SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

INDIANA AND MICHIGAN ELECTIC COMPANY

DONALD C. COOK NUCLEAR PLANT UNIT NO. 2

DOCKET NO. 50-316

Introduction

On March 15, 1985, Exxon Nuclear Corporation informed the NRC of a coding error in the TOODEE2 computer code which affected the LOCA-ECCS analyses for several PWRs. In reference 1, Exxon provided a description of the coding error. The error was in an expression for a multiplier on the reflood heat transfer coefficient. The incorrect coding caused the heat transfer coefficient multiplier to be 1.045, when it was intended to be 1.0.

In addition to the coding error in the TOODEE2 code, the staff has also become aware of other errors in Exxon LOCA analyses. These include:

- Use of heat transfer augmentation factors for local rod peaking and mixing vanes in some recently submitted LOCA analyses performed to support license amendment applications. The use of these factors was found unacceptable some time ago during our review of the EXEM/PWR ECCS evaluation model.

- Discovery of an input error in the St. Lucie Unit 1 LOCA analysis. This error is described in reference 2.

- Assuming the validity and applicability of applying the Westinghouse-derived K(z) curve to Exxon fuel.

In order to determine the extent to which our concerns with respect to the Exxon LOCA models and analysis methods were generically applicable, the staff contacted all PWR licensees using Exxon fuel on March 20, 1985. At that time, each of the licensees was requested to evaluate these concerns with respect to their plants and determine if they were applicable.

On March 20, the licensee for D. C. Cook 2, the Indiana and Michigan Electric Company, provided in reference 3 their evaluation of the Exxon LOCA issue. Supplemental information was provided by the licensee in references 4 and 5. Our evaluation of this information follows.

Evaluation

The currently approved LOCA analyses which support Cycle 5 operation of D. C. Cook 2 are documented in reference 6. The evaluation model utilized for that analysis was the EXEM/PWR ECCS evaluation model, reference 7. In addition, the evaluation model utilized the revised methods of reference 8, developed specifically for Cycle 5 operation of D. C. Cook 2, to account for local rod peaking effects, along with the z-equivalent methodology of reference 9 which adjusts the EXEM/PWR reflood heat transfer correlations for different power shapes. These models were reviewed and approved for specific application to Cycle 5 operation of D. C. Cook 2, in reference 10.

The licensee has reviewed the current Cycle 5 LOCA analyses and stated in reference 3 that the TOODEE2 coding error was not present in that analysis. Also, our concerns with respect to the use of heat transfer augmentation factors do not impact the Cycle 5 LOCA analysis because a different methodology, which has been approved by the staff, was utilized for D. C. Cook 2. The input error for St. Lucie Unit 1 was not present in the D. C. Cook 2 analysis.

We have reviewed the licensee's response, as well as the description of the ECCS evaluation model utilized which was provided in reference 5, and have concluded that our first three concerns with respect to the Exxon LOCA analysis do not apply to D. C. Cook 2.

The fourth issue concerns the validity of assuming use of the Westinghouse-derived K(z) curve for Exxon fuel. Currently, Exxon LOCA analyses are performed to substantiate the maximum allowable peaking factor, F_q, based upon a chopped cosine power shape. To assure conformance to 10 CFR 50.46 for a range of power shapes, the K(z) curve is utilized, in conjunction with F_q, to limit allowable peaking factors as a function of core elevation. This K(z) curve was developed by Westinghouse for its fuel utilizing an ECCS evaluation model which is wholly in conformance with Appendix K. Exxon has assumed that the Westinghouse-derived K(z) curve applies to the Exxon fuel. This K(z) curve is currently incorporated in the D. C. Cook 2 Technical Specifications. However, D. C. Cook 2 has been administratively imposing a more restrictive K(z) curve in order to assure conformance with 10 CFR 50.46.

As part of its response to the Exxon LOCA issues, the licensee provided, in reference 11, additional LOCA analyses in order to verify the current Technical Specification K(z) curve. Two power shapes, representative of the maximum power peaking in the top of the core, were analyzed. Specific axial power distributions were calculated for Cycle 5 operation of D. C. Cook 2 utilizing the power distribution control procedures (PDC-II) currently in effect at the plant. The skewed power shapes analyzed have peak linear heat generation rates of 11.38 kw/ft at 91 inches (X/L=0.63) and 11.13 kw/ft at 114 inches (X/L=0.79). These linear heat generation rates are the maximum allowed by the Technical Specification K(z) curve.

Peak cladding temperature of 1857°F and 2008°F were calculated for the X/L=0.63 and X/L=0.79 cases, respectively. Their respective local metal-water reactions were 2.62% and 4.44%. In both cases, whole-core metal-water reaction was less than 1%. Thus, these analyses demonstrated conformance to the criteria of 10 CFR 50.46.

