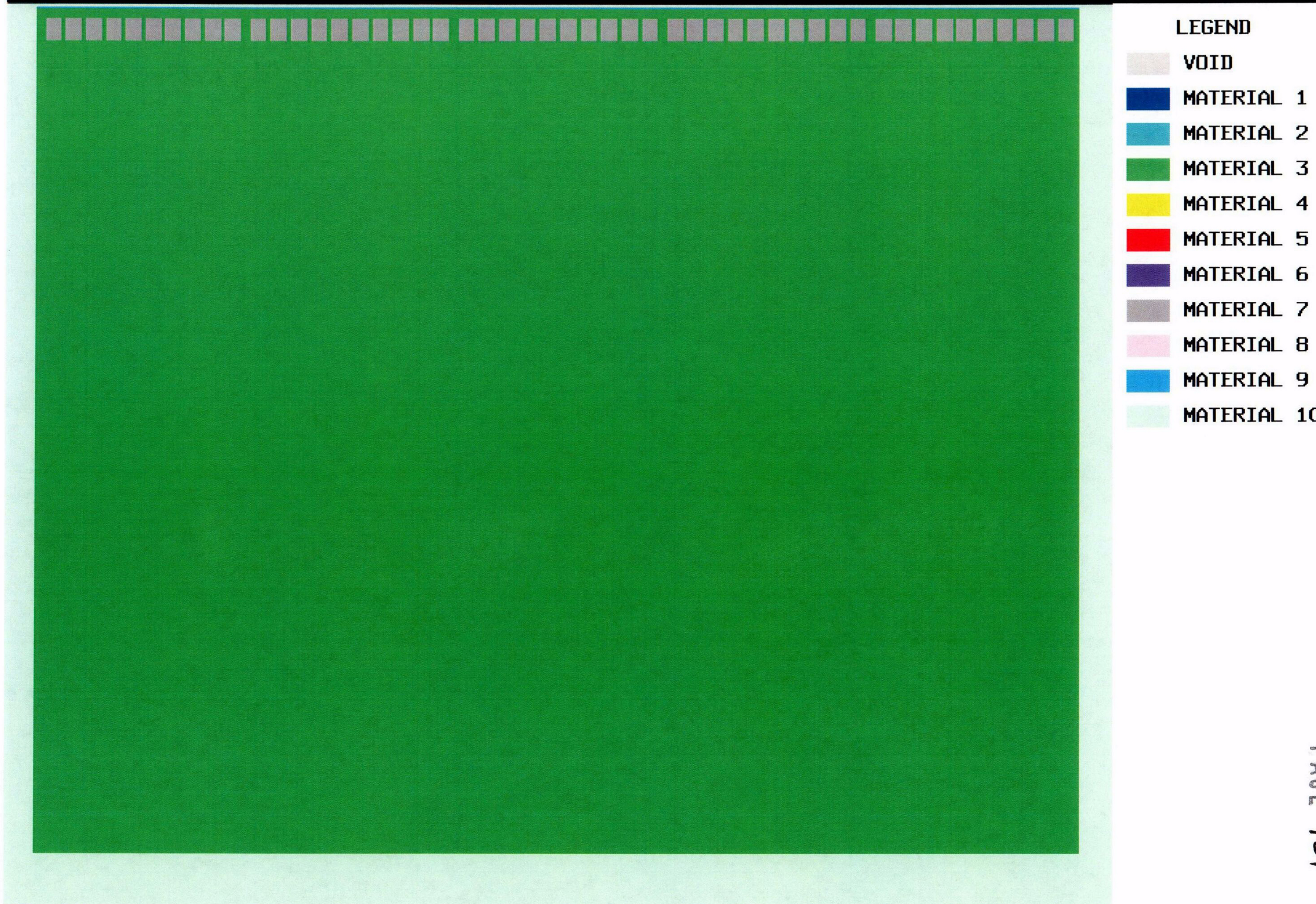
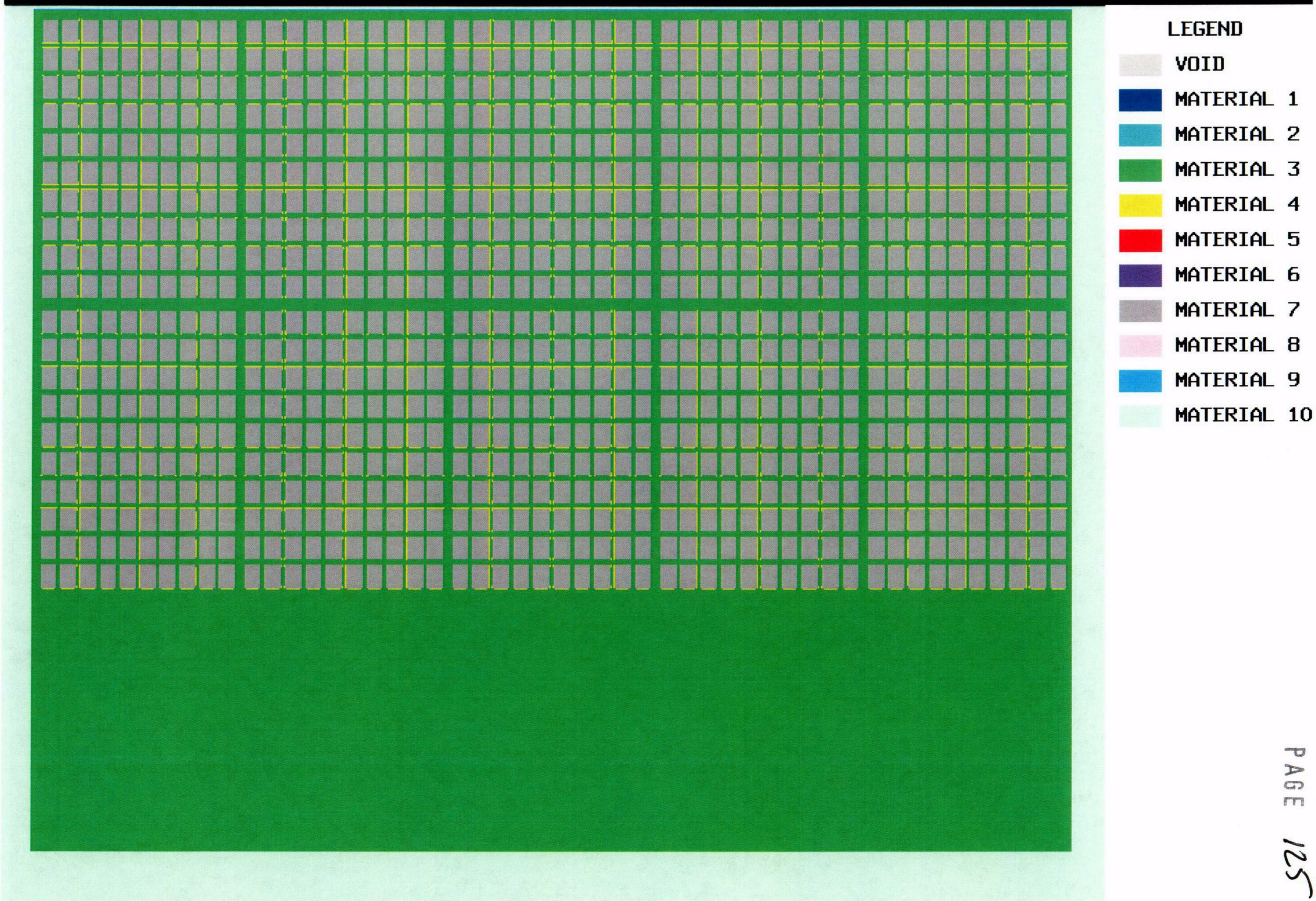
KU2SFPCR X-Y GEOMETRY FOR UNIT 2 SFP AT Z=420.0 CM

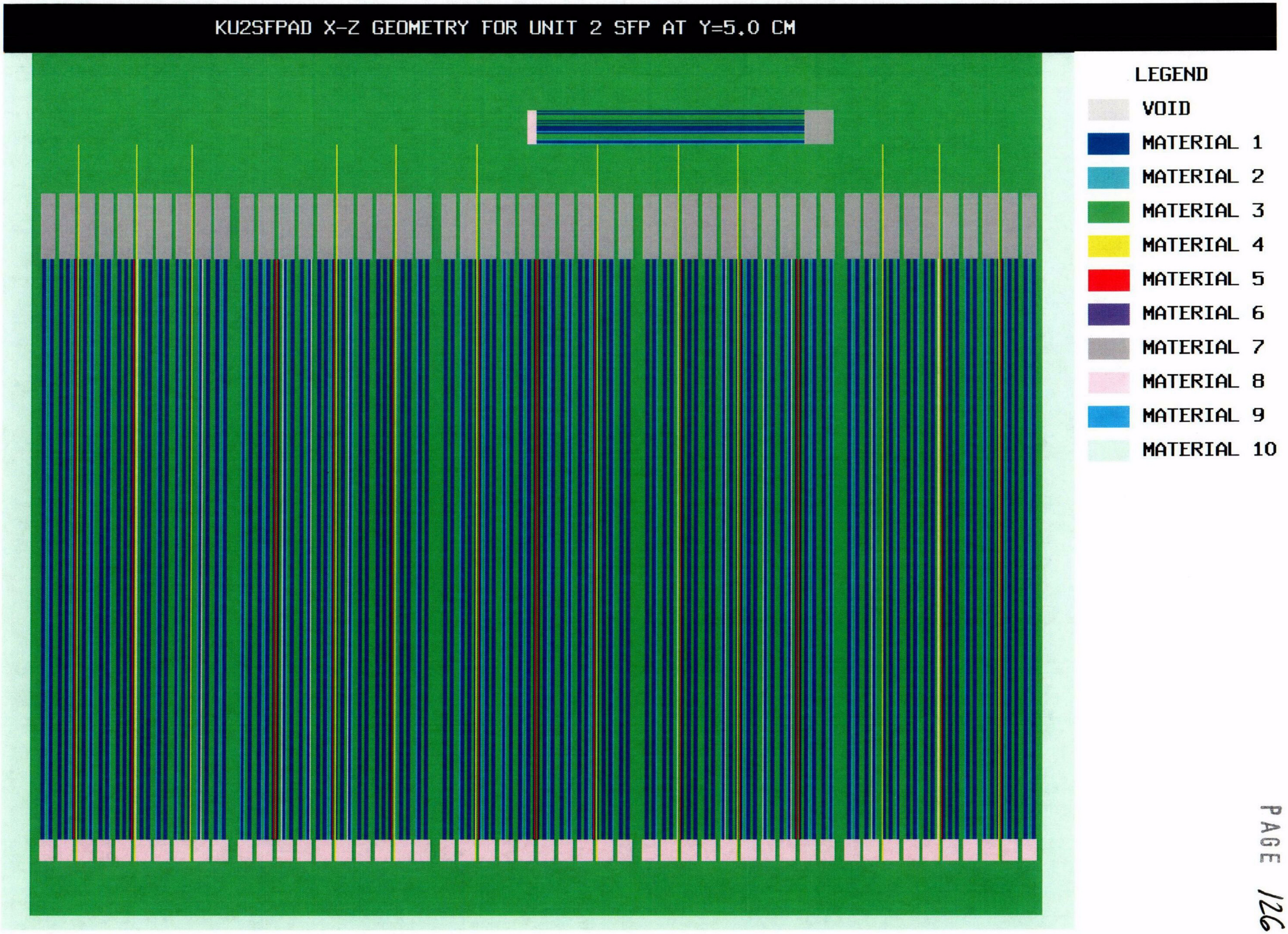


KU2SFPAD X-Y GEOMETRY FOR UNIT 2 SFP AT Z=375.0 CM



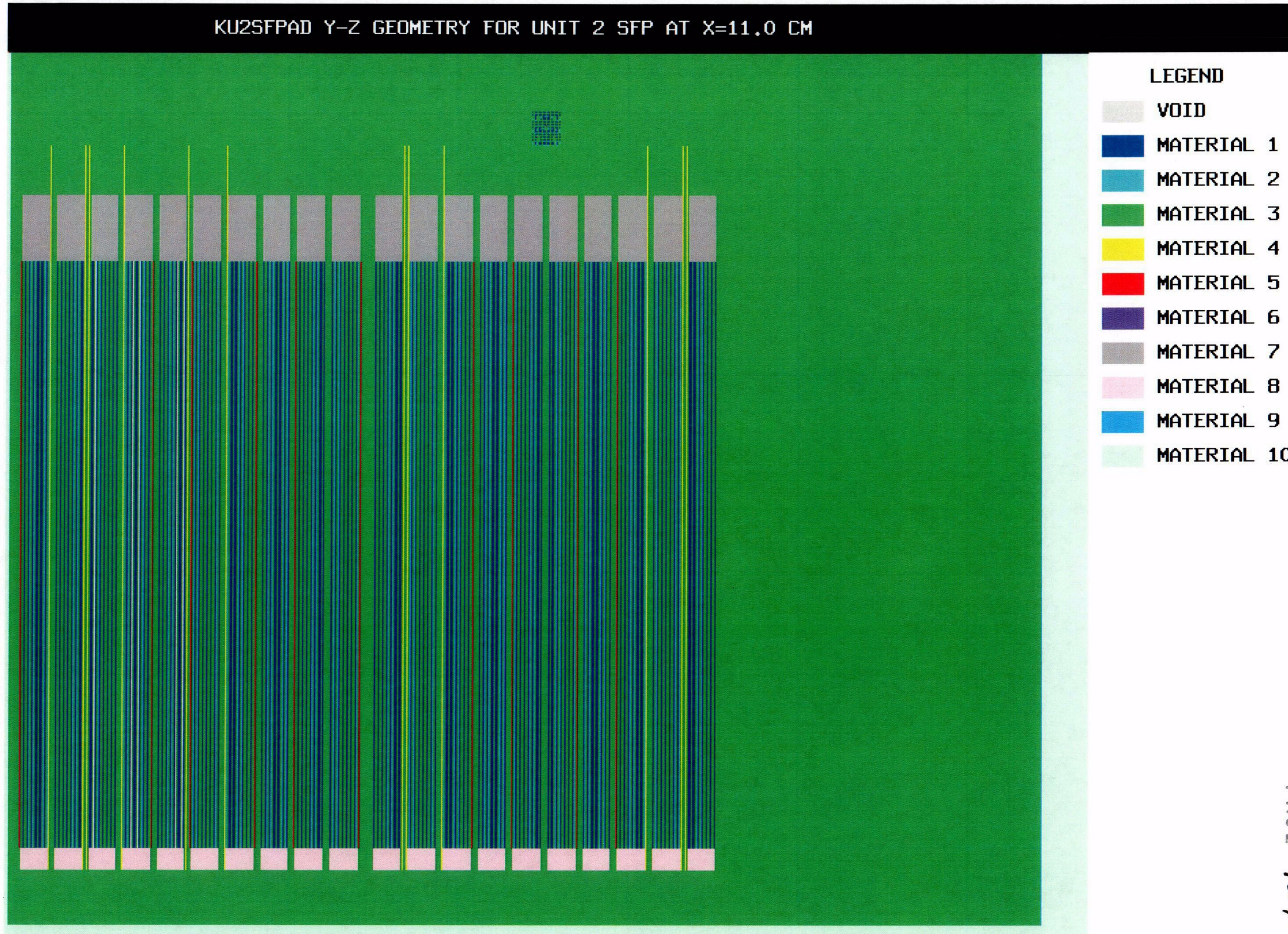
CA06015 REV 0
PAGE 125

C07



CA06015 REV 0
PAGE 126

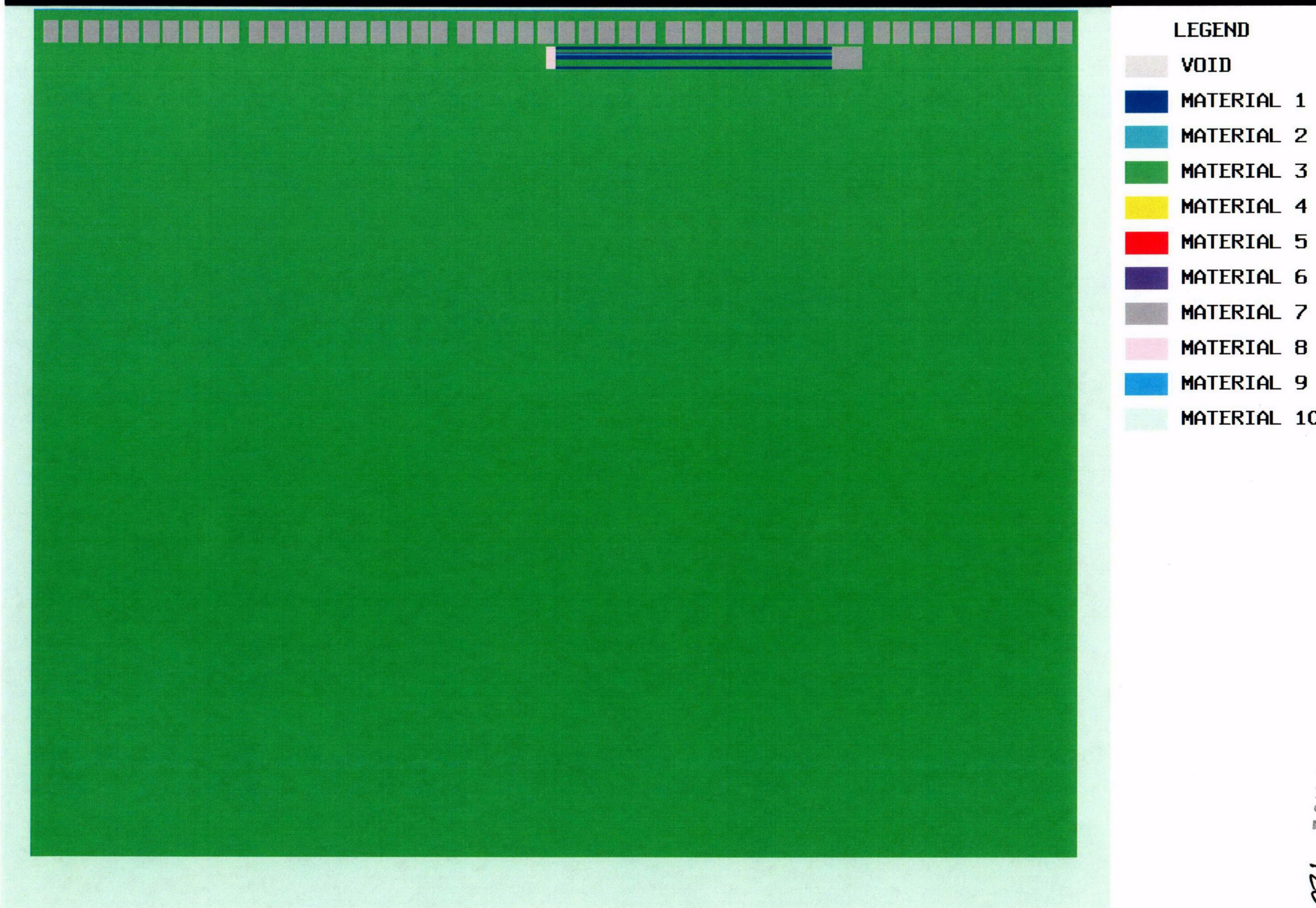
C08



CA06015 REV 0
PAGE 127

c09

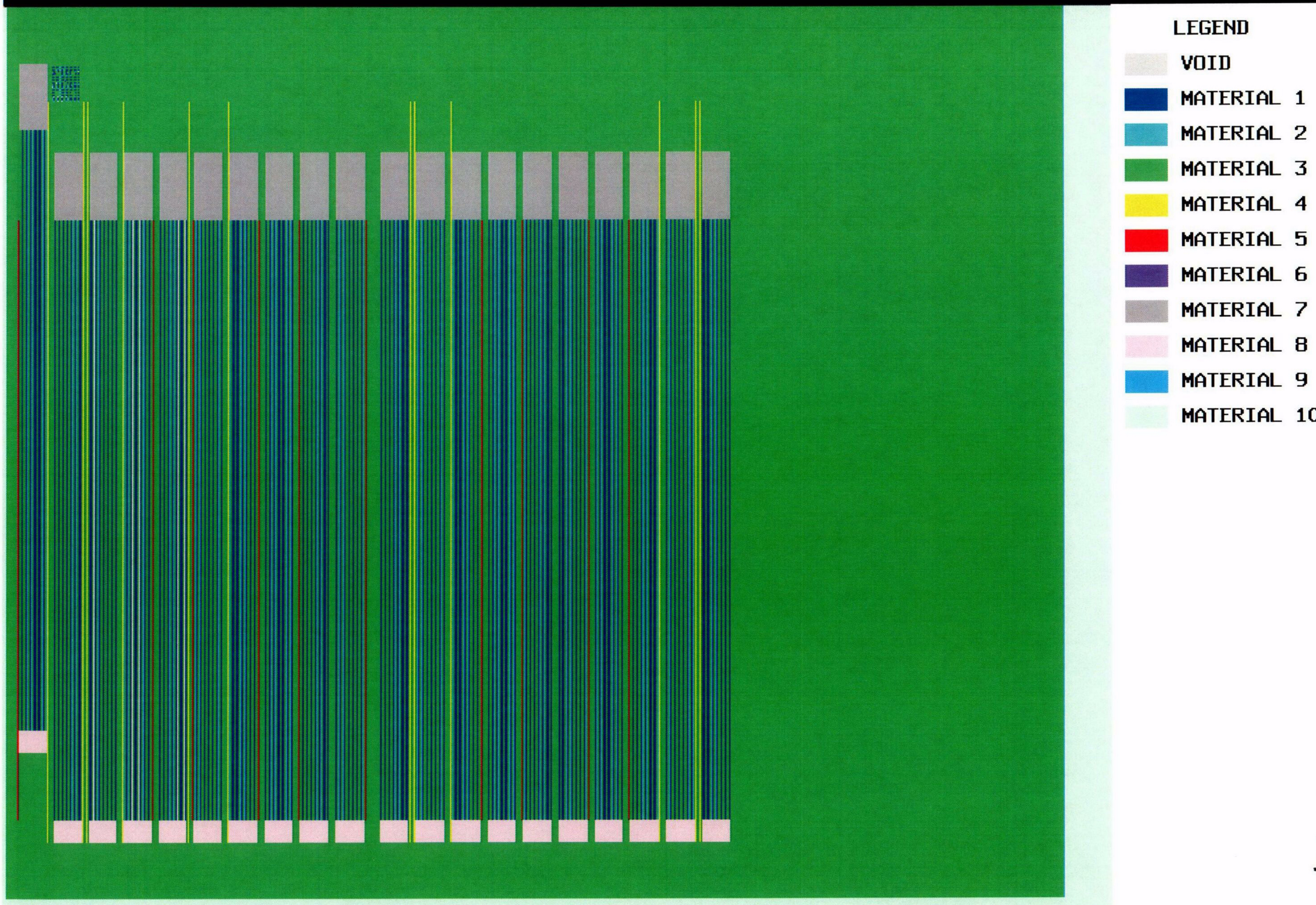
KU2SFPARD X-Y GEOMETRY FOR UNIT 2 SFP AT Z=420.0 CM



CA06015 REV 0
PAGE 128

C10

KU2SFPCRD Y-Z GEOMETRY FOR UNIT 2 SFP AT X=11.0 CM



CA06015 REV 0
PAGE 129

ATTACHMENT I
AXIAL BURNUP PROFILES

Worst Case Axial Burnup Distributions from ORNL/TM-1999/246

Midpoints %	Endpoints %	Delta %	46+	42-46	38-42	34-38	30-34	26-30	22-26	18-22	14-18	10-14	6-10	6-
	0.00													
2.78	5.56	5.56	0.573	0.615	0.607	0.520	0.537	0.551	0.544	0.540	0.502	0.489	0.478	0.470
8.33	11.11	5.56	0.917	0.918	0.914	0.888	0.895	0.886	0.869	0.860	0.817	0.772	0.773	0.775
13.89	16.67	5.56	1.021	1.020	1.024	1.009	1.007	1.007	0.962	0.965	0.925	0.944	0.950	0.955
19.44	22.22	5.56	1.040	1.045	1.041	1.046	1.045	0.974	0.918	0.921	0.796	0.857	1.059	1.064
25.00	27.78	5.56	1.126	1.120	1.124	1.155	1.141	1.146	1.138	1.174	1.260	1.179	1.205	1.141
30.56	33.34	5.56	1.123	1.112	1.117	1.143	1.140	1.138	1.140	1.176	1.254	1.151	1.201	1.162
36.11	38.90	5.57	1.118	1.116	1.108	1.136	1.135	1.140	1.153	1.171	1.242	1.186	1.211	1.180
41.69	44.46	5.56	1.113	1.114	1.107	1.137	1.130	1.135	1.153	1.166	1.234	1.181	1.215	1.189
47.22	50.00	5.55	1.109	1.104	1.103	1.137	1.125	1.138	1.172	1.167	1.277	1.180	1.218	1.192
52.78	55.56	5.56	1.105	1.107	1.102	1.133	1.121	1.166	1.192	1.185	1.323	1.236	1.216	1.191
58.33	61.11	5.56	1.101	1.101	1.099	1.130	1.138	1.173	1.201	1.188	1.336	1.261	1.209	1.185
63.89	66.67	5.55	1.098	1.101	1.101	1.145	1.145	1.173	1.203	1.186	1.335	1.265	1.194	1.172
69.44	72.22	5.56	1.101	1.107	1.111	1.145	1.142	1.169	1.199	1.182	1.325	1.261	1.170	1.158
75.00	77.78	5.56	1.098	1.104	1.112	1.143	1.136	1.157	1.185	1.173	1.299	1.244	1.151	1.130
80.56	83.34	5.56	1.028	1.025	1.029	1.025	1.020	1.022	1.014	1.008	0.756	0.951	0.976	1.021
86.11	88.89	5.55	0.986	0.981	0.981	0.970	0.953	0.882	0.871	0.898	0.614	0.847	0.806	0.900
91.67	94.45	5.55	0.831	0.800	0.823	0.743	0.738	0.701	0.689	0.669	0.481	0.650	0.596	0.714
97.22	100.00	5.56	0.512	0.512	0.498	0.393	0.451	0.444	0.396	0.373	0.225	0.348	0.370	0.403
			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

CA06015 REV 0
PAGE 131

Worst Case Axial Burnup Distributions from ORNL/TM-1999/246

Burnup=	50	gwd/mtu										
Axial	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
cm	46+	42-46	38-42	34-38	30-34	26-30	22-26	18-22	14-18	10-14	6-10	6-
0.000	28.650	30.750	30.350	26.000	26.850	27.550	27.200	27.000	25.100	24.450	23.900	23.500
19.288	45.850	45.900	45.700	44.400	44.750	44.300	43.450	43.000	40.850	38.600	38.650	38.750
38.576	51.050	51.000	51.200	50.450	50.350	50.350	48.100	48.250	46.250	47.200	47.500	47.750
57.864	52.000	52.250	52.050	52.300	52.250	48.700	45.900	46.050	39.800	42.850	52.950	53.200
77.152	56.300	56.000	56.200	57.750	57.050	57.300	56.900	58.700	63.000	58.950	60.250	57.050
96.457	56.150	55.600	55.850	57.150	57.000	56.900	57.000	58.800	62.700	57.550	60.050	58.100
115.745	55.900	55.800	55.400	56.800	56.750	57.000	57.650	58.550	62.100	59.300	60.550	59.000
135.068	55.650	55.700	55.350	56.850	56.500	56.750	57.650	58.300	61.700	59.050	60.750	59.450
154.356	55.450	55.200	55.150	56.850	56.250	56.900	58.600	58.350	63.850	59.000	60.900	59.600
173.609	55.250	55.350	55.100	56.650	56.050	58.300	59.600	59.250	66.150	61.800	60.800	59.550
192.897	55.050	55.050	54.950	56.500	56.900	58.650	60.050	59.400	66.800	63.050	60.450	59.250
212.185	54.900	55.050	55.050	57.250	57.250	58.650	60.150	59.300	66.750	63.250	59.700	58.600
231.473	55.050	55.350	55.550	57.250	57.100	58.450	59.950	59.100	66.250	63.050	58.500	57.900
250.761	54.900	55.200	55.600	57.150	56.800	57.850	59.250	58.650	64.950	62.200	57.550	56.500
270.066	51.400	51.250	51.450	51.250	51.000	51.100	50.700	50.400	37.800	47.550	48.800	51.050
289.354	49.300	49.050	49.050	48.500	47.650	44.100	43.550	44.900	30.700	42.350	40.300	45.000
308.642	41.550	40.000	41.150	37.150	36.900	35.050	34.450	33.450	24.050	32.500	29.800	35.700
327.930	25.600	25.600	24.900	19.650	22.550	22.200	19.800	18.650	11.250	17.400	18.500	20.150
347.218	50.000	50.006	50.003	49.994	49.997	50.006	49.997	50.006	50.003	50.006	49.994	50.006

CA06015 REV 0
PAGE 132

Worst Case Axial Burnup Distributions from ORNL/TM-1999/246

Burnup=	62.00	46.00	42.00	38.00	34.00	30.00	26.00	22.00	18.00	14.00	10.00	6.00
Axial	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
cm	46+	42-46	38-42	34-38	30-34	26-30	22-26	18-22	14-18	10-14	6-10	6-
0.000	35.526	28.290	25.494	19.760	18.258	16.530	14.144	11.880	9.036	6.846	4.780	2.820
19.288	56.854	42.228	38.388	33.744	30.430	26.580	22.594	18.920	14.706	10.808	7.730	4.650
38.576	63.302	46.920	43.008	38.342	34.238	30.210	25.012	21.230	16.650	13.216	9.500	5.730
57.864	64.480	48.070	43.722	39.748	35.530	29.220	23.868	20.262	14.328	11.998	10.590	6.384
77.152	69.812	51.520	47.208	43.890	38.794	34.380	29.588	25.828	22.680	16.506	12.050	6.846
96.457	69.626	51.152	46.914	43.434	38.760	34.140	29.640	25.872	22.572	16.114	12.010	6.972
115.745	69.316	51.336	46.536	43.168	38.590	34.200	29.978	25.762	22.356	16.604	12.110	7.080
135.068	69.006	51.244	46.494	43.206	38.420	34.050	29.978	25.652	22.212	16.534	12.150	7.134
154.356	68.758	50.784	46.326	43.206	38.250	34.140	30.472	25.674	22.986	16.520	12.180	7.152
173.609	68.510	50.922	46.284	43.054	38.114	34.980	30.992	26.070	23.814	17.304	12.160	7.146
192.897	68.262	50.646	46.158	42.940	38.692	35.190	31.226	26.136	24.048	17.654	12.090	7.110
212.185	68.076	50.646	46.242	43.510	38.930	35.190	31.278	26.092	24.030	17.710	11.940	7.032
231.473	68.262	50.922	46.662	43.510	38.828	35.070	31.174	26.004	23.850	17.654	11.700	6.948
250.761	68.076	50.784	46.704	43.434	38.624	34.710	30.810	25.806	23.382	17.416	11.510	6.780
270.066	63.736	47.150	43.218	38.950	34.680	30.660	26.364	22.176	13.608	13.314	9.760	6.126
289.354	61.132	45.126	41.202	36.860	32.402	26.460	22.646	19.756	11.052	11.858	8.060	5.400
308.642	51.522	36.800	34.566	28.234	25.092	21.030	17.914	14.718	8.658	9.100	5.960	4.284
327.930	31.744	23.552	20.916	14.934	15.334	13.320	10.296	8.206	4.050	4.872	3.700	2.418
347.218	62.00	46.01	42.00	38.00	34.00	30.00	26.00	22.00	18.00	14.00	10.00	6.00

CA06015 REV 0
PAGE 123

Worst Case Axial Burnup Distributions from NUREG/CR-ORNL/TM-2001/33

Midpoints %	Endpoints %	Delta %	46+	42-46	38-42	34-38	30-34	26-30	22-26	18-22	14-18	10-14	6-10	6-
	0.00													
2.78	5.56	5.56	0.573	0.674	0.660	0.585	0.652	0.619	0.630	0.668	0.649	0.633	0.662	0.574
8.33	11.11	5.56	0.917	0.949	0.936	0.957	0.967	0.924	0.936	1.034	1.044	0.989	0.930	0.947
13.89	16.67	5.56	1.066	1.053	1.044	1.091	1.074	1.056	1.066	1.150	1.208	1.019	1.049	1.091
19.44	22.22	5.56	1.106	1.085	1.080	1.121	1.103	1.097	1.103	1.094	1.215	0.857	1.059	1.105
25.00	27.78	5.56	1.114	1.095	1.091	1.126	1.108	1.103	1.108	1.053	1.214	0.776	1.108	1.094
30.56	33.34	5.56	1.111	1.095	1.093	1.111	1.106	1.101	1.109	1.048	1.208	0.754	1.144	1.087
36.11	38.90	5.57	1.106	1.093	1.092	1.094	1.102	1.103	1.112	1.064	1.197	0.785	1.168	1.086
41.69	44.46	5.56	1.101	1.091	1.090	1.093	1.097	1.112	1.119	1.095	1.189	1.013	1.183	1.087
47.22	50.00	5.55	1.097	1.089	1.089	1.092	1.094	1.125	1.126	1.121	1.188	1.185	1.189	1.091
52.78	55.56	5.56	1.093	1.088	1.088	1.091	1.094	1.136	1.132	1.135	1.192	1.253	1.190	1.096
58.33	61.11	5.56	1.089	1.086	1.088	1.092	1.095	1.143	1.135	1.140	1.195	1.278	1.183	1.102
63.89	66.67	5.55	1.086	1.084	1.086	1.099	1.096	1.143	1.135	1.138	1.190	1.283	1.167	1.105
69.44	72.22	5.56	1.081	1.081	1.084	1.096	1.095	1.136	1.129	1.130	1.156	1.276	1.135	1.105
75.00	77.78	5.56	1.073	1.073	1.077	1.087	1.086	1.115	1.109	1.106	1.022	1.251	1.079	1.096
80.56	83.34	5.56	1.051	1.053	1.057	1.073	1.059	1.047	1.041	1.049	0.756	1.193	0.976	1.066
86.11	88.89	5.55	0.993	0.987	0.996	1.003	0.971	0.882	0.871	0.933	0.614	1.075	0.806	0.986
91.67	94.45	5.55	0.832	0.800	0.823	0.796	0.738	0.701	0.689	0.669	0.481	0.863	0.596	0.806
97.22	100.00	5.56	0.512	0.524	0.525	0.393	0.462	0.456	0.448	0.373	0.284	0.515	0.375	0.474
			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

