

October 5, 2004

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

SUBJECT: DRAFT SAFETY EVALUATION FOR TOPICAL REPORT (TR) 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 WCAP-16009-P, Revision 0, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)," to the staff for review. Enclosed for Westinghouse's review and comment is a copy of the staff's draft safety evaluation (SE) for the TR. Also enclosed for Westinghouse's information is a copy of a non-public staff audit analysis of proprietary data presented in the submittal.

Pursuant to 10 CFR 2.390, we have determined that the enclosed draft SE does not contain proprietary information. However, we will delay placing the draft SE in the public document room for a period of ten working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects. If you believe that any information in the enclosure is proprietary, please identify such information line-by-line and define the basis pursuant to the criteria of 10 CFR 2.390. After ten working days, the draft SE will be made publicly available, and an additional ten working days are provided to you to comment on any factual errors or clarity concerns contained in the SE. The final SE will be issued after making any necessary changes and will be made publicly available. The staff's disposition of your comments on the draft SE will be discussed in the final SE.

To facilitate the staff's review of your comments, please provide a marked-up copy of the draft SE showing proposed changes and provide a summary table of the proposed changes.

J. Gresham

- 2 -

If you have any questions, please contact Bill Macon at (301) 415-3965.

Sincerely,

/RA/

Robert A. Gramm, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 700

Enclosures: 1. Draft Safety Evaluation
2. Staff Audit Analysis

cc w/encl 1 only:

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

J. Gresham

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***SE Dated: October 5, 2004**

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DRAFT 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 1.0 INTRODUCTION

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

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

29 Throughout this SE the terms "realistic LOCA EM" and "best-estimate LOCA EM" may be used
30 interchangeably as was done in Regulatory Guide (RG) 1.157, "Best Estimate Calculation of

1 Emergency Core Cooling System Performance" (Reference 7). The principal difference
2 between this best estimate EM and EMs previously approved based on the provisions of
3 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," is that with a best estimate EM,
4 LOCA calculations are performed with realistic models and correlations, and uncertainties in the
5 calculations are explicitly accounted for; whereas, Appendix K models and correlations are
6 justified on the basis of conservatism which bounds the uncertainties.

7 2.0 REGULATORY EVALUATION

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

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

17 The staff reviewed WCAP-16009-P for conformance with the requirements of 10 CFR
18 50.46(a)(1)(i). In quantifying the "high level of probability" criterion of 10 CFR 50.46(a)(1)(i),
19 the staff determined that a 95th percentile probability based on best approximations of the
20 constituent parameter distributions and the statistical approach used in the methodology is
21 appropriately high for this application. Because this application only applies to LBLOCA design
22 basis analyses (which assume a single failure), a higher probability of not exceeding the ECCS
23 criteria is not needed to assure a safe design. Below this value, uncertainties are not a
24 dominant contributor to the overall ECCS reliability.

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

31 3.0 TECHNICAL EVALUATION

32 3.1 Comparison With the CSAU Methodology

33 The CSAU methodology is identified in RG 1.157 as one approach which conforms with the
34 guidance provided by the RG. NUREG-5249, Section 2, lists 14 steps, divided among 3
35 elements, which constitute the CSAU methodology. This section summarizes the staff's review
36 of the WCOBRA/TRAC EM and its comparison to the 14 steps of the CSAU methodology.
37 Because many of the steps in the CSAU methodology pertain only to the suitability and
38 qualification of the computer code used in the methodology, which are the same for both the
39 CQD and the ASTRUM methodologies, the previous review of the CQD adequately addressed
40 these steps and the staff findings from the previous reviews of those steps will be summarized

1 in this SE. For certain steps, such as those affected by the application of WCOBRA/TRAC to
2 CE plant designs, the staff reviewed the ASTRUM provisions to address those steps.

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

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

7 3.1.1 CSAU Step 1 - Scenario Specification

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

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

16 3.1.2 CSAU Step 2 - Nuclear Plant Selection

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

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

25 3.1.3 CSAU Step 3 - Phenomenon Identification and Ranking

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

1 approved CQD methodologies employ the same WCOBRA/TRAC methodology containing
2 essentially the same physical models to apply to the same classes of plants, the staff concludes
3 that the PIRT(s) for ASTRUM is consistent with CSAU Step 3.

4 3.1.4 CSAU Step 4 - Frozen Code Selection

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

11 3.1.5 CSAU Step 5 - Provision of Complete Code Documentation

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

15 ASTRUM employs essentially the same code. WCAP-16009-P refers to WCOBRA/TRAC and
16 the CQD documentation, and in Appendix B, "Validation of WCOBRA/TRAC MOD7A Revision
17 6," it describes the changes made to WCOBRA/TRAC since the previous NRC review.

18 3.1.6 CSAU Step 6 - Determination of Code Applicability

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

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

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

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

1 3.1.7 CSAU Step 7 - Establish Assessment Matrix

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

12 3.1.8 CSAU Step 8 - Nuclear Power Plant (NPP) Nodalization Definition

13 NUREG/CR-5249 discusses the tradeoffs and comparisons in determining an adequate NPP
14 nodalization. In previous applications of WCOBRA/TRAC to Westinghouse 2-loop, 3-loop and
15 4-loop designs, Westinghouse has defined nodalizations to be used which are roughly
16 equivalent to the CSAU nodalization, and has supported these nodalizations with direct
17 comparisons to test data. The nodalization for each design is part of the frozen code version
18 for each NPP design. The staff has concluded from its review that the statistical treatment
19 proposed for the ASTRUM methodology will not affect the NPP nodalizations versus the
20 previously approved methodologies. Because the WCOBRA/TRAC computer code used in the
21 ASTRUM methodology is the same as the one used in the previously approved methodologies,
22 the staff concludes that nodalizations for the Westinghouse 2-loop, 3-loop and 4-loop designs
23 continue to be acceptable for use in the ASTRUM methodology.

