ENTERGY

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Vice President,
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February 2, 1995

U.S. Nuclear Regulatory Commission
Mail Station P1-137
Washington, D.C. 20555

Attention: Document Control Desk

SUBJECT: Request For Additional Information Regarding Entergy Topical Report Verification of CECOR Coefficient Methodology for Application to Pressurized Water Reactors of the Entergy System, (ENEAD-02-NP, Revision 0) (TAC Nos. M90609 and M90626)

Arkansas Nuclear One Unit 2	Waterford 3 Steam Electric Station
Docket No. 50-368	Docket No. 50-382
License No. NPF-6	License No. NPF-38

CNRO-95/00004

Gentlemen:

By letter dated December 21, 1994, Mr. Chandu P. Patel, Office of Nuclear Reactor Regulation, requested additional information concerning the subject document. In accordance with Mr. Patel's request, Energy Operations, Inc. is providing the additional information.

NRC review and approval of the subject document is essential to our refueling schedules. As mentioned in our previous submittals, we requested your approval by October 5, 1995.

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Please contact Mr. Robert B. Lang at telephone number (601) 368-5450 if you require additional information in regard to this matter.

Sincerely,

FWT/rlt
attachment
cc: Mr. R. P. Barkhurst, w/o
Mr. J. L. Blount, w/o
Mr. L. J. Callan, w/o
Mr. J. L. Colvin, w/o
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Additional Information requested in U. S. NRC 12/21/94 Letter

1. In addition to the use of 3-dimensional SIMULATE-3 nodal calculations, are there any other differences in the way the CASMO-3/SIMULATE-3 codes will be used as compared to the current PDQ/EPRI-NODE-P codes to generate the CECOR libraries?

There are improvements on the CECOR libraries due to the new capabilities of CASMO-3/SIMULATE-3 codes. The SIMULATE-3 code is capable of calculating the instrument location neutron fluxes at all axial locations. The signal-to-power conversion factors (W') and pin-to-assembly peaking factors (1-PIN) from CASMO-3/SIMULATE-3 are now detector axial level dependent in addition to the coupling coefficients (CC). In the PDQ/EPRI-NODE-P system, W' and 1-PIN factors are based on a 2-D core average plane PDQ calculation while coupling coefficients are detector axial level dependent and based on a 3-D NODE-P calculation.

2. Describe any differences between the methods used and those described in the INCA/CECOR Power Peaking Uncertainty report CENPD-153-P, Rev. 1-P-A.

CENPD-153-P, Rev 1–P–A defines four uncertainty components:

1. Box Power Measurement Uncertainty - This uncertainty accounts for box power measurement error. It is estimated by comparing measured box powers to predicted box powers from the ROCS code to obtain uncertainty between measurement and calculation, s_D. The relationship $s^2_M = s^2_D - s^2_C$ is used with the assumption that the uncertainty between calculations and truth ,s_C, will be small and thus s_D can be assumed to bound s_M. The signal-to-power error is accounted for.

2. Box Power Synthesis Uncertainty - This uncertainty accounts for the CECOR box synthesis error. It is estimated by using core follow cases and comparing ROCS box powers to CECOR box powers using signals generated from ROCS. Coupling and Fourier fit errors are accounted for.

3. Pin/box Synthesis Uncertainty - This uncertainty accounts for the pin–to–box synthesis error as a function of axial height. This is necessary because PDQ uses pin/box factors from one axial plane. The uncertainty is estimated by comparing pin/box factors calculated at core mid plane and at 85% of core height from fine mesh diffusion theory.

4. Pin/box Calculational Uncertainty - This uncertainty accounts for error introduced in inferring pin peaking from calculations. Comparisons between measured criticals and calculations are made to determine the observed differences, s_D. The measurement uncertainty, s_M, is obtained directly from the

experiment. The calculational uncertainty is obtained from the difference uncertainty and the measurement uncertainty, $s^2_C = s^2_D - s^2_M$

ENEAD-02 uses three uncertainty components. Components 1 and 4 as defined above are unchanged, except for the computer codes used to generate them. Components 2 and 3 from CENPD–153–P are combined into one Power Synthesis Uncertainty. This combination is possible because of SIMULATE3's ability to do 3-D pin-by-pin calculations compared to PDQ's 2–D calculations.

Another improvement is in the calculation of the signal–to–power conversion factors and pin–to–assembly peaking factors. In CENPD–153–P the factors were calculated based on a 2–D model; in ENEAD–02 they are calculated based on a 3–D model.

3. Do the benchmarks include all core/fuel designs and plant instrumentation systems to which the CECOR libraries will be applied? If not, justify the use of the calculated uncertainties for these applications.

Yes they do.

The benchmarking was done over nine cycles at ANO-2 and six cycles at WSES-3. During these cycles a number of different fuel and core designs were used. The different fuel designs included variations in fuel and burnable absorber enrichments, variation in the burnable absorber loading scheme, and axially offsetting the fuel. Variations in core design included cores with and without burnable absorbers, different fuel enrichments, cores for short (~12 months) and long (~18 months) cycle lengths, and normal and low leakage cores.

As for the instrumentation systems, the benchmarking involved designs in which fresh detectors were placed in fresh and burned fuel assemblies, as well as depleted detectors also being located in fresh and burned assemblies, thereby covering a wide range of possible detector/fuel combinations. It should be noted though that this topical is not applicable to the ANO-1 reactor which uses detectors (and fuel) of a different design of that used in ANO-2 and WSES-3. Application of this topical to the ANO-1 reactor will require a supplemental submittal.

