ENTERGY

VERIFICATION OF CECOR COEFFICIENT METHODOLOGY FOR APPLICATION TO PRESSURIZED WATER REACTORS OF THE ENTERGY SYSTEM

ENEAD-02-NP REV 0
EDC FILE QR-038-42 REV 0

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ACKNOWLEDGMENTS

The authors gratefully acknowledge calculations done by Mr. R. E. Griffith, Mr. B. A. Hawes, Mr. R. E. Machado, and Mr. K. B. Megehee that provide the calculational basis for the report.

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1.0 INTRODUCTION

The CECOR program (Reference 1) is a computer program that synthesizes detailed three-dimensional assembly and peak pin power distributions from fixed incore detector signals. The purpose of this report is to re-quantify the CECOR power distribution uncertainty of the CECOR libraries generated with CASMO3/ SIMULATE3 physics methods. The methodology used in the report for the generation of CECOR libraries is based on the previously NRC approved CECOR Topical Reports (References 3, 4) which have been expanded and modified to work with the CASMO3/SIMULATE3 computer code system. In the text SIMULATE3 is referred to as the nodal code and CASMO3 is referred to as the lattice physics code.

Section two of this report describes the incore instrumentation for Arkansas Nuclear One - Unit 2 (ANO-2) and Waterford - Unit 3 (WSES-3). Section three describes the algorithms used by CECOR to synthesize the three-dimensional power distribution from the incore detector readings and the coefficient library. A precalculated library of coefficients is used in the power synthesis. Section four describes the generation of the coefficient libraries from data generated from the Entergy reactor physics methods described in Reference 2. Section five provides a quantification of CECOR uncertainties using Entergy generated libraries. The measurement data was taken from cycles 2-10 of ANO-2 and cycles 1-6 of WSES-3.

2.0 IN-CORE INSTRUMENTATION

The incore instrumentation at Arkansas Nuclear One - Unit 2 and Waterford Unit 3 consists of fixed self-powered rhodium detector strings, movable self-powered rhodium detectors and background detectors. Figures 2.1 and 2.2 give the layout of incore instrumentation for ANO-2 and WSES-3. Each fixed incore detector string consists of five detectors equally spaced axially over the active fuel height. Each detector string is centered in the large center water hole of an assembly.

The CECOR power distribution is based only on the fixed incore detector readings. The movable detectors were designed for detector cross calibration and the background detectors are used periodically to determine a background correction for the fixed self-powered rhodium detectors. The movable detectors have never worked.

A typical rhodium detector consists of a rhodium emitter, insulation, a collector sheath and signal lead wire as shown in Figure 2.3. The emitter consists of 99.9% rhodium-103 which is surrounded by a Al_2O_3 insulator which is enclosed in an Inconel sheath. The detectors are ~40 centimeters in length and are centered approximately at locations as presented in Figure 2.3.

When the rhodium-103 in the detector absorbs a neutron, rhodium-104 is produced which decays through beta emission. The complete rhodium decay scheme is shown in Figure 2.4. The escape of beta particles from the emitter produces a low-level current. A measuring resistor is utilized to produce a measurable voltage as shown in Figure 2.5. The voltage is amplified, then digitized by an analog to digital converter for use by the plant computer.

Figure 2.1. ANO-2 Instrument Pattern

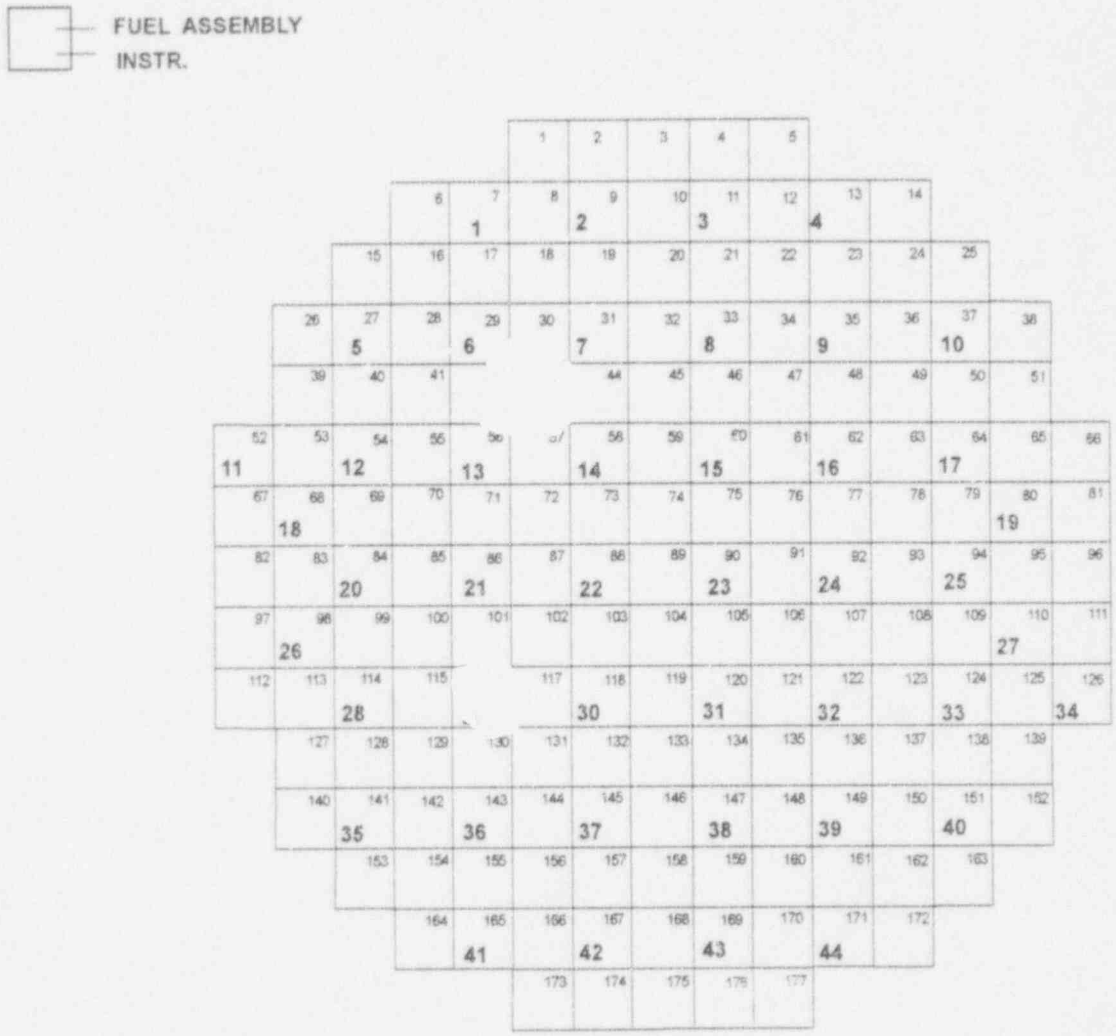


Figure 2.2. WSES-3 Instrument Pattern

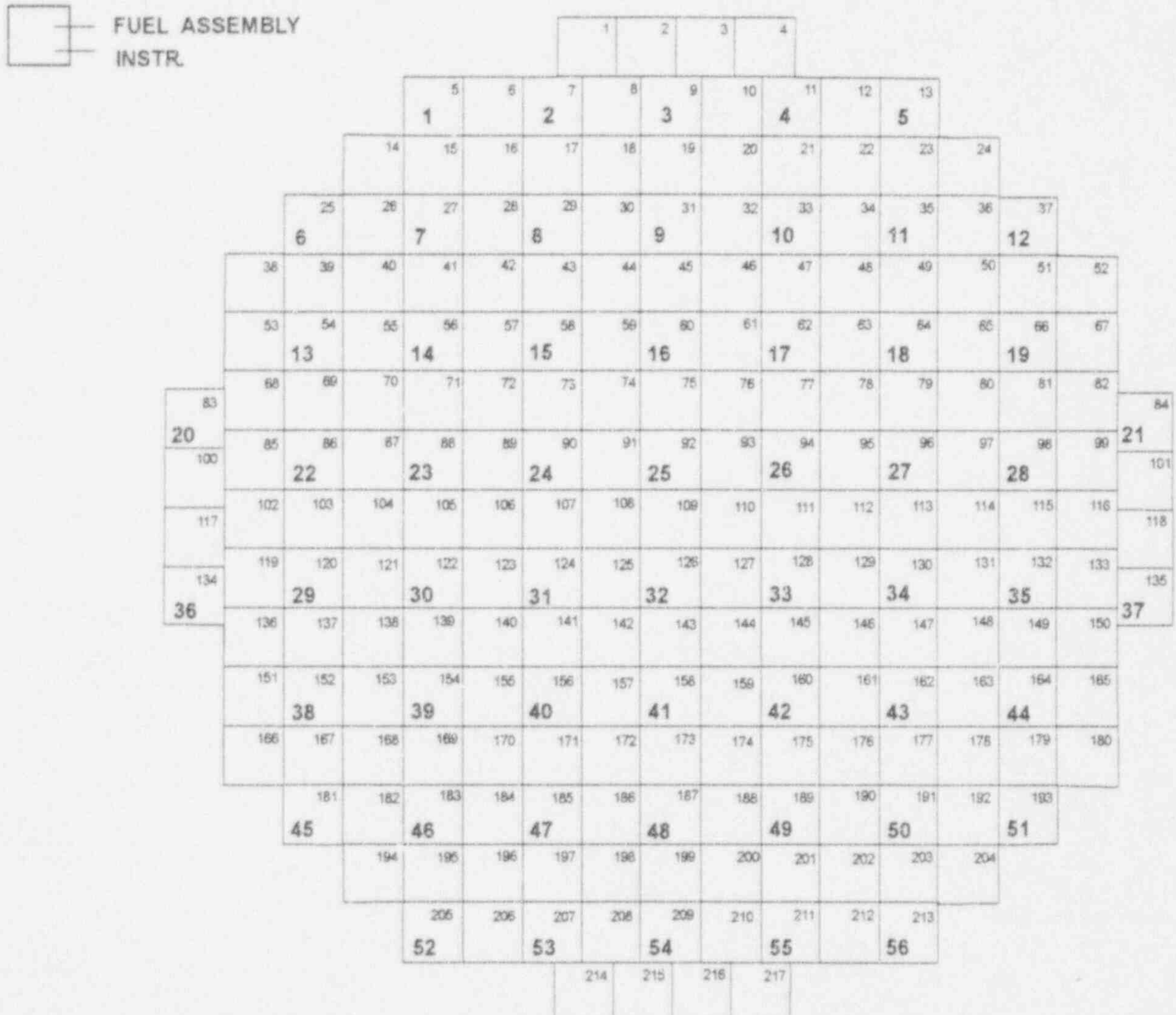
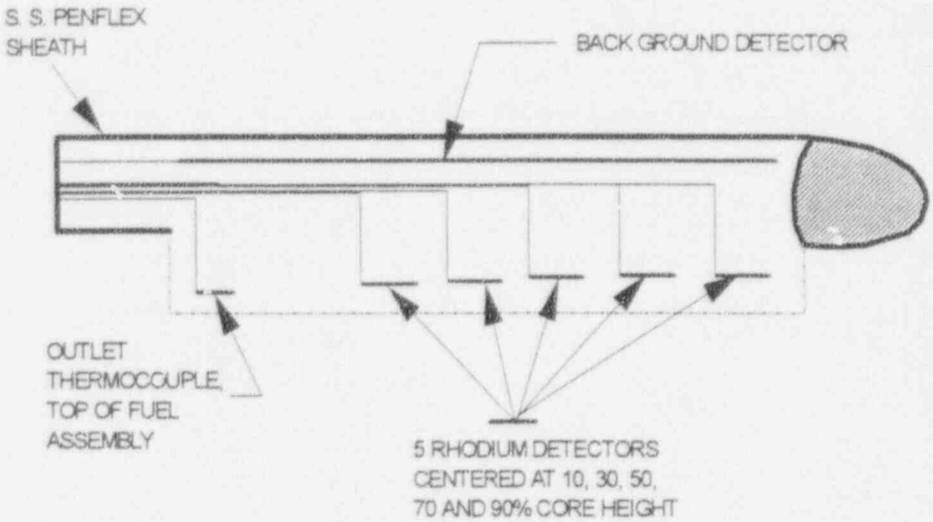
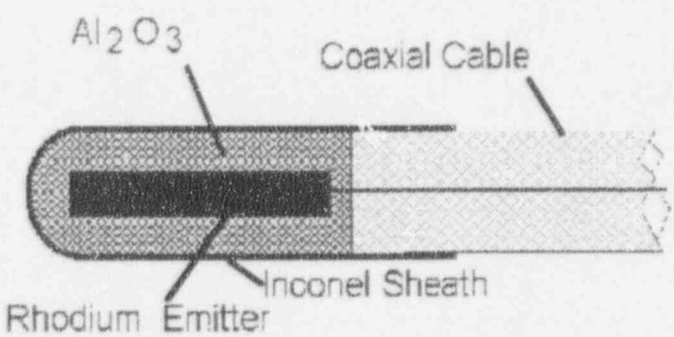


Figure 2.3. Typical Neutron Detector and Detector Assembly



TYPICAL INSTRUMENT ASSEMBLY



TYPICAL RHODIUM DETECTOR

Figure 2.4. Rhodium Emitter Decay Scheme

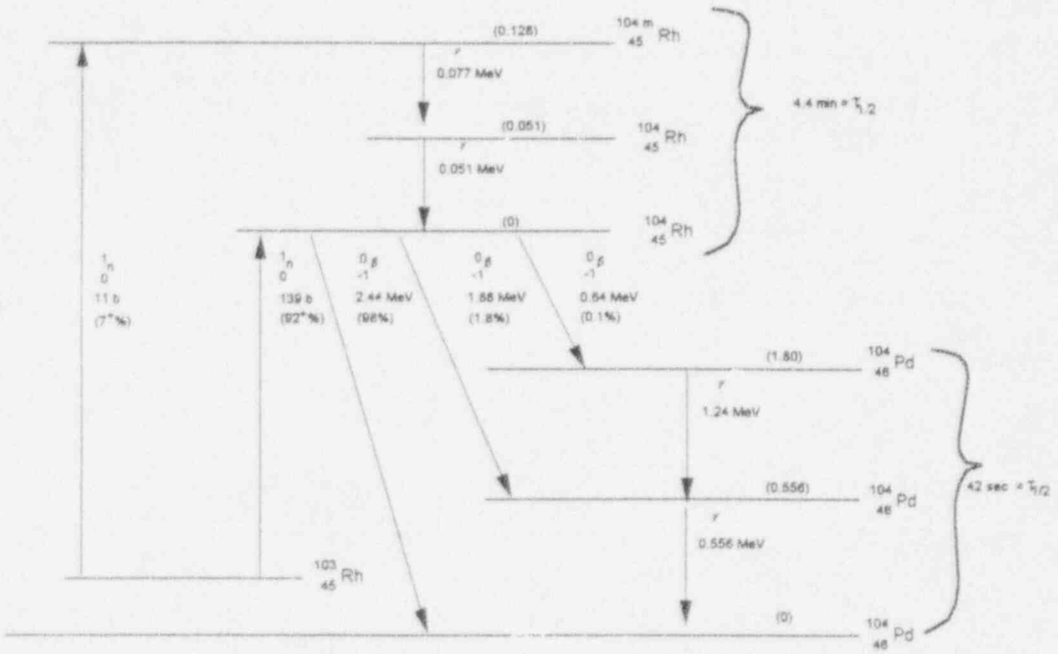
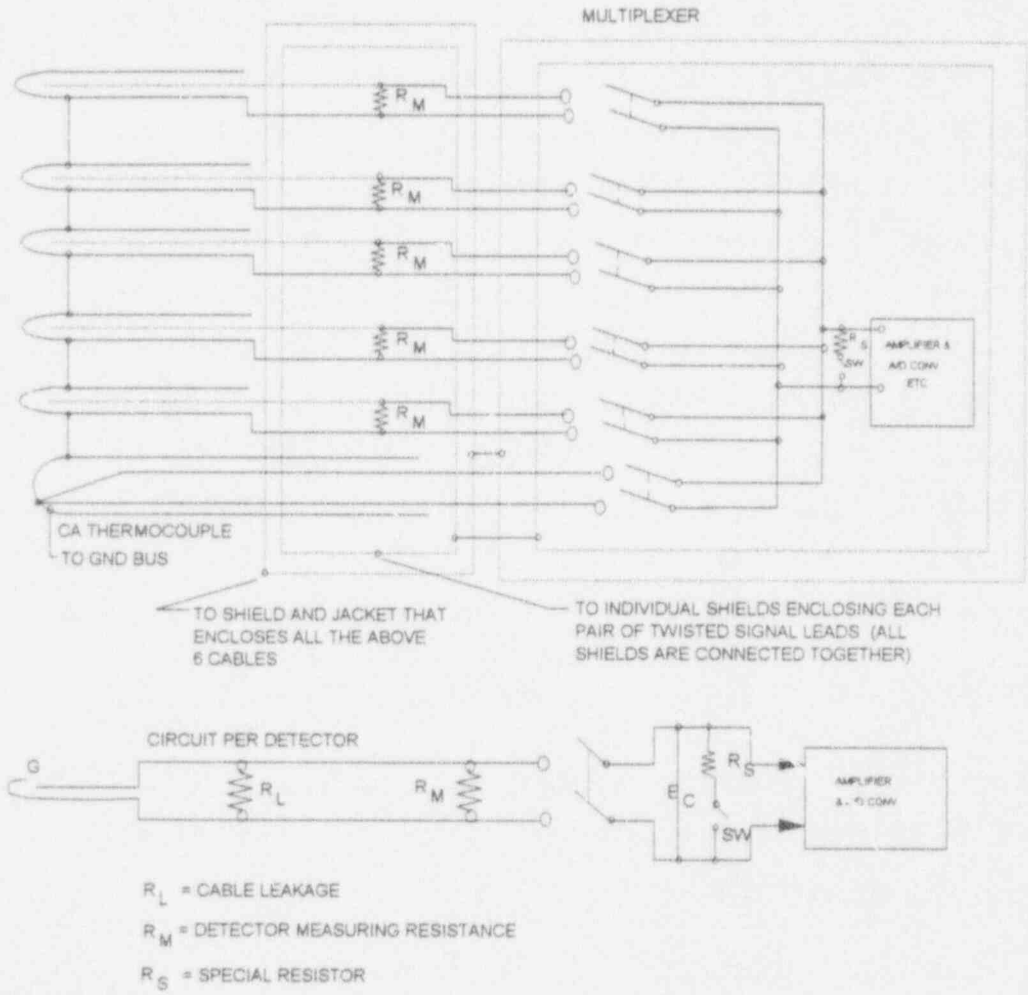


Figure 2.5. In-Core Instrumentation Wiring Diagram



3.0 CECOR POWER DISTRIBUTION CALCULATION

3.1 General

The CECOR program synthesizes 3-D power distributions from fixed incore detector readings. The first step in the process is to convert the signals from the five axially spaced detectors in a string to powers. Coupling coefficients are next used to calculate pseudo-detector powers at each of the five detector levels in uninstrumented assemblies or assemblies with failed detectors. A five term Fourier fit is used to construct assembly axial shapes based on the five detector level powers. Calculation of the maximum 1-pin and 4-pin assembly peaks are done using 1-pin and 4-pin peaking library coefficients. Libraries are a function of burnup, control rod position and axial detector location. Separate library coefficients are used at each of the five axial detector locations. The following sections present the Entergy methodology for determining the flux-to-power conversion library, coupling coefficient library and 1-pin peaking factor libraries.

