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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Subject: Waterford 3 SES
Docket No. 50-382
License No. NPF-38
Annual Report on Westinghouse Electric Company LLC Combustion Engineering Emergency Core Cooling System Performance Evaluation Models

Gentlemen:

Pursuant to 10CFR50.46(a)(3)(ii), Entergy Operations, Inc. (EOI) hereby submits for the Waterford Steam Electric Station Unit 3 an annual evaluation of changes and errors identified in the Westinghouse Electric Company LLC Combustion Engineering Emergency Core Cooling System (ECCS) performance evaluation models used for Loss-of-Coolant Accident (LOCA) analyses. The results of the annual evaluation for the calendar year 2002 are provided in Attachment 1, CENPD-279, "Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs," Supplement 14, Revision 1, dated April 2003. Please note that as indicated on the Table of Contents, CENPD-279 contains Appendices A – G, which provides Plant Specific Considerations for Combustion Engineering Pressurized Water Reactors. However, Waterford 3 will only submit page E.2 of Appendix E which provides Waterford 3 plant specific data.

For calendar year 2002, two errors in the evaluation models (EM) or application of the models that affect the cladding temperature calculation were identified as described in Attachment 1. Both of the errors were in STRIKIN-II code models that affect the results of LBLOCA analyses using either the 1985 or 1999 EM for LBLOCA. Waterford 3 uses the 1985 LBLOCA evaluation model. The sum of the absolute magnitude of peak cladding temperature changes for the Large Break LOCA June 1985 evaluation model, from all reports to date remained less than 1°F in 2002.

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There are no errors in the Small Break LOCA S2M methodology identified in 2002. The effect of previous code errors on the SBLOCA peak cladding temperature is an absolute magnitude of 38°F. The effects of facility/fuel inputs are not included in this report since they are evaluated under the provisions of 10 CFR 50.59. No changes or errors were reported by Westinghouse Electric Company LLC in the post-LOCA Long Term Cooling evaluation model. Per the criteria of 10 CFR 50.46, no action beyond this annual report is required.

There are no commitments contained in this submittal. Should you have any qustions regarding the attached report, please contact T.M. Manzella at (504) 739-6882.

Very truly yours,

K.J. Peters
Director
Nuclear Safety Assurance

KJP/TMM/cbh

Attachment : CENPD-279, "Annual Report on Combusion Engineering ECCS Performance Evaluation Models for PWRs"

cc: E.W. Merschoff, NRC Region IV
N. Kalyanam, NRC-NRR
J. Smith
N.S. Reynolds
NRC Resident Inspectors Office

Attachment 1

CENPD-279

Supplement 14, Revision 1

Annual Report on Combusion Engineering

ECCS Performance Evaluation Models for PWRs

April 2003

CENPD-279
Supplement 14, Rev. 1

ANNUAL REPORT ON COMBUSTION ENGINEERING ECCS PERFORMANCE EVALUATION MODELS for PWRs

April 2003

Westinghouse Electric Company LLC

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ABSTRACT

This report describes changes and errors in the ECCS performance evaluation models for PWRs developed by Combustion Engineering in calendar year (CY) 2002 per the requirements of 10CFR50.46. For this reporting period, errors were found in the evaluation models (EM) or application of the models that affect the cladding temperature calculation. In particular, errors in the STRIKIN-II code used in the large break LOCA evaluation models were found and corrected.

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. 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-G.

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 2-15.

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 are performed with 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 STRIKIN-II Code Errors

Errors in the implementation of the time step algorithm and the Coffman plastic strain model were identified and corrected in 2002.

3.1.1 Time Step Algorithm

The algorithms used in the automatic time step selection method for STRIKIN-II are described in Appendix C of Reference 16. They are designed to automatically adjust the time step length such that STRIKIN-II calculates an appropriate solution for the fuel, cladding and coolant temperature and the heat flux to the coolant by limiting the Courant number. They are designed to ensure that the Courant number, R_j, defined for Eq. II.2-6 in Reference 17, never exceeds 1.0 which ensures conservation of energy. That is,

$$R_j \equiv G_j \bullet \Delta t / (\rho_j \bullet \Delta z) \leq 1.0$$

where

G_j = Mass flux at axial node j (lbm/ft^2-sec)
Δt = Time step interval (sec)
ρ_j = Coolant density at axial node j (lbm/ft^3)
Δz = Axial node length (ft).

While the numerical limit for the Courant number is 1.0, the time step algorithm in STRIKIN-II further limits it to a value of 0.5. An error in the implementation of the algorithm bypassed this test which could allow the Courant number to exceed the normal limit. This error was corrected.

An additional problem that could produce a Courant number greater than 1.0 was found with the implementation of a user input for the minimum time step length. When the user input for the minimum time step is less than the value calculated by the automatic time step algorithm, the minimum time step length is used. An error test was added to stop the code with an error message if the minimum time step specified by the user would allow the Courant number to exceed 0.99.

3.1.2 Coffman Plastic Strain Model for Cladding

A problem with the implementation of the Coffman plastic strain model for fuel cladding in STRIKIN-II was discovered. The model is only used when the heating rate and the cladding temperature are within bounds set for application of the model. The calculated plastic strain is continuous except when the cladding conditions are outside these bounds and later return within the bounds at a higher cladding temperature. In order to address the resulting discontinuity, a ramp function is used to introduce the strain over several time steps. The problem occurred when the heating rate fell below the lower bound for the model within the time duration of the ramp. This was corrected by terminating the ramp when the conditions for the use of the model described above are not satisfied.

3.1.3 Effect of Correcting STRIKIN-II Errors

Analyses of several plants with the 1985 EM for Zircaloy-4 cladding shows that the effect on PCT is less than $|0.2°F|$. Analyses of plants with the 1999 EM for Zircaloy-4 and ZIRLO™ cladding show that the effect on cladding PCT is less than $|1.2°F|$.

4.0 CONCLUSIONS

There were two errors in the ECCS evaluation models for PWRs in CY 2002. Both of the errors were in STRIKIN-II code models that affect the results of LBLOCA analyses using either the 1985 or 1999 EM. 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 2-15, remains less than 1°F. The total 1985 EM LBLOCA impact on PCT for a given plant remains <1°F. The maximum impact on PCT with the 1999 EM is less than 1.2°F. Plant specific LBLOCA considerations for each plant are discussed in Appendices A through G.

There are no errors for SBLOCA in CY 2002. Previous plant specific PCT effects for both the S1M and S2M SBLOCA evaluation models are discussed in Appendices A through G 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 accumulated change in cladding temperature for the S2M.

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.
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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, March, 1997.
11. "Annual Report on ABB CE ECCS Performance Evaluation Models," CENPD-279, Supplement 9, February, 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. "STRIKIN-II – A Cylindrical Geometry Fuel Rod Heat Transfer Program," CENPD-135-P, Supplement 5, April 1977.

17. "STRIKIN-II, A Cylindrical Geometry Fuel Rod Heat Transfer Program," CENPD-135P, August 1974.

Plant Specific Considerations for Waterford Unit 3

The total effect on PCT due to the STRIKIN-II errors described in Section 3 is less than 1°F for all LBLOCA analyses of Waterford Unit 3 to date that were done with the 1985 EM including the Appendix K power uprate analysis and the analysis for Cycle 12.

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." This applies to the earlier S2M SBLOCA analyses, the Appendix K power uprate analysis and Cycle 12 operation of Waterford Unit 3.

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