CA06015 REV 0
PAGE 134

Worst Case Axial Burnup Distributions from NUREG/CR-ORNL/TM-2001/33

Burnup=	62.00	46.00	42.00	38.00	34.00	30.00	26.00	22.00	18.00	14.00	10.00	6.00
Axial	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL
cm	46+	42-46	38-42	34-38	30-34	26-30	22-26	18-22	14-18	10-14	6-10	6-
0.000	35.526	31.004	27.720	22.230	22.168	18.570	16.380	14.696	11.682	8.862	6.620	3.444
19.288	56.854	43.654	39.312	36.366	32.878	27.720	24.336	22.748	18.792	13.846	9.300	5.682
38.576	66.092	48.438	43.848	41.458	36.516	31.680	27.716	25.300	21.744	14.266	10.490	6.546
57.864	68.572	49.910	45.360	42.598	37.502	32.910	28.678	24.068	21.870	11.998	10.590	6.630
77.152	69.068	50.370	45.822	42.788	37.672	33.090	28.808	23.166	21.852	10.864	11.080	6.564
96.457	68.882	50.370	45.906	42.218	37.604	33.030	28.834	23.056	21.744	10.556	11.440	6.522
115.745	68.572	50.278	45.864	41.572	37.468	33.090	28.912	23.408	21.546	10.990	11.680	6.516
135.068	68.262	50.186	45.780	41.534	37.298	33.360	29.094	24.090	21.402	14.182	11.830	6.522
154.356	68.014	50.094	45.738	41.496	37.196	33.750	29.276	24.662	21.384	16.590	11.890	6.546
173.609	67.766	50.048	45.696	41.458	37.196	34.080	29.432	24.970	21.456	17.542	11.900	6.576
192.897	67.518	49.956	45.696	41.496	37.230	34.290	29.510	25.080	21.510	17.892	11.830	6.612
212.185	67.332	49.864	45.612	41.762	37.264	34.290	29.510	25.036	21.420	17.962	11.670	6.630
231.473	67.022	49.726	45.528	41.648	37.230	34.080	29.354	24.860	20.808	17.864	11.350	6.630
250.761	66.526	49.358	45.234	41.306	36.924	33.450	28.834	24.332	18.396	17.514	10.790	6.576
270.066	65.162	48.438	44.394	40.774	36.006	31.410	27.066	23.078	13.608	16.702	9.760	6.396
289.354	61.566	45.402	41.832	38.114	33.014	26.460	22.646	20.526	11.052	15.050	8.060	5.916
308.642	51.584	36.800	34.566	30.248	25.092	21.030	17.914	14.718	8.658	12.082	5.960	4.836
327.930	31.744	24.104	22.050	14.934	15.708	13.680	11.648	8.206	5.112	7.210	3.750	2.844
347.218	62.00	46.00	42.00	38.00	34.00	30.00	26.00	22.00	18.00	14.00	10.00	6.00

CA06015 REV 0
PAGE 135

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

CCNPP Assembly Burnups in Tenth GWD/MTU

plane	node (in)	node (cm)	1-S0	2-S0	3-S1	4-V0	5-T0	6-V1	7-V0	8-S2	9-V0	10-T0	11-V1
bottom 1	3.500	0.000	2.6689	2.5499	2.7430	0.7488	1.9598	1.1234	1.1822	2.8928	0.9750	1.9232	1.4213
2	3.500	8.890	3.5647	3.4090	3.6629	1.0180	2.6043	1.5108	1.5895	3.8669	1.3112	2.5659	1.9100
3	3.500	17.780	4.2539	4.7860	4.3705	1.2591	3.1397	1.8421	1.9399	4.5995	1.6087	3.1028	2.3209
4	1.500	26.670	4.5666	4.3857	4.6899	1.3771	3.3877	1.9933	2.1043	4.9156	1.7529	3.3540	2.5076
5	2.000	30.480	4.7102	4.5290	4.8355	1.4350	3.5030	2.0526	2.1802	5.0419	1.8230	3.4723	2.5828
6	5.466	35.560	4.9019	4.7204	5.0402	1.5171	3.6551	2.0998	2.2787	5.2346	1.9223	3.6317	2.6502
7	7.874	49.444	5.0640	4.8832	5.2188	1.5879	3.7828	2.1673	2.3609	5.4138	2.0088	3.7675	2.7344
8	7.874	69.444	5.1246	4.9448	5.2858	1.6152	3.8298	2.1957	2.3908	5.4851	2.0424	3.8188	2.7690
9	5.796	89.444	5.1354	4.9560	5.2983	1.6205	3.8372	2.2002	2.3947	5.4994	2.0489	3.8276	2.7739
10	5.796	104.166	5.1350	4.9555	5.2985	1.6204	3.8356	2.1988	2.3925	5.5001	2.0487	3.8260	2.7712
11	7.874	118.888	5.1322	4.9523	5.2963	1.6187	3.8317	2.1955	2.3882	5.4979	2.0466	3.8216	2.7657
12	7.874	138.888	5.1290	4.9486	5.2937	1.6165	3.8270	2.1914	2.3829	5.4952	2.0437	3.8160	2.7589
13	5.796	158.888	5.1273	4.9463	5.2924	1.6147	3.8235	2.1880	2.3785	5.4939	2.0414	3.8115	2.7531
14	5.796	173.610	5.1266	4.9451	5.2923	1.6135	3.8210	2.1854	2.3751	5.4937	2.0398	3.8083	2.7485
15	7.874	188.332	5.1272	4.9451	5.2934	1.6125	3.8191	2.1830	2.3717	5.4950	2.0384	3.8054	2.7437
16	7.874	208.332	5.1289	4.9462	5.2958	1.6116	3.8175	2.1804	2.3681	5.4976	2.0371	3.8027	2.7384
17	5.796	228.332	5.1301	4.9465	5.2975	1.6101	3.8156	2.1773	2.3640	5.4992	2.0353	3.7994	2.7326
18	5.796	243.054	5.1274	4.9429	5.2951	1.6068	3.8108	2.1719	2.3578	5.4962	2.0313	3.7928	2.7241
19	7.874	257.776	5.1070	4.9212	5.2742	1.5954	3.7914	2.1560	2.3406	5.4728	2.0176	3.7702	2.7017
20	7.874	277.776	5.0160	4.8296	5.1793	1.5553	3.7167	2.1039	2.2851	5.3706	1.9693	3.6894	2.6335
21	5.466	297.776	4.7985	4.6147	4.9504	1.4677	3.5453	1.9947	2.1672	5.1322	1.8630	3.5099	2.4946
22	2.000	311.660	4.5620	4.3827	4.7016	1.3759	3.3614	1.8857	2.0446	4.8810	1.7513	3.3202	2.3572
23	1.500	316.740	4.3986	4.2226	4.5335	1.3145	3.2357	1.8215	1.9627	4.7192	1.6764	3.1917	2.2745
24	3.500	320.550	4.0699	4.9017	4.1970	1.1954	2.9845	1.7042	1.8002	4.3989	1.5303	2.9371	2.1214
25	3.500	329.440	3.3688	3.2237	3.4738	0.9602	2.4581	1.3961	1.4651	3.6564	1.2384	2.4109	1.7387
top 26	3.500	338.330	2.4808	2.3743	2.5572	0.7051	1.8422	1.0377	1.0882	2.6869	0.9186	1.8003	1.2920
	136.701	347.220	4.8013	4.6688	4.9523	1.4894	3.5696	2.0408	2.2090	5.1485	1.8880	3.5485	2.5651
Burnup	Gwd/Mtu		48.0130	46.6878	49.5234	14.8945	35.6956	20.4081	22.0901	51.4849	18.8796	35.4847	25.6513

CA06015 REV 0
PAGE 136

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

CCNPP Assembly Burnups in GWD/MTU

plane		node (in)	node (cm)	1-S0	2-S0	3-S1	4-V0	5-T0	6-V1	7-V0	8-S2	9-V0	10-T0	11-V1
bottom	1	3.500	0.000	26.689	25.499	27.430	7.488	19.598	11.234	11.822	28.928	9.750	19.232	14.213
	2	3.500	8.890	35.647	34.090	36.629	10.180	26.043	15.108	15.895	38.669	13.112	25.659	19.100
	3	3.500	17.780	42.539	47.860	43.705	12.591	31.397	18.421	19.399	45.995	16.087	31.028	23.209
	4	1.500	26.670	45.666	43.857	46.899	13.771	33.877	19.933	21.043	49.156	17.529	33.540	25.076
	5	2.000	30.480	47.102	45.290	48.355	14.350	35.030	20.526	21.802	50.419	18.230	34.723	25.828
	6	5.466	35.560	49.019	47.204	50.402	15.171	36.551	20.998	22.787	52.346	19.223	36.317	26.502
	7	7.874	49.444	50.640	48.832	52.188	15.879	37.828	21.673	23.609	54.138	20.088	37.675	27.344
	8	7.874	69.444	51.246	49.448	52.858	16.152	38.298	21.957	23.908	54.851	20.424	38.188	27.690
	9	5.796	89.444	51.354	49.560	52.983	16.205	38.372	22.002	23.947	54.994	20.489	38.276	27.739
	10	5.796	104.166	51.350	49.555	52.985	16.204	38.356	21.988	23.925	55.001	20.487	38.260	27.712
	11	7.874	118.888	51.322	49.523	52.963	16.187	38.317	21.955	23.882	54.979	20.466	38.216	27.657
	12	7.874	138.888	51.290	49.486	52.937	16.165	38.270	21.914	23.829	54.952	20.437	38.160	27.589
	13	5.796	158.888	51.273	49.463	52.924	16.147	38.235	21.880	23.785	54.939	20.414	38.115	27.531
	14	5.796	173.610	51.266	49.451	52.923	16.135	38.210	21.854	23.751	54.937	20.398	38.083	27.485
	15	7.874	188.332	51.272	49.451	52.934	16.125	38.191	21.830	23.717	54.950	20.384	38.054	27.437
	16	7.874	208.332	51.289	49.462	52.958	16.116	38.175	21.804	23.681	54.976	20.371	38.027	27.384
	17	5.796	228.332	51.301	49.465	52.975	16.101	38.156	21.773	23.640	54.992	20.353	37.994	27.326
	18	5.796	243.054	51.274	49.429	52.951	16.068	38.108	21.719	23.578	54.962	20.313	37.928	27.241
	19	7.874	257.776	51.070	49.212	52.742	15.954	37.914	21.560	23.406	54.728	20.176	37.702	27.017
	20	7.874	277.776	50.160	48.296	51.793	15.553	37.167	21.039	22.851	53.706	19.693	36.894	26.335
	21	5.466	297.776	47.985	46.147	49.504	14.677	35.453	19.947	21.672	51.322	18.630	35.099	24.946
	22	2.000	311.660	45.620	43.827	47.016	13.759	33.614	18.857	20.446	48.810	17.513	33.202	23.572
	23	1.500	316.740	43.986	42.226	45.335	13.145	32.357	18.215	19.627	47.192	16.764	31.917	22.745
	24	3.500	320.550	40.699	49.017	41.970	11.954	29.845	17.042	18.002	43.989	15.303	29.371	21.214
	25	3.500	329.440	33.688	32.237	34.738	9.602	24.581	13.961	14.651	36.564	12.384	24.109	17.387
top	26	3.500	338.330	24.808	23.743	25.572	7.051	18.422	10.377	10.882	26.869	9.186	18.003	12.920
		136.701	347.220	48.0130	46.6878	49.5234	14.8945	35.6956	20.4081	22.0901	51.4849	18.8796	35.4847	25.6513
Burnup		Gwd/Mtu		48.013	46.688	49.523	14.894	35.696	20.408	22.090	51.485	18.880	35.485	25.651

CA06015 REV 0
PAGE 137

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

12-T0	13-T1	14-T2	15-V0	16-T2	17-V1	18-T2	19-V1	20-T2	21-S0	22-V0	23-T2	24-V1	25-T2
2.2953	2.4129	1.9834	0.9950	2.6685	1.4846	2.8927	1.5266	2.8369	2.7829	1.0037	2.6807	1.4740	2.7428
3.0365	3.1875	2.6303	1.3378	3.5139	1.9904	3.8034	2.0425	3.7257	3.7036	1.3523	3.5304	1.9743	3.6136
3.6417	3.8148	3.1625	1.6403	4.1852	2.4135	4.5148	2.4700	4.4207	4.4119	1.6605	4.2051	2.3917	4.2998
3.9190	4.1012	3.4026	1.7866	4.4837	2.6046	4.8262	2.6607	4.7248	4.7331	1.8104	4.5054	2.5791	4.6022
4.0466	4.2309	3.5023	1.8576	4.6084	2.6812	4.9532	2.7359	4.8493	4.8814	1.8838	4.6310	2.6533	4.7261
4.2139	4.3962	3.6083	1.9576	4.7465	2.7499	5.0877	2.8009	4.9816	5.0772	1.9874	4.7707	2.7176	4.8560
4.3550	4.5404	3.7265	2.0461	4.8872	2.8368	5.2215	2.8821	5.1140	5.2429	2.0783	4.9129	2.8013	4.9881
4.4084	4.5934	3.7753	2.0816	4.9456	2.8741	5.2782	2.9168	5.1704	5.3068	2.1136	4.9721	2.8386	5.0440
4.4182	4.6026	3.7848	2.0892	4.9584	2.8807	5.2918	2.9238	5.1847	5.3209	2.1203	4.9850	2.8464	5.0561
4.4174	4.6020	3.7849	2.0897	4.9598	2.8793	5.2946	2.9235	5.1884	5.3235	2.1197	4.9864	2.8462	5.0570
4.4138	4.5991	3.7826	2.0884	4.9587	2.8753	5.2952	2.9211	5.1902	5.3243	2.1172	4.9852	2.8437	5.0553
4.4091	4.5954	3.7794	2.0865	4.9569	2.8700	5.2954	2.9177	5.1917	5.3252	2.1138	4.9832	2.8401	5.0527
4.4055	4.5928	3.7770	2.0851	4.9557	2.8656	5.2961	2.9150	5.1933	5.3270	2.1110	4.9820	2.8371	5.0509
4.4030	4.5912	3.7754	2.0842	4.9553	2.8622	5.2972	2.9130	5.1953	5.3294	2.1090	4.9815	2.8350	5.0500
4.4010	4.5903	3.7744	2.0837	4.9558	2.8587	5.2994	2.9112	5.1985	5.3334	2.1072	4.9819	2.8331	5.0499
4.3992	4.5899	3.7737	2.0835	4.9569	2.8549	5.3025	2.9093	5.2026	5.3393	2.1054	4.9829	2.8310	5.0502
4.3967	4.5888	3.7724	2.0827	4.9568	2.8504	5.3040	2.9066	5.2050	5.3440	2.1031	4.9827	2.8281	5.0493
4.3905	4.5842	3.7679	2.0795	4.9525	2.8430	5.3010	2.9008	5.2028	5.3443	2.0986	4.9782	2.8221	5.0441
4.3672	4.5631	3.7488	2.0667	4.9299	2.8216	5.2793	2.8819	5.1826	5.3270	2.0837	4.9552	2.8027	5.0196
4.2809	4.4787	3.6740	2.0187	4.8385	2.7532	5.1871	2.8177	5.0943	5.2382	2.0324	4.8627	2.7375	4.9250
4.0869	4.2815	3.5039	1.9114	4.6291	2.6119	4.9732	2.6813	4.8873	5.0184	1.9206	4.6514	2.6005	4.7132
3.8803	4.0680	3.3263	1.7980	4.4087	2.4713	4.7472	2.5428	4.6668	4.7761	1.8037	4.4292	2.4635	4.4930
3.7393	3.9236	3.2150	1.7220	4.2667	2.3862	4.6002	2.4579	4.5229	4.6074	1.7256	4.2861	2.3806	4.3515
3.4565	3.6358	3.0009	1.5733	3.9864	2.2274	4.3053	2.2974	4.2340	4.2665	1.5737	4.0038	2.2249	4.0699
2.8596	3.0123	2.4833	1.2744	3.3250	1.8291	3.6034	1.8911	3.5446	3.5396	1.2720	3.3391	1.8296	3.3995
2.1509	2.2666	1.8633	0.9452	2.5091	1.3615	2.7233	1.4101	2.6811	2.6192	0.9417	2.5192	1.3632	2.5657
4.1171	4.2997	3.5350	1.9295	4.6518	2.6726	4.9829	2.7257	4.8874	4.9941	1.9506	4.6756	2.6492	4.7452
41.1714	42.9968	35.3501	19.2955	46.5177	26.7260	49.8292	27.2573	48.8735	49.9415	19.5057	46.7559	26.4922	47.4521

CA06015 REV 0
PAGE 138

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

12-T0	13-T1	14-T2	15-V0	16-T2	17-V1	18-T2	19-V1	20-T2	21-S0	22-V0	23-T2	24-V1	25-T2
22.953	24.129	19.834	9.950	26.685	14.846	28.927	15.266	28.369	27.829	10.037	26.807	14.740	27.428
30.365	31.875	26.303	13.378	35.139	19.904	38.034	20.425	37.257	37.036	13.523	35.304	19.743	36.136
36.417	38.148	31.625	16.403	41.852	24.135	45.148	24.700	44.207	44.119	16.605	42.051	23.917	42.998
39.190	41.012	34.026	17.866	44.837	26.046	48.262	26.607	47.248	47.331	18.104	45.054	25.791	46.022
40.466	42.309	35.023	18.576	46.084	26.812	49.532	27.359	48.493	48.814	18.838	46.310	26.533	47.261
42.139	43.962	36.083	19.576	47.465	27.499	50.877	28.009	49.816	50.772	19.874	47.707	27.176	48.560
43.550	45.404	37.265	20.461	48.872	28.368	52.215	28.821	51.140	52.429	20.783	49.129	28.013	49.881
44.084	45.934	37.753	20.816	49.456	28.741	52.782	29.168	51.704	53.068	21.136	49.721	28.386	50.440
44.182	46.026	37.848	20.892	49.584	28.807	52.918	29.238	51.847	53.209	21.203	49.850	28.464	50.561
44.174	46.020	37.849	20.897	49.598	28.793	52.946	29.235	51.884	53.235	21.197	49.864	28.462	50.570
44.138	45.991	37.826	20.884	49.587	28.753	52.952	29.211	51.902	53.243	21.172	49.852	28.437	50.553
44.091	45.954	37.794	20.865	49.569	28.700	52.954	29.177	51.917	53.252	21.138	49.832	28.401	50.527
44.055	45.928	37.770	20.851	49.557	28.656	52.961	29.150	51.933	53.270	21.110	49.820	28.371	50.509
44.030	45.912	37.754	20.842	49.553	28.622	52.972	29.130	51.953	53.294	21.090	49.815	28.350	50.500
44.010	45.903	37.744	20.837	49.558	28.587	52.994	29.112	51.985	53.334	21.072	49.819	28.331	50.499
43.992	45.899	37.737	20.835	49.569	28.549	53.025	29.093	52.026	53.393	21.054	49.829	28.310	50.502
43.967	45.888	37.724	20.827	49.568	28.504	53.040	29.066	52.050	53.440	21.031	49.827	28.281	50.493
43.905	45.842	37.679	20.795	49.525	28.430	53.010	29.008	52.028	53.443	20.986	49.782	28.221	50.441
43.672	45.631	37.488	20.667	49.299	28.216	52.793	28.819	51.826	53.270	20.837	49.552	28.027	50.196
42.809	44.787	36.740	20.187	48.385	27.532	51.871	28.177	50.943	52.382	20.324	48.627	27.375	49.250
40.869	42.815	35.039	19.114	46.291	26.119	49.732	26.813	48.873	50.184	19.206	46.514	26.005	47.132
38.803	40.680	33.263	17.980	44.087	24.713	47.472	25.428	46.668	47.761	18.037	44.292	24.635	44.930
37.393	39.236	32.150	17.220	42.667	23.862	46.002	24.579	45.229	46.074	17.256	42.861	23.806	43.515
34.565	36.358	30.009	15.733	39.864	22.274	43.053	22.974	42.340	42.665	15.737	40.038	22.249	40.699
28.596	30.123	24.833	12.744	33.250	18.291	36.034	18.911	35.446	35.396	12.720	33.391	18.296	33.995
21.509	22.666	18.633	9.452	25.091	13.615	27.233	14.101	26.811	26.192	9.417	25.192	13.632	25.657
41.1714	42.9968	35.3501	19.2955	46.5177	26.7260	49.8292	27.2573	48.8735	49.9415	19.5057	46.7559	26.4922	47.4521
41.171	42.997	35.350	19.295	46.518	26.726	49.829	27.257	48.874	49.941	19.506	46.756	26.492	47.452

CA06015 REV 0
PAGE 139

26-V1	27-T2	28-V1	29-V0	30-T0	31-V1	32-T2	33-V2	34-T2	35-V2	36-T2	37-T0	38-V1	39-T2
1.5674	2.9135	1.5555	0.7569	1.9338	1.4911	2.7455	1.5828	2.9159	1.5780	2.8950	1.9602	1.4251	2.8968
2.0958	3.8271	2.0795	1.0292	2.5802	1.9992	3.6172	2.1172	3.8292	2.1094	3.8028	2.6049	1.9150	3.8071
2.5314	4.5383	2.5114	1.2732	3.1201	2.4242	4.3041	2.5546	4.5376	2.5437	4.5068	3.1404	2.3271	4.5183
2.7242	4.8478	2.7023	1.3928	3.3728	2.6163	4.6069	2.7451	4.8439	2.7319	4.8110	3.3885	2.5144	4.8293
2.7991	4.9727	2.7763	1.4518	3.4920	2.6934	4.7310	2.8139	4.9660	2.7992	4.9320	3.5038	2.5898	4.9555
2.8617	5.1032	2.8375	1.5354	3.6527	2.7630	4.8614	2.8542	5.0906	2.8366	5.0549	3.6560	2.6578	5.0901
2.9404	5.2337	2.9149	1.6076	3.7899	2.8506	4.9938	2.9251	5.2148	2.9041	5.1766	3.7838	2.7425	5.2255
2.9753	5.2905	2.9493	1.6356	3.8419	2.8882	5.0499	2.9589	5.2697	2.9365	5.2294	3.8307	2.7772	5.2836
2.9832	5.3054	2.9574	1.6410	3.8507	2.8949	5.0621	2.9669	5.2851	2.9449	5.2440	3.8382	2.7821	5.2977
2.9837	5.3092	2.9583	1.6408	3.8491	2.8935	5.0630	2.9677	5.2899	2.9464	5.2489	3.8366	2.7794	5.3004
2.9820	5.3111	2.9574	1.6390	3.8446	2.8895	5.0613	2.9665	5.2931	2.9460	5.2524	3.8327	2.7740	5.3008
2.9794	5.3125	2.9556	1.6366	3.8388	2.8842	5.0587	2.9643	5.2961	2.9449	5.2559	3.8281	2.7671	5.3007
2.9772	5.3142	2.9542	1.6347	3.8342	2.8798	5.0569	2.9626	5.2991	2.9441	5.2594	3.8246	2.7614	5.3010
2.9757	5.3161	2.9533	1.6333	3.8309	2.8763	5.0559	2.9614	5.3022	2.9437	5.2628	3.8222	2.7568	5.3019
2.9745	5.3193	2.9529	1.6322	3.8279	2.8729	5.0558	2.9606	5.3067	2.9438	5.2678	3.8203	2.7521	5.3038
2.9733	5.3234	2.9526	1.6311	3.8250	2.8692	5.0561	2.9598	5.3124	2.9440	5.2742	3.8189	2.7468	5.3064
2.9710	5.3257	2.9511	1.6295	3.8216	2.8647	5.0552	2.9578	5.3162	2.9430	5.2787	3.8170	2.7410	5.3075
2.9655	5.3232	2.9465	1.6261	3.8149	2.8573	5.0498	2.9525	5.3149	2.9386	5.2784	3.8122	2.7326	5.3039
2.9464	5.3018	2.9288	1.6142	3.7919	2.8358	5.0252	2.9336	5.2957	2.9212	5.2610	3.7929	2.7103	5.2811
2.8814	5.2101	2.8664	1.5732	3.7101	2.7669	4.9303	2.8690	5.2080	2.8595	5.1771	3.7183	2.6418	5.1865
2.7440	4.9982	2.7320	1.4839	3.5288	2.6247	4.7180	2.7334	5.0020	2.7278	4.9754	3.5468	2.5024	4.9703
2.6051	4.7747	2.5950	1.3906	3.3376	2.4830	4.4975	2.5985	4.7833	2.5959	4.7592	3.3628	2.3644	4.7437
2.5198	4.6293	2.5107	1.3283	3.2081	2.3973	4.3557	2.5194	4.6405	2.5182	4.6175	3.2371	2.2814	4.5971
2.3574	4.3362	2.3497	1.2075	2.9519	2.2374	4.0737	2.3731	4.3506	2.3737	4.3295	2.9858	2.1276	4.3038
1.9435	3.6336	1.9378	0.9695	2.4228	1.8371	3.4026	1.9622	3.6499	1.9645	3.6323	2.4592	1.7437	3.6029
1.4505	2.7484	1.4466	0.7118	1.8091	1.3673	2.5679	1.4648	2.7627	1.4676	2.7493	1.8430	1.2956	2.7236
2.7861	5.0026	2.7664	1.5073	3.5690	2.6856	4.7505	2.7782	4.9939	2.7639	4.9592	3.5707	2.5728	4.9860
27.8612	50.0264	27.6636	15.0726	35.6902	26.8562	47.5053	27.7820	49.9388	27.6388	49.5922	35.7070	25.7281	49.8601

CA06015 REV 0
PAGE 1/0

26-V1	27-T2	28-V1	29-V0	30-T0	31-V1	32-T2	33-V2	34-T2	35-V2	36-T2	37-T0	38-V1	39-T2
15.674	29.135	15.555	7.569	19.338	14.911	27.455	15.828	29.159	15.780	28.950	19.602	14.251	28.968
20.958	38.271	20.795	10.292	25.802	19.992	36.172	21.172	38.292	21.094	38.028	26.049	19.150	38.071
25.314	45.383	25.114	12.732	31.201	24.242	43.041	25.546	45.376	25.437	45.068	31.404	23.271	45.183
27.242	48.478	27.023	13.928	33.728	26.163	46.069	27.451	48.439	27.319	48.110	33.885	25.144	48.293
27.991	49.727	27.763	14.518	34.920	26.934	47.310	28.139	49.660	27.992	49.320	35.038	25.898	49.555
28.617	51.032	28.375	15.354	36.527	27.630	48.614	28.542	50.906	28.366	50.549	36.560	26.578	50.901
29.404	52.337	29.149	16.076	37.899	28.506	49.938	29.251	52.148	29.041	51.766	37.838	27.425	52.255
29.753	52.905	29.493	16.356	38.419	28.882	50.499	29.589	52.697	29.365	52.294	38.307	27.772	52.836
29.832	53.054	29.574	16.410	38.507	28.949	50.621	29.669	52.851	29.449	52.440	38.382	27.821	52.977
29.837	53.092	29.583	16.408	38.491	28.935	50.630	29.677	52.899	29.464	52.489	38.366	27.794	53.004
29.820	53.111	29.574	16.390	38.446	28.895	50.613	29.665	52.931	29.460	52.524	38.327	27.740	53.008
29.794	53.125	29.556	16.366	38.388	28.842	50.587	29.643	52.961	29.449	52.559	38.281	27.671	53.007
29.772	53.142	29.542	16.347	38.342	28.798	50.569	29.626	52.991	29.441	52.594	38.246	27.614	53.010
29.757	53.161	29.533	16.333	38.309	28.763	50.559	29.614	53.022	29.437	52.628	38.222	27.568	53.019
29.745	53.193	29.529	16.322	38.279	28.729	50.558	29.606	53.067	29.438	52.678	38.203	27.521	53.038
29.733	53.234	29.526	16.311	38.250	28.692	50.561	29.598	53.124	29.440	52.742	38.189	27.468	53.064
29.710	53.257	29.511	16.295	38.216	28.647	50.552	29.578	53.162	29.430	52.787	38.170	27.410	53.075
29.655	53.232	29.465	16.261	38.149	28.573	50.498	29.525	53.149	29.386	52.784	38.122	27.326	53.039
29.464	53.018	29.288	16.142	37.919	28.358	50.252	29.336	52.957	29.212	52.610	37.929	27.103	52.811
28.814	52.101	28.664	15.732	37.101	27.669	49.303	28.690	52.080	28.595	51.771	37.183	26.418	51.865
27.440	49.982	27.320	14.839	35.288	26.247	47.180	27.334	50.020	27.278	49.754	35.468	25.024	49.703
26.051	47.747	25.950	13.906	33.376	24.830	44.975	25.985	47.833	25.959	47.592	33.628	23.644	47.437
25.198	46.293	25.107	13.283	32.081	23.973	43.557	25.194	46.405	25.182	46.175	32.371	22.814	45.971
23.574	43.362	23.497	12.075	29.519	22.374	40.737	23.731	43.506	23.737	43.295	29.858	21.276	43.038
19.435	36.336	19.378	9.695	24.228	18.371	34.026	19.622	36.499	19.645	36.323	24.592	17.437	36.029
14.505	27.484	14.466	7.118	18.091	13.673	25.679	14.648	27.627	14.676	27.493	18.430	12.956	27.236
27.8612	50.0264	27.6636	15.0726	35.6902	26.8562	47.5053	27.7820	49.9388	27.6388	49.5922	35.7070	25.7281	49.8601
27.861	50.026	27.664	15.073	35.690	26.856	47.505	27.782	49.939	27.639	49.592	35.707	25.728	49.860

CA06015 REV 0
PAGE 141

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

40-V1	41-T2	42-V2	43-T2	44-V2	45-S0	46-V1	47-T0	48-V1	49-T2	50-V2	51-T2	52-V2	53-T0
1.5688	2.9112	1.5845	2.8765	1.5910	2.6683	1.1244	2.2978	1.5279	2.9126	1.5783	2.8744	1.5605	2.3043
2.0977	3.8228	2.1177	3.7831	2.1276	3.5646	1.5121	3.0409	2.0444	3.8259	2.1098	3.7803	2.0854	3.0348
2.5337	4.5299	2.5524	4.4901	2.5647	4.2538	1.8437	3.6470	2.4723	4.5369	2.5442	4.4866	2.5135	3.6278
2.7267	4.8354	2.7400	4.7974	2.7535	4.5664	1.9950	3.9247	2.6632	4.8463	2.7325	4.7935	2.6985	3.8944
2.8018	4.9569	2.8064	4.9206	2.8205	4.7100	2.0545	4.0524	2.7386	4.9712	2.7998	4.9166	2.7641	4.0140
2.8646	5.0809	2.8416	5.0461	2.8567	4.9017	2.1018	4.2199	2.8037	5.1015	2.8372	5.0418	2.7992	4.1652
2.9435	5.2049	2.9060	5.1711	2.9206	5.0643	2.1694	4.3612	2.8851	5.2318	2.9047	5.1665	2.8613	4.2886
2.9784	5.2598	2.9372	5.2252	2.9506	5.1253	2.1979	4.4148	2.9198	5.2886	2.9372	5.2204	2.8896	4.3368
2.9862	5.2752	2.9453	5.2385	2.9581	5.1362	2.2024	4.4246	2.9267	5.3034	2.9456	5.2337	2.8967	4.3486
2.9866	5.2802	2.9469	5.2411	2.9593	5.1359	2.2010	4.4238	2.9263	5.3073	2.9470	5.2363	2.8980	4.3513
2.9850	5.2835	2.9467	5.2414	2.9589	5.1331	2.1977	4.4203	2.9239	5.3092	2.9467	5.2367	2.8980	4.3523
2.9824	5.2868	2.9459	5.2410	2.9579	5.1300	2.1935	4.4158	2.9205	5.3107	2.9456	5.2364	2.8975	4.3529
2.9803	5.2900	2.9452	5.2410	2.9570	5.1283	2.1902	4.4123	2.9178	5.3124	2.9447	5.2366	2.8971	4.3538
2.9788	5.2932	2.9449	5.2415	2.9564	5.1278	2.1876	4.4099	2.9158	5.3144	2.9443	5.2372	2.8969	4.3550
2.9776	5.2979	2.9452	5.2431	2.9563	5.1284	2.1851	4.4080	2.9141	5.3177	2.9443	5.2388	2.8973	4.3573
2.9765	5.3039	2.9456	5.2452	2.9564	5.1303	2.1825	4.4063	2.9122	5.3219	2.9445	5.2411	2.8980	4.3605
2.9742	5.3079	2.9447	5.2458	2.9552	5.1316	2.1795	4.4039	2.9094	5.3243	2.9435	5.2418	2.8974	4.3625
2.9687	5.3069	2.9405	5.2417	2.9508	5.1290	2.1741	4.3978	2.9037	5.3219	2.9391	5.2377	2.8938	4.3605
2.9497	5.2881	2.9234	5.2184	2.9338	5.1085	2.1582	4.3746	2.8848	5.3007	2.9217	5.2147	2.8782	4.3436
2.8848	5.2009	2.8624	5.1250	2.8731	5.0172	2.1061	4.2884	2.8206	5.2092	2.8599	5.1217	2.8209	4.2694
2.7472	4.9955	2.7322	4.9137	2.7429	4.7993	1.9966	4.0943	2.6840	4.9975	2.7282	4.9108	2.6952	4.0937
2.6081	4.7774	2.6016	4.6931	2.6116	4.5627	1.8875	3.8876	2.5453	4.7741	2.5962	4.6905	2.5671	3.9018
2.5226	4.6351	2.5246	4.5502	2.5338	4.3993	1.8232	3.7464	2.4603	4.6288	2.5185	4.5479	2.4909	3.7684
2.3599	4.3463	2.3808	4.2620	2.3884	4.0706	1.7058	3.4630	2.2995	4.3358	2.3740	4.2600	2.3487	3.4948
1.9455	3.6468	1.9716	3.5696	1.9773	3.3694	1.3973	2.8645	1.8928	3.6333	1.9648	3.5681	1.9449	2.9053
1.4519	2.7605	1.4733	2.6982	1.4770	2.4807	1.0386	2.1538	1.4113	2.7482	1.4678	2.6971	1.4539	2.1978
2.7890	4.9858	2.7667	4.9325	2.7779	4.8021	2.0428	4.1236	2.7284	5.0012	2.7644	4.9287	2.7236	4.0843
27.8904	49.8577	27.6672	49.3253	27.7794	48.0211	20.4280	41.2359	27.2841	50.0122	27.6441	49.2867	27.2356	40.8434

CA06015 REV 0
PAGE 192

40-V1	41-T2	42-V2	43-T2	44-V2	45-S0	46-V1	47-T0	48-V1	49-T2	50-V2	51-T2	52-V2	53-T0
15.688	29.112	15.845	28.765	15.910	26.683	11.244	22.978	15.279	29.126	15.783	28.744	15.605	23.043
20.977	38.228	21.177	37.831	21.276	35.646	15.121	30.409	20.444	38.259	21.098	37.803	20.854	30.348
25.337	45.299	25.524	44.901	25.647	42.538	18.437	36.470	24.723	45.369	25.442	44.866	25.135	36.278
27.267	48.354	27.400	47.974	27.535	45.664	19.950	39.247	26.632	48.463	27.325	47.935	26.985	38.944
28.018	49.569	28.064	49.206	28.205	47.100	20.545	40.524	27.386	49.712	27.998	49.166	27.641	40.140
28.646	50.809	28.416	50.461	28.567	49.017	21.018	42.199	28.037	51.015	28.372	50.418	27.992	41.652
29.435	52.049	29.060	51.711	29.206	50.643	21.694	43.612	28.851	52.318	29.047	51.665	28.613	42.886
29.784	52.598	29.372	52.252	29.506	51.253	21.979	44.148	29.198	52.886	29.372	52.204	28.896	43.368
29.862	52.752	29.453	52.385	29.581	51.362	22.024	44.246	29.267	53.034	29.456	52.337	28.967	43.486
29.866	52.802	29.469	52.411	29.593	51.359	22.010	44.238	29.263	53.073	29.470	52.363	28.980	43.513
29.850	52.835	29.467	52.414	29.589	51.331	21.977	44.203	29.239	53.092	29.467	52.367	28.980	43.523
29.824	52.868	29.459	52.410	29.579	51.300	21.935	44.158	29.205	53.107	29.456	52.364	28.975	43.529
29.803	52.900	29.452	52.410	29.570	51.283	21.902	44.123	29.178	53.124	29.447	52.366	28.971	43.538
29.788	52.932	29.449	52.415	29.564	51.278	21.876	44.099	29.158	53.144	29.443	52.372	28.969	43.550
29.776	52.979	29.452	52.431	29.563	51.284	21.851	44.080	29.141	53.177	29.443	52.388	28.973	43.573
29.765	53.039	29.456	52.452	29.564	51.303	21.825	44.063	29.122	53.219	29.445	52.411	28.980	43.605
29.742	53.079	29.447	52.458	29.552	51.316	21.795	44.039	29.094	53.243	29.435	52.418	28.974	43.625
29.687	53.069	29.405	52.417	29.508	51.290	21.741	43.978	29.037	53.219	29.391	52.377	28.938	43.605
29.497	52.881	29.234	52.184	29.338	51.085	21.582	43.746	28.848	53.007	29.217	52.147	28.782	43.436
28.848	52.009	28.624	51.250	28.731	50.172	21.061	42.884	28.206	52.092	28.599	51.217	28.209	42.694
27.472	49.955	27.322	49.137	27.429	47.993	19.966	40.943	26.840	49.975	27.282	49.108	26.952	40.937
26.081	47.774	26.016	46.931	26.116	45.627	18.875	38.876	25.453	47.741	25.962	46.905	25.671	39.018
25.226	46.351	25.246	45.502	25.338	43.993	18.232	37.464	24.603	46.288	25.185	45.479	24.909	37.684
23.599	43.463	23.808	42.620	23.884	40.706	17.058	34.630	22.995	43.358	23.740	42.600	23.487	34.948
19.455	36.468	19.716	35.696	19.773	33.694	13.973	28.645	18.928	36.333	19.648	35.681	19.449	29.053
14.519	27.605	14.733	26.982	14.770	24.807	10.386	21.538	14.113	27.482	14.678	26.971	14.539	21.978
27.8904	49.8577	27.6672	49.3253	27.7794	48.0211	20.4280	41.2359	27.2841	50.0122	27.6441	49.2867	27.2356	40.8434
27.890	49.858	27.667	49.325	27.779	48.021	20.428	41.236	27.284	50.012	27.644	49.287	27.236	40.843

