VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

November 25, 2002

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 02-334A
NL&OS/GDM: R0
Docket Nos. 50-280
50-281
50-338
50-339
License Nos. DPR-32
DPR-37
NPF-4
NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
REQUEST FOR ADDITIONAL INFORMATION
TOPICAL REPORT DOM-NAF-1 - QUALIFICATION OF THE STUDSVIK CORE MANAGEMENT SYSTEM REACTOR PHYSICS METHODS FOR APPLICATION TO NORTH ANNA AND SURRY POWER STATIONS

In a letter dated June 13, 2002 (Serial No. 02-334), Virginia Electric and Power Company (Dominion) requested approval of Topical Report DOM-NAF-1 for qualification of the Studsvik Core Management System reactor physics methodology for application at North Anna and Surry Power Stations. During staff review of the Topical Report, the NRC determined that additional information was necessary to complete their review. The staff provided Dominion with thirteen questions and requested a conference call to discuss the questions and our responses. The conference call was held on October 17, 2002, and upon completion of the conference call, Dominion agreed to provide the NRC our response to their questions on the docket. Consequently, the questions provided by the NRC are included in the attachment along with Dominion's response to each question. Subsequent to the conference call, six additional questions were received from the NRC, and these questions and our responses are also included in the attachment.

Consistent with our initial submittal, Dominion considers a portion of the additional information provided in the attached response proprietary. To conform with the requirements of 10 CFR 2.790 concerning the protection of proprietary information, the proprietary information provided in Attachment 1 is contained within brackets. Where the proprietary information has been deleted in the non-proprietary version, only the brackets remain (i.e., the information that was contained within the brackets in the

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proprietary version has been redacted). Attachment 2 has been redacted to provide a non-proprietary version of Dominion's response. The basis for redacting certain information as proprietary in this correspondence is addressed in the application for withholding and affidavit provided in our June 13, 2002 letter pursuant to 10 CFR 2.790(b)(1) and is applicable to this supplemental submittal as well.

If you have any further questions or require additional information, please contact us.

Very truly yours,

Leslie N. Hartz
Vice President – Nuclear Engineering

Attachment

Commitments made in this letter: None

cc: U.S. Nuclear Regulatory Commission (Att. 2 only)
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NON-PROPRIETARY VERSION

Attachment 2

Topical Report DOM-NAF-1

Qualification of the Studsvik Core Management System Reactor Physics Methods for Application to North Anna and Surry Power Stations

Response To NRC Request for Additional Information

Virginia Electric and Power Company
(Dominion)

Response To NRC Request for Additional Information
Topical Report DOM-NAF-1

North Anna and Surry Power Stations Units 1 and 2

1. *Page 7, paragraph 2 states that the CMS package is used by the nuclear industry in the U.S. and worldwide. What other utilities or vendors use this methodology in the U.S? Has this methodology been reviewed and approved by the NRC for these vendors/utilities?*

   The utilities/vendors that are currently using the CMS package (no version specified) are listed below. The list was obtained from Studsvik ca. 2000:

   American Electric Power, Arizona Public Service, Carolina Power and Light (Progress Energy), Commonwealth Edison (Excelon), Consumers Energy, Duke Power, Entergy, Illinois Power, Iowa Electric, New York Power Authority, Northern States Power, Omaha Public Power District, Philadelphia Electric, Southern California Edison, Texas Utilities Electric, Toledo Edison, Union Electric, Framatome, and Siemens.

