CEOG COMBUSTION ENGINEERING OWNERS GROUP

CE NPSD-911
Amendment 1

Analysis Of Moderator Temperature Coefficients In Support Of A Change In The Technical Specifications End of Cycle Negative MTC Limit

CEOG TASK 1009

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ABB Combustion Engineering Nuclear Operations

ABB

ANALYSIS OF MODERATOR TEMPERATURE COEFFICIENTS IN SUPPORT OF A CHANGE IN THE TECHNICAL SPECIFICATION END OF CYCLE NEGATIVE MTC LIMIT

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ANALYSIS OF MODERATOR TEMPERATURE COEFFICIENTS IN SUPPORT OF A CHANGE IN THE TECHNICAL SPECIFICATION END OF CYCLE NEGATIVE MTC LIMIT

I. Introduction

The accurate knowledge of the moderator temperature coefficient (MTC) at end of cycle is of prime importance in the fuel management of long reload cycles. The designer must ensure that the most negative MTC will always be conservative to the Technical Specification limit. The required amount of conservatism depends on the accuracy of the calculational model, and on the uncertainty attached to the knowledge of the true MTC. If enough reliance can be placed on the calculational models and on the end of cycle predicted MTC, a surveillance test becomes unnecessary.

The calculational accuracy of the analytical models and the confidence assigned to the knowledge of the true MTC are established by comparing calculated and measured values. A moderator temperature coefficient design margin (uncertainty) is established such that if the best estimate design MTC is conservative relative to the Technical Specification limit by an amount equal to or greater than the design margin, then the Technical Specification limit will not be violated. The best estimate value is defined as the calculated value using the current ABB-CE methodology augmented by a bias term. Although the Technical Specification limit on negative MTC must be satisfied at end-of-cycle, it is shown that the design margin applies to all times in life. It is also established that if the measured beginning-of-cycle moderator temperature coefficients agree with the predictions within the design margin, then all measured coefficients for that cycle are expected to pool with the data base presented in this report, including the end-of-cycle MTC. Thus if the end-of-cycle MTC is expected to fall within the design margin, its measurement is not required.

In this analysis, isothermal temperature coefficients (ITC) are used since they are the measured quantities. The measured ITC is assumed to represent the true value. The impact of systematic errors in the measurements is reduced by combining values obtained on several plants by several utilities using different techniques. The accuracy of the model is expressed as a bias representing systematic differences between measured and calculated values, and the uncertainty is expressed as the random fluctuations between these values. The uncertainty can be viewed as a limitation in the search for the true value. Thus, to ensure compliance with the Tech. Spec. with a high confidence level, the most negative raw calculated design MTC at EOC must be less negative than the Tech. Spec. MTC by an amount equal to the bias plus total uncertainty.

This Amendment 1 updates the data base and validates the conclusions of the original issuance with respect to the most recent plant predicted versus measured startup data available. Thirty-four data points have been added since the original report was issued, for a total of 105 data points. For 15 cycles, all three conditions (BOC at hot zero power, near BOC at power, and near EOC at power) have been analyzed. An additional set of six cycles consists of BOC hot zero power and near EOC at power. A total of 30 near EOC values have been analyzed. Of the 105 data points, only one shows a residual deviation which equals the design margin. This amendment demonstrates that enough reliance can be placed on the calculational models and on the EOC predicted MTCs, and that a surveillance test becomes unnecessary.

II. Summary

In order to ensure that the moderator temperature coefficient will not exceed the Technical Specification limit with a confidence/tolerance of 95/95%, the cycle must be designed, using the ABB-CE methodology, such that the best estimate MTC is:

a. *more negative than the BOC Technical Specification limit by the design margin, and*

b. *more positive than the EOC Technical Specification limit by the design margin.*

The design margin is determined to be 1.6 pcm/°F at all times in life.

The analysis of a revised data base including the most recent measured and calculated MTC's has established that **if the measured beginning-of-cycle moderator temperature coefficients fall within 1.6 pcm/°F of the best estimate prediction, then it can be assumed that the end-of-cycle coefficient will too and its measurement is not required.**

The measured data reduction must be based on the current ABB-CE methodology as described in this report.

If the beginning-of-cycle fails the acceptance criteria of ±1.6 pcm/°F and the discrepancy cannot be resolved, then the end-of-cycle surveillance test must be performed.

III. Methodology

The methodology used for this Amendment 1 is identical to that employed in the original issuance.

IV. Data Base and Data Reduction

The data base of cycles analyzed within this amendment and to be included in the previous data base of the original issuance are Waterford Unit 3 Cycle 8, Arkansas Unit 2 Cycles 11 and 12, Calvert Cliffs Unit 1 Cycle 12 and Unit 2 Cycle 11, Palo Verde Unit 1 Cycle 6, Palo Verde Unit 2 Cycle 6 and Cycle 7, and Palo Verde Unit 3 Cycle 6, and include 23 measurements. An additional set of 11 measurements had been added in the interim. The augmented data base contains a significant sample from all Combustion Engineering plants (2700 MW, 2815 MW, 3400 MW, and 3800 MW), using both the rod insertion and the power trade measurement techniques. The data reduction of all measurements and predictions for the most recent plant data is summarized in Table 1.

ITC predictions have all been made at the measured critical conditions, so that no adjustments were needed. The test initial conditions (power level, exposure, inlet temperature, soluble boron concentration and lead bank insertion) were simulated, taking into account all thermal-hydraulics and xenon feedbacks. Then, without changing the xenon distribution, a change of ±3°F was applied to the inlet temperature, keeping the thermal-hydraulics feedback effects active. The core average temperature was obtained from edited output, and the ITC calculated.

The 105 data points were analyzed for normality using the American National Standard Institute Standard Normality Test. The D' Test statistic was 301.39 which implies that the assumption of normality is appropriate based on the percentage points of the D' Test Statistic.

V. Results

A complete list of all measured and calculated ITC's is given in Table 1. Table 1 lists the plants and cycles, the core enrichment and exposure, the operating conditions (PPM soluble boron, power and moderator temperature), the measured and calculated ITC and the difference (M-C) in units of pcm/°F.