3.2 Flux-to-Power Conversion

The flux-to-power conversion factors are used to convert from background and depletion corrected instrument flux to assembly power integrated over detector length. The equation used is:

$$P_{in} = I_{in} * W \qquad (3.2\text{-}1)$$

Where P_{in} is the power for assembly i at detector level n and

I_{in} is the background and depletion corrected incore detector flux reading, and

W is the flux-to-power conversion factor.

The flux-to-power factors (W') are updated for each reload and are defined as the assembly power integrated over detector length divided by the rhodium reaction rate per rhodium atom.

The details of the W' calculations are described in Reference 2. The W' coefficients are fit by cubic expressions in assembly burnup. Separate W' coefficients are produced at each of the five axial detector locations.

3.3 Coupling Coefficients

Coupling coefficients relate the detector powers in instrumented assemblies to pseudo-detector powers in uninstrumented assemblies. Coupling coefficients are obtained from the nodal depletion calculations. The coupling calculation is done prior to the axial synthesis described in Section 3.4. The coupling coefficient for assembly j is defined as:

$$CC_j = \sum_{i=1}^{N_j} P_i / (N_j * P_j) \qquad \textbf{(3.3-1)}$$

Where N_j is the number of assemblies neighboring assembly j

P_i are the powers in the neighboring assemblies at a specific detector level, and

P_j is the power in assembly j at the same detector level.

Coupling coefficients are generated for both rodded and unrodded core configurations and are fit by cubic expression versus assembly burnup. Separate coupling coefficients are produced at each of the five axial detector locations.

3.4 Axial Power Synthesis

The axial power distribution synthesis converts the five incore detector level readings into a 51 node axial power shape using a Fourier fit as described in

Reference 1. The choice of the input variable (wave number B_i) is the only required calculation. Entergy uses a location and burnup dependent value of B_i based on 3-D nodal calculations. The wave number, B_i, is chosen to minimize the axial differences between CECOR and the 3-D nodal calculations.

3.5 1-Pin Peaking Factor

The 1-pin peaking factor is defined as the ratio of the maximum pin power in an assembly to the average pin power in the assembly. The 1-pin peaking factors are obtained from 3-D nodal calculations with pin power reconstruction. The 1-pin peaking factors are input to CECOR as polynomial fits as a function of assembly burnup for each assembly and rod configuration. Separate 1-pin peaking coefficients are produced at each of the five axial detector locations.

3.6 4-Pin Peaking Factor

The 4-pin peaking factor is defined as the ratio of the maximum channel power in an assembly to the average power in the assembly. CECOR used to use the results of the 4-pin peaking calculation to pass to another program to calculate DNBR. Currently however, the 1-pin peaking information is used for this purpose. Entergy, therefore, supplies dummy data for the 4-pin peaking factor. If in the future the 4-pin peaking data is needed, the methodology will be identical to that for the 1-pin factors as described in Section 3.5.

4.0 CECOR LIBRARY GENERATION

All of the information necessary to generate the CECOR data library comes from three dimensional, quarter core, full power, nodal code depletion calculations and lattice physics calculations. A schematic of the CECOR library generation methodology is shown in Figure 4.1. Inputs are generated by the nodal code and the lattice physics code (Reference 2) . The outputs include the CECOR cycle dependent data libraries as well as files used for quality assurance of the library. Output also includes graphs of the evaluated polynomial fits of the coefficients. Figure 4.2 is an example of the coupling coefficient for an assembly of ANO-2, Cycle 10. These graphs serve to verify a smooth, well behaved fit between the input points.

Figure 4.1. Schematic of CECOR Library Generation

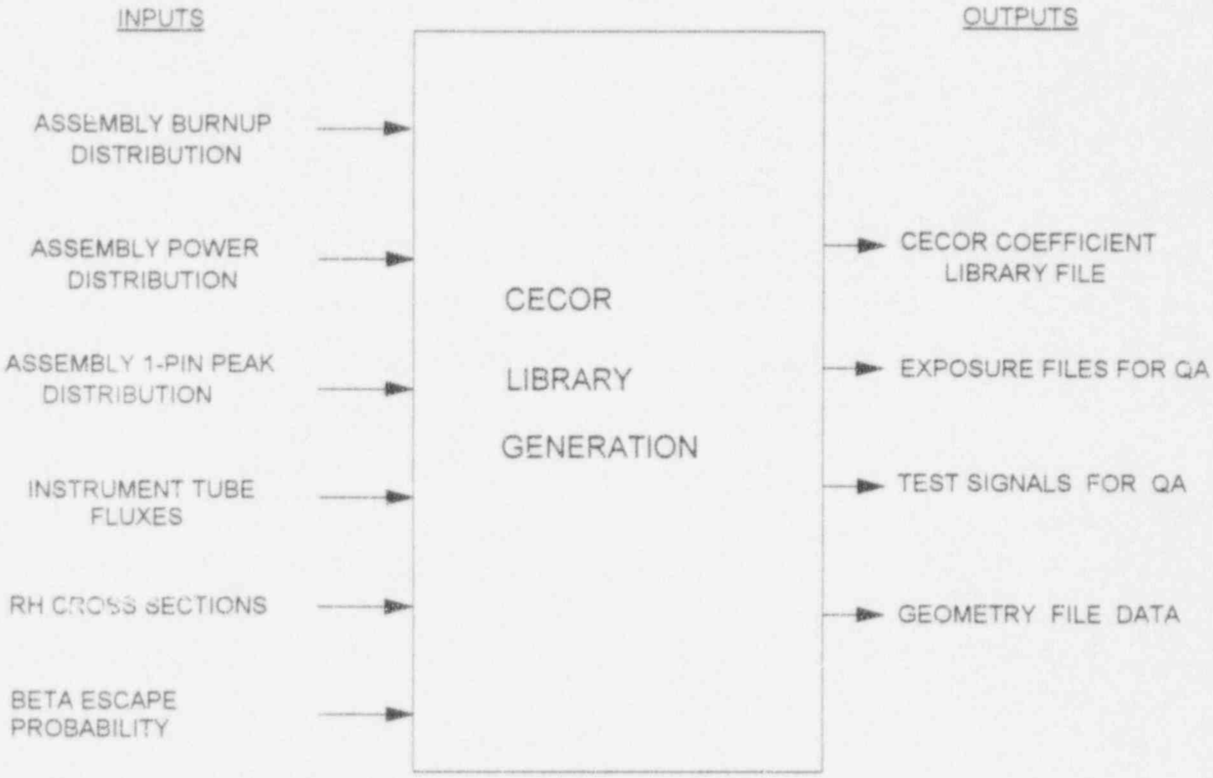
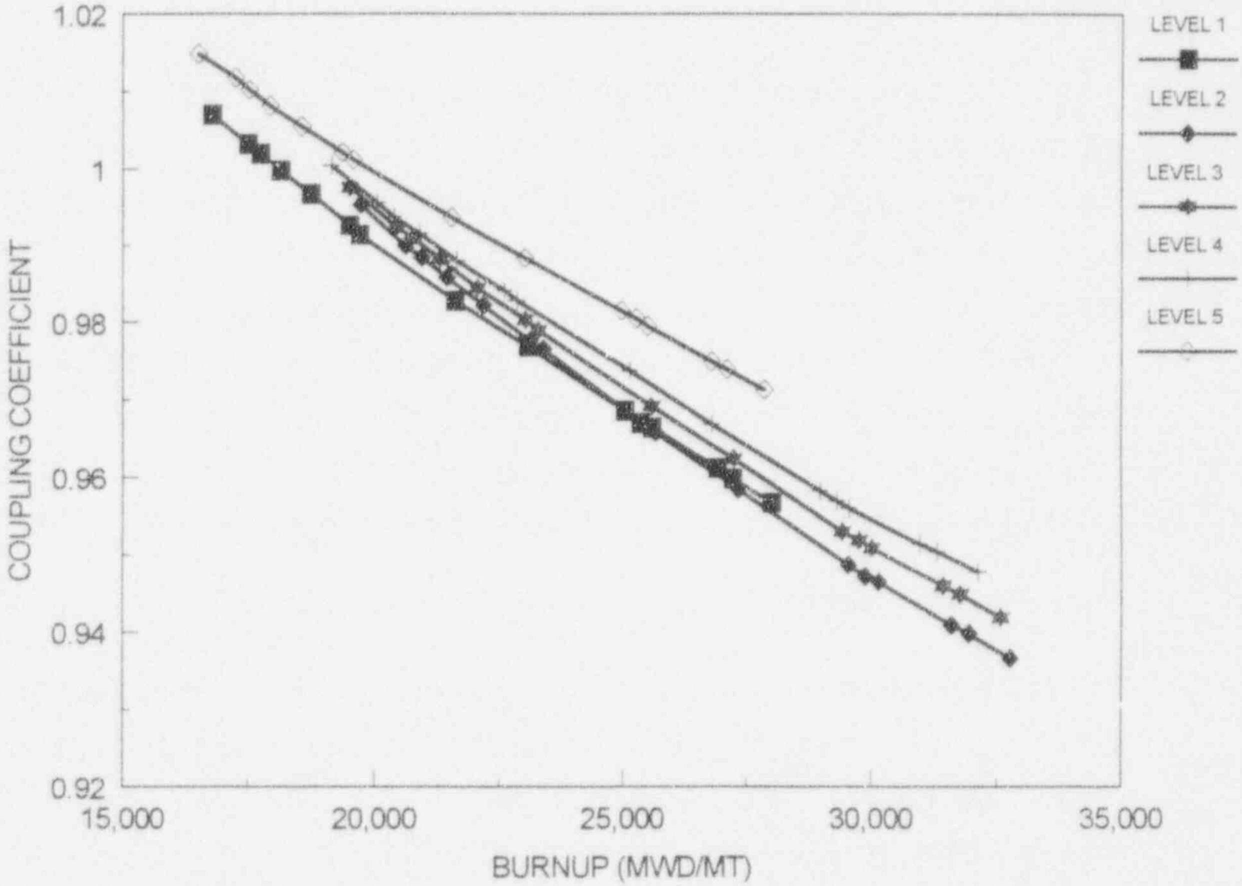


Figure 4.2. Assembly 18 Coupling Coefficient vs Burnup for ANO-2 Cycle 10



THE LARGEST FIT ERROR AND ITS OCCURENCE FOR LEVEL 1: .0 %. & AT 23084.0 MWD/MT
LEVEL 2 .0 %. & AT 19719.0 MWD//MT LEVEL 3: .0 %. & 27245 .0 MWD/MT
LEVEL 4 - .1 %. & AT 25136 MWD//MT LEVEL 5 : .0 %. & 17255 .0 MWD/MT

5.0 DETERMINATION OF CECOR UNCERTAINTIES

5.1 General

The CECOR power distribution uncertainties relating to Fxy, Fr and Fq which are defined in Appendix A of this report is composed of three components which are discussed in detail in the following sections. The three are identified as the Box Power Measurement Uncertainty, Power Synthesis Uncertainty, and Pin Peaking Calculational Uncertainty. The Pin Peaking Synthesis uncertainty as mentioned in the previous CECOR topical (Reference 3) is eliminated because the nodal code is capable of constructing detailed 3-D Pin Peaking distributions. Thus the Power Synthesis Uncertainty includes both the Box Power Synthesis and Pin Peaking Synthesis Uncertainties of Reference 3.

5.2 Box Power Measurement Uncertainty (Nodal Peaking Uncertainty)

The Box Power Measurement Uncertainty (S_M) is the uncertainty associated with the measurement of power at the five detector levels. It includes uncertainties in the measured signals in instrumented locations and the uncertainties in the signal-to-power (W') conversion. The Observed Uncertainty between measured powers and predicted powers consists of the Box Power Measurement Uncertainty (measurement) and Box Power Calculational Uncertainty (model) and is related as shown in Equation 5.2-1 taken from Reference 2. One can conservatively set the Box Power Calculational Uncertainty (model) equal to zero and assume that the Observed Uncertainty is due entirely to the Box Power Measurement Uncertainty.

$$S^2_{observed} = S^2_{measurement} + S^2_{model} \qquad \textbf{(5.2-1)}$$

The process for calculating the Box Power Measurement Uncertainty then consists of comparing CECOR measured instrument powers using actual measured detector signals from fifteen cycles of reactor operation to powers

calculated by the nodal design code. These comparisons were carried out in Reference 2. The results of the comparisons are summarized in Table 5.2-1.

Table 5.2-1. Observed (Box Power Measurement) Uncertainties

Unit	Parameter	$S_{observed}$	f	Mean
ANO-2	Fq	0.01966	11806	0.00484
	Fr	0.01333	3482	0.0
	Fxy	0.01703	19761	0.0
WSES-3	Fq	0.01959	14251	0.00391
	Fr	0.01149	4344	0.0
	Fxy	0.01550	23694	0.0

The statistics above are based on the differences calculated using Equation 5.2-2.

$$\text{DIFFERENCE} = X_m - X_c \qquad (5.2\text{-}2)$$

where:

X_m is the measured power from CECOR.

and

X_c is the calculated power from the nodal design program.

The variable X is defined differently for Fq, Fr, and Fxy. For the purpose of quantifying Fq uncertainty, the variable X is defined as the power in any instrumented segment. For Fr the variable X is defined as the sum of five detector segments in any assembly. For Fxy the variable X is the power at any instrumented segment within a core level. For each calculation the powers X are converted to relative power distributions by a normalization to the true average power density which is approximated by the CECOR calculation.

Nine cycles of data for ANO-2 and six cycles of data for WSES-3 were analyzed. Appendix B lists the CECOR cases used to calculate the Box Power Measurement Uncertainty. Absolute differences were converted to relative differences by dividing by the minimum measured peaking factor. Examples of

the comparisons of measured and predicted detector powers for representative cycles are provided in Appendix C and D for ANO-2 and WSES-3 respectively.

The distribution of the nodal Fq, Fr and Fxy observed differences between measured and calculated instrument powers were tested for normality. The D' test was used for testing of normality because of the large number of samples. The results indicated that some of the observed differences did not pass the D' test for normality at the 5% significance level, but histograms of the data were bounded by the normal distribution in the area of interest. Figures 5.2-1 through 5.2-6 give comparisons of the sample box power measurement difference distributions and the normal distributions with the 95%95% normal tolerance limits. As can be seen in the figures, the normal distribution tolerance limit bounds the sample difference distributions except for very small percents shown in the figures, indicating that the normal assumption and standard deviations are conservative.

