CEOG COMBUSTION ENGINEERING OWNERS GROUP

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SUPPLEMENT 4

ANNUAL REPORT ON
C-E ECCS CODES AND METHODS
FOR 10CFR50.46

FINAL REPORT

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Abstract

This report describes changes and errors in the ABB Combustion Engineering codes and analysis methodology for ECCS analysis in 1992 per the requirements of 10CFR50.46. For this reporting period, no errors were corrected nor were any models or methods changed for the large break, small break or post-LOCA long term cooling calculations. The codes used for LOCA analysis were converted from the CDC mainframe to HP/Apollo workstations (WS). The change in numerical precision between the computers had a slight effect on the peak cladding temperature (PCT) for large break LOCA, 0.26 °F. The sum of the absolute magnitudes of the temperature changes for large break LOCA from all reports to date continues to be less than 1 °F. No changes occurred in the peak cladding temperature due to small break LOCA or post-LOCA long term cooling. Per the criteria of 10CFR50.46, no action beyond this annual report is required.

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1.0 Introduction

This report addresses the NRC requirement to report changes or errors in licensed codes for ECCS analysis. The revision to the ECCS Acceptance Criteria, Reference 1, delineates the 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 10CFR50.46.

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 changes, made in the year covered by this report, to the presently licensed ABB C-E LOCA analysis models and methodology which have not been reviewed by the NRC staff. This document is provided to satisfy the reporting requirements of the second item above.

2.0 C-E Codes Used for ECCS Evaluation

ABB C-E uses several digital computer codes for ECCS analysis that are described in topical reports, are licensed by the NRC, and are covered by the provisions of 10CFR50.46. Those codes for large break LOCA 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 small break LOCA calculations. The codes for post-LOCA long term cooling analysis are BORON, CEPAC, NATFLOW, and CELDA.

3.0 Error Corrections and Model or Other Changes in Computer Codes

This section discusses all error corrections, along with model or other changes, to the licensed codes which may affect the calculated PCT. No corrections of errors or changes to the evaluation models were made in 1992. However, all of the C-E codes used to analyze large break LOCAs, small break LOCAs, and post-LOCA long term cooling were converted from the CDC mainframe computer to HP/Apollo workstations (WS) during 1992. This required numerous changes to the FORTRAN coding as described below.

3.1 Generic Changes to Coding

Several types of changes to the coding are common to most or all of the computer programs. This includes coding dependent on the compiler, operating system, or hardware of the computer. Examples are management and naming of files, use of code segmentation or overlays for memory management, and CDC extensions to the FORTRAN language that added features such as a statement with multiple assignments in a single line of code, (e.g. A = B = C = 0), or the ability to make overlapping references to an array in DATA statements. Some are changes to convert the coding from FORTRAN 4 to FORTRAN 77, particularly using CHARACTER variables for alpha-numeric strings. Other changes are to the CEMODEL subroutine libraries used for input and the user library which provides time, date, job identification, etc. Revisions to the coding for making plots add flexibility and support plotting on WS and personal computers (PCs). The licensed LOCA analysis codes were converted from the CDC mainframe to the WS incorporating these changes, as needed, and the code specific changes discussed below. The resulting WS version of each code was quality assured following the requirements of CE's quality assurance program.

The numerical methods used in some of the LOCA analysis programs require a high level of numerical precision. The CDC computers, where these codes were developed and have been run to date, have 60 bits in a word which provides approximately 14 decimal digits of precision. The HP/Apollo WS, to which the codes have been converted, is a byte oriented machine which needs 8 bytes to provide a similar level of precision, 64 bits or approximately 16 decimal digits. On the CDC mainframe 60 bit precision is the default; on the HP/Apollo WS the coding is changed by use of the IMPLICIT REAL*8 (A-H, O-Z) statement to obtain 64 bit precision. 64 bit precision is obtained for FORTRAN intrinsic math library functions such as AMIN1 or EXP by using the generic form of the function. The FORTRAN compiler then ensures that the precision of the intrinsic math library function is the same as that of the variables used in the calculation. Constants in parameter lists for subroutine or function subprograms are replaced by double precision constants to maintain the precision of the calculation. The program specific discussion identifies those programs which were modified in this way to maintain a high level of numeric precision.

3.2 Large Break LOCA Analysis Codes

The generic changes listed in Section 3.1 were made to all of the licensed large break LOCA analysis codes as needed. In addition, code specific changes were made as described below.

CEFLASH-4A was modified as described in Section 3.1 to obtain 64 bit precision in the calculations. Some variables that had to remain at 32 bit precision were specifically declared by means of the REAL*4 statement. To simplify memory management, the real variables were placed in separate COMMON blocks from the INTEGER and CHARACTER variables. The parameter lists of some calls to subprograms were modified to conform with the requirements of standard FORTRAN. Small coding changes were made as needed. Examples are protection against a possibility of dividing by zero, replacing system dependent coding for messages to the dayfile, and elimination of an unused variable.

