Westinghouse Non-Proprietary Class 3

CENPD-279, Supplement 16 March 2005

Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs

LEGAL NOTICE

This report was prepared as an account of work performed by Westinghouse Electric Company LLC. Neither Westinghouse Electric Company LLC nor any person acting on its behalf:

A. Makes any warranty or representation, express or implied including the warranties of fitness for a particular purpose or merchantability, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

COPYRIGHT NOTICE

This report has been prepared by Westinghouse Electric Company LLC (WEC) and bears a Westinghouse Electric Company LLC copyright notice. Information in this report is the property of and contains copyright information owned by WEC and/or its subcontractors and suppliers. It is transmitted to you in confidence and trust, and you agree to treat this document and the information contained therein in strict accordance with the terms and conditions of the agreement under which it was provided to you.

You are permitted to make the number of copies of the information contained in this report which are necessary for your internal use in connection with your implementation of the report results for your plant(s) in your normal conduct of business. Should implementation of this report involve a third party, you are permitted to make the number of copies of the information contained in this report which are necessary for the third party's use in supporting your implementation at your plant(s) in your normal conduct of business if you have received the prior, written consent of WEC to transmit this information to a third party or parties. All copies made by you must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

The NRC is permitted to make the number of copies beyond those necessary for its internal use that are necessary in order to have one copy available for public viewing in the appropriate docket files in the NRC public document room in Washington, DC if the number of copies submitted is insufficient for this purpose, subject to the applicable federal regulations regarding restrictions on public disclosure to the extent such information has been identified as proprietary. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

© Copyright 2005, Westinghouse Electric Company LLC. All rights reserved.

ABSTRACT

This report describes changes and errors in the ECCS performance evaluation models (EM) for PWRs developed by Combustion Engineering in calendar year (CY) 2004 per the requirements of 10CFR50.46. For this reporting period, there was one change in the implementation of the 1999 EM for LBLOCA that affects the cladding temperature calculation. There were no other changes or errors in the evaluation models or application of the models that affect the cladding temperature calculation.

The sum of the absolute magnitude of the generic peak cladding temperature (PCT) changes for the large break LOCA June 1985 EM from all reports to date continues to be less than 1°F excluding plant specific effects. The generic impact on the peak cladding temperature for the large break LOCA 1999 EM is less than 1.2°F for plants analyzed with the Automated/Integrated Code System (AICS) and less than 3°F for plants analyzed with the Advanced AICS. The generic sum of the absolute magnitude of the peak cladding temperature changes for the small break LOCA S1M evaluation model from all reports to date is less than 3°F. There is no generic accumulated change in peak cladding temperature for the small break LOCA S2M evaluation model. No change occurred in the PCT due to post-LOCA long term cooling issues. The total effect relative to the 50°F definition of a significant change in PCT for each evaluation model is the sum of the generic effects for that model and plant specific effects, if any, described in Appendices A-F.

TABLE OF CONTENTS

1.0 INTRODUCTION

This report addresses the NRC requirement to report changes or errors in ECCS performance evaluation models. The ECCS Acceptance Criteria, Reference 1, spell out reporting requirements and actions required when errors are corrected or changes are made in an evaluation model or in the application of a model for an operating licensee or construction permittee of a nuclear power plant.

The action requirements in 10CFR50.46(a)(3) are:

1. Each applicant for or holder of an operating license or construction permit shall estimate the effect of any change to or error in an acceptable evaluation model or in the application of such a model to determine if the change or error is significant. For this purpose, a significant change or error is one which results in a calculated peak fuel cladding temperature (PCT) different by more than 50°F from the temperature calculated for the limiting transient using the last acceptable model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50°F.

2. For each change to or error discovered in an acceptable evaluation model or in the application of such a model that affects the temperature calculation, the applicant or licensee shall report the nature of the change or error and its estimated effect on the limiting ECCS analysis to the Commission at least annually as specified in 10CFR50.4.

3. If the change or error is significant, the applicant or licensee shall provide this report within 30 days and include with the report a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with 10CFR50.46 requirements. This schedule may be developed using an integrated scheduling system previously approved for the facility by the NRC. For those facilities not using an NRC approved integrated scheduling system, a schedule will be established by the NRC staff within 60 days of receipt of the proposed schedule.

4. Any change or error correction that results in a calculated ECCS performance that does not conform to the criteria set forth in paragraph (b) of 10CFR50.46 is a reportable event as described in 10CFR50.55(e), 50.72 and 50.73. The affected applicant or licensee shall propose immediate steps to demonstrate compliance or bring plant design or operation into compliance with 10CFR50.46 requirements.

This report documents all the errors corrected in and/or changes to the presently licensed ECCS performance evaluation models for PWRs developed by Combustion Engineering, made in the year covered by this report, which have not been reviewed by the NRC staff. This document is provided to satisfy the reporting requirements of the second item above. Reports for earlier years are given in References 2-17.