   The utilities/vendors that have received licensing approval include the following:

   - Yankee Atomic (Duke, 1990)
   - Entergy (CASMO3/S3 9/95)
   - Duke (CASMO3/S3P 12/97)
   - Northern States Power (CASMO4/S3 9/13/00)
   - Arizona Public Service (Palo Verde)(CASMO4/S3 3/20/01)

2. *Page 16, paragraph 1 - The subject of bias is brought up. Please provide an example of how bias is calculated for any of the neutronic key parameters, such as those listed for the CASMO model.*

   Bias refers to the mean of the set of observed differences between predicted (CASMO or SIMULATE) and reference values (measured or Monte Carlo). Using Table 3 for example, the CASMO soluble boron worth bias for 17x17 fuel is [ ], which means that CASMO tends to [ ] soluble boron worth relative to KENO-V.a. The bias for some parameters is stated in terms of percent difference and for others in terms of difference (such as ppm for critical boron concentration). The definition of difference is given below each table. For comparison of reactivity worth, worth is calculated in units of pcm ($(1/K_1-1/K_2) \times 10^5$).

3. *On page 19, paragraph 2, the Doppler defect comparisons were only extended to 4.0% enrichment. Why was the comparison not extended to 5.0% like the rest of the parameters? Why is this acceptable?*

   The range of comparisons was not expanded because we did not observe any significant trend with either enrichment or burnup in the 3 and 4 w/o observations. All differences over a 600K ΔT (900K to 300K fuel temperature) were between [ ] with no trend apparent given the statistical uncertainty. In addition, because these are very long running Monte Carlo cases (40 million histories) and each worth calculation requires two cases, we did not perform an exhaustive set. The insensitivity of these comparisons to small changes in U^{235} enrichment is understandable due to the dominant role of U^{238} in resonance absorption for low enrichment fuel.

4. *On the last two lines of page 20, Table 3, it is stated that the number of observations for the Doppler defect is only 3 for both North Anna and Surry. This appears to be relatively few observations. Also, the mean % difference is large compared to the other means listed in the same table. Please provide technical justification for these differences.*

   As noted in the answer to question no. 3 above, a limited number of comparisons were performed because of the long run times for the Monte Carlo cases and the consistency of results. The mean differences for the Doppler comparisons in Table 3 are large. The standard deviation associated with the Doppler comparisons is relatively small, which indicates that the mean Doppler difference is significant.

   Early testing of CMS suggested (based on instability of some xenon transient modeling) that the Doppler feedback in SIMULATE was probably too low. The CASMO comparisons to Monte Carlo calculations confirm this suspicion. We speculate that the Doppler difference is related to the use of ENDF/B-IV cross section data in CASMO versus ENDF/B-V data in KENO. We identify these biases at the CASMO level so that they can be eliminated prior to reaching SIMULATE as discussed in Sections 2.4.1 and 3.1.

5. *Page 23, paragraph 3, makes a case for "strong gradients increase pin-to-box factors that result in challenging and conservative conditions for both W-prime and pin-to-box uncertainties." Please provide additional clarification of this statement. Does challenging and conservative mean that you have considered worst case scenarios?*

   These are not necessarily the worst case scenarios. However, control rod insertion introduces a very large inter-assembly and intra-assembly heterogeneity into the core. CASMO cases are run using single assembly geometry with reflective boundary conditions. The more homogenous the assembly and core design, the more the pin powers tend toward unity and the less challenging the problem is to the modeling theory and the reflective boundary condition assumption.

Control rod insertion represents roughly 30% ΔK reactivity insertion and introduces assembly power differences on the order of a factor of two across neighboring assemblies in the core. This represents not only a challenge to the intra-assembly pin power reconstruction in SIMULATE, but also to the inter-assembly flux calculation.

The presence of burnable absorbers (integral or discrete) does increase intra-assembly heterogeneity; however, burnable poisons are used in core design to reduce core-wide heterogeneity and inter-assembly gradients. Therefore, modeling assemblies with burnable poisons would not necessarily be more challenging than the rodded/unrodded checkerboard described. We view the rodded/unrodded checkerboard cases as representing well above average difficulty level for determining pin/box and W-prime uncertainty. We also note that our results are consistent with critical experiment comparisons reported by others (Section 3.2).

