mwA 12/8/97

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QA RECORD?

X YES

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FOR INFORMATION ONLY

YANKEE NUCLEAR SERVICES DIVISION
CALCULATION/ANALYSIS FOR

TITLE Spent Fuel Pool Thermal-Hydraulic Calculations

PLANT Maine Yankee CYCLE NA

CALCULATION NUMBER MYC-2004

	PREPARED BY /DATE	REVIEWED BY /DATE	APPROVED BY /DATE	SUPERSEDES CALC./REV. NO.
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KEYWORDS: Spent Fuel Pool, Boron, Decay Heat, Boil Off, QuatroPro

COMPUTER CODES: POOL

EQUIP/TAG NOs. : NA

SYSTEMS: Spent Fuel Pool

REFERENCES: MYC-481 Revs. 0 - 6, MYC-1755, MYC-1562 Revs. 0 - 2, MYC-1253 Revs. 0, 1, MYC-1463 Rev. 0

FORM WE-103-1
Revision 3

9909210210 990826
PDR REVGP ERGNUMRC
PDR

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3.0 Structure/System/Component Applicability

This calculation is applicable to the Maine Yankee Spent Fuel Pool (SFP).

4.0 Problem Description

This calculation provides a portion of the response to Maine Yankee Service Request M-97-27 (Reference 1). The first, second, and fourth TAG items in this service request asks the following:

1. "Spent Fuel Pool Heat Load: Calculate the heat load in the SFP as a function of time."

2. "Loss of Two Spent Fuel Pool Cooling Pumps - Time to Boil: Calculate the time to boil in the spent fuel pool as a function of time and initial temperature."

4. "Operation with One Spent Fuel Pool Pump: Calculate the temperature in the SFP as a function of time with one spent fuel pool pump in operation."

This calculation provides the heat load in the spent fuel pool as a function of time. The calculation also determines time to boil for a loss of two spent fuel pool cooling pumps. The calculation is done as a function of time, initial spent fuel pool temperature and, as requested by W. Henries, an additional parametric is added on initial level. As requested by D. Boynton boil off rate as a function of heat load (time) and time to reach various levels in the pool as a function of heat load (time) are also calculated. Operation with one spent fuel pool cooling pump is assessed.

4.1 Background Data

Maine Yankee is permanently shutdown and has permanently defueled the reactor. This analysis was requested by Maine Yankee (Reference 1) to support the desired operation of the spent fuel pool in the post-shutdown condition.

4.2 Objectives

The objectives of this calculation are:

1. To determine the heat load as a function of time in the SFP.
2. To determine time to boil for a loss of two SFP pumps as a function of time, initial temperature, and initial level.
3. To determine boil off rate as a function of heat load (time) and time to reach various levels in the pool as a function of heat load (time).
4. To determine if normal operation with one spent fuel pool cooling pump is acceptable from a pool temperature standpoint.

4.3 Intended Solution Method

This calculation was done using the POOL computer code to determine decay heat levels in the SFP and QuatroPro spreadsheets and hand calculations to perform the other calculations.

4.4 Pertinent Literature Review

The following were reviewed before and/or during the analysis presented in this calculation:

1. MY Service Request M-97-27, "Post Shutdown Safety Analysis," (Reference 1)
2. MYC 481, Revs. 0 thru 6, 'Pool Computer Code," (Reference 2)
3. MYC 1755, Rev. 0, "End of Cycle 14 Allowable Fuel Removal Rate," (Reference 3)
4. MYC-1562, Revs. 0, 1, 2, "Spent Fuel Pool Rerack Analysis," (Reference 4)

4.5 Acceptance Criteria and Design Criteria Applied

The calculation of decay heat performed in the POOL code used Branch Technical Position ASB 9-2 with an uncertainty factor of 0.1 for times greater than 10^7 seconds consistent with the USNRC Standard Review Plan, Section 9.1.3, "Spent Fuel Pool Cooling and Cleanup System." This is a user option in the POOL code.

5.0 Details of Analysis

5.1 Design Inputs

Spent fuel pool heat exchanger design inputs were taken from MYC-1562 (Reference 4). Table I from WE-100 Design Input Considerations was reviewed. It was found that none of the considerations were applicable to this calculation. There are no relevant SER conditions/restrictions for this calculation.