Figure 5.2-1. ANO-2 Fxy Box Measurement Error vs Normal Histogram

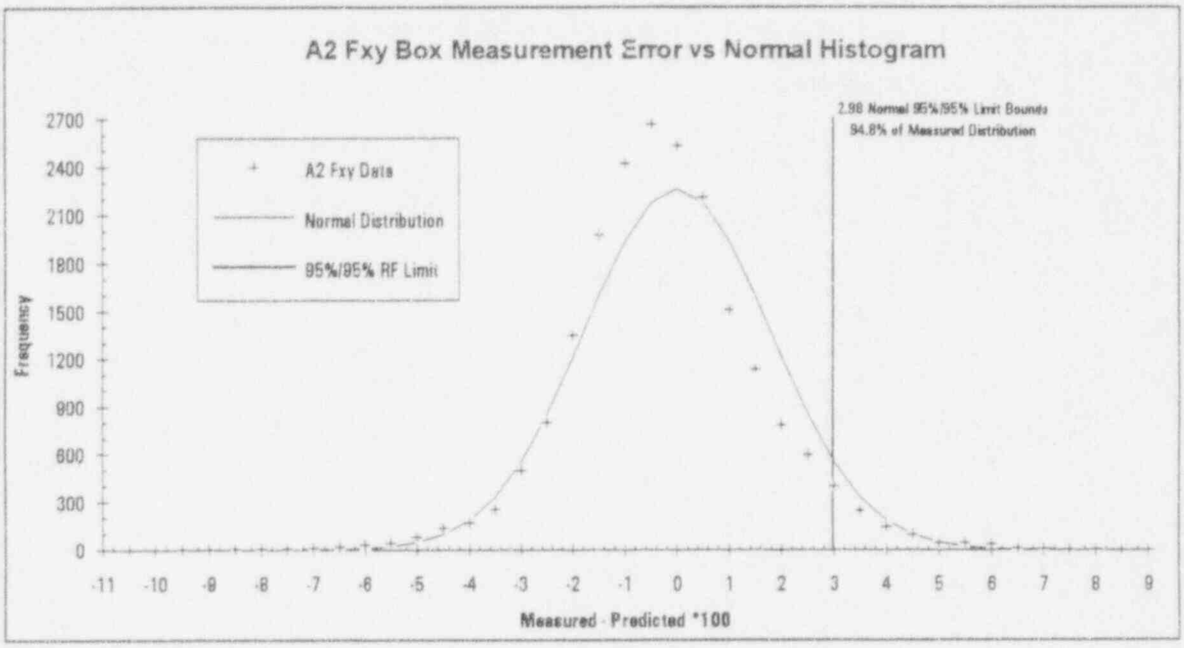


Figure 5.2-2. ANO-2 Fr Box Measurement Error vs Normal Histogram

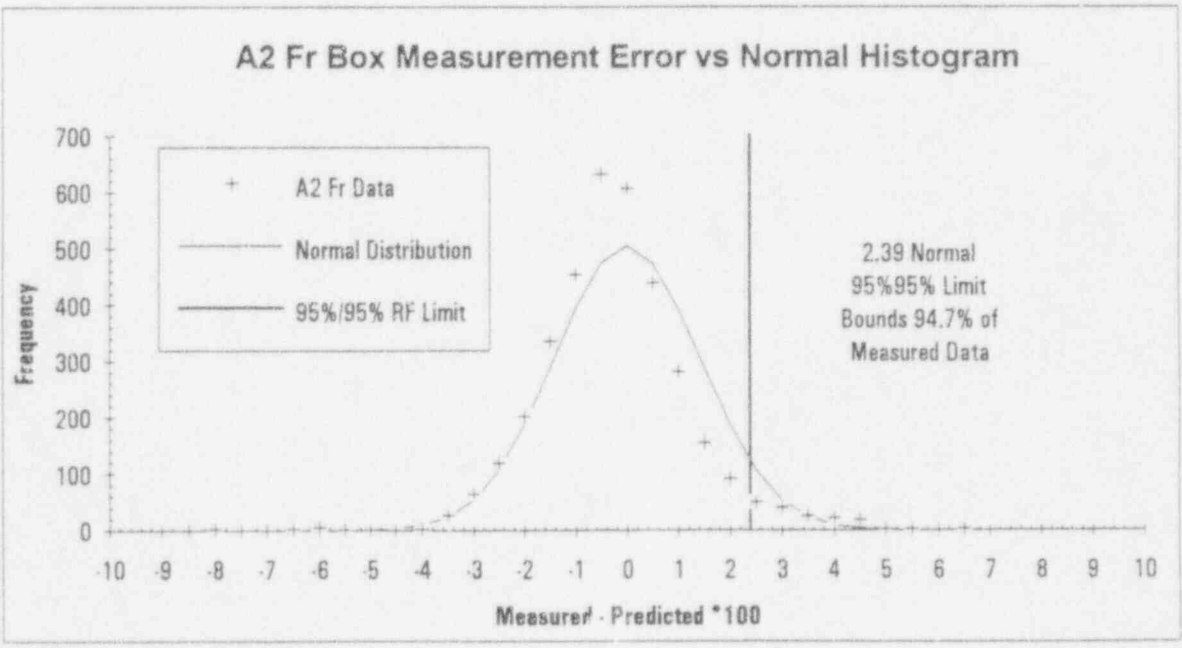


Figure 5.2-3. ANO-2 Fq Box Measurement Error vs Normal Histogram

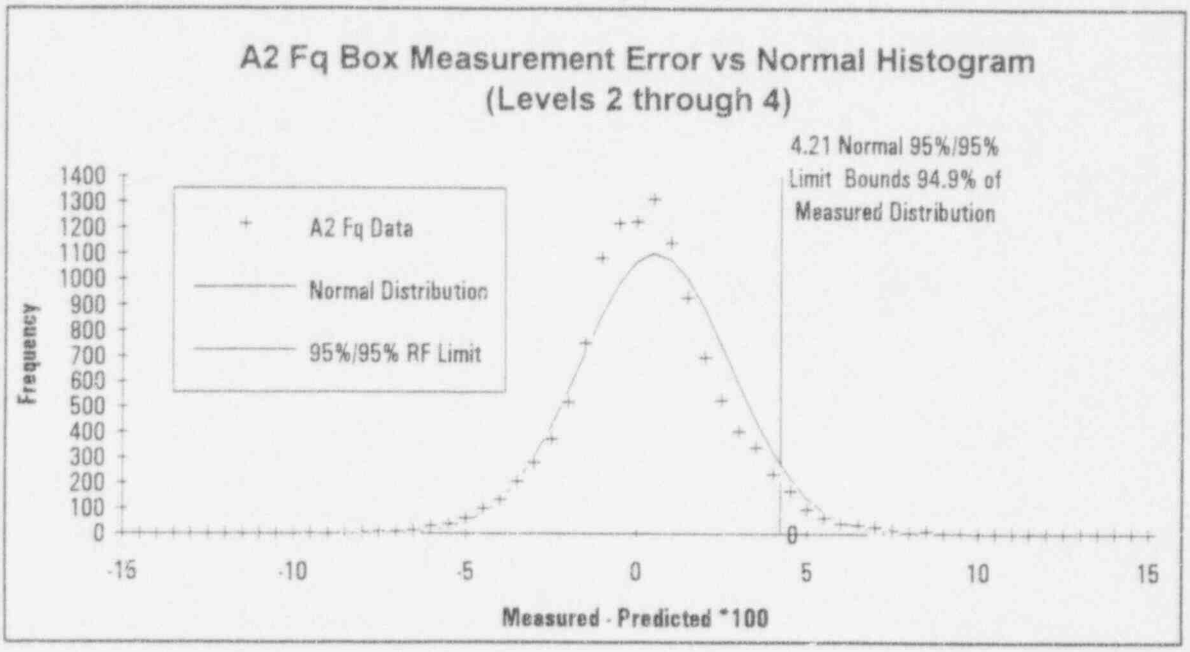


Figure 5.2-4. WSES-3 Fxy Box Measurement Error vs Normal Histogram

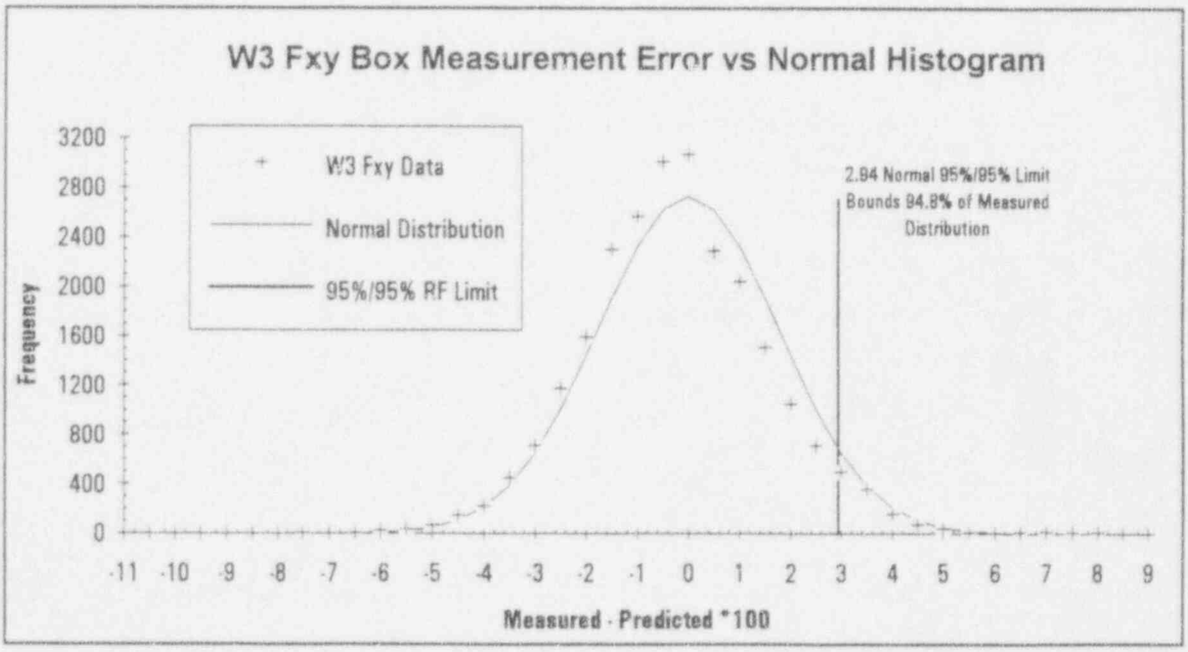


Figure 5.2-5. WSES-3 Fr Box Measurement Error vs Normal Histogram

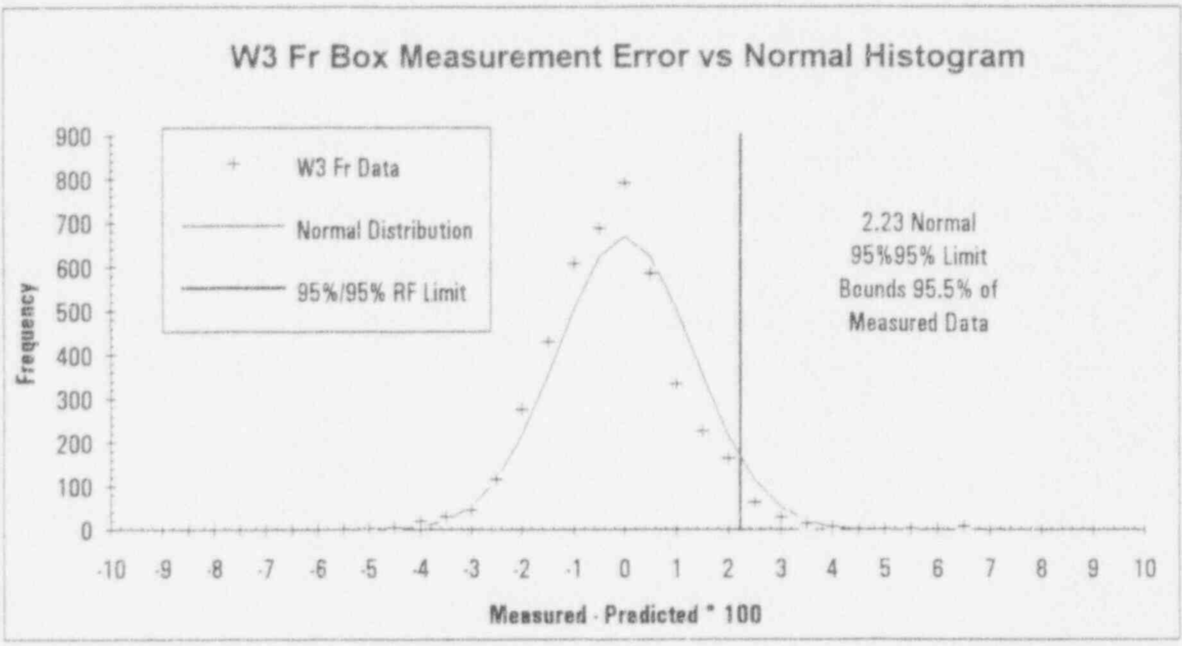
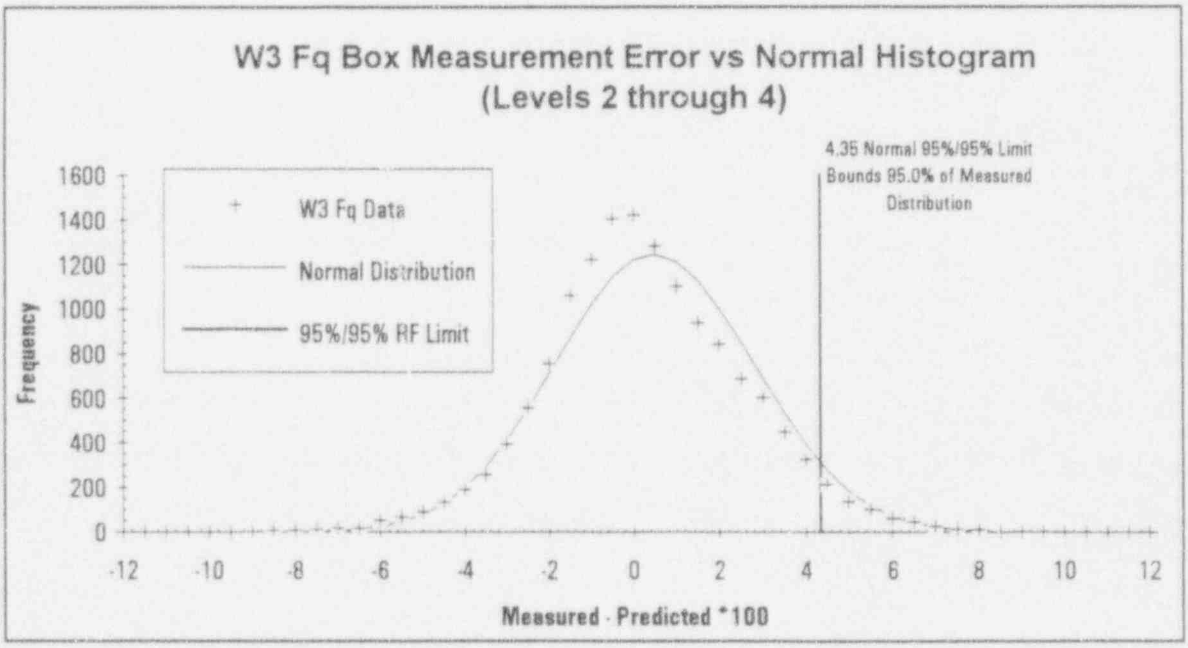


Figure 5.2-6. WSES-3 Fq Box Measurement Error vs Normal Histogram



5.3 Power Synthesis Uncertainty

The Power Synthesis Uncertainty (S_{PS}) is the uncertainty associated with the construction of pin powers from detector powers. The Power Synthesis Uncertainty includes uncertainties associated with coupling coefficient synthesis, pin-to-box synthesis and axial fitting. The Power Synthesis uncertainty also includes uncertainty associated with the number of operable detectors.

The Power Synthesis differences are obtained by re-running the same CECOR cases used to derive the Box Power Measurement Uncertainty in Section 5.2 but using pseudo signals derived from nodal design calculations. The CECOR results are compared to the results of the nodal design calculation with pin power synthesis turned on.

For the Fr Power Synthesis uncertainty, the relative axially integrated peak pin powers for all assemblies from CECOR and the nodal design calculation are compared. The differences in Fr are defined as:

DFRi = (Pni - Pci)/Pci **(5.3-1)**

where Pni is the peak pin relative power for each assembly (i) from the nodal design program (truth).

Pci is the peak pin relative power from CECOR.

For the Fq Power Synthesis uncertainty, the relative axial peak pins in all assemblies from CECOR and the nodal design calculation are compared. The differences in Fq are defined as:

DFQi = (Pnik - Pcik)/Pcik **(5.3-2)**

where Pnik are the axial peak pin (k) for each assembly (i) from the nodal design program.

Pcik are the axial peak pin (k) for each assembly (i) from the CECOR calculation.

For the Fxy Power Synthesis Uncertainty, the planar pin peaks for each axial plane from CECOR and the nodal design calculation are compared. Consistent with the use of CECOR in monitoring the reactor core, only planes between 15 and 85% of core height were compared. The differences in Fxy are defined as:

$$DFXYk = (Pnk - Pck)/Pck \qquad (5.3\text{-}3)$$

where Pnk is the planar peak pin peak to planar average pin from the nodal design program for each axial plane (k) between 15 and 85% of core height.

Pck is the planar peak pin to planar average pin from the CECOR calculation

Difference distributions are generated by comparing Fxy, Fr and Fq from the nodal calculations to Fxy, Fr and Fq generated by CECOR using CECOR libraries generated from the nodal calculations and pseudo detector signals also generated from the nodal calculations. The differences were assembled for each cycle and the statistics for (NODAL-CECOR)/CECOR were calculated.

The difference distributions shown in Figures 5.3-1 through 5.3-6 were found to be non-normal by observation and by the application of the D' test, so a non-parametric approach was used to set the 95%95% reliability factor limits. Conservative estimates for the mean and standard deviations were estimated from the reliability factors. Appendix B gives a list of the cases used in the development of the Power Synthesis Uncertainties. Appendices E and F contain comparisons of Fq and Fr Power Synthesis differences for representative cycles of ANO-2 and WSES-3 respectively. The statistical results

for the Power Synthesis Uncertainty with zero failed detectors are given in Tables 5.3-1 and 5.3-2.

Finally, a parametric study was done of Power Synthesis Uncertainty as a function of the percent of failed incore detectors. It is anticipated that as the number of operable detectors is reduced, the Power Synthesis Uncertainty will increase as the power distribution is constructed more based on the coupling coefficient library than on actual detector readings.

In these parametric studies, off nominal nodal calculations were run at BOC, MOC and EOC for several cycles. The off nominal cases were full core calculations with large power tilts (8-10%). Signals for CECOR were generated from the nodal calculations as in the base Power Synthesis Uncertainty study.

Next multiple CECOR calculations were run with 0, 12.5, 25, 37.5 and 50% of the detectors failed. Detectors were basically failed randomly but in such a manner as to not violate any technical specification requirements, except the percent failed limit. This was done to provide a foundation for increasing the allowed percent failed detectors in technical specifications in the future. The output of the CECOR cases were compared to the original tilted full core nodal calculations. Statistics for Fq, Fr and Fxy were compiled on (NODAL-CECOR)/CECOR.

The statistics were used to calculate a normal reliability factor using the equation: $RF=D+k\sigma$. Reliability factors were tabulated vs percent failed detectors. The reliability factors were normalized to the overall reliability based on nominal operating conditions from the base Power Synthesis Uncertainty calculation. The normalized reliability factors were used with the means and 95%/95% k factors from the base Power Synthesis Uncertainty calculation to calculate an equivalent standard deviation that conserves the reliability factors from the failed detector study. The calculations are summarized in Tables 5.3-3 and 5.3-4.