6. *The last paragraph on page 34 talks about differential rod worth (DRW). It states that SIMULATE tends to over-predict the peak DRW. One presumes that this is a conservative effect. Please provide technical justification for this assumption. Also, please provide additional clarification of the last sentence of the same paragraph.*

We do not assume that over-prediction of DRW is conservative, rather we use the data to develop separate upper and lower reliability factors.

The last part of question 6 refers to a statement justifying the use of a percent difference Nuclear Reliability Factor (NRF) for the DRW rather than an arithmetic difference NRF. For some accident analyses, such as the rod withdrawal accident, maximum DRW is limiting. The DRW limit can be 25-100 pcm/step and represent some highly skewed core conditions. However, measured values used to determine the DRW reliability factor (NRF) are from symmetric core measurements in the range of 8-15 pcm/step. The DRW upper NRF of 1.15 corresponds to arithmetic differences of roughly 1-2 pcm/step for the typical measured DRW. However, at accident conditions it represents as much as 15 pcm/step conservatism (15% of 100 pcm/step), much greater than a 1-2 pcm/step NRF. Use of a percent difference NRF is also logical, since the rod worth, the peak DRW and the error in the peak DRW are closely related quantities.

7. *Figure 22 on page 54 shows significant scatter. Please explain how this data supports your statement that the bias is primarily in the middle of the boron range.*

Figure 22 was not intended to demonstrate a strong correlation between boron concentration and ECP error. In fact, no correlation with boron is expected except that which results from the mis-modeling of ECP conditions due to B^{10} depletion. Figure 22 was included to show that a portion of the ECP data scatter is probably due to B^{10} depletion rather than SIMULATE uncertainty. However, for simplicity, all of the data have been included in the determination of the ECP statistics in Table 10.

B^{10} depletion introduces mis-modeling because the measured boron before the ECP can have a different B^{10}/B^{11} ratio than the measured boron at the time of the ECP return to critical. SIMULATE boron predictions are based on a constant B^{10}/B^{11} ratio. The reactivity comparison between measurement and prediction is skewed by the B^{10}/B^{11} difference. Although it is possible to correct for this mismatch, the process involves a great deal of measured data and was not practical due to the large number of cycles modeled.

B^{10} depletion mis-modeling is most likely to occur at mid cycle, during which boron concentration tends to be in the middle of the range shown in Figure 22. The bow in the fit is consistent with the expected influence of uncorrected B^{10} depletion on an ECP. The point in demonstrating this is to show that B^{10} depletion tends to increase the scatter in the ECP data (introduces a positive bias for certain cases but not for others) leading to a conservative estimate of SIMULATE ECP accuracy. The ECP statistics are presented as a general confirmation of SIMULATE reactivity predictions. These statistics were not used to develop an NRF.

8. *On page 68, you indicate that SIMULATE's calculated peak F(z) values tend to be low by 0.01 to 0.04. Explain how you account for this tendency when conservatively modeling the transient.*

   Best estimate models are used to determine appropriate uncertainty factors. When we perform FAC or RPDC operational transient modeling, we apply the FQ NRF and other factors. The FQ NRF includes the effect of differences between measured and predicted F(Z).

9. *On page 68 for the S2C2 Load Follow Demonstration, you indicate that SIMULATE has a critical boron concentration initial bias of -34 ppm. On page 71, for the N1C3 Trip and Return to Power, you do not indicate a bias for the critical boron concentration. On page 75, paragraph 2, for the N1C9 HFP MTC Measurement you indicate that the bias is -24 ppm. On page 82, for the N1C11 Initial Power Ascension, you do not indicate a bias. And on page 86, paragraph 3, for the N2C14 Power Transient, you indicate that the bias is 60 ppm. Describe why these biases vary significantly and why this variation is acceptable. In addition, given the*

variability of the bias, describe how you account for the bias when using SIMULATE in a predictive capacity.