5.2 Assumptions

Any assumptions made are included in the calculation/analysis writeups.

5.3 Calculation/Analysis

5.3.1 POOL Code Runs to Determine Decay Heat Load in the SFP

The first calculation performed was heat load in the SFP as a function of time for the final SFP assembly loading. This calculation was performed using the POOL computer code. The POOL code is documented in MYC-481 Revs. 0 - 6 (Reference 2). The method for performing calculations with the POOL computer code is well documented in MYC-1253, MYC-1463 (References 5 and 6, respectively), and other calculations. The POOL code's actual purpose was to calculate fuel unloading rate schedules for the refueling activity. In order to determine the unloading rate, the code first calculates the existing decay heat load in the SFP. This is the only portion of the calculations the POOL code performs that is necessary for this calculation. Dummy information was left as input for the section of the code that deals with the fuel to be off loaded into the SFP so that the code would run.

An example input listing for one of the actual cases run for this calculation is included on the next page. A description for each input card follows:

Card 1 The title card indicates that this is a run to determine existing decay heat load. The date the heat load is being calculated on is included in the title.

Card 2 The first entry, Cycle number to be unloaded is 16. This value will place all of the actual fuel at Maine Yankee in the SFP. Cycle 16 isn't really being unloaded, but it doesn't matter, since that portion of the calculation is not being used.

The second, third, and fourth entry is the date unload is to start. This is important because it is the date that the POOL code will use to calculate the existing decay heat load. This date will be varied on each run to calculate decay heat load versus time.

The fifth entry is the calculation option chosen. This entry is set at 6 to use Branch Technical Position 9-2 ,"Residual Decay Energy for Light-Water Reactors for Long-Term Cooling" (located in SRP Section 9.2.5). This entry is consistent with the guidance provided by the NRC in SRP 9.1.3, "Spent Fuel Pool Cooling and Cleanup System."

The sixth entry burnup uncertainty multiplier for the old fuel is set at 1.00.

The seventh entry shutdown power uncertainty multiplier for the old fuel is set at 1.00.

The values for the sixth and seventh entries are acceptable, since the actual average power for the old fuel is over 2% less than the 2700 MW value input in the eighth entry. ✓

The eighth entry core average power (MW) for the old fuel is set at 2700.0.

The ninth entry length of coastdown period in days is set at 0.001 to mimic a no-coast power profile. ✓

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Sample POOL Input File
plimc92.oct30.97
Input File to Calculate Heat Load on October 30, 1997

```
      Calculation of Existing SFP Heat Load DKB92 on Oct 30 1997 $
16    10    30 1997     6       1.00       1.00   2700.0     0.001     0.000        .04        .10
 1             0.370  0.390623    32800.    37102.
 2             0.382  0.389811    34761.    39074.
 3             0.441  0.390623    31691.    37164.
 4             0.941  0.391319        0.    12507.
 5             1.110  0.381933        0.    14463.
 6             1.152  0.373550        0.    14294.
 7             0.768  0.382465    35639.    45018.
 8             0.504  0.390417    28492.    34577.
 9             1.117  0.381933        0.    14378.
10             1.125  0.381292    15453.    30580.
11             1.163  0.389966    13075.    28776.
12             1.157  0.372285    18615.    33881.
13             1.367  0.382035        0.    17775.
15             1.119  0.373550        0.    13913.
16             1.112  0.372285    18472.    33040.
17             1.383  0.373550        0.    17918.
18             0.955  0.374061    36235.    48638.
19             1.358  0.373550        0.    17411.
20             0.945  0.374061    35366.    47528.
24             1.112  0.390455    15470.    30084.
25             0.951  0.374061    35428.    47693.
26             1.327  0.381933        0.    17352.
27             0.890  0.382465    35777.    47288.
28             1.024  0.381292    18521.    31960.
33             1.329  0.373550        0.    17006.
34             0.922  0.390623    31964.    44003.
35             1.058  0.391394    15409.    29650.
36             1.045  0.381292    18339.    32479.
42             1.058  0.372285    18466.    32592.
43             1.098  0.381292    15073.    29896.
44             1.084  0.381292    18464.    33162.
52             0.935  0.390623    32339.    44607.
53             1.352  0.373550        0.    17454.
62             0.922  0.361722    31507.    43590.
      0.0       1.00       1.00    2    2
2700.0  2700.0 -2695.0
```

