UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO LICENSING TOPICAL REPORT "BWR TRANSIENT ANALYSIS METHODS"

COMMONWEALTH EDISON COMPANY

AND

MIDAMERICAN ENERGY COMPANY

LASALLE COUNTY STATION, UNITS 1 AND 2

QUAD CITIES NUCLEAR POWER STATION, UNITS 1 AND 2

DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3, AND

DOCKET NOS. 50-373, 50-374, 50-237, 50-249, 50-254 AND 50-265

1.0 INTRODUCTION

On June 26, 1995, Commonwealth Edison Company (ComEd, the licensee) submitted a topical report describing its methods for in-house transient analyses (Reference 1). On April 30, 1996, the staff received a response from ComEd (Reference 2) to a staff request for additional information. Revision 1 of the topical report was submitted on August 27, 1998 (Reference 3) to reflect an error correction in one of the codes used in the report. This safety evaluation addresses Revision 1 of the topical report.

The ComEd report describes the development of the RETRAN models for ComEd's boiling water reactors (BWRs), the methods used to initialize the models, and ComEd's application of RETRAN. The report presents the results of benchmarking against plant startup data and the NRC standard problem. This report was the second of a three part submittal. The final report will present ComEd's methods for analyzing anticipated operational occurrences (AOOs). These methods will be used to develop changed critical power ratio (ΔCPR) values to establish operating limit minimum critical power ratio (OLMCPR) values. Therefore, the report reviewed here does not discuss code uncertainty, analytical assumptions beyond those necessary to perform the benchmark calculations, or hot channel methods.

2.0 DISCUSSION

The ComEd methods are primarily based on the Electric Power Research Institute (EPRI) RETRAN code. This report discusses the several codes used to perform a RETRAN analysis. These include PETRA (and a ComEd developed code WIDE), ESCORE, and FIBWR2. Appendix A to the ComEd submittal discusses the PETRA methodology which is used to collapse the three-dimensional (3-D) CASMO/MICROBURN results into a one-dimensional (1-D) format compatible with RETRAN. The WIDE code is used to collapse the CASMO results into a form compatible with RETRAN. As a demonstration that this method properly collapses the 3-D results, ComEd compared results of RETRAN calculated power distributions and control rod worth to the CASMO/MICROBURN calculated values. The Peach Bottom benchmark demonstrates that this method is acceptable for BWR analysis.

The FIBWR2 code is used to establish the steady-state core pressure drop, the core inlet pressure, and the bypass flow distribution. ComEd stated that the steady-state option of FIBWR2 that is used in this methodology is the same as the one approved in the FIBWR code. FIBWR2 is used by ComEd in a manner that is consistent with MICROBURN and RETRAN to ensure that there are no inconsistencies in the calculation results. The ComEd FIBWR2 methodology is used to initialize the Peach Bottom benchmark study inputs.

ESCORE is used to calculate the fuel rod gap conductance. The calculated values are used as input to the RETRAN code. These values impact the peak power during fast pressurization transients. However, ComEd demonstrates in section 3.6 of its submittal that the calculated peak fission power is not very sensitive to this value. This is because the pulse width is small (approximately 1.5 seconds) for these events due to doppler feedback and the conduction rate in the fuel does not change significantly during the pulse because of a fuel thermal time constant of approximately 6 seconds. The gap conductance should affect the time of the peak heat flux and this was confirmed by the ComEd sensitivity study presented in Section 3.6. The ComEd ESCORE methodology was used to initialize the Peach Bottom benchmarking input deck.

The ComEd report describes the RETRAN input deck for each of the ComEd units. The decks use very similar noding consistent with the following guidelines:

- 24 (or 25) 6 in. active core nodes
- 2 lower plenum nodes
- 1 downcomer node
- 2 bulk water nodes
- 1 steam dome node

All of the decks have fully integrated control systems to model the recirculation system, the feedwater system, the pressure controller, and the reactor protection system.

ComEd proposes to use the RETRAN code consistent with the restrictions in its safety evaluation (Reference 4). ComEd, therefore, needed to justify the use of several models. These models are the following (only the models that ComEd is actually using are discussed):

- non-equilibrium separator
- algebraic slip
- nonmechanistic separator model
- subcooled void model
- bubble rise model

The restriction on the non-equilibrium separator model (actually a pressurizer model in RETRAN parlance) relates to the fact that it was not evaluated when the node is either empty or full and that there is no fluid boundary heat transfer. ComEd includes a control block to monitor the fluid mass during transient calculations. Should the non-equilibrium node either approach a full or empty state, ComEd states that modeling studies will be performed to determine the conservative approach. ComEd states that the lack of fluid boundary heat transfer is conservative because it will tend to increase the peak pressure.

The restrictions on the use of the algebraic slip and subcooled void models relate to the fact that no "separate effects" testing was performed on these models. ComEd references as justification for the use of these models, separate effects testing performed by the Philadelphia Electric Company and documented in Reference 5.

The restriction on the nonmechanistic separator model relates to the fact that it imposes a constant carryover/carryunder relationship and flow inertia. ComEd states that the carryover/carryunder performance of the separators is input from the vendor data. Furthermore, ComEd concludes that the low flow/low-quality regime where the constant inertia assumption is incorrect is not required to be modeled during the relevant phases of a reload licensing analysis. ComEd also states that the Peach Bottom benchmark indicates that this model is being used conservatively.

The restriction on the bubble rise model relates to the need to justify its use because of the assumptions used to derive the model. ComEd states that the use of the bubble rise model is consistent with the assumptions used in its development and that the Peach Bottom benchmark was used to determine a conservative bubble rise velocity and void profile for pressurization transients.