Table 5.3-1. ANO-2 Power Synthesis Uncertainty Components

PARAMETER	MEAN (%)	STANDARD DEVIATION (%)	N	F	RF	K
Fxy	0.0318	0.3202	1822	1728	.0058	1.712
Fr	-0.0048	0.4819	16638	16544	0.0080	1.670
Fq	-1.7533	1.4331	16638	16544	0.0064	1.670

Table 5.3-2. WSES-3 Power Synthesis Uncertainty Components

PARAMETER	MEAN (%)	STANDARD DEVIATION (%)	N	F	RF	K
Fxy	0.0542	0.8488	1275	1200	0.0152	1.727
Fr	-0.0186	0.2267	16275	16200	0.0036	1.670
Fq	-1.7223	2.2110	16275	16200	0.0197	1.670

Table 5.3-3. ANO-2 Power Synthesis Uncertainty vs % Failed Detectors

Failure Rate (%)	Parameter	Mean (%)	Standard Deviation (%)	N	F	RF
0	Fxy	-0.0649	0.7960	528	504	1.3360
	Fr	0.0867	0.9180	4248	4224	1.6399
	Fq	-1.4035	1.8566	4248	4224	1.7378
12.5	Fxy	-0.0203	0.8605	5280	5040	1.4263
	Fr	0.0800	1.0062	42480	42240	1.7604
	Fq	-1.3997	1.8840	42480	42240	1.7466
25.0	Fxy	0.0659	0.9818	5280	5040	1.7163
	Fr	0.0711	1.1718	42480	42240	2.0280
	Fq	-1.3913	1.9359	42480	42240	1.8416
37.5	Fxy	0.1509	1.0789	5280	5040	1.9645
	Fr	0.0629	1.3481	42480	42240	2.3141
	Fq	-1.3973	1.9852	42480	42240	1.9179
50.0	Fxy	0.3116	1.1529	5280	5040	2.2496
	Fr	0.0504	1.5883	42480	42240	2.7028
	Fq	-1.3908	2.0651	42480	42240	2.0579

Table 5.3-4. WSES-3 Power Synthesis Uncertainty vs % Failed Detectors

Failure Rate (%)	Parameter	Mean (%)	Standard Deviation (%)	N	F	RF
0.0	Fxy	-0.1240	0.5993	308	294	0.9548
	Fr	0.0430	0.8499	3038	3024	1.4811
	Fq	-1.5690	1.8943	3038	3024	1.6362
12.5	Fxy	-0.0640	0.7064	3080	2940	1.1312
	Fr	0.0371	0.9110	30380	30240	1.5585
	Fq	-1.5639	1.9026	30380	30240	1.6134
25.0	Fxy	-0.0320	0.7635	3080	2940	1.2599
	Fr	0.0323	1.0050	30380	30240	1.7107
	Fq	-1.5782	1.9582	30380	30240	1.6921
37.5	Fxy	-0.0311	0.7728	3080	2940	1.2764
	Fr	0.0250	1.0994	30380	30240	1.8611
	Fq	-1.5910	1.9924	30380	30240	1.7363
50.0	Fxy	0.0781	0.8449	3080	2940	1.5076
	Fr	0.0185	1.2892	30380	30240	2.1715
	Fq	-1.5788	2.0107	30380	30240	1.7790

Figure 5.3-1. ANO-2 Fxy Power Synthesis Error vs Normal Histogram

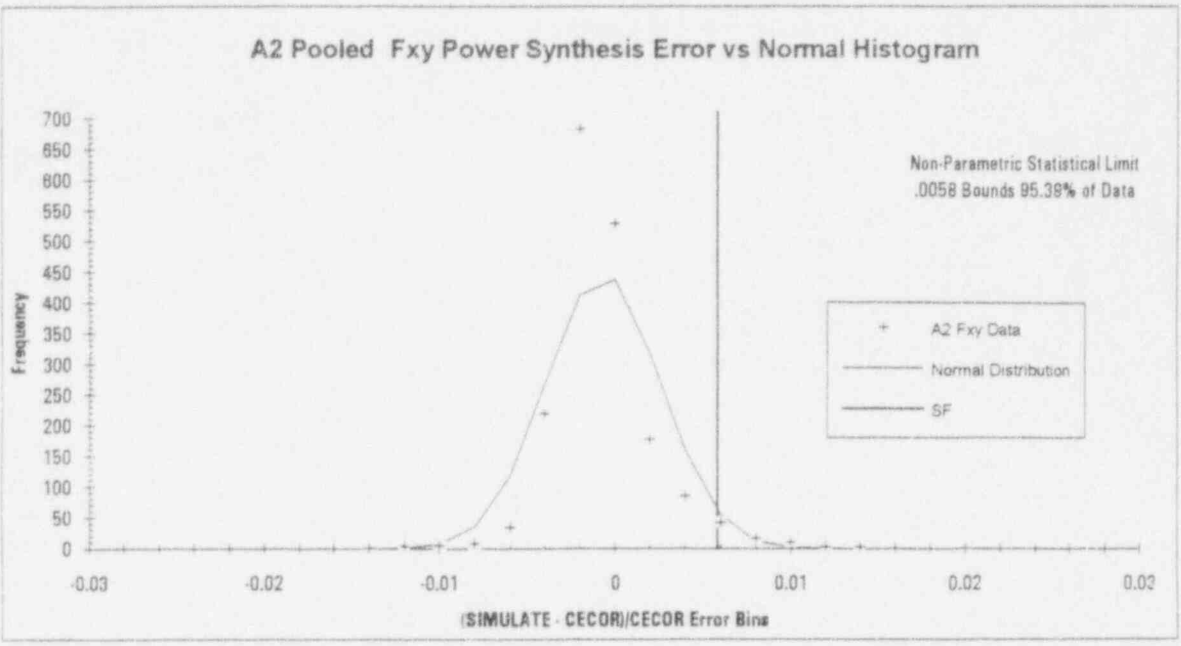


Figure 5.3-2. ANO-2 Fr Power Synthesis Error vs Normal Histogram

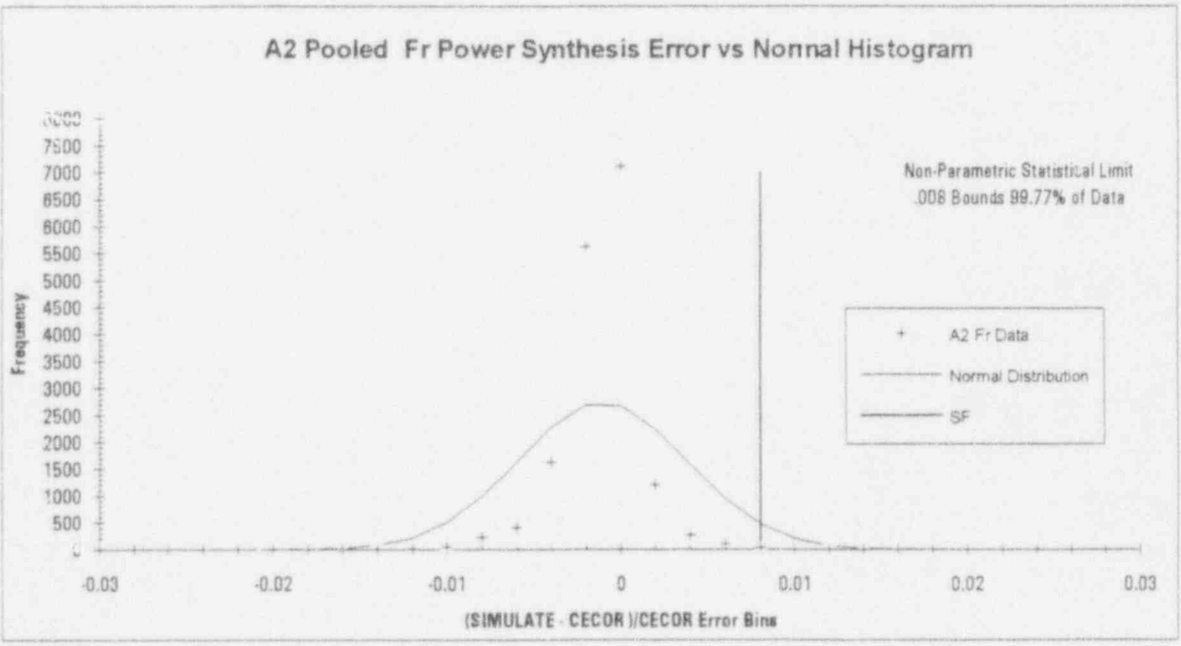


Figure 5.3-3. ANO-2 Fq Power Synthesis Error vs Normal Histogram

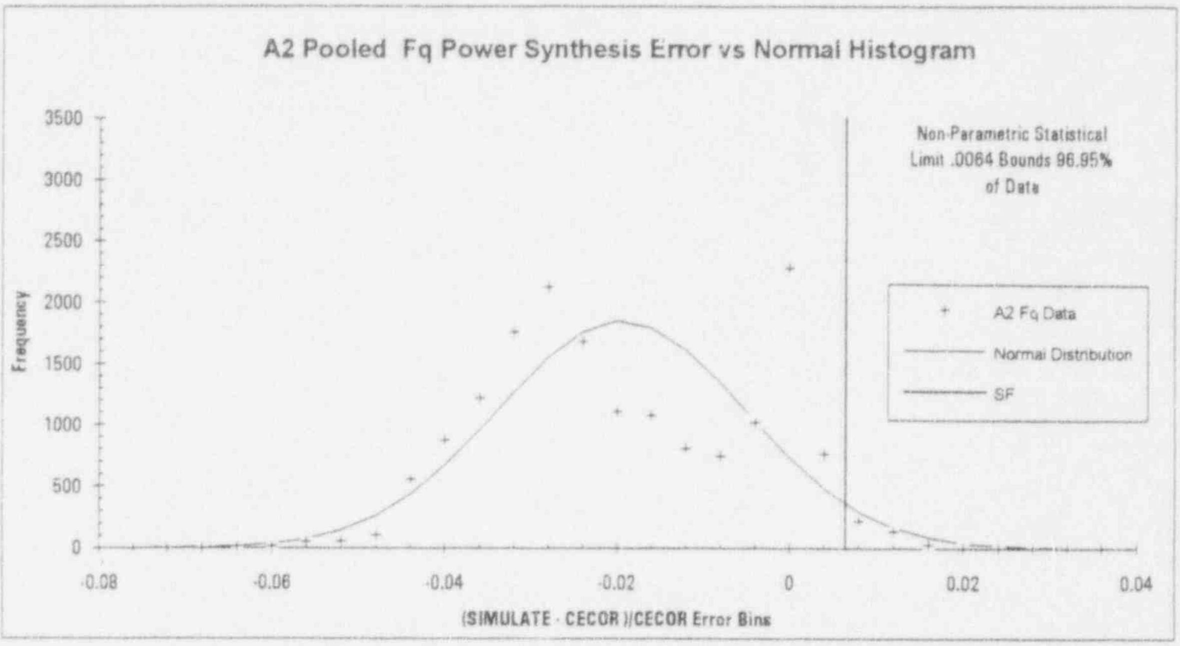


Figure 5.3-4. WSES-3 Fxy Power Synthesis Error vs Normal Histogram

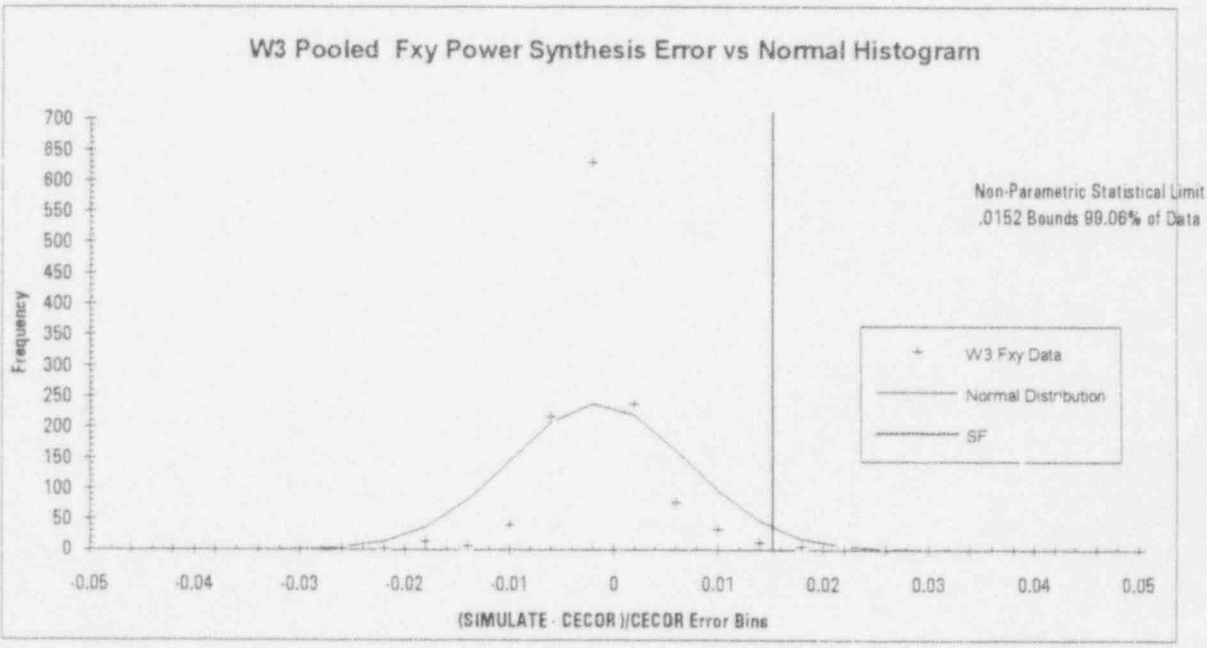


Figure 5.3-5. WSES-3 Fr Power Synthesis Error vs Normal Histogram

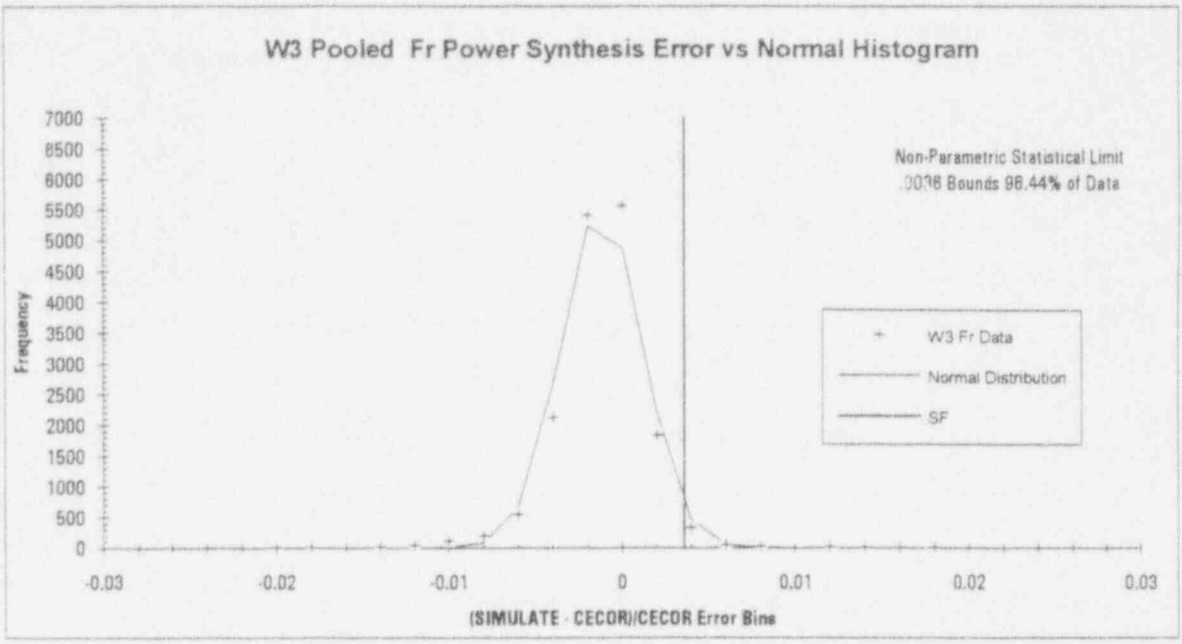
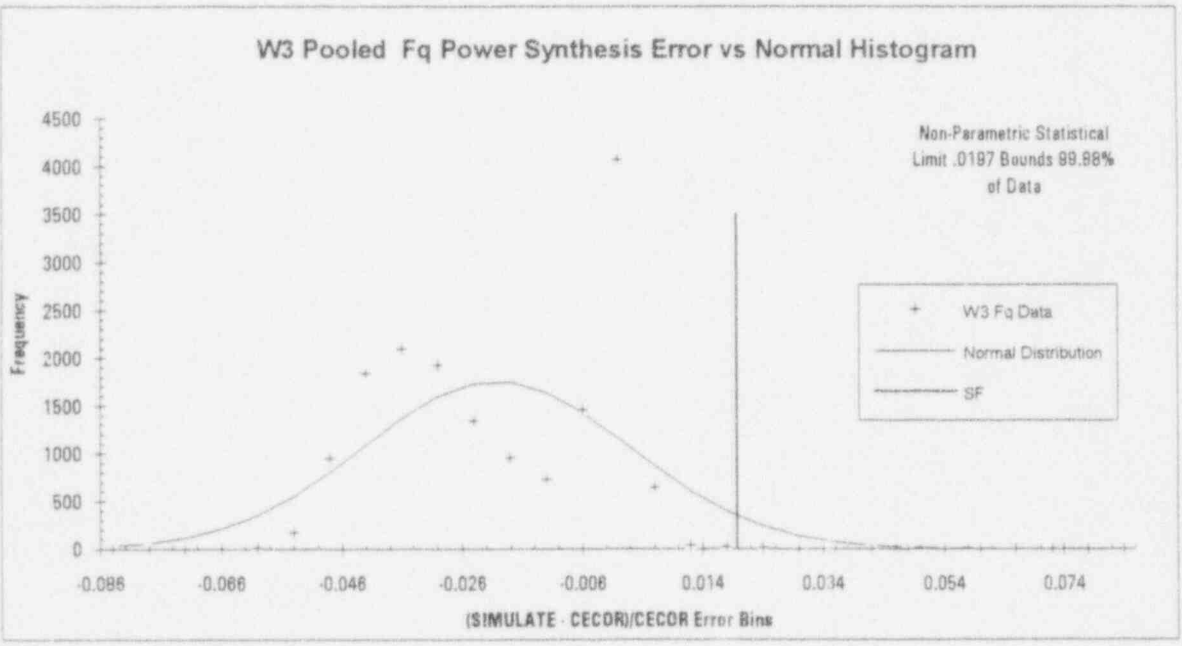


Figure 5.3-6. WSES-3 Fq Power Synthesis Error vs Normal Histogram



5.4 Pin Peaking Calculational Uncertainty

Since the local pin power cannot be measured directly in the operating reactor, the pin power synthesis process must rely on calculated values of pin-to-box factors. The pin peaking calculational uncertainty is the uncertainty associated with the nodal code calculation of pin-to-box peaking factors. The Entergy pin peaking calculational uncertainties were based on the nodal code comparisons to critical experiments. The Entergy pin peaking calculational uncertainties were documented in the physics methodology report [Reference 2]. The pin peaking calculational uncertainty established in Reference 2 was σ_{ppc} = .01261 and pin peaking calculational bias was $\overline{D}_{ppc} = 0.00$, corresponding to a sample size of 124.

5.5 Combination of Uncertainties

In order to determine a reliability factor for the random error in pin peaking factors Fq, Fr, and Fxy as measured by CECOR, it is necessary to statistically combine the three uncertainty components described in Sections 5.2 through 5.4. The method of combination is the same as that presented in Reference 4, except the Pin Peaking Synthesis Uncertainty has been combined with the Box Synthesis Uncertainty into the Power Synthesis Uncertainty. The three components of uncertainties are Measurement (M), Power Synthesis (PS), and Pin Peaking Calculations (PPC). Since the error components are due to entirely different and unrelated factors, they are independent and uncorrelated random variables, and one may write:

$$\mu = \mu_M + \mu_{PS} + \mu_{PPC} \qquad \textbf{(5.5-1)}$$

and

$$\sigma^2 = \sigma^2_M + \sigma^2_{PS} + \sigma^2_{PPC} \qquad \textbf{(5.5-2)}$$

Using the sample means and variances from Sections 5.2 through 5.4 as estimates of the true bias and variance, one can write:

$$\mu \approx \overline{D} = \overline{D_M} + \overline{D_{PS}} + \overline{D_{PPC}} \qquad \textbf{(5.5-3)}$$

and

$$\sigma^2 \approx S^2 = S^2_M + S^2_{PS} + S^2_{PPC} \qquad \textbf{(5.5-4)}$$

The sample statistics $\overline{D}$ and S from Equations 5.5-3 and Equation 5.5-4 are estimates of the true parameters μ and σ and are therefore subject to a random distribution of their own. The one sided lower tolerance limit can be calculated such that the uncertainty in the CECOR power can be estimated on a 95%/95% probability/confidence level.