The tenth entry bias term on the spent fuel pool cooling limit is set at 0.000 (this entry doesn't matter for this calculation). ✓

The eleventh entry uncertainty factor to equation #13 of the ANS79 standard is set at .04 (this entry doesn't matter for this calculation). ✓

The twelveth entry Branch Technical Position 9-2 long term uncertainty fraction for cooling times greater than 10^7 seconds is set at .10 as recommended in NRC SRP 9.1.3. ✓

Card 3 Actinide correction factors is not used when option 6 is selected on Card 2.

Card 4 Thirty-four cards representing the 1/8 core for the fuel being discharged. These cards are unimportant, since this portion of the calculation will be disregarded.

Cards 5, 6 These cards also deal with the fuel being discharged and are therefore unimportant.

Fuel Schedule Input Files

The POOL code also requires two fuel schedule input files: fsxm042 and fsqm042. These files were provided by the Reactor Physics Group in Reference 7. A modified version of the fsxm042 file was created and named fsxm042.mod. The documentation for the modified input is contained in Reference 3. This version is in the format that the POOL code can read. It's the same as the original with the batch parameters removed. POOL doesn't need the batch parameters and will not execute if they are not deleted from the file. The files fsqm042, and fsxm042.mod are listed on the pages that immediately follow. Also listed are the pool file (driver file to run SCL POOL code and the pool.proc file (the procedure file to run the SCL POOL code).

Decay Heat Load vs Time Results

The decay heat load vs time results are presented in Table 5.3.1-1. The table includes the

PREPARED BY ____ REVIEWED BY [signature]