CA06015 REV 0
PAGE 143

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

54-S0	55-V0	56-T1	57-T2	58-V1	59-T2	60-V2	61-T0	62-J*
2.5546	1.1824	2.4124	2.8184	1.5557	2.8936	1.5886	2.4846	2.8810
3.4157	1.5897	3.1869	3.7005	2.0797	3.8009	2.1241	3.2682	3.7742
4.0867	1.9402	3.8140	4.3901	2.5117	4.5051	2.5605	3.8978	4.4609
4.3944	2.1046	4.1004	4.6918	2.7026	4.8103	2.7489	4.1800	4.8199
4.5380	2.1806	4.2300	4.8152	2.7767	4.9327	2.8157	4.3062	4.8708
4.7301	2.2791	4.3952	4.9466	2.8379	5.0562	2.8516	4.4662	5.1030
4.8935	2.3613	4.5393	5.0781	2.9153	5.1775	2.9154	4.5969	5.2642
4.9554	2.3912	4.5923	5.1339	2.9497	5.2299	2.9453	4.6478	5.3319
4.9666	2.3951	4.6016	5.1484	2.9578	5.2442	2.9529	4.6598	5.3539
4.9660	2.3929	4.6009	5.1525	2.9588	5.2488	2.9542	4.6623	5.3641
4.9628	2.3886	4.5980	5.1549	2.9578	5.2521	2.9539	4.6629	5.3736
4.9590	2.3833	4.5943	5.1570	2.9560	5.2554	2.9529	4.6631	5.3838
5.1283	2.3789	4.5917	5.1593	2.9546	5.2587	2.9521	4.6636	5.3931
4.9554	2.3755	4.5902	5.1618	2.9537	5.2620	2.9516	4.6644	5.4017
4.9553	2.3721	4.5893	5.1656	2.9533	5.2669	2.9516	4.6664	5.4124
4.9562	2.3685	4.5889	5.1704	2.9530	5.2730	2.9518	4.6692	5.4247
4.9565	2.3644	4.5878	5.1735	2.9515	5.2775	2.9507	4.6707	5.4337
4.9528	2.3583	4.5832	5.1719	2.9468	5.2771	2.9464	4.6681	5.4369
4.9309	2.3410	4.5621	5.1530	2.9292	5.2597	2.9295	4.6496	5.4226
4.8388	2.2855	4.4778	5.0672	2.8667	5.1758	2.8690	4.5698	5.3405
4.6232	2.1675	4.2807	4.8635	2.7322	4.9741	2.7391	4.3819	5.1328
4.3905	2.0450	4.0672	4.6454	2.5953	4.7574	2.6082	4.1776	4.8523
4.2301	1.9630	3.9228	4.5026	2.5109	4.6150	2.5306	4.0358	4.7934
3.9085	1.8005	3.6351	4.2157	2.3499	4.3252	2.3856	3.7454	4.3922
3.2292	1.4654	3.0118	3.5303	1.9380	3.6279	1.9750	3.1186	3.6616
2.3780	1.0884	2.2662	2.6712	1.4468	2.7464	1.4755	2.3601	2.7259
4.6417	2.2094	4.2987	4.8568	2.7667	4.9583	2.7735	4.3765	5.0648
46.4167	22.0939	42.9873	48.5683	27.6671	49.5834	27.7353	43.7650	50.6483

CA06015 REV 0
PAGE 1/44

Unit 1 Cycle 16 As Built Depletion EOC Fuel Assembly Burnup Distribution

54-S0	55-V0	56-T1	57-T2	58-V1	59-T2	60-V2	61-T0	62-J*
25.546	11.824	24.124	28.184	15.557	28.936	15.886	24.846	28.810
34.157	15.897	31.869	37.005	20.797	38.009	21.241	32.682	37.742
40.867	19.402	38.140	43.901	25.117	45.051	25.605	38.978	44.609
43.944	21.046	41.004	46.918	27.026	48.103	27.489	41.800	48.199
45.380	21.806	42.300	48.152	27.767	49.327	28.157	43.062	48.708
47.301	22.791	43.952	49.466	28.379	50.562	28.516	44.662	51.030
48.935	23.613	45.393	50.781	29.153	51.775	29.154	45.969	52.642
49.554	23.912	45.923	51.339	29.497	52.299	29.453	46.478	53.319
49.666	23.951	46.016	51.484	29.578	52.442	29.529	46.598	53.539
49.660	23.929	46.009	51.525	29.588	52.488	29.542	46.623	53.641
49.628	23.886	45.980	51.549	29.578	52.521	29.539	46.629	53.736
49.590	23.833	45.943	51.570	29.560	52.554	29.529	46.631	53.838
51.283	23.789	45.917	51.593	29.546	52.587	29.521	46.636	53.931
49.554	23.755	45.902	51.618	29.537	52.620	29.516	46.644	54.017
49.553	23.721	45.893	51.656	29.533	52.669	29.516	46.664	54.124
49.562	23.685	45.889	51.704	29.530	52.730	29.518	46.692	54.247
49.565	23.644	45.878	51.735	29.515	52.775	29.507	46.707	54.337
49.528	23.583	45.832	51.719	29.468	52.771	29.464	46.681	54.369
49.309	23.410	45.621	51.530	29.292	52.597	29.295	46.496	54.226
48.388	22.855	44.778	50.672	28.667	51.758	28.690	45.698	53.405
46.232	21.675	42.807	48.635	27.322	49.741	27.391	43.819	51.328
43.905	20.450	40.672	46.454	25.953	47.574	26.082	41.776	48.523
42.301	19.630	39.228	45.026	25.109	46.150	25.306	40.358	47.934
39.085	18.005	36.351	42.157	23.499	43.252	23.856	37.454	43.922
32.292	14.654	30.118	35.303	19.380	36.279	19.750	31.186	36.616
23.780	10.884	22.662	26.712	14.468	27.464	14.755	23.601	27.259
46.4167	22.0939	42.9873	48.5683	27.6671	49.5834	27.7353	43.7650	50.6483
46.417	22.094	42.987	48.568	27.667	49.583	27.735	43.765	50.648

CA06015 REV 0
PAGE 145

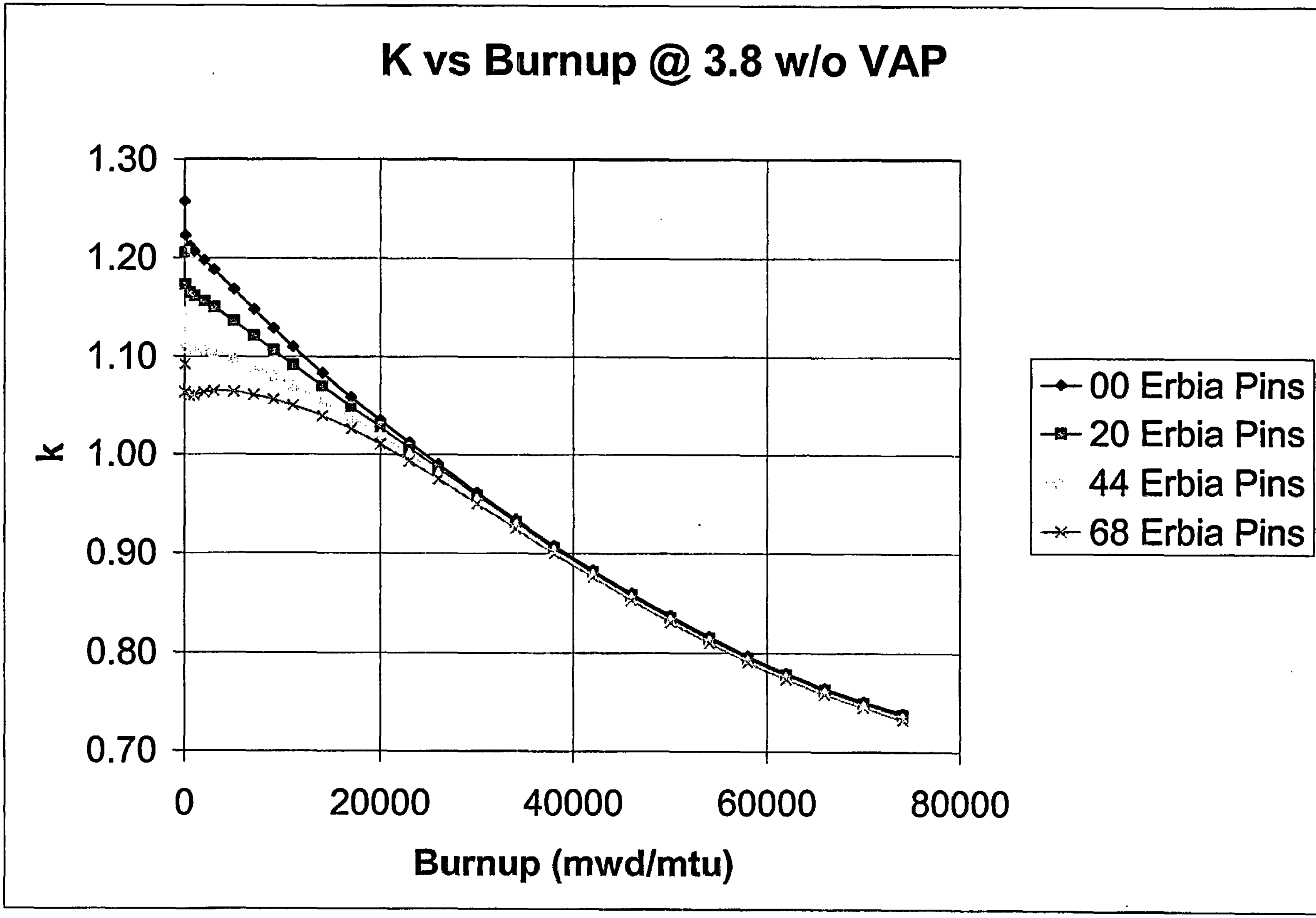
ATTACHMENT J
EFFECT OF INTEGRAL BURNABLE ABSORBERS

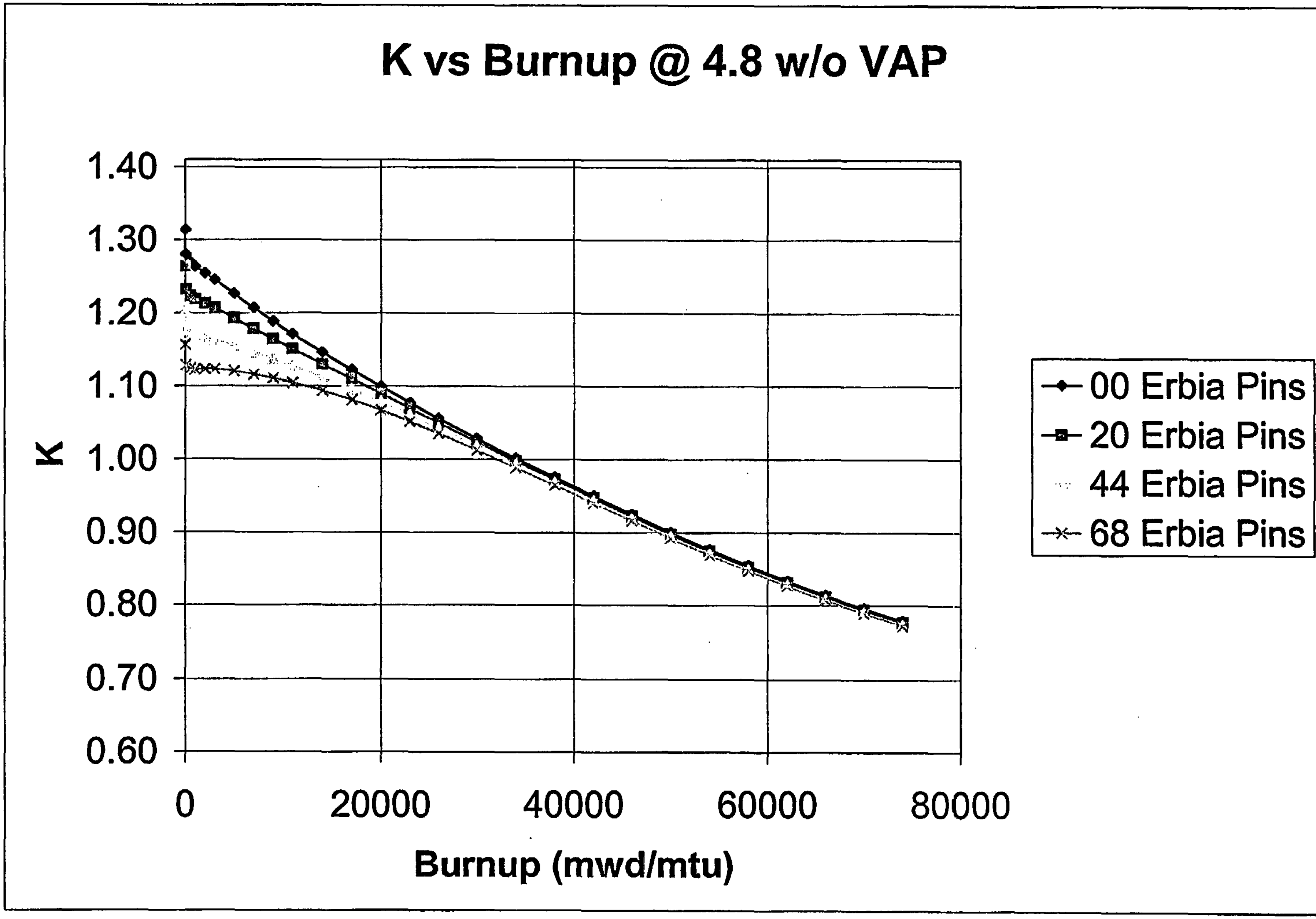
DIT K-INF Values for 4.8 w/o VAP Fuel with 2 w/o Erbia

Exposure MWD/MTU	Erbia Pins 0	Erbia Pins 20	Erbia Pins 44	Erbia Pins 68
0	1.31307	1.26372	1.20639	1.15650
50	1.27950	1.23185	1.17629	1.12818
500	1.26885	1.22299	1.16954	1.12310
1000	1.26271	1.21857	1.16714	1.12226
2000	1.25366	1.21263	1.16487	1.12278
3000	1.24457	1.20644	1.16215	1.12270
5000	1.22566	1.19280	1.15479	1.12022
7000	1.20669	1.17850	1.14604	1.11588
9000	1.18831	1.16426	1.13664	1.11045
11000	1.17063	1.15020	1.12678	1.10413
14000	1.14551	1.12964	1.11145	1.09335
17000	1.12173	1.10948	1.09540	1.08105
20000	1.09893	1.08945	1.07847	1.06712
23000	1.07690	1.06949	1.06081	1.05177
26000	1.05550	1.04960	1.04261	1.03534
30000	1.02799	1.02348	1.01804	1.01244
34000	1.00115	0.99753	0.99308	0.98861
38000	0.97493	0.97186	0.96805	0.96432
42000	0.94932	0.94662	0.94323	0.93999
46000	0.92436	0.92189	0.91879	0.91590
50000	0.90014	0.89785	0.89496	0.89229
54000	0.87688	0.87471	0.87198	0.86948
58000	0.85465	0.85256	0.84996	0.84759
62000	0.83357	0.83155	0.82906	0.82677
66000	0.81378	0.81181	0.80939	0.80718
70000	0.79539	0.79345	0.79110	0.78893
74000	0.77848	0.77656	0.77425	0.77210

DIT K-INF Values for 3.8 w/o VAP Fuel with 2 w/o Erbia

Exposure MWD/MTU	Erbia Pins 0	Erbia Pins 20	Erbia Pins 44	Erbia Pins 68
0	1.25725	1.20557	1.14494	1.09252
50	1.22277	1.17309	1.11454	1.06416
500	1.21204	1.16455	1.10860	1.06026
1000	1.20655	1.16113	1.10767	1.06119
2000	1.19765	1.15601	1.10709	1.06402
3000	1.18804	1.14992	1.10522	1.06537
5000	1.16783	1.13597	1.09876	1.06474
7000	1.14762	1.12120	1.09040	1.06155
9000	1.12819	1.10643	1.08105	1.05672
11000	1.10959	1.09180	1.07100	1.05058
14000	1.08335	1.07035	1.05499	1.03948
17000	1.05854	1.04909	1.03773	1.02599
20000	1.03483	1.02791	1.01934	1.01042
23000	1.01193	1.00676	1.00016	0.99329
26000	0.98975	0.98578	0.98053	0.97512
30000	0.96145	0.95850	0.95439	0.95029
34000	0.93414	0.93177	0.92835	0.92504
38000	0.90783	0.90579	0.90279	0.89996
42000	0.88267	0.88082	0.87808	0.87555
46000	0.85887	0.85712	0.85456	0.85221
50000	0.83658	0.83489	0.83244	0.83021
54000	0.81587	0.81420	0.81184	0.80966
58000	0.79685	0.79520	0.79288	0.79074
62000	0.77962	0.77796	0.77566	0.77353
66000	0.76418	0.76249	0.76021	0.75806
70000	0.75050	0.74877	0.74649	0.74432
74000	0.73853	0.73677	0.73446	0.73227


K vs Burnup @ 3.8 w/o VAP
1.30
1.20
1.10
1.00
0.90
0.80
0.70
k
0
20000
40000
60000
80000
Burnup (mwd/mtu)
00 Erbia Pins
20 Erbia Pins
44 Erbia Pins
68 Erbia Pins



CA06015 REV 0
PAGE 150

ATTACHMENT K
SAS2H FUEL TEMPERATURE CALCULATIONS

SAS2H Tfuel Calculations

Tfuel = Tmod + (A1*B^2 + A2*B + A3)*L + (B1*B^3 + B2*B^2 + B3*B + B4)*L^2

A1=	-2.34607E-07
A2=	1.10995E-03
A3=	1.30080E+02
B1=	-9.50512E-13
B2=	5.13836E-08
B3=	-5.11639E-04
B4=	-1.67177E+00

L=(2700000kw)*(1.1)*(1.65)/(11.39167')/(217)/(176)= 11.263688 kw/ft
Tmod= 601

Assembly Power = (2700 * 1.1 * 1.65 / 217) = 22.582949 MW/assm
Specific Power = (2700 * 1.1 * 1.65 / 217/ 0.410372) = 55.030434 MW/MTU
Vfuel=176*PI*(0.96774/2)^2*(347.218)= 44949.183 cc
Mfuel=(10.96)*(0.945)*Vfuel*(238/270)= 410371.65 gm

Burnup mwd/mtu	Tfuel deg-F	Tfuel deg-K	EFPD
0	1854.08	1285.42	0.00
1000	1805.43	1258.39	18.17
2000	1763.80	1235.26	36.34
3000	1728.49	1215.64	54.52
4000	1698.75	1199.12	72.69
5000	1673.87	1185.30	90.86
6000	1653.13	1173.78	109.03
7000	1635.80	1164.15	127.20
8000	1621.16	1156.02	145.37
9000	1608.48	1148.97	163.55
10000	1597.04	1142.62	181.72
11000	1586.13	1136.55	199.89
12000	1575.00	1130.37	218.06
13000	1562.95	1123.68	236.23
14000	1549.24	1116.06	254.40
15000	1533.16	1107.13	272.58
16000	1513.97	1096.47	290.75
17000	1490.96	1083.69	308.92
18000	1463.41	1068.38	327.09
19000	1430.58	1050.14	345.26
20000	1391.76	1028.57	363.44
25000	1391.76	1028.57	454.29
30000	1391.76	1028.57	545.15
35000	1391.76	1028.57	636.01
40000	1391.76	1028.57	726.87
45000	1391.76	1028.57	817.73
50000	1391.76	1028.57	908.59
55000	1391.76	1028.57	999.45
60000	1391.76	1028.57	1090.31
65000	1391.76	1028.57	1181.16
70000	1391.76	1028.57	1272.02

SAS2H Tfuel Calculations

Tfuel = Tmod + (A1*B^2 + A2*B + A3)*L + (B1*B^3 + B2*B^2 + B3*B + B4)*L^2

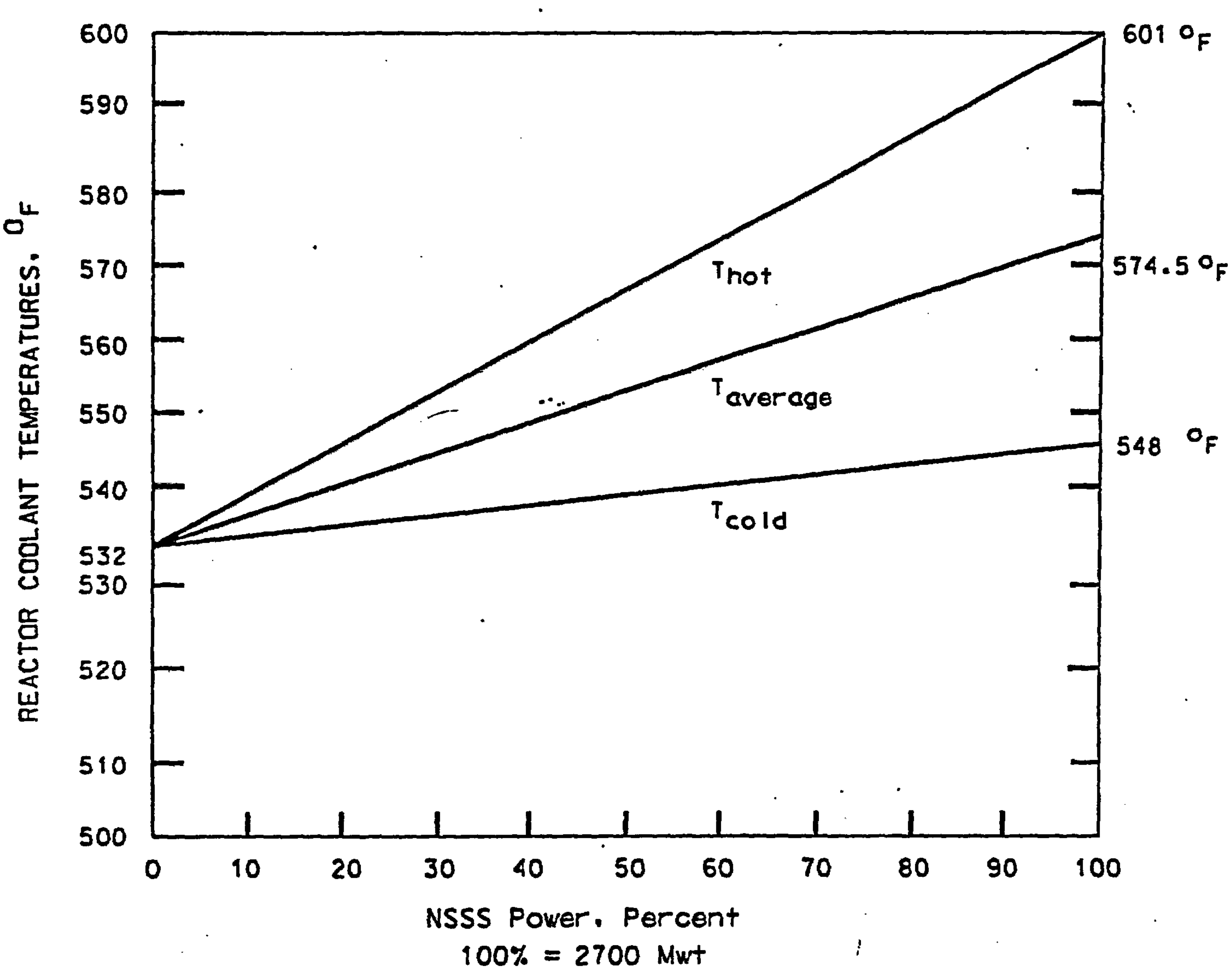
A1=	-2.34607E-07
A2=	1.10995E-03
A3=	1.30080E+02
B1=	-9.50512E-13
B2=	5.13836E-08
B3=	-5.11639E-04
B4=	-1.67177E+00

L=(2700000kw)*(1.1)*(1.65)/(11.39167')/(217)/(176)= 11.263688 kw/ft
Tmod= 601

Assembly Power = (2700 / 217) = 12.442396 MW/assm
Specific Power = (2700/ 217/ 0.410372) = 30.319798 MW/MTU
Vfuel=176*PI*(0.96774/2)^2*(347.218)= 44949.183 cc
Mfuel=(10.96)*(0.945)*Vfuel*(238/270)= 410371.65 gm

Burnup mwd/mtu	Tfuel deg-F	Tfuel deg-K	EFPD
0	1854.08	1285.42	0.00
1000	1805.43	1258.39	32.98
2000	1763.80	1235.26	65.96
3000	1728.49	1215.64	98.95
4000	1698.75	1199.12	131.93
5000	1673.87	1185.30	164.91
5800	1656.98	1175.92	191.29
6000	1653.13	1173.78	197.89
7000	1635.80	1164.15	230.87
8000	1621.16	1156.02	263.85
9000	1608.48	1148.97	296.84
10000	1597.04	1142.62	329.82
11000	1586.13	1136.55	362.80
12000	1575.00	1130.37	395.78
13400	1557.70	1120.76	441.96
13500	1556.35	1120.01	445.25
14000	1549.24	1116.06	461.74
15000	1533.16	1107.13	494.73
16000	1513.97	1096.47	527.71
17000	1490.96	1083.69	560.69
18000	1463.41	1068.38	593.67
19000	1430.58	1050.14	626.65
20000	1391.76	1028.57	659.63
25000	1391.76	1028.57	824.54
26300	1391.76	1028.57	867.42
30000	1391.76	1028.57	989.45
32000	1391.76	1028.57	1055.42
35000	1391.76	1028.57	1154.36
37500	1391.76	1028.57	1236.82
40000	1391.76	1028.57	1319.27
43000	1391.76	1028.57	1418.22

45000	1391.76	1028.57	1484.18
50000	1391.76	1028.57	1649.09
55000	1391.76	1028.57	1814.00
60000	1391.76	1028.57	1978.90
65000	1391.76	1028.57	2143.81
70000	1391.76	1028.57	2308.72



NOTE:

THIS FIGURE SHOWS MAXIMUM T_{hot} AND $T_{average}$ ASSUMING MINIMUM RCS FLOW.

BALTIMORE GAS & ELECTRIC CO. Calvert Cliffs Nuclear Power Plant	TEMPERATURE CONTROL PROGRAM	REV. 24	Figure 4-9

ATTACHMENT L
WATER DENSITY SPREADSHEET

Subcooled Water Density (gm/cc) as a Function of Temperature and Pressure											
					P(psia)						
T(F)	3000	2500	2250	2000	1500	1000	800	600	400	200	T(K)
50	1.0084	1.0069	1.0062	1.0055	1.0040	1.0025	1.0019	1.0013	1.0007	1.0000	283.15
100	1.0018	1.0004	0.9997	0.9989	0.9975	0.9960	0.9954	0.9948	0.9942	0.9936	310.93
150	0.9893	0.9878	0.9871	0.9864	0.9849	0.9834	0.9828	0.9822	0.9815	0.9809	338.71
200	0.9725	0.9709	0.9702	0.9694	0.9679	0.9663	0.9656	0.9650	0.9644	0.9637	366.48
250	0.9522	0.9505	0.9497	0.9489	0.9472	0.9455	0.9449	0.9442	0.9435	0.9428	394.26
300	0.9289	0.9271	0.9262	0.9252	0.9234	0.9215	0.9208	0.9200	0.9192	0.9185	422.04
350	0.9026	0.9006	0.8996	0.8985	0.8964	0.8943	0.8934	0.8925	0.8916		449.82
400	0.8733	0.8709	0.8697	0.8685	0.8660	0.8634	0.8624	0.8613	0.8603		477.59
450	0.8405	0.8375	0.8360	0.8345	0.8314	0.8281	0.8268	0.8255			505.37
500	0.8029	0.7992	0.7972	0.7952	0.7911	0.7869	0.7851				533.15
510	0.7947	0.7907	0.7887	0.7866	0.7822	0.7776					538.71
520	0.7862	0.7820	0.7798	0.7776	0.7729	0.7680					544.26
530	0.7775	0.7729	0.7706	0.7682	0.7632	0.7579					549.82
532		0.7710	0.7686	0.7662							550.93
540	0.7683	0.7635	0.7610	0.7584	0.7530	0.7472					555.37
548		0.7557	0.7530	0.7502							559.82
550	0.7589	0.7537	0.7510	0.7482	0.7423						560.93
560	0.7490	0.7434	0.7404	0.7374	0.7310						566.48
567.6		0.7352	0.7320	0.7288							570.71
570	0.7386	0.7326	0.7294	0.7261	0.7190						572.04
572.5		0.7298	0.7264	0.7231							573.43
580	0.7278	0.7212	0.7177	0.7141	0.7062						577.59
590	0.7164	0.7092	0.7052	0.7012	0.6923						583.15
600	0.7043	0.6963	0.6919	0.6874							588.71
601		0.6949	0.6905	0.6860							589.26
610	0.6915	0.6825	0.6775	0.6724							594.26
620	0.6777	0.6676	0.6617	0.6558							599.82
630	0.6629	0.6512	0.6441	0.6370							605.37
640	0.6467	0.6329									610.93
650	0.6288	0.6119									616.48
660	0.6086	0.5866									622.04
670	0.5850										627.59
680	0.5559										633.15

ATTACHMENT M
SAS2HED50 CODE

```
      PROGRAM SAS2HED50
C*********************************************************************
C*         D:\KENO\KENOINP2\SAS2HED50.FOR
C*         COMPILE COMMAND IS    FORT51 SAS2HED50
C*                               LINK51 SAS2HED50
C*     EDIT SAS2H OUTPUT FOR MOLES OF ACTIVITY
C*     CONVERT MOLES TO ATOMS/B-CM
C*     PRINT INPUT FOR KENO
C*********************************************************************
      DIMENSION A1A(14),A1B(14),B1A(14),B1B(14)
      DIMENSION A2A(36),A2B(36),B2A(36),B2B(36)
      CHARACTER A1A*8,A1B*8,A1C*8,A1D*8,A1E*8,A1F*8,AT*8
      CHARACTER A2A*8,A2B*8,A2C*8,A2D*8,A2E*8,A2F*8
      DATA A1A/' u234   ',' u235   ',
     1         ' u236   ',' u238   ','np237   ',
     2         'pu238   ','pu239   ',
     3         'pu240   ','pu241   ','pu242   ','am241   ',
     4         'cm242   ','cm243   ','cm244   '/
      DATA A1B/'U-234   ','U-235   ',
     1         'U-236   ','U-238   ','NP-237  ',
     2         'PU-238  ','PU-239  ',
     3         'PU-240  ','PU-241  ','PU-242  ','AM-241  ',
     4         'CM-242  ','CM-243  ','CM-244  '/
      DATA A1C/'actinide'/
      DATA A1D/'decay, f'/
      DATA A1E/'gram ato'/
      DATA A1F/'tal     '/
      DATA A2A/'kr 83   ','kr 84   ','kr 86   ',
     1         'mo 95   ',
     2         'tc 99   ',
     3         'ru101   ','rh103   ',
     4         'ag109   ','sn126   ',
     5         ' i129   ','xe131   ','xe132   ',
     6         'cs133   ','xe134   ','cs134   ','cs135   ',
     7         'cs137   ','nd143   ',
     8         'nd144   ','nd145   ','nd146   ',
     9         'pm147   ','sm147   ','nd148   ',
     a         'sm148   ','sm149   ','nd150   ','sm150   ',
     b         'sm151   ','eu151   ','sm152   ','eu153   ','eu154   ',
     c         'gd154   ','eu155   ','gd155   '/
      DATA A2B/'KR-83   ','KR-84   ','KR-86   ',
     1         'MO-95   ',
     2         'TC-99   ',
     3         'RU-101  ','RH-103  ',
     4         'AG-109  ','SN-126  ',
     5         'I-129   ','XE-131  ','XE-132  ',
     6         'CS-133  ','XE-134  ','CS-134  ','CS-135  ',
     7         'CS-137  ','ND-143  ',
     8         'ND-144  ','ND-145  ','ND-146  ',
     9         'PM-147  ','SM-147  ','ND-148  ',
     a         'SM-148  ','SM-149  ','ND-150  ','SM-150  ',
     b         'SM-151  ','EU-151  ','SM-152  ','EU-153  ','EU-154  ',
     c         'GD-154  ','EU-155  ','GD-155  '/
      DATA A2C/'fission '/
      DATA A2D/'decay, f'/
      DATA A2E/'gram ato'/
      DATA A2F/'tal     '/
      CALL START
C*********************************************************************
C*  OPEN ALL FILES TO BE USED:                                       *
C*       6 = OUTPUT (OPENED IN SUBROUTINE START)                     *
```

```
C*        9 = INPUT (DATA FOR CASE    OPENED IN SUBROUTINE START)     *
C***********************************************************************
C     READ ACTINIDE DATA
      DO 10 I=1,14
   10 B1A(I)=1.E-20
  100 READ(9,200,END=990) AT
      IF(AT.NE.A1C) GO TO 100
      READ(9,201) AT
      IF(AT.NE.A1D) GO TO 100
      READ(9,202)
      READ(9,203) AT
      IF(AT.NE.A1E) GO TO 100
      READ(9,202)
      READ(9,202)
  105 READ(9,204) AT
      IF(AT.EQ.A1F) GO TO 120
      DO 110 I=1,14
      IF(AT.NE.A1A(I)) GO TO 110
      BACKSPACE 9
      READ(9,205)X
      B1A(I)=X
      GO TO 105
  110 CONTINUE
      GO TO 105
  120 CONTINUE
      DO 130 I=1,14
  130 B1B(I)=B1A(I)*0.6023/44949.183
      WRITE(6,210)
      DO 140 I=1,14
  140 WRITE(6,211) A1B(I),B1A(I),B1B(I)
  200 FORMAT(101X,A8)
  201 FORMAT(A8)
  202 FORMAT(1X)
  203 FORMAT(67X,A8)
  204 FORMAT(4X,A8)
  205 FORMAT(72X,E8.2)
  210 FORMAT(' SAS2H ACTINIDE EDIT',/
     1,5X,' NUCLIDE',15X,'MOLES',10X,'ATOMS/B-CM')
  211 FORMAT(5X,A8,1P2E20.5)
C***********************************************************************
C     READ FISSION PRODUCT DATA
      DO 20 I=1,36
   20 B2A(I)=1.E-20
  300 READ(9,400,END=990) AT
      IF(AT.NE.A2C) GO TO 300
      READ(9,401) AT
      IF(AT.NE.A2D) GO TO 300
      READ(9,402)
      READ(9,403) AT
      IF(AT.NE.A2E) GO TO 300
      READ(9,402)
      READ(9,402)
  305 READ(9,404) AT
      IF(AT.EQ.A2F) GO TO 320
      DO 310 I=1,36
      IF(AT.NE.A2A(I)) GO TO 310
      BACKSPACE 9
      READ(9,405)X
      B2A(I)=X
      GO TO 305
  310 CONTINUE
```

```
      GO TO 305
  320 CONTINUE
      B2A(39)=1.E-20
      DO 330 I=1,36
  330 B2B(I)=B2A(I)*0.6023/44949.183
      WRITE(6,410)
      DO 340 I=1,36
  340 WRITE(6,411) A2B(I),B2A(I),B2B(I)
  400 FORMAT(94X,A8)
  401 FORMAT(A8)
  402 FORMAT(1X)
  403 FORMAT(67X,A8)
  404 FORMAT(4X,A8)
  405 FORMAT(72X,E8.2)
  410 FORMAT(//,' SAS2H FISSION PRODUCT EDIT',/
     1,5X,' NUCLIDE',15X,'MOLES',10X,'ATOMS/B-CM')
  411 FORMAT(5X,A8,1P2E20.5)
C*********************************************************************
C     PRINT DATA IN KENO FORMAT
      WRITE(6,600)
      DO 500 I=1,36
  500 WRITE(6,601) A2B(I),B2B(I)
      DO 501 I=1,14
  501 WRITE(6,601) A1B(I),B1B(I)
  600 FORMAT(//,'KENO INPUT DATA')
  601 FORMAT(A8,' 1 0 ',1PE11.5,' END')
C
      GO TO 995
  990 WRITE(*,991)
  991 FORMAT(' END OF DATA AT 100')
  995 CONTINUE
      CLOSE(6)
      CLOSE(9)
      STOP
      END
      SUBROUTINE START
C
C**********************************************************************
C*                                                                    *
C*  ROUTINE TO GET THE REQUIRED DATA TO GET STARTED                   *
C*                                                                    *
C**********************************************************************
C
      CHARACTER INFILE*100
   10 CONTINUE
      PRINT 20
   20 FORMAT(/////,2X,'WHAT IS THE NAME OF THE INPUT FILE ',
     +       '(DO NOT FORGET DIRECTORY)',/,'   ? ')
      READ(*,30) INFILE
   30 FORMAT(A100)
      OPEN(9,FILE=INFILE,STATUS='OLD',IOSTAT=IERROR)
      IF(IERROR .EQ. 0) GO TO 50
      PRINT 40
   40 FORMAT('  CANNOT FIND FILE        PLEASE TRY AGAIN',///)
      GO TO 10
   50 CONTINUE
      OPEN(6,FILE='SAS2HED.OUT',STATUS='UNKNOWN')
      RETURN
      END
```