The residuals of the fit [(M-C) values - fitted values] are plotted in Figure 1 vs. soluble boron concentration. This figure indicates a fairly uniform distribution of points, with no obvious PPM dependence. The residuals of the fit are also plotted vs. various parameters, to demonstrate independence of the residual against these parameters, and to show that no significant variables were omitted in the model, i.e. that the soluble boron is really the only correlating variable. The residuals are plotted vs. core exposure, enrichment, power, moderator temperature, bias and calculated ITC, in Figures 2 to 7. In all Figures, the scatter of the residuals appears random, indicating that there is no correlation of the residuals against any of the chosen variables when including the most recent plant data available.

The result of this Amendment 1 states that when the data base of measured versus predicted MTC includes the most recent plant data available, the conclusions of the original issuance remain valid. It is also concluded that the addition of more data beyond the present data base will not affect the current conclusions. Specifically, the end-of-cycle MTC monitoring procedure in the absence of a measurement is as follows:

> ***If the isothermal temperature coefficients measured at zero power during the cycle startup program, and at power during the first power ascension, fall within the design margin (acceptance criteria) of ±1.6 pcm/°F, then the end-of-cycle best estimate prediction will also be within ±1.6 pcm/°F of the true MTC. To establish compliance with the Technical Specifications, the best estimate end-of-cycle MTC must be less negative than the Tech. Spec. value by 1.6 pcm/°F.***

Table 1

Measured ITC's, Calculated ITC's, and Residual of ITC's

PLANT	Cycle	Core Avg Burnup	Core Avg Enrich	PPM	PWR (%)	Tmod (°F)	ITC Meas E-4/°F	ITC Calc E-4/°F	M-C pcm/°F	Bias pcm/°F	Residual pcm/°F
ANO-2	9	28367	3.98	276	95	580	-2.251	-2.296	0.450	-0.423	0.873
ANO-2	11	14949	4.00	1762	0	541	0.083	0.228	-1.450	-1.883	0.433
ANO-2	11	15320	4.00	1240	95.5	572	-0.623	-0.575	-0.480	-1.370	0.890
ANO-2	12	13806	4.01	1657	0	548	-0.110	0.012	-1.220	-1.780	0.560
ANO-2	12	14151	4.01	1110	98	578	-1.042	-0.892	-1.500	-1.243	-0.257
ANO-2	12	28843	4.01	288	97	575	-2.011	-2.022	0.110	-0.435	0.545
CC-1	8	14526	3.81	1600	0	532	0.344	0.417	-0.730	-1.724	0.994
CC-1	8	14526	3.81	1330	0	532	-0.560	-0.408	-1.520	-1.459	-0.061
CC-1	8	24723	3.81	310	97	570	-1.782	-1.801	0.190	-0.457	0.647
CC-1	9	16502	3.77	1398	0	532	0.064	0.187	-1.230	-1.526	0.296
CC-1	9	24783	3.77	275	97	570	-1.865	-1.870	0.050	-0.422	0.472
CC-1	10	10971	3.95	1750	0	532	0.265	0.422	-1.570	-1.871	0.301
CC-1	10	10971	3.95	1735	0	532	0.200	0.452	-2.520	-1.857	-0.663
CC-1	10	27443	3.95	285	97	570	-1.757	-1.781	0.240	-0.432	0.672
CC-1	12	15399	4.19	2024	0	535	0.440	0.580	-1.400	-1.071	-0.329
CC-1	12	15579	4.19	1521	100	567	-0.260	-0.116	-1.440	-0.577	-0.863
CC-1	12	31905	4.19	357	72	559	-1.770	-1.645	-1.250	-0.503	-0.747
CC-2	5	24423	3.42	44	0	530	-1.610	-1.550	-0.600	-0.195	-0.405
CC-2	5	24423	3.42	44	0	530	-1.740	-1.670	-0.700	-0.195	-0.505
CC-2	5	24423	3.42	44	0	530	-1.950	-1.950	0.000	-0.195	0.195
CC-2	5	24423	3.42	44	0	530	-2.080	-2.110	0.300	-0.195	0.495
CC-2	5	24423	3.42	330	0	530	-1.050	-1.090	0.400	-0.476	0.876
CC-2	5	24423	3.42	330	0	530	-1.110	-1.080	-0.300	-0.476	0.176
CC-2	5	24423	3.42	69	100	572	-2.089	-2.058	-0.310	-0.220	-0.090
CC-2	8	12937	3.93	1496	0	521	0.200	0.387	-1.870	-1.622	-0.248
CC-2	8	27120	3.93	297	97	570	-1.810	-1.779	-0.310	-0.444	0.134
CC-2	9	13895	4.15	1801	0	532	0.370	0.544	-1.740	-1.921	0.181
CC-2	9	13895	4.15	1389	0	532	-0.470	-0.338	-1.320	-1.517	0.197
CC-2	11	15926	4.21	1995	0	535	0.470	0.610	-1.400	-0.872	-0.477
CC-2	11	15962	4.21	1527	100	567	-0.228	-0.095	-1.330	-0.413	-0.917
CC-2	11	32372	4.21	284	100	567	-2.072	-1.900	-1.720	-0.431	-1.289
OPPD	12	15738	3.73	1507	0	523	0.240	0.433	-1.930	-1.633	-0.297
OPPD	12	16520	3.73	1050	91	565	-0.516	-0.448	-0.680	-1.184	0.504
OPPD	12	25777	3.73	309	92	565	-1.711	-1.804	0.930	-0.456	1.386

