FRAMATOME
TECHNOLOGIES

April 8, 1997
JHT/97-19

U. S. Nuclear Regulatory Commission
ATTN.: Document Control Desk
Washington, D.C. 20555

Subject: Revised Measurement Uncertainty for Westinghouse 193 Plant Control Rod Worth Calculations

Reference: J. H. Taylor to U. S. Nuclear Regulatory Commission, Revised Measurement Uncertainty for Westinghouse 193 Plant Control Rod worth Calculations, JHT/96-76, November 7, 1996.

Gentlemen:

The reference letter provided the justification for reducing the uncertainty factor that Framatome Cogema Fuels (FCF) currently applies to control rod worth calculations for Westinghouse 193 assembly cores. Since the submittal of that letter the NRC has expressed concern over the wording of FCF's commitment to validate the uncertainty factor on a cycle by cycle basis. In order to eliminate this concern FCF is revising the commitment to read as follows:

> The validity of these reliability factors will be checked each cycle through zero power physics testing. The acceptance criteria for individual group rod worth and total rod worth will be the same as the reliability factors used in the reload licensing evaluation for that cycle. If any acceptance criterion is not met, an evaluation will be performed. Power will not be escalated until the evaluation shows that plant safety will not be compromised by such escalation.

Also, in a teleconference held on April 8, 1997, FCF provided additional information satisfying a question about the determination of the K factor used to calculate the nuclear reliability factor (NRF). A copy of that information is attached.

3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Telephone: 804-832-3000 Fax: 804-832-3663
Internet: http://www.framatech.com

FCF has used the revised NRF in the licensing evaluation for Sequoyah Unit 1 cycle 9 which includes the determination of refueling boron concentration. Sequoyah Unit 1 cycle 9 is scheduled to begin refueling on April 16, 1997. Please provide your approval for the revised uncertainty by April 15, 1997.

Very truly yours,

C F McPhatter for

J. H. Taylor, Manager
Licensing Services

cc: R. B. Borsum
J. E. Lyons, NRC
M. S. Chatterton, NRC
Dan Lurie, NRC
R. W. Hernan, NRC

