing in licensing applications for Westinghouse and Combustion Engineering designed pressurized water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed SE. The SE defines the basis for 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 SE between the title page and the abstract. They must be well indexed such that information is readily located. Also, they must contain historical review information, such as questions and accepted responses, draft SE comments, and original TR pages that were replaced. The accepted versions shall include a "-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 Robert A. Gramm for/
Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 700

Enclosure: Safety Evaluation

cc w/encl:

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

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-16009-P, REVISION 0, "REALISTIC LARGE BREAK LOCA EVALUATION METHODOLOGY USING AUTOMATED STATISTICAL TREATMENT OF UNCERTAINTY METHOD (ASTRUM)"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

By letter dated June 2, 2003 (Reference 1), Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16009-P, Revision 0, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)," to the staff for review. By letters dated May 11 (Reference 2) and August 13, 2004 (Reference 3), Westinghouse responded to staff requests for additional information (RAIs). WCAP-16009-P, Revision 0, describes a realistic emergency core cooling system (ECCS) evaluation model (EM) that Westinghouse proposes to use in licensing applications to demonstrate plant conformance with the regulatory requirements defined in Title 10 of the *Code of Federal Regulations,* Section 50.46 (10 CFR 50.46), "Acceptance criteria for emergency core cooling systems for light-water nuclear reactors," for postulated pressurized water reactor (PWR) large-break (LB) loss-of-coolant accidents (LOCAs) for Westinghouse 2-, 3- and 4- loop, and Combustion Engineering (CE) nuclear power reactor designs.

The computer code used in this ECCS EM is WCOBRA/TRAC (Reference 4). WCOBRA/TRAC is Westinghouse's modified version of the NRC's COBRA/TRAC program. WCOBRA/TRAC is the same computer code used in the realistic LBLOCA EMs described in WCAP-12945-P-A, "Westinghouse Code Qualification Document for Best Estimate Loss of Coolant Analysis," (Reference 5), and WCAP-14449-P-A, Revision 1, "Application of Best Estimate Large Break LOCA Methodology to Westinghouse PWRs with Upper Plenum Injection" (Reference 6). WCAP-16009-P, Revision 0, describes an improvement to the uncertainty methodology, hereafter referred to as ASTRUM. The differences between ASTRUM and the previously approved Code Qualification Document (CQD) methodology are described in the TR. The principal difference between ASTRUM and CQD methodologies lies in the difference between the statistical treatments of the two methodologies. In addition to its presentation of the ASTRUM statistical approach, WCAP-16009-P, Revision 0, describes updates in WCOBRA/TRAC to reflect minor corrections in thermal hydraulic treatments to effect conformance with the model descriptions understood in the NRC Safety Evaluations (SEs) related to the CQD and to support application of ASTRUM to CE reactor designs.

Throughout this SE the terms "realistic LOCA EM" and "best-estimate LOCA EM" may be used interchangeably as was done in Regulatory Guide (RG) 1.157, "Best Estimate Calculation of Emergency Core Cooling System Performance" (Reference 7). The principal difference between this best estimate EM and EMs previously approved based on the provisions of 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," is that with a best estimate EM, LOCA calculations are performed with realistic models and correlations, and uncertainties in the calculations are explicitly accounted for; whereas, Appendix K models and correlations are justified on the basis of conservatism which bounds the uncertainties.

2.0 REGULATORY EVALUATION

Westinghouse currently has three approved best-estimate LBLOCA analysis methodologies, the two cited above and a recently approved abbreviated methodology, "Addendum 1 to WCAP-12945-P-A and WCAP-14449-P-A, Method for Satisfying 10CFR50.46 Reanalysis Requirements for Best-Estimate LOCA Evaluation Models" (Reference 8), for recalculating results of analyses previously performed using one of the other two methodologies. All three methodologies use adaptations of WCOBRA/TRAC and variations of the same statistical approach.

The proposed ASTRUM LBLOCA analysis methodology uses essentially the same WCOBRA/TRAC computer code, but with a different statistical approach.