Tables 5.5-1 and 5.5-2 list the estimates of $\overline{D}$ and S and the number of degrees of freedom of the three components of CECOR pin power uncertainty. If one expresses the sample variance as being proportional to a χ^2 distribution, one may write:

$$S^2 = \frac{\chi^2 \sigma^2}{f} \tag{5.5-5}$$

or substituting in Equation 5.5-4, one can write:

$$\frac{\chi^2 \sigma^2}{f} = \frac{\chi^2 \sigma_M^2}{f_M} + \frac{\chi^2 \sigma_{PS}^2}{f_{PS}} + \frac{\chi^2 \sigma_{PPC}^2}{f_{PPC}} \tag{5.5-6}$$

and taking the variance of both sides gives

$$\frac{\sigma^4}{f} = \frac{\sigma_M^4}{f_M} + \frac{\sigma_{PS}^4}{f_{PS}} + \frac{\sigma_{PPC}^4}{f_{PPC}} \tag{5.5-7}$$

Using the sample variances as approximations for the true variances, one can write:

$$f = \frac{S^4}{\frac{S_M^4}{f_M} + \frac{S_{PS}^4}{f_{PS}} + \frac{S_{PPC}^4}{f_{PPC}}} \tag{5.5-8}$$

where all measured variances are known. The number of degrees of freedom is used to determine the one-sided tolerance limit for the 95%/95% probability/confidence interval. The results for Fq, Fxy and Fr are given in Tables 5.5-3 and 5.5-4.

The analysis in this section was repeated for the Power Synthesis Uncertainties based on 12.5, 25, 37.5, and 50% failed incore detectors. The impact of failed detectors is included in the overall CECOR uncertainties given in Table 5.5-5

Thus it was decided to use the more limiting reliability factors between ANO-2 and WSES-3 for both reactors as presented in Table 5.5-7.

These tolerance limits ensure that there is a 95% probability that at least 95% of the true Fxy, Fr and Fq will be less than the Fxy, Fr and Fq measured by CECOR plus the percents shown in Table 5.5-7 with the specified percentage of failed detectors. For example, for 25% failed detectors there is a 95%/95% confidence/probability that the true Fxy, Fr and Fq will be less than the CECOR measured value times 1.0393, 1.0345 and 1.0414 respectively.

Table 5.5-1. ANO-2 CECOR Peaking Factor Uncertainty Components

ANO-2						
PARAMETER	UNCERTAINTY COMPONENT	D(%)	S(%)	f	k	D+kS(%)
Fxy	Measurement	0.0000	1.7030	19761		
	Power Synthesis	0.0318	0.3202	1728		
	Pin Power Calculation	0.0000	1.2610	124		
	Combined	0.0318	2.1431	1013	1.7270	3.7329
Fr	Measurement	0.0000	1.3330	3482		
	Power Synthesis	-0.0048	0.4819	16544		
	Pin Power Calculation	0.0000	1.2610	124		
	Combined	-0.0048	1.8972	608	1.7520	3.3190
Fq	Measurement	0.4840	1.9660	11806		
	Power Synthesis	-1.7530	1.4331	16544		
	Pin Power Calculation	0.0000	1.2610	124		
	Combined	-1.2690	2.7403	2573	1.7030	3.3977

Table 5.5-2. WSES-3 CECOR Peaking Factor Uncertainty Components

WSES-3						
PARAMETER	UNCERTAINTY COMPONENT	D(%)	S(%)	f	k	D+kS(%)
Fxy	Measurement	0.0000	1.5500	23694		
	Power Synthesis	0.0542	0.8488	1200		
	Pin Power Calculation	0.0000	1.2610	124		
	Combined	0.0542	2.1710	1054	1.7270	3.8035
Fr	Measurement	0.0000	1.1490	4344		
	Power Synthesis	-0.0190	0.2267	16200		
	Pin Power Calculation	0.0000	1.2610	124		
	Combined	-0.0190	1.7210	422	1.7780	3.0409
Fq	Measurement	0.3910	1.9590	14251		
	Power Synthesis	-1.7220	2.2110	16200		
	Pin Power Calculation	0.0000	1.2610	124		
	Combined	-1.3310	3.2119	4648	1.6920	4.1035

Table 5.5-3. Combined Uncertainties for ANO-2

Parameter	D (%)	S(%)	f	k	D+kS (%)
Fxy	0.0318	2.1431	1013	1.7270	3.7329
Fr	-0.0048	1.8972	608	1.7520	3.3190
Fq	-1.2690	2.7403	2573	1.7030	3.3977

Table 5.5-4. Combined Uncertainties for WSES-3

Parameter	D (%)	S(%)	f	k	D+kS (%)
Fxy	0.0542	2.1710	1054	1.7270	3.8035
Fr	-0.0190	1.7210	422	1.7780	3.0409
Fq	-1.3310	3.2119	4648	1.6920	4.1035

Table 5.5-5. ANO-2 CECOR Reliability Factors vs % Failed Detectors

Parameter	Failure Rate (%)	RF=D+kS
Fxy	0	3.7329
	12.5	3.7476
	25	3.8093
	37.5	3.8791
	50	3.9773
Fr	0	3.3190
	12.5	3.3534
	25	3.4450
	37.5	3.5649
	50	3.7601
Fq	0	3.3977
	12.5	3.4024
	25	3.4539
	37.5	3.4963
	50	3.5764

Table 5.5-6. WSES-3 CECOR Reliability Factors vs % Failed Detectors

Parameter	Failure Rate (%)	RF=D+kS
Fxy	0	3.8035
	12.5	3.8758
	25	3.9329
	37.5	3.9405
	50	4.0520
Fr	0	3.0409
	12.5	3.0528
	25	3.0826
	37.5	3.1199
	50	3.2207
Fq	0	4.1035
	12.5	4.0876
	25	4.1426
	37.5	4.1738
	50	4.2041

Table 5.5-7. 95%/95% CECOR Reliability Factors vs % Failed Detectors

Parameter	D+kS (%) 0% Detector Failures	D+kS (%) 12.5% Detector Failures	D+kS (%) 25% Detector Failures	D+kS (%) 37.5% Detector Failures	D+kS (%) 50% Detector Failures
Fxy	3.80	3.88	3.93	3.94	4.05
Fr	3.32	3.35	3.45	3.56	3.76
Fq	4.10	4.09	4.14	4.17	4.20

6.0 REFERENCES

1. CECOR 2.0 General Description, Methods and Algorithms, NPSD-103-P, Combustion Engineering, 6/80.
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3. INCA/CECOR Power Peaking Uncertainty, CENPD-153-P Revision 1-P-A, Combustion Engineering, 5/80.
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5. American National Standard Assessment of the Assumption of Normality, ANSI N15.15 - 1974.
6. W. J. Conover, Practical Non-Parametric Statistics, John Wiley and Sons, New York, 1980.
7. R. E. Odeh and D. B. Owen, Tables for Normal Tolerance Limits, Sampling Plans, and Screening, Marcel Dekker, Inc., New York, 1980.

APPENDIX A: DEFINITION OF TERMS

1.0 F_q: The maximum 3-D power. One value for the core; i.e., the maximum for a <u>nodal</u> power (i.e., the maximum of any of (177 / ANO-2, 217 / WSES-3) XY assembly power values on any of the 51 Z planes) times the appropriate pin to assembly factor.

2.0 F_{xy} Calculated for each axial plane as follows:

Let there be 51 axial nodes (i = 1, 51)

Let there be 177 assemblies (j = 1, 177) (WSES-3 = 217 assemblies)

a) Search for maximum P_j within that plane i

$P_{j\max}$ = Max of $[P_1, P_2, P_3 \ldots\ldots P_{177}]$i

b) Find the average power for that plane i

$$\overline{P}_{ji} = \frac{1}{177}\sum_{j=1}^{177} P_{ji}$$

c) Increase $P_{j\max}$ as defined in a) by the pin to assembly ratio to account for local peaking, i.e.

$P_{j\max\,LocalPeaked}$ = $P_{j\max}$ * (pin to assembly ratio)

d) Then, define F_{xy} for that plane i

$$F_{xyi} = \frac{P_{j\max\,LocalPeaked}}{\overline{P}_{ji}}$$

e) F_{xy} is the maximum of F_{xyi}

3.0 F_r: Defined for any assembly as follows:

$$F_{rj} = \frac{1}{51}\sum_{i=1} P_{ji}$$

where P_{ji} is maximum pin power in assembly j at level i

APPENDIX B: POWER DISTRIBUTION MEASUREMENT STATEPOINTS

Table B.0-1. ANO-2 Cycle 2 Statepoints

					CEA Position (% withdrawn)		
Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	PLR	Group 5	Group 6
1	08/03/81	19.0	785	100.0	100.0	100.0	99.8
2	08/31/81	38.3	730	99.15	100.0	100.0	100.0
3	09/11/81	48.4	702	100.0	100.0	100.0	100.0
4	09/24/81	60.9	708	77.70	100.0	100.0	94.5
5	10/28/81	75.8	626	100.0	100.0	100.0	100.0
6	11/18/81	92.6	571	99.58	99.5	99.5	99.5
7	12/10/81	113.2	510	99.81	99.5	99.5	99.5
8	01/30/82	142.1	425	100.1	99.5	99.5	99.5
9	02/24/82	170.8	340	99.63	99.5	99.5	95.5
10	03/30/82	199.0	255	100.2	98.9	98.9	98.9
11	04/15/82	214.0	200	99.94	99.1	98.9	98.4
12	05/14/82	225.0	206	84.55	98.9	98.9	97.3
13	06/29/82	252.4	79	99.49	98.6	98.1	95.8
14	07/18/82	273.2	26	99.30	98.1	98.1	96.6
15	08/17/82	290.5	22	76.12	98.1	98.1	98.1

Table B.0-2. ANO-2 Cycle 3 Statepoints

					CEA Position (% withdrawn)		
Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	PLR	Group 5	Group 6
1	01/06/83	28.21	794	100.0	100.0	100.0	100.0
2	02/07/83	33.44	757	99.34	100.0	100.0	100.0
3	03/16/83	62.03	657	99.66	100.0	100.0	100.0
4	04/19/83	96.16	552	100.1	99.5	99.5	99.5

Table B.0-3. ANO-2 Cycle 4 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	03/20/84	43.14	1057	97.24	100.0	100.0	100.0
2	05/29/84	101.8	847	99.97	99.5	99.5	99.5
3	06/15/84	118.8	785	99.29	99.5	99.5	99.5
4	07/19/84	150.8	678	99.75	99.5	99.5	99.5
5	08/10/84	161.6	626	99.66	99.5	99.5	99.5
6	09/24/84	198.8	484	99.72	99.0	99.0	99.0
7	10/08/84	212.5	446	100.1	99.0	99.0	99.0
8	11/21/84	248.6	318	99.69	99.0	99.0	99.0
9	12/05/84	262.0	275	99.97	99.0	99.0	99.0
10	01/16/85	304.0	140	99.55	99.5	99.5	99.5
11	03/13/85	353.6	7	89.86	99.5	99.5	99.5

Table B.0-4. ANO-2 Cycle 5 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	07/30/85	43.00	895	99.87	99.3	100.0	99.7
2	08/30/85	69.64	816	99.48	100.0	100.0	100.0
3	10/14/85	94.98	748	99.62	99.5	99.5	99.5
4	11/25/85	129.1	638	99.95	99.5	99.5	99.5
5	12/23/85	146.1	582	99.47	99.5	99.5	97.5
6	01/31/86	185.1	462	99.79	99.0	99.0	99.0
7	02/28/86	210.8	383	99.99	99.0	99.0	99.0
8	03/25/86	235.3	314	100.1	99.0	99.0	99.0
9	04/11/86	252.4	261	100.1	99.0	99.0	99.0
10	05/22/86	290.1	145	99.60	98.5	98.5	98.5
11	06/05/86	304.2	99	100.2	98.5	98.5	98.5

Table B.0-5. ANO-2 Cycle 6 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	11/15/86	45.28	1050	99.89	100.0	100.0	100.0
2	01/21/87	112.0	899	99.55	99.5	99.5	99.5
3	03/20/87	169.2	762	100.0	99.5	99.5	95.5
4	04/18/87	197.9	688	99.60	99.0	99.0	99.0
5	06/30/87	234.7	569	99.47	99.0	99.0	99.0
6	07/30/87	254.0	506	99.91	99.0	99.0	99.0
7	08/31/87	286.1	433	99.60	98.6	98.6	98.6
8	09/30/87	314.6	345	99.72	98.5	98.5	96.0
9	10/22/87	336.4	295	99.82	98.5	98.5	98.5
10	11/21/87	361.6	224	100.1	98.8	98.5	98.5
11	12/29/87	399.3	107	99.08	98.5	98.5	98.5
12	01/29/88	430.3	23	99.66	98.5	98.5	98.5

Table B.0-6. ANO-2 Cycle 7 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	07/20/88	54.27	976	99.38	100.0	100.0	100.0
2	10/19/88	121.3	815	100.1	99.5	99.5	99.5
3	11/30/88	163.2	724	99.62	99.5	99.5	95.5
4	01/31/89	212.5	570	99.83	99.0	99.0	99.0
5	02/28/89	240.3	493	99.79	99.0	99.0	99.0
6	05/12/89	292.7	351	99.46	99.0	99.0	99.0

Table B.0-7. ANO-2 Cycle 8 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	12/20/89	25.8	970	99.89	100	100	100
2	12/11/90	351.9	155	99.83	98.5	98.5	98.5
3	1/17/91	388.7	50	99.98	98.5	98.5	98.5

Table B.0-8. ANO-2 Cycle 9 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	05/07/91	13.88	1050	99.90	100.0	100.0	100.0
2	05/28/91	34.51	1007	100.0	100.0	100.0	100.0
3	06/19/91	56.45	965	100.1	100.0	100.0	100.0
4	07/10/91	77.03	927	99.65	100.0	100.0	100.0
5	07/31/91	97.11	875	99.70	99.5	99.5	99.5
6	08/28/91	124.8	818	99.68	99.5	99.5	99.5
7	09/25/91	153.1	739	99.97	99.5	99.5	99.5
8	10/23/91	176.9	656	99.67	99.5	99.5	99.5
9	11/22/91	201.7	602	100.2	99.5	99.5	99.5
10	12/17/91	225.8	540	99.89	99.0	99.0	99.0
11	01/12/92	252.5	480	99.96	99.0	99.0	99.0
12	02/02/92	272.9	432	100.3	99.0	99.0	99.0
13	03/02/92	301.4	350	99.85	99.0	99.0	99.0
14	05/22/92	326.7	271	99.85	99.0	99.0	99.0
15	06/18/92	352.4	201	99.68	98.5	98.5	98.5
16	07/10/92	374.5	141	100.0	98.5	98.5	98.5
17	08/07/92	402.4	72	99.89	98.5	98.5	98.5

Table B.0-9. ANO-2 Cycle 10 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn) PLR	Group 5	Group 6
1	11/12/92	20.09	1113	99.97	100.0	100.0	100.0
2	12/01/92	37.69	1098	99.81	100.0	100.0	99.9
3	12/07/92	49.11	1089	99.68	100.0	100.0	100.0
4	12/17/92	53.99	1072	99.68	100.0	100.0	100.0
5	12/31/92	68.65	1051	99.54	100.0	100.0	100.0
6	01/19/93	87.38	1009	100.1	100.0	100.0	100.0
7	01/25/93	92.61	983	99.62	100.0	100.0	100.0
8	03/12/93	138.73	888	99.54	99.5	99.5	99.5
9	04/16/93	173.36	809	99.95	99.5	99.5	99.5
10	06/18/93	219.47	676	99.99	99.5	99.5	99.5
11	06/25/93	226.65	661	99.80	99.4	99.4	99.4
12	06/30/93	232.18	648	100.1	99.0	99.0	99.0
13	08/01/93	263.13	580	99.91	99.0	99.0	99.0
14	08/08/93	270.46	563	99.94	99.0	99.0	99.0
15	08/26/93	288.26	514	99.88	99.0	99.0	99.0

Table B.0-10. WSES-3 Cycle 1 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn) PLR	Group 5	Group 6
1	10/24/85	49.02	475	99.84	100	100	100
2	12/30/85	99.24	465	99.70	99	99	99
3	02/27/86	156.59	420	99.10	99	99	99
4	04/07/86	171.43	390	99.60	98	98	98
5	06/16/86	236.30	300	99.77	98	98	98
6	07/22/86	261.30	261	100.04	100	100	100
7	08/07/86	276.97	225	99.92	100	100	100
8	09/22/86	320.00	131	99.44	98	98	98
9	10/31/86	354.80	47	99.38	94	98	98

Table B.0-11. WSES-3 Cycle 2 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn) PLR	Group 5	Group 6
1	02/11/87	1.42	1235	68.48	100	100	100
2	02/18/87	7.18	1195	84.61	100	100	100
3	02/24/87	12.34	1137	99.94	100	100	100
4	03/31/87	42.83	980	99.73	100	100	100
5	05/20/87	90.35	866	99.52	99	99	99
6	07/31/87	159.26	684	99.85	99	99	99
7	08/10/87	167.45	640	99.80	99	99	99
8	08/31/87	187.83	582	99.93	98	98	98
9	09/17/87	201.83	554	99.59	98	98	98
10	10/26/87	221.86	494	99.56	99	99	99
11	11/19/87	245.10	407	99.50	98	98	98
12	12/22/87	275.91	323	99.93	98	98	98
13	01/31/87	309.70	222	99.68	99	99	99
14	02/29/88	338.79	124	100.02	99	99	99
15	03/31/88	366.44	47	99.80	98	98	98

Table B.0-12. WSES-3 Cycle 3 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn) PLR	Group 5	Group 6
1	06/27/88	17.45	1010	99.97	99	99	99
2	07/15/88	38.13	976	99.35	100	100	100
3	08/17/88	68.46	907	99.37	98	98	98
4	09/01/88	83.38	880	99.89	98	98	98
5	09/16/88	97.38	874	90.00	98	98	98
6	10/07/88	114.80	829	90.60	100	100	100
7	12/01/88	140.77	737	99.37	98	98	98
8	12/22/88	160.36	685	99.87	99	99	99
9	03/31/89	253.33	454	99.73	99	99	99
10	06/02/89	315.95	318	99.21	99	99	99
11	06/30/89	343.54	240	99.65	99	99	99
12	09/01/89	399.05	84	99.60	100	100	100
13	09/15/89	414.01	43	99.48	100	100	100
14	09/22/89	420.95	22	99.50	100	100	100