Table 1 Continued

PLANT	Cycle	Core Avg Burnup	Core Avg Enrich	PPM	PWR (%)	Tmod (°F)	ITC Meas E-4/°F	ITC Calc E-4/°F	M-C pcm/°F	Bias pcm/°F	Residual pcm/°F
OPPD	13	14835	3.72	1563	0	521	0.310	0.506	-1.960	-1.688	-0.272
OPPD	13	15209	3.72	1113	92	565	-0.461	-0.341	-1.200	-1.246	0.046
OPPD	13	25531	3.72	325	92	565	-1.640	-1.728	0.880	-0.471	1.351
OPPD	14	14562	3.60	1178	0	523	-0.090	0.035	-1.250	-1.309	0.059
OPPD	14	14916	3.60	768	88	564	-0.912	-0.789	-1.230	-0.907	-0.323
PV-1	1	0	2.65	1055	0	320	-0.128	-0.038	-0.900	-1.189	0.289
PV-1	1	0	2.65	824	0	320	-0.369	-0.208	-1.610	-0.962	-0.648
PV-1	1	0	2.65	1025	0	565	-0.442	-0.223	-2.190	-1.159	-1.031
PV-1	1	0	2.65	893	0	565	-0.972	-0.709	-2.630	-1.029	-1.601
PV-1	1	82	2.65	825	23	565	-0.587	-0.502	-0.850	-0.963	0.113
PV-1	2	11269	3.15	1462	0	565	0.150	0.308	-1.580	-1.588	0.008
PV-1	2	11269	3.15	1178	0	565	-0.422	-0.244	-1.780	-1.309	-0.471
PV-1	3	9727	3.66	1739	0	565	0.133	0.256	-1.230	-1.861	0.631
PV-1	3	9727	3.66	1438	0	565	-0.445	-0.262	-1.830	-1.565	-0.265
PV-1	3	9727	3.66	1653	0	565	-0.130	0.003	-1.330	-1.776	0.446
PV-1	3	11209	3.66	1170	100	595	-0.813	-0.821	0.080	-1.302	1.382
PV-1	3	22404	3.66	484	100	595	-2.291	-2.184	-1.070	-0.628	-0.442
PV-1	6	16533	3.84	1753	0	565	-0.044	0.038	-0.820	-1.033	0.213
PV-1	6	18110	3.84	1160	99	589	-1.095	-1.014	-0.810	-0.450	-0.360
PV-1	6	27460	3.84	415	100	589	-2.490	-2.342	-1.480	-0.560	-0.920
PV-1	7	16140	3.98	2070	0	565	-0.038	0.059	-0.970	-1.183	0.213
PV-2	2	9123	3.32	1452	0	565	-0.048	0.080	-1.280	-1.579	0.299
PV-2	2	9123	3.32	1140	0	565	-0.458	-0.295	-1.730	-1.272	-0.458
PV-2	3	12102	3.76	1595	0	595	0.065	0.209	-1.440	-1.719	0.279
PV-2	3	12102	3.76	1315	0	565	-0.693	-0.535	-1.580	-1.444	-0.136
PV-2	3	14662	3.76	1029	100	595	-1.146	-0.961	-1.850	-1.163	-0.687
PV-2	4	13988	3.73	1741	0	565	0.174	0.328	-1.540	-1.863	0.323
PV-2	4	15516	3.73	1126	100	595	-0.972	-0.882	-0.900	-1.258	0.358
PV-2	4	24121	3.73	455	100	595	-2.352	-2.270	-0.820	-0.599	-0.221
PV-2	6	17972	3.65	1563	0	565	-0.070	0.043	-1.130	-1.415	0.285
PV-2	6	19543	3.65	959	99.95	588	-1.219	-1.094	-1.250	-0.822	-0.428
PV-2	6	26022	3.65	385	100	589	-2.205	-2.235	0.300	-0.530	0.830
PV-2	7	13683	3.71	1784	0	565	-0.125	-0.038	-0.870	-0.816	-0.054
PV-3	1	0	2.65	805	0	565	-0.837	-0.617	-2.200	-0.943	-1.257
PV-3	2	8402	3.26	1479	0	565	0.061	0.218	-1.570	-1.605	0.035
PV-3	2	8402	3.26	1200	0	565	-0.424	-0.232	-1.920	-1.331	-0.589
PV-3	2	19015	3.26	411	99	595	-2.054	-2.043	-0.110	-0.556	0.446
PV-3	3	22874	3.47	330	100	595	-2.641	-2.437	-2.040	-0.476	-1.564
PV-3	4	14284	3.61	1586	0	565	0.040	0.183	-1.430	-1.710	0.280
PV-3	5	13153	3.76	1836	0	565	0.100	0.147	-0.470	-1.055	0.585

Table 1 Continued

PLANT	Cycle	Core Avg Burnup	Core Avg Enrich	PPM	PWR (%)	Tmod (°F)	ITC Meas E-4/°F	ITC Calc E-4/°F	M-C pcm/°F	Bias pcm/°F	Residual pcm/°F
PV-3	6	17053	3.91	1862	0	565	-0.285	-0.037	-2.480	-1.400	-1.080
PV-3	6	18631	3.91	1222	100	588	-1.253	-1.113	-1.400	-0.771	-0.629
PV-3	6	27676	3.91	449	99.95	586	-2.495	-2.362	-1.330	-0.593	-0.737
SONGS2	4	8419	3.75	1798	0	545	0.077	0.278	-2.010	-1.919	-0.091
SONGS2	4	8419	3.75	1563	0	545	-0.364	-0.205	-1.590	-1.688	0.098
SONGS2	5	11355	3.95	1615	0	545	-0.082	0.071	-1.530	-1.739	0.209
SONGS2	5	11355	3.95	1208	0	545	-0.860	-0.755	-1.050	-1.339	0.289
ST-L-2	5	14397	3.65	1705	0	535	0.208	0.370	-1.620	-1.827	0.207
ST-L-2	5	26200	3.65	280	100	572	-2.114	-2.026	-0.880	-0.427	-0.453
ST-L-2	6	16024	3.85	1784	0	532	0.219	0.372	-1.530	-1.905	0.375
ST-L-2	6	22570	3.85	782	100	572	-1.203	-1.234	0.310	-0.920	1.230
ST-L-2	6	28462	3.85	283	100	572	-2.033	-2.094	0.610	-0.430	1.040
ST-L-2	7	18519	3.93	1510	0	532	-0.063	0.080	-1.430	-1.636	0.206
ST-L-2	8	16648	3.86	1714	0	532	- 0.203	0.370	-1.670	-1.836	0.166
ST-L-2	9	16029	3.94	1550	0	532	-0.096	0.020	-1.160	-1.675	0.515
WSES-3	4	14074	3.82	1540	0	545	-0.074	0.065	-1.390	-1.665	0.275
WSES-3	4	14211	3.82	1077	92	582	-0.964	-0.855	-1.090	-1.210	0.120
WSES-3	4	25206	3.82	370	95	582	-2.129	-2.049	-0.800	-0.516	-0.284
WSES-3	5	14898	3.91	1530	0	545	-0.097	0.003	-1.000	-1.655	0.655
WSES-3	5	15040	3.91	1066	91	582	-0.918	-0.913	-0.050	-1.199	1.149
WSES-3	5	25907	3.91	404	93	582	-2.134	-2.017	-1.170	-0.549	-0.621
WSES-3	6	15524	3.95	1647	0	545	-0.114	0.173	-2.870	-1.770	-1.100
WSES-3	6	15524	3.95	1411	0	545	-0.600	-0.383	-2.170	-1.538	-0.632
WSES-3	6	15638	3.95	1131	90	578	-0.819	-0.726	-0.930	-1.263	0.333
WSES-3	6	27465	3.95	444	96	580	-1.898	-1.875	-0.230	-0.588	0.358
WSES-3	7	14974	3.95	1741	0	545	0.160	0.253	-0.930	-1.863	0.933
WSES-3	7	14974	3.95	1471	0	545	-0.435	-0.305	-1.300	-1.597	0.297
WSES-3	7	16199	3.95	1162	94	578	-0.703	-0.666	-0.370	-1.294	0.924
WSES3	8	14961	4.08	1833	0	548	0.139	0.224	-0.850	-1.953	1.103
WSES3	8	16054	4.08	1254	94.5	578	-0.736	-0.641	-0.950	-1.384	0.434
WSES3	8	26993	4.08	590	92	577	-1.749	-1.583	-1.660	-0.732	-0.928