ATTACHMENT N
SAS2HED101 CODE

```
      PROGRAM SAS2HED
C***********************************************************************
C*         D:\KENO\KENOINP2\SAS2HED.FOR
C*         COMPILE COMMAND IS    FORT51 SAS2HED
C*                               LINK51 SAS2HED
C*     EDIT SAS2H OUTPUT FOR MOLES OF ACTIVITY
C*     CONVERT MOLES TO ATOMS/B-CM
C*     PRINT INPUT FOR KENO
C***********************************************************************
      DIMENSION A1A(28),A1B(28),B1A(28),B1B(28)
      DIMENSION A2A(73),A2B(73),B2A(73),B2B(73)
      CHARACTER A1A*8,A1B*8,A1C*8,A1D*8,A1E*8,A1F*8,AT*8
      CHARACTER A2A*8,A2B*8,A2C*8,A2D*8,A2E*8,A2F*8
      DATA A1A/'th232   ',' u232   ',' u233   ',' u234   ',' u235   ',
     1         ' u236   ',' u237   ',' u238   ','np237   ','np238   ',
     2         'pu236   ','pu237   ','pu238   ','pu239   ',
     3         'pu240   ','pu241   ','pu242   ','am241   ','am242   ',
     4         'am242m  ','am243   ','cm242   ','cm243   ','cm244   ',
     5         'cm245   ','cm246   ','cm247   ','cm248   '/
      DATA A1B/'TH-232  ','U-232   ','U-233   ','U-234   ','U-235   ',
     1         'U-236   ','U-237   ','U-238   ','NP-237  ','NP-238  ',
     2         'PU-236  ','PU-237  ','PU-238  ','PU-239  ',
     3         'PU-240  ','PU-241  ','PU-242  ','AM-241  ','AM-242  ',
     4         'AM-242M ','AM-243  ','CM-242  ','CM-243  ','CM-244  ',
     5         'CM-245  ','CM-246  ','CM-247  ','CM-248  '/
      DATA A1C/'actinide'/
      DATA A1D/'decay, f'/
      DATA A1E/'gram ato'/
      DATA A1F/'tal     '/
      DATA A2A/'kr 83   ','kr 84   ','kr 85   ','kr 86   ','zr 91   ',
     1         'zr 92   ','zr 93   ','zr 94   ','nb 95   ','mo 95   ',
     2         'zr 96   ','mo 97   ','mo 98   ','tc 99   ','ru100   ',
     3         'ru101   ','ru102   ','ru103   ','rh103   ','ru104   ',
     4         'pd104   ','rh105   ','pd105   ','ru106   ','pd106   ',
     5         'pd107   ','pd108   ','ag109   ','cd113   ','sn126   ',
     6         ' i127   ',' i129   ','xe131   ','xe132   ','xe133   ',
     7         'cs133   ','xe134   ','cs134   ','xe135   ','cs135   ',
     8         'cs137   ','la139   ','pr141   ','pr143   ','nd143   ',
     9         'ce144   ','nd144   ','nd145   ','nd146   ','nd147   ',
     A         'pm147   ','sm147   ','nd148   ','pm148   ','pm148m  ',
     B         'sm148   ','pm149   ','sm149   ','nd150   ','sm150   ',
     C         'sm151   ','eu151   ','sm152   ','eu153   ','eu154   ',
     D         'gd154   ','eu155   ','gd155   ','eu156   ','gd156   ',
     E         'gd157   ','gd158   ','gd160   '/
      DATA A2B/'KR-83   ','KR-84   ','KR-85   ','KR-86   ','ZR-91   ',
     1         'ZR-92   ','ZR-93   ','ZR-94   ','NB-95   ','MO-95   ',
     2         'ZR-96   ','MO-97   ','MO-98   ','TC-99   ','RU-100  ',
     3         'RU-101  ','RU-102  ','RU-103  ','RH-103  ','RU-104  ',
     4         'PD-104  ','RH-105  ','PD-105  ','RU-106  ','PD-106  ',
     5         'PD-107  ','PD-108  ','AG-109  ','CD-113  ','SN-126  ',
     6         'I-127   ','I-129   ','XE-131  ','XE-132  ','XE-133  ',
     7         'CS-133  ','XE-134  ','CS-134  ','XE-135  ','CS-135  ',
     8         'CS-137  ','LA-139  ','PR-141  ','PR-143  ','ND-143  ',
     9         'CE-144  ','ND-144  ','ND-145  ','ND-146  ','ND-147  ',
     A         'PM-147  ','SM-147  ','ND-148  ','PM-148  ','PM-148M ',
     B         'SM-148  ','PM-149  ','SM-149  ','ND-150  ','SM-150  ',
     C         'SM-151  ','EU-151  ','SM-152  ','EU-153  ','EU-154  ',
     D         'GD-154  ','EU-155  ','GD-155  ','EU-156  ','GD-156  ',
     E         'GD-157  ','GD-158  ','GD-160  '/
      DATA A2C/'fission '/
      DATA A2D/'decay, f'/
      DATA A2E/'gram ato'/
      DATA A2F/'tal     '/
      CALL START
C***********************************************************************
C*  OPEN ALL FILES TO BE USED:                                         *
C*        6 = OUTPUT (OPENED IN SUBROUTINE START)                      *
```

LA06015 REV 0
PAGE 164

```
C*        9 = INPUT (DATA FOR CASE    OPENED IN SUBROUTINE START)     *
C**********************************************************************
C     READ ACTINIDE DATA
      DO 10 I=1,28
   10 B1A(I)=1.E-20
  100 READ(9,200,END=990) AT
      IF(AT.NE.A1C) GO TO 100
      READ(9,201) AT
      IF(AT.NE.A1D) GO TO 100
      READ(9,202)
      READ(9,203) AT
      IF(AT.NE.A1E) GO TO 100
      READ(9,202)
      READ(9,202)
  105 READ(9,204) AT
      IF(AT.EQ.A1F) GO TO 120
      DO 110 I=1,28
      IF(AT.NE.A1A(I)) GO TO 110
      BACKSPACE 9
      READ(9,205)X
      B1A(I)=X
      GO TO 105
  110 CONTINUE
      GO TO 105
  120 CONTINUE
      DO 130 I=1,28
  130 B1B(I)=B1A(I)*0.6023/44949.183
      WRITE(6,210)
      DO 140 I=1,28
  140 WRITE(6,211) A1B(I),B1A(I),B1B(I)
  200 FORMAT(101X,A8)
  201 FORMAT(A8)
  202 FORMAT(1X)
  203 FORMAT(67X,A8)
  204 FORMAT(4X,A8)
  205 FORMAT(72X,E8.2)
  210 FORMAT(' SAS2H ACTINIDE EDIT',/
     1,5X,' NUCLIDE',15X,'MOLES',10X,'ATOMS/B-CM')
  211 FORMAT(5X,A8,1P2E20.5)
C**********************************************************************
C     READ FISSION PRODUCT DATA
      DO 20 I=1,73
   20 B2A(I)=1.E-20
  300 READ(9,400,END=990) AT
      IF(AT.NE.A2C) GO TO 300
      READ(9,401) AT
      IF(AT.NE.A2D) GO TO 300
      READ(9,402)
      READ(9,403) AT
      IF(AT.NE.A2E) GO TO 300
      READ(9,402)
      READ(9,402)
  305 READ(9,404) AT
      IF(AT.EQ.A2F) GO TO 320
      DO 310 I=1,73
      IF(AT.NE.A2A(I)) GO TO 310
      BACKSPACE 9
      READ(9,405)X
      B2A(I)=X
      GO TO 305
  310 CONTINUE
      GO TO 305
  320 CONTINUE
      B2A(39)=1.E-20
      DO 330 I=1,73
  330 B2B(I)=B2A(I)*0.6023/44949.183
      WRITE(6,410)
```

```
      DO 340 I=1,73
  340 WRITE(6,411) A2B(I),B2A(I),B2B(I)
  400 FORMAT(94X,A8)
  401 FORMAT(A8)
  402 FORMAT(1X)
  403 FORMAT(67X,A8)
  404 FORMAT(4X,A8)
  405 FORMAT(72X,E8.2)
  410 FORMAT(//,' SAS2H FISSION PRODUCT EDIT',/
     1,5X,' NUCLIDE',15X,'MOLES',10X,'ATOMS/B-CM')
  411 FORMAT(5X,A8,1P2E20.5)
C**********************************************************************
C     PRINT DATA IN KENO FORMAT
      WRITE(6,600)
      DO 500 I=1,73
  500 WRITE(6,601) A2B(I),B2B(I)
      DO 501 I=1,28
  501 WRITE(6,601) A1B(I),B1B(I)
  600 FORMAT(//,'KENO INPUT DATA')
  601 FORMAT(A8,' 1 0 ',1PE11.5,' END')
C
      GO TO 995
  990 WRITE(*,991)
  991 FORMAT(' END OF DATA AT 100')
  995 CONTINUE
      CLOSE(6)
      CLOSE(9)
      STOP
      END
      SUBROUTINE START
C
C************************************************************************
C*                                                                      *
C*  ROUTINE TO GET THE REQUIRED DATA TO GET STARTED                     *
C*                                                                      *
C************************************************************************
C
      CHARACTER INFILE*100
   10 CONTINUE
      PRINT 20
   20 FORMAT(/////,2X,'WHAT IS THE NAME OF THE INPUT FILE ',
     +        '(DO NOT FORGET DIRECTORY)',/,'    ? ')
      READ(*,30) INFILE
   30 FORMAT(A100)
      OPEN(9,FILE=INFILE,STATUS='OLD',IOSTAT=IERROR)
      IF(IERROR .EQ. 0) GO TO 50
      PRINT 40
   40 FORMAT('  CANNOT FIND FILE        PLEASE TRY AGAIN',///)
      GO TO 10
   50 CONTINUE
      OPEN(6,FILE='SAS2HED.OUT',STATUS='UNKNOWN')
      RETURN
      END
```

ATTACHMENT O
SAS2HLIN CODE

CA06015 REV 0
PAGE 167

```
      PROGRAM SAS2HLIN
C*********************************************************************
C*         D:\KENO\KENOINP2\SAS2HLIN.FOR
C*         COMPILE COMMAND IS    FORT51 SAS2HLIN
C*                               LINK51 SAS2HLIN
C*     INTERPOLATE SAS2H EDIT FILES AS A FUNCTION OF BURNUP
C*     LINEAR INTERPOLATION
C*     PRINT INPUT FOR KENO
C*********************************************************************
      CHARACTER A1A*8,AD*4
      REAL*8 B1A,C1A,C,B,XXX,ENR,D1,D2
      DIMENSION A1A(50),B1A(15,50),C1A(15)
      DIMENSION D1(70),D2(70,30),AD(70)
      DIMENSION B(30,50),C(30)
      CALL START(NP,NS)
C*********************************************************************
C*  OPEN ALL FILES TO BE USED:
C*        * = ONSCREEN INPUT
C*            NP = PROFILE NUMBER (70 MAX)
C*            NS = 1(SINGLE BURNUP POINT), = 2(MULTIPLE BURNUP POINTS)
C*        6 = OUTPUT (OPENED IN SUBROUTINE START)
C*        9 = INPUT (ISOTOPE DATA     OPENED IN SUBROUTINE START)
C*            ENR = ENRICHMENT IN W/O
C*            C1A(15) = BURNUP POINTS IN GWD/MTU
C*            A1A(50) = ISOTOPE LABEL
C*            B1A(15,50) = ISOTOPICS IN ATOMS/BN-CM
C*       10 = INPUT (PROFILE DATA     OPENED IN SUBROUTINE START)
C*            NB = NUMBER OF AXIAL BURNUPS (30 MAX)
C*            NF = NUMBER OF PROFILES (70 MAX)
C*            AD(NF) = PROFILE LABEL
C*            D1(NF) = AVERAGE PROFILE BURNUP IN GWD/MTU
C*            D2(NF,NB) = PROFILE BURNUPS IN GWD/MTU
C*********************************************************************
C     READ ACTINIDE DATA
      DO 10 I=1,15
      READ(9,100) ENR,C1A(I)
      DO 11 J=1,50
   11 READ(9,101) A1A(J),B1A(I,J)
   10 CONTINUE
  100 FORMAT(F4.2,F7.2)
  101 FORMAT(A8,5X,E11.5)
C*********************************************************************
C     READ PROFILE DATA
      READ(10,20) NB
      READ(10,20) NF
      DO 21 I=1,NF
      READ(10,22) AD(I)
      READ(10,23) D1(I)
   21 READ(10,24) (D2(I,J),J=1,NB)
   20 FORMAT(23X,I2)
   22 FORMAT(A4)
   23 FORMAT(2X,F7.3)
   24 FORMAT(2X,10F7.3)
C*********************************************************************
C     INTERPOLATE NEW DATA
      GO TO (30,35),NS
   30 N=1
      C(1)=D1(NP)
      GO TO 39
   35 N=NB
      DO 36 I=1,N
   36 C(I)=D2(NP,I)
   39 DO 40 K=1,N
      DO 42 I=2,15
      IF(C(K).GT.C1A(I)) GO TO 42
      I1=I-1
      I2=I
      GO TO 43
   42 CONTINUE
      I1=14
      I2=15
   43 CONTINUE
      XXX=(C(K)-C1A(I2))/(C1A(I1)-C1A(I2))
      DO 44 J=1,50
      B(K,J)=B1A(I2,J)+(B1A(I1,J)-B1A(I2,J))*XXX
   44 IF(B(K,J).LT.1.E-24) B(K,J)=1.E-24
```

```
   40 CONTINUE
C**********************************************************************
C     PRINT DATA IN KENO FORMAT
      WRITE(6,601) ENR
      WRITE(6,602) N
      WRITE(6,603) (C(K),K=1,N)
      DO 500 K=1,N
      MX=100+K
      DO 501 J=1,50
  501 WRITE(6,600) A1A(J),MX,B(K,J)
  500 CONTINUE
  600 FORMAT(A8,I4,' 0 ',1PE11.5,' END')
  601 FORMAT(2X,'ENRICHMENT        = ',F5.2)
  602 FORMAT(2X,'NUMBER OF BURNUPS = ',I5)
  603 FORMAT(2X,'BURNUPS=',10F7.3)
C
      CLOSE(6)
      CLOSE(9)
      CLOSE(10)
      STOP
      END
      SUBROUTINE START(NP,NS)
C
C***********************************************************************
C*                                                                     *
C*  ROUTINE TO GET THE REQUIRED DATA TO GET STARTED                    *
C*                                                                     *
C***********************************************************************
C
      CHARACTER INFILE*100
   10 CONTINUE
      PRINT 11
   11 FORMAT(/////,2X,'WHAT IS THE NAME OF THE ISOTOPE FILE ',
     +       '(DO NOT FORGET DIRECTORY)',/,'   ? ')
      READ(*,12) INFILE
   12 FORMAT(A100)
      OPEN(9,FILE=INFILE,STATUS='OLD',IOSTAT=IERROR)
      IF(IERROR .EQ. 0) GO TO 14
      PRINT 13
   13 FORMAT('  CANNOT FIND FILE        PLEASE TRY AGAIN',///)
      GO TO 10
   14 CONTINUE
   20 CONTINUE
      PRINT 21
   21 FORMAT(/////,2X,'WHAT IS THE NAME OF THE PROFILE FILE ',
     +       '(DO NOT FORGET DIRECTORY)',/,'   ? ')
      READ(*,22) INFILE
   22 FORMAT(A100)
      OPEN(10,FILE=INFILE,STATUS='OLD',IOSTAT=IERROR)
      IF(IERROR .EQ. 0) GO TO 24
      PRINT 23
   23 FORMAT('  CANNOT FIND FILE        PLEASE TRY AGAIN',///)
      GO TO 10
   24 CONTINUE
      OPEN(6,FILE='SAS2HLAG.XXX',STATUS='UNKNOWN')
      PRINT 60
   60 FORMAT(/////,2X,'READ NUMBER OF PROFILE ')
      READ(*,*) NP
      PRINT 70
   70 FORMAT(/////,2X,'READ MULTI OR SINGLE')
      READ(*,*) NS
      RETURN
      END
```

ATTACHMENT P
SAS2HLAG CODE

```
      PROGRAM SAS2HLAG
C***********************************************************************
C*         D:\KENO\KENOINP2\SAS2HLAG.FOR
C*         COMPILE COMMAND IS    FORT51 SAS2HLAG
C*                               LINK51 SAS2HLAG
C*     INTERPOLATE SAS2H EDIT FILES AS A FUNCTION OF BURNUP
C*     SECOND ORDER LAGRANGIAN INTERPOLATION
C*     PRINT INPUT FOR KENO
C***********************************************************************
      CHARACTER A1A*8,AD*4
      REAL*8 B1A,C1A,C,B,XX1,XX2,XX3,ENR,D1,D2,Y,Y1
      DIMENSION A1A(50),B1A(15,50),C1A(15)
      DIMENSION D1(70),D2(70,30),AD(70)
      DIMENSION B(30,50),C(30)
      CALL START(NP,NS)
C***********************************************************************
C*  OPEN ALL FILES TO BE USED:
C*        * = ONSCREEN INPUT
C*            NP = PROFILE NUMBER (70 MAX)
C*            NS = 1(SINGLE BURNUP POINT), = 2(MULTIPLE BURNUP POINTS)
C*        6 = OUTPUT (OPENED IN SUBROUTINE START)
C*        9 = INPUT (ISOTOPE DATA     OPENED IN SUBROUTINE START)
C*            ENR = ENRICHMENT IN W/O
C*            C1A(15) = BURNUP POINTS IN GWD/MTU
C*            A1A(50) = ISOTOPE LABEL
C*            B1A(15,50) = ISOTOPICS IN ATOMS/BN-CM
C*       10 = INPUT (PROFILE DATA     OPENED IN SUBROUTINE START)
C*            NB = NUMBER OF AXIAL BURNUPS (30 MAX)
C*            NF = NUMBER OF PROFILES (70 MAX)
C*            AD(NF) = PROFILE LABEL
C*            D1(NF) = AVERAGE PROFILE BURNUP IN GWD/MTU
C*            D2(NF,NB) = PROFILE BURNUPS IN GWD/MTU
C***********************************************************************
C     READ ACTINIDE DATA
      DO 10 I=1,15
      READ(9,100) ENR,C1A(I)
      DO 11 J=1,50
   11 READ(9,101) A1A(J),B1A(I,J)
   10 CONTINUE
  100 FORMAT(F4.2,F7.2)
  101 FORMAT(A8,5X,E11.5)
C***********************************************************************
C     READ PROFILE DATA
      READ(10,20) NB
      READ(10,20) NF
      DO 21 I=1,NF
      READ(10,22) AD(I)
      READ(10,23) D1(I)
   21 READ(10,24) (D2(I,J),J=1,NB)
   20 FORMAT(23X,I2)
   22 FORMAT(A4)
   23 FORMAT(2X,F7.3)
   24 FORMAT(2X,10F7.3)
C***********************************************************************
C     INTERPOLATE NEW DATA
      GO TO (30,35),NS
   30 N=1
      C(1)=D1(NP)
      GO TO 39
   35 N=NB
      DO 36 I=1,N
   36 C(I)=D2(NP,I)
   39 DO 40 K=1,N
      Y=C(K)
      DO 42 I=2,14
      Y1=(C1A(I)+C1A(I+1))/2.
      IF(Y.GT.Y1) GO TO 42
      I0=I-1
      I1=I
      I2=I+1
      GO TO 43
   42 CONTINUE
      I0=13
      I1=14
      I2=15
   43 CONTINUE
```

CA06015 REV 0
PAGE 171

```
      XX1=(Y-C1A(I1))*(Y-C1A(I2))/(C1A(I0)-C1A(I1))/(C1A(I0)-C1A(I2))
      XX2=(Y-C1A(I0))*(Y-C1A(I2))/(C1A(I1)-C1A(I0))/(C1A(I1)-C1A(I2))
      XX3=(Y-C1A(I0))*(Y-C1A(I1))/(C1A(I2)-C1A(I0))/(C1A(I2)-C1A(I1))
      DO 44 J=1,50
      B(K,J)=XX1*B1A(I0,J)+XX2*B1A(I1,J)+XX3*B1A(I2,J)
   44 IF(B(K,J).LT.1.E-24) B(K,J)=1.E-24
   40 CONTINUE
C*********************************************************************
C     PRINT DATA IN KENO FORMAT
      WRITE(6,601) ENR
      WRITE(6,602) N
      WRITE(6,603) (C(K),K=1,N)
      DO 500 K=1,N
      MX=100+K
      DO 501 J=1,50
  501 WRITE(6,600) A1A(J),MX,B(K,J)
  500 CONTINUE
  600 FORMAT(A8,I4,' 0 ',1PE11.5,' END')
  601 FORMAT(2X,'ENRICHMENT        = ',F5.2)
  602 FORMAT(2X,'NUMBER OF BURNUPS = ',I5)
  603 FORMAT(2X,'BURNUPS=',10F7.3)
C
      CLOSE(6)
      CLOSE(9)
      CLOSE(10)
      STOP
      END
      SUBROUTINE START(NP,NS)
C
C***********************************************************************
C*                                                                     *
C*  ROUTINE TO GET THE REQUIRED DATA TO GET STARTED                    *
C*                                                                     *
C***********************************************************************
C
      CHARACTER INFILE*100
   10 CONTINUE
      PRINT 11
   11 FORMAT(/////,2X,'WHAT IS THE NAME OF THE ISOTOPE FILE ',
     +       '(DO NOT FORGET DIRECTORY)',/,'    ? ')
      READ(*,12) INFILE
   12 FORMAT(A100)
      OPEN(9,FILE=INFILE,STATUS='OLD',IOSTAT=IERROR)
      IF(IERROR .EQ. 0) GO TO 14
      PRINT 13
   13 FORMAT('  CANNOT FIND FILE        PLEASE TRY AGAIN',///)
      GO TO 10
   14 CONTINUE
   20 CONTINUE
      PRINT 21
   21 FORMAT(/////,2X,'WHAT IS THE NAME OF THE PROFILE FILE ',
     +       '(DO NOT FORGET DIRECTORY)',/,'    ? ')
      READ(*,22) INFILE
   22 FORMAT(A100)
      OPEN(10,FILE=INFILE,STATUS='OLD',IOSTAT=IERROR)
      IF(IERROR .EQ. 0) GO TO 24
      PRINT 23
   23 FORMAT('  CANNOT FIND FILE        PLEASE TRY AGAIN',///)
      GO TO 10
   24 CONTINUE
      OPEN(6,FILE='SAS2HLAG.XXX',STATUS='UNKNOWN')
      PRINT 60
   60 FORMAT(/////,2X,'READ NUMBER OF PROFILE ')
      READ(*,*) NP
      PRINT 70
   70 FORMAT(/////,2X,'READ MULTI OR SINGLE')
      READ(*,*) NS
      RETURN
      END
```

ATTACHMENT Q
SAS2HLIN/LAG INPUT FILES

```
NUMBER OF BURNUPS =     18
NUMBER OF FILES =       24
06AL
    6.000
    2.820  4.650  5.730  6.384  6.846  6.972  7.080  7.134  7.152  7.146
    7.110  7.032  6.948  6.780  6.126  5.400  4.284  2.418
10AK
   10.000
    4.780  7.730  9.500 10.590 12.050 12.010 12.110 12.150 12.180 12.160
   12.090 11.940 11.700 11.510  9.760  8.060  5.960  3.700
14AJ
   14.000
    6.846 10.808 13.216 11.998 16.506 16.114 16.604 16.534 16.520 17.304
   17.654 17.710 17.654 17.416 13.314 11.858  9.100  4.872
18AI
   18.000
    9.036 14.706 16.650 14.328 22.680 22.572 22.356 22.212 22.986 23.814
   24.048 24.030 23.850 23.382 13.608 11.052  8.658  4.050
22AH
   22.000
   11.880 18.920 21.230 20.262 25.828 25.872 25.762 25.652 25.674 26.070
   26.136 26.092 26.004 25.806 22.176 19.756 14.718  8.206
26AG
   26.000
   14.144 22.594 25.012 23.868 29.588 29.640 29.978 29.978 30.472 30.992
   31.226 31.278 31.174 30.810 26.364 22.646 17.914 10.296
30AF
   30.000
   16.530 26.580 30.210 29.220 34.380 34.140 34.200 34.050 34.140 34.980
   35.190 35.190 35.070 34.710 30.660 26.460 21.030 13.320
34AE
   34.000
   18.258 30.430 34.238 35.530 38.794 38.760 38.590 38.420 38.250 38.114
   38.692 38.930 38.828 38.624 34.680 32.402 25.092 15.334
38AD
   38.000
   19.760 33.744 38.342 39.748 43.890 43.434 43.168 43.206 43.206 43.054
   42.940 43.510 43.510 43.434 38.950 36.860 28.234 14.934
42AC
   42.000
   25.494 38.388 43.008 43.722 47.208 46.914 46.536 46.494 46.326 46.284
   46.158 46.242 46.662 46.704 43.218 41.202 34.566 20.916
46AB
   46.000
   28.290 42.228 46.920 48.070 51.520 51.152 51.336 51.244 50.784 50.922
   50.646 50.646 50.922 50.784 47.150 45.126 36.800 23.552
62AA
   62.000
   35.526 56.854 63.302 64.480 69.812 69.626 69.316 69.006 68.758 68.510
   68.262 68.076 68.262 68.076 63.736 61.132 51.522 31.744
06BL
    6.000
    3.444  5.682  6.546  6.630  6.564  6.522  6.516  6.522  6.546  6.576
    6.612  6.630  6.630  6.576  6.396  5.916  4.836  2.844
10BK
   10.000
    6.620  9.300 10.490 10.590 11.080 11.440 11.680 11.830 11.890 11.900
   11.830 11.670 11.350 10.790  9.760  8.060  5.960  3.750
14BJ
   14.000
    8.862 13.846 14.266 11.998 10.864 10.556 10.990 14.182 16.590 17.542
   17.892 17.962 17.864 17.514 16.702 15.050 12.082  7.210
18BI
   18.000
   11.682 18.792 21.744 21.870 21.852 21.744 21.546 21.402 21.384 21.456
   21.510 21.420 20.808 18.396 13.608 11.052  8.658  5.112
22BH
   22.000
   14.696 22.748 25.300 24.068 23.166 23.056 23.408 24.090 24.662 24.970
   25.080 25.036 24.860 24.332 23.078 20.526 14.718  8.206
26BG
   26.000
   16.380 24.336 27.716 28.678 28.808 28.834 28.912 29.094 29.276 29.432
   29.510 29.510 29.354 28.834 27.066 22.646 17.914 11.648
30BF
   30.000
```

```
    18.570 27.720 31.680 32.910 33.090 33.030 33.090 33.360 33.750 34.080
    34.290 34.290 34.080 33.450 31.410 26.460 21.030 13.680
34BE
    34.000
    22.168 32.878 36.516 37.502 37.672 37.604 37.468 37.298 37.196 37.196
    37.230 37.264 37.230 36.924 36.006 33.014 25.092 15.708
38BD
    38.000
    22.230 36.366 41.458 42.598 42.788 42.218 41.572 41.534 41.496 41.458
    41.496 41.762 41.648 41.306 40.774 38.114 30.248 14.934
42BC
    42.000
    27.720 39.312 43.848 45.360 45.822 45.906 45.864 45.780 45.738 45.696
    45.696 45.612 45.528 45.234 44.394 41.832 34.566 22.050
46BB
    46.000
    31.004 43.654 48.438 49.910 50.370 50.370 50.278 50.186 50.094 50.048
    49.956 49.864 49.726 49.358 48.438 45.402 36.800 24.104
62BA
    62.000
    35.526 56.854 66.092 68.572 69.068 68.882 68.572 68.262 68.014 67.766
    67.518 67.332 67.022 66.526 65.162 61.566 51.584 31.744
```

CA06015 REV 0
PAGE 175

```
NUMBER OF BURNUPS =     26
NUMBER OF FILES =       43
01S0
   48.013
   26.689 35.647 42.539 45.666 47.102 49.019 50.640 51.246 51.354 51.350
   51.322 51.290 51.273 51.266 51.272 51.289 51.301 51.274 51.070 50.160
   47.985 45.620 43.986 40.699 33.688 24.808
02S0
   46.688
   25.499 34.090 47.860 43.857 45.290 47.204 48.832 49.448 49.560 49.555
   49.523 49.486 49.463 49.451 49.451 49.462 49.465 49.429 49.212 48.296
   46.147 43.827 42.226 49.017 32.237 23.743
03S1
   49.523
   27.430 36.629 43.705 46.899 48.355 50.402 52.188 52.858 52.983 52.985
   52.963 52.937 52.924 52.923 52.934 52.958 52.975 52.951 52.742 51.793
   49.504 47.016 45.335 41.970 34.738 25.572
04V0
   14.895
    7.488 10.180 12.591 13.771 14.350 15.171 15.879 16.152 16.205 16.204
   16.187 16.165 16.147 16.135 16.125 16.116 16.101 16.068 15.954 15.553
   14.677 13.759 13.145 11.954  9.602  7.051
05T0
   35.696
   19.598 26.043 31.397 33.877 35.030 36.551 37.828 38.298 38.372 38.356
   38.317 38.270 38.235 38.210 38.191 38.175 38.156 38.108 37.914 37.167
   35.453 33.614 32.357 29.845 24.581 18.422
06V1
   20.408
   11.234 15.108 18.421 19.933 20.526 20.998 21.673 21.957 22.002 21.988
   21.955 21.914 21.880 21.854 21.830 21.804 21.773 21.719 21.560 21.039
   19.947 18.857 18.215 17.042 13.961 10.377
07V0
   22.090
   11.822 15.895 19.399 21.043 21.802 22.787 23.609 23.908 23.947 23.925
   23.882 23.829 23.785 23.751 23.717 23.681 23.640 23.578 23.406 22.851
   21.672 20.446 19.627 18.002 14.651 10.882
08S2
   51.485
   28.928 38.669 45.995 49.156 50.419 52.346 54.138 54.851 54.994 55.001
   54.979 54.952 54.939 54.937 54.950 54.976 54.992 54.962 54.728 53.706
   51.322 48.810 47.192 43.989 36.564 26.869
09V0
   18.880
    9.750 13.112 16.087 17.529 18.230 19.223 20.088 20.424 20.489 20.487
   20.466 20.437 20.414 20.398 20.384 20.371 20.353 20.313 20.176 19.693
   18.630 17.513 16.764 15.303 12.384  9.186
10T0
   35.485
   19.232 25.659 31.028 33.540 34.723 36.317 37.675 38.188 38.276 38.260
   38.216 38.160 38.115 38.083 38.054 38.027 37.994 37.928 37.702 36.894
   35.099 33.202 31.917 29.371 24.109 18.003
11V1
   25.651
   14.213 19.100 23.209 25.076 25.828 26.502 27.344 27.690 27.739 27.712
   27.657 27.589 27.531 27.485 27.437 27.384 27.326 27.241 27.017 26.335
   24.946 23.572 22.745 21.214 17.387 12.920
12T0
   41.171
   22.953 30.365 36.417 39.190 40.466 42.139 43.550 44.084 44.182 44.174
   44.138 44.091 44.055 44.030 44.010 43.992 43.967 43.905 43.672 42.809
   40.869 38.803 37.393 34.565 28.569 21.509
13T1
   42.997
   24.129 31.875 38.148 41.012 42.309 43.962 45.404 45.934 46.026 46.020
   45.991 45.954 45.928 45.912 45.903 45.899 45.888 45.842 45.631 44.787
   42.815 40.680 39.236 36.358 30.123 22.666
```