The other large break LOCA analysis codes were modified as follows. The COMPERC-II code for large break LOCA analysis was modified to obtain 64 bit precision. Changes of the type listed in Section 3.1 were made to the HCROSS and PARCH codes used for large break LOCA analysis without the change for 64 bit precision. STRIKIN-II was modified as described in Section 3.1 to provide 64 bit precision. Some variables were renamed to avoid conflicts with reserved names or FORTRAN intrinsic function names. Some coding was changed to remove non-standard FORTRAN usage which did not function as intended on the WS. COMZIRC was changed as described in Section 3.1 without the changes for 64 bit precision.

Conversion of the large break LOCA codes to the WS has a small effect on the results from the codes relative to the results from the CDC computer. CEFLASH-4A produces slightly different blowdown hydraulic results on the WS for some transients than it does on the CDC mainframe. COMPERC-II, on the WS, produces essentially the same refill-reflood hydraulic behavior and heat transfer coefficients as it does on the CDC mainframe. On the WS, HCROSS calculates coolant cross flows that are passed on to the PARCH heat transfer calculation which are the same as those calculated on the CDC computer. PARCH on the WS produces heat transfer coefficients which are essentially the same as those from the CDC. There is no change in the PCT from STRIKIN-II run with the same input on the WS and CDC computers. The overall impact of code conversion on the PCT for a large break LOCA was examined as a combined effect due to using the output from each code in the analysis chain to drive the next code. The resulting PCT from STRIKIN-II run on the WS increases 0.26 °F relative to the result from the CDC. The primary source of the increase in PCT was due to the small changes in blowdown hydraulic behavior predicted by CEFLASH-4A. Overall cladding oxidation and hydrogen release predictions calculated by COMZIRC on the WS agree with those from the CDC.

3.3 Small Break LOCA Analysis Codes

The generic changes listed in Section 3.1 were made to all of the licensed small break LOCA analysis codes as needed. In addition, code specific changes were made. CEFLASH-4AS was changed as described above to obtain 64 bit precision. Minor changes were made to improve the plotting features and the header for each page of output from the code. The COMPERC-II code for small break LOCA analysis was modified to obtain 64 bit precision as described in Section 3.1. The changes made to STRIKIN-II are discussed above. 64 bit precision was added to the time step calculation of the PARCH code for small break analysis.

Conversion of the small break LOCA codes to the WS slightly changes the results relative to the CDC computer. Small break LOCA refill-reflood hydraulic results from COMPERC-II run on the WS agree with those from the CDC mainframe within 0.01%. Maximum cladding temperature results from PARCH for a small break LOCA run on the WS are not more than 0.2 °F different from the CDC results. Due to changes in the blowdown hydraulic results, the two phase fluid level in the core calculated by CEFLASH-4AS is slightly different on the WS for part of the time the core is uncovered. This has no meaningful effect on PCT for small break LOCA due to the procedure used to transfer two-phase level from the CEFLASH-4AS hydraulic results to the PARCH cladding temperature calculation. The difference in two-phase level calculated by the WS and CDC computers is less than the variation in level introduced by the manual procedure used to transfer the two-phase level from CEFLASH-4AS to PARCH.

3.4 Post-LOCA Long Term Cooling Codes

The generic changes listed in Section 3.1 were made to all of the licensed long term cooling LOCA analysis codes as needed. In addition, code specific changes were made. The page headers for BORON, CELDA, and NATFLOW were modified to add job identification information. CELDA and NATFLOW were changed as described in Section 3.1 to implement 64 bit precision. The results from the converted WS codes agree with the results from the CDC mainframe within 0.01%. Since no changes to the results for availability of adequate cooling water or coolability occurred due to the conversion from the CDC to the WS, there was no effect on the peak cladding temperature.

4.0 Conclusions

There were no errors corrected, changes to the models or changes to the methods used by C-E for LOCA analysis in 1992. The sum of the absolute magnitudes of the changes in PCT calculated using the C-E ECCS evaluation models, including those from previous annual reports, References 2-5, remains less than 1 °F.

The computer type used to perform ECCS analyses was changed from a CDC mainframe to HP Apollo workstations in 1992. This required some changes to the coding. The converted codes produce the same results in most calculations. Some results are slightly different (< 0.01% in most cases) due to the change in numerical precision between the computers.

The results calculated on the WS are equivalent to those calculated on the CDC mainframe for the purpose of calculating peak cladding temperature for large and small break LOCAs and for demonstrating compliance with Criterion 5 of 10CFR50.46 for long term cooling. That is:

1. There is no effect on PCT for a stand-alone calculation of a large break LOCA using STRIKIN-II on the WS. The integral effect on PCT for a large break LOCA when the entire large break LOCA calculational sequence is done on a WS is 0.26 °F. Consequently, use of a WS to perform all or part of the PCT calculation has no significant effect on the results.

2. The maximum cladding temperature for small break LOCA has not changed.

3. There have been no changes in the post-LOCA long term cooling results that affect the availability of adequate cooling water.

Consequently, calculations of ECCS behavior performed on the WS have no significant effect on the results of the analysis.

Based on the results reported here, there was no significant change in the sense of 10CFR50.46 in 1992 and no action beyond the submission of this report is needed.

5.0 References

1. "Emergency Core Cooling System; Revisions to Acceptance Criteria, "10CFR50, Federal Register, Vol. 53, No. 180, September 16, 1988.

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.