Table B.0-13. WSES-3 Cycle 4 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn) PLR	Group 5	Group 6
1	12/06/89	13.25	996	99.56	99	99	99
2	12/14/89	21.20	985	99.70	99	99	99
3	04/10/90	117.05	797	99.71	100	100	100
4	05/02/90	139.00	758	99.98	100	100	100
5	06/01/90	168.93	677	99.81	100	100	100
6	06/25/90	192.87	629	99.81	99	99	99
7	07/31/90	228.67	541	99.75	100	100	100
8	10/23/90	299.49	361	99.85	100	100	100
9	11/12/90	319.67	297	100.04	100	100	100
10	12/17/90	354.53	213	99.74	95	100	100
11	01/10/91	378.18	151	99.86	100	100	100
12	02/22/91	420.57	40	99.85	100	100	100
13	03/12/91	438.39	43	96.36	93	100	100

Table B.0-14. WSES-3 Cycle 5 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn) PLR	Group 5	Group 6
1	06/07/91	8.45	1030	99.84	100	100	100
2	06/21/91	22.19	995	99.74	100	100	100
3	07/09/91	38.31	999	99.75	100	100	100
4	08/02/91	60.49	945	99.90	100	100	100
5	09/10/91	99.06	873	99.77	100	100	100
6	10/09/91	128.91	800	99.83	100	100	100
7	11/11/91	160.86	736	99.94	100	100	100
8	02/07/92	245.25	507	99.86	100	100	100
9	03/18/92	277.47	425	99.84	99	99	99
10	04/16/92	303.71	365	99.69	100	100	100
11	06/02/92	349.21	258	99.82	99	99	99
12	07/30/92	405.87	103	99.80	100	100	100
13	08/05/92	411.72	87	99.89	100	100	100

Table B.0-15. WSES-3 Cycle 6 Statepoints

Map #	Date	Exposure (EFPD)	Boron (ppm)	Power (%)	CEA Position (% withdrawn)		
					PLR	Group 5	Group 6
1	11/20/92	8.77	1089	99.53	100	100	100
2	12/10/92	28.68	1043	100.07	100	100	100
3	12/23/92	41.46	1021	100.15	100	100	100
4	01/15/93	64.34	986	99.44	100	100	100
5	02/12/93	92.16	946	99.86	100	100	100
6	03/17/93	122.94	893	99.78	100	100	100
7	04/16/93	152.00	829	99.66	100	100	100
8	05/18/93	184.98	746	99.76	99.5	99.5	99.5
9	06/11/93	209.22	685	100.26	99.5	99.5	99.5
10	07/20/93	246.83	595	100.03	99.0	99.0	99.0
11	08/12/93	269.10	540	99.76	100	100	100

APPENDIX C: ANO-2 REPRESENTATIVE BOX MEASUREMENT COMPARISONS

Figure C.0-1. ANO-2 Cycle 2 BOC Box Power Measurement Differences

```
                                001-00 002-00 003-00 004-00 005-00                Statistics for Integral Powers

                                                                                  ANO-2   CYCLE 02 FLUX MAP # 1   .728 GWD/MTU

                    006-00 007-01 008-00 009-02 010-00 011-03 012-00 013-04 014-00
                            1.080         1.104         1.112         1.106
                            -.034         -.013         -.004         -.009

             015-00 016-00 017-00 018-00 019-00 020-00 021-00 022-00 023-00 024-00 025-00


      026-00 027-05 028-00 029-06 030-00 031-07 032-00 033-08 034-00 035-09 036-00 037-10 038-00
              .000          .945          .979          .976          .959          .000
              .000         -.023          .007          .004         -.009          .000

      039-00 040-00 041-00 042-00 043-00 044-00 045-00 046-00 047-00 048-00 049-00 050-00 051-00


052-11 053-00 054-12 055-00 056-13 057-00 058-14 059-04 060-15 061-00 062-16 063-00 064-17 065-00 066-00
 .000          .987          .958          .897          .894          .957         1.002
 .000         -.015          .014          .024          .020          .013          .001

067-00 068-18 069-00 070-00 071-00 072-00 073-00 074-00 075-00 076-00 077-00 078-00 079-00 080-19 081-00
       1.122                                                                               1.083
        .010                                                                               -.024

082-00 083-00 084-20 085-00 086-21 087-00 088-22 089-00 090-23 091-00 092-24 093-00 094-25 095-00 096-00
               .990          .893          .798          .000          .895          .990
              -.015          .002          .022          .000          .004         -.015

097-00 098-26 099-00 100-00 101-00 102-00 103-00 104-00 105-00 106-00 107-00 108-00 109-00 110-27 111-00
       1.118                                                                               1.089
        .006                                                                               -.022

112-00 113-00 114-28 115-00 116-29 117-00 118-30 119-00 ...-31 121-00 122-32 123-00 124-33 125-00 126-34
               .998          .933          .882          .873          .934          .986          .000
              -.003         -.011          .008          .000         -.010         -.016          .000

      127-00 128-00 129-00 130-00 131-00 132-00 133-00 134-00 135-00 136-00 137-00 138-00 139-00


      140-00 141-35 142-00 143-36 144-00 145-37 146-00 147-38 148-00 149-39 150-00 151-40 152-00      ======== PICTURE FORMAT ========
              .000          .969         1.000          .000          .963          .000              ASSEMBLY # - INSTRUMENT STRING #
              .000          .001          .028          .000         -.005          .000              MEASURED POWERS
                                                                                                      M-P
             153-00 154-00 155-00 156-00 157-00 158-00 159-00 160-00 161-00 162-00 163-00
                                                                                                      PEAKS  MEASURED  CALCULATED
                                                                                                      Fr       1.15       1.12
                    164-00 165-41 166-00 167-42 168-00 169-43 170-00 171-44 172-00
                           1.132         1.146         1.127         1.120                            NORMAL DISTRIBUTION = YES
                            .017          .029          .010          .005                            STANDARD DEVIATION  =   .01556
                                                                                                      BIAS                =   .00000
                                173-00 174-00 175-00 176-00 177-00
```

Figure C.0-2. ANO-2 Cycle 2 MOC Box Power Measurement Differences

					001-00	002-00	003-00	004-00	005-00					
			006-00	007-01 1.053 -.032	008-00	009-02 1.064 -.010	010-00	011-03 1.067 -.007	012-00	013-04 1.067 -.018	014-00			
		015-00	016-00	017-00	018-00	019-00	020-00	021-00	022-00	023-00	024-00	025-00		
	026-00	027-05 .000 .000	028-00	029-06 .970 -.006	030-00	031-07 .990 .008	032-00	033-08 .982 .000	034-00	035-09 .973 -.003	036-00	037-10 .000 .000	038-00	
	039-00	040-00	041-00	042-00	043-00	044-00	045-00	046-00	047-00	048-00	049-00	050-00	051-00	
052-11 .000 .000	053-00	054-12 .989 -.002	055-00	056-13 .983 .018	057-00	058-14 .945 .019	059-04	060-15 .934 .008	061-00	062-16 [illegible] [illegible]	063-00	064-17 .996 .005	065-00	066-00
067-00	068-18 1.073 .006	069-00	070-00	071-00	072-00	073-00	074-00	075-00	076-00	077-00	078-00	079-00	080-19 1.045 -.022	081-00
082-00	083-00	084-20 .994 -.003	085-00	086-21 .937 .004	087-00	088-22 .871 .016	089-00	090-23 .000 .000	091-00	092-24 .930 -.003	093-00	094-25 .990 -.007	095-00	096-00
097-00	098-26 1.074 .006	099-00	100-00	101-00	102-00	103-00	104-00	105-00	106-00	107-00	108-00	109-00	110-27 1.046 -.022	111-00
112-00	113-00	114-28 1.001 .009	115-00	116-29 .959 -.005	117-00	118-30 .930 .003	119-00	120-31 .920 -.006	121-00	122-32 .954 -.011	123-00	124-33 .987 -.004	125-00	126-34 .000 .000
	127-00	128-00	129-00	130-00	131-00	132-00	133-00	134-00	135-00	136-00	137-00	138-00	139-00	
	140-00	141-35 .000 .000	142-00	143-36 .986 .009	144-00	145-37 1.008 .026	146-00	147-38 .000 .000	148-00	149-39 .980 .004	150-00	151-40 .000 .000	152-00	
		153-00	154-00	155-00	156-00	157-00	158-00	159-00	160-00	161-00	162-00	163-00		
			164-00	165-41 1.088 .003	166-00	167-42 1.086 .012	168-00	169-43 1.076 .002	170-00	171-44 1.076 -.009	172-00			
					173-00	174-00	175-00	176-00	177-00					

Statistics for Integral Powers
ANO-2 CYCLE 02 FLUX MAP # 8 5.446 GWD/MTU

======== PICTURE FORMAT ========
ASSEMBLY # - INSTRUMENT STRING #
MEASURED POWERS
M-P

PEAKS MEASURED CALCULATED
Fr 1.09 1.09

NORMAL DISTRIBUTION = YES
STANDARD DEVIATION = .01221
BIAS = .00000

Figure C.0-3. ANO-2 Cycle 2 EOC Box Power Measurement Differences

```
Statistics for Integral Powers
ANO-2   CYCLE 02 FLUX MAP #15 11.133 GWD/MTU

                                   001-00 002-00 003-00 004-00 005-00

                     006-00 007-01 008-00 009-02 010-00 011-03 012-00 013-04 014-00
                             1.074         1.058          .000         1.081
                             -.018         -.001          .000         -.011

              015-00 016-00 017-00 018-00 019-00 020-00 021-00 022-00 023-00 024-00 025-00


       026-00 027-05 028-00 029-06 030-00 031-07 032-00 033-08 034-00 035-09 036-00 037-10 038-00
               .000          .986          .983          .973          .988          .000
               .000          .004          .010          .001          .006          .000

       039-00 040-00 041-00 042-00 043-00 044-00 045-00 046-00 047-00 048-00 049-00 050-00 051-00


052-11 053-00 054-12 055-00 056-13 057-00 058-14 059-04 060-15 061-00 062-16 063-00 064-17 065-00 066-00
 .000          .988          .977          .000          .940          .000         1.000
 .000         -.001          .016          .000          .004          .000          .011

067-00 068-18 069-00 070-00 071-00 072-00 073-00 074-00 075-00 076-00 077-00 078-00 079-00 080-19 081-00
        1.064                                                                               1.037
         .012                                                                               -.015

082-00 083-00 084-20 085-00 086-21 087-00 088-22 089-00 090-23 091-00 092-24 093-00 094-25 095-00 096-00
               .000          .936          .903          .000          .932          .985
               .000          .000          .014          .000         -.005         -.002

097-00 098-26 099-00 100-00 101-00 102-00 103-30 104-00 105-00 106-00 107-00 108-00 109-00 110-27 111-00
        1.054                                                                               1.040
         .002                                                                               -.012

112-00 113-00 114-28 115-00 116-29 117-00 118-30 119-00 120-31 121-00 122-32 123-00 124-33 125-00 126-34
               .994          .948          .934          .926          .949          .990          .000
               .005         -.013         -.003         -.010         -.012          .001          .000

       127-00 128-00 129-00 130-00 131-00 132-00 133-00 134-00 135-00 136-00 137-00 138-00 139-00


       140-00 141-35 142-00 143-36 144-00 145-37 146-00 147-38 148-00 149-39 150-00 151-40 152-00
               .000          .984          .991          .000          .991          .000
               .000          .002          .018          .000          .008          .000

              153-00 154-00 155-00 156-00 157-00 158-00 159-00 160-00 161-00 162-00 163-00

                     164-00 165-41 166-00 167-42 168-00 169-43 170-00 171-44 172-00
                             1.080         1.069         1.060         1.083
                             -.012          .010          .001         -.009

                                   173-00 174-00 175-00 176-00 177-00

======== PICTURE FORMAT ========
ASSEMBLY # - INSTRUMENT STRING #
MEASURED POWERS
M-P

PEAKS  MEASURED  CALCULATED
Fr       1.08       1.09

NORMAL DISTRIBUTION = YES
STANDARD DEVIATION  =   .00974
BIAS                =   .00000
```

APPENDIX D: WSES-3 REPRESENTATIVE BOX MEASUREMENT COMPARISONS

Figure D.0-1. WSES-3 Cycle 3 BOC Box Power Measurement Differences

```
                              001-00 002-00 003-00 004-00                    Statistics for Integral Powers
                                                                             WSES-3  CYCLE 03 FLUX MAP # 2   1.445 GWD/MTU

                     005-01 006-00 007-02 008-00 009-03 010-00 011-04 012-00 013-05
                      .406          .000         1.078         1.181          .415
                      .007          .000          .024          .031          .015

              014-00 015-00 016-00 017-00 018-00 019-00 020-00 021-00 022-00 023-00 024-00

       025-06 026-00 027-07 028-00 029-08 030-00 031-09 032-00 033-10 034-00 035-11 036-00 037-12
        .419         1.226         1.263         1.271         1.271         1.230          .418
        .009          .021         -.010         -.004         -.002          .025          .009

038-00 039-00 040-00 041-00 042-00 043-00 044-00 045-00 046-00 047-00 048-00 049-00 050-00 051-00 052-00

053-00 054-13 055-00 056-14 057-00 058-15 059-00 060-16 061-00 062-17 063-00 064-18 065-00 066-19 067-00
       1.292         1.142          .940         1.159          .950         1.176         1.290
        .011         -.013         -.028         -.020         -.018          .021          .008

       068-00 069-00 070-00 071-00 072-00 073-00 074-00 075-00 076-00 077-00 078-00 079-00 080-00 081-00 082-00
083-20                                                                                                        084-2?
 .434                                                                                                          .431
 .016                                                                                                          .013
       085-00 086-22 087-00 088-23 089-00 090-24 091-00 092-25 093-00 094-26 095-00 096-27 097-00 098-28 099-00
100-00        1.249         1.083         1.119         1.071         1.150         1.117         1.241         101-00
               .017         -.029         -.049         -.038         -.019          .005          .009

       102-00 103-00 104-00 105-00 106-00 107-00 108-00 109-00 110-00 111-00 112-00 113-00 114-00 115-00 116-00
117-00                                                                                                        118-00

       119-00 120-29 121-00 122-30 123-00 124-31 125-00 126-32 127-00 128-33 129-00 130-34 131-00 132-35 133-00
134-36        1.246         1.085          .000         1.068         1.131         1.129          .000         135-37
 .000          .014         -.027          .000         -.041         -.038          .017          .000          .425
 .000                                                                                                          .007
       136-00 137-00 138-00 139-00 140-00 141-00 142-00 143-00 144-00 145-00 146-00 147-00 148-00 149-00 150-00

       151-00 152-38 153-00 154-39 155-00 156-40 157-00 158-41 159-00 160-42 161-00 162-43 163-00 164-44 165-00
              1.296         1.170          .939         1.166          .948         1.149         1.278
               .014          .014         -.029         -.013         -.020         -.006         -.003

       166-00 167-00 168-00 169-00 170-00 171-00 172-00 173-00 174-00 175-00 176-00 177-00 178-00 179-00 180-00

       181-45 182-00 183-46 184-00 185-47 186-00 187-48 188-00 189-49 190-00 191-50 192-00 193-51        ======== PICTURE FORMAT ========
        .417         1.222         1.277         1.282         1.283         1.222          .420         ASSEMBLY # - INSTRUMENT STRING #
        .008          .017          .005          .007          .011          .016          .010         MEASURED POWERS
                                                                                                         M-P
              194-00 195-00 196-00 197-00 198-00 199-00 200-00 201-00 202-00 203-00 204-00
                                                                                                         PEAKS  MEASURED  CALCULATED
                     205-52 206-00 207-53 208-00 209-54 210-00 211-55 212-00 213-56                       Fr       1.30       1.28
                      .407          .000          .000          .000          .417
                      .008          .000          .000          .000          .017                       NORMAL DISTRIBUTION =  NO
                                                                                                         STANDARD DEVIATION  =   .01981
                              214-00 215-00 216-00 217-00                                                BIAS                =   .00000
```

Figure D.0-2. WSES-3 Cycle 3 MOC Box Power Measurement Differences

```
                                      001-00 002-00 003-00 004-00                         00Statistics for Integral Power
                                                                                          WSES-3  CYCLE 03 FLUX MAP # 4  3.160 GWD/MTU
                        005-01 006-00 007-02 008-00 009-03 010-00 011-04 012-00 013-05
                         .414          .000          1.083          1.180          .423
                         .002          .000           .014           .018          .012

                 014-00 015-00 016-00 017-00 018-00 019-00 020-00 021-00 022-00 023-00 024-00

          025-06 026-00 027-07 028-00 029-08 030-00 031-09 032-00 033-10 034-00 035-11 036-00 037-12
           .428          1.224          1.248          1.259          1.257          1.231          .427
           .005           .011          -.011          -.003          -.002           .018          .004

   038-00 039-00 040-00 041-00 042-00 043-00 044-00 045-00 046-00 047-00 048-00 049-00 050-00 051-00 052-00

   053-00 054-13 055-00 056-14 057-00 058-15 059-00 060-16 061-00 062-17 063-00 064-18 065-00 066-19 067-00
          1.303          1.145           .954          1.180           .961          1.174          1.298
           .003          -.011          -.019          -.011          -.012           .018          -.002

   068-00 069-00 070-00 071-00 072-00 073-00 074-00 075-00 076-00 077-00 078-00 079-00 080-00 081-00 082-00
083-20                                                                                                        084-21
 .444                                                                                                          .439
 .013                                                                                                          .008
   085-00 086-22 087-00 088-23 089-00 090-24 091-00 092-25 093-00 094-26 095-00 096-27 097-00 098-28 099-00
100-00    1.239          1.094          1.131           .000          1.158          1.120           .228         101-00
           .016          -.021          -.037           .000          -.010           .006           .005

   102-00 103-00 104-00 105-00 106-00 107-00 108-00 109-00 110-00 111-00 112-00 113-00 114-00 115-00 116-00
117-00                                                                                                        118-00

   119-00 120-29 121-00 122-30 123-00 124-31 125-00 126-32 127-00 128-33 129-00 130-34 131-00 132-35 133-00
134-36    1.236           .000           .000          1.073          1.138          1.134           .000         135-37
 .000      .013           .000           .000          -.031          -.030           .019           .000          .433
 .000                                                                                                          .001
   136-00 137-00 138-00 139-00 140-00 141-00 142-00 143-00 144-00 145-00 146-00 147-00 148-00 149-00 150-00

   151-00 152-38 153-00 154-39 155-00 156-40 157-00 158-41 159-00 160-42 161-00 162-43 163-00 164-44 165-00
          1.308          1.172           .952          1.187           .958          1.148          1.284
           .007           .016          -.021          -.004          -.014          -.009          -.016

   166-00 167-00 168-00 169-00 170-00 171-00 172-00 173-00 174-00 175-00 176-00 177-00 178-00 179-00 180-00

          181-45 182-00 183-46 184-00 185-47 186-00 187-48 188-00 189-49 190-00 191-50 192-00 193-51
           .427          1.223          1.262          1.270          1.267          1.218           .428
           .004           .010           .003           .007           .007           .005           .005

                 194-00 195-00 196-00 197-00 198-00 199-00 200-00 201-00 202-00 203-00 204-00

                        205-52 206-00 207-53 208-00 209-54 210-00 211-55 212-00 213-56
                         .415          .000           .000           .000          .423
                         .004          .000           .000           .000          .011

                                      214-00 215-00 216-00 217-00

======== PICTURE FORMAT ========
ASSEMBLY # - INSTRUMENT STRING #
MEASURED POWER
M-P

PEAKS  MEASURED  CALCULATED
 Fr      1.31       1.3C

NORMAL DISTRIBUTION =  NO
STANDARD DEVIATION  =   .01383
BIAS                =   .00000
```