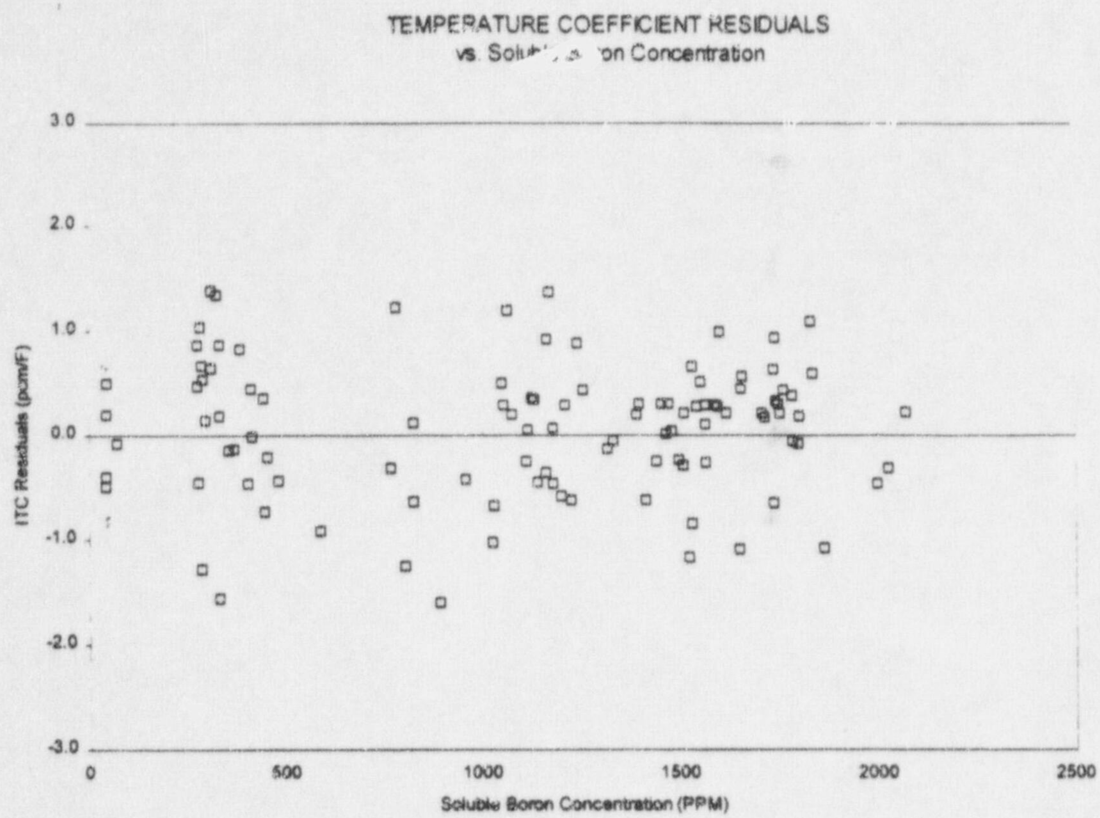
TEMPERATURE COEFFICIENT RESIDUALS
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
ITC Residuals (pcm/F)
0
500
1000
1500
2000
2500
Soluble Boron Concentration (PPM)