The staff reviewed WCAP-16009-P for conformance with the requirements of 10 CFR 50.46(a)(1)(i). In quantifying the "high level of probability" criterion of 10 CFR 50.46(a)(1)(i), the staff determined that a 95th percentile probability based on best approximations of the constituent parameter distributions and the statistical approach used in the methodology is appropriately high for this application. Because this application only applies to LBLOCA design basis analyses (which assume a single failure), a higher probability of not exceeding the ECCS criteria is not needed to assure a safe design. Below this value, uncertainties are not a dominant contributor to the overall ECCS reliability.

The staff also referred to the guidance provided in RG 1.157 and the methodology described in NUREG/CR-5249, "Quantifying Reactor Safety Margins: Application of Code Scaling, Applicability, and Uncertainty Evaluation Methodology to a Large-Break, Loss-of-Coolant Accident" (Reference 9). The code scaling, applicability, and uncertainty (CSAU) methodology is also described in NUREG-1230, "Compendium of ECCS Research for Realistic LOCA Analysis" (Reference 10).

3.0 TECHNICAL EVALUATION

3.1 Comparison With the CSAU Methodology

The CSAU methodology is identified in RG 1.157 as one approach which conforms with the guidance provided by the RG. NUREG-5249, Section 2, lists 14 steps, divided among 3 elements, which constitute the CSAU methodology. This section summarizes the staff’s review of the WCOBRA/TRAC EM and its comparison to the 14 steps of the CSAU methodology. Because many of the steps in the CSAU methodology pertain only to the suitability and qualification of the computer code used in the methodology, which are the same for both the

CQD and the ASTRUM methodologies, the previous review of the CQD adequately addressed these steps and the staff findings from the previous reviews of those steps will be summarized in this SE. For certain steps, such as those affected by the application of WCOBRA/TRAC to CE plant designs, the staff reviewed the ASTRUM provisions to address those steps.

ELEMENT 1 - REQUIREMENTS AND CAPABILITIES (Steps 1 - 6)

"The applicability of a code to the analysis of a transient in a NPP is determined by comparison of the scenario - and plant- dictated requirements with the simulation capabilities of the code." (NUREG/CR-5249)

3.1.1 CSAU Step 1 - Scenario Specification

This step is needed because the dominant processes and safety parameters can change from one scenario to another. ASTRUM identifies LBLOCA (cold leg pump discharge guillotine or split break) as the scenario it addresses. This is the same scenario that the NRC-approved CQD methodology addresses.

There are no significant differences between the versions of the WCOBRA/TRAC computer code used by the two methodologies. Therefore, the ASTRUM version of COBRA/TRAC can also acceptably calculate the same LBLOCA scenarios for which the CQD version was approved.

3.1.2 CSAU Step 2 - Nuclear Plant Selection

Because the dominant phenomena and their interactions differ to varying degrees with plant design, the plant class must be selected to assess model adequacies and to specify applicabilty limits for the EM. The CQD methodology is approved for analyses of LBLOCA in the cold leg of a Westinghouse-designed PWR. Because ASTRUM and the CQD methodologies are based on essentially the same computer code (WCOBRA/TRAC), the physical models of ASTRUM are also applicable to the same Westinghouse designs.

Westinghouse also proposes that ASTRUM is applicable for LBLOCA analyses of CE PWR designs. This is discussed below in Section 3.4.

3.1.3 CSAU Step 3 - Phenomenon Identification and Ranking

As indicated in Steps 1 and 2, plant behavior is not equally influenced by all processes and phenomena that occur during a transient. This step allows for the simplification of the analysis to make it manageable. ASTRUM provides a discussion supplemented by a Phenomenon Identification and Ranking Table (PIRT) applying to all presently operating plants of Westinghouse design. As part of the methodology, ASTRUM provides a PIRT identifying nine physical models as being significant to overall uncertainty: critical flow, break path resistance, fuel rod parameters, core heat transfer, delivery and bypassing of emergency core cooling, steam binding and entrainment, condensation, non-condensable gases, and upper plenum drain distribution. In its previous review of WCAP-12945-P-A, the staff concluded that the Westinghouse PIRT for Westinghouse 3-loop and 4-loop designs were consistent with CSAU Step 3. In the SE for WCAP-14449-P-A, the staff noted that the differences in the phenomenon descriptions and rankings between the PIRTs for Westinghouse 2-loop, 3-loop and 4-loop designs were found to be appropriate, minor, and reasonable. Since ASTRUM and approved CQD methodologies employ the same WCOBRA/TRAC methodology containing essentially the same physical models to apply to the same classes of plants, the staff concludes that the PIRT(s) for ASTRUM is consistent with CSAU Step 3.