Each of the input models was tested against plant startup data. ComEd developed a set of acceptance criteria to apply to the results based on guidance in Reference 5. These benchmarks used data from both pressurization and nonpressurization tests. Several model changes were made and discussed to facilitate the benchmark calculations. These changes primarily consisted of modifications to control variables.

Comparisons were made to the NRC standard benchmark data set, the Peach Bottom turbine trip tests. ComEd stated that it used the methods described in Reference 3 to develop the Peach Bottom RETRAN model. The nodalization was chosen to be consistent with what is used in the ComEd plant models. The results of the pressurization and peak power comparison are as follows:

Item	TT1			TT2			TT3		
	Calc	Meas	Err	Calc	Meas	Err	Calc	Meas	Err
Press[1]	37.5	33.0	4.5	44.4	44.9	-0.5	50.7	50.9	-0.2
Pow[2]	6.48	4.86	33.3	4.34	4.53	-4.2	4.83	4.91	-1.6

[1]core exit pressure rise in psi
[2]normalized fraction of rated. Error is presented as percent error.

3.0 EVALUATION

ComEd's methods for preparing the input for RETRAN are discussed in Chapter 3 of the report. The codes fall into three categories: (1) industry codes approved for use by the staff, (2) industry codes without generic staff approval, and (3) in-house codes developed by ComEd. The industry codes need to be used in accordance with their approval bases and ComEd states that they will be. One code, FIBWR2, is a revision to the staff-approved FIBWR code (Reference 7). The part of the FIBWR2 code that ComEd intends to use for preparing RETRAN input is unchanged from FIBWR; it has been approved for use by other licensees (Reference 8), and its use for input preparation by ComEd is acceptable. The industry code PETRA is being used by ComEd to collapse 3-D physics results into a 1-D format compatible with RETRAN. Although the staff has not generically approved PETRA, the information in Appendix A and the benchmarking results indicate clearly that the use of PETRA does not introduce large errors into the ComEd RETRAN methodology and it is, therefore, acceptable. The in-house codes WIDE and MICPET are used to manipulate data calculated by CASMO/MICROBURN into a format compatible with the ComEd RETRAN methodology. Their use is also justified by the benchmarking studies presented in the report.

The input decks prepared for the ComEd BWRs are described in the report. The information provided was sufficient to conclude that the nodalization chosen is consistent with standard industry practice. The nodalization was demonstrated to be acceptable for application to the ComEd BWRs in the benchmarking study presented, and is, therefore, considered to be acceptable. As with any analytical method, noding studies may need to be performed to evaluate any unusual or unexpected results.

A sensitivity study was performed to evaluate the effect of perturbations to the model, constitutive relationships, and time step control. This study confirms that the ComEd RETRAN models behave as expected to the imposed perturbations and that the time step chosen for analysis is acceptable. This study can also be used to conclude that the bubble rise velocity and the steam line nodalization chosen by ComEd are acceptable.

ComEd proposed to use RETRAN consistent with the bases for its acceptance as an evaluation tool. The justification given by ComEd in response to the numerous restrictions in the RETRAN safety evaluation is acceptable and the code options chosen should ensure that the code will calculate conservative results. ComEd will have to justify any modifications to the modeling options it uses and the staff will have to review the justifications.

The benchmarking study presented by ComEd exercised the input models for all of the ComEd BWRs for both pressurization and nonpressurization transients. The results demonstrate that the models are acceptable for use in licensing analysis. However, should these models be used for analysis of plant conditions that differ significantly from the plant data used to benchmark the models, further justification will be needed. For example, these models (and RETRAN itself) are not qualified to perform stability analysis, and further benchmarking would be needed to apply them in this manner.

The information in the ComEd report is sufficient to validate the ComEd BWR RETRAN models. However, it is not sufficient to justify ComEd's use of these methods to perform AOO analysis. Additional information must be provided in the third and final ComEd submittal regarding the specific assumptions and plant conditions for each AOO that will be analyzed.

4.0 CONCLUSIONS

The staff has reviewed the ComEd RETRAN methodology described in NFSR-0111. The methodology and input decks described in the report are acceptable and, as with any approved topical report, should meet the following conditions:

(1) All analyses performed in conjunction with the ComEd RETRAN methodology described in Reference 3 must be controlled by procedures developed in accordance with 10 CFR Part 50, Appendix B, requirements.

(2) The methodology will be used in a manner consistent with its validation database.

(3) All of the codes in the methodology will be used in a manner consistent with their approval.

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Date: April 1, 1999

5.0 REFERENCES

1. "BWR Transient Analysis Methods," NFSR-0111, Revision 0, Commonwealth Edison Company, June 1995.

2. Letter from John B. Hosmer (ComEd) to USNRC, "Responses to NRC RAI on ComEd Licensing Topical Report NFSR-0111," April 30, 1996.

3. "BWR Transient Analysis Methods," NFSR-0111, Revision 1, Commonwealth Edison Company, June 1998.

4. "RETRAN02 - A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems," Volumes 1 to 5, EPRI NP 1850-CCM-A, Electric Power Research Institute, Palo Alto, CA., 1987.

5. "Methods for Performing BWR Systems Transient Analysis," PECo-FMS-0004-A, Philadelphia Electric Company, November 1988.

6. "Qualification of RETRAN for Simulator Application," EPRI NP-5840, Electric Power Research Institute, July 1988.

7. "FIBWR: A Steady-State Core Flow Distribution Code for Boiling Water Reactors," EPRI NP-1923, Electric Power Research Institute, July 1981.

8. "FIBWR Code: Thermal-Hydraulic Methods," Docket Nos. 50-324/325, October 22, 1984.