Figure 1

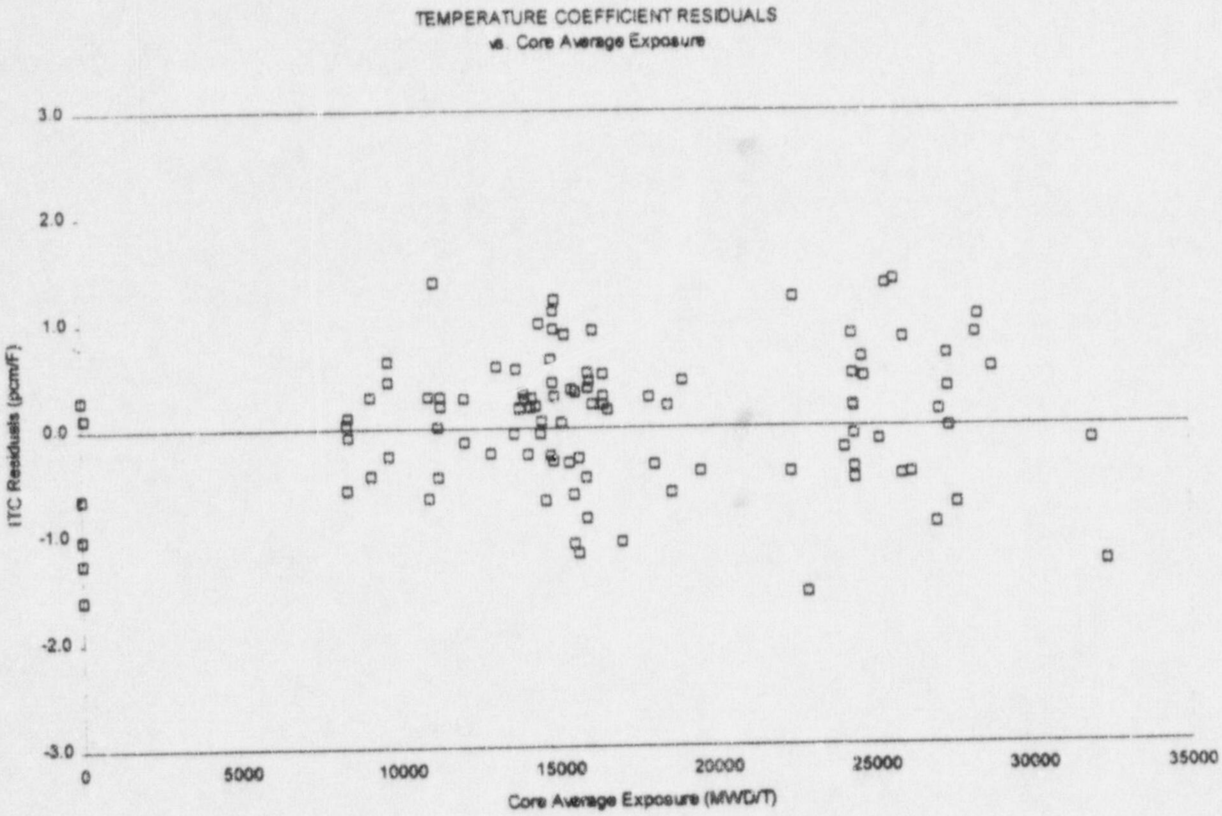
TEMPERATURE COEFFICIENT RESIDUALS
vs. Core Average Exposure
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
ITC Residuals (pcm/F)
0
5000
10000
15000
20000
25000
30000
35000
Core Average Exposure (MWD/T)

Figure 2

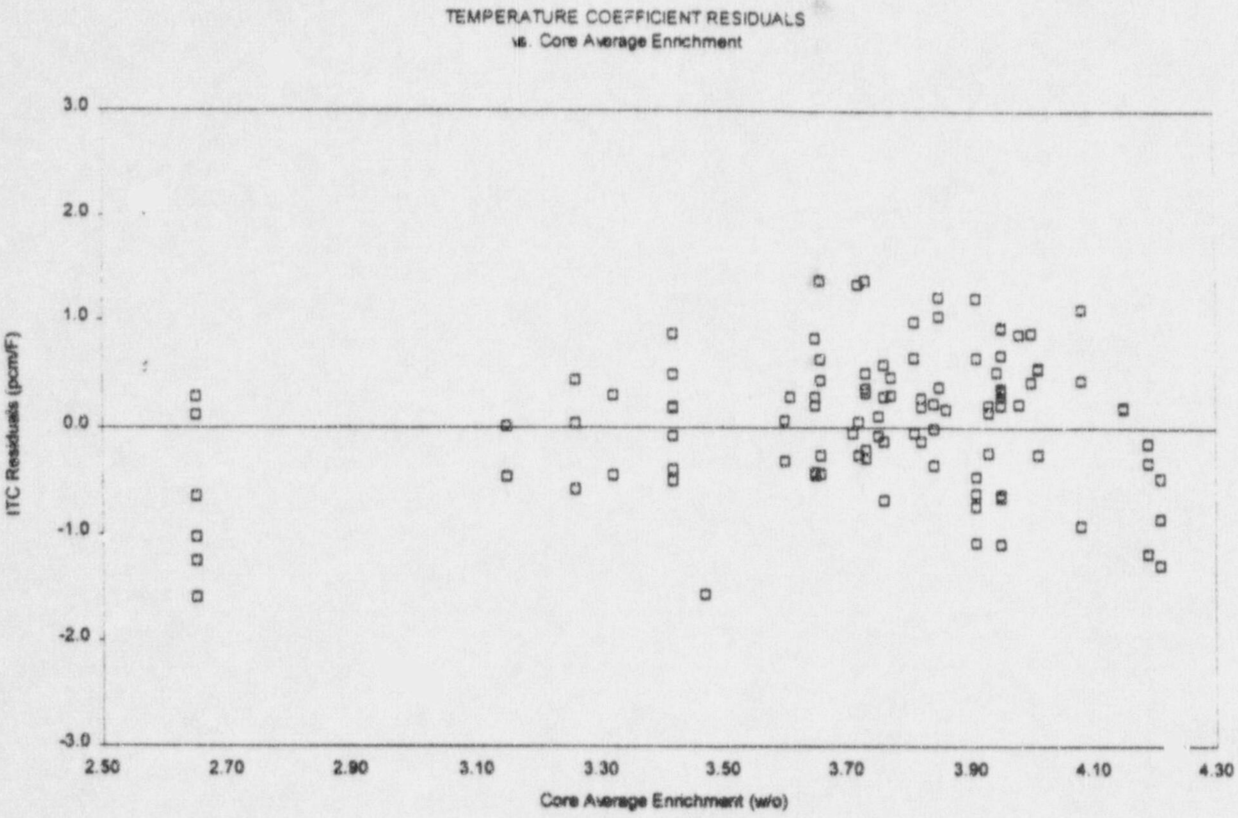
TEMPERATURE COEFFICIENT RESIDUALS
vs. Core Average Enrichment
ITC Residuals (pcm/F)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
2.50
2.70
2.90
3.10
3.30
3.50
3.70
3.90
4.10
4.30
Core Average Enrichment (w/o)