4. Do the benchmark comparisons indicate any dependence of the uncertainties on local assembly power, fuel burnup, core power level, or CEA insertion?

Local Assembly Power - Uncertainties in Fxy, Fr, and Fq were examined as a function of local assembly power. The assembly powers range from 0.4 to 1.25 relative power fractions for ANO-2 and WSES-3. No correlation between uncertainties and local power was observed.

Fuel Burnup - Uncertainties in Fxy, Fr, and Fq were examined as a function of fuel burnup. The cycle burnups range from 0 to 16.7 GWD/MTU for ANO-2 and WSES-3. No correlation between uncertainties and burnup was observed.

Core Power Level - Uncertainties in Fxy, Fr, and Fq were examined as a function of core power level. The core powers range from 67% to 100% full power for ANO-2 and WSES-3. No correlation between uncertainties and core power was observed

CEA Insertion - Uncertainties in Fxy, Fr, and Fq were examined as a function of CEA insertion. The CEA insertions ranged from all rods out (ARO) to Bank 6 fully inserted and Bank P 75% inserted. The uncertainties of the rodded cases were examined for any trends vs. CEA insertion. No correlation between uncertainties and CEA insertion was observed.

5. Have adjustments been made to the calculations to improve the agreement with the benchmarks? If so, please discuss the effect of these adjustments on the uncertainty results.

No empirical adjustments were made to the calculations. The raw signals were corrected for background and rhodium depletion before they were compared to the calculated signals. The detector location powers were calculated as the products of the signal-to-power conversion factors (W') and the detector signals. The W's were obtained from the CASMO/SIMULATE calculations as functions of detector burnup, fuel burnup and core location.

6. What types of burnable absorbers were included in the benchmark comparisons? Do the comparisons indicate any dependence on the type of burnable absorber?

Calculations were benchmarked against ANO-2 and WSES-3 cores containing B_4C burnable poisons. In addition, the development of the pin peaking calculational uncertainty factor included benchmarking against fuel designs that contained burnable absorbers of erbium and gadolinium. Erbium cores showed slightly larger uncertainties than other burnable poisons. For this reason the Erbium uncertainty (1.261%) was used in the overall CECOR uncertainty.

7. Have the number of degrees of freedom used to determine the one-sided upper tolerance limit been reduced to account for any axial correlation between the calculation-to-measurement differences?

No adjustments to the number of degrees of freedom have been made. The number of degrees of freedom to be used in calculating the overall one sided upper tolerance limit from the three independent CECOR uncertainty components was calculated using equation 5.5–8 in Section 5.5. This is the same methodology used in the reports CENPD-153-P and MSS-NA3-P, which were previously approved by the NRC.

8. What is the effect of using the 1-pin peaking information rather than the 4-pin peaking results to calculate DNBR? What criteria will be used to determine if 4-pin peaking data is required in the future?

CECOR does not itself calculate DNBR. An earlier version of CECOR created an input file containing peaking information for a peripheral code that calculated DNBR. That is the reason for the input requirement of 4-pin peaking factors. The option to generate the input file for the DNBR program has been disabled in Entergy's version of CECOR. The 4-pin peaking results have no impact on any outputs used from the CECOR program, as demonstrated by the fact that no results used by Entergy are changed when dummy 4-pin factors are input.

9. The power synthesis uncertainty includes an uncertainty associated with the number of operable incore detectors. How sensitive are the results to the manner in which the incore detectors are assumed to fail and why is a random failure assumption conservative?

The detector failure patterns used in the analysis in ENEAD-02 for the determination of the power synthesis uncertainty were based on fifteen cycles of operation of ANO-2 and WSES-3. The actual failure patterns of detectors observed during those fifteen cycles of operation have been random. The detector failure patterns used in the analysis were also subjected to the constraints of Technical Specifications. The Technical Specifications place restrictions on the failure patterns that are allowed during operation. For example, ANO-2 Technical Specifications require sufficient operable incore detectors to perform at least six tilt estimates.

To determine the sensitivity of the results to the manner in which the incore detectors are assumed to fail, additional analyses were run. Analysis statepoints were chosen covering five cycles of operation. All cases were run at or near the Technical Specification limits for core tilt, that is, at or near 10% tilt. In these cases, "worst allowable" failure patterns were selected. These patterns were characterized by failing as many detectors as possible in a high power part of the core while maintaining Technical Specification requirements.

The results of the study are shown in Figure 1. The uncertainties (standard deviations) for the individual core map cases run are shown for 25 and 50% detector failures. ENEAD-02 uses the uncertainty to calculate a 95%/95% reliability factor (k*s) by multiplying the uncertainty by a one sided tolerance factor based on the number of samples. The 95%/95% reliability factor from

ENEAD-02 based on the uncertainty from random failures bounded all "worst allowable" cases as shown in Figure 1.

The uncertainty based on the random failure pattern used in ENEAD-02 is conservative because:

1. All the "worst allowable" failure patterns are bounded by the 95%/95% reliability factor based on random failure standard deviations.

2. Fifteen cycles of operation of ANO-2 and WSES-3 have shown that detectors fail in a basically random pattern during actual operation.

Figure 1
WSES-3 Fr Uncertainty Vs. Failure Rate