SCR-607

Sandia Corporation

MONOGRAPH

FACTORS FOR ONE-SIDED TOLERANCE LIMITS AND FOR VARIABLES SAMPLING PLANS

by

D B Owen

MARCH 1963

4.2.11 Values of k for $\gamma = .95$ and $n = 17$

$$Pr\{T_f \leq k\sqrt{n} \mid K_p\sqrt{n}\} = \gamma$$

f	.75000	.90000	.95000	.97500	.99000	.99900	.99990	.99999
				P				
1	10.757	20.436	26.230	31.255	37.098	49.280	59.3[illegible]	68.013
2	3.147	5.749	7.333	8.713	10.322	13.682	16.452	18.858
3	2.160	3.850	4.888	5.794	6.853	9.069	10.897	12.487
4	1.803	3.159	3.996	4.730	5.587	7.382	8.866	10.155
5	1.622	2.806	3.539	4.182	4.934	6.512	7.817	8.951
6	1.513	2.591	3.260	3.847	4.535	5.980	7.174	8.213
7	1.440	2.446	3.072	3.621	4.265	5.618	6.737	7.712
8	1.388	2.342	2.936	3.457	4.069	5.355	6.420	7.347
9	1.348	2.264	2.833	3.333	3.920	5.155	6.178	7.069
10	1.318	2.202	2.752	3.235	3.803	4.997	5.987	6.849
11	1.294	2.153	2.686	3.156	3.708	4.869	5.832	6.670
12	1.274	2.112	2.633	3.091	3.629	4.763	5.703	6.522
13	1.257	2.078	2.587	3.036	3.563	4.673	5.594	6.396
14	1.243	2.049	2.549	2.989	3.506	4.596	5.501	6.289
15	1.231	2.023	2.515	2.948	3.457	4.530	5.420	6.195
16	1.220	2.002	2.486	2.913	3.414	4.471	5.348	6.113
17	1.211	1.983	2.461	2.882	3.376	4.420	5.285	6.040
18	1.203	1.966	2.438	2.854	3.343	4.374	5.229	5.975
19	1.196	1.950	2.418	2.829	3.312	4.332	5.179	5.917
20	1.190	1.937	2.399	2.807	3.285	4.295	5.133	5.864
21	1.184	1.925	2.383	2.786	3.260	4.261	5.091	5.816
22	1.179	1.914	2.368	2.768	3.238	4.230	5.054	5.772
23	1.174	1.903	2.354	2.751	3.217	4.201	5.019	5.732
24	1.170	1.894	2.342	2.735	3.198	4.175	4.987	5.694
25	1.166	1.886	2.330	2.721	3.181	4.151	4.957	5.660
26	1.162	1.878	2.319	2.708	3.165	4.128	4.929	5.628
27	1.158	1.870	2.309	2.696	3.150	4.108	4.904	5.598
28	1.155	1.864	2.300	2.684	3.136	4.088	4.880	5.571
29	1.152	1.857	2.292	2.674	3.123	4.070	4.857	5.545
30	1.150	1.851	2.284	2.664	3.110	4.053	4.836	5.520
31	1.147	1.846	2.276	2.654	3.09[illegible]	4.037	4.817	5.497
32	1.145	1.841	2.269	2.646	3.088	4.022	4.798	5.476
33	1.143	1.836	2.262	2.637	3.078	4.008	4.781	5.455
34	1.140	1.831	2.256	2.630	3.068	3.994	4.764	5.436
35	1.139	1.827	2.250	2.622	3.059	3.981	4.748	5.417
36	1.137	1.823	2.245	2.615	3.051	3.969	4.733	5.400
37	1.135	1.819	2.239	2.609	3.042	3.958	4.719	5.383
38	1.133	1.816	2.234	2.602	3.035	3.947	4.706	5.368
39	1.132	1.812	2.230	2.597	3.027	3.937	4.693	5.353
40	1.130	1.809	2.225	2.591	3.020	3.927	4.680	5.338
41	1.129	1.806	2.221	2.585	3.014	3.917	4.669	5.325
42	1.127	1.803	2.217	2.580	3.007	3.908	4.657	5.312
43	1.126	1.800	2.213	2.575	3.001	3.900	4.647	5.299
44	1.125	1.797	2.209	2.571	2.995	3.891	4.636	5.287
45	1.124	1.795	2.206	2.566	2.990	3.884	4.627	5.275