Figure D.0-3. WSES-3 Cycle 3 EOC Box Power Measurement Differences

```
                                                001-00  002-00  003-00  004-00                          Statistics for Integral Power
                                                                                                        WSES-3  CYCLE 03 FLUX MAP #14 15.954 GWD/MTU

                                005-01  006-00  007-02  008-00  009-03  010-00  011-04  012-00  013-05
                                  .467            .000           1.118           1.177            .479
                                 -.017            .000            .014           -.010           -.005

                        014-00  015-00  016-00  017-00  018-00  019-00  020-00  021-00  022-00  023-00  024-00

                025-06  026-00  027-07  028-00  029-08  030-00  031-09  032-00  033-10  034-00  035-11  036-00  037-12
                  .491           1.191           1.147           1.176           1.149           1.193            .487
                 -.016            .003           -.003            .003           -.001            .005           -.021

        038-00  039-00  040-00  041-00  042-00  043-00  044-00  045-00  046-00  047-00  048-00  049-00  050-00  051-00  052-00

        053-00  054-13  055-00  056-14  057-00  058-15  059-00  060-16  061-00  062-17  063-00  064-18  065-00  066-19  067-00
                 1.333           1.129           1.022           1.226           1.018           1.128           1.317
                  .001            .015            .022            .014            .018            .014           -.015

        068-00  069-00  070-00  071-00  072-00  073-00  074-00  075-00  076-00  077-00  078-00  079-00  080-00  081-00  082-00
083-20                                                                                                                          084-21
  .507                                                                                                                            .500
 -.011                                                                                                                           -.018
        085-00  086-22  087-00  088-23  089-00  090-24  091-00  092-25  093-00  094-26  095-00  096-27  097-00  098-28  099-00
100-00           1.157           1.130           1.132            .000           1.163           1.131           1.139          101-00
                  .011            .012           -.007            .000            .023            .013           -.008

        102-00  103-00  104-00  105-00  106-00  107-00  108-00  109-00  110-00  111-00  112-00  113-00  114-00  115-00  116-00
117-00                                                                                                                          118-00

        119-00  120-29  121-00  122-30  123-00  124-31  125-00  126-32  127-00  128-33  129-00  130-34  131-00  132-35  133-00
134-36           1.152            .000            .000           1.040           1.123           1.162            .000          135-37
  .000            .005            .000            .000           -.014           -.017            .043            .000            .493
  .000                                                                                                                           -.024
        136-00  137-00  138-00  139-00  140-00  141-00  142-00  143-00  144-00  145-00  146-00  147-00  148-00  149-00  150-00

        151-00  152-38  153-00  154-39  155-00  156-40  157-00  158-41  159-00  160-42  161-00  162-43  163-00  164-44  165-00
                 1.337           1.135            .998           1.225           1.001           1.126           1.310
                  .005            .021           -.002            .014            .001            .012           -.022

        166-00  167-00  168-00  169-00  170-00  171-00  172-00  173-00  174-00  175-00  176-00  177-00  178-00  179-00  180-00

                181-45  182-00  183-46  184-00  185-47  186-00  187-48  188-00  189-49  190-00  191-50  192-00  193-51
                  .491           1.194           1.153            .000           1.167           1.181            .489
                 -.016            .006            .003            .000            .017           -.008           -.018

                        194-00  195-00  196-00  197-00  198-00  199-00  200-00  201-00  202-00  203-00  204-00

                                205-52  206-00  207-53  208-00  209-54  210-00  211-55  212-00  213-56
                                  .472            .000            .000           1.170            .473
                                 -.012            .000            .000           -.016           -.011

                                                214-00  215-00  216-00  217-00
```

```
======== PICTURE FORMAT ========
ASSEMBLY # - INSTRUMENT STRING #
MEASURED POWER
M-P

PEAKS  MEASURED  CALCULATED
 Fr      1.34       1.33

NORMAL DISTRIBUTION = YES
STANDARD DEVIATION  =   .01502
BIAS                =   .00000
```

APPENDIX E: ANO-2 REPRESENTATIVE POWER SYNTHESIS COMPARISONS

Figure E.0-1. ANO-2 BOC-2 Fr Power Synthesis Differences

0.7282
GWD/MTU

	8	9	10	11	12	13	14	15
H	89-00 0.710 0.710 0.000	90-23 0.882 0.883 0.001	91-00 1.224 1.226 0.001	92-24 0.966 0.967 0.001	93-00 1.372 1.374 0.001	94-25 1.070 1.069 -0.001	95-00 1.234 1.243 0.008	96-00 1.309 1.307 -0.002
K	104-00 0.882 0.883 0.001	105-00 1.108 1.108 0.000	106-00 0.942 0.942 0.000	107-00 1.028 1.031 0.003	108-00 1.055 1.057 0.002	109-00 1.267 1.266 0.000	110-27 1.205 1.205 0.000	111-00 1.311 1.310 -0.001
L	119-00 1.224 1.225 0.001	120-31 0.942 0.941 -0.001	121-00 1.294 1.297 0.002	122-32 1.023 1.024 0.001	123-00 1.393 1.396 0.002	124-33 1.076 1.075 -0.001	125-00 1.233 1.236 0.002	126-34 1.155 1.154 -0.001
M	133-00 0.967 0.967 0.000	134-00 1.024 1.027 0.003	135-00 1.021 1.021 0.000	136-00 1.202 1.199 -0.002	137-00 1.062 1.062 0.000	138-00 1.283 1.285 0.002	139-00 1.319 1.320 0.001	
N	146-00 1.372 1.374 0.001	147-38 1.052 1.052 0.000	148-00 1.390 1.393 0.002	149-39 1.054 1.054 0.000	150-00 1.211 1.212 0.001	151-40 1.125 1.128 0.003	152-00 1.157 1.160 0.003	
O	158-00 1.070 1.069 -0.001	159-00 1.268 1.267 -0.001	160-00 1.077 1.076 -0.001	161-00 1.281 1.283 0.001	162-00 1.124 1.127 0.003	163-00 1.128 1.127 -0.001		
P	168-00 1.234 1.243 0.008	169-43 1.211 1.209 -0.002	170-00 1.232 1.235 0.002	171-44 1.318 1.319 0.001	172-00 1.155 1.159 0.004			
Q	175-00 1.309 1.307 -0.002	176-00 1.310 1.309 -0.001	177-00 1.155 1.153 -0.002					

172-00	FC Assy # - Detector #
1.155	CECOR Fr
1.159	SIMULATE Fr
0.004	Difference (SIMULATE-CECOR)/CECOR

Figure E.0-2. ANO-2 BOC-2 Fq Power Synthesis Differences

0.7282
GWD/MTU

	8	9	10	11	12	13	14	15
H	89-00 0.826 0.817 -0.011	90-23 1.018 1.008 -0.010	91-00 1.408 1.408 0.000	92-24 1.101 1.101 0.000	93-00 1.587 1.590 0.002	94-25 1.211 1.213 0.002	95-00 1.414 1.416 0.001	96-00 1.537 1.536 -0.001
K	104-00 1.018 1.008 -0.010	105-00 1.265 1.264 -0.001	106-00 1.069 1.073 0.004	107-00 1.188 1.186 -0.002	108-00 1.201 1.203 0.001	109-00 1.449 1.454 0.003	110-27 1.370 1.379 0.006	111-00 1.537 1.539 0.001
L	119-00 1.408 1.408 0.000	120-31 1.068 1.072 0.003	121-00 1.491 1.492 0.001	122-32 1.162 1.162 0.000	123-00 1.609 1.617 0.005	124-33 1.220 1.223 0.002	125-00 1.433 1.431 -0.002	126-34 1.349 1.354 0.004
M	133-00 1.101 1.101 0.000	134-00 1.183 1.181 -0.002	135-00 1.158 1.158 0.000	136-00 1.362 1.362 0.000	137-00 1.202 1.204 0.002	138-00 1.484 1.481 -0.002	139-00 1.543 1.547 0.002	
N	146-00 1.587 1.590 0.002	147-38 1.198 1.198 0.000	148-00 1.605 1.613 0.005	149-39 1.192 1.194 0.002	150-00 1.379 1.388 0.006	151-40 1.284 1.285 0.001	152-00 1.355 1.362 0.005	
O	158-00 1.211 1.213 0.001	159-00 1.451 1.455 0.003	160-00 1.220 1.223 0.002	161-00 1.481 1.479 -0.002	162-00 1.282 1.284 0.002	163-00 1.303 1.310 0.005		
P	168-00 1.415 1.416 0.001	169-43 1.376 1.384 0.006	170-00 1.431 1.429 -0.001	171-44 1.541 1.545 0.002	172-00 1.352 1.361 0.006			
Q	175-00 1.537 1.536 -0.001	176-00 1.536 1.538 0.001	177-00 1.349 1.353 0.003					

172-00	FC Assy # - Detector #
1.352	CECOR Fq
1.361	SIMULATE Fq
0.006	Difference (SIMULATE-CECOR)/CECOR

Figure E.0-3. ANO-2 MOC-2 Fr Power Synthesis Differences

5.4459
GWD/MTU

	8	9	10	11	12	13	14	15
H	89-00 0.809 0.810 0.002	90-23 0.944 0.943 -0.001	91-00 1.267 1.265 -0.002	92-24 0.992 0.991 -0.001	93-00 1.341 1.338 -0.003	94-25 1.057 1.058 0.001	95-00 1.225 1.230 0.004	96-00 1.232 1.233 0.001
K	104-00 0.944 0.943 -0.001	105-00 1.162 1.162 0.000	106-00 0.984 0.983 -0.001	107-00 1.068 1.069 0.001	108-00 1.049 1.049 0.000	109-00 1.275 1.281 0.005	110-27 1.187 1.191 0.003	111-00 1.241 1.243 0.001
L	119-00 1.267 1.265 -0.002	120-31 0.984 0.982 -0.002	121-00 1.302 1.300 -0.002	122-32 1.028 1.027 -0.001	123-00 1.346 1.344 -0.001	124-33 1.059 1.059 0.000	125-00 1.198 1.193 -0.004	126-34 1.118 1.121 0.002
M	133-00 0.992 0.991 -0.001	134-00 1.064 1.066 0.002	135-00 1.026 1.025 -0.001	136-00 1.204 1.204 0.000	137-00 1.053 1.053 0.000	138-00 1.251 1.252 0.001	139-00 1.271 1.273 0.002	
N	146-00 1.341 1.338 -0.002	147-33 1.047 1.046 -0.001	148-00 1.345 1.342 -0.002	149-39 1.049 1.049 0.000	150-00 1.215 1.214 -0.001	151-40 1.116 1.117 0.001	152-00 1.147 1.152 0.004	
O	158-00 1.057 1.058 0.001	159-00 1.277 1.283 0.005	160-00 1.059 1.059 0.000	161-00 1.250 1.251 0.001	162-00 1.115 1.117 0.002	163-00 1.139 1.142 0.002		
P	168-00 1.225 1.230 0.004	169-43 1.195 1.198 0.002	170-00 1.197 1.192 -0.004	171-44 1.270 1.273 0.002	172-00 1.145 1.151 0.005			
Q	175-00 1.232 1.233 0.001	176-00 1.241 1.243 0.002	177-00 1.119 1.121 0.002					

172-00	FC Assy # - Detector #
1.352	CECOR Fr
1.361	SIMULATE Fr
0.006	Difference (SIMULATE-CECOR)/CECOR

Figure E.0-4. ANO-2 MOC-2 Fq Power Synthesis Differences

5.4459
GWD/MTU

	8	9	10	11	12	13	14	15
H	89-00 0.917 0.900 -0.019	90-23 1.056 1.036 -0.019	91-00 1.468 1.416 -0.035	92-24 1.116 1.088 -0.025	93-00 1.563 1.506 -0.036	94-25 1.205 1.166 -0.032	95-00 1.430 1.373 -0.040	96-00 1.465 1.402 -0.043
K	104-00 1.057 1.036 -0.020	105-00 1.303 1.283 -0.015	106-00 1.110 1.078 -0.029	107-00 1.203 1.181 -0.019	108-00 1.190 1.158 -0.027	109-00 1.461 1.427 -0.024	110-27 1.377 1.329 -0.035	111-00 1.476 1.414 -0.042
L	119-00 1.468 1.416 -0.035	120-31 1.110 1.077 -0.029	121-00 1.512 1.457 -0.036	122-32 1.160 1.128 -0.028	123-00 1.571 1.515 -0.035	124-33 1.210 1.170 -0.033	125-00 1.407 1.336 -0.050	126-34 1.327 1.275 -0.039
M	133-00 1.116 1.088 -0.025	134-00 1.199 1.177 -0.019	135-00 1.159 1.126 -0.028	136-00 1.365 1.332 -0.024	137-00 1.193 1.162 -0.026	138-00 1.464 1.400 -0.044	139-00 1.508 1.447 -0.040	
N	146-00 1.562 1.506 -0.036	147-38 1.187 1.154 -0.028	148-00 1.568 1.513 -0.035	149-39 1.188 1.156 -0.027	150-00 1.402 1.364 -0.027	151-40 1.309 1.239 -0.053	152-00 1.361 1.313 -0.035	
O	158-00 1.204 1.166 -0.032	159-00 1.463 1.429 -0.023	160-00 1.210 1.170 -0.033	161-00 1.463 1.398 -0.044	162-00 1.308 1.239 -0.053	163-00 1.347 1.295 -0.039		
P	168-00 1.430 1.373 -0.040	169-43 1.385 1.336 -0.035	170-00 1.405 1.335 -0.050	171-44 1.507 1.446 -0.040	172-00 1.358 1.313 -0.033			
Q	175-00 1.464 1.402 -0.043	176-00 1.474 1.413 -0.041	177-00 1.327 1.274 -0.040					

172-00	FC Assy # - Detector #
1.352	CECOR Fq
1.361	SIMULATE Fq
0.006	Difference (SIMULATE-CECOR)/CECOR

Figure E.0-5. ANO-2 EOC-2 Fr Power Synthesis Differences

11.1326 GWD/MTU

	8	9	10	11	12	13	14	15
H	89-00 0.876 0.868 -0.009	90-23 0.959 0.962 0.003	91-00 1.240 1.248 0.006	92-24 0.983 0.986 0.003	93-00 1.288 1.297 0.007	94-25 1.040 1.036 -0.003	95-00 1.225 1.226 0.001	96-00 1.194 1.202 0.007
K	104-00 0.965 0.962 -0.003	105-00 1.149 1.148 -0.001	106-00 0.990 0.986 -0.004	107-00 1.059 1.054 -0.005	108-00 1.031 1.032 0.001	109-00 1.252 1.239 -0.011	110-27 1.184 1.175 -0.008	111-00 1.210 1.214 0.003
L	119-00 1.242 1.248 0.005	120-31 0.986 0.986 0.000	121-00 1.264 1.273 0.007	122-32 1.011 1.014 0.003	123-00 1.296 1.306 0.008	124-33 1.048 1.045 -0.003	125-00 1.229 1.229 0.000	126-34 1.120 1.120 0.000
M	133-00 0.989 0.986 -0.003	134-00 1.058 1.051 -0.007	135-00 1.014 1.013 -0.001	136-00 1.181 1.169 -0.010	137-00 1.046 1.045 0.000	138-00 1.264 1.266 0.001	139-00 1.257 1.267 0.008	
N	146-00 1.289 1.297 0.006	147-38 1.027 1.030 0.003	148-00 1.295 1.305 0.008	149-39 1.041 1.042 0.001	150-00 1.215 1.219 0.004	151-40 1.160 1.161 0.001	152-00 1.168 1.177 0.008	
O	158-00 1.042 1.036 -0.006	159-00 1.255 1.240 -0.012	160-00 1.050 1.045 -0.004	161-00 1.265 1.266 0.000	162-00 1.153 1.160 0.006	163-00 1.167 1.169 0.001		
P	168-00 1.225 1.226 0.001	169-43 1.191 1.182 -0.008	170-00 1.230 1.229 -0.001	171-44 1.267 1.266 -0.001	172-00 1.168 1.177 0.008			
Q	175-00 1.193 1.202 0.007	176-00 1.207 1.214 0.006	177-00 1.116 1.120 0.003					

Legend	
172-00	FC Assy # - Detector #
1.352	CECOR Fr
1.361	SIMULATE Fr
0.006	Difference (SIMULATE-CECOR)/CECOR

Figure E.0-6. ANO-2 EOC-2 Fq Power Synthesis Differences

11.1326 GWD/MTU

	8	9	10	11	12	13	14	15
H	89-00 1.072 1.036 -0.033	90-23 1.141 1.140 -0.001	91-00 1.446 1.442 -0.003	92-24 1.184 1.172 -0.010	93-00 1.508 1.510 0.001	94-25 1.253 1.229 -0.019	95-00 1.490 1.439 -0.034	96-00 1.407 1.375 -0.023
K	104-00 1.149 1.140 -0.007	105-00 1.359 1.348 -0.008	106-00 1.189 1.167 -0.019	107-00 1.283 1.249 -0.026	108-00 1.242 1.222 -0.016	109-00 1.517 1.455 -0.041	110-27 1.426 1.380 -0.033	111-00 1.428 1.390 -0.027
L	119-00 1.447 1.442 -0.004	120-31 1.183 1.167 -0.014	121-00 1.486 1.482 -0.003	122-32 1.219 1.203 -0.013	123-00 1.515 1.512 -0.002	124-33 1.260 1.234 -0.020	125-00 1.458 1.417 -0.028	126-34 1.313 1.279 -0.026
M	133-00 1.192 1.172 -0.017	134-00 1.282 1.246 -0.028	135-00 1.222 1.202 -0.016	136-00 1.414 1.377 -0.026	137-00 1.248 1.232 -0.013	138-00 1.507 1.466 -0.027	139-00 1.474 1.448 -0.017	
N	146-00 1.509 1.510 0.001	147-38 1.236 1.219 -0.014	148-00 1.513 1.511 -0.001	149-39 1.244 1.229 -0.012	150-00 1.433 1.421 -0.008	151-40 1.378 1.353 -0.018	152-00 1.357 1.332 -0.019	
O	158-00 1.256 1.229 -0.022	159-00 1.518 1.456 -0.041	160-00 1.261 1.233 -0.022	161-00 1.509 1.465 -0.029	162-00 1.368 1.353 -0.011	163-00 1.366 1.332 -0.025		
P	168-00 1.489 1.439 -0.034	169-43 1.435 1.388 -0.033	170-00 1.459 1.416 -0.030	171-44 1.487 1.447 -0.027	172-00 1.357 1.332 -0.018			
Q	175-00 1.407 1.375 -0.022	176-00 1.426 1.389 -0.026	177-00 1.313 1.278 -0.027					