Figure 3

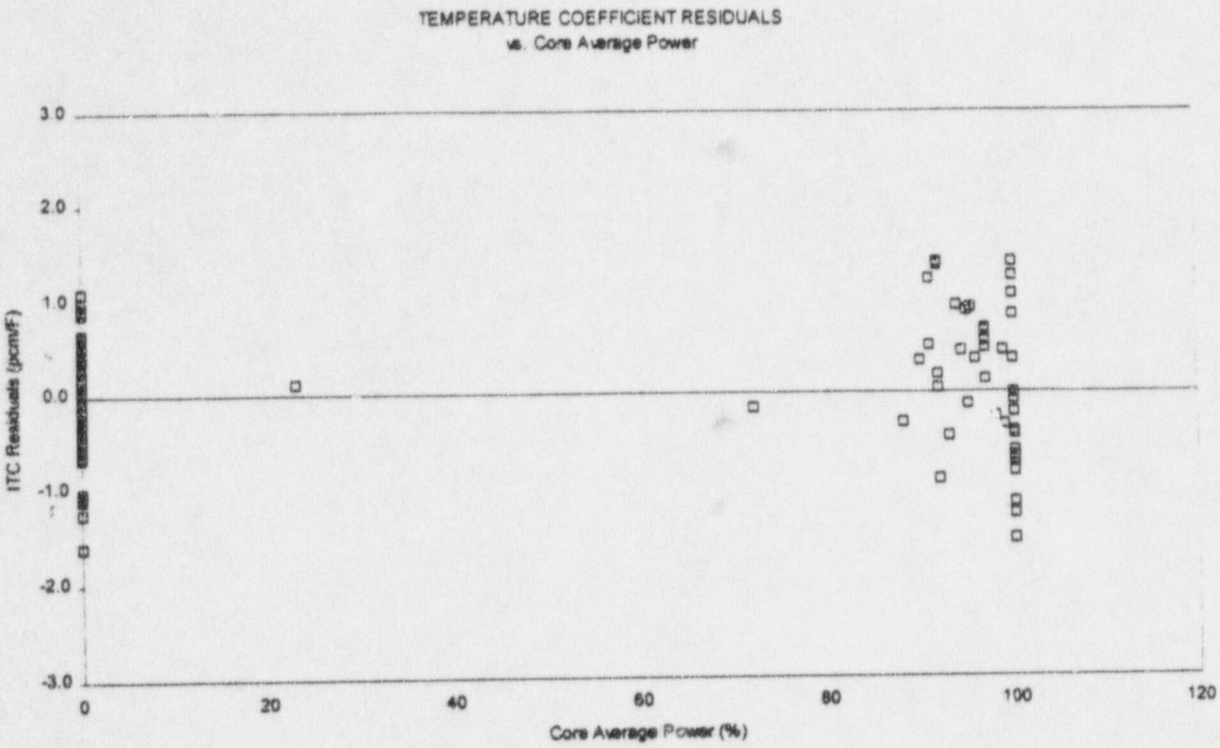
TEMPERATURE COEFFICIENT RESIDUALS
vs. Core Average Power
ITC Residuals (pcm/F)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
0
20
40
60
80
100
120
Core Average Power (%)

Figure 4

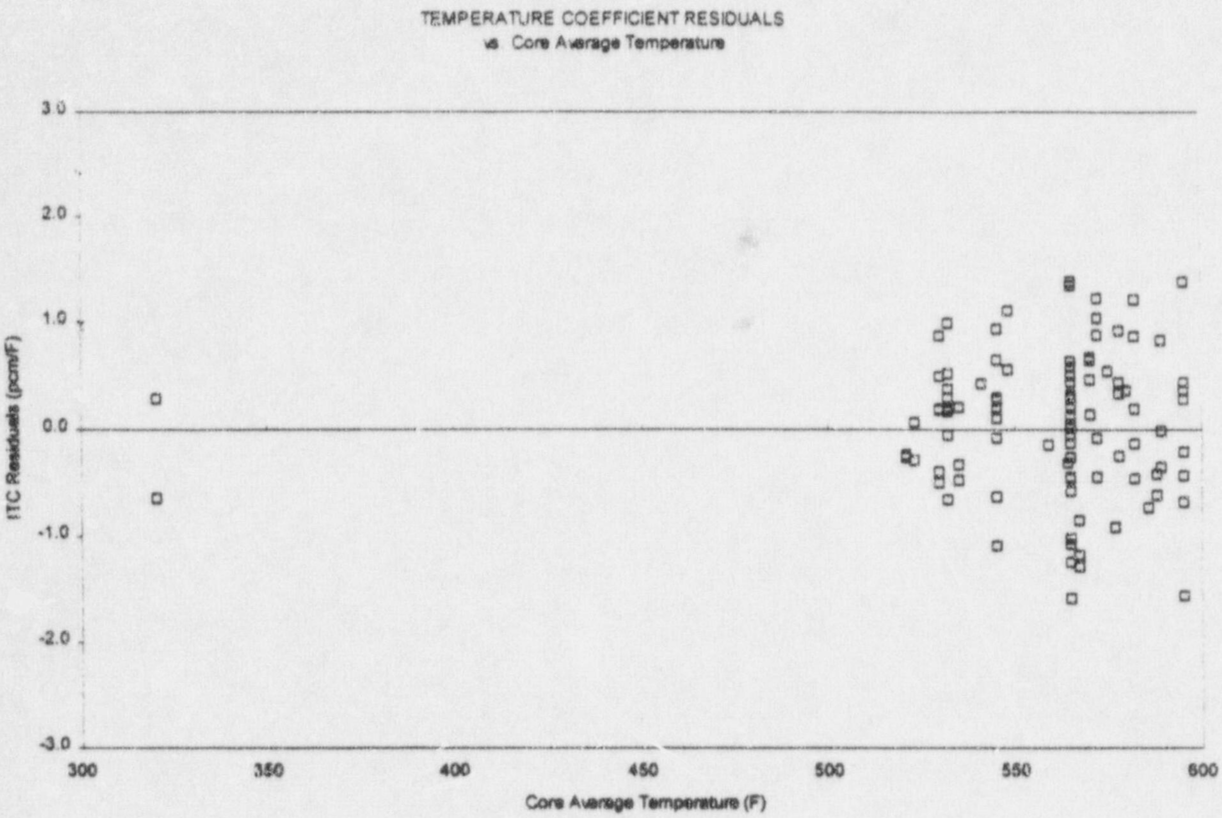
TEMPERATURE COEFFICIENT RESIDUALS
vs Core Average Temperature
ITC Residuals (pcm/F)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
300
350
400
450
500
550
600
Core Average Temperature (F)