3.1.4 CSAU Step 4 - Frozen Code Selection

This step assures that changes to the code after an evaluation has been completed do not impact the conclusions and that changes occur in an auditable and traceable manner. The ASTRUM is based on the frozen code version (i.e., WCOBRA/TRAC MOD7A Revision 6), which is an updated version of the same frozen code used in the CQD (i.e., WCOBRA/TRAC MOD7A Revision 1). The differences in these versions are insignificant and appropriate, as described below in Section 3.3.

3.1.5 CSAU Step 5 - Provision of Complete Code Documentation

As discussed above, the computer code used for the previously approved CQD is WCOBRA/TRAC. This is the same code used in the approved methodologies described in WCAP-12945-P-A and WCAP-14449-P-A.

ASTRUM employs essentially the same code. WCAP-16009-P refers to WCOBRA/TRAC and the CQD documentation, and in Appendix B, "Validation of WCOBRA/TRAC MOD7A Revision 6," it describes the changes made to WCOBRA/TRAC since the previous NRC review.

3.1.6 CSAU Step 6 - Determination of Code Applicability

In this step, code capabilities for the given scenario and plant design are qualitatively assessed for four analytical elements of modeling requirements identified as important in the PIRT developed in Step 3: field (conservation) equations, closure equations, numerics, and structure and nodalization. In doing so, this step combines the findings from the previous five steps to make a code applicability finding and to identify any modifications needed to make that finding.

The WCOBRA/TRAC code was shown to be applicable for the specified scenario and for the specified Westinghouse plant types described in WCAP-12945-P-A and WCAP-14449-P-A. In implementing this step, Westinghouse determined that there is no feature of ASTRUM that would affect those conclusions from the previously approved TRs. WCAP-16009, Appendix A, "Extension of ASTRUM to Combustion Engineering Designs," provides justification for the applicability of WCOBRA/TRAC and ASTRUM to CE-designed plants. The staff's review of Appendix A is discussed below in Section 3.4.

ELEMENT 2 - ASSESSMENT AND ARRANGING OF PARAMETERS (Steps 9-10)

"The total uncertainty in a safety analysis includes contributions from code limitations, scaling effects embedded in the experimental data (and therefore the code), and uncertainty associated with the state of the reactor. The latter uncertainty arises from design and operating uncertainties associated with manufacturing tolerances and the life of the fuel." The steps of this element "are needed to quantify the effects of the individual contributors, through parameter ranging." (NUREG/CR-5249)

3.1.7 CSAU Step 7 - Establish Assessment Matrix

In this step, with reference to the PIRT (Step 3), an assessment matrix of separate and integral effects tests is assembled to best address the important phenomena and components. WCAP-16009-P includes two tables which summarize the main features of each test facility in the assessment matrix, indicating which physical processes were present in each test series. Three other tables list all of the highly ranked phenomena from the PIRT, and indicate which of the tests were examined for each phenomenon. Because neither the WCOBRA/TRAC computer code nor the applications are changed, the ASTRUM methodology does not affect the selection of tests and phenomena in the assessment matrix versus the matrices for previously approved WCOBRA/TRAC best estimate methodologies. Therefore, the assessment matrix is also acceptable for the ASTRUM methodology.

3.1.8 CSAU Step 8 - Nuclear Power Plant (NPP) Nodalization Definition

NUREG/CR-5249 discusses the tradeoffs and comparisons in determining an adequate NPP nodalization. In previous applications of WCOBRA/TRAC to Westinghouse 2-loop, 3-loop and 4-loop designs, Westinghouse has defined nodalizations to be used which are roughly equivalent to the CSAU nodalization, and has supported these nodalizations with direct comparisons to test data. The staff has concluded from its review that the statistical treatment proposed for the ASTRUM methodology will not affect the NPP nodalizations versus the previously approved methodologies. Because the WCOBRA/TRAC computer code used in the ASTRUM methodology is the same as the one used in the previously approved methodologies, the staff concludes that nodalizations for the Westinghouse 2-loop, 3-loop and 4-loop designs continue to be acceptable for use in the ASTRUM methodology.

