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U. S. Nuclear Regulatory Commission
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Washington, DC 20555-0001

References: 1) Letter dated May 3, 2002, "10 CFR 50.46(a)(3)(ii) 30-Day Report for Changes in LOCA/ECCS Performance Evaluation Models," from David Mauldin, APS to USNRC

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Emergency Core Cooling System (ECCS) Performance Evaluation Models, 10 CFR 50.46(a)(3)(ii) Annual Report

Dear Sirs:

Pursuant to 10 CFR 50.46(a)(3)(ii), Arizona Public Service Company (APS) has enclosed the Westinghouse Electric Company "Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs, CENPD-279, Supplement 13, March 2002." This report describes the changes and errors in Combustion Engineering models for Pressurized Water Reactors (PWRs) ECCS performance analysis in calendar year 2001. Appendix A of this report is specific to PVNGS. All other appendices of this report are plant-specific to other Combustion Engineering (CE) designed facilities and have not been included as part of this submittal.

During the calendar year 2001, the Large Break Loss of Coolant Accident (LBLOCA) Analysis of Record for PVNGS utilized the evaluation model version referred to as "1985 EM" and the Small Break Loss of Coolant Accident (SBLOCA) Analysis of Record for PVNGS utilized the evaluation model version referred to as "S1M" for CE designed facilities. For this reporting period, calendar year 2001, there were some changes or errors in the evaluation models (1985 EM and S1M) or application of the

A001

models that affects the peak cladding temperature calculations. The cumulative sum of the absolute magnitudes of changes in Peak Clad Temperature (PCT) remains < 1 °F for the 1985 LBLOCA evaluation model, is now < 34 °F for the S1M SBLOCA evaluation model, and remains 0 °F (no change) for the post LOCA long term cooling (LTC) evaluation model.

Additionally, on May 3, 2002, PVNGS notified the NRC (reference 1) of changes to the Peak Cladding Temperature (PCT) due to the implementation to the "1999 EM" evaluation model for LBLOCA and the "S2M" evaluation model for SBLOCA.

No commitments are being made to the NRC by this letter.

If you have any questions, please contact Thomas N. Weber at (623) 393-5764.

Sincerely,

SAB/TNW/JAP/kg

Enclosure

cc: E. W. Merschoff
D. G. Naujock
J. N. Donohew
N. L. Salgado

ENCLOSURE

Annual Report on Combustion Engineering ECCS Performance Evaluation Models for PWRs, CENPD-279, Supplement 13, dated March 2002

CENPD-279
Supplement 13

ANNUAL REPORT ON COMBUSTION ENGINEERING ECCS PERFORMANCE EVALUATION MODELS for PWRs

March 2002

Westinghouse Electric Company LLC

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ABSTRACT

This report describes changes and errors in the ECCS performance analysis models for PWRs developed by Combustion Engineering in calendar year 2002 per the requirements of 10CFR50.46. For this reporting period, there were four changes and one error in the evaluation models or application of the models that affect the cladding temperature calculation.

1. The 1999 Evaluation Model (EM) for LBLOCA was accepted by the NRC at the end of calendar year 2000 and introduced for licensing analyses in calendar year 2001. Introduction of the new models and methodology for the 1999 EM has no effect on ECCS performance analysis results for the other LBLOCA and SBLOCA evaluation models.
2. The hot rod heat-up codes HCROSS, PARCH, and STRIKIN-II were combined into an Integrated STRIKIN-II code to support the 1999 EM. This has no effect on the PCT for the other LBLOCA and SBLOCA evaluation models.
3. Properties for ZIRLO™ cladding were introduced into the computer codes used for the 1999 EM for LBLOCA and the S2M for SBLOCA and NRC accepted in calendar year 2001. This has no effect on the PCT for licensing analyses with Zircaloy-4 cladding.
4. The computer system state was changed for the ECCS performance analysis computer codes. The changes include use of a new version of the FORTRAN 77 compiler, new compiler and loader options for codes that were compiled in calendar year 2001 (CEFLASH-4A, COMPERC-II, HCROSS, PARCH, STRIKIN-II, COMZIRC, CEFLASH-4AS and some of the related utility codes), and operation under a new version of the computer operating system. These changes had a negligible effect on the PCT (< 0.1°F) for each of the evaluation models – 1985 EM and 1999 EM for LBLOCA and the S1M and S2M for SBLOCA.
5. An error in the CEFLASH-4AS code for SBLOCA blowdown analysis was found and corrected. The effect on the SBLOCA PCT is different for each plant or related set of plants. Plant specific results are given in Appendices A-G.