The "bias" cited for each transient is actually the initial difference between measured and predicted boron at the beginning of each transient (snapshots for specific times in specific cycles). These observations provide a reference point to demonstrate the degree of boron consistency (measured versus predicted) throughout the transient. The initial differences cited are acceptable because they are consistent with the data used to determine the critical boron NRF (+/- 50 ppm). When a conservative estimate of critical boron concentration is needed, the NRF is applied to the best estimate SIMULATE prediction in the conservative direction.

In the case of N2C14, we identified a known contributor to the mid-cycle M-P boron difference (B^{10} depletion) but did not attempt to model it. The presence of B^{10} depletion complicates the determination of SIMULATE reactivity modeling accuracy. The primary purpose of the transient modeling is to demonstrate that the SIMULATE model is robust and is capable of accurately calculating the time dependent reactivity and power distribution response of the core to complex changing core conditions (control rod position, core power, xenon concentration, boron concentration, and moderator temperature). To that end, it is not necessary to correct for B^{10} depletion. However, in order to arrive at absolute reactivity comparisons between SIMULATE and measurements, a correction for B^{10} depletion is required. As noted in the response to question 7, such a correction is possible, but is not practical due to the large number of cycles modeled. It is for this reason that only BOC and EOC comparisons have been used for the determination of the critical boron NRF (Section 3.3.1).

10. *On page 75, you indicate that the Figure 38 SIMULATE boron values followed the measured values within about +18/-15 ppm. However, you only provide 4 data points for comparison purposes during the power transient. Describe how SIMULATE accurately models this transient given the limited data. Additionally, describe why the +18/-15 ppm assessment is accurate.*

    There are only four critical boron data points available for the N1C6 transient. The "+18/-15" comment indicates the range of difference (P-M) for those four points after accounting for the initial difference at the beginning of the transient. These results are consistent with the body of data from the other transients and consistent with the critical boron NRF. The good agreement between predicted and measured delta-I data is the best evidence of modeling accuracy for this transient.

11. *On page 110, paragraph 2, you state that, "... the remaining 60 pcm standard deviation is assumed to be equally distributed between the Doppler defect and the*

xenon worth change..." Why is it acceptable to assume the standard deviation can be divided equally between Doppler defect and xenon worth change?

The assessment of Doppler uncertainty based on ECP data is a "very crude approximation" (Section 4.3.6). We attempted to use the ECP data to support or refute as much as possible the conclusions concerning Doppler feedback from other areas (Table 3, Table 5, and transient axial stability). The assumption was used only to arrive at a reasonable estimate of Doppler uncertainty based on the probability that the xenon uncertainty is non-zero and because the Doppler worth is similar in magnitude to the xenon worth. Even if the entire 60 pcm is attributed solely to Doppler uncertainty, the resulting reliability factor is estimated to be ±10%, which is the same as the NRF chosen.

12. *On page 114, paragraph 1, you indicate that a value of 1.10 for the Doppler Temperature Coefficient and Doppler Power Coefficient was proposed in Dominion Topical Report VEP-FRD- 45A, dated October 1982 and accepted by the NRC. Describe why this topical report is still valid given the changes to fuel designs and loading patterns since 1982.*

VEP-FRD-45A was cited for historical perspective, but is not assumed to remain valid. Information summarized in Section 4.3.8 is intended to support a Doppler feedback NRF of ±10% based on the benchmarking of the CMS model. The data presented covers all North Anna and Surry cycles up to the time DOM-NAF-1 was assembled.

13. *On page 115, paragraph 3, you indicate that there are three sets of basic delayed neutron data available in CASMO. Provide clarification as to which data set you use for your CASMO modeling.*

Dominion plans to use the Tuttle delayed neutron data based on calculations of the effect of the various options on startup physics measurements. The specific choice of CASMO delayed neutron data can shift reactivity computer measurements by approximately 3%. Based on the Dominion startup physics measurements available, the Tuttle data provides the most consistent alignment of measured and predicted control rod worth and boron worth. Little or no bias is expected in these worth predictions due to the benchmarking and bias adjustment process described in Sections 2.4.1 and 3.1.