4.2.12 Values of k for $\gamma = .95$ and $n = 37$

$$\Pr\left\{T_f \le k\sqrt{n} \mid K_p\sqrt{n}\right\} = \gamma$$

	P							
F	.75000	.90000	.95000	.97500	.99000	.99900	.99990	.99999
1	10.755	20.437	26.230	31.256	37.098	49.280	59.308	68.013
2	3.057	5.700	7.295	8.681	10.295	13.662	16.435	18.844
3	2.062	3.792	4.842	5.756	6.821	9.045	10.877	12.469
4	1.701	3.096	3.946	4.587	5.550	7.355	8.843	10.135
5	1.517	2.738	3.485	4.135	4.895	6.482	7.792	8.929
6	1.405	2.520	3.202	3.798	4.493	5.947	7.147	8.189
7	1.331	2.372	3.011	3.569	4.220	5.583	6.709	7.686
8	1.277	2.265	2.872	3.403	4.022	5.319	6.390	7.320
9	1.237	2.184	2.767	3.276	3.871	5.187	6.146	7.041
10	1.205	2.121	2.684	3.176	3.752	4.958	5.954	6.820
11	1.180	2.069	2.616	3.095	3.655	4.828	5.797	6.640
12	1.159	2.027	2.560	3.028	3.575	4.720	5.667	6.490
13	1.142	1.991	2.513	2.971	3.507	4.629	5.557	6.36[illegible]
14	1.127	1.960	2.473	2.923	3.448	4.551	5.462	6.25[illegible]
15	1.114	1.934	2.438	2.881	3.398	4.483	5.380	6.160
16	1.103	1.911	2.408	2.844	3.354	4.423	5.308	6.077
17	1.094	1.890	2.381	2.811	3.314	4.371	5.244	6.004
18	1.085	1.872	2.357	2.782	3.279	4.323	5.187	5.938
19	1.077	1.856	2.336	2.756	3.248	4.281	5.135	5.878
20	1.071	1.841	2.316	2.732	3.220	4.242	5.088	5.825
21	1.064	1.828	2.299	2.711	3.194	4.207	5.046	5.776
22	1.059	1.816	2.283	2.691	3.170	4.176	5.007	5.731
23	1.054	1.805	2.268	2.673	3.149	[illegible].146	4.972	5.690
24	1.049	1.795	2.254	2.657	3.129	4.119	4.939	5.652
25	1.045	1.786	2.242	2.642	3.110	4.094	4.908	5.6[illegible]
26	1.041	1.777	2.230	2.628	3.093	4.071	4.880	5.584
27	1.037	1.7[illegible]	2.220	2.615	3.077	4.049	4.854	5.554
28	1.034	1.762	2.210	2.602	3.062	4.029	4.829	5.525
29	1.031	1.755	2.200	2.591	3.048	4.010	4.806	5.499
30	1.028	1.749	2.192	2.580	3.035	3.992	4.784	5.474
31	1.025	1.743	2.183	2.570	3.023	3.975	4.764	5.450
32	1.023	1.737	2.176	2.561	3.012	3.960	4.744	5.428
33	1.020	1.732	2.168	2.552	3.001	3.945	4.726	5.407
34	1.018	1.726	2.162	2.543	2.991	3.931	4.709	5.387
35	1.016	1.722	2.155	2.535	2.981	3.917	4.693	5.368
36	1.014	1.717	2.149	2.528	2.972	3.904	4.677	5.350
37	1.012	1.713	2.143	2.521	2.963	3.892	4.662	5.333
38	1.010	1.709	2.138	2.514	2.954	3.881	4.648	5.316
39	1.009	1.705	2.132	2.507	2.947	3.870	4.635	5.301
40	1.007	1.701	2.127	2.501	2.939	3.859	4.622	5.286
41	1.005	1.698	2.123	2.495	2.932	3.849	4.610	5.272
42	1.004	1.695	2.118	2.490	2.925	3.840	4.598	5.258
43	1.003	1.691	2.114	2.484	2.918	3.831	4.587	5.245
44	1.001	1.688	2.110	2.479	2.912	3.822	4.576	5.233
45	1.000	1.686	2.106	2.474	2.906	3.813	4.566	5.221

Combine 193 Plant Rod Uncertainty Data with Mk-B Data

One thing that can be done is to "pool" the 193 plant rod worth by dilution data with the Mark-B data. Statistical results of the two sets are compared below:

Data Set	Mean, Xbar	STD	Sample Size, n
193 plant	1.82	2.70	23
Mk-B	-1.52	2.67	20

Comparison of the above data suggests that the mean is not poolable (ie., there is a bias between the Mk-B and 193 plant results) but the standard deviation is poolable. Assuming only the standard deviation is poolable, the Mark-B and 193 plant data were combined as follows. First, the variances were combined:

$$S_p^2 = [(n_{193} - 1)*S_{193}^2 + (n_{MkB} - 1)*S_{MkB}^2]/(n_{193} + n_{MkB} - 2)$$

$$= (22*2.70^2 + 19*2.67^2) / 41 = 7.2153$$

and

$$STD_p = SQRT(S_p^2) = 2.6861$$

Therefore the combined dataset is:

Data Set	Mean, Xbar	STD	Sample Size, n
Combined	1.82	2.6861	43 (41 df)

Calculation of the reliability or uncertainty factor is $RF_p = Xbar + K_p * STD_p$, where K_p needs to be determined for a situation where the number of degrees of freedom for the mean (ie.,n= 23) is different from the number of degrees of freedom for the STD (or variance), ie., f=41 (f used for degrees of freedom for STD, to differeniate from n, which is used for Xbar). K_p can be calculated from Table 4 of SCR-607. The following data is extracted from Table 4.2.11 and 4.2.12 for P=.95 and gamma = .95:

n	f	K_p
17	41	2.221
37	41	2.123

(Note: n = sample size or degrees of freedom for the mean and f=degrees of freedom for the variance)

Linearly interpolating to $n=23$ gives $k = 2.1916$. Therefore

$RF = 1.82 + 2.1916 * 2.6861 = 7.71$ % or

$RF = 8$% (conservatively rounded up)