3.1.9 CSAU Step 9 - Definition of Code and Experimental Accuracy

In this step, simulations of the experiments from the Step 7 assessment matrix using the NPP nodalization defined in Step 8 are used to determine a minimum value for code accuracy. In the previous review for the 2-loop, 3-loop and 4-loop versions of the WCOBRA/TRAC, the staff concluded that Westinghouse defines code and experimental accuracy consistent with, but not the same as, CSAU Step 9.

3.1.10 CSAU Step 10 - Determination of the Effect of Scale

In this step, the potential effects of scale (i.e., actual plant versus experiment) on uncertainty are assessed. The ASTRUM report summarized the scaling effects test comparisons and findings for the CQD methodology. Because the computer code and the plants are the same for the CQD and ASTRUM methodologies, the staff concludes that the scaling effects conclusions found acceptable for the CQD also apply to ASTRUM.

ELEMENT 3 - SENSITIVITY AND UNCERTAINTY ANALYSIS (Steps 11-14)

"The ultimate objective of the CSAU process is to provide a simple singular element of uncertainty with the primary safety criteria used as a basis for determining the acceptability of a specific reactor design. This objective is accomplished when the effect of important individual contributions to uncertainty in the primary safety criteria are determined. These individual contributions are then combined to give the desired uncertainty statement." (NUREG/CR-5249)

3.1.11 <u>CSAU Step 11 - Determination of Reactor Input Parameters and State</u>

This step accounts for uncertainties in plant calculations that may result from uncertainties in the plant operating state at the initiation of the transient. As in the CQD methodology, the effects of reactor input parameters and reactor state at the time of the design basis LOCA in ASTRUM are accounted for by a combination of plant-specific confirmatory analyses and uncertainty analyses. These analyses supplement those performed to demonstrate applicability to specific classes of plants. On each individual plant application, the NRC confirms that the licensee and its vendor (i.e., Westinghouse) have processes to assure that the LOCA analysis parameter input values and ranges bound the as-operated plant values and ranges for those parameters. This provides assurance that the requirements of 10 CFR 50.46(c) are met.

3.1.12 <u>CSAU Step 12 - Performance of NPP Sensitivity Studies</u>

In this step, sensitivity calculations are performed in order to establish the total uncertainty for various plant operating conditions that arise from uncertainties in reactor state at the initiation of the transient.

The ASTRUM methodology differs from the CQD methodology in the number of event calculations needed to determine the code sensitivity for a given plant-specific design. This is due to the difference in statistical approach between the two methods. However, the ASTRUM approach is also acceptable, as discussed below in Section 3.2.

3.1.13 <u>CSAU Step 13 - Determination of Combined Bias and Uncertainty</u>

In this step, the individual uncertainties resulting from code modeling of important phenomena, scale effects and NPP input variations are combined. The ASTRUM methodology differs from the CQD methodology in the number of event calculations needed to determine the code sensitivity for a given plant-specific design. This is due to the difference in statistical approach between the two methods. However, the ASTRUM approach is also acceptable, as discussed below in Section 3.2.

3.1.14 <u>CSAU Step 14 - Determination of Total Uncertainty</u>

In this step, the statement of total uncertainty is given as the probability for the limiting value(s) of the safety criteria. The effect of uncertainty contributions that cannot be quantified as bias and distribution because the data are limited, or because it is not economical to obtain data, can be quantified as separate biases based on bounding sensitivity calculations with the NPP model. These separate biases are then included in the total uncertainty.

The CQD methodology uses a response surface approach consistent with the CSAU process which, because of its modular nature in treating uncertainties, included such a correction step. In the ASTRUM approach, no such adjustment to account for these uncertainty biases is necessary because each individual calculation is continuous from start to finish, and thereby inherently accounts for those added uncertainties which are envisioned by the CSAU and exist in the CQD. The ASTRUM methodology also does not require adjustments to the oxidation values for each transient calculation for the same reason.