Figure 5

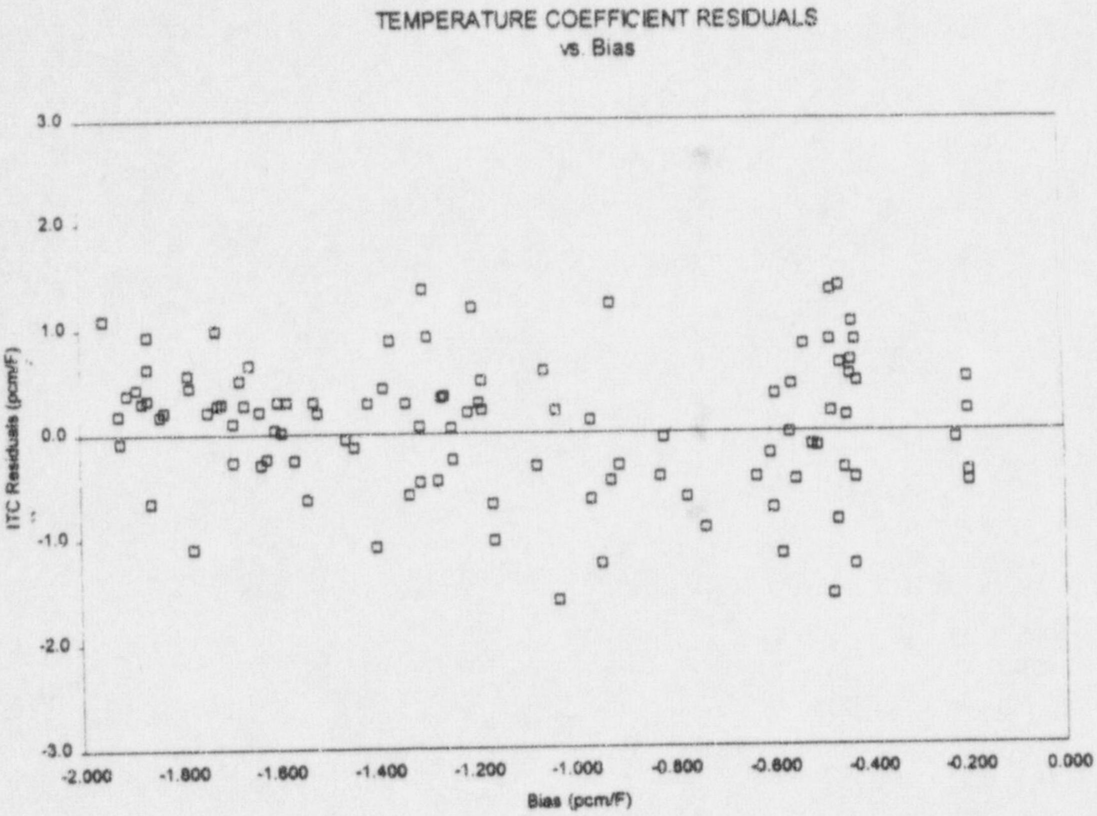
TEMPERATURE COEFFICIENT RESIDUALS
vs. Bias
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
ITC Residuals (pcm/F)
-2.000
-1.800
-1.600
-1.400
-1.200
-1.000
-0.800
-0.600
-0.400
-0.200
0.000
Bias (pcm/F)

Figure 6

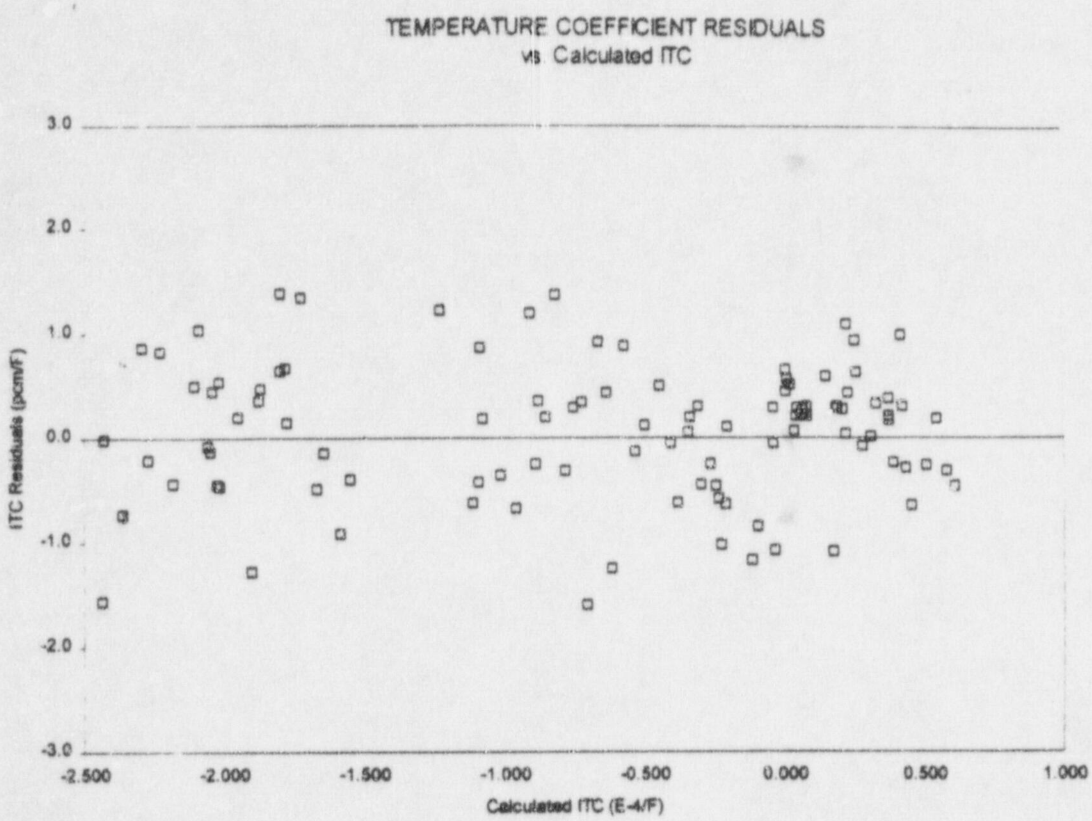
TEMPERATURE COEFFICIENT RESIDUALS
vs Calculated ITC
ITC Residuals (pcm/F)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-2.500
-2.000
-1.500
-1.000
-0.500
0.000
0.500
1.000
Calculated ITC (E-4/F)

Figure 7

Appendix A

ABB-CE Response to Questions

This Appendix A has been prepared in response to a number of questions raised by the NRC on the original submittal.