2.0 COMBUSTION ENGINEERING ECCS EVALUATION MODELS AND CODES

Five evaluation models (EM) for ECCS performance analysis of PWRs developed by Combustion Engineering are described in topical reports, are licensed by the NRC, and are covered by the provisions of 10CFR50.46. The evaluation models for large break LOCA (LBLOCA) are the June 1985 EM and the 1999 EM. There are two evaluation models for small break LOCA (SBLOCA): the SBLOCA Evaluation Model (S1M) and the S2M SBLOCA EM. Post-LOCA long term cooling (LTC) analyses use the LTC evaluation model.

Several digital computer codes are used to do ECCS performance analyses of PWRs for the evaluation models described above that are covered by the provisions of 10CFR50.46. Those for LBLOCA calculations are CEFLASH-4A, COMPERC-II, HCROSS, PARCH, STRIKIN-II, and COMZIRC. CEFLASH-4AS is used in conjunction with COMPERC-II, STRIKIN-II, and PARCH for SBLOCA calculations. The codes for post-LOCA LTC analyses are BORON, CEPAC, NATFLOW, and CELDA.

3.0 EVALUATION MODEL CHANGES AND ERROR CORRECTIONS

This section discusses all error corrections and model changes to the ECCS performance evaluation models for PWRs described in Section 2.0 that may affect the calculated PCT.

3.1 Zirconium Diboride Integral Fuel Burnable Absorber

Use of zirconium diboride integral fuel burnable absorbers (ZrB_2 IFBA) in CE designed PWRs was accepted by the NRC in Calendar Year (CY) 2004, Reference 19. The PCT impact is handled on a plant specific basis as discussed in Section 3.4.

3.2 Automation of LOCA Analysis Methods

The current (1999) EM for LBLOCA is described in the NRC accepted topical report, Reference 20. The methodology is implemented by the Automated / Integrated Code System (AICS) described in Reference 20 which automates data flow between the separate computer codes. A new version of the AICS called the Advanced Automated / Integrated Code System (AAICS) has been implemented to further automate data flow, reduce manual input preparation, ensure consistency of input between the codes, facilitate parametric studies and support new options. There are no changes to the EM or any of its components including those controlled by Appendix K in 10CFR50. The maximum effects on the relevant LOCA acceptance criteria are:

Acceptance Criterion	Units	Maximum Difference
Peak Cladding Temperature (PCT)	°F	1.4
Maximum Cladding Oxidation (MCO)	% oxidation	0.023
Core Wide Oxidation (CWO)	% oxidation	0.015

These changes are due to small differences in the precision of input manually prepared by the analyst and that calculated by the computer codes.

The current SBLOCA EM is the S2M described in the NRC accepted topical report, Reference 21. Some of the principles used to automate data flow between codes and facilitate parametric studies for the AAICS have been implemented in the procedures used to perform SBLOCA analyses. There are no changes to the EM or any of its components including those controlled by Appendix K in 10CFR50. The change in the implementation of the S2M SBLOCA EM has no effect on the analysis results.

3.3 Change in Computing Platform and Version of HP-UX Operating System

The version of the operating system (OS) used for the computers that perform LOCA calculations changed from HP-UX 11.00 to HP-UX 11.11. Also, a new hardware platform, the HP C8000, was introduced in 2004. A system state equivalency test demonstrates that these changes have no effect on any analysis results.

3.4 Rod Internal Pressure Effect on SBLOCA Cladding Temperature and Oxidation

Up to now, SBLOCA analyses have been performed at the burnup with the highest initial stored energy in the fuel rod per the SBLOCA EM described in Reference 22. However, a hot rod heatup calculation performed at the burnup with the maximum initial stored energy in the fuel may not be limiting for a ZrB_2 IFBA rod design because of its internal pressure behavior during a hot rod heatup calculation. A parametric study on rod internal pressure (RIP) is now used to evaluate this effect for all CE fuel assembly designs as discussed in Section 4.2.3.2 of the NRC accepted topical report for fuel with ZrB_2 IFBA rods, Reference 19. An additional RIP parametric study is performed to determine the effect on MCO. Future SBLOCA analyses for CE fuel assembly designs with ZrB_2 IFBA rods will include the results of RIP parametric studies for PCT and MCO. Because the change in PCT may be significant, e.g., greater than 50°F, the implications for 10CFR50.46 reporting requirements will be addressed in plant specific submittals, such as 30 day letters, describing introduction of fuel assemblies with ZrB_2 IFBA rods.

4.0 CONCLUSIONS

There were no changes to or errors in the ECCS evaluation models for PWRs or their application for LBLOCA, SBLOCA, or post-LOCA long term cooling that affect the calculated cladding temperature during CY 2004 except as noted below. Implementation of the AAICS for the 1999 EM had a maximum PCT impact of 1.4°F.

The sum of the absolute magnitude of the changes in PCT calculated using the June 1985 EM for LBLOCA, including those from previous annual reports, References 2-17, remains less than 1°F. The maximum impact on PCT calculated with the 1999 EM is less than 3°F (1.2°F from Reference 16 plus 1.4°F for the AAICS). Plant specific LBLOCA considerations for each plant including application of the AAICS are discussed in Appendices A through F.