3.2 ASTRUM Uncertainty Approach

The ASTRUM methodology differs from the previously approved CQD methodology primarily in the statistical technique used to make a probabilistic statement with regard to the conformance of the system under analysis to the regulatory requirements of 10 CFR 50.46. The CQD methodology requires the construction of a response surface, that in effect replaces the WCOBRA/TRAC code. The response surface allows a Monte Carlo computation to estimate the appropriate percentile of the variables (e.g., peak cladding temperature, maximum local oxidation, and core-wide oxidation) of the acceptance criteria of 10 CFR 50.46. The ASTRUM methodology, on the other hand, applies a non-parametric statistical technique directly to a random sample of outputs (e.g., peak cladding temperature, maximum local oxidation, and core-wide oxidation) from the WCOBRA/TRAC calculations. These sample outputs are computed by applying Monte Carlo sampling to the inputs of WCOBRA/TRAC calculations. This approach allows the formulation of a simple singular statement of uncertainty in the form of a tolerance interval for the numerical acceptance criteria of 10 CFR 50.46. Based on the computed tolerance interval, a decision can be made with regard to the conformance of the performance of the system under analysis to the regulatory requirements of 10 CFR 50.46. A unique characteristic of the non-parametric statistical approach is that once a desired tolerance level is defined, the number of Monte Carlo code runs required to construct the tolerance interval that meets the desired level of safety can be easily computed. The ASTRUM methodology has chosen a 95/95 tolerance level to demonstrate conformance to 10 CFR 50.46; this tolerance level requires 124 runs.

The ASTRUM methodology of using Monte Carlo sampling of the inputs (as specified in Table 11-5 of the TR) for 124 runs of WCOBRA/TRAC demonstrates the conformance of the computed numerical values of peak cladding temperature, maximum local oxidation and core-wide oxidation to the acceptance criteria of 10 CFR 50.46 at the 95/95 tolerance level and, therefore, is acceptable.

3.3 Thermal Hydraulic Issues

3.3.1 <u>Changes in How WCOBRA/TRAC is Used</u>

Westinghouse has not changed the WCOBRA/TRAC code itself in developing the ASTRUM methodology, but has made usage changes to accommodate the ASTRUM uncertainty approach. These are discussed below in Sections 3.3.1.1 through 3.3.1.6.

3.3.1.1 Break Size and Type

The ASTRUM methodology accounts for the requirement that a spectrum of breaks be considered in the analysis by sampling three distributions: break type (double-ended cold-leg guillotine or split), cold-leg break area (A_{CL}), and discharge coefficient (CD). All three are taken into account to define the problem boundary condition at the break. The break type is determined by sampling from a uniform distribution with a 50 percent probability of choosing either type. If the break type is a double-ended cold-leg guillotine, A_{CL} is constant and equal to the cross-sectional area of the pipe. If the break-type is a split, the flow area is chosen from a uniform distribution with a range of 1 ft^2/A_{CL} to 2. For both break types, the value of the discharge coefficient is randomly sampled from a distribution constructed based on Marviken critical flow data.

The staff reviewed this and finds the ASTRUM treatment of LBLOCA break size and type is acceptable.

3.3.1.2 Time in Cycle

Section 11-2-2 of the TR discusses the treatment of time in the cycle and its associated burnup effects on stored energy and peak cladding temperature. The proposed treatment is different from the approved CQD approach. However, Section 11-2-2 of the TR provides justification for this deviation from the CQD approach. The staff reviewed this and finds the ASTRUM time in cycle treatment acceptable because it is conservative, consistent with plant operation, and consistent with the current NRC interpretation of burnup effects treatment.

3.3.1.3 Confirmatory Calculations

Prior to performing the detailed uncertainty analyses, Westinghouse performs confirmatory (sensitivity) studies to identify limiting scenario assumptions (e.g. loss of off-site power versus availability of off-site power). This is consistent with the approved CQD and therefore is acceptable.

3.3.1.4 NPP Uncertainty Analyses (CSAU Step 13)

This is included in Sections 3.1 and 3.2 of this safety evaluation.