172-00	FC Assy # - Detector #
1.352	CECOR Fq
1.361	SIMULATE Fq
0.006	Difference (SIMULATE-CECOR)/CECOR

APPENDIX F: WSES-3 REPRESENTATIVE POWER SYNTHESIS COMPARISONS

Figure F.0-1. WSES-3 BOC-3 Fr Power Synthesis Differences

1.445 GWD/MTU

	9	10	11	12	13	14	15	16	17
9	109-00 0.818 0.819 0.001	110-00 1.120 1.119 -0.009	111-00 1.432 1.438 0.004	112-00 1.179 1.176 -0.003	113-00 1.376 1.378 0.001	114-00 1.266 1.263 -0.002	115-00 1.396 1.403 0.005	116-00 1.084 1.084 0.000	118-00 1.073 1.07 -0.003
10	126-32 1.120 1.119 -0.001	127-00 1.198 1.197 -0.001	128-33 1.161 1.158 -0.003	129-00 1.398 1.403 0.004	130-34 1.087 1.085 -0.002	131-00 1.355 1.352 -0.002	132-35 1.255 1.253 -0.002	133-00 1.295 1.298 0.002	135-37 0.64 0.639 -0.002
11	143-00 1.432 1.438 0.004	144-00 1.160 1.157 -0.003	145-00 1.131 1.129 -0.002	146-00 0.928 0.929 0.001	147-[illegible] 1.35 1.353 0.002	148-00 1.291 1.287 -0.003	149-00 1.318 1.314 -0.003	150-00 1.331 [illegible] [illegible]	
12	158-41 1.179 1.176 -0.003	159-00 1.398 1.403 0.004	160-42 0.934 0.934 0.000	161-00 1.195 1.193 -0.002	162-43 1.155 1.152 -0.003	163-00 1.181 1.179 -0.002	164-44 1.356 1.358 0.001	165-00 1.252 1.252 0.000	
13	173-00 1.377 1.378 0.001	174-00 1.087 1.086 -0.001	175-00 1.354 1.356 0.001	176-00 1.165 1.161 -0.003	177-00 1.343 1.346 0.002	178-00 1.163 1.163 0.000	179-00 1.207 1.211 0.003	180-00 0.651 0.652 0.002	
14	187-48 1.266 1.263 -0.002	188-00 1.357 1.354 -0.002	189-49 1.292 1.289 -0.002	190-00 1.184 1.182 -0.002	191-50 1.165 1.165 0.000	192-00 1.215 1.217 0.002	193-51 0.651 0.651 0.000		
15	199-00 1.396 1.403 0.005	200-00 1.256 1.254 -0.002	201-00 1.319 1.316 -0.002	202-00 1.357 1.361 0.003	203-00 1.208 1.213 0.004	204-00 0.653 0.651 -0.003			
16	209-54 1.084 1.084 0.000	210-00 1.295 1.299 0.003	211-55 1.331 1.332 0.001	212-00 1.251 1.253 0.002	213-56 0.653 0.651 -0.003				
17	216-00 1.073 1.070 -0.003	217-00 0.639 0.640 0.002							

213-56	FC Assy # - Detector #
0.735	CECOR Fr
0.732	SIMULATE Fr
-0.004	Difference (SIMULATE-CECOR)/CECOR

Figure F.0-2. WSES-3 BOC-3 Fq Power Synthesis Differences

1.445 GWD/MTU

	9	10	11	12	13	14	15	16	17
9	109-00 0.924 0.920 -0.004	110-00 1.264 1.269 0.004	111-00 1.624 1.630 0.004	112-00 1.325 1.33 0.004	113-00 1.555 1.557 0.001	114-00 1.433 1.436 0.002	115-00 1.595 1.602 0.004	116-00 1.239 1.242 0.002	118-00 1.243 1.246 0.002
10	126-32 1.263 1.269 0.005	127-00 1.352 1.357 0.004	128-33 1.306 1.310 0.003	129-00 1.579 1.584 0.003	130-34 1.211 1.214 0.002	131-00 1.539 1.541 0.001	132-35 1.426 1.428 0.001	133-00 1.490 1.495 0.003	135-37 0.732 0.732 0.000
11	143-00 1.623 1.630 0.004	144-00 1.305 1.309 0.003	145-00 1.270 1.274 0.003	146-00 1.030 1.034 0.004	147-00 1.529 1.533 0.003	148-00 1.462 1.464 0.001	149-00 1.502 1.505 0.002	150-00 1.533 1.537 0.003	
12	158-41 1.325 1.330 0.004	159-00 1.579 1.584 0.003	160-42 1.036 1.040 0.004	161-00 1.351 1.353 0.001	162-43 1.306 1.309 0.002	163-00 1.344 1.345 0.001	164-44 1.557 1.559 0.001	165-00 1.448 1.452 0.003	
13	173-00 1.555 1.557 0.001	174-00 1.211 1.215 0.003	175-00 1.533 1.537 0.003	176-00 1.317 1.32 0.002	177-00 1.533 1.537 0.003	178-00 1.326 1.33 0.003	179-00 1.389 1.393 0.003	180-00 0.744 0.746 0.003	
14	187-48 1.432 1.436 0.003	188-00 1.540 1.543 0.002	189-49 1.464 1.467 0.002	190-00 1.346 1.348 0.001	191-50 1.328 1.331 0.002	192-00 1.396 1.399 0.002	193-51 0.739 0.74 0.001		
15	199-00 1.594 1.602 0.005	200-00 1.426 1.430 0.003	201-00 1.502 1.507 0.003	202-00 1.556 1.562 0.004	203-00 1.391 1.395 0.003	204-00 0.741 0.741 0.000			
16	209-54 1.238 1.242 0.003	210-00 1.489 1.496 0.005	211-55 1.534 1.538 0.003	212-00 1.448 1.453 0.003	213-56 0.747 0.746 -0.001				
17	216-00 1.243 1.246 0.002	217-00 0.731 0.733 0.003							

213-56	FC Assy # - Detector #
0.735	CECOR Fq
0.732	SIMULATE Fq
-0.004	Difference (SIMULATE-CECOR)/CECOR

Figure F.0-3. WSES-3 MOC-3 Fr Power Synthesis Differences

6.078 GWD/MTU

	9	10	11	12	13	14	15	16	17
9	109-00 0.807 0.810 0.004	110-00 1.093 1.095 0.002	111-00 1.452 1.448 -0.003	112-00 1.186 1.185 -0.001	113-00 1.400 1.400 0.000	114-00 1.206 1.205 -0.001	115-00 1.394 1.395 0.001	116-00 1.088 1.088 0.000	118-00 1.091 1.089 -0.002
10	126-32 1.095 1.095 0.000	127-00 1.169 1.169 0.000	128-33 1.149 1.150 0.001	129-00 1.432 1.426 -0.004	130-34 1.067 1.064 -0.003	131-00 1.272 1.270 -0.002	132-35 1.190 1.189 -0.001	33-00 1.310 1.306 -0.003	135-37 0.670 0.668 -0.003
11	143-00 1.452 1.448 -0.003	144-00 1.148 1.149 0.001	145-00 1.108 1.109 0.001	146-00 0.930 0.927 -0.003	147-00 1.351 1.348 -0.002	148-00 1.218 1.216 -0.002	149-00 1.248 1.241 -0.006	150-00 1.303 1.295 -0.006	
12	158-41 1.185 1.185 0.000	159-00 1.431 1.425 -0.004	160-42 0.935 0.931 -0.004	161-00 1.169 1.168 -0.001	162-43 1.130 1.129 -0.001	163-00 1.142 1.140 -0.002	164-44 1.351 1.352 0.001	165-00 1.237 1.237 0.000	
13	173-00 1.399 1.400 0.001	174-00 1.066 1.065 -0.001	175-00 1.354 1.350 -0.003	176-00 1.138 1.137 -0.001	177-00 1.363 1.364 0.001	178-00 1.154 1.156 0.002	179-00 1.230 1.233 0.002	180-00 0.672 0.673 0.001	
14	187-48 1.205 1.205 0.000	188-00 1.273 1.271 -0.002	189-49 1.218 1.217 -0.001	190-00 1.144 1.142 -0.002	191-50 1.156 1.158 0.002	192-00 1.238 1.238 0.000	193-51 0.674 [illegible] -0.004		
15	199-00 1.394 1.395 0.001	200-00 1.191 1.189 -0.002	201-00 1.249 1.242 -0.006	202-00 1.354 1.354 0.000	203-00 1.231 1.234 0.002	204-00 0.674 0.671 -0.004			
16	209-54 1.087 1.088 0.001	210-00 1.308 1.306 -0.002	211-55 1.301 1.295 -0.005	212-00 1.236 1.237 0.001	213-56 0.674 0.672 -0.003				
17	216-00 1.090 1.089 -0.001	217-00 0.667 0.668 0.001							

213-56	FC Assy # - Detector #
0.735	CECOR Fr
0.732	SIMULATE Fr
-0.004	Difference (SIMULATE-CECOR)/CECOR

Figure F.0-4. WSES-3 MOC-3 Fq Power Synthesis Differences

6.078 GWD/MTU

	9	10	11	12	13	14	15	16	17
9	109-00 0.886 0.859 -0.030	110-00 1.184 1.171 -0.011	111-00 1.628 1.580 -0.029	112-00 1.291 1.273 -0.014	113-00 1.569 1.524 -0.029	114-00 1.322 1.295 -0.020	115-00 1.572 1.534 -0.024	116-00 1.202 1.183 -0.016	118-00 1.253 1.218 -0.028
10	126-32 1.185 1.171 -0.012	127-00 1.284 1.254 -0.023	128-33 1.249 1.231 -0.014	129-00 1.602 1.550 -0.032	130-34 1.162 1.130 -0.028	131-00 1.420 1.376 -0.031	132-35 1.308 1.280 -0.021	133-00 1.489 1.446 -0.029	135-37 0.739 0.727 -0.016
11	143-00 1.628 1.580 -0.029	144-00 1.248 1.230 -0.014	145-00 1.217 1.181 -0.030	146-00 0.998 0.979 -0.019	147-00 1.503 1.458 -0.030	148-00 1.338 1.304 -0.025	149-00 1.415 1.368 -0.033	150-00 1.500 1.440 -0.040	
12	158-41 1.290 1.273 -0.013	159-00 1.600 1.549 -0.032	160-42 1.002 0.984 -0.018	161-00 1.288 1.253 -0.027	162-43 1.231 1.210 -0.017	163-00 1.258 1.230 -0.022	164-44 1.535 1.493 -0.027	165-00 1.430 1.385 -0.031	
13	173-00 1.569 1.524 -0.029	174-00 1.160 1.131 -0.025	175-00 1.505 1.460 -0.030	176-00 1.238 1.217 -0.017	177-00 1.531 1.495 -0.024	178-00 1.281 1.255 -0.020	179-00 1.403 1.365 -0.027	180-00 0.743 0.732 -0.015	
14	187-48 1.323 1.295 -0.021	188-00 1.422 1.377 -0.032	189-49 1.339 1.305 -0.025	190-00 1.260 1.232 -0.022	191-50 1.282 1.256 -0.020	192-00 1.407 1.366 -0.029	193-51 0.737 0.723 -0.019		
15	199-00 1.573 1.534 -0.025	200-00 1.310 1.281 -0.022	201-00 1.417 1.368 -0.035	202-00 1.538 1.494 -0.029	203-00 1.405 1.366 -0.028	204-00 0.739 0.723 -0.022			
16	209-54 1.202 1.183 -0.016	210-00 1.488 1.447 -0.028	211-55 1.499 1.441 -0.039	212-00 1.429 1.386 -0.030	213-56 0.745 0.731 -0.019				
17	216-00 1.253 1.218 -0.028	217-00 0.736 0.727 -0.012							

213-56	FC Assy # - Detector #
0.735	CECOR Fq
0.732	SIMULATE Fq
-0.004	Difference (SIMULATE-CECOR)/CECOR

Figure F.0-5. WSES-3 EOC-3 Fr Power Synthesis Differences

15.954 GWD/MTU

	9	10	11	12	13	14	15	16	17
9	109-00 0.801 0.803 0.002	110-00 1.034 1.034 0.000	111-00 1.461 1.462 0.001	112-00 1.156 1.154 -0.002	113-00 1.415 1.417 0.001	114-00 1.112 1.112 0.000	115-00 1.378 1.379 0.001	116-00 1.082 1.081 -0.001	118-00 1.106 1.104 -0.002
10	126-32 1.035 1.034 -0.001	127-00 1.100 1.100 0.000	128-33 1.108 1.108 0.000	129-00 1.469 1.470 0.001	130-34 1.037 1.038 0.001	131-00 1.157 1.157 0.000	132-35 1.102 1.101 -0.001	133-00 1.333 1.334 0.001	135-37 0.744 0.742 -0.003
11	143-00 1.461 1.462 0.001	144-00 1.108 1.107 -0.001	145-00 1.077 1.077 0.000	146-00 0.948 0.951 0.003	147-00 1.349 1.350 0.001	148-00 1.101 1.098 -0.003	149-00 1.165 1.165 0.000	150-00 1.285 1.285 0.000	
12	158-41 1.156 1.154 -0.002	159-00 1.469 1.470 0.001	160-42 0.949 0.951 0.002	161-00 1.116 1.114 -0.002	162-43 1.070 1.070 0.000	163-00 1.075 1.075 0.000	164-44 1.341 1.341 0.000	165-00 1.214 1.212 -0.002	
13	173-00 1.415 1.417 0.001	174-00 1.037 1.039 0.002	175-00 1.350 1.351 0.001	176-00 1.076 1.075 -0.001	177-00 1.353 1.352 -0.001	178-00 1.120 1.119 -0.001	179-00 1.269 1.271 0.002	180-00 0.734 0.733 -0.001	
14	187-48 1.112 1.112 0.000	188-00 1.157 1.157 0.000	189-49 1.100 1.098 -0.002	190-00 1.075 1.075 0.000	191-50 1.121 1.119 -0.002	192-00 1.262 1.260 -0.002	193-51 0.736 0.733 -0.004		
15	199-00 1.377 1.379 0.001	200-00 1.102 1.101 -0.001	201-00 1.164 1.165 0.001	202-00 1.340 1.341 0.001	203-00 1.269 1.271 0.002	204-00 0.737 0.733 -0.005			
16	209-54 1.082 1.081 -0.001	210-00 1.331 1.334 0.002	211-55 1.284 1.285 0.001	212-00 1.212 1.212 0.000	213-56 0.735 0.732 -0.004				
17	216-00 1.106 1.104 -0.002	217-00 0.743 0.742 -0.001							

213-56	FC Assy # - Detector #
0.735	CECOR Fr
0.732	SIMULATE Fr
-0.004	Difference (SIMULATE-CECOR)/CECOR

Figure F.0-6. WSES-3 EOC-3 Fq Power Synthesis Differences

15.954 GWD/MTU

	9	10	11	12	13	14	15	16	17
9	109-00 0.885 0.862 -0.026	110-00 1.139 1.098 -0.036	111-00 1.662 1.609 -0.032	112-00 1.278 1.237 -0.032	113-00 1.612 1.556 -0.035	114-00 1.220 1.181 -0.032	115-00 1.569 1.511 -0.037	116-00 1.202 1.160 -0.035	118-00 1.280 1.216 -0.050
10	126-32 1.14 1.098 -0.037	127-00 1.229 1.177 -0.042	128-33 1.227 1.183 -0.036	129-00 1.675 1.619 -0.033	130-34 1.131 1.112 -0.017	131-00 1.288 1.243 -0.035	132-35 1.206 1.173 -0.027	133-00 1.514 1.464 -0.033	135-37 0.816 0.800 -0.020
11	143-00 1.664 1.609 -0.033	144-00 1.228 1.182 -0.037	145-00 1.208 1.154 -0.045	146-00 1.047 1.016 -0.030	147-00 1.523 1.476 -0.031	148-00 1.206 1.170 -0.030	149-00 1.316 1.272 -0.033	150-00 1.464 1.415 -0.033	
12	158-41 1.278 1.237 -0.032	159-00 1.675 1.619 -0.033	160-42 1.046 1.016 -0.029	161-00 1.244 1.195 -0.039	162-43 1.177 1.136 -0.035	163-00 1.186 1.145 -0.035	164-44 1.528 1.475 -0.035	165-00 1.404 1.340 -0.046	
13	173-00 1.613 1.556 -0.035	174-00 1.131 1.112 -0.017	175-00 1.524 1.478 -0.030	176-00 1.182 1.140 -0.036	177-00 1.545 1.481 -0.041	178-00 1.256 1.206 -0.040	179-00 1.460 1.400 -0.041	180-00 0.807 0.794 -0.016	
14	187-48 1.22 1.181 -0.032	188-00 1.289 1.243 -0.036	189-49 1.206 1.170 -0.030	190-00 1.187 1.145 -0.035	191-50 1.257 1.206 -0.041	192-00 1.450 1.385 -0.045	193-51 0.809 0.791 -0.022		
15	199-00 1.569 1.511 -0.037	200-00 1.206 1.173 -0.027	201-00 1.316 1.272 -0.033	202-00 1.528 1.475 -0.035	203-00 1.461 1.400 -0.042	204-00 0.812 0.791 -0.026			
16	209-54 1.203 1.16 -0.036	210-00 1.512 1.464 -0.032	211-55 1.464 1.415 -0.033	212-00 1.402 1.340 -0.044	213-56 0.809 0.792 -0.021				
17	216-00 1.281 1.216 -0.051	217-00 0.814 0.8 -0.017							

213-56	FC Assy # - Detector #
0.735	CECOR Fq
0.732	SIMULATE Fq
-0.004	Difference (SIMULATE-CECOR)/CECOR