24 3.1.9 CSAU Step 9 - Definition of Code and Experimental Accuracy

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

30 3.1.10 CSAU Step 10 - Determination of the Effect of Scale

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

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

37 "The ultimate objective of the CSAU process is to provide a simple singular element of
38 uncertainty with the primary safety criteria used as a basis for determining the acceptability of a
39 specific reactor design. This objective is accomplished when the effect of important individual

1 contributions to uncertainty in the primary safety criteria are determined. These individual
2 contributions are then combined to give the desired uncertainty statement." (NUREG/CR-5249)

3 3.1.11 CSAU Step 11 - Determination of Reactor Input Parameters and State

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

13 3.1.12 CSAU Step 12 - Performance of NPP Sensitivity Studies

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

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

21 3.1.13 CSAU Step 13 - Determination of Combined Bias and Uncertainty

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

28 3.1.14 CSAU Step 14 - Determination of Total Uncertainty

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

34 The CQD methodology uses a response surface approach consistent with the CSAU process
35 which, because of its modular nature in treating uncertainties, included such a correction step.
36 In the ASTRUM approach, no such adjustment to account for these uncertainty biases is
37 necessary because each individual calculation is continuous from start to finish, and thereby
38 inherently accounts for those added uncertainties which are envisioned by the CSAU and exist

1 in the CQD. The ASTRUM methodology also does not require adjustments to the oxidation
2 values for each transient calculation for the same reason.

3 3.2 ASTRUM Uncertainty Approach

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

24 The ASTRUM methodology of using Monte Carlo sampling of the inputs (as specified in Table
25 11-5 of the TR) for 124 runs of WCOBRA/TRAC demonstrates the conformance of the
26 computed numerical values of peak cladding temperature, maximum local oxidation and core-
27 wide oxidation to the acceptance criteria of 10 CFR 50.46 at the 95/95 tolerance level and,
28 therefore, is acceptable.

29 3.3 Thermal Hydraulic Issues

30 3.3.1 Changes in How WCOBRA/TRAC is Used

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

34 3.3.1.1 Break Size and Type

35 The ASTRUM methodology accounts for the requirement that a spectrum of breaks be
36 considered in the analysis by sampling three distributions: break type (double-ended cold-leg
37 guillotine or split), cold-leg break area (A_{CL}), and discharge coefficient (CD). All three are taken
38 into account to define the problem boundary condition at the break. The break type is
39 determined by sampling from a uniform distribution with a 50 percent probability of choosing
40 either type. If the break type is a double-ended cold-leg guillotine, A_{CL} is constant and equal to

1 the cross-sectional area of the pipe. If the break-type is a split, the flow area is chosen from a
2 uniform distribution with a range of $1 \text{ ft}^2/A_{CL}$ to 2. For both break types, the value of the
3 discharge coefficient is randomly sampled from a distribution constructed based on Marviken
4 critical flow data.

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

7 3.3.1.2 Time in Cycle

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

14 3.3.1.3 Confirmatory Calculations

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

19 3.3.1.4 NPP Uncertainty Analyses (CSAU Step 13)

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

21 3.3.1.5 Determination of Total Uncertainty (CSAU Step 14)

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

23 3.3.1.6 Local Oxidation and Core-wide Hydrogen Generation

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

29 3.3.2 Code Updates Included in WCOBRA/TRAC MOD7A Revision 6

30 Appendix B to the TR discusses validation of WCOBRA/TRAC MOD7A Revision 6 (the version
31 of WCOBRA/TRAC used in the ASTRUM methodology). Appendix B does this by discussing
32 changes made to WCOBRA/TRAC from frozen code version WCOBRA/TRAC MOD7A
33 Revision 1 (the previously approved version) to WCOBRA/TRAC MOD7A Revision 6. Most of
34 the changes or errors were stated to have no effect on prior code assessment results for a
35 variety of reasons. The staff considered the list of items identified by Westinghouse and

1 concludes that the changes and errors do not affect the prior code assessments, such that
2 those assessments continue to apply for Westinghouse 2-loop, 3-loop and 4-loop plant versions
3 of WCOBRA/TRAC input models.

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

13 3.4 Application to CE Designs

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

21 3.4.1 PIRT for CE Designs

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

27 3.4.2 Review of the Assessment Matrix

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

34 4.0 CONDITIONS AND LIMITATIONS

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

37 The current ASTRUM methodology only applies to LBLOCA analyses.

1 This SE does not generically approve the ASTRUM process of determining the maximum
2 oxidation and hydrogen generation results.

3 Unless specifically addressed in this SE, the conditions and limitations previously identified for
4 WCOBRA/TRAC continue to apply for usage of WCOBRA/TRAC as part of the ASTRUM
5 methodology.

6 Unless specifically otherwise approved in this SE, the treatments of the performance criteria of
7 10 CFR 50.46(b) as addressed in the CQD methodologies continue to apply unchanged, as
8 previously approved in the SEs for their respective documentation(s).

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

15 5.0 CONCLUSION

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

26 6.0 REFERENCES

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