The sum of the absolute magnitude of the 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 total effect relative to the 50°F definition of a significant change in PCT is the sum of <1°F and plant specific effects, if any, described in Appendices A-G. The accumulated change in cladding temperature for the large break LOCA 1999 EM is 0°F. The sum of the absolute magnitude of the maximum cladding temperature changes for the small break LOCA S1M evaluation model from all reports to date is < 3°F plus the plant specific results in Appendices A-G. The accumulated change in cladding temperature for the small break LOCA S2M evaluation model is limited to plant specific effects given in Appendices A-G. No change occurred in the PCT due to post-LOCA long term cooling issues.

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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 2-14.

2.0 COMBUSTION ENINEERING 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 accepted by the NRC in 2000. There are two evaluation models for small break LOCA (SBLOCA): the SBLOCA Evaluation Model (S1M) and the S2M SBLOCA EM accepted by the NRC in 1997. Post-LOCA long term cooling (LTC) analyses are performed with the LTC evaluation model.

Several digital computer codes developed by Combustion Engineering 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 analysis 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 developed by Combustion Engineering which may affect the calculated PCT.

3.1 1999 Evaluation Model for LBLOCA

A revised Appendix K model for LBLOCA called the 1999 EM was NRC accepted at the end of calendar year 2000 per Reference 15 and introduced for licensing analysis in calendar year 2001. Implementation of the 1999 EM methodology included changes to the following codes: CEFLASH-4A, COMPERC-II, HCROSS, PARCH, STRIKIN-II, and COMZIRC as well as some supporting utility codes. The new models and methodology for the 1999 EM are added as an option to the existing codes that support the 1985 EM for LBLOCA and the SBLOCA models. These changes have no effect on results produced for the June 1985 EM, S1M or S2M.

3.2 Integrated STRIKIN-II Rod Temperature Code

The codes used for rod temperature calculations for all LBLOCA and SBLOCA methodologies (HCROSS, PARCH, and STRIKIN-II) have been integrated into a single code to accomodate data flow requirements between them for the 1999 EM methodology. Each code is incorporated as a module that can perform all of its previous functions as a stand-alone code or can be used in a linked mode for the 1999 EM. The combined tool is called the Integrated STRIKIN-II code. It supports the 1985 and 1999 EM for LBLOCA licensing analyses, the S1M and S2M for SBLOCA licensing analyses, and a realistic evaluation model used for non-licensing calculations. Testing has demonstrated that all previous functions of the stand-alone codes are supported and the modules of the Integrated STRIKIN-II code give the same results as the stand-alone codes.

3.3 ZIRLO™ Cladding Properties

Physical properties for ZIRLO™ cladding were added to the following codes for use in the 1999 EM and the S2M: CEFLASH-4A, COMPERC-II, PARCH, STRIKIN-II, COMZIRC, and CEFLASH-4AS. They are a new option in addition to the Zircaloy-4 cladding properties which continue to be supported in these codes. These changes have no effect on results produced for Zircaloy-4 cladding. NRC acceptance of the models and methodology for ZIRLO™ cladding is documented in Reference 16.

3.4 Change in Computer System State

Changes to the version of the FORTRAN 77 compiler, the operating system (OS), and the computer hardware are accomodated as part of the code changes summarized in Sections 3.1, 3.2, and 3.3. In addition, the coding for CEFLASH-4A, COMPERC-II, HCROSS, PARCH, STRIKIN-II, COMZIRC, CEFLASH-4AS and some of the related utility codes were revised to address three issues related to portability and stability of the codes. The codes were tested for occurance of out-of-range subscripts and corrected as needed. The compilation options were changed to stop execution when a floating-point arithmetic exception occurs and coding was revised as necessary to avoid floating-point arithmetic exceptions. Finally, the linking options for the loader were changed to statically link the FORTRAN libraries to the executables which makes the coding insensitive to changes in the OS version (changes in the FORTRAN library routines).