14. *Are all tolerance limits calculated as 95/95?*

All tolerance limits are calculated as 95/95.

15. Are all statistical tests conducted at the 0.05 level of significance?

All statistical tests are conducted at the 0.05 level of significance.

16. Please include a column with the number of observations in Table 4, Page 26.

See the attached revision to Table 4 (p. 26 of Report) which includes the sample sizes.

17. Various datasets were tested for normality using more than one test. Since different tests are sensitive to different departures from normality, the more tests one uses, the more likely it is that normality would be acceptable by at least one test. Please discuss the use of multiple tests in light of this concern.

This question addresses the issue of using multiple null hypothesis tests for normality as discussed in Section 4.2. Inspection of the histograms found in the Report shows they all exhibit a bell-shaped behavior, that is, a central peak with diminishing tails, indicative of a normal or near-normal distribution. In a prior submission (Topical Ref. 23), Dominion relied on the W test of Shapiro and Wilk for small size samples (up to 50), and the Kolmogorov-Smirnov (K-S) test for larger size samples. This use of a single test for any particular sample was viewed as unrealistic, since no test is foolproof, each having certain strengths and weaknesses. Considering the diversity of parameters, measurement procedures, and conditions reflected in the Report, it would be surprising if any single normality test was equally reliable for all parameters.

The decision of which tests to use was complicated by the large number of available candidates, and the ongoing debate over the applicability, meaning and validity of different tests. (See, for examples, Appendices A and B of the ANSI standard (Topical Ref. 32), and the discussion on higher moments and null hypothesis testing in *Numerical Recipes in Fortran 77: 2nd Edition.*) Since a survey of the literature failed to identify any consensus for a single test, Dominion concluded that the use of more than one test was a reasonable approach in avoiding either a type I or type II error. Where normality was assumed in the determination of a NRF, normality tests of the combined data (North Anna and Surry together) indicated normality in at least two out of three tests. Expanded tables for three key parameters are attached: Table 5 critical boron, Table 6 integral control rod worth, and Table 8 HZP BOC isothermal temperature coefficient. These revised tables include:

- the calculated D' statistic and the bounding D' one-sided and two-sided D' limits,
- the calculated significance level for the K-S and Kuiper tests,

- the calculated W statistic and the W statistic for a 0.05 level of significance,
- the number of observations outside the 95/95 NRF, and
- the percent of observations outside the 95/95 NRF.

The attached Table 5 also corrects three typos in the Report table.

It should be noted that:

1) both the data to be tested and the null hypothesis tests were selected before any testing was performed, thus avoiding prejudicing a conclusion by hindsight, and
2) no tests were performed to remove suspected outliers from the data.

It appears ironic that the only comparisons to measurement for which the hypothesis of normality was clearly rejected were the two with the largest sample sizes and the most normal appearing histograms, that is, the integral and peak reaction rates. Although we suspect the results of these tests to be type I errors on the part of the K-S and Kuiper tests, we nevertheless derived the tolerance limits using a non-parametric method. However, in this realm of sample size, the tolerance limits which would have resulted if the samples were assumed to be normal tend to converge with those based on the non-parametric method.

Finally, should a type II error have been committed, that is, if a NUF is calculated assuming a normal distribution when in reality it is not, additional factors reduce the impact of such an error. These are:

1) NUFs calculated by comparison of predictions with measurements inherently include measurement uncertainty in addition to model prediction uncertainty, and
2) the NRF is chosen to be equally conservative as or more conservative than the NUF.