In performing these analyses, a revision to the currently approved ECCS evaluation model for D. C. Cook 2 was utilized. This revision, documented in reference 12, modified the reflood quench and heat transfer correlations of reference 7 for 17x17 fuel rods. The same set of FLECHT tests and correlation techniques used to develop the current EXEM/PWR correlations was utilized. However, the original data base only included data for rod elevations at or below 10 feet; the new correlations are based on data up to the 11.5 foot elevation.

As a result of the revised correlation effort, a new quench front correlation and a new heat transfer correlation was developed. The new quench correlation is applied at all core elevations, while the new heat transfer correlation is applied at core elevation at and above 8 feet. The current EXEM/PWR heat transfer correlations are applied below 8 feet. Benchmarks to five FLECHT constant flooding rate tests were provided to support these new correlations. The tests selected for benchmarking were representative of the calculated reflooding conditions for D. C. Cook 2. In addition, benchmarks were provided for two FLECHT variable flooding rate tests.

We have reviewed the new correlations and the supporting benchmarks. The new quench correlation provides similar results to the previous EXEM/PWR correlation below the 8 foot elevation. Above this elevation, the new correlation predicts earlier quenches which are in better agreement with the FLECHT data. The revised heat transfer coefficients are generally conservative, although less conservative than the EXEM/PWR correlations, with respect to the FLECHT data. Up to the time of peak cladding temperature, the revised correlation predicts integral heat transfer coefficients that are 0.93 times that obtained from the FLECHT data. Based upon these comparisons, we find the revised correlation acceptable and in conformance with Appendix K.

Conclusion

Based upon the foregoing, we have concluded that:

- The previous D.C. Cook 2, Cycle 5 LOCA analyses of reference 6 did not contain the TOODEE2 code error, did not utilize the unapproved heat transfer augmentation factors, nor did it contain the St. Lucie 1 input error.

- The revised analysis of reference 11 utilized an evaluation model in conformance with Appendix K.

- The revised analysis verifies that the Cycle 5 K(z) curve ensures compliance with 10 CFR 50.46. We note, however, that a new analysis will be required for Cycle 6.

Thus, we find that Cycle 5 operation of D. C. Cook 2 complies with 10 CFR 50.46 and Appendix K.

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REFERENCES

1. Letter, G. F. Owsley (ENC) to H. Denton (NRC), "Error in the 48,000 MWD/MTU LOCA-ECCS Analysis for D. C. Cook Unit 1," GFO:85:008, March 21, 1985.

2. Letter, J. W. Williams, Jr. (FPL) to J. R. Miller (NRC), "St. Lucie Unit 1 Docket No. 50-335, ECCS Analysis," L-85-124, March 22, 1985.

3. Letter, M. P. Alexich (IMECO) to H. R. Denton (NRC), "Revision to Analysis Which Supported a Technical Specification Change," AEP:NRC:0745T, March 20, 1985.

4. Letter, M. P. Alexich (IMECO) to H. R. Denton (NRC), "Description of LOCA/ECCS Models Used by Exxon Nuclear Company," AEP:NRC:0745V, April 3, 1985.

5. Letter, M. P. Alexich (IMECO) to H. R. Denton (NRC), "Unit 2, Cycle 5 LOCA Analysis," AEP:NRC:0860AB, April 26, 1985.

6. XN-NF-84-21(P), Revision 2, "Donald C. Cook Unit 2, Cycle 5, 5% Steam Generator Tube Plugging, Limiting Break LOCA/ECCS Analysis," Exxon Nuclear Company, Inc., Richland, WA 99352, July 1984.

7. XN-NF-82-20(P), Revision 1, August 1982; Supplement 1, March 1982; and Supplement 2, March 1982, "Exxon Nuclear Company Evaluation Model EXEM/PWR ECCS Model Updates," Exxon Nuclear Company, Inc. Richland, WA 99352.

8. Letter, J. C. Chandler (ENC) to H. R. Denton (NRC), "Additional Information Regarding Unit 2 Cycle 5 LOCA ECCS Analysis," May 7, 1984.

9. XN-NF-82-20(P), Revision 1, Supplement 4, "Exxon Nuclear Company Evaluation Model EXEM/PWR ECCS Model Updates: Adjustments to FLECHT Based Heat Transfer Coefficients," Exxon Nuclear Company Inc., Richland, WA 99352, July 1984.

10. Memorandum, R. Houston to G. Lainas, "D. C. Cook 2 Cycle 5 LOCA Reanalysis," March 8, 1975.

11. XN-NF-84-21, Revision 2, Supplement 2, "Donald C. Cook, Unit 2, Cycle 5, 5% Steam Generator Tube Plugging Limiting Break LOCA-ECCS Analysis:K(z) Curve," Exxon Nuclear Company, April 18, 1985.

12. XN-NF-85-20(P), Modification of the EXEM/PWR FLECHT Based REFLOOD Quench and Heat Transfer Correlations for D. C. Cook, Unit 2," Exxon Nuclear Company, April 3, 1985.