3.3.1.5 Determination of Total Uncertainty (CSAU Step 14)

This is included in Sections 3.1 and 3.2 of this safety evaluation.

3.3.1.6 Local Oxidation and Core-wide Hydrogen Generation

The ASTRUM methods for calculating local oxidation and core-wide hydrogen generation are the same as in the approved CQD methodology. However, the CQD uses a different uncertainty methodology to determine the appropriate oxidation and hydrogen generation results. The ASTRUM approach to explicitly determine these LBLOCA results is discussed above in Section 3.2, and is therefore acceptable.

3.3.2 Code Updates Included in WCOBRA/TRAC MOD7A Revision 6

Appendix B to the TR discusses validation of WCOBRA/TRAC MOD7A Revision 6 (the version of WCOBRA/TRAC used in the ASTRUM methodology). Appendix B does this by discussing changes made to WCOBRA/TRAC from frozen code version WCOBRA/TRAC MOD7A Revision 1 (the previously approved version) to WCOBRA/TRAC MOD7A Revision 6. Most of the changes or errors were stated to have no effect on prior code assessment results for a variety of reasons. The staff considered the list of items identified by Westinghouse and concludes that the changes and errors do not affect the prior code assessments, such that those assessments continue to apply for Westinghouse 2-loop, 3-loop and 4-loop plant versions of WCOBRA/TRAC input models.

Appendix B also identifies eleven other changes (error corrections) that could potentially affect the prior assessment of biases and uncertainties associated with the use of WCOBRA/TRAC. The changes were made to correct coding errors such that the code was configured in accordance with the staff's SE related to the previous version of WCOBRA/TRAC. Westinghouse evaluated each of the changes and concluded that each error and its correction has an insignificant impact on the WCOBRA/TRAC results and therefore insignificantly affects the prior assessments and uncertainties. Based on this, the staff concludes that the corrections are reasonable, effectual, and therefore WCOBRA/TRAC MOD7A Revision 6 is acceptable for application to Westinghouse 2-loop, 3-loop and 4-loop plant designs.

The staff also evaluated the conditions and limitations previously identified for WCOBRA/TRAC to determine if they continue to apply for usage of WCOBRA/TRAC as part of the ASTRUM methodology. For those conditions and limitations that deal with WCOBRA/TRAC, Westinghouse either described its literal compliance or described its compliance with the intent of the condition or limitation. An example of the latter case is the extension of the applicability of ASTRUM to CE-designed plants as described in Section 3.4. For those that deal with the CQD uncertainty approach, Westinghouse stated that these either do not apply to the ASTRUM uncertainty approach or identified how the ASTRUM approach met the intent of the condition or limitation. For example, "As part of the methodology, Westinghouse agreed ... to verify the normality assumption for the initial condition uncertainty distribution on a plant-specific basis." In response to this, Section 13-3-1 of the TR states, "Initial conditions are now sampled for each run, and the initial conditions uncertainty distribution is no longer used. Therefore, this requirement is no longer applicable." The staff reviewed Section 13-3 of the TR, "Effect of Revised Uncertainty Methodology On Prior SER Requirements," and found that it acceptably dispositions each of the identified conditions and limitations related to WCOBRA/TRAC and the CQD uncertainty approach.

3.4 Application to CE Designs

Appendix A to the TR discusses extension of the ASTRUM methodology to CE designs. Appendix A outlines the steps of the CSAU guidance, and addresses items which may differ between the designs for which the discussions of Section 3.3 of this safety evaluation apply and their application to the CE design. In Appendix A, Westinghouse identified three CSAU steps that would differ from previously considered applications: CSAU Step 3 (PIRT rankings), Step 7 (Assessment Matrix), and Step 8 (Nodalization). The following paragraphs summarize the WCAP-16009-P, Revision 0, discussions of the Westinghouse conclusions.

3.4.1 PIRT for CE Designs

Appendix A provided comparative phenomena rankings for CE designs versus the Westinghouse designs covered by the CQD. The PIRT rankings for CE designs differed only slightly from those for the other designs in four ranking areas: core, upper plenum, downcomer, and lower plenum. The staff reviewed these minor differences and found them reasonable and acceptable.