CA06015 REV 0
PAGE 176

```
14T2
    35.350
    19.834 26.303 31.625 34.026 35.023 36.083 37.265 37.753 37.848 37.849
    37.826 37.794 37.770 37.754 37.744 37.737 37.724 37.679 37.488 36.740
    35.039 33.263 32.150 30.009 24.833 18.633
15V0
    19.296
     9.950 13.378 16.403 17.866 18.576 19.576 20.461 20.816 20.892 20.897
    20.884 20.865 20.851 20.842 20.837 20.835 20.827 20.795 20.667 20.187
    19.114 17.980 17.220 15.733 12.744  9.452
16T2
    46.518
    26.685 35.139 41.852 44.837 46.084 47.465 48.872 49.456 49.584 49.598
    49.587 49.569 49.557 49.553 49.558 49.569 49.568 49.525 49.299 48.385
    46.291 44.087 42.667 39.864 33.250 25.091
17V1
    26.726
    14.846 19.904 24.135 26.046 26.812 27.499 28.368 28.741 28.807 28.793
    28.753 28.700 28.656 28.622 28.587 28.549 28.504 28.430 28.216 27.532
    26.119 24.713 23.862 22.274 18.291 13.615
18T2
    49.829
    28.927 38.034 45.148 48.262 49.532 50.877 52.215 52.782 52.918 52.946
    52.952 52.954 52.961 52.972 52.994 53.025 53.040 53.010 52.793 51.871
    49.732 47.472 46.002 43.053 36.034 27.233
19V1
    27.257
    15.266 20.425 24.700 26.607 27.359 28.009 28.821 29.168 29.238 29.235
    29.211 29.177 29.150 29.130 29.112 29.093 29.066 29.008 28.819 28.177
    26.813 25.428 24.579 22.974 18.911 14.101
20T2
    48.874
    28.369 37.257 44.207 47.248 48.493 49.816 51.140 51.704 51.847 51.884
    51.902 51.917 51.933 51.953 51.985 52.026 52.050 52.028 51.826 50.943
    48.873 46.668 45.229 42.340 35.446 26.811
24V1
    26.492
    14.740 19.743 23.917 25.791 26.533 27.176 28.013 28.386 28.464 28.462
    28.437 28.401 28.371 28.350 28.331 28.310 28.281 28.221 28.027 27.375
    26.005 24.635 23.806 22.249 18.296 13.632
25T2
    47.452
    27.428 36.136 42.998 46.022 47.261 48.560 49.881 50.440 50.561 50.570
    50.553 50.527 50.509 50.500 50.499 50.502 50.493 50.441 50.196 49.250
    47.132 44.930 43.515 40.699 33.995 25.657
26V1
    27.861
    15.674 20.958 25.314 27.242 27.991 28.617 29.404 29.753 29.832 29.837
    29.820 29.794 29.772 29.757 29.745 29.733 29.710 29.655 29.464 28.814
    27.440 26.051 25.198 23.574 19.435 14.505
27T2
    50.026
    29.135 38.271 45.383 48.478 49.727 51.032 52.337 52.905 53.054 53.092
    53.111 53.125 53.142 53.161 53.193 53.234 53.257 53.232 53.018 52.101
    49.982 47.747 46.293 43.362 36.336 27.484
28V1
    27.664
    15.555 20.795 25.114 27.023 27.763 28.375 29.149 29.493 29.574 29.583
    29.574 29.556 29.542 29.533 29.529 29.526 29.511 29.465 29.288 28.664
    27.320 25.950 25.107 23.497 19.378 14.466
33V2
    27.782
    15.828 21.172 25.546 27.451 28.139 28.542 29.251 29.589 29.669 29.677
    29.665 29.643 29.626 29.614 29.606 29.598 29.578 29.525 29.336 28.690
    27.334 25.985 25.194 23.731 19.622 14.648
34T2
    49.939
```

```
    29.159 38.292 45.376 48.439 49.660 50.906 52.148 52.697 52.851 52.899
    52.931 52.961 52.991 53.022 53.067 53.124 53.162 53.149 52.957 52.080
    50.020 47.833 46.405 43.506 36.499 27.627
35V2
    27.639
    15.780 21.094 25.437 27.319 27.992 28.366 29.041 29.365 29.449 29.464
    29.460 29.449 29.441 29.437 29.438 29.440 29.430 29.386 29.212 28.595
    27.278 25.959 25.182 23.737 19.645 14.676
36T2
    49.592
    28.950 38.028 45.068 48.110 49.320 50.549 51.766 52.294 52.440 52.489
    52.524 52.559 52.594 52.628 52.678 52.742 52.787 52.784 52.610 51.771
    49.754 47.592 46.175 43.295 36.323 27.493
42V2
    27.667
    15.845 21.177 25.524 27.400 28.064 28.416 29.060 29.372 29.453 29.469
    29.467 29.459 29.452 29.449 29.452 29.456 29.447 29.405 29.234 28.624
    27.322 26.016 25.246 23.808 19.716 14.733
43T2
    49.325
    28.765 37.831 44.901 47.974 49.206 50.461 51.711 52.252 52.385 52.411
    52.414 52.410 52.410 52.415 52.431 52.452 52.458 52.417 52.184 51.250
    49.137 46.931 45.502 42.620 35.696 26.982
44V2
    27.779
    15.910 21.276 25.647 27.535 28.205 28.567 29.206 29.506 29.581 29.593
    29.589 29.579 29.570 29.564 29.563 29.564 29.552 29.508 29.338 28.731
    27.429 26.116 25.338 23.884 19.773 14.770
52V2
    27.236
    15.605 20.854 25.135 26.985 27.641 27.992 28.613 28.896 28.967 28.980
    28.980 28.975 28.971 28.969 28.973 28.980 28.974 28.938 28.782 28.209
    26.952 25.671 24.909 23.487 19.449 14.539
53T0
    40.843
    23.043 30.348 36.278 38.944 40.140 41.652 42.886 43.368 43.486 43.513
    43.523 43.529 43.538 43.550 43.573 43.605 43.625 43.605 43.436 42.694
    40.937 39.018 37.684 34.948 29.053 21.978
54S0
    46.417
    25.546 34.157 40.867 43.944 45.380 47.301 48.935 49.554 49.666 49.660
    49.628 49.590 51.283 49.554 49.553 49.562 49.565 49.528 49.309 48.388
    46.232 43.905 42.301 39.085 32.292 23.780
55V0
    22.094
    11.824 15.897 19.402 21.046 21.806 22.791 23.613 23.912 23.951 23.929
    23.886 23.833 23.789 23.755 23.721 23.685 23.644 23.583 23.410 22.855
    21.675 20.450 19.630 18.005 14.654 10.884
56T1
    42.987
    24.124 31.869 38.140 41.004 42.300 43.952 45.393 45.923 46.016 46.009
    45.980 45.943 45.917 45.902 45.893 45.889 45.878 45.832 45.621 44.778
    42.807 40.672 39.228 36.351 30.118 22.662
57T2
    48.568
    28.184 37.005 43.901 46.918 48.152 49.466 50.781 51.339 51.484 51.525
    51.549 51.570 51.593 51.618 51.656 51.704 51.735 51.719 51.530 50.672
    48.635 46.454 45.026 42.157 35.303 26.712
58V1
    27.667
    15.557 20.797 25.117 27.026 27.767 28.379 29.153 29.497 29.578 29.588
    29.578 29.560 29.546 29.537 29.533 29.530 29.515 29.468 29.292 28.667
    27.322 25.953 25.109 23.499 19.380 14.468
59T2
    49.583
    28.936 38.009 45.051 48.103 49.327 50.562 51.775 52.299 52.442 52.488
    52.521 52.554 52.587 52.620 52.669 52.730 52.775 52.771 52.597 51.758
```

```
   49.741 47.574 46.150 43.252 36.279 27.464
60V2
   27.735
   15.886 21.241 25.605 27.489 28.157 28.516 29.154 29.453 29.529 29.542
   29.539 29.529 29.521 29.516 29.516 29.518 29.507 29.464 29.295 28.690
   27.391 26.082 25.306 23.856 19.750 14.755
61T0
   43.765
   24.846 32.682 38.978 41.800 43.062 44.662 45.969 46.478 46.598 46.623
   46.629 46.631 46.636 46.644 46.664 46.692 46.707 46.681 46.496 45.698
   43.819 41.776 40.358 37.454 31.186 23.601
62J0
   50.648
   28.810 37.742 44.609 48.199 48.708 51.030 52.642 53.319 53.539 53.641
   53.736 53.838 53.931 54.017 54.124 54.247 54.337 54.369 54.226 53.405
   51.328 48.523 47.934 43.922 36.616 27.259
```

```
5.00  00.00
KR-83     1 0 1.33996E-25 END
KR-84     1 0 1.33996E-25 END
KR-86     1 0 1.46055E-12 END
MO-95     1 0 1.33996E-25 END
TC-99     1 0 2.84071E-12 END
RU-101    1 0 3.85908E-12 END
RH-103    1 0 1.33996E-25 END
AG-109    1 0 1.33996E-25 END
SN-126    1 0 1.33996E-25 END
I-129     1 0 1.33996E-25 END
XE-131    1 0 1.33996E-25 END
XE-132    1 0 1.88934E-12 END
CS-133    1 0 1.33996E-25 END
XE-134    1 0 5.88241E-12 END
CS-134    1 0 1.33996E-25 END
CS-135    1 0 4.91764E-12 END
CS-137    1 0 4.71665E-12 END
ND-143    1 0 1.33996E-25 END
ND-144    1 0 1.33996E-25 END
ND-145    1 0 2.96131E-12 END
ND-146    1 0 2.25113E-12 END
PM-147    1 0 1.33996E-25 END
SM-147    1 0 1.33996E-25 END
ND-148    1 0 1.33996E-25 END
SM-148    1 0 1.33996E-25 END
SM-149    1 0 1.33996E-25 END
ND-150    1 0 1.33996E-25 END
SM-150    1 0 1.33996E-25 END
SM-151    1 0 1.33996E-25 END
EU-151    1 0 1.33996E-25 END
SM-152    1 0 1.33996E-25 END
EU-153    1 0 1.33996E-25 END
EU-154    1 0 1.33996E-25 END
GD-154    1 0 1.33996E-25 END
EU-155    1 0 1.33996E-25 END
GD-155    1 0 1.33996E-25 END
U-234     1 0 1.33996E-25 END
U-235     1 0 1.16978E-03 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.19753E-02 END
NP-237    1 0 1.33996E-25 END
PU-238    1 0 1.33996E-25 END
PU-239    1 0 2.41192E-11 END
PU-240    1 0 1.33996E-25 END
PU-241    1 0 1.33996E-25 END
PU-242    1 0 1.33996E-25 END
AM-241    1 0 1.33996E-25 END
CM-242    1 0 1.33996E-25 END
CM-243    1 0 1.33996E-25 END
CM-244    1 0 1.33996E-25 END
5.00  05.00
KR-83     1 0 6.23080E-07 END
KR-84     1 0 1.28234E-06 END
KR-86     1 0 2.30473E-06 END
MO-95     1 0 2.67992E-06 END
TC-99     1 0 7.47696E-06 END
RU-101    1 0 6.36480E-06 END
RH-103    1 0 2.80051E-06 END
AG-109    1 0 1.76874E-07 END
SN-126    1 0 6.53899E-08 END
I-129     1 0 9.41990E-07 END
XE-131    1 0 3.32309E-06 END
XE-132    1 0 5.54742E-06 END
CS-133    1 0 7.97275E-06 END
XE-134    1 0 9.64770E-06 END
CS-134    1 0 1.09609E-07 END
CS-135    1 0 3.47049E-06 END
CS-137    1 0 7.71815E-06 END
ND-143    1 0 6.28440E-06 END
ND-144    1 0 1.39356E-06 END
ND-145    1 0 4.68985E-06 END
ND-146    1 0 3.72508E-06 END
PM-147    1 0 2.25113E-06 END
SM-147    1 0 1.28904E-07 END
ND-148    1 0 2.09033E-06 END
SM-148    1 0 1.02641E-07 END
SM-149    1 0 1.36676E-07 END
ND-150    1 0 8.64273E-07 END
SM-150    1 0 1.27296E-06 END
SM-151    1 0 3.41689E-07 END
EU-151    1 0 4.32806E-10 END
SM-152    1 0 5.64122E-07 END
EU-153    1 0 2.65312E-07 END
EU-154    1 0 1.55435E-08 END
GD-154    1 0 2.02334E-10 END
EU-155    1 0 2.09033E-08 END
```

CA06015 REV 0
PAGE 180

```
GD-155    1 0 3.12210E-10 END
U-234     1 0 8.46853E-09 END
U-235     1 0 1.03311E-03 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.18413E-02 END
NP-237    1 0 6.21740E-07 END
PU-238    1 0 2.33153E-08 END
PU-239    1 0 4.75685E-05 END
PU-240    1 0 3.16230E-06 END
PU-241    1 0 6.78019E-07 END
PU-242    1 0 1.84914E-08 END
AM-241    1 0 4.16727E-09 END
CM-242    1 0 1.43375E-10 END
CM-243    1 0 1.33996E-25 END
CM-244    1 0 1.10814E-11 END
5.00  10.00
KR-83     1 0 1.18988E-06 END
KR-84     1 0 2.51912E-06 END
KR-86     1 0 4.44866E-06 END
MO-95     1 0 9.13851E-06 END
TC-99     1 0 1.47395E-05 END
RU-101    1 0 1.27162E-05 END
RH-103    1 0 6.76679E-06 END
AG-109    1 0 5.34643E-07 END
SN-126    1 0 1.51415E-07 END
I-129     1 0 1.99654E-06 END
XE-131    1 0 6.59259E-06 END
XE-132    1 0 1.15504E-05 END
CS-133    1 0 1.59455E-05 END
XE-134    1 0 1.91614E-05 END
CS-134    1 0 4.32806E-07 END
CS-135    1 0 6.94098E-06 END
CS-137    1 0 1.54095E-05 END
ND-143    1 0 1.27430E-05 END
ND-144    1 0 4.89085E-06 END
ND-145    1 0 9.15191E-06 END
ND-146    1 0 7.49036E-06 END
PM-147    1 0 4.03327E-06 END
SM-147    1 0 4.86405E-07 END
ND-148    1 0 4.18067E-06 END
SM-148    1 0 4.34146E-07 END
SM-149    1 0 1.48735E-07 END
ND-150    1 0 1.75534E-06 END
SM-150    1 0 2.81391E-06 END
SM-151    1 0 4.87745E-07 END
EU-151    1 0 8.58913E-10 END
SM-152    1 0 1.31048E-06 END
EU-153    1 0 6.51219E-07 END
EU-154    1 0 6.39160E-08 END
GD-154    1 0 1.58115E-09 END
EU-155    1 0 3.34989E-08 END
GD-155    1 0 5.29283E-10 END
U-234     1 0 1.62135E-08 END
U-235     1 0 9.12511E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.18413E-02 END
NP-237    1 0 1.79554E-06 END
PU-238    1 0 1.33996E-07 END
PU-239    1 0 8.12014E-05 END
PU-240    1 0 9.52710E-06 END
PU-241    1 0 3.53749E-06 END
PU-242    1 0 2.07693E-07 END
AM-241    1 0 4.31466E-08 END
CM-242    1 0 2.90771E-09 END
CM-243    1 0 1.67495E-11 END
CM-244    1 0 5.56082E-10 END
5.00  15.00
KR-83     1 0 1.70175E-06 END
KR-84     1 0 3.72508E-06 END
KR-86     1 0 6.47200E-06 END
MO-95     1 0 1.63475E-05 END
TC-99     1 0 2.18413E-05 END
RU-101    1 0 1.90274E-05 END
RH-103    1 0 1.07063E-05 END
AG-109    1 0 1.01569E-06 END
SN-126    1 0 2.53252E-07 END
I-129     1 0 3.09530E-06 END
XE-131    1 0 9.63429E-06 END
XE-132    1 0 1.79554E-05 END
CS-133    1 0 2.35833E-05 END
XE-134    1 0 2.86751E-05 END
CS-134    1 0 9.32610E-07 END
CS-135    1 0 1.03847E-05 END
CS-137    1 0 2.29133E-05 END
ND-143    1 0 1.86254E-05 END
ND-144    1 0 9.83529E-06 END
ND-145    1 0 1.33862E-05 END
```

```
ND-146    1 0 1.13226E-05 END
PM-147    1 0 5.33303E-06 END
SM-147    1 0 9.90229E-07 END
ND-148    1 0 6.24420E-06 END
SM-148    1 0 9.56730E-07 END
SM-149    1 0 1.56775E-07 END
ND-150    1 0 2.67992E-06 END
SM-150    1 0 4.43526E-06 END
SM-151    1 0 5.72162E-07 END
EU-151    1 0 1.10145E-09 END
SM-152    1 0 2.07693E-06 END
EU-153    1 0 1.15504E-06 END
EU-154    1 0 1.47395E-07 END
GD-154    1 0 5.35983E-09 END
EU-155    1 0 5.11864E-08 END
GD-155    1 0 8.07994E-10 END
U-234     1 0 2.34493E-08 END
U-235     1 0 8.02635E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.17073E-02 END
NP-237    1 0 3.34989E-06 END
PU-238    1 0 3.79208E-07 END
PU-239    1 0 1.05455E-04 END
PU-240    1 0 1.70175E-05 END
PU-241    1 0 8.03975E-06 END
PU-242    1 0 7.49036E-07 END
AM-241    1 0 1.46055E-07 END
CM-242    1 0 1.42036E-08 END
CM-243    1 0 1.29708E-10 END
CM-244    1 0 4.95784E-09 END
5.00  20.00
KR-83     1 0 2.17073E-06 END
KR-84     1 0 4.90424E-06 END
KR-86     1 0 8.40153E-06 END
MO-95     1 0 2.33153E-05 END
TC-99     1 0 2.86751E-05 END
RU-101    1 0 2.53252E-05 END
RH-103    1 0 1.44715E-05 END
AG-109    1 0 1.58115E-06 END
SN-126    1 0 3.65808E-07 END
I-129     1 0 4.22087E-06 END
XE-131    1 0 1.24080E-05 END
XE-132    1 0 2.46552E-05 END
CS-133    1 0 3.10870E-05 END
XE-134    1 0 3.81888E-05 END
CS-134    1 0 1.58115E-06 END
CS-135    1 0 1.38016E-05 END
CS-137    1 0 3.04170E-05 END
ND-143    1 0 2.39852E-05 END
ND-144    1 0 1.58115E-05 END
ND-145    1 0 1.74194E-05 END
ND-146    1 0 1.52755E-05 END
PM-147    1 0 6.25760E-06 END
SM-147    1 0 1.58115E-06 END
ND-148    1 0 8.29434E-06 END
SM-148    1 0 1.64815E-06 END
SM-149    1 0 1.62135E-07 END
ND-150    1 0 3.63128E-06 END
SM-150    1 0 6.11021E-06 END
SM-151    1 0 6.35140E-07 END
EU-151    1 0 1.24080E-09 END
SM-152    1 0 2.80051E-06 END
EU-153    1 0 1.75534E-06 END
EU-154    1 0 2.67992E-07 END
GD-154    1 0 1.27564E-08 END
EU-155    1 0 7.51716E-08 END
GD-155    1 0 1.18720E-09 END
U-234     1 0 3.08190E-08 END
U-235     1 0 7.03478E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.17073E-02 END
NP-237    1 0 5.19904E-06 END
PU-238    1 0 7.94595E-07 END
PU-239    1 0 1.23008E-04 END
PU-240    1 0 2.47892E-05 END
PU-241    1 0 1.33460E-05 END
PU-242    1 0 1.74194E-06 END
AM-241    1 0 3.20250E-07 END
CM-242    1 0 3.96627E-08 END
CM-243    1 0 4.99804E-10 END
CM-244    1 0 2.21093E-08 END
5.00  25.00
KR-83     1 0 2.58612E-06 END
KR-84     1 0 6.05661E-06 END
KR-86     1 0 1.02239E-05 END
MO-95     1 0 3.01490E-05 END
TC-99     1 0 3.52409E-05 END
```

CA06015 REV 0
PAGE 182

```
RU-101     1 0 3.16230E-05 END
RH-103     1 0 1.80894E-05 END
AG-109     1 0 2.22433E-06 END
SN-126     1 0 4.87745E-07 END
I-129      1 0 5.37323E-06 END
XE-131     1 0 1.48735E-05 END
XE-132     1 0 3.16230E-05 END
CS-133     1 0 3.81888E-05 END
XE-134     1 0 4.75685E-05 END
CS-134     1 0 2.34493E-06 END
CS-135     1 0 1.70175E-05 END
CS-137     1 0 3.77868E-05 END
ND-143     1 0 2.89431E-05 END
ND-144     1 0 2.25113E-05 END
ND-145     1 0 2.13053E-05 END
ND-146     1 0 1.91614E-05 END
PM-147     1 0 6.88738E-06 END
SM-147     1 0 2.19753E-06 END
ND-148     1 0 1.03445E-05 END
SM-148     1 0 2.46552E-06 END
SM-149     1 0 1.63475E-07 END
ND-150     1 0 4.59605E-06 END
SM-150     1 0 7.81195E-06 END
SM-151     1 0 6.87398E-07 END
EU-151     1 0 1.32522E-09 END
SM-152     1 0 3.49729E-06 END
EU-153     1 0 2.43872E-06 END
EU-154     1 0 4.19407E-07 END
GD-154     1 0 2.49232E-08 END
EU-155     1 0 1.05723E-07 END
GD-155     1 0 1.66155E-09 END
U-234      1 0 3.89928E-08 END
U-235      1 0 6.12361E-04 END
U-236      1 0 1.00000E-20 END
U-238      1 0 2.15733E-02 END
NP-237     1 0 7.23577E-06 END
PU-238     1 0 1.40696E-06 END
PU-239     1 0 1.35336E-04 END
PU-240     1 0 3.26950E-05 END
PU-241     1 0 1.88934E-05 END
PU-242     1 0 3.21590E-06 END
AM-241     1 0 5.52063E-07 END
CM-242     1 0 8.22734E-08 END
CM-243     1 0 1.32924E-09 END
CM-244     1 0 6.76679E-08 END
5.00  30.00
KR-83      1 0 2.97471E-06 END
KR-84      1 0 7.19557E-06 END
KR-86      1 0 1.19658E-05 END
MO-95      1 0 3.67148E-05 END
TC-99      1 0 4.16727E-05 END
RU-101     1 0 3.77868E-05 END
RH-103     1 0 2.15733E-05 END
AG-109     1 0 2.90771E-06 END
SN-126     1 0 6.19060E-07 END
I-129      1 0 6.53899E-06 END
XE-131     1 0 1.72855E-05 END
XE-132     1 0 3.88588E-05 END
CS-133     1 0 4.50226E-05 END
XE-134     1 0 5.69482E-05 END
CS-134     1 0 3.21590E-06 END
CS-135     1 0 2.03674E-05 END
CS-137     1 0 4.51566E-05 END
ND-143     1 0 3.33649E-05 END
ND-144     1 0 2.98811E-05 END
ND-145     1 0 2.49232E-05 END
ND-146     1 0 2.33153E-05 END
PM-147     1 0 7.31617E-06 END
SM-147     1 0 2.81391E-06 END
ND-148     1 0 1.23678E-05 END
SM-148     1 0 3.41689E-06 END
SM-149     1 0 1.63475E-07 END
ND-150     1 0 5.58762E-06 END
SM-150     1 0 9.51370E-06 END
SM-151     1 0 7.31617E-07 END
EU-151     1 0 1.38016E-09 END
SM-152     1 0 4.15387E-06 END
EU-153     1 0 3.17570E-06 END
EU-154     1 0 5.98961E-07 END
GD-154     1 0 4.26107E-08 END
EU-155     1 0 1.42036E-07 END
GD-155     1 0 2.22433E-09 END
U-234      1 0 4.85065E-08 END
U-235      1 0 5.30623E-04 END
U-236      1 0 1.00000E-20 END
U-238      1 0 2.14393E-02 END
NP-237     1 0 9.40650E-06 END
```

```
PU-238    1 0 2.25113E-06 END
PU-239    1 0 1.44715E-04 END
PU-240    1 0 4.03327E-05 END
PU-241    1 0 2.42532E-05 END
PU-242    1 0 5.15884E-06 END
AM-241    1 0 8.25414E-07 END
CM-242    1 0 1.42036E-07 END
CM-243    1 0 2.80051E-09 END
CM-244    1 0 1.63475E-07 END
5.00  35.00
KR-83     1 0 3.30970E-06 END
KR-84     1 0 8.32114E-06 END
KR-86     1 0 1.36676E-05 END
MO-95     1 0 4.30126E-05 END
TC-99     1 0 4.77025E-05 END
RU-101    1 0 4.39506E-05 END
RH-103    1 0 2.46552E-05 END
AG-109    1 0 3.63128E-06 END
SN-126    1 0 7.55736E-07 END
I-129     1 0 7.71815E-06 END
XE-131    1 0 1.92954E-05 END
XE-132    1 0 4.64965E-05 END
CS-133    1 0 5.14544E-05 END
XE-134    1 0 6.61939E-05 END
CS-134    1 0 4.16727E-06 END
CS-135    1 0 2.34493E-05 END
CS-137    1 0 5.23923E-05 END
ND-143    1 0 3.72508E-05 END
ND-144    1 0 3.76528E-05 END
ND-145    1 0 2.82731E-05 END
ND-146    1 0 2.74691E-05 END
PM-147    1 0 7.58416E-06 END
SM-147    1 0 3.41689E-06 END
ND-148    1 0 1.43375E-05 END
SM-148    1 0 4.48886E-06 END
SM-149    1 0 1.62135E-07 END
ND-150    1 0 6.59259E-06 END
SM-150    1 0 1.12020E-05 END
SM-151    1 0 7.71816E-07 END
EU-151    1 0 1.40696E-09 END
SM-152    1 0 4.75685E-06 END
EU-153    1 0 3.93948E-06 END
EU-154    1 0 7.98615E-07 END
GD-154    1 0 6.65959E-08 END
EU-155    1 0 1.83574E-07 END
GD-155    1 0 2.85411E-09 END
U-234     1 0 6.00301E-08 END
U-235     1 0 4.56926E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.14393E-02 END
NP-237    1 0 1.16308E-05 END
PU-238    1 0 3.30970E-06 END
PU-239    1 0 1.50075E-04 END
PU-240    1 0 4.75685E-05 END
PU-241    1 0 2.90771E-05 END
PU-242    1 0 7.53056E-06 END
AM-241    1 0 1.11618E-06 END
CM-242    1 0 2.17073E-07 END
CM-243    1 0 5.05164E-09 END
CM-244    1 0 3.39009E-07 END
5.00  40.00
KR-83     1 0 3.59109E-06 END
KR-84     1 0 9.43330E-06 END
KR-86     1 0 1.52755E-05 END
MO-95     1 0 4.90424E-05 END
TC-99     1 0 5.35983E-05 END
RU-101    1 0 4.99804E-05 END
RH-103    1 0 2.76031E-05 END
AG-109    1 0 4.36826E-06 END
SN-126    1 0 8.99112E-07 END
I-129     1 0 8.89732E-06 END
XE-131    1 0 2.10373E-05 END
XE-132    1 0 5.42683E-05 END
CS-133    1 0 5.77522E-05 END
XE-134    1 0 7.54396E-05 END
CS-134    1 0 5.18564E-06 END
CS-135    1 0 2.66652E-05 END
CS-137    1 0 5.94941E-05 END
ND-143    1 0 4.07347E-05 END
ND-144    1 0 4.58265E-05 END
ND-145    1 0 3.16230E-05 END
ND-146    1 0 3.17570E-05 END
PM-147    1 0 7.71815E-06 END
SM-147    1 0 3.96627E-06 END
ND-148    1 0 1.63475E-05 END
SM-148    1 0 5.64122E-06 END
SM-149    1 0 1.60795E-07 END
```

CA06015 REV 0
PAGE 184

```
ND-150    1 0 7.61096E-06 END
SM-150    1 0 1.28636E-05 END
SM-151    1 0 8.06654E-07 END
EU-151    1 0 1.42036E-09 END
SM-152    1 0 5.33303E-06 END
EU-153    1 0 4.73005E-06 END
EU-154    1 0 1.01167E-06 END
GD-154    1 0 9.70129E-08 END
EU-155    1 0 2.29133E-07 END
GD-155    1 0 3.52409E-09 END
U-234     1 0 7.42336E-08 END
U-235     1 0 3.91268E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.13053E-02 END
NP-237    1 0 1.39356E-05 END
PU-238    1 0 4.60945E-06 END
PU-239    1 0 1.54095E-04 END
PU-240    1 0 5.42683E-05 END
PU-241    1 0 3.34989E-05 END
PU-242    1 0 1.02909E-05 END
AM-241    1 0 1.40696E-06 END
CM-242    1 0 3.04170E-07 END
CM-243    1 0 8.12014E-09 END
CM-244    1 0 6.23080E-07 END
5.00  45.00
KR-83     1 0 3.84568E-06 END
KR-84     1 0 1.05321E-05 END
KR-86     1 0 1.67495E-05 END
MO-95     1 0 5.48043E-05 END
TC-99     1 0 5.92261E-05 END
RU-101    1 0 5.58762E-05 END
RH-103    1 0 3.04170E-05 END
AG-109    1 0 5.11864E-06 END
SN-126    1 0 1.04919E-06 END
I-129     1 0 1.00765E-05 END
XE-131    1 0 2.26453E-05 END
XE-132    1 0 6.23080E-05 END
CS-133    1 0 6.36480E-05 END
XE-134    1 0 8.45513E-05 END
CS-134    1 0 6.25760E-06 END
CS-135    1 0 2.96131E-05 END
CS-137    1 0 6.65959E-05 END
ND-143    1 0 4.36826E-05 END
ND-144    1 0 5.42683E-05 END
ND-145    1 0 3.47049E-05 END
ND-146    1 0 3.60449E-05 END
PM-147    1 0 7.77175E-06 END
SM-147    1 0 4.47546E-06 END
ND-148    1 0 1.83574E-05 END
SM-148    1 0 6.88738E-06 END
SM-149    1 0 1.58115E-07 END
ND-150    1 0 8.64273E-06 END
SM-150    1 0 1.44715E-05 END
SM-151    1 0 8.37473E-07 END
EU-151    1 0 1.42036E-09 END
SM-152    1 0 5.88241E-06 END
EU-153    1 0 5.53402E-06 END
EU-154    1 0 1.23008E-06 END
GD-154    1 0 1.33862E-07 END
EU-155    1 0 2.77371E-07 END
GD-155    1 0 4.20747E-09 END
U-234     1 0 9.16531E-08 END
U-235     1 0 3.32309E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.13053E-02 END
NP-237    1 0 1.60795E-05 END
PU-238    1 0 6.12361E-06 END
PU-239    1 0 1.55435E-04 END
PU-240    1 0 6.05661E-05 END
PU-241    1 0 3.73848E-05 END
PU-242    1 0 1.33996E-05 END
AM-241    1 0 1.67495E-06 END
CM-242    1 0 3.97967E-07 END
CM-243    1 0 1.19926E-08 END
CM-244    1 0 1.04919E-06 END
5.00  50.00
KR-83     1 0 4.06007E-06 END
KR-84     1 0 1.16174E-05 END
KR-86     1 0 1.82234E-05 END
MO-95     1 0 6.02981E-05 END
TC-99     1 0 6.45860E-05 END
RU-101    1 0 6.17720E-05 END
RH-103    1 0 3.28290E-05 END
AG-109    1 0 5.86901E-06 END
SN-126    1 0 1.20328E-06 END
I-129     1 0 1.12690E-05 END
XE-131    1 0 2.39852E-05 END
```

CA06015 REV 0
PAGE 185

```
XE-132    1 0 7.06158E-05 END
CS-133    1 0 6.92758E-05 END
XE-134    1 0 9.37970E-05 END
CS-134    1 0 7.38317E-06 END
CS-135    1 0 3.25610E-05 END
CS-137    1 0 7.35637E-05 END
ND-143    1 0 4.62285E-05 END
ND-144    1 0 6.31120E-05 END
ND-145    1 0 3.75188E-05 END
ND-146    1 0 4.04667E-05 END
PM-147    1 0 7.75835E-06 END
SM-147    1 0 4.91764E-06 END
ND-148    1 0 2.03674E-05 END
SM-148    1 0 8.21394E-06 END
SM-149    1 0 1.54095E-07 END
ND-150    1 0 9.70129E-06 END
SM-150    1 0 1.60795E-05 END
SM-151    1 0 8.62933E-07 END
EU-151    1 0 1.40696E-09 END
SM-152    1 0 6.39160E-06 END
EU-153    1 0 6.31120E-06 END
EU-154    1 0 1.44715E-06 END
GD-154    1 0 1.76874E-07 END
EU-155    1 0 3.26950E-07 END
GD-155    1 0 4.90424E-09 END
U-234     1 0 1.12556E-07 END
U-235     1 0 2.80051E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.11713E-02 END
NP-237    1 0 1.82234E-05 END
PU-238    1 0 7.82535E-06 END
PU-239    1 0 1.56775E-04 END
PU-240    1 0 6.61939E-05 END
PU-241    1 0 4.06007E-05 END
PU-242    1 0 1.67495E-05 END
AM-241    1 0 1.91614E-06 END
CM-242    1 0 4.95784E-07 END
CM-243    1 0 1.64815E-08 END
CM-244    1 0 1.64815E-06 END
5.00  55.00
KR-83     1 0 4.23427E-06 END
KR-84     1 0 1.27028E-05 END
KR-86     1 0 1.95634E-05 END
MO-95     1 0 6.56579E-05 END
TC-99     1 0 6.96778E-05 END
RU-101    1 0 6.76679E-05 END
RH-103    1 0 3.49729E-05 END
AG-109    1 0 6.61939E-06 END
SN-126    1 0 1.36676E-06 END
I-129     1 0 1.24482E-05 END
XE-131    1 0 2.51912E-05 END
XE-132    1 0 7.91915E-05 END
CS-133    1 0 7.45016E-05 END
XE-134    1 0 1.02775E-04 END
CS-134    1 0 8.52213E-06 END
CS-135    1 0 3.55089E-05 END
CS-137    1 0 8.03975E-05 END
ND-143    1 0 4.82385E-05 END
ND-144    1 0 7.22237E-05 END
ND-145    1 0 4.03327E-05 END
ND-146    1 0 4.51566E-05 END
PM-147    1 0 7.67796E-06 END
SM-147    1 0 5.29283E-06 END
ND-148    1 0 2.23773E-05 END
SM-148    1 0 9.60750E-06 END
SM-149    1 0 1.51415E-07 END
ND-150    1 0 1.07599E-05 END
SM-150    1 0 1.75534E-05 END
SM-151    1 0 8.87052E-07 END
EU-151    1 0 1.39356E-09 END
SM-152    1 0 6.86058E-06 END
EU-153    1 0 7.08838E-06 END
EU-154    1 0 1.66155E-06 END
GD-154    1 0 2.25113E-07 END
EU-155    1 0 3.77868E-07 END
GD-155    1 0 5.58762E-09 END
U-234     1 0 1.38016E-07 END
U-235     1 0 2.33153E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.10373E-02 END
NP-237    1 0 2.02334E-05 END
PU-238    1 0 9.70129E-06 END
PU-239    1 0 1.56775E-04 END
PU-240    1 0 7.11517E-05 END
PU-241    1 0 4.32806E-05 END
PU-242    1 0 2.03674E-05 END
AM-241    1 0 2.11713E-06 END
```

```
CM-242    1 0 5.92261E-07 END
CM-243    1 0 2.15733E-08 END
CM-244    1 0 2.45212E-06 END
5.00  60.00
KR-83     1 0 4.36826E-06 END
KR-84     1 0 1.38016E-05 END
KR-86     1 0 2.07693E-05 END
MO-95     1 0 7.07498E-05 END
TC-99     1 0 7.45016E-05 END
RU-101    1 0 7.32957E-05 END
RH-103    1 0 3.69828E-05 END
AG-109    1 0 7.35637E-06 END
SN-126    1 0 1.52755E-06 END
I-129     1 0 1.36676E-05 END
XE-131    1 0 2.61292E-05 END
XE-132    1 0 8.79012E-05 END
CS-133    1 0 7.94595E-05 END
XE-134    1 0 1.11886E-04 END
CS-134    1 0 9.70129E-06 END
CS-135    1 0 3.84568E-05 END
CS-137    1 0 8.72312E-05 END
ND-143    1 0 4.99804E-05 END
ND-144    1 0 8.14694E-05 END
ND-145    1 0 4.28786E-05 END
ND-146    1 0 4.97124E-05 END
PM-147    1 0 7.58416E-06 END
SM-147    1 0 5.60102E-06 END
ND-148    1 0 2.43872E-05 END
SM-148    1 0 1.10546E-05 END
SM-149    1 0 1.47395E-07 END
ND-150    1 0 1.18318E-05 END
SM-150    1 0 1.90274E-05 END
SM-151    1 0 9.07151E-07 END
EU-151    1 0 1.36676E-09 END
SM-152    1 0 7.30277E-06 END
EU-153    1 0 7.82535E-06 END
EU-154    1 0 1.86254E-06 END
GD-154    1 0 2.78711E-07 END
EU-155    1 0 4.27446E-07 END
GD-155    1 0 6.25760E-09 END
U-234     1 0 1.66155E-07 END
U-235     1 0 1.92954E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.09033E-02 END
NP-237    1 0 2.21093E-05 END
PU-238    1 0 1.16844E-05 END
PU-239    1 0 1.56775E-04 END
PU-240    1 0 7.54396E-05 END
PU-241    1 0 4.52906E-05 END
PU-242    1 0 2.41192E-05 END
AM-241    1 0 2.27793E-06 END
CM-242    1 0 6.84718E-07 END
CM-243    1 0 2.67992E-08 END
CM-244    1 0 3.47049E-06 END
5.00  65.00
KR-83     1 0 4.47546E-06 END
KR-84     1 0 1.48735E-05 END
KR-86     1 0 2.21093E-05 END
MO-95     1 0 7.55736E-05 END
TC-99     1 0 7.91915E-05 END
RU-101    1 0 7.89235E-05 END
RH-103    1 0 3.87248E-05 END
AG-109    1 0 8.09334E-06 END
SN-126    1 0 1.68835E-06 END
I-129     1 0 1.47395E-05 END
XE-131    1 0 2.67992E-05 END
XE-132    1 0 9.67449E-05 END
CS-133    1 0 8.41493E-05 END
XE-134    1 0 1.20864E-04 END
CS-134    1 0 1.08805E-05 END
CS-135    1 0 4.12707E-05 END
CS-137    1 0 9.39310E-05 END
ND-143    1 0 5.11864E-05 END
ND-144    1 0 9.11171E-05 END
ND-145    1 0 4.51566E-05 END
ND-146    1 0 5.45363E-05 END
PM-147    1 0 7.45016E-06 END
SM-147    1 0 5.84221E-06 END
ND-148    1 0 2.62632E-05 END
SM-148    1 0 1.25420E-05 END
SM-149    1 0 1.44715E-07 END
ND-150    1 0 1.29172E-05 END
SM-150    1 0 2.03674E-05 END
SM-151    1 0 9.27251E-07 END
EU-151    1 0 1.33996E-09 END
SM-152    1 0 7.71815E-06 END
EU-153    1 0 8.53553E-06 END
```