Physics Input File fsqm042 to Be Read by POOL Code
Fuel Schedule Input File

0100010	A0	12	393.887 *	2.027 *	1.117	.984	.378	1	-	-	-	-	10611	-	-	-	-	10611
0101010	B16	56	358.295 *	2.407 *	1.346	.982	.397	1	-	-	-	-	11912	-	-	-	-	11912
0102010	C0	2	395.219 *	2.944 *	2.271	.990	.261	1	-	-	-	-	6522	-	-	-	-	6522
0103010	C12	1	368.196 *	2.957 *	1.934	.985	.365	1	-	-	-	-	10470	-	-	-	-	10470
0104010	C16	1	358.808 *	2.957 *	1.945	.985	.364	1	-	-	-	-	10359	-	-	-	-	10359
0100011	A0	57	393.993 *	2.023 *	.830	.977	.456	1	1A	-	-	-	11059	4636	-	-	-	15695
0101011	B16	24	358.201 *	2.410 *	1.089	.977	.450	1	1A	-	-	-	10846	5148	-	-	-	15994
0102011	C0	22	394.659 *	2.947 *	2.090	.987	.317	1	1A	-	-	-	6056	2509	-	-	-	8565
0103011	C12	35	367.985 *	2.950 *	1.716	.981	.417	1	1A	-	-	-	9289	4041	-	-	-	13330
0104011	C16	7	358.410 *	2.953 *	1.602	.979	.440	1	1A	-	-	-	10359	4525	-	-	-	14884
0110011	RF0	2	395.455 *	2.341 *	1.735	.995	.145	1A	-	-	-	-	2769	-	-	-	-	2769
0111011	RF0	2	395.323 *	1.938 *	1.511	.993	.210	1A	-	-	-	-	4316	-	-	-	-	4316
0112011	RF4	2	386.173 *	1.930 *	1.449	.992	.241	1A	-	-	-	-	5058	-	-	-	-	5058
0113011	RF5	1	380.050 *	2.006 *	1.442	.992	.244	1A	-	-	-	-	5150	-	-	-	-	5150
0110030	RF0	12	395.273 *	1.938 *	.789	.978	.451	1A	3	-	-	-	5387	10463	-	-	-	15850
0111030	RF4	53	386.436 *	1.935 *	.776	.977	.454	1A	3	-	-	-	5079	11144	-	-	-	16223
0200020	D0	69	389.669 *	1.950 *	.715	.976	.466	2	-	-	-	-	18042	-	-	-	-	18042
0201020	E16	1	354.183 *	2.515 *	1.013	.973	.494	2	-	-	-	-	20434	-	-	-	-	20434
0200030	E16	12	353.782 *	2.517 *	.582	.962	.530	2	3	-	-	-	18697	10726	-	-	-	29423
0201030	F0	28	389.028 *	2.887 *	1.026	.968	.540	2	3	-	-	-	12368	12041	-	-	-	24409
0202030	F8	12	372.158 *	2.884 *	.810	.962	.554	2	3	-	-	-	17689	11153	-	-	-	28842
0203030	F12	16	363.271 *	2.884 *	.787	.962	.548	2	3	-	-	-	18124	11138	-	-	-	29262
0200040	E16	61	353.710 *	2.517 *	.575	.961	.530	2	4	-	-	-	19758	9938	-	-	-	29696
0201040	F0	12	389.409 *	2.888 *	.647	.957	.585	2	3	4	-	-	11134	12226	9833	-	-	33193
0200050	E16	1	351.636 *	2.506 *	.623	.963	.528	2	5	-	-	-	17697	10373	-	-	-	28070
0200060	E16	1	352.289 *	2.524 *	.617	.963	.528	2	6	-	-	-	17697	11115	-	-	-	28812
0200070	E16	1	354.361 *	2.517 *	.554	.961	.531	2	7	-	-	-	17697	12779	-	-	-	30476
0200080	E16	1	353.373 *	2.530 *	.522	.960	.532	2	8	-	-	-	20434	11431	-	-	-	31865
0200090	E16	1	354.368 *	2.517 *	.469	.958	.533	2	9	-	-	-	20404	13415	-	-	-	33819
0200100	E16	1	353.516 *	2.518 *	.466	.958	.533	2	10	-	-	-	20434	13242	-	-	-	33676
0300050	G0	16	388.814 *	2.741 *	.595	.958	.576	3	4	5	-	-	11956	10726	9262	-	-	31944
0301050	G41	4	379.997 *	2.744 *	.552	.957	.568	3	4	5	-	-	13294	10953	8788	-	-	33035
0302050	G42	12	380.382 *	2.738 *	.533	.956	.570	3	4	5	-	-	13361	10492	9834	-	-	33687
0303050	H0	40	387.765 *	3.036 *	.770	.959	.586	3	4	5	-	-	8959	11901	10601	-	-	31461
0400060	I0	48	388.812 *	3.035 *	.775	.959	.586	4	5	6	-	-	8887	11782	11243	-	-	31912
0401060	I4	24	378.882 *	3.032 *	.633	.955	.585	4	5	6	-	-	12823	11802	10780	-	-	35405