The revised codes were tested to evaluate the effect of these changes and introduction of the new models described in Sections 3.1, 3.2, and 3.3 on the existing methodologies for LBLOCA and SBLOCA. The effect of correcting out-of-range subscripts for the SBLOCA PCT is documented on a plant specific basis as discussed in Section 3.5 and Appendices A-G. The effect of the other changes on PCT for SBLOCA is discussed here. Test results for PCT are summarized in the table below.

Model	PCT Change (°F)
1985 EM for LBLOCA	None
1999 EM for LBLOCA	< 0.1
S1M for SBLOCA	< 0.1
S2M for SBLOCA	< 0.1

The PCT for the 1985 EM is not affected by the changes in the computer system state changes described above. The PCT effect for the 1999 EM is less that 0.1°F which is negligible. The PCT effects for the S1M and S2M are also less than 0.1°F. Their effect is included in the plant specific SBLOCA results discussed in Appendices A-G.

3.5 Code Error in CEFLASH-4AS

The testing for out-of-range subscripts described in Section 3.4 identified one important subscripting error in CEFLASH-4AS that affects the leak flow rate and PCT results for

SBLOCA. A couple of additional subscripting errors had a minor effect (< 1°F) on the PCT results. Two addditional code problems were discovered during the code testing process with the new compiler options enabled that stop the code from completing the transient calculation. These problems were addressed and the effects of the necessary coding changes were evaluated. Only the out-of range subscript error for the leak flow rate affected the PCT. Addressing the other problems allowed CEFLASH-4AS to run to the end of the transient but had no PCT consequnces. The SBLOCA PCT effect of the out-of-range subscripts is plant specific and is discussed in Appendices A-G.

4.0 CONCLUSIONS

There were five changes to or errors in the ECCS evaluation models for PWRs developed by Combustion Engineering for LBLOCA, SBLOCA, or post-LOCA long term cooling. Two changes are implementation of the 1999 EM for LBLOCA and incorportion of ZIRLO™ properties in the LBLOCA and SBLOCA codes which were accepted by the NRC per References 15 and 16; therefore, they have no effect on the results for this report. The third change is integration of PARCH and HCROSS as modules of the Integrated STRIKIN-II code. This has no effect on results for the 1985 EM for LBLOCA or the SBLOCA S1M and S2M. It was done to support creation of the 1999 EM. The fourth change is installation of the computer codes on a new computer system state including coding changes to address out-of-range subscripts and floating point arithmatic exceptions. This has a negligible effect on the PCT results except as discussed below for SBLOCA. 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 2-14, remains less than 1°F relative to the 50°F criterion for a significant change in PCT. The total LBLOCA PCT impact for a given plant is <1°F plus the plant specific effects, if any, discribed in Appendices A through G. There is no accumulated PCT error for the 1999 EM for LBLOCA.

Out-of-range subscripts in CEFLASH-4AS affected the PCT results for both S1M and S2M SBLOCA evaluation modes in a plant specific way as discused in Appendices A through G. In addition, there is an 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. Plant specific SBLOCA considerations for each plant are discussed in Appendices A through G.

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

16. "Implementation of ZIRLO™ Cladding Material in CE Nuclear Power Fuel Assembly Designs," CENPD-404-P-A, Revision 0, November, 2001.

APPENDIX A

ARIZONA PUBLIC SERVICE COMPANY

Plant Specific Considerations for Palo Verde Units 1, 2 and 3

Introduction

As described in Section 3.5, an error in the leak flow rate for the CEFLASH-4AS code due to out-of-range subscripts produced a plant specific impact on cladding temperature for SBLOCA. A 10 CFR 21 evaluation was performed. Based on the results of sensitivity analyses, as well as known results from improved Appendix K and best estimate SBLOCA methodologies for CENP plant designs, it was determined that the error was not capable of creating a substantial safety hazard, as defined in 10 CFR 21 (Reference 1); therefore, it was not reportable.