18. *Please indicate which nonparametric tests were used when data normality was rejected.*

The NUF for a non-normal distribution was determined based on the non-parametric ranking method of Somerville (Topical Ref. 26) and referenced in USNRC Regulatory Guide 1.126 (Topical Ref. 29). This method was used for determining the tolerance limits for the integral and peak reaction rates (Table 23), and the pin-to-box ratios (Table 4). For example, for the North Anna integral reaction rate sample of Table 23, the number of observations was 3453. Extension of the data in Table 2 of Topical Ref. 29 indicates the 150th most negative value (*m*) to be the 95/95 limiting tolerance value for a non-normal distribution of this size. The tolerance limit corresponding to this value is 2.23%.

As a check on the accuracy of extending the data in Table 2 of Topical Ref. 29, values of *m* were rigorously calculated for the reported sample sizes based on the incomplete Beta function method described in the Somerville paper (Topical Ref. 26). The results, found in the attached update to Table 23 under the column "Rigorous One Sided Tolerance Limit," demonstrate that the tolerance limits presented in the Report are conservative.

19. *The last paragraph of page 92 needs to be addressed for conservatism. The multiplier of the standard deviation (used to derive tolerance limits) is smaller for one-sided than a two-sided criterion. Therefore, when we have a two-sided concern (when we are concerned with accedence that is too low as well as too high) a two-sided multiplier is applicable.*

The application of a one-sided multiplier is based on the present Dominion methodology for ensuring conservatism for reload safety evaluations. This methodology, which uses a limiting key parameter approach, has been previously reviewed and accepted by the USNRC (Topical Refs. 12, 23). Briefly, the method for determining NUFs (and, by extension, NRFs) is as follows. We desire a value for an NRF such that when applied to a predicted value *X*, the result *Z* is expected to bound the "real" value of the parameter 95% of the time with a 95% confidence level. Here the "real" value is the actual value of the parameter which would exist for the core conditions assumed by the prediction. In practice, the NRF is developed using measured data (or in some cases Monte Carlo data) as the best available estimate of the "real" value.

The confusion over the use of one-sided versus two-sided multipliers appears to arise from the fact that when considering the complete reload safety evaluation process, both over-prediction and under-prediction may be important for some parameters. However, a concern of simultaneous over-prediction and under-prediction does not apply to a parameter for a given event; that is, a key parameter used in a particular safety event will either be conservative in the high direction or low direction, but never both at the same time. For example, for a transient where maximum control rod worth is limiting, increasing the predicted control rod worth by 10% (one-sided multiplier) provides a 95/95 conservative value. The use of a two-sided multiplier would be even more conservative, but would represent a 95/95 conservatism relative to both high and low rod worth simultaneously, and, in addition, would constitute a change to the Dominion methodology previously reviewed by the USNRC.

Table 4

CASMO-4 W-prime and Pin-to-box Ratio Comparisons

Fuel Type / Parameter	Assembly	Sample Size	Mean (%)	Std. Dev. (%)	Normal	Tolerance Limit
Surry 15x15 W-prime	Rodded	186	[ ]	[ ]	Yes	[ ]
	Unrodded	186	[ ]	[ ]	Yes	[ ]
	Combined	372	[ ]	[ ]	Yes	[ ]
North Anna 17x17 W-prime	Rodded	234	[ ]	[ ]	Yes	[ ]
	Unrodded	234	[ ]	[ ]	Yes	[ ]
	Combined	468	[ ]	[ ]	Yes	[ ]
Combined data W-prime	Combined	840	[ ]	[ ]	Yes	[ ]
Pin-to-box Ratio Statistics (Including Gamma Smearing)						
Surry 15x15 Pin-to-box ratio	Rodded	186	[ ]	[ ]	No	[ ]
	Unrodded	186	[ ]	[ ]	No	[ ]
	Combined	372	[ ]	[ ]	No	[ ]
North Anna 17x17 Pin-to-box ratio	Rodded	234	[ ]	[ ]	No	[ ]
	Unrodded	234	[ ]	[ ]	No	[ ]
	Combined	468	[ ]	[ ]	No	[ ]
Pin-to-box Ratio Statistics (Excluding Gamma Smearing)						
Surry 15x15 Pin-to-box ratio	Rodded	186	[ ]	[ ]	No	[ ]
	Unrodded	186	[ ]	[ ]	No	[ ]
	Combined	372	[ ]	[ ]	No	[ ]
North Anna 17x17 Pin-to-box ratio	Rodded	234	[ ]	[ ]	No	[ ]
	Unrodded	234	[ ]	[ ]	No	[ ]
	Combined	468	[ ]	[ ]	No	[ ]