0500070	J0	48	381.481 *	3.003 *	.713	.958	.577	5	6	7	-	-	9178	12752	10796	-	-	32726
0501070	J4	4	372.852 *	3.003 *	.520	.952	.579	5	6	7	-	-	13293	12998	11944	-	-	38235
0502070	J8	20	363.991 *	3.003 *	.619	.955	.566	5	6	7	-	-	13325	12926	8622	-	-	34873
0600080	K0	48	380.831 *	3.002 *	.631	.955	.582	6	7	8	-	-	9536	14039	11934	-	-	35509
0601080	K4	4	371.499 *	3.004 *	.531	.952	.578	6	7	8	-	-	13449	13845	11047	-	-	38341
0602080	K8	20	363.157 *	3.002 *	.603	.955	.567	6	7	8	-	-	13658	13615	8412	-	-	35685
0700090	L0	8	379.564 *	3.288 *	.651	.951	.610	7	8	9	-	-	11253	13808	14623	-	-	39684
0701090	L4	12	371.060 *	3.288 *	.573	.948	.606	7	8	9	-	-	14123	13473	14121	-	-	41717
0702090	L8	40	362.447 *	3.288 *	.764	.955	.585	7	8	9	-	-	13769	12718	9317	-	-	35804
0703090	L12	4	354.176 *	3.288 *	.552	.948	.587	7	8	9	-	-	15236	13924	12828	-	-	41988
0700110	L0	8	379.415 *	3.288 *	.712	.953	.606	7	8	9	10	11	10315	7276	7831	5101	6013	36536
0800090	M8	3	362.029 *	3.303 *	.960	.960	.577	8	9	-	-	-	15703	16515	-	-	-	32218
0801100	M4	28	370.051 *	3.303 *	.648	.951	.601	8	9	10	-	-	12935	14282	11935	-	-	39152
0802100	M8	28	361.453 *	3.302 *	.616	.950	.594	8	9	10	-	-	15406	16215	7922	-	-	39543
0800110	M8	1	362.537 *	3.299 *	.411	.942	.593	8	9	11	-	-	16373	16296	13376	-	-	46045
0800120	M8	1	362.544 *	3.300 *	.408	.942	.593	8	9	12	-	-	16373	16296	14410	-	-	47079
0800130	M8	1	361.651 *	3.304 *	.487	.945	.594	8	9	13	-	-	15234	15699	13324	-	-	44257
0800140	M8	1	361.722 *	3.299 *	.476	.945	.594	8	9	14	-	-	15234	15699	12273	-	-	43206
0800150	M0	8	378.931 *	3.301 *	.696	.952	.607	8	9	10	15	-	11899	16843	5772	2204	-	36718
0801150	M8	1	361.382 *	3.302 *	.638	.951	.592	8	9	15	-	-	15234	15699	7204	-	-	38137
0900100	N8	8	369.564 *	3.301 *	.943	.959	.588	9	10	-	-	-	18420	13885	-	-	-	32305
0900110	N0	4	388.183 *	3.307 *	.602	.949	.627	9	10	11	-	-	14878	13079	12225	-	-	40182
0901110	N4	24	378.365 *	3.303 *	.550	.947	.618	9	10	11	-	-	14956	14026	12799	-	-	41781
0902110	N8	36	370.192 *	3.302 *	.603	.949	.607	9	10	11	-	-	17880	14035	7806	-	-	39721
1000120	P0	20	389.140 *	3.502 *	.748	.950	.633	10	11	12	-	-	12754	15445	11393	-	-	39592
1001120	P4	20	379.850 *	3.501 *	.559	.944	.629	10	11	12	-	-	15558	15360	14366	-	-	45284
1002120	P8	16	370.907 *	3.500 *	.621	.946	.619	10	11	12	-	-	16819	15453	10667	-	-	42939
1000130	P8	8	371.834 *	3.496 *	.582	.945	.619	10	11	12	13	-	16790	15364	6496	4951	-	43601
1000140	P0	8	389.811 *	3.502 *	.711	.949	.636	10	11	12	14	-	13718	15348	5626	4709	-	39401
1100120	Q4	4	380.873 *	3.694 *	1.131	.957	.617	11	12	-	-	-	16172	18078	-	-	-	34250
1100130	Q0	28	390.712 *	3.690 *	.751	.947	.650	11	12	13	-	-	14347	17011	10997	-	-	42355
1101130	Q4	32	380.545 *	3.693 *	.681	.945	.641	11	12	13	-	-	17783	17139	9118	-	-	44040
1102130	Q8	8	372.789 *	3.695 *	.524	.939	.632	11	12	13	-	-	18150	17861	13230	-	-	49241
1200140	R0	36	390.577 *	3.684 *	.826	.949	.647	12	13	14	-	-	16223	15309	7680	-	-	39212
1201140	R4	12	382.465 *	3.682 *	.581	.941	.642	12	13	14	-	-	20215	14829	10984	-	-	46028