Effect

Plant specific sensitivity studies for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2 and 3 were transmitted to Arizona Public Service Company by Reference 2. The results of those sensitivity studies are summarized in the table below.

CORRECTED SBLOCA RESULTS FOR CEFLASH-4AS COMPUTER CODE ERROR

RESULT / PARAMETER	PEAK CLAD TEMPERATURE, °F	MAXIMUM LOCAL CLADDING OXIDATION, %	CORE-WIDE CLADDING OXIDATION, %
CORRECTED CODE VERSION LIMITING CASE	1704	1.87	0.30
AOR BENCHMARK UNCORRECTED CODE VERSION LIMITING CASE♦	1735	2.11	0.34
DIFFERENTIAL IMPACT	-31	-0.24	-0.04

♦ Note that the "benchmark" AOR case PCT and the previously reported licensing case AOR PCT may or may not be the same depending on the vintage of the licensing case AOR.

The analysis underlying these results has been independently reviewed pursuant to CE Nuclear Power LLC's (now WEC) quality procedures and the verification status is categorized as "COMPLETE".

Conclusion

The effect of the CEFLASH-4AS code error on the SBLOCA PCT is 31°F based on calculations for 5% stretch power with the S1M. This analysis predates the change in S1M methodology to automate data transfer between CEFLASH-4AS and PARCH; consequently, there is no accumulated PCT difference and the total effect is 31°F. WEC believes that the impact of this error does not exceed the 50°F reporting criterion for a significant error.

References:

1. NSAL-01-002, "Small Break LOCA ECCS Performance Computer Code Error," C. M. Molnar, et al., April 4, 2001.
2. Letter from D. E. Sipes (WEC) to M. F. Sauvageau (APS), V-2001-040, "CEFLASH-4AS Code Error and SBLOCA Results for PVNGS Units 1, 2 and 3 after Correction," May 15, 2001.

Attachment 2

Problems in Codes Used for PWR ECCS Performance Analysis

The code problems described here were identified in calendar year 2001 during code maintenance activities done per the provisions of the computer software section, QP 3.13, of the WEC QMS. They have no impact on the peak cladding temperature (PCT); therefore, they are not reported under the provisions of 10CFR50.46. This information is provided for completeness in the reporting process.

PARCH Module of Integrated STRIKIN-II Code

The PARCH module of the Integrated STRIKIN-II code is part of the PWR ECCS analysis evaluation models developed by Combustion Engineering. It calculates steam-cooling heat transfer coefficients for the LBLOCA 1985 and 1999 evaluation models (85EM and 99EM), performs SBLOCA rod temperature calculations for the SBLOCA S1M and S2M and is part of the non-licensed realistic evaluation model (REM) for SBLOCA.

Preliminary use of the Integrated STRIKIN-II code revealed three problems with the PARCH module for LBLOCA analyses – power shape renormalization, temperature initialization of the rupture node at the one-inch per second time for steam heat transfer, and the 99EM automatic nodal mapping of steam cooling heat transfer data for rupture in STRIKIN-II Node 19. PARCH was modified to ensure that the power shape is renormalized to exactly 1.0 instead of a total slightly diferent than 1.0 when the 20 node axial shape is linearly interpolated to obtain values for 50 axial nodes. This affects both the 85EM and 99EM. Initialization of fuel and cladding temperature at the one-inch per second time was changed to improve consistency of the STRIKIN-II and PARCH temperatures for the 99EM. Mapping of the steam heat transfer coefficient node number interface between PARCH and STRIKIN-II for rupture in STRIKIN-II Node 19 was corrected. Finally, an error message is provided and the calculation is stopped when the cladding temperature is increasing in an unbounded manner above 2200°F due to heat from the zirconium water reaction.

The impact of these changes on the 10CFR50.46 acceptance criteria results including PCT is negligible for LBLOCA based on testing of the PARCH module for 85EM and 99EM applications. SBLOCA results are not affected by these changes.