Note: Difference is ((SIMULATE – MCNP) / SIMULATE) x 100%.
* Eliminating the MCNP W-prime uncertainty component (conservatively set at [ ]) by root sum square results in a W-prime tolerance interval of [ ].

Table 5
SIMULATE Critical Boron Comparisons

Plant	Condition	Mean (ppm)	Sigma (ppm)	Obs.	Max.	Min.	Normal	D'	D' P=.025	D' P=.05	D' P=.95	D' P=.975	K-S Sig L	Kuiper Sig L	Calc. W	0.05 W	# > NRF	% > NRF
NA	BOC HZP	-8.1	20.3	30	30	-53	Yes						0.8179	0.9995	0.9653	0.927	1	3.3
	BOC HFP	-7.2	16.4	228	30	-51	Yes*	948.2	955.7	958.6	980.7	982.3	0.1868	0.6974			1	0.4
	EOC HFP	-5.9	14.6	199	24	-39	**Yes**	792.3	777.8	780.3	799.7	801	0.0872	0.4539			0	0.0
	ECP	-10.1	13.2	5	4	-31	N/A										0	0.0
	ALL	-6.7	15.9	462	30	-53	Yes'	2768	2770	2776	2821	2825	0.0261	0.1978			2	0.4
SY	BOC HZP	-5	23.4	35	48	-49	Yes						0.7569	0.9982	0.9758	0.934	0	0.0
	BOC HFP	-11.2	16.5	212	35	-54	Yes*	854.9	856.4	859.1	879.7	881.1	0.079	0.4264			5	2.4
	EOC HFP	-14.8	14.6	305	16	-48	Yes*	1518	1482	1486	1516	1517.5	0.175	0.6761			0	0.0
	ECP	2.8	24.4	4	30	**-29**	N/A										0	0.0
	ALL	-12.7	16.3	556	48	-54	Yes	3683	3662	3668	3722	3727	0.2652	0.8143			5	0.9
ALL	BOC HZP	-6.4	21.9	65	48	-53	Yes	148	142.7	143.7	149.9	150.1	0.7423	0.9979			1	1.5
	BOC HFP	-9.1	16.5	440	35	-54	Yes'	2550	2574	2579	2622	2625	0.0315	0.2276			6	1.4
	EOC HFP	-11.2	15.2	**504**	24	-48	Yes*	3227	3158	3164	3213	3217	0.1003	0.497			0	0.0
	ECP	-4.3	18.9	9	30	-31	N/A										0	0.0
	ALL	-10	16.4	1018	48	-54	Yes^	9126	9099	9110	9211	9218	0.0141	0.1244			7	0.7

Note: Critical boron difference is (SIMULATE – Measured) (ppm)

Yes - Passed all tests
Yes* - Failed the D' test but passed the K-S and Kuiper tests.
Yes' - Failed the D' and K-S tests but passed the Kuiper test.
Yes^ - Failed the K-S test but passed the D' and Kuiper tests.

Corrections:

1. North Anna EOC HFP normality test results should be "Yes," i.e., passed all tests instead of 2 out of 3.
2. Number of observations for combined EOC HFP should be 504 instead of 521.
3. Surry ECP minimum value should be –29 instead of –31.