1. What methodology is used for calculating MTC?

The Isothermal Moderator Temperature Coefficients (ITC) are calculated with the ROCS coarse mesh nuclear design code. (Reference 1) This code performs two- or three-dimensional flux calculations in full-, half- or quarter-core geometries. A typical ROCS core geometry consists of four radial nodes per fuel assembly and 20 to 30 axial planes. The nodal macroscopic cross sections are calculated from detailed isotopic concentrations and microscopic cross sections. The nuclides are divided into three categories:

Fuel:	Includes two uranium, one neptunium and four plutonium nuclides,
Fission products:	Includes I-135 and Xe-135, Pm-149 and Sm-149 and a lumped fission products,
Burnable absorbers:	Includes depletable boron (B-10), erbium or gadolinium nuclides.

The microscopic cross sections are functionalized vs burnup and operating conditions such as moderator temperature, moderator density, fuel temperature and soluble boron concentration. This treatment provides for a very accurate representation of the cross sections under any operating conditions, and for accurate spatial isotopic distributions, accounting for all history effects. During the flux calculation, thermal-hydraulic feedback and equilibrium xenon calculations are performed to ensure consistency between the power, moderator temperature and density, fuel temperature and xenon distributions. The local fuel temperature is determined from a correlation vs burnup and power, and from the local moderator temperature.

The calculation of the moderator temperature coefficient is performed as follows:

1. A reference calculation is performed to simulate the core conditions at the beginning of the testing program. All thermal-hydraulic and xenon feedback options are exercised, and the critical control rod position and soluble boron concentration are supplied.

2. Two off-nominal calculations are performed by changing the inlet temperature above and below that of the reference condition, usually by 3°F. The power level, xenon distribution, control rod insertion and soluble boron concentration are kept unchanged from the reference condition. The change in core reactivity is therefore due to the change in inlet temperature, and to the ensuing change in the distribution of the moderator temperature and density and of the fuel temperature. For the nominal and the off-nominal cases, the ROCS code provides an edit of the core reactivity and of the volume average moderator temperature. The moderator temperature coefficient is defined as the ratio of the reactivity change to the core average moderator temperature change.

The moderator temperature coefficient prediction is usually accompanied by one of two of the following calculations, depending upon the measuring technique. If the ITC is measured by the rod insertion technique, a prediction of the lead bank insertion worth curve is performed, using full thermal-hydraulic feedback, but keeping the power level, xenon distribution, inlet temperature and soluble boron concentration of the reference case. If the ITC is measured with the power trade technique, a prediction of the power coefficient is performed, again under the rod insertion, boron concentration and xenon distribution of the reference case.

2. *Has the methodology changed since the data analysis presented in the report? If yes, please explain changes and the effect of these changes.*

All results presented in this topical report and its amendment have been generated with the same methodology.

3. *Is only the methodology referenced in answering question 1 involved or are there more than one m..nodologies involved?*

The methodology described in paragraph 1 above is the only one which has been used in the preparation of this report.

4. *Will Combustion Engineering perform the calculations in all cases or will the utilities perform them in some cases? If utilities perform the calculations, what codes will they use?*

Combustion Engineering has performed all calculations presented in this report. Should Utilities perform such calculations in the future, they will use a consistent methodology. The analysis presented in this report has demonstrated the random nature of the residual between measured and predicted temperature coefficients. Since the residual cannot be correlated against any parameter, one can assume that it is due entirely to measurement uncertainties, and as such is independent of the analytical technique. Any NRC approved physics code system, e.g. DIT-ROCS or CASMO-SIMULATE, will lead to the same level of uncertainties. However, the calculational bias will be established for each code system.

5. *Assuming Combustion Engineering has performed all the calculations, why is there not more data? In addition, please supply all additional data obtained since the report was prepared (Update Table 1 to include all data available)*

The data base presented in the Topical Report contains a large number of measurements, collected under various operating conditions for all classes of Combustion Engineering plants. The purpose of the report was to present a large enough data base and to perform statistical tests to show that data from various plants, under various power levels or exposures, measured with various experimental techniques, belong to the same population. Therefore, the addition or removal of some data points will not impact the conclusions.

The data base was considered to be large enough to justify the conclusions reached in the report. Since the Report was issued in 1993, 34 data points have been added to the data base and are presented in this Amendment. The additional data provides a significant sample of all Combustion Engineering plants (2700 MW, 2815 MW, 3400 MW and 3800 MW), using both the rod insertion and the power trade measurement techniques. The extended data confirms the validity of the conclusions reached earlier. Because of the truly random nature of the data base, the sample size chosen for this amendment is deemed sufficient.

Some experimental data from earlier cycles of older plants has not been incorporated, because it was originally analyzed with slightly different methods and also because the fuel management used at the time was not representative of current fuei management practices.

6. In examining the data on Table 1, it appears that there are only a small number of sets (consisting of 3 measurements - a BOC, zero power measurement; - a BOC, full power measurement; and a near EOC full power measurement) of data. Why is this the case?

The data base presented in this amendment has been increased and now contains 15 sets of 3 measurements per cycle (- a BOC, zero power measurement; - a BOC, full power measurement; and a near EOC full power measurement). In addition, 6 sets of 2 measurements (- a BOC, zero power measurement and a near EOC full power measurement) are included. A total of 30 near EOC values are included in the data base.

7. From the data in Table 1, there are only 5 cases in which all three measurements fall within the acceptance criteria. Please discuss why this should be sufficient.

In the increased data base, only one data point shows a deviation equal to the design basis. Of the 15 sets of three measurements and 6 sets of 2 measurements, no data point exceeds the design basis.

<u>**Reference:**</u>

1. "The ROCS and DIT Computer Codes for Nuclear Design," CENPD-266-P-A, April, 1983.