3.4.2 Review of the Assessment Matrix

Most phenomena rankings for the CE designs were closely similar of the other plant designs. However, one significant difference was found in the ranking of blowdown/reflood heat transfer. This difference was addressed by Westinghouse in its RAI response dated August 13, 2004 (Reference 3). The staff confirmed the Westinghouse findings by performing audit analyses using an alternative approach. The staff finds the comparative analyses provided by Westinghouse adequately address the concern and are, therefore, acceptable.

4.0 CONDITIONS AND LIMITATIONS

The findings in this SE apply only to the current ASTRUM methodology and do not apply to other LOCA methodologies.

The current ASTRUM methodology only applies to LBLOCA analyses.

This SE approves the ASTRUM process of determining the maximum local oxidation and whole core hydrogen generation results, but requires that this information be reported on a plant-specific application which uses ASTRUM. For uses other than as part of the ASTRUM methodology, the process and all of its elements, including a description of its intended use and justification, must be submitted to the NRC for review and approval.

Unless specifically addressed in this SE, the conditions and limitations previously identified for WCOBRA/TRAC continue to apply for usage of WCOBRA/TRAC as part of the ASTRUM methodology. The staff reviewed Section 13-3 of WCAP-16009-P and found that it acceptably dispositions each of the identified conditions and limitations related to WCOBRA/TRAC and the CQD uncertainty approach.

Unless specifically addressed in this SE, the treatments of the performance criteria of 10 CFR 50.46(b) as addressed in the CQD methodologies continue to apply unchanged, as previously approved in the SEs for their respective documentation(s).

The methodology described in WCAP-16009-P, Revision 0, is a separate and unique methodology. Any other version derived from this TR, such as designated by a new revision number, amendment number, addendum number or other equivalent designation, would constitute a definition of a new methodology requiring NRC review and acceptance prior to generic application and prior to any specific plant licensing application of a new methodology derived from ASTRUM.

5.0 CONCLUSION

Westinghouse has successfully used the CQD methodology and the WCOBRA/TRAC computer code to perform LBLOCA analyses for its 2-loop, 3-loop and 4-loop plant designs, and for the AP600 and AP1000 advanced plant designs. The staff finds that the improvement to the uncertainty methodology as described in WCAP-16009-P, Revision 0, for the ASTRUM methodology is acceptable for meeting the regulatory requirements of 10 CFR 50.46. In Appendix A, Westinghouse has demonstrated that ASTRUM modeling of phenomena for these plant designs is also appropriate for the modeling of CE plant designs by showing that the important phenomena for CE designs are similar to those for which the CQD methodology using WCOBRA/TRAC has been previously approved for Westinghouse designs. Therefore, the ASTRUM methodology is also applicable to CE plant designs.

6.0 REFERENCES

1. Letter from H.A. Sepp (Westinghouse) to NRC, "Request for Review and Approval of Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)," LTR-NRC-03-22, dated June 2, 2003. (Accession No. ML031600574).

2. Letter from J.A. Gresham (Westinghouse) to NRC, "Westinghouse Proprietary and Nonproprietary Responses to the Requests for Additional Information (RAIs) on WCAP-16009, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)" (Proprietary)," LTR-NRC-04-30, dated May 11, 2004. (Accession No. ML041340596)

3. Letter from J.A. Gresham (Westinghouse) to NRC, "Responses to Requests for Additional Information (RAIs) on WCAP-16009, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)," LTR-NRC-04-48, dated August 13, 2004. (Accession No. ML042320633)

4. NUREG/CR-3046, "COBRA/TRAC - A Thermal-Hydraulics Code for Transient Analysis of Nuclear Reactor Vessels and Primary Coolant Systems," March 1983.

5. WCAP-12945-P-A, "Westinghouse Code Qualification Document for Best Estimate Loss of Coolant Analysis," March 1998.

6. WCAP-14449-P-A, Revision 1, "Application of Best Estimate Large Break LOCA Methodology to Westinghouse PWRs with Upper Plenum Injection," October 1999.