CA06015 REV 0
PAGE 187

```
EU-154    1 0 2.06353E-06 END
GD-154    1 0 3.37669E-07 END
EU-155    1 0 4.74345E-07 END
GD-155    1 0 6.90078E-09 END
U-234     1 0 1.98314E-07 END
U-235     1 0 1.59455E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.09033E-02 END
NP-237    1 0 2.38512E-05 END
PU-238    1 0 1.38016E-05 END
PU-239    1 0 1.55435E-04 END
PU-240    1 0 7.93255E-05 END
PU-241    1 0 4.70325E-05 END
PU-242    1 0 2.80051E-05 END
AM-241    1 0 2.39852E-06 END
CM-242    1 0 7.67796E-07 END
CM-243    1 0 3.21590E-08 END
CM-244    1 0 4.74345E-06 END
5.00  70.00
KR-83     1 0 4.55586E-06 END
KR-84     1 0 1.59455E-05 END
KR-86     1 0 2.33153E-05 END
MO-95     1 0 8.01295E-05 END
TC-99     1 0 8.34794E-05 END
RU-101    1 0 8.45513E-05 END
RH-103    1 0 4.01987E-05 END
AG-109    1 0 8.79012E-06 END
SN-126    1 0 1.86254E-06 END
I-129     1 0 1.59455E-05 END
XE-131    1 0 2.74691E-05 END
XE-132    1 0 1.05723E-04 END
CS-133    1 0 8.85712E-05 END
XE-134    1 0 1.29708E-04 END
CS-134    1 0 1.20596E-05 END
CS-135    1 0 4.40846E-05 END
CS-137    1 0 1.00497E-04 END
ND-143    1 0 5.21243E-05 END
ND-144    1 0 1.00765E-04 END
ND-145    1 0 4.74345E-05 END
ND-146    1 0 5.94941E-05 END
PM-147    1 0 7.31617E-06 END
SM-147    1 0 6.02981E-06 END
ND-148    1 0 2.82731E-05 END
SM-148    1 0 1.40696E-05 END
SM-149    1 0 1.42036E-07 END
ND-150    1 0 1.40696E-05 END
SM-150    1 0 2.15733E-05 END
SM-151    1 0 9.43330E-07 END
EU-151    1 0 1.32120E-09 END
SM-152    1 0 8.10674E-06 END
EU-153    1 0 9.20551E-06 END
EU-154    1 0 2.23773E-06 END
GD-154    1 0 3.97967E-07 END
EU-155    1 0 5.19904E-07 END
GD-155    1 0 7.51716E-09 END
U-234     1 0 2.34493E-07 END
U-235     1 0 1.29708E-04 END
U-236     1 0 1.00000E-20 END
U-238     1 0 2.07693E-02 END
NP-237    1 0 2.54592E-05 END
PU-238    1 0 1.58115E-05 END
PU-239    1 0 1.54095E-04 END
PU-240    1 0 8.25414E-05 END
PU-241    1 0 4.82385E-05 END
PU-242    1 0 3.18910E-05 END
AM-241    1 0 2.47892E-06 END
CM-242    1 0 8.41493E-07 END
CM-243    1 0 3.73848E-08 END
CM-244    1 0 6.25760E-06 END
```

ATTACHMENT R
ISOTOPIC BENCHMARK CASES

Isotopic Benchmark Cases for Calvert Cliffs Fuel										
	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03	Percent
	MHP109	MHP109	MHP109	MLA098	MLA098	MLA098	NBD107	NBD107	NBD107	Difference
nuclide	27.35	37.12	44.34	18.68	26.62	33.17	31.40	37.27	46.46	(c-m)/m
U234	-1.875	-3.571	0.833	12.857	14.876	4.167	-23.529	-15.748	25.901	1.546
U235	-5.431	-8.704	-9.322	-1.463	-4.179	-1.883	-1.036	-4.428	1.707	-3.860
U236	2.866	2.833	1.626	-0.800	-0.669	-1.227	1.049	-0.990	-0.658	0.448
U238	-0.653	-0.324	-0.109	-1.181	-1.616	-0.974	-0.781	-1.280	-0.387	-0.812
Pu238	-9.406	-6.349	-5.576	-23.299	-12.693	-6.271	-3.927	-2.928	-3.941	-8.266
Pu239	-1.970	-1.308	0.987	-3.676	-3.340	1.982	3.304	4.042	8.072	0.899
Pu240	-2.269	-3.528	-4.444	-2.655	-3.171	-2.890	-1.306	-1.766	-1.116	-2.572
Pu241	-2.349	-2.879	-1.961	-6.869	-3.987	-0.062	-4.132	-3.567	0.542	-2.807
Pu242	3.460	4.688	2.738	-3.874	-0.333	-0.621	-3.716	-3.908	-5.902	-0.830
Np237	5.970	16.011	7.479	-1.626	-8.057	6.224	21.739	19.027	24.436	10.134
Cs133	1.529	2.752	3.226							2.503
Cs134	-2.800	-12.500	-18.333							-11.211
Cs135	3.889	2.000	1.395	3.943	3.526	4.819	8.911	11.566	5.637	5.076
Cs137	1.688	1.923	1.600	0.218	0.306	1.117	-0.669	2.921	-1.786	0.813
Nd143	0.489	-0.140	0.393							0.248
Nd144	0.848	0.897	0.426							0.724
Nd145	0.196	-0.459	-0.538							-0.267
Nd146	1.020	1.173	1.325							1.173
Nd148	0.755	0.279	0.234							0.422
Nd150	2.419	3.488	4.327							3.412
Pm147-Sm147	-0.769	-3.031	-4.888							-2.896
Sm148	-17.642	-14.634	-18.018							-16.765
Sm149	-31.379	-27.333	-49.149							-35.954
Sm150	-2.415	3.690	-5.540							-1.422
Sm151-Eu151	11.028	26.559	35.276							24.288
Sm152	14.598	24.038	22.314							20.317
Eu153	1.013	11.009	2.703							4.908
Sm154-Eu154-Gd154	-5.072	3.130	-2.969							-1.637
Eu155-Gd155	-26.160	-19.577	-24.440							-23.393
Am241	-5.023	-11.017	-10.687	-7.946	-4.844	-3.333	-3.390	-14.384	-36.697	-10.813
Cm243-Cm244	-6.812	-4.130	-3.438	-18.902	-8.221	0.474	0.535	-3.893	-2.028	-5.157
Se79	8.791	9.013	18.952							12.252
Sr90	8.932	6.102	7.143							7.392
Tc99	5.318	6.504	12.593	0.707	4.696	5.310	45.455	45.089	41.284	18.551
Sn126				179.070	180.882	201.183	248.227	283.125	286.190	153.186
I129				-11.429	-6.224	-14.583				-10.745

ATTACHMENT S
BURNUP VS ENRICHMENT REGRESSION ANALYSIS

Y = A + B(1) x + B(2) x2 + B(3) x3 + B(4) x4 + ...

Degree Of Fit, Standard Deviation, and Coefficient A Are:

Degree Of Fit:..........	3
Standard Deviation:.....	.9449E-01
Coefficient A:..........	-.3597023810E+02

Coefficients B(i) Are:

.2657539683E+02	-.3238095238E+01	.2222222222E+00

X	Y(entered)	Y(calculated)	Diff%
2.00000	6.00000	6.00595	.09921
2.50000	13.75000	13.70238	.34632
3.00000	20.50000	20.61310	.55168
3.50000	27.00000	26.90476	.35273
4.00000	32.75000	32.74405	.01818
4.50000	38.25000	38.29762	.12449
5.00000	43.75000	43.73214	.04082

ATTACHMENT (6)

CALVERT CLIFFS UNIT 2

SFP DILUTION ANALYSIS

ESP No.:	ES200100780	Supp No.	0	Rev. No.	0	Page 1 of 1

FORM 19, CALCULATION COVER SHEET

INITIATION (Control Doc Type - DCALC) Page 1 of 46

DCALC No.: CA06016 Revision No.: 0

Vendor Calculation (Check one): ☐ Yes ☒ No

Responsible Group: NEU

Responsible Engineer: Gerard E. Gryczkowski

CALCULATION

ENGINEERING DISCIPLINE:

☐ Civil ☐ Instr & Controls ☒ Nuc Engrg
☐ Electrical ☐ Mechanical ☐ Diesel Gen Project
☐ Life Cycle Mngmt ☐ Reliability Engrg ☐ Nuc Fuel Mngmt
☐ Other:

Title: UNITS 1 AND 2 SPENT FUEL POOL DILUTION ANALYSIS

Unit ☐ UNIT 1 ☐ UNIT 2 ☒ COMMON

Proprietary or Safeguards Calculation ☐ YES ☒ NO

Comments:

Vendor Calc No.: REVISION NO.:

Vendor Name:

Safety Class (Check one): ☒ SR ☐ AQ ☐ NSR

There are assumptions that require Verification during walkdown: AIT #:

This calculation SUPERSEDES:

REVIEW AND APPROVAL:

Responsible Engineer:	Gerard E. Gryczkowski	Date:	12/3/2002
Independent Reviewer:	K.I.R.Knippel	Date:	12/3/02
Approval:	M.T.Finley	Date:	12/10/02

2. LIST OF EFFECTIVE PAGES

Page	Latest Rev	Page	Latest Rev	Page	Latest Rev	Page	Latest Rev	Page	Latest Rev
001	0	002	0	003	0	004	0	005	0
006	0	007	0	008	0	009	0	010	0
011	0	012	0	013	0	014	0	015	0
016	0	017	0	018	0	019	0	020	0
021	0	022	0	023	0	024	0	025	0
026	0	027	0	028	0	029	0	030	0
031	0	032	0	033	0	034	0	035	0
036	0	037	0	038	0	039	0	040	0
041	0	042	0	043	0	044	0	045	0
046	0								

3. REVIEWER COMMENTS

4. TABLE OF CONTENTS

5. PURPOSE

The objective of this evaluation is to confirm that design features, instrumentation, administrative procedures, and sufficient time are available to detect and mitigate boron dilution in the spent fuel pool (SFP) before the boron concentration is reduced below the value assumed in the SFP criticality analyses which credit boron to remain below the design basis criticality limit of 0.95 k-eff. This report identifies the potential boron dilution sources and dilution events, the instrumentation available for detection of dilution, and the operating and administrative procedures available for the detection and mitigation of dilution. The report also identifies the potential events which could dilute the soluble boron contained in the Calvert Cliffs Nuclear Power Plant (CCNPP) Units 1 and 2 SFPs and quantifies the dilution rates and response times of each event. This report provides a methodology to evaluate potential spent fuel pool dilution events and is provided in conjunction with the criticality methodology of References 1 and 2.

Per Ref.45, allowing credit for soluble boron will allow the fresh fuel enrichment limit to be increased and the number of fresh fuel assemblies per cycle to be decreased. This will decrease fuel cycle costs, increase SFP cyclic capacities, decrease ISFSI requirements, decrease permanent DOE storage requirements, and result in an inherently safer operation.

CCNPP currently has Technical Specification requirements on the boron concentration in the spent fuel pool that are applicable during the movement of fuel assemblies. The precedents for crediting soluble boron to provide negative reactivity in the spent fuel pool have already been established when considering abnormal or accident conditions with respect to fuel handling and misloading by applying the double contingency principle. During refueling operations, the subcritical requirement of the fuel assemblies in the reactor core is met solely by controlling the boron concentration in the filled portions of the reactor coolant system. Credit for the boron in the spent fuel pool is an extension of the use of soluble boron for reactor core reactivity control purposes.

For an infinite axial and radial array of storage cells of nominal dimensions containing the maximum enrichment of 5.0 w/o Value Added Pellet (VAP) fuel at the worst case temperature of 40°F, the maximum unborated k-effective value of 0.986 is calculated with all biases and uncertainties, which is less than the 10 CFR 50.68 regulatory value of 1.0. The maximum k-effective value of 0.947 at a moderator boron concentration of 300 ppm with all biases and uncertainties is less than the 10 CFR 50.68 regulatory value of 0.95. (If credit is taken for soluble boron, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95% probability, 95% confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical) at a 95% probability, 95% confidence level, if flooded with unborated water.). Note that 300 ppm is a minimum boron concentration requirement. Per the Technical Assumptions of Refs. 1 and 2, 15% should be added to this value to account for all uncertainties. Thus a boron level of 350 ppm with uncertainties is required to credit soluble boron in the SFP and to safely store 5 w/o VAP fuel in the SFP.

The potential initiating events that could cause dilution of the boron in the spent fuel pool to a level below that credited in the criticality analyses fall into three categories: dilution by flooding, dilution by loss of coolant induced makeup, and dilution by loss of cooling system induced makeup. It is not credible that dilution could occur for the required length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of unborated water must be added to the SFP to reach 350 ppm soluble boron concentration. This is more water volume than is contained in both pretreated water storage tanks and also more water volume than is contained in

the demineralized water storage tank and both condensate storage tanks combined. Even in the unlikely event that the SFP is completely diluted of boron, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986 including all biases and uncertainties.

6. INPUT DATA AND TECHNICAL ASSUMPTIONS

(6.A) Spent Fuel Pool Geometry
The SFP is a large rectangular structure that holds the spent fuel assemblies from the reactors in both units. Borated water fills the SFP and completely covers the spent fuel assemblies. The SFP is constructed of 6' of reinforced concrete and is lined with a 3/16" stainless steel plate, which serves as a leakage barrier. A 3.5' dividing wall separates the SFP, with the north half being associated with Unit-1 and the south half associated with Unit-2. A slot in the dividing wall has removable gates, which allow movement of fuel assemblies between the two halves of the pool. The SFP is located in the Auxiliary Building between the two containment structures. (Ref.8)

Each half of the SFP is equipped with vertical spent fuel racks installed on the pool bottom. The fuel rack cells are individual double-walled containers approximately 14' 1" in height. The inner wall of each cell is made from a 0.06 inch thick sheet of stainless steel formed into a square cross-section container, indented on the corners, with an inside dimension of 8.5625 inches. The outer, or external, wall is also formed from a stainless steel sheet 0.06 inches thick. Plates of borated, neutron absorbing material are inserted between the two walls, in each of the four spaces formed by the indentations in the inner wall. The plates are made of a boron carbide (B_4C) composite material (carborundum in Unit 1 and Boraflex in Unit 2) and are 6.5 inches wide by 0.09 inches thick. Each plate contains at least 0.020 grams of boron-10 per square centimeter of plate. Attachments C and F display a single SFP planar and axial storage cell geometry. The spacing between the cells is maintained at 10 3/32 inches, center to center, by external sheets and welded spacers. The boron plate inserts and assembly spacing help maintain the SFP assemblies in a subcritical condition. (Ref.15)

Storage Cell Pitch	= 10.09375" (Ref.15)
Storage Cell Inner Dimension	= 8.5625" (Ref.15)
Poison Sheet	= 6.5" * 0.09" (Ref.15)
Inner Steel Wall	= 0.06" (Ref.15)
Outer Steel Wall	= 0.06" (Ref.15)
Storage Cell Height	=14' 1" (Ref.25)

(6.B) SFP Levels
(6.B.1) The SFP low level alarm point is at 66'6" per Refs. 25 and 66.
(6.B.2) The SFP operating level is at 67'0" per Refs.08 and 32.
(6.B.3) The SFP overflow level (pipe centerline of 4" pipes) to the Auxiliary Building gravity drains is at 67'3" per Refs. 8 and 23. Note that the Auxiliary Building floor drains and the SFP overflow drains are connected, thus any backup would flood the 5' elevation first.
(6.B.4) The SFP floor elevation is 69'0" per Ref.32.
(6.B.5) The SFP curb elevation is 69'6" per Ref.32.
(6.B.6) The fuel transfer tube midpoint elevation is 35'6" per Ref.32.
(6.B.7) The SFP upper level alarm point is at 67'2.75" per Ref. 66.

(6.C) Spent Fuel Pool Water Inventories at Lower Alarm Limit
The Unit 1 SFP Gross Volume (VGS1) can be derived from the dimensions delineated in Attachments D and F, assuming that the SFP water level is at the lower alarm limit of 66'6" per Ref.25:

VGS1 = (43'3")*(25'0"-96.0")*(66'6"-30'0") + (54'0")*(96.0")*(66'6"-29'6") + (11'0")*(9'0")*(30'0"-28'0")
= 7.433618E+07 in^3 = 43018.63 ft^3

The Unit 2 SFP Gross Volume (VGS2) can be derived from the dimensions delineated in Attachments E and F, assuming that the SFP water level is at the lower alarm limit of 66'6" per Ref.25:

VGS2 = (43'3")*(25'0"-96.0")*(66'6"-30'0") + (54'0")*(96.0")*(66'6"-29'6")
= 7.399404E+07 in^3 = 42820.63 ft^3

The corresponding Unit 1, Unit 2, and total SFP areas are

AS1 = (43'3")*(25'0"-96.0")+ (54'0")*(96.0") = 168084.0 in^2 = 1167.250 ft^2
AS2 = (43'3")*(25'0"-96.0")+ (54'0")*(96.0") = 168084.0 in^2 = 1167.250 ft^2
AST = 2334.500 ft^2

It is necessary to adjust the SFP gross volumes by the assembly and storage rack displacements. The Unit 1 SFP contains 830 assemblies and storage rack structures, while the Unit 2 SFP contains 1000 assemblies and storage rack structures (UFSAR 9.7.2.1). Each assembly and storage cell is composed of 176 VAP fuel pins of volume VFP, 5 guide tubes of volume VGT, an upper end fitting of volume VUEF, a lower end fitting of volume VLEF, and a storage cell of volume VSR. The data for the following calculations was extracted from Attachments A and B.

VFP = π*(0.440"/2)^2*(145.9")*(176) = 3904.480 in^3 = 2.259537 ft^3
VGT = π*(1.115^2-1.035^2)/4*(145.9")*(5) = 98.54705 in^3 = 0.057030 ft^3
VUEF = (1008.46665 in^3)*(1.-0.886177) = 114.7867 in^3 = 0.066427 ft^3
VLEF = (345.89186 in^3)*(1.-0.859993) = 48.42728 in^3 = 0.028025 ft^3
VSR = 4*(136.7")*(6.5")*(0.09") + 4*(169")*(8.5625"+0.12")*(0.12")
= 1024.202 in^3 = 0.592710 ft^3

The Units 1 and 2 and combined SFP Net Volumes can thus be calculated.

VNS1 = 43018.63 ft^3 - 830*(2.259537+0.057030+0.066427+0.028025+0.592710)
= 40525.53 ft^3
VNS2 = 42820.63 ft^3 - 1000*(2.259537+0.057030+0.066427+0.028025+0.592710)
= 39816.90 ft^3
VNS = 40525.53 ft^3 + 39816.90 ft^3 = 80342.43 ft^3

A total SFP Net Volume of 79000 ft^3 to the lower alarm limit will conservatively be used in all calculations in this work.

(6.D) Spent Fuel Pool Water Inventories at Overflow Limit

The Unit 1 SFP Gross Volume (VGS1) can be derived from the dimensions delineated in Attachments D and F, assuming that the SFP water level is at the overflow limit of 67'3" per Ref.08:

VGS1 = (43'3")*(25'0"-96.0")*(67'1"-30'0") + (54'0")*(96.0")*(67'1"-29'6") +
(11'0")*(9'0")*(30'0"-28'0")
= 43699.52 ft^3

The Unit 2 SFP Gross Volume (VGS2) can be derived from the dimensions delineated in Attachments E and F, assuming that the SFP water level is at the overflow limit of 67'3" per Ref.08:

VGS2 = (43'3")*(25'0"-96.0")*(67'1"-30'0") + (54'0")*(96.0")*(67'1"-29'6")
= 43501.52 ft^3

The Units 1 and 2 and combined SFP Net Volumes can thus be calculated.

VNS1 = 43699.52 ft^3 - 830*(2.259537+0.057030+0.066427+0.028025+0.592710)
= 41206.42 ft^3

$VNS2 = 43501.52\ ft^3 - 1000*(2.259537+0.057030+0.066427+0.028025+0.592710)$
$= 40497{,}79\ ft^3$
$VNS = 41206.42\ ft^3 + 40497.79\ ft^3 = 81704.21\ ft^3$

A total SFP Net Volume of 80000 ft^3 to the overflow limit will conservatively be used in all calculations in this work.

(6.E) Maximum SFP Decay Heat Rate
The maximum decay heat rate anticipated for 1830 fuel assemblies stored in the SFP is $37.6x10^6$ Btu/hr per UFSAR 9.4.1.

(6.F) SFP Temperature
Per UFSAR 9.4.1, in the event that any one loop is lost, the remaining two loops (either two SFPC loops or one SFPC loop and one SDC loop) can continue to maintain the pool temperature at or below 155°F (68°C or 341.48°K @ 0.9785 gm/cc per Ref. 16) for 1830 fuel assemblies in the SFP including a full core offload.

(6.G) SFP Time to Boil
Assuming that the SFP is at 155°F (See 6F), the time to boil excluding assembly heatup can be computed from the appropriate Ref.16 specific enthalpies and volumes:

T_{sat}= 155°F V_s=0.01637 ft^3/lbm h_f=123.0 btu/lbm h_{fg}=1005.2 btu/bm
T_{sat}= 212°F V_s=0.01672 ft^3/lbm h_f=180.2 btu/lbm h_{fg}= 970.3 btu/bm
t = (79000 ft^3)/(0.01637 ft^3/lbm)*(180.2-123.0 btu/lbm)/(37.6E+06 btu/hr)
= 7.3415 hr

(6.H) Bounding SFP Boron Concentration
The normal boron concentration maintained in the spent fuel pool is expected to be at least the same as that for the refueling boron Technical Specification. Per Refs.47 and 48, the Technical Specification Refueling Boron Concentration is greater than 2150 ppm. 2000 ppm will be conservatively used in this work.

(6.I) Time to Dilute to 350 PPM from 2000 PPM Due to Loss of Cooling
Assuming that the water added to the SFP is unborated and at 100°F and assuming that sufficient unborated water is added to the SFP to maintain the SFP at 212°F, the flow rate of water out of the SFP and down the gravity drains can be calculated to be

T_{sat}= 100°F V_s=0.01613 ft^3/lbm h_f=68.0 btu/lbm h_{fg}=1037.1 btu/bm
T_{sat}= 212°F V_s=0.01672 ft^3/lbm h_f=180.2 btu/lbm h_{fg}= 970.3 btu/bm

F = (37.6E+06 btu/hr)*(0.01672 ft^3/lbm)/(180.2-68.0 btu/lbm)=5603.137 ft^3/hr = 698.57 gpm

SFP dilution can be modeled by the following algorithm (Ref.45):

$dC/dt = -F*C/V$
$C = C_o * \exp(-t*F/V)$
$t = (V/F)*\ln(C_o/C)$
$t = (80000\ ft^3 / 5603.135\ ft^3/hr) * \ln(2000/350) = 24.88\ hr$

The amount of water flowing down the gravity drain is
$V_W = (24.88\ hr) * (5603.137\ ft^3/hr) = 139406.0\ ft^3 = 1042827\ gals$

(6.J) Time to Fuel Uncovery Due to Loss of Cooling:
The boiloff rate due the maximum decay heat rate is
$B = (37.6E{+}06\ btu/hr)*(0.01672\ ft^3/lbm)/(970.3\ btu/lbm) = 647.9151\ ft^3/hr$

The time rate of decrease in pool level is
$D = B/AST = 647.9151\ ft^3/hr / 2334.5\ ft^2 = 0.2775\ ft/hr$

The time to fuel uncovery is thus
t=(67'1"-45'1.625")/(0.2775 ft/hr) = 79.09 hr

(6.K) RWT Boron Concentration
Per Technical Specification Surveillance Requirement 3.5.4.4 and Ref.58, the RWT boron concentration must be greater than or equal to 2300 ppm. This must be verified every 7 days.

(6.L) Water Sources (MAXIMUMS)
(6.L.1) 2 Pretreated Water Storage Tanks:
$Vol=\pi(23.25')^2(39.5')=67080\ ft^3=501792\ gal$ (Refs.49-50)
(6.L.2) 2 Condensate Storage Tanks:
$Vol=\pi(20.25')^2(32.66667')=42083\ ft^3=314801\ gal$ (Refs.49-51)
(6.L.3) 1 Demineralized Water Storage Tank:
$Vol=\pi(20.25')^2(36.33333')=46806\ ft^3=350135\ gal$ (Refs.49-52, UFSAR 9.4.4)
(6.L.4) 2 Refueling Water Tanks:
$Vol = 420000\ gal = 56146\ ft^3$ (Refs.49 and UFSAR 9.4.4)
(6.L.5) Well water: 3 well water pumps and filters at 175 gpm each (Ref.56 and UFSAR 9.4.4)
(6.L.6) Water for the fire protection system is supplied by two full-capacity fire pumps. One pump is an electrically driven 2500 gpm horizontal centrifugal pump, and the other is a diesel engine-driven 2500 gpm horizontal centrifugal pump. The fire pumps take suction from the two 500000 gallon capacity pretreated water storage tanks. (Ref.54 and UFSAR 9.9.4) Fire stations HS-69-4 and HS-69-6 service the fuel handling and storage area. (Ref.54)
(6.L.7) Plant service water isolation valves 0-PSW-140, 0-PSW-139, and 0-PSW-251 are low flow rate systems which take suction on the two 500000 gallon capacity pretreated water storage tanks. (Ref.54).
(6.L.8) Demineralized water isolation valves 0-DW-302 and 0-DW-190 are low flow rate (150 gpm) systems which take suction on the 350000 gallon demineralized water storage tank (Ref.54 and UFSAR 9.4.4).
(6.L.9) Plant heating system valve 0-PH-281 is a low flow rate system which take suction on the two 500000 gallon capacity pretreated water storage tanks. (Ref.54).
(6.L.10) The two 1390 gpm SFP cooling pumps can supply 420000 gallons of borated water from each refueling water tank (Ref.54 and UFSAR 9.4.4).
(6.L.11) No fire protection sprinkler system exists in the fuel handling area (Ref.54)

7. REFERENCES

(01) "Unit 1 Spent Fuel Pool Enrichment Limit with Soluble Boron Credit", CA06011

(02) "Unit 2 Spent Fuel Pool Criticality Analysis with Soluble Boron and Burnup Credit but without Boraflex Credit", CA06015.

(03) "Criticality Accident Requirements", 10 CFR 50.68

(04) "Design Bases for Protection Against Natural Phenomena", 10 CFR 50 App.A GDC 2

(05) "Fuel Storage and Handling and Radioactivity Control", 10 CFR 50 App.A GDC 61

(06) "Monitoring Fuel and Waste Storage", 10 CFR 50 App.A GDC 63

(07) "Review and Acceptance of Spent Fuel Storage and Handling Applications", B.K.Grimes (NRC) to All Power Reactor Licensees, 4/14/78

(08) "Spent Fuel Pool and Cooling System Description", Rev.0, October 1997.

(15) "Nuclear Design Analysis Report for the CCNPP Unit 1 High Density Spent Fuel Storage Racks", NES Report 81A0567 Rev.2.

(16) 1967 Steam Tables, New York St. Martin's press, 1967

(17) "Impact of Zirlo on the Reactivity Bias", Westinghouse Interoffice Correspondence CA-2001-0026

(18) "Implementation of Zirlo Cladding Material in CE Nuclear Power Fuel Assembly Designs", CENPD-404-P Rev.0

(19) "Nuclides and Isotopes, Chart of the Nuclides", GE Nuclear 14th Edition.

(20) "Introduction to Nuclear Engineering", J.R.Lamarsh, 12/77.

(21) "Standard Composition Library", NUREG/CR-0200 Rev.6 Volume 3 Section M8

(22) "Fuel Storage Rack Installation in Pool", BGE Drawing 13939-0014 Rev.5

(23) "Auxiliary Building SFP Liner Plan and Sections Sheet 1", BGE Drawing 61-706-E Rev.18.

(24) " Fuel Storage Rack Installation in Pool", BGE Drawing 13939-0038 Rev.2

(25) "Fuel Handling Accident during Reconstitution", CA04048

(26) "Design Input Data for CCNPP ISFSI", NEU-01-016.

(27) "Guide Tube Assembly Details", BGE Drawing E-STD-701-303 Rev.5.

(28) "Evaluation of Type A Irradiated Fuel Assembly Drop on SFP Floor", BGE Calculation 95-0128 Rev.02.

(29) "Evaluation of Type B Irradiated Fuel Assembly Drop on SFP Floor", BGE Calculation 95-0125 Rev.02.

(30) "Evaluation of Type C Irradiated Fuel Assembly Drop on SFP Floor", BGE Calculation 95-0180 Rev.01.

(31) "Evaluation of Fuel Assembly Drop on SFP Floor", BGE Calculation 95-0115 Rev.02.

(32) "Equipment Location Containment and Auxiliary Building Unit No.1 Section A-A", BGE Drawing 60215 Rev.3.

(33) "SFP Cooling, Pool Fill and Drain Systems", BGE Drawing 60716, Rev.51.

(34) "Area No.16 Piping Partial Plan and Sections El.27'0" ", BGE Drawing 60421, Rev.17.

(35) "Area No. 16 Spent Fuel Cooling", BGE Drawing 12530A-64, Rev.6.

(36) "Area No. 16 Spent Fuel Cooling Pipe MK. No. 8" HC-4-1020", BGE Drawing 12530A-65, Rev.4.

(37) "Area No. 16 Spent Fuel Cooling", BGE Drawing 12530A-55, Rev.3.

(38) "Area No. 16 Spent Fuel Cooling", BGE Drawing 12530A-14, Rev.2.

(39) "Area No. 16 Spent Fuel Cooling", BGE Drawing 13530A-35, Rev.4.

(40) "Area No. 16 Spent Fuel Cooling", BGE Drawing 13530A-14, Rev.5.

(41) "Auxiliary Building SFP Liner Sections and Details", BGE Drawing 61707SH0002, Rev.19.

(42) "Spent Fuel Pool Storage", SRP 9.1.2 Rev.3, 7/81.

(43) "Spent Fuel Pool Cooling and Cleanup System", SRP 9.1.3, Rev.1, 7/81.

(44) "Spent Fuel Storage Facility Design Basis", Regulatory Guide 1.13, Rev.1, 12/75.

(45) "Crediting Soluble Boron in LWR Spent Fuel Pools", CE NPSD-985-P, 01/1995.

(46) "New Fuel Storage", SRP 9.1.1, Rev.2, 7/81.

(47) "Unit 1 Cycle 15 Technical Data Book", NEOP-13 Rev.14.

(48) "Unit 2 Cycle 14 Technical Data Book", NEOP-23 Rev.14.

(49) "Plant Property and Buildings", BGE Drawing 61502SH0002 Rev.19

(50) "2 Pretreated Water Storage Tanks 46'6" Dia x 39'6" High", BGE Drawing 12329A-0001 Rev.2

(51) "Condensate Storage Tank #12", BGE Drawing 12329C-12 Rev.D

(52) "Demineralized Water Tank", BGE Drawing 12329D-01.

(53) "CCNPP Unit 1 and 2 Filling Spent Fuel Pool", Procedure OI-24F Rev.3.

(54) "Exemption from Criticality Monitoring Requirements", Letter from C.H.Cruise to NRC, NRC-97-008, 8/19/96.

(55) "Fire Suppression Water System", Technical Requirements Manual 15.7.5.

(56) "Well Water", OI-23A Rev.12

(57) "SFP Skimmer Operation", OI-24C Rev.1.

(58) "Specification and Surveillance Primary Systems", CP-204 Rev.15

(59) "Control of Shift Activities", NO-1-200 Rev.22

(60) "Beyond Design Basis Accidents in Spent Fuel Pools", NUREG- 1353, April 1989.

(61) "0-TIA-2001 Master Calibration Data Package", 11/13/97

(62) "0-TIA-2002 Master Calibration Data Package", 2/4/98

(63) "0-TS-1997 Master Calibration Data Package", 8/9/00

(64) "0-TS-1998 Master Calibration Data Package", 8/9/00

(65) "ISFSI Loading", ISFSI-01, Rev.6.

(66) "Setpoint File for System 067", NEQR440, 04/13/2000.

8. METHODOLOGY, CALCULATIONS, AND RESULTS

The first step in the dilution analysis is to identify potential initiating events that could cause dilution of the boron in the spent fuel pool that could eventually lead to a substantial reduction of at least several hundred ppm in the pool boron concentration. A boron dilution event in the spent fuel pool could be initiated by external events, a variety of human errors, or component malfunctions. The potential initiating events were developed based on a review of the events in NUREG -1353 (Ref.60) and a systematic evaluation of the unborated water sources that interface with the pool. External events include fire in the vicinity of the pool, external floods at the site, storms causing runoff into the spent fuel pool area, seismic induced failures of piping, missile generation causing leaks in the piping, and airplane crashes into the fuel handling building. Other dilution events include small loss of inventory events, tank ruptures in the vicinity of the pool, breaks in the cooling system piping or heat exchangers, random breaks in the piping, dilution events initiated in the reactor coolant system, and misalignment of valves interfacing with the spent fuel pool. The NUREG-1353 initiating events include structural failures – (Missiles, Aircraft Crashes, Heavy Load Drops), pneumatic seal failures, inadvertent drainage, loss of cooling/makeup, and seismic structural failure.

The methodology employed in this work entails calculation of the SFP volumes, dilution volumes, and dilution times for SFP boron dilution events with various dilution sources and flow rates. The initial SFP boron concentration was determined in Section 6.H, while the endpoint of the boron dilution event corresponds to the SFP boron concentration credited in the criticality analyses (Refs.1-2) to maintain k-eff≤0.95. The time to dilute to this endpoint determines the available response time for the operators to detect and stop the dilution event.

(8.A) Flooding

Per Ref.4, structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and tsunami, without loss of capability to perform their safety functions. Even in the unlikely event that the SFP is completely diluted of boron, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986.