Table 6
SIMULATE Integral Control Rod Worth Comparisons

Plant	Type	Mean (%)	Sigma (%)	Nobs	Max.	Min.	Normal	D'	D' P=.025	D' P=.05	D' P=.95	D' P=.975	K-S Sig L	Kuiper Sig L	Calc. W	0.05 W	# > NRF	% > NRF
NA	Dilution	2.4	4.3	39	16.1	-7.3	Yes						0.4678	0.9532	0.9621	0.939	2	5.1
	Rod Swap	0.6	4.1	139	13.4	-12.4	Yes*	449.4	452.1	454	467.5	468.3	0.6507	0.9927			6	4.3
	ALL	0.9	4.2	178	16.1	-12.4	Yes*	647	657.3	659.7	677	678.1	0.3599	0.9000			8	4.5
SU	Dilution	1.7	5.2	54	13.6	-17.4	Yes*	104.9	107.5	108.4	113.5	113.7	0.7026	0.9961			3	5.6
	Rod Swap	1.8	3.7	130	10.4	-9.7	Yes	415.5	409.4	411.2	423.8	424.5	0.9823	1.0000			1	0.8
	ALL	1.8	4.2	184	13.6	-17.4	Yes*	678.4	691.3	693.7	711.6	712.7	0.5599	0.9806			4	2.2
ALL	Dilution	2	4.8	93	16.1	-17.4	Yes*	238.6	245.9	247.2	256.1	256.6	0.4803	0.9595			4	4.3
	Rod Swap	1.2	3.9	269	13.4	-12.4	Yes*	1224	1226	1230	1256	1258	0.7952	0.9992			8	3.0
	ALL	1.4	4.2	362	16.1	-17.4	Yes*	1883	1918	1923	1958	1960	0.3544	0.8971			12	3.3

Note: Rod worth difference is ((SIMULATE - Measured)/SIMULATE) x 100%.

Yes* - Failed the D' test but passed the K-S and Kuiper tests.

Table 8
SIMULATE HZP BOC ITC Comparisons

Plant	Mean (pcm/F)	Sigma (pcm/F)	Nobs	Max.	Min.	Normal	D'	D' P=.025	D' P=.05	D' P=.95	D' P=.975	K-S Sig L	Kuiper Sig L	Calc. W	0.05 W	# > NRF	% > NRF
NA	0.84	0.73	38	2.24	-1.72	Yes'						0.5773	0.9825	0.9148	0.938	2	5.3
SU	0.44	0.55	49	1.49	-1.64	Yes'						0.5557	0.9787	0.9325	0.947	0	0.0
ALL	0.62	0.66	87	2.24	-1.72	Yes*	215.2	222.2	223.5	231.8	232.2	0.3182	0.8651			2	2.3

Note: ITC difference is (SIMULATE - Measured) (pcm/F).

Yes' - Failed the W test but passed the K-S and Kuiper tests.
Yes* - Failed the D' test but passed the K-S and Kuiper tests.

Table 23
SIMULATE Reaction Rate NUF
(Non-normality Assumed)

Plant	Data Type	Mean (%)	Std. Dev. (%)	Number Of Obs.	Reported Limiting Tolerance Value	Reported One Sided Tolerance Limit (%)	Rigorous Limiting Tolerance Value	Rigorous One Sided Tolerance Limit (%)	Number of Obs. > NRF	% of Obs. > NRF
N. Anna	Integral	-0.02	1.34	3453	150	2.23	152	2.21	20	0.6
Surry	Integral	0.07	1.34	2322	98	**2.34**	99	2.33	9	0.4
Combined	Integral	0.01	1.34	5775	257	2.25	262	2.24	29	0.5
N. Anna	32 Node	0.14	2.41	93070	4273	3.96	4544	3.89	1969	2.1
Surry	32 Node	0.38	2.79	64354	2952	4.53	3127	4.42	2270	3.5
Combined	32 Node	0.24	2.58	157424	7233	4.17	7728	4.07	4239	2.7

Note: Sign on computed tolerance limits changed to positive for consistency.

Correction: Surry Integral One Sided Tolerance Limit should be 2.34 instead of 2.35.