7. Regulatory Guide 1.157, "Best Estimate Calculation of Emergency Core Cooling System Performance," May 1989. (Accession No. ML003739584)

8. "Addendum 1 to WCAP-12945-P-A and WCAP-14449-P-A, Method for Satisfying 10CFR50.46 Reanalysis Requirements for Best-Estimate LOCA Evaluation Models," March 2004.

9. NUREG/CR-5249, "Quantifying Reactor Safety Margins: Application of Code Scaling, Applicability, and Uncertainty Evaluation Methodology to a Large-Break, Loss-of-Coolant Accident," December 1989.

10. NUREG-1230, "Compendium of ECCS Research for Realistic LOCA Analysis," December 1988.

Attachment: Resolution of Comments

Principal Contributor: F. Orr, NRR

Date: Novemb er 5, 2004

RESOLUTION OF COMMENTS

ON DRAFT SAFETY EVALUATION FOR TOPICAL REPORT WCAP-16009-P, REVISION 0,

"REALISTIC LARGE BREAK LOCA EVALUATION METHODOLOGY USING AUTOMATED

STATISTICAL TREATMENT OF UNCERTAINTY METHOD (ASTRUM)"

By e-mail dated October 25, 2004, Westinghouse provided comments on the draft safety evaluation (SE) for WCAP-16009-P, Revision 0, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)." The following is the staff's resolution of those comments.

1. Westinghouse Comment: Page 3, line 35. Strike "2-loop."

   Westinghouse Basis: Two-loop PIRT [Phenomenon Identification and Ranking Table] is addressed in WCAP-14449-P-A, not WCAP-12945-P-A. The following sentence on lines 36-38 is adequate as is, to address 2-loop PIRT.

   NRC Action: The comment was fully adopted into the final SE.

2. Westinghouse Comment: Page 5, lines 17 and 18. Delete the sentence "The nodalization for each design is part of the frozen code version for each NPP design."

   Westinghouse Basis: As currently written, one would think that this section concludes that the nodalization for all 2-loop plants is the same, and ditto for 3- and 4-loop designs. The nodalization is a function of the plant-specific design. This was illustrated in WCAP-12945-P-A; see, for example, Figures 20-2-5 and 20-3-2. These show how the noding is adjusted for two 4-loop plants that have different upper internals designs. The important thing is the nodalization philosophy, which is to maintain a consistent strategy between the noding used for code assessment and NPP [nuclear power plant] analysis.

   NRC Action: The comment was fully adopted into the final SE.

3. Westinghouse Comment: Page 5, line 19. Typographical error; "nodaliztions" should be "nodalizations."

   NRC Action: The comment was fully adopted into the final SE.

4. Westinghouse Comment: Page 10, lines 1-2. Replace the first sentence with something like "This SE generically approves the ASTRUM process of determining the maximum oxidation and hydrogen generation results, but requires that this information be reported on a plant-specific application which uses ASTRUM."

   Westinghouse Basis: Page 8, lines 23-28, indicate that the methodology is acceptable. Current text on page 10 implies otherwise. The suggested replacement text is more along the lines of what the staff has in mind.

   NRC Action: The comment was adopted into the final SE with clarifications.

5. Westinghouse Comment: Page 10, lines 3-5. Section 13-3 of WCAP-16009-P reviews all of the prior SE applicability limits and usage conditions from the NRC review of WCAP-12945-P-A and WCAP-14449-P-A, and indicates which are still applicable and which are not. (Some became irrelevant due to change in uncertainty method.) It was not clear that the staff agreed with our assessment, based on this general statement on page 10.

   Westinghouse Proposed Resolution: "It is Westinghouse's understanding that our conclusions in Section 13-3 of WCAP-16009-P regarding the continued validity of prior SER requirements are acceptable to the staff."

   NRC Action: The comment was adopted into the final SE with minor rewording. Additionally, clarifying statements were added to Section 3.3.2 to state that the staff reviewed the previously identified conditions and limitations regarding the CQD uncertainty approach and the usage of WCOBRA/TRAC and found that Section 13-3 acceptably dispositions each of the identified conditions and limitations.

6. Westinghouse Comment: Page 10, line 34. The correct reference should be LTR-NRC-04-30. The AW-04-1834 reference is for the accompanying Affidavit for Withholding.

   NRC Action: The comment was fully adopted into the final SE.