(8.A.1) Flooding by Tsunami

Since there has been no record of tsunamis on the northeastern United States coast, it is not believed that the site will be subjected to a significant tsunami effect (UFSAR 2.6.6).

(8.A.2) Flooding by Hurricane

The relative frequency of hurricane occurrence for the CCNPP site is slightly more than one hurricane per year. For the Probable Maximum Hurricane (PMH), it is assumed that the peak hurricane surge is coincident with normal high tide and with a 99th percentile wave height. The total predicted wave run-up is to Elevation 27.1', which is considerably less than the 69' elevation of the top of the SFP. Thus the maximum hypothetical flood level is below the top of the SFP elevation (UFSAR 2.8.3).

(8.A.3) Flooding by Storms

The auxiliary building is a concrete structure and qualified for high winds. Therefore, severe storms with high winds are not expected to cause sufficient damage to the roof, thus allowing a large volume of rain to enter the building and becoming an unborated source of water to the pool. The 6" lip around the SFP (BGE Drawing 61706E Sheet 1 Rev.18 - Ref.23) should cause the bulk of the entering rain water to flow out of the SFP area via the 13 floor drains, 13 doors, and 2 tendon end cap shafts.

(8.A.4) Flooding by Onsite Water Sources
The onsite water sources that can flood the SFP and cause dilution below the minimum boron concentration calculated in Refs.1-2 are detailed in Section 6.L. The large volume of water necessary to dilute the pool to the boron endpoint precludes many small tanks as potential dilution sources. The large unborated water sources such as reactor makeup water and demineralizer water are in tanks at the tank farm at elevations below the spent fuel pool, so that gravity feed from these tanks to the spent fuel pool is not possible. It would be very unlikely that the large volumes of water necessary, to substantially dilute the spent fuel pool (i.e., to the boron endpoint) could be 'silently" transferred from these tanks to the spent fuel pool without being detected by plant personnel. Dilution events that have the potential to dilute the SFP boron concentration to a value less than the minimum required are not credible events based on existing level alarms and the stored inventory of demineralized water in the systems interfacing with the SFP.

(8.A.4.a) Fire Protection System
The possibility of a fire in the spent fuel pool area leading to a boron dilution event is not a credible event. Typically, combustible loadings around the pool area are expected to be minor. If the fire hose stations were used to extinguish a fire, the volume of water required to extinguish a local fire is not expected to be of sufficient magnitude to dilute the pool such that a several hundred ppm reduction in the pool boron concentration would occur.

Water for the fire protection system is supplied by two full-capacity fire pumps. One pump is an electrically driven 2500 gpm horizontal centrifugal pump, and the other is a diesel engine-driven 2500 gpm horizontal centrifugal pump. The fire pumps take suction from the two 500000 gallon capacity pretreated water storage tanks. (Ref.54 and UFSAR 9.9.4) Fire stations HS-69-4 and HS-69-6 service the fuel handling and storage area. (Ref.54)

Fire in the fuel handling building could result in a large amount of unborated water entering the SFP while attempting to extinguish the fire. The rate of addition of unborated water from a fire would be insufficient to exceed the minimum boron level of 350 ppm, since sufficient time would exist to take compensatory measures (i.e., add additional boron to the SFP). In addition, the discussion on incomplete boron mixing indicates that the unborated water would tend to float on the surface of the pool and overflow the SFP as water continues to flow into the SFP. Thus the fuel assemblies should remain surrounded by borated water. Finally, assuming that the fire is not directly over the SFP, the 6" lip around the SFP (BGE Drawing 61706E Sheet 1 Rev.18 - Ref.23) should cause the bulk of the water used to extinguish the fire to flow out of the SFP area via the 13 floor drains, 13 doors, and 2 tendon end cap shafts.

At a dilution rate of 2500 gpm directly into the SFP, it will take 6.95 hours to dilute the SFP from 2000 to 350 ppm.

$t = (80000\ ft^3) / (20052.14\ ft^3/hr) * \ln(2000/350) = 6.95\ hr$

It is not credible that dilution could occur for this length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of pretreated water must be added to the SFP to reach 350 ppm soluble boron concentration. This is twice the water volume that is contained in a single pretreated water storage tank. Assuming that a fire hose was inserted into the SFP and discharged at the maximum rate of 2500 gpm, it would exhaust the pretreated water storage tank ~~that it was aligned to in approximately 3.45 hours. Two well water pumps would automatically~~ actuate and pump 600 gpm into the pretreated water storage tank. An additional 13 hours would be required for the SFP to be diluted to 350 ppm at this rate.

(8.A.4.b) Plant Service Water Isolation Valves 0-PSW-140, 0-PSW-139, and 0-PSW-251
Plant service water isolation valves 0-PSW-140, 0-PSW-139, and 0-PSW-251 are low flow rate systems which take suction on the two 500000 gallon capacity pretreated water storage tanks. (Ref.54). Note that this case is bounded by 8.A.4.a.

(8.A.4.c) Misalignment of Valves Interfacing with the SFP: Demineralized Water Isolation Valves 0-DW-302 and 0-DW-190
A path that interfaces with the spent fuel pool and unborated water sources could become a dilution path. If isolation valves are either left in the open position or fail in the open position, a potential dilution path is available. During spent fuel pool operation, makeup to the spent fuel pool may be required. The resins in the demineralizer tank may also have to be flushed or changed periodically. If valves are misaligned, it is possible that unborated water could be delivered to the spent fuel pool. Demineralized water isolation valves 0-DW-302 and 0-DW-190 are low flow rate (150 gpm) systems which take suction on the 350000 gallon demineralized water storage tank (Ref.54 and UFSAR 9.4.4).

At a dilution rate of 150 gpm, it will take 115.9 hours to dilute the SFP from 2000 to 350 ppm.

$$t = (80000\ ft^3) / (1203.128\ ft^3/hr) * \ln(2000/350) = 115.9\ hr$$

It is not credible that dilution could occur for this length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of demineralized water must be added to the SFP to reach 350 ppm soluble boron concentration. This is three times more water volume than is contained in the demineralized water tank.

(8.A.4.d) Plant Heating System Valve 0-PH-281
Plant heating system valve 0-PH-281 is a low flow rate system which take suction on the two 500000 gallon capacity pretreated water storage tanks. (Ref.54). Note that this case is bounded by 8.A.4.a.

(8.A.4.e) SFP Cooling Pumps
The two 1390 gpm SFP cooling pumps can supply 420000 gallons of borated water from each refueling water tank (Ref.54 and UFSAR 9.4.4). Note that per 6.J, the RWT boron concentration exceeds that in the SFP. Thus this does not constitute a dilution event.

(8.A.4.f) Incomplete Mixing Via Stratification
The unlikely probability of an inadvertent boron dilution event reducing the SFP boron concentration to less than 350 ppm is based on the assumption of complete mixing of the boron in the SFP. The complete mixing assumption may not always be valid, if the circulation flow in the SFP is insufficient to prevent stratification. Where stratification has occurred (Robinson 2 12/20/88 and San Onofre 1 1/23/89 - Ref.45), it was observed that the diluted water floated on the higher borated water. This suggests that if stratification does occur, the water with the higher boron concentration will tend to be in the lower level of the SFP where the fuel assemblies are located. The possibility of boron stratification in the SFP can be eliminated by circulating the SFP water via the SFP cooling or purification systems.

(8.A.4.g) Incomplete Mixing Via Ribbon Effect
Another type of incomplete boron mixing is a ribbon effect, where a channel of unborated water bores its way to a SFP assembly location. If the SFP cooling or purification systems are in operation, mixing will occur in the piping systems eliminating any ribbon effects. Assuming that the SFP cooling and purification systems are not in operation, an analysis using turbulent jet and diffusion theory was performed to determine the extent of any ribbon effect. Per Ref.45,

the change in concentration per length of the jet flow can be estimated via the algorithm $Q/Q_o = 0.42 * z/d$, where Q_o is the volumetric flow rate at the nozzle discharge, d is the nozzle diameter, and Q is the volumetric flow rate at a distance z from the nozzle along the axis of symmetry. The volumetric flow will increase along the jet flow path, due to entrainment of the bulk liquid as the jet flow diameter increases. The ratio of volumetric flow rate to the initial volumetric flow rate determines the amount of bulk fluid entrained in the jet flow and thus is representative of the boron concentration along the flow path

$$C * Q = Co * (Q - Qo)$$
$$Q/Qo = Co/(Co - C) = 0.42 * z / d$$

For a C_o of 2000 ppm and a 10" diameter pipe (the largest discharge pipe in the SFP is an 8" diameter pipe, thus the use of a 10" pipe is conservative), C will reach 350 ppm within 29" of the nozzle discharge. Thus it is unlikely that a diluted ribbon flow of less than 350 ppm could reach the fuel, since the tops of the SFP racks and nearest nozzle are in excess of 27" above the active fuel region of the assemblies stored in the racks.

(8.A.4.h) Tank Rupture in the Vicinity of the SFP
No tanks containing any significant amount of water are stored in the vicinity of the SFPs.

(8.A.4.i) Breaks in the Spent Fuel Pool Cooling System Piping or Heat Exchangers
A break in the heat exchanger would cause a dilution of the spent fuel pool due to the inflow of water from the cooling water system. The SFPC heat exchangers are cooled by service water (UFSAR 9.4.2). The service water system is a closed system and uses plant demineralized water with a corrosion inhibitor added. Additional makeup may be provided by the condensate system. (UFSAR 9.5.2.2) Assuming that the break occurs in one loop of the SFPC system and that the corresponding 1390 gpm pump stays in operation pumping unborated water into the SFP, the time to dilution is

$$t = (80000 \text{ ft}^3) / (11149 \text{ ft}^3/\text{hr}) * \ln(2000/350) = 12.5 \text{ hr}$$

It is not credible that dilution could occur for this length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of demineralized water must be added to the SFP to reach 350 ppm soluble boron concentration. This is more water volume than is contained in the demineralized water storage tank and both condensate storage tanks combined.

(8.A.4.k) Dilution Events Initialed in the Reactor Coolant System
Another set of dilution events could be initiated by failures that could dilute both the boron concentration in the reactor coolant system (RCS) and the spent fuel pool via the refueling pool. There are valves from the CVCS to the spent fuel pool that could be left open so that an inadvertent dilution event of the reactor coolant system would not only deliver unborated water to the reactor vessel, but also to the spent fuel pool. Possible initiating events that could impact the reactor coolant system are operator error such as selecting dilution instead of makeup, failures in the makeup system (e.g., valves do not open, boric acid pumps do not operate) so that boric acid is not delivered to the blender, the valve for the emergency boration flushing line is left open, failures of the temperature control system in the thermal regenerative demineralizers during the storage mode of operation, valves left open following flushing operations of the demineralizer tanks, and valves left open after chemical addition to the chemical addition tank. The above inadvertent dilution events in the reactor coolant system would be readily observed and emergency boration would be initiated (which would provide borated water to the spent fuel pool). The amount of water required to dilute the SFP, the refueling pool, and the reactor coolant system is much greater than that required to dilute just the SFP. Thus more water volume than is

contained in the demineralized water storage tank and both condensate storage tanks combined would be required for dilution. It is not credible that dilution could occur for this length of time during a refueling outage without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding.

(8.A.4.I) Dilution Event Coupled with a Loss of Offsite Power
The SFP instrumentation is not powered from the emergency diesel generators, thus a loss of offsite power would therefore affect the plant's ability to respond to a dilution event. However, the loss of offsite power would also affect electric pumps involved in the dilution event. The large unborated water sources such as reactor makeup water and demineralizer water are in tanks at the tank farm at elevations below the spent fuel pool, so that gravity feed from these tanks to the spent fuel pool is not possible. It would be very unlikely that the large volumes of water necessary, to substantially dilute the spent fuel pool (i.e., to the boron endpoint) could be 'silently" transferred from these tanks to the spent fuel pool without being detected by plant personnel. Dilution events that have the potential to dilute the SFP boron concentration to a value less than the minimum required are not credible events based on the stored inventory of unborated water in the systems interfacing with the SFP.

(8.B) Dilution by Loss of SFP Coolant Inventory
Per Ref.44, the fuel handling and storage facilities should be designed to prevent loss of water from the fuel pool that would uncover fuel, via natural events (Seismic Category 1), dropping of heavy loads (single-failure proof crane), and small leaks (coolant makeup system and level and radiation monitors). Per Ref.5, the SFP fuel storage and handling systems shall be designed to prevent significant reduction in fuel storage coolant inventory under accident conditions. Per UFSAR 14.18.1, fuel pool structural integrity is assured by designing the pool and the spent fuel storage racks as Category I structures.

Only partial structural failures, where makeup can compensate for the loss of coolant, can cause a dilution event. Even in the unlikely event that the SFP is completely diluted of boron by a total loss of inventory and a refill with unborated water, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986.

(8.B.1) Earthquake and Tornado Induced Loss of Coolant
Per Ref.4, structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and tsunami, without loss of capability to perform their safety functions.

(8.B.1.a) Tornadoes
Per UFSAR 5.6.1.1, the Auxiliary Building is primarily a reinforced concrete structure and the mat foundation supports a structural steel and reinforced concrete frame, which consists mainly of reinforced concrete walls and floors. On the top structure and over the fuel handling area is a secondary steel frame structure with missile resistant concrete walls and roof, which houses the Spent Fuel Cask Handling Crane. Per UFSAR 5.6.1.3, the steel-framed structure over the SFP is designed to resist tornadoes and missiles without partial or complete collapse, except for the west wall. A study indicates that the possibility of tornado missiles impacting the SFP from the west side is remote. A minimum of 18" thick concrete for missile protection is provided in the roof and the north, east, and south walls. In addition, a 2 foot thick concrete missile barrier positioned at the 118-foot elevation protects the SFP from a high trajectory missile generated by a turbine overspeed incident (Ref.08).

(8.B.1.b) Earthquakes
In accordance with Seismic Category I requirements, the SFP and SFPCS are designed to withstand the maximum calculated vibratory ground motion of an earthquake.

(8.B.2) Heavy Object Drop Induced Loss of Coolant
Per Ref.42, the weight of all loads being handled above stored spent fuel shall not exceed that of one fuel assembly and its associated handling tool.

(8.B.2.a) Dropped Cask
Per Ref.7, accidents shall include dropping of a fuel assembly on top of the racks and a cask or heavy object drop onto the SFP racks. Heavy loads in excess of 1600 lbs are prohibited from travel over spent fuel assemblies in the SFP unless such loads are handled by a single-failure proof device. The Spent Fuel Cask Handling Crane was upgraded to single-failure proof in 1992, is designed in accordance with the single-failure proof criteria of NUREG-0554 and NUREG-0612, and is used to handle heavy loads in the SFP area. The maximum design rated load for the Spent Fuel Cask Handling Crane is 150 tons for the main hoist and 15 tons for the auxiliary hoist (UFSAR 9.7.2.4). Thus the cask or heavy object drop accident is not a credible event.

Per UFSAR 14.18, structural integrity of the fuel pool is further ensured due to the presence of an energy absorbing cask support platform in the cask pit area of Unit 1 as a Seismic Category 1 structure which can absorb the impact of a cask drop from the cask handling crane and safely transfer the loads to the pit floor. This platform provides a second line of defense against the extremely unlikely event of a cask drop, which is already precluded by the single-failure-proof spent fuel handling crane.

(8.B.2.b) Dropped Assembly
Per UFSAR 14.18.1, the likelihood of a fuel handling incident is minimized by administrative controls and physical limitations imposed on fuel handling operations. All refueling operations are conducted in accordance with prescribed procedures under direct surveillance of a qualified supervisor. Inadvertent disengagement of a fuel assembly from the fuel handling machine is prevented by mechanical interlocks; consequently, the possibility of dropping and damaging of a fuel assembly is remote. The maximum elevation to which the fuel assemblies can be raised is limited by the design of the fuel handling hoists and manipulators to assure that the minimum depth of water above the top of a fuel assembly required for shielding is always present.

Even though the assembly drop is unlikely, per Refs.28-31, the SFP concrete plus liner plate are stronger than the assembly bottom casting and fuel and guide tubes for impact of a fresh or irradiated VAP fuel assembly with an inserted CEA (1350-1360 lbm). The bottom casting is, in turn, stronger than the fuel and guide tubes. Essentially all impact kinetic energy absorption will take place in the fuel and guide tubes. Interface forces between the bottom assembly and the liner plate would be limited by the buckling of the fuel and guide tubes which is of insufficient magnitude to cause perforation of the liner plate. In addition, for impact over the collection trenches in the SFP, the interface forces between the bottom assembly and the liner plate would be limited by the buckling of the fuel and guide tubes which is of insufficient magnitude to cause perforation of the liner plate. Therefore, for both full contact impact and impact over the collection trenches of a fresh or irradiated VAP fuel assembly with an inserted CEA (1350-1360 lbm), the liner plate would not be perforated.

(8.B.2.C) Airplane Crash into the SFP

Per UFSAR 5.6.1.1, the Auxiliary Building is primarily a reinforced concrete structure and the mat foundation supports a structural steel and reinforced concrete frame, which consists mainly of reinforced concrete walls and floors. On the top structure and over the fuel handling area is a secondary steel frame structure with missile resistant concrete walls and roof, which houses the Spent Fuel Cask Handling Crane. This steel-framed structure over the SFP will resist airplane crashes without partial or complete collapse. Two foot thick concrete for missile protection is provided in the roof and the north, east, and south walls. In addition, a 2 foot thick concrete missile barrier positioned at the 118-foot elevation protects the SFP from a high trajectory incident (Ref.08).

It is possible that an airplane crash that does not damage the spent fuel pool could cause damage in the immediate area of the spent fuel pool. It is likely that a large fire would occur. If water were used to extinguish the fire, it is possible that the boron concentration in the spent fuel pool could be diluted significantly. However, the mean hit frequency is estimated to be 6E-9/yr in NUREG- 1353 (Ref. 60). The frequency of this event is small enough that the event need not be analyzed further.

(8.B.3) Pipe Break Induced Loss of Coolant

Per Ref.43, the SFP and cooling systems must be designed so that in the event of failure of inlets, outlets, piping, or drains, the pool level will not be inadvertently drained below a point approximately 10 feet above the top of the active fuel. Pipes or external lines extending into the pool that are equipped with siphon breakers, check valves, or other devices to prevent drainage are acceptable as a means of implementing this requirement.

The most serious failure to the system is the loss of SFP water. This is avoided by routing all SFP piping connections and penetrations above the water level and providing them with siphon breakers to prevent gravity drainage (UFSAR 9.4.4). Per Refs.33-41, the SFP inlets to the SFP cooling and purification systems (pipes 8"-HC-4-1020 and 8"-HC-4-2020) are above the spent fuel racks but penetrate the SFP liner at 65' 11" centerline elevation, while the SFP discharge pipes from the shutdown cooling system, purification system, RWT, and demineralized water tank (10"-HC-4-1042 and 10"-HC-4-2042) are above the spent fuel racks but also penetrate the SFP liner at 65' 11" centerline elevation. The SFP does not contain any permanent drains, thereby, preventing accidental drain down.

Per Ref.08, the SFP is located in the Auxiliary Building between the two containment structures. During refueling operations, the SFP is connected to the refueling pool in containment by the water-filled transfer tube, which is the only SFP penetration below the waterline. The fuel transfer tube penetration consists of a 36" diameter stainless steel tube inside a 42" diameter stainless steel penetration sleeve. The two concentric tubes are sealed to each other by a bellows-type expansion joint. Thus transfer tube leakage would require an unlikely double pipe break. During plant operations, the fuel transfer tube is closed in the SFP by a 36-inch stainless steel parallel slide gate valve. Inside the containment, the fuel transfer tube is sealed with a double O-ring blind flange. Thus leakage during plant operations would also require the simultaneous failure of the gate valve and blind flange. Loss of SFP level via a pipe break in the refueling pool during refueling operations would be minimized by rapid closure of the transfer tube valve.

(8.B.4) SFP Leakage

Per UFSAR 9.4.4, the SFP is designed to preclude the loss of structural integrity. Per UFSAR 5.6.1.2, a 3/16" solid stainless steel liner plate was used on the inside face of both pools for leak tightness, and all of the field welds have leak-test channels welded to the outer side of the liner

plates. The channels are grouped into ten zones, each with its own detector pipe to localize leaks in the liner seams. Even with the precautions described, small leaks may still occur in the SFP. Early detection of pool leakage and prompt replacement of water is essential. Early leakage detection is assured by a surveillance, which requires that the minimum pool level be verified at least once every 7 days. In practice, level is checked once every 12 hours as required by the Auxiliary Building log sheets. In addition, a level alarm keeps the Control Room Operator aware of level changes. PEO 0-067-02-O-M (SFP Leakage Test) requires a regular check for leakage, as well.

Per Ref.08, prompt replacement of water loss due to leakage prevents the fuel from being uncovered. Makeup water can be supplied, via the SFP Cooling and Purification System, from the refueling water tanks or the Demineralized Water System.

(8.C) Loss of Cooling System
Per Ref.7, accidents shall include loss of cooling systems or flow unless single failure proof. Even in the unlikely event that the SFP is completely diluted of boron due to a loss of cooling incident, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986.

The Spent Fuel Pool Cooling (SFPC) system is common to both units. The SFPC system is a closed-loop system consisting of two half-capacity 1390 gpm pumps and two half-capacity heat exchangers in parallel, a bypass 128 gpm cartridge-type filter which removes insoluble particulates, and a bypass 128 gpm mixed bed resin demineralizer which removes soluble ions. The SFPC heat exchangers are cooled by service water (UFSAR 9.4.2 and Ref.08). The normal configuration for the cooling system is one pump/one cooler loop in operation on each half of the spent fuel pool to cool the water. However, the purity and clarity of the water is maintained by passing a portion of the flow through the purification system. The purification system consists of a filter to remove insoluble particulates and a demineralizer (ion exchanger) which removes soluble ions. Ten skimmers are provided in the spent fuel pools to remove accumulated dust and debris from the surface of the water.

Connections are provided for tie-in to the Shut Down Cooling (SDC) system to provide for 2000 gpm of additional heat removal in the event that 1830 fuel assemblies are contained in the pool. One shutdown cooling heat exchanger in the unit whose core was off-loaded may be operated to supplement the SFP cooling system. The SFP Cooling and Purification System has temporary connections which, with the installation of spool pieces, permit cross connection with the Safety Injection System (SIS). The connections that go to the SIS are in the suction lines of the SFP pumps. The connections that return the cooled water from the SIS tap in downstream of the SFP coolers. When the pressure in the SDC system is greater than the design pressure of the SFPC system, the SFPC system is isolated from the SDC system via two manual isolation valves. Although not required by the design code, double valve isolation is provided at this system interface to meet the original FSAR design basis (UFSAR 9.4.2).

Per UFSAR 9.4.4, the design of the SFPC System and pool structural components (e.g., pool liner plate, SFPC piping and pumps) for a total loss of cooling is not part of the system's design basis. The entire SFPC system is tornado-protected and is located in a Seismic Category I structure (UFSAR 9.4.2).

Even though loss of SFP cooling is not part of the design basis, the effect of that event will be analyzed. Assuming that the Units 1 and 2 SFPs contain 1830 assemblies generating the maximum possible heat load of 37.6E+06 btu/hr (Section 6E) and assuming the worst case initial SFP temperature of 155°F (Section 6F), then the time to boil can be calculated as 7.34 hours

(Section 6G). Time to core uncovery is 78.9 hours (Section 6J). However, loss of coolant via boiling will not result in a loss of soluble boron, since the soluble boron is not volatile. Thus loss of SFPC system without makeup flow is not a mechanism for boron dilution. If sufficient unborated water is added to the SFP to just keep the water from boiling and if the excess fluid flows down the Auxiliary Building gravity drains associated with the SFP overflow level (Section 6.B.3), it would take 24.88 hours to dilute the SFP to 350 ppm (Section 6.I). It is not credible that dilution could occur for this length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of demineralized water must be added to the SFP to reach 350 ppm soluble boron concentration. This is three times more water volume than is contained in the demineralized water tank.

(8.D) Radiation Monitors and Alarms
Per Ref.6, appropriate systems shall be provided in fuel storage and radioactive waste systems and associated handling areas (i) to detect conditions that may result in loss of residual heat removal capability and excessive radiation levels and (ii) to initiate appropriate safety actions. Per Ref.43, the SFPCS except for the cleanup portion of the system must withstand the effects of natural phenomena, must have an adequate monitoring system (leakage detection, radioactivity monitors, conductivity monitors, flow alarms, temperature alarms, level alarms), must have adequate valve isolation, must have an inservice inspection program.

(8.D.1) Radiation Monitors
Per UFSAR 14.18.1, radiation monitors located at the fuel handling areas would provide both audible and visual warning of high radiation levels in the event of a low water level or dropped assembly in the SFP. Per Ref.54, three area radiation monitors are provided for detecting high radiation levels in the fuel storage areas. The monitors are located in the SFP area, the Spent Fuel Handling Machine, and the New Fuel Storage Area. Each monitor contains a gamma sensitive Geiger-Mueller tube and has an indicating range of 10^{-4} to 10^{1} R per hour. The SFP area and New Fuel Storage Area monitor alarm setpoint is 5×10^{-3} R per hour, while the Spent Fuel Handling Machine monitor alarm setpoint is 1×10^{-2} R per hour. At the alarm setpoint, audible and visual alarms annunciate locally and in the Control Room. The output of each monitor is also recorded in the Control Room.

Radiation monitors are also installed in the Service Water return header from the SFP coolers to detect possible in-leakage of radioactive liquids through the heat exchangers (UFSAR 9.5.2.2).

(8.D.2) SFP High Level Alarms
The spent fuel pool high level alarm would alert the operators to increasing volume in the spent fuel pool. If the alarm does not function, water would be flowing out of the pool and would drain to other levels in the building such that a dilution event would be readily noticed well before any substantial reduction in the spent fuel pool boron concentration occurs. Per Section 6.B.7, the high level alarm point is at 67' 2.75".

(8.D.3) SFP Low Level Alarms
The spent fuel pool low level alarm would alert the operators to decreasing volume in the spent fuel pool. If the alarm does not function, the pool level could continue to drop. Eventually, radiation from the fuel in the SFP racks would cause the radiation alarms to activate. Per Section 6.B.1, the low level alarm is at 66'6".

(8.D.4) SFP Temperature Alarm
SFP temperature instrumentation 0-TIA-2001 and 0-TIA-2002 provides SFP indication and alarm on the control room panel 1C13. The instrument temperature range is from 80°F to 160°F, while the upper alarm setpoint is at 120°F (Refs.61-62).

(8.D.5) SFP Cooling System Alarms
Temperature switch 0-TS-1997 (-1998) on the SFP cooler outlet causes an audio-visual alarm to actuate in the Control Room if the outlet temperature reaches 110°F. This alarm (SFP Cooler Disch Temp Hi) is on panel 1C13 (Refs.63-64). Additional instrumentation is provided to monitor the pressure and flow of the spent fuel pool cooling and cleanup system.

(8.E) Supervision and Inspection
Dilution of the SFP to below the minimum boron level of 350 ppm will be prevented by supervision and inspection activities.

(8.E.1) Filling the SFP Via Procedure OI-24F
Filling the SFP with demineralized water from the Demineralized Water Tank or with borated water from the Refueling Water Tank is controlled by Procedure OI-24F (Ref.53). In each case, an operator must be stationed on the 69 foot level to monitor SFP level, while lineup is being performed and while the pool is being filled. The operator monitoring the pool levels shall be in radio communication with the control room and with the person doing the lineup.

If demineralized water is being added to the SFP via the 69' demineralized water hose connection (150 gpm), the rate of SFP level rise is very slow (~1 inch/hr), therefore a continuous SFP watch is not required. However, frequent tours of the SFP area are required and the level must be closely monitored at 1C13 in the control room.

(8.E.2) Inspection of the Pretreated Water Storage Tank Via TRM 15.7.5
Technical Verification Requirement 15.7.5.1 requires verification that each Pretreated Water Storage Tank contains greater than or equal to 300000 gallons of water every 7 days.

(8.E.3) SFP Skimmer Operation Via OI-24C
Per Ref.57, prior to placing any skimmers on service, the SFP water level shall be at least one or two inches above the top edge of the skimmer plate. In addition, all SFP system evolutions shall be supervised by a Plant Watch Supervisor.

(8.E.4) SFP Boron Level
Per Ref.58, the SFP boron concentration should be verified to be at the Refueling Boron Concentration Administrative Limit in Modes 1-5 at least once per week. In Mode 6, the verification shall be performed daily.

(8.E.5) Control of Shift Activities Via NO-1-200
Per Ref.59, the duties of Operations shall include
(a) During core alterations, a Senior Reactor Operator shall be designated as Fuel Handling Supervisor, shall directly supervise alteration from the Containment 69' elevation, and have no other concurrent duties. His duties shall also include implementation of appropriate AOPs for abnormally rising count rates and reduction in SFP level.
(b) Plant Operators shall make one complete round during each 12 hour shift including level indication in the SFP area. The operator shall identify and contain all water leakage and shall look for damaged piping and instrument tubing, noting excessive vibration.
(c) An operator shall normally be present at a pump prior to startup.

(8.E.6) ISFSI Cask Loading

Per Ref.65, approximately 1000 gallons of borated water are pumped from the SFP to the DSC/TC prior to insertion of the DSC/TC into the SFP. In addition. demineralized water is used to wash down the TC and cables to control contamination and is used to fill the DSC/TC annulus. This has the potential to cause some dilution of the SFP. However, the following administrative controls minimize the dilution potential: (1) the control room supervisor and plant chemistry shall be notified prior to the discharge of water into the SFP, (2) pipes and hoses passing into the SFP shall not be left unattended, (3) ensure that plant chemistry is notified to collect a SFP sample to verify a boron concentration greater than 1950 ppm prior to DSC/TC operations, (4) notify control room supervisor that no actions shall be taken that may reduce SFP boron concentration. Note that the maximum dilution rate for this operation is ~200 gpm, thus the consequences of this operation are bounded by those of Section 8.A.4.a.

9. DOCUMENTATION OF COMPUTER CODES

No computer codes were utilized in this work.

10. CONCLUSIONS

The objective of this evaluation is to confirm that design features, instrumentation, administrative procedures, and sufficient time are available to detect and mitigate boron dilution in the spent fuel pool before the boron concentration is reduced below the value assumed in the SFP criticality analyses which credit boron to remain below the design basis criticality limit of 0.95 k-eff. This report identifies the potential boron dilution sources and dilution events, the instrumentation available for detection of dilution, and the operating and administrative procedures available for the detection and mitigation of dilution. The report also identifies the potential events which could dilute the soluble boron contained in the Calvert Cliffs Nuclear Power Plant (CCNPP) Units 1 and 2 SFPs and quantifies the dilution rates and response times of each event. This report provides a methodology to evaluate potential spent fuel pool dilution events and is provided in conjunction with the criticality methodology of References 1 and 2.

Per Refs.1-2, a boron level of 350 ppm with uncertainties is required to credit soluble boron in the SFP and to safely store 5.0 w/o VAP fuel in the SFP. The normal boron concentration maintained in the spent fuel pool is expected to be at least the same as that for the refueling boron Technical Specification, which is greater than 2150 ppm. 2000 ppm was conservatively used in this work.

The potential boron dilution sources include the two 500000 gallon Pretreated Water Storage Tanks, the two 314800 gallon Condensate Storage Tanks, the 350000 gallon Demineralized Water Storage Tank, the two 420000 gallon Refueling Water Tanks, and three well water pumps and filters at 175 gpm each. Water for the fire protection system is supplied by two full-capacity 2500 gpm fire pumps, which take suction from the two 500000 gallon capacity pretreated water storage tanks. No fire protection sprinkler system exists in the fuel handling area. Plant service water isolation valves 0-PSW-140, 0-PSW-139, and 0-PSW-251 are low flow rate systems which take suction on the two 500000 gallon capacity pretreated water storage tanks. Demineralized water isolation valves 0-DW-302 and 0-DW-190 are low flow rate (150 gpm) systems which take suction on the 350000 gallon demineralized water storage tank. Plant heating system valve 0-PH-281 is a low flow rate system which take suction on the two 500000 gallon capacity pretreated water storage tanks. The two 1390 gpm SFP cooling pumps can supply 420000 gallons of borated water from each refueling water tank.

Potential initiating events that could cause dilution of the boron in the spent fuel pool to a level below that credited in the criticality analyses fall into three categories: dilution by flooding, dilution by loss of coolant induced makeup, and dilution by loss of cooling system induced makeup. Even in the unlikely event that the SFP is completely diluted of boron, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986.

Dilution by flooding includes the effects of tsunamis, hurricanes, storms, failure of the fire protection system, failure of the plant service water isolation valves, misalignment of the demineralized water isolation valves, failure of the plant heating system valves, effects of the SFP cooling pumps, tank rupture in the vicinity of the SFP, breaks in the SFP cooling system piping or heat exchangers, and reactor coolant system failures. Since there has been no record of tsunamis on the northeastern United States coast, it is not believed that the site will be subjected to a significant tsunami effect. While the relative frequency of hurricane occurrence for the CCNPP site is slightly more than one hurricane per year, the total predicted wave run-up is to Elevation 27.1', which is considerably less than the 69' elevation of the top of the SFP. The auxiliary building is a concrete structure and qualified for high winds; therefore, severe storms with high winds are not expected to cause sufficient damage to the roof and thus will not result in

a large volume of rain entering the building and becoming an unborated source of water to the pool. In addition, the 6" lip around the SFP should cause the bulk of the entering rain water to flow out of the SFP area via the 13 floor drains, 13 doors, and 2 tendon end cap shafts. Onsite water sources can flood the SFP and cause dilution below the minimum boron concentration. The worst case dilution source is a 2500 gpm fire hose discharging directly into the SFP. At a dilution rate of 2500 gpm directly into the SFP, it will take 6.95 hours to dilute the SFP from 2000 to 350 ppm. It is not credible that dilution could occur for this length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of pretreated water must be added to the SFP to reach 350 ppm soluble boron concentration. This is more water volume than is contained in both pretreated water storage tanks and also more water volume than is contained in the demineralized water storage tank and both condensate storage tanks combined. Dilution events that have the potential to dilute the SFP boron concentration to a value less than the minimum required are not credible events based on existing level alarms and the stored inventory of unborated water in the systems interfacing with the SFP.

The unlikely probability of an inadvertent boron dilution event reducing the SFP boron concentration to less than 350 ppm is based on the assumption of complete mixing of the boron in the SFP. The complete mixing assumption may not always be valid, if the circulation flow in the SFP is insufficient to prevent stratification. Where stratification has occurred, it was observed that the diluted water floated on the higher borated water. This suggests that if stratification does occur, the water with the higher boron concentration will tend to be in the lower level of the SFP where the fuel assemblies are located. The possibility of boron stratification in the SFP can be eliminated by circulating the SFP water via the SFP cooling or purification systems.

Another type of incomplete boron mixing is a ribbon effect, where a channel of unborated water bores its way to a SFP assembly location. If the SFP cooling or purification systems are in operation, mixing will occur in the piping systems eliminating any ribbon effects. If the SFP cooling and purification systems are not in operation, an analysis using turbulent jet and diffusion theory indicates that the fluid will homogenize within 29" of the nozzle discharge. Thus it is not possible that a diluted ribbon flow of less than 350 ppm could reach the fuel.