Previous plant specific PCT effects for both the S1M and S2M SBLOCA evaluation models are discussed in Appendices A through F of Reference 15. In addition, there is a generic effect on maximum cladding temperature for the SBLOCA S1M (due to the change in application of the SBLOCA S1M described in Reference 11) that is less than 3°F. There is no previous generic accumulated change in cladding temperature for the S2M. The overall plant specific PCT effects for SBLOCA are summarized in Appendices A through F.

There is no PCT effect for the post-LOCA long term cooling evaluation model.

5.0 REFERENCES

1. "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Reactors," Code of Federal Regulations, Title 10, Part 50, Section 50.46.
2. "Annual Report on C-E ECCS Codes and Methods for 10CFR50.46," CENPD-279, April, 1989.
3. "Annual Report on C-E ECCS Codes and Methods for 10CFR50.46," CENPD-279, Supplement 1, February, 1990.
4. "Annual Report on C-E ECCS Codes and Methods for 10CFR50.46," CENPD-279, Supplement 2, April, 1991.
5. "Annual Report on C-E ECCS Codes and Methods for 10CFR50.46," CENPD-279, Supplement 3, April, 1992.
6. "Annual Report on C-E ECCS Codes and Methods for 10CFR50.46," CENPD-279, Supplement 4, April, 1993.
7. "Annual Report on C-E ECCS Codes and Methods for 10CFR50.46," CENPD-279, Supplement 5, February, 1994.
8. "Annual Report on ABB C-E ECCS Performance Evaluation Models," CENPD-279, Supplement 6, February, 1995.
9. "Annual Report on ABB C-E ECCS Performance Evaluation Models," CENPD-279, Supplement 7, February, 1996.
10. "Annual Report on ABB CE ECCS Performance Evaluation Models," CENPD-279, Supplement 8, February, 1997.
11. "Annual Report on ABB CE ECCS Performance Evaluation Models," CENPD-279, Supplement 9, March, 1998.
12. "Annual Report on ABB CE ECCS Performance Evaluation Models," CENPD-279, Supplement 10, February, 1999.
13. "Annual Report on ABB CE ECCS Performance Evaluation Models," CENPD-279, Supplement 11, March, 2000.
14. "Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs," CENPD-279, Supplement 12, April, 2001.
15. "Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs," CENPD-279, Supplement 13, Rev. 1, April, 2002.
16. "Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs," CENPD-279, Supplement 14, Rev. 1, April, 2003.
17. "Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs," CENPD-279, Supplement 15, March 2004.

18. "Post-LOCA Long Term Cooling Evaluation Model," CENPD-254-NP-A, June 1980.

19. "Implementation of Zirconium Diboride Absorber Coatings in CE Nuclear Power Fuel Assembly Designs," WCAP-16072-NP-A, August 2004.

20. "Calculative Methods for the CE Nuclear Power Large Break LOCA Evaluation Model," CENPD-132, Supplement 4-NP-A, March 2001.

21. "Calculative Methods for the ABB CE Small Break LOCA Evaluation Model," CENPD-137, Supplement 2-A (non-proprietary), April 1998.

22. "Calculative Methods for the C-E Small Break LOCA Evaluation Model," CENPD-137, Rev. 1 (non-proprietary), August 1974.

Plant Specific Considerations for Waterford Unit 3

There is no PCT effect for the Cycle 13 SBLOCA reanalysis with no charging pump flow and a revised HPSI performance done for the 30 day letter due to methodology or code issues. The plant specific geometry errors discussed below are already accounted for in the results of this analysis.

Information for previous cycles is provided below for completeness.

Appendix E of the CY 2002 10CFR50.46 report for Waterford Unit 3 in Reference 16 was revised in Reference E.1 to address two plant specific geometry errors. It concluded that there was no PCT effect for LBLOCA and a 3°F effect for SBLOCA.

The total effect on PCT is less than 1°F for all LBLOCA analyses of Waterford Unit 3 done with the 1985 EM including the 10CFR50 Appendix K power uprate analysis and the analysis for Cycles 12 and 13.

The plant specific effect for analyses done with the S2M SBLOCA methodology is stated in Reference 15 to be that "The effect of the CEFLASH-4AS code error on the SBLOCA PCT is -38°F based on the S2M analysis using revised HPSI pump flow rate data." The plant geometry errors discussed in Reference E.1 produced a 3°F effect. The total PCT effect is |-38°F| + |3°F| or 41°F. This applies to the earlier S2M SBLOCA analyses, the 10CFR50 Appendix K power uprate analysis and Cycle 12 through 13 operation of Waterford Unit 3.

Reference:

E.1 CWTR3-03-138, Letter from M. M. Stickel (WEC) to J. Holman (EOI), "Revision of CY 2002 10CFR50.46 Report for Combustion Engineering PWRs," September 30, 2003.