Dilution via loss of SFP coolant inventory includes the effects of tornadoes, earthquakes, cask drop, assembly drop, airplane crash, pipe break and general SFP leakage. Structural failures caused by dropping of heavy loads or by missiles are postulated to cause enough damage to the pool so that there is no possibility of retaining water in the pool. Since the pool cannot hold water, this accident sequence directly leads to a zircaloy cladding fire and cannot cause a dilution event. Only partial structural failures, where makeup can compensate for the loss of coolant, can cause a dilution event. Even in the unlikely event that the SFP is completely diluted of boron by a total loss of inventory and a refill with unborated water, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986. The steel-framed structure over the SFP is designed to resist tornadoes and missiles. In addition, a 2 foot thick concrete missile barrier positioned at the 118-foot elevation protects the SFP from a high trajectory missile generated by a turbine overspeed incident. In accordance with Seismic Category I requirements, the SFP and SFPCS are designed to withstand the maximum calculated vibratory ground motion of an earthquake.

The Spent Fuel Cask Handling Crane was upgraded to single-failure proof in 1992 and is used to handle heavy loads in the SFP area. Thus the cask or heavy object drop accident is not a credible event. Structural integrity of the fuel pool is further ensured due to the presence of an energy

absorbing cask support platform in the cask pit area of Unit 1 as a Seismic Category 1 structure which can absorb the impact of a cask drop from the cask handling crane and safely transfer the loads to the pit floor. This platform provides a second line of defense against the extremely unlikely event of a cask drop, which is already precluded by the single-failure-proof spent fuel handling crane. In addition. an analysis of the pool floor indicates that the SFP bottom is capable of safely withstanding the impact of the accidental drop of the cask. Cracks will be developed by diagonal tension near the support but they will be of microscopic type considering the sheer stresses. The structural integrity of the SFP bottom will not be impaired.

The likelihood of a fuel handling incident is minimized by administrative controls and physical limitations imposed on fuel handling operations. All refueling operations are conducted in accordance with prescribed procedures under direct surveillance of a qualified supervisor. Inadvertent disengagement of a fuel assembly from the fuel handling machine is prevented by mechanical interlocks; consequently, the possibility of dropping and damaging of a fuel assembly is remote. For both full contact impact and impact over the collection trenches of a fresh or irradiated VAP fuel assembly with an inserted CEA (1350-1360 lbm), the liner plate would not be perforated.

The steel-framed structure over the SFP will resist airplane crashes without partial or complete collapse. Two foot thick concrete for missile protection is provided in the roof and the north, east, and south walls. In addition, a 2 foot thick concrete missile barrier positioned at the 118-foot elevation protects the SFP from a high trajectory incident.

The most serious failure to the system is the loss of SFP water. This is avoided by routing all SFP piping connections and penetrations above the water level and providing them with siphon breakers to prevent gravity drainage. The SFP does not contain any permanent drains, thereby, preventing accidental drain down.

Dilution may also occur via loss of SFP cooling. The design of the SFPC System and pool structural components (e.g., pool liner plate, SFPC piping and pumps) for total loss of cooling is not part of the system's design basis. The entire SFPC system is tornado-protected and is located in a Seismic Category I structure. Even though loss of SFP cooling is not part of the design basis, the effect of that event was analyzed. Assuming that the Units 1 and 2 SFPs contain 1830 assemblies generating the maximum possible heat load of 37.6E+06 btu/hr and assuming the worst case initial SFP temperature of 155°F, then the time to boil can be calculated as 7.34 hours. Time to core uncovery is 78.9 hours. However, loss of coolant via boiling will not result in a loss of soluble boron, since the soluble boron is not volatile. Thus loss of SFPC system without makeup flow is not a mechanism for boron dilution. If sufficient unborated water is added to the SFP to just keep the water from boiling and if the excess fluid flows down the Auxiliary Building gravity drains associated with the SFP overflow level, it would take 24.88 hours to dilute the SFP to 350 ppm. It is not credible that dilution could occur for this length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of demineralized water must be added to the SFP to reach 350 ppm soluble boron concentration. This is three times more water volume than is contained in the demineralized water tank.

The instrumentation available for detection of dilution are the following: SFP Radiation Monitors and Alarms, SFP High Level Alarms, SFP Low Level Alarms, SFP Temperature Alarm, and SFP Cooling System Alarms. Additional instrumentation is provided to monitor the pressure and flow of the spent fuel pool cooling and cleanup system.

Operating and administrative procedures are available for the detection and mitigation of dilution events. Filling the SFP with demineralized water from the Demineralized Water Tank or with borated water from the Refueling Water Tank is controlled by Procedure OI-24F. In each case, an operator must be stationed on the 69 foot level to monitor SFP level, while lineup is being performed and while the pool is being filled. The operator monitoring the pool levels shall be in radio communication with the control room and with the person doing the lineup. The SFP boron concentration should be verified to be at the Refueling Boron Concentration Administrative Limit in Modes 1-5 at least once per week. In Mode 6, the verification shall be performed daily. Per procedure NO-1-200, during core alterations, a Senior Reactor Operator shall be designated as Fuel Handling Supervisor, shall directly supervise alteration from the Containment 69' elevation, and have no other concurrent duties. His duties shall also include implementation of appropriate AOPs for abnormally rising count rates and reduction in SFP level. Plant Operators shall make one complete round during each 12 hour shift including level indication in the SFP area. The operator shall identify and contain all water leakage and shall look for damaged piping and instrument tubing, noting excessive vibration. An operator shall normally be present at a pump prior to startup.

In conclusion, the potential initiating events that could cause dilution of the boron in the spent fuel pool to a level below that credited in the criticality analyses fall into three categories: dilution by flooding, dilution by loss of coolant induced makeup, and dilution by loss of cooling system induced makeup. It is not credible that dilution could occur for the required length of time without operator notice, since this event would activate the high level alarm and initiate Auxiliary Building flooding. In addition, in excess of 1043000 gallons of unborated water must be added to the SFP to reach 350 ppm soluble boron concentration. This is more water volume than is contained in both pretreated water storage tanks and also more water volume than is contained in the demineralized water storage tank and both condensate storage tanks combined. Even in the unlikely event that the SFP is completely diluted of boron, the SFP will remain subcritical by a design margin of k-eff not to exceed 0.986.

ATTACHMENT A
DENSITY CALCULATIONS

CA0G016 Rev.0
Page 31

	A	B	C	D	E	F	G	H
1	**Carborundum Material Densities:**							
2								
3	F =	B4C density fraction = B10L / PST / B10A * MWB4C / AWB4 / DB4C						
4	F =				0.240685	0.213007	0.191706	
5								
6	B10L = B10 Loading (gm/cm2)				0.020	0.017700	0.015930	Ref.15
7	PST = Poison Sheet Thickness (cm) = 0.090" * 2.54 =				0.2286	0.2286	0.2286	Ref.15
8	B10A = Abundance of B10 in a/f				0.19900	0.19900	0.19900	Ref.19
9	B11A = B11 abundance in a/f				0.80100	0.80100	0.80100	Ref.19
10	AWB10 = B10 atomic weight in gm/mole				10.012937	10.012937	10.012937	Ref.19
11	AWB11 = B11 atomic weight in gm/mole				11.009306	11.009306	11.009306	Ref.19
12	AWB = B atomic weight in gm/mole				10.81103	10.81103	10.81103	calculated
13	AWC = Atomic Weight of C				12.01100	12.01100	12.01100	Ref.19
14	MWB4C = Molecular Weight of B4C				55.2551	55.2551	55.2551	calculated
15	AWB4 = Atomic Weight of Natural B in B4C				43.2441	43.2441	43.2441	calculated
16	DB4C = Density of B4C in gm/cc				2.52	2.52	2.52	Ref.21
17	B10W = B10 abundance in w/f				0.18431	0.18431	0.18431	Ref.21
18								
19								
20	**ZIRLO Material Densities**							
21								
22	N(ATOMS/B-CM) = DZ * f * NA / AW / C							
23								
24		f(w/o)	AW(gm/mole)	N				
25	Sn	1.00	118.71	3.2594E-04				
26	Fe	0.11	55.847	7.6211E-05				
27	Nb	1.00	92.90638	4.1647E-04				
28	Zr	97.89	91.224	4.1520E-02				
29		100.00						
30								
31	f = Zirlo composition in w/o							Refs.17-18
32	DZ = Zirlo density in gm/cc				6.425			Ref.18
33	AW = Atomic weight in gm/mole							Ref.19
34	NA = Avogadro's Number in atoms/mole				6.022E+23			Ref.20
35	C = barns/cm2				1.00E+24			Ref.20
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								

Densities

	A	B	C	D	E	F	G	H
51	**OPTIN Material Densities**							
52								
53	N(ATOMS/B-CM) = DZ * f * NA / AW / C							
54								
55		f(w/o)	AW(gm/mole)	N				
56	Sn	1.25	118.71	4.1535E-04				
57	Fe	0.21	55.847	1.4832E-04				
58	Cr	0.10	51.996	7.5862E-05				
59	O	0.12	15.9994	2.9585E-04				
60	Zr	98.32	91.224	4.2514E-02				
61		100.00						
62								
63	f = Optin composition in w/o							Refs.17-18
64	DZ = Optin density in gm/cc				6.550			Ref.18
65	AW = Atomic weight in gm/mole							Ref.19
66	NA = Avogadro's Number in atoms/mole				6.022E+23			Ref.20
67	C = barns/cm2				1.00E+24			Ref.20
68								
69								
70	**Soluble Boron Density**							
71								
72	D(H3BO3) = f * D(H2O) * MW(H3BO3) / AWB = Density of H3BO3 in gm/cc							
73								
74	B10A = B10 abundance in w/o				19.9			Ref.19
75	B11A = B11 abundance in w/o				80.1			Ref.19
76	AWB10 = B10 atomic weight in gm/mole				10.012937			Ref.19
77	AWB11 = B11 atomic weight in gm/mole				11.009306			Ref.19
78	AWB = B atomic weight in gm/mole				10.81103			calculated
79	AWH = H atomic weight in gm/mole				1.00780			Ref.19
80	AWO = O atomic weight in gm/mole				15.99940			Ref.19
81	MWH3BO3 = H3BO3 molecular weight in gm/mole				61.83263			calculated
82								
83	f	DH2O	DH3BO3					
84	0.000100	1.0000	0.00057194					
85	0.000200	1.0000	0.001143881					
86	0.000300	1.0000	0.001715821					
87	0.000400	1.0000	0.002287761					
88	0.000500	1.0000	0.002859702					
89	0.002000	1.0000	0.011438806					
90	0.000100	1.0000	0.00057194					
91	0.000200	0.9785	0.001119287					
92	0.000300	0.9785	0.001678931					
93	0.000400	0.9785	0.002238574					
94	0.000500	0.9785	0.002798218					
95	0.002000	0.9785	0.011192872					
96								
97								
98								
99								
100								

CA06016 Rev.0
Page 33

Densities

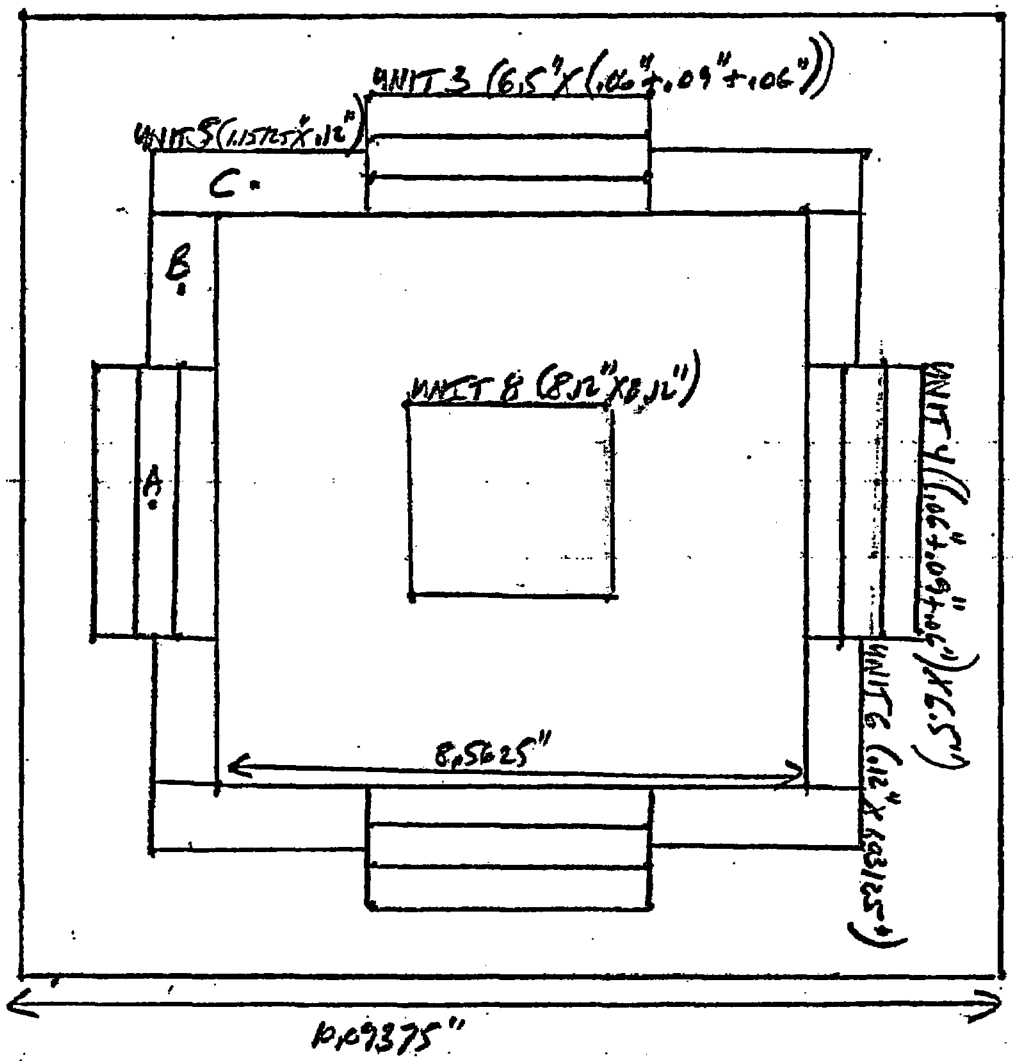
	A	B	C	D	E	F	G	H
101	Upper End Fitting:							
102	Length	8.12	in	20.6248	cm	UFSAR Fig.3.3-1		
103	Width	8.12	in	20.6248	cm	UFSAR Fig.3.3-1		
104	Height	15.295	in	38.8493	cm	Ref.25		
105	Total Volume	1008.46665	in3	16525.8075	cc			
106	Inconel X-750	1100	gm			Ref.26		
107	SS-304	5080	gm			Ref.26		
108	Zirc-4	680	gm			Ref.26		
109	SS-302	7980	gm			Ref.26		
110	Inconel X-750	8.30	gm/cc-ref			Ref.21		
111	SS-304	7.94	gm/cc-ref			Ref.21		
112	Zirc-4	6.56	gm/cc-ref			Ref.21		
113	SS-302	7.94	gm/cc-ref			Ref.21		
114	Inconel X-750	132.5301	cc	0.008020	vol frac			
115	SS-304	639.7985	cc	0.038715	vol frac			
116	Zirc-4	103.6585	cc	0.006273	vol frac			
117	SS-302	1005.0378	cc	0.060816	vol frac			
118	Water Vol	14644.7826	cc	0.886177	vol frac			
119								
120								
121	Lower End Fitting:							
122	Length	8.12	in	20.6248	cm	UFSAR Fig.3.3-1		
123	Width	8.12	in	20.6248	cm	UFSAR Fig.3.3-1		
124	Height	5.246	in	13.32484	cm	Ref.25		
125	Volume	345.89186	in3	5668.152086	cc			
126	Inconel-625	1360	gm			Ref.26		
127	SS-304	5000	gm			Ref.26		
128	Inconel	8.30	gm/cc-ref			Ref.21		
129	SS-304	7.94	gm/cc-ref			Ref.21		
130	Inconel	163.8554	cc	0.028908	vol frac			
131	SS-304	629.7229	cc	0.111098	vol frac			
132	Water Vol	4874.5737	cc	0.859993	vol frac			

ATTACHMENT B
FUEL DATA SPREADSHEET

CA06016 Rev. 0
Page 35

217			Assemblies per core	UFSAR 3.1
77			CEAs per core	UFSAR 3.1
176			Rods per assembly	UFSAR 3.1
5			Guide tubes per assembly	UFSAR 3.1
136.7	347.218	in-cm	Active core height	UFSAR 3.1
1.035	2.6289	in-cm	Guide tube ID	BGE Drwg E-550-701-303 - Ref.27
1.115	2.8321	in-cm	Guide tube oD	BGE Drwg E-550-701-303 - Ref.27
0.580	1.4732	in-cm	Fuel rod pitch	UFSAR Figure 3.3-1
0.20	0.508	in-cm	Assembly spacing, fuel ros surface-surface	UFSAR Table 3.3-5
8.12	20.6248	in-cm	Assembly pitch (14*0.58")	UFSAR Figure 3.3-1
0.06	0.1524	in-cm	Assembly gap (8.18"-8.12")	UFSAR Figure 3.3-1
548		deg F	Tcold	UFSAR Figure 4-9
572.5		deg F	Tave	UFSAR Figure 4-9
599.4		deg F	Thot	UFSAR Figure 4-9
532		deg F	Thzp	UFSAR Figure 4-9
Standard Fuel Design				
0.3795	0.96393	in-cm	Pellet diameter (A-C U1)	UFSAR Table 3.3-1
15.4626		in3	Pin fuel volume	
0.3805	0.96647	in-cm	Pellet diameter (A-C U2)	UFSAR Table 3.3-2
15.5442		in3	Pin fuel volume	
0.3765	0.95631	in-cm	Pellet diameter (D-S U1, D-R U2)	UFSAR Table 3.3-1/2
15.2191		in3	Pin fuel volume	
0.388	0.98552	in-cm	Clad ID (A-C U1-U2)	UFSAR Table 3.3-1/2
0.384	0.97536	in-cm	Clad ID	UFSAR Table 3.3-1/2
0.440	1.1176	in-cm	Clad OD	UFSAR Table 3.3-1/2
10.170		gm/cc	Stack height density (max)	UFSAR Table 3.3-1/2
0.9279			Stack height density (% TD)	
VAP Fuel Design				
0.381	0.96774	in-cm	Pellet diameter	UFSAR Table 3.3-1/2
15.585		in3	Pin fuel volume	
0.388	0.98552	in-cm	Clad ID	UFSAR Table 3.3-1/2
0.440	1.1176	in-cm	Clad OD	UFSAR Table 3.3-1/2
10.310		gm/cc	Stack height density	UFSAR Table 3.3-1/2
0.9407			Stack height density (% TD)	
SAS2H Larger Unit Cell Effective Radii for 176 pin assembly (Standard and VAP Fuel Design)				
1.31445		cm	Clad ID/2 = 1.035"/2 = 0.5175" (H2O)	
1.41605		cm	Clad OD/2 = 1.115"/2 = 0.5575" (Zirc)	
1.66233		cm	SQRT[4*(0.58)^2/pi] = 0.65446" (H2O)	
5.20391		cm	SQRT[196*(0.58)^2/5/pi] = 2.04878" (Fuel)	
5.22314		cm	SQRT[(8.15)^2/5/pi] = 2.05635" (H2O)	In ORNL/TM-12667, uses 8.18".
SAS2H Larger Unit Cell Effective Radii for 172 pin assembly (Standard and VAP Fuel Design)				
1.31445		cm	Clad ID/2 = 1.035"/2 = 0.5175" (H2O)	
1.41605		cm	Clad OD/2 = 1.115"/2 = 0.5575" (Zirc)	
1.66233		cm	SQRT[4*(0.58)^2/pi] = 0.65446" (H2O)	
5.15054		cm	SQRT[192*(0.58)^2/5/pi] = 2.02777" (Fuel)	
5.22314		cm	SQRT[(8.15)^2/5/pi] = 2.05635" (H2O)	In ORNL/TM-12667, uses 8.18".

ATTACHMENT C
SFP SINGLE RACK PLANAR GEOMETRY



A: X = 8.5625"/2 + .06" + .09"/2 = 4.38625" = 11.141075 CM

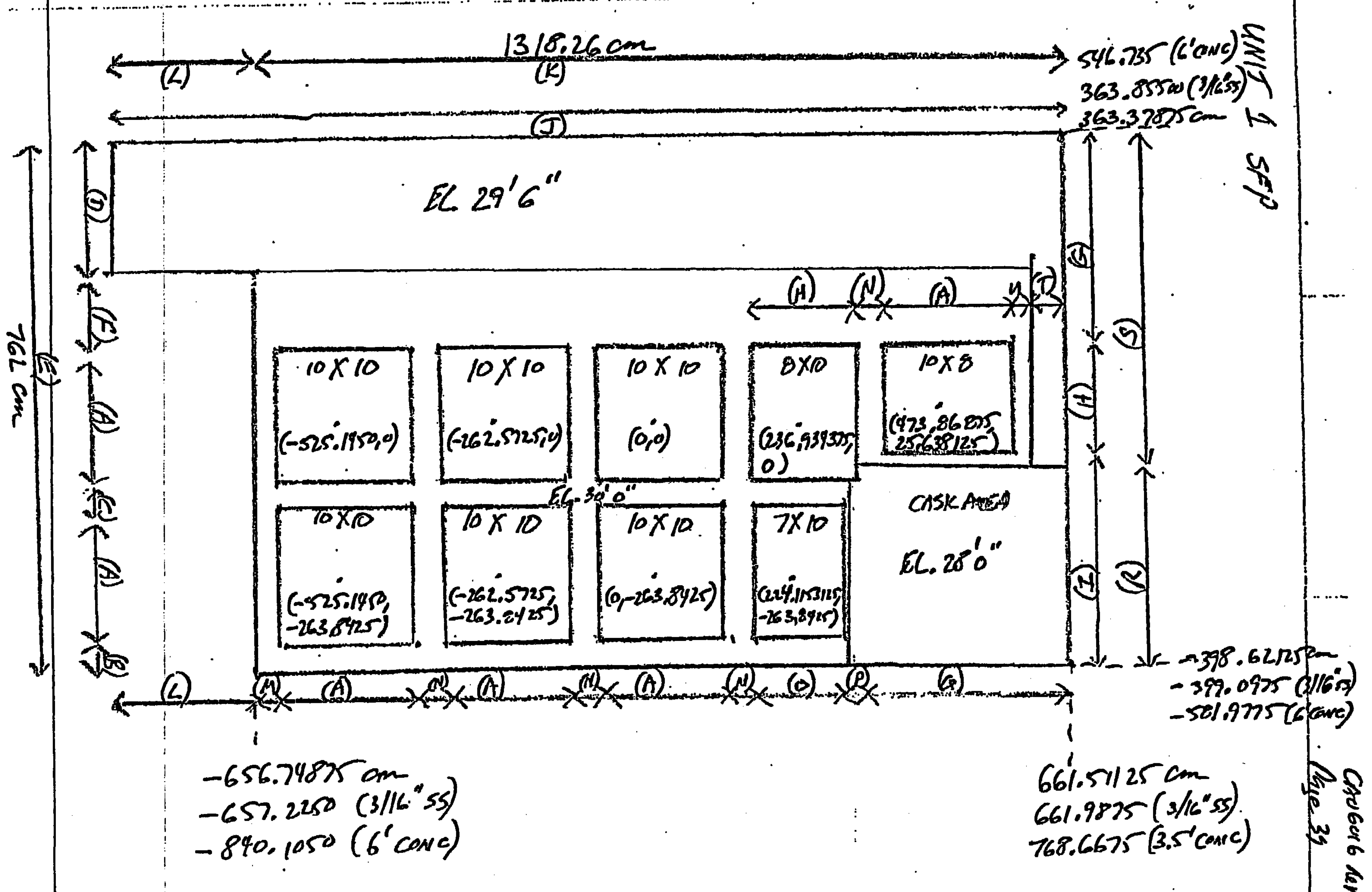
B: X = 8.5625"/2 + .12"/2 = 4.34125" = 11.026775 CM

Y = (8.5625" + 6.5")/4 = 3.765625" = 9.5646875 cm

C: X = (8.5625" + 6.5" + .24")/4 = 3.825625" = 9.7170875 cm

Y = 8.5625"/2 + .06" = 4.34125" = 11.026775 CM

ATTACHMENT D
UNIT 1 SFP PLANAR GEOMETRY


1318.26 cm
546.735 (6' CONC)
363.8550 (3/16" SS)
363.37875 cm
UNIT 1 SFP
EL. 29'6"
762 cm
10 X 10
(-525.1950,0)
10 X 10
(-262.5125,0)
10 X 10
(0,0)
8X10
(236.939375, 0)
10X8
(473.86875, 25.638125)
EL. 30'0"
10X10
(-525.1950, -263.8425)
10 X 10
(-262.5725, -263.2425)
10 X 10
(0,-263.8425)
7X10
(224.1153125, -263.8425)
CASK AREA
EL. 28'0"
-398.62125 cm
-399.0975 (3/16" SS)
-501.9775 (6' CONC)
-656.74875 cm
-657.2250 (3/16" SS)
-840.1050 (6' CONC)
661.51125 cm
661.9875 (3/16" SS)
768.6675 (3.5' CONC)
C90606 Rev. 0
Page 39

(A) 10 * 10.09375" = 100.9375" Ref. 15

(B) 2.5" + 0.09375" = 2.59375" Refs. 15 & 22

(C) 2.75" + 2*0.09375" = 2.9375" Refs 15 & 22

(D) 83.625" Ref. 22

(E) 25' 0" Ref. 22

(F) E - 2A - B - C - D = 8.96875" Refs. 15 & 22

(G) D + F = 92.59375" Refs. 15 & 22

(H) 8 * 10.09375" = 80.75" Ref. 15

(I) E - G - H = 126.65625" Refs. 15 & 22

(J) 54' 0" Ref. 23

(K) 43' 3" Refs. 22-23

(L) J - K = 10' 9" Refs. 22-23

(M) 1.25" + 0.09375" = 1.34375" Refs. 22-23

(N) 2.25" + 2*0.09375" = 2.4375" Refs. 22-23

(O) 7 * 10.09375" = 70.65625" Refs. 15 & 22

(P) K - 3A - M - 3N - O - Q = 4.875" Ref. 15-22-23

(Q) 11' 0" Ref. 23

(R) 9' 0" Ref. 23

(S) E - R = 16' 0" Refs. 22-23

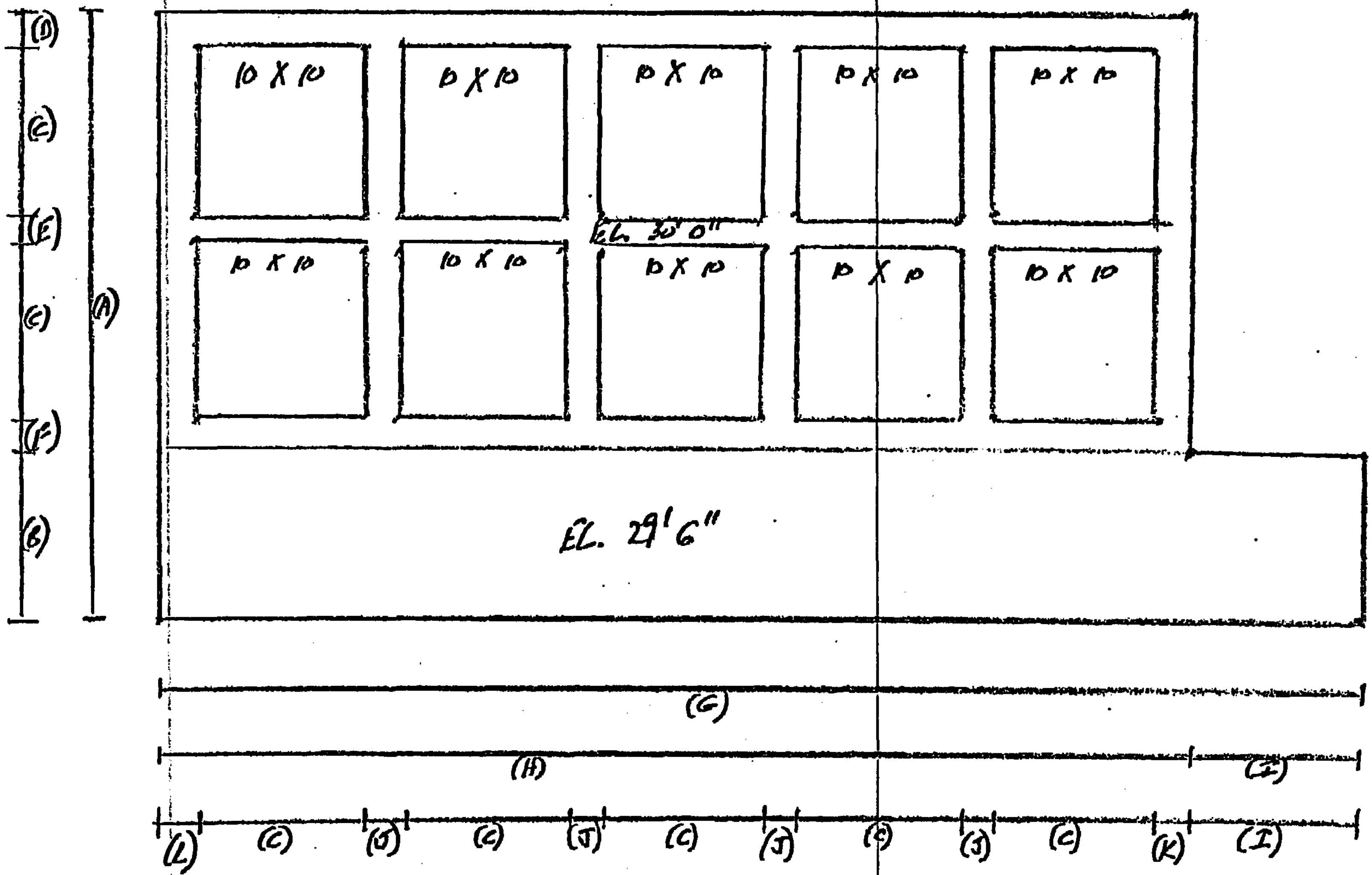
(T) 1' 6" Ref. 23

(U) O + P + Q - H - A - N - T = 5.40625" Ref. 23

~~(V) ELEVATIONS Ref. 23~~

ATTACHMENT E
UNIT 2 SFP PLANAR GEOMETRY

UNIT 2 SFP



[illegible] Rev. 0
Page 48

(A) 25' 0"	Refs. 23-24
(B) 83.625"	Ref. 24
(C) 10 * 10.09375" = 100.9375"	Ref. 15
(D) 2.5" + 0.09375" = 2.59375"	Ref. 24
(E) 2.25" + 2 * 0.09375" = 2.4375"	Ref. 24
(F) A-B-2C-D-E = 9.46875"	Refs. 23-24
(G) 54' 0"	Ref. 23
(H) 43' 3"	Ref. 24
(I) G-H = 10' 9"	Refs. 23-24
(J) 2.25" + 2 * 0.09375" = 2.4375"	Ref. 24
~~(K) 1.25" + 0.09375" = 1.34375"~~	~~Ref. 24~~
(L) 3.125" + 0.09375" = 3.21875"	Ref. 23-24
(M) ELEVATIONS	Ref. 23

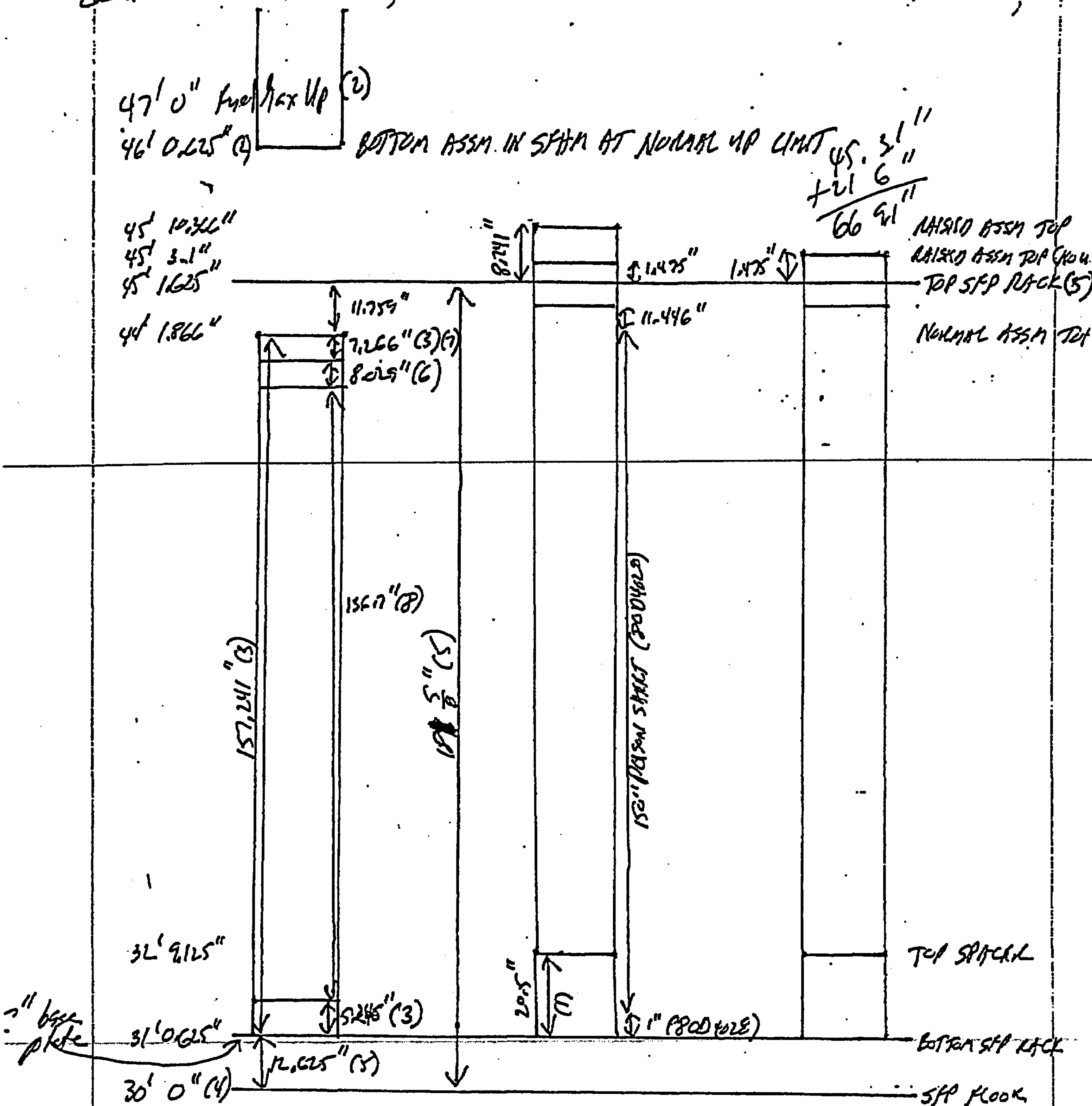
ATTACHMENT F
SFP AXIAL GEOMETRY

AXIAL GEOMETRY
(Reference 25)

Thickness	Region	Elevation at boundary
		420.129" / 1067.12766 cm
256.375"	WATER	
		163.754" / 415.93516 cm
11.759"	RACK	
		151.995" / 386.0673 cm
15.295"	UEF + RACK	
		136.7" / 347.218 cm
136.7"	AFR + RACK + POISON	
		0" / 0 cm
5.246"	LEF + RACK	
		-5.246" / -13.32484 cm
12.625"	WATER	
		-17.871" / -45.39234 cm
3/16"	SS	
		-18.0585" / -45.86859 cm
72"	CONCRETE	
		-90.0585"

OP UNIT – 67'
CL Mech – 66.5'

SPENT FUEL POOL DIAGRAM



(1) E-HSJ-501-099 Sh.1 Rev.1
(2) 15534-0001 Sh.3 Rev.7
(3) 12131-0250 Rev.0
(5) 13539-37 Rev.4
(6) 0-F14-E000-R63 Rev.2
NK4-52-374
(8) UFSAR TRS 3.3-1