Physics Input File fsqm042 to Be Read by POOL Code
Fuel Schedule Input File

1202140 R8	20	374.061 *	3.681 *	.520	.939	.632	12	13	14	-	-	20098	15369	12456	-	-	47923
1200150 R4	4	381.497 *	3.681 *	.782	.948	.641	12	13	15	-	-	20180	12661	7399	-	-	40240
1300140 S0	4	390.455 *	3.702 *	1.252	.960	.613	13	14	-	-	-	15341	14711	-	-	-	30052
1300150 S0	16	390.680 *	3.702 *	1.118	.957	.624	13	14	15	-	-	14239	14992	3508	-	-	32739
1301150 S4	28	381.292 *	3.701 *	.925	.952	.632	13	14	15	-	-	16568	14618	5678	-	-	[illegible]
1302150 S8	20	372.285 *	3.702 *	.769	.948	.632	13	14	15	-	-	18404	14830	7301	-	-	40535
1400150 T0	8	391.319 *	3.918 *	1.969	.971	.535	14	15	-	-	-	12446	8776	-	-	-	21222
1401150 T4	28	381.947 *	3.906 *	1.719	.966	.573	14	15	-	-	-	15780	9058	-	-	-	24838
1402150 T8	36	373.550 *	3.895 *	1.666	.965	.578	14	15	-	-	-	16453	9190	-	-	-	25643
1500150 U0	8	390.342 *	3.742 *	2.956	.989	.275	15	-	-	-	-	7340	-	-	-	-	7340
1501150 U24	32	389.643 *	3.739 *	2.771	.986	.333	15	-	-	-	-	9340	-	-	-	-	9340
1502150 U48	28	389.498 *	3.740 *	2.723	.985	.354	15	-	-	-	-	9905	-	-	-	-	9905

Modified Physics Input File fsxm042.mod to Be Read by POOL Code
Fuel Schedule Input File

1

FIGURE PAGE
MAINE YANKEE FUEL SCHEDULE FOR END OF CYCLE 15
CYCLES 1 THROUGH 24 (REVISED 08/11/97)

CYCLE PARAMETERS

CYCLE	DATES IN	DATES OUT	CYCLE LENGTH (MWD/MT)	CYCLE LOADING (KGU) DESIGN	CYCLE LOADING (KGU) AS-BUILT	BASIS OF CYCLE LENGTH AND BATCH BURNUPS
1	11/08/72	06/29/74	10336	81549	81434	MEASURED
1A	10/12/74	05/02/75	4509	83119	83084	MEASURED
2	06/29/75	04/09/77	17396	80953	81027	MEASURED
3	06/11/77	07/14/78	11076	83118	83130	MEASURED
4	08/28/78	01/11/80	10495	81908	81822	MEASURED
5	03/17/80	05/08/81	10795	83076	83006	MEASURED
6	07/20/81	09/24/82	11582	82264	82220	MEASURED
7	12/12/82	03/31/84	12465	80872	80905	MEASURED
8	06/20/84	08/17/85	12455	80257	80231	MEASURED
9	10/25/85	03/28/87	14361	80221	80120	MEASURED
10	06/18/87	10/15/88	12647	81362	81227	MEASURED
11	12/16/88	04/07/90	13798	82554	82389	MEASURED
12	06/30/90	02/14/92	15423	83135	83051	MEASURED
13	04/19/92	07/30/93	13668	83075	83028	MEASURED
14	10/14/93	01/14/95	13075	82700	82819	MEASURED
15	01/16/96	12/06/96	7859	83044	83062	MEASURED
16 *	02/06/97	03/15/98	0	0	0	ESTIMATED
17 *	05/24/98	09/15/99	0	0	0	ESTIMATED
18 *	11/24/99	03/15/01	0	0	0	ESTIMATED
19 *	05/24/01	09/15/02	0	0	0	ESTIMATED
20 *	11/24/02	03/15/04	0	0	0	ESTIMATED
21 *	05/24/04	09/15/05	0	0	-	
22 *	11/24/05	03/15/07	0	0	-	
23 *	05/24/07	09/15/08	0	0	-	
24 *	11/24/08	03/15/10	0	0	-	

* CYCLE LENGTH AND BATCH BURNUPS ARE ESTIMATED
** INCLUDING DESIGN LOADINGS, AS INDICATED BELOW

This is dummy data. It is not used in the calculation. It was added so that the format matches previous calculations.
MWD 11/19/97

The rest of the original fsxm042 file is deleted. This is all that's needed as input to the POOL code.
MWD 11/19/97

pool mws 11/19/97

Driver File to Run SCL POOL Code
Used to Determine Decay Heat LOad
PAGE 1 OF 2

This file is run by just typing pool. It's menu driven after that. mws 11/19/97

```
#! /bin/ksh
echo 'TYPE STOP TO TERMINATE EXECUTION'
while
   true
do
   echo 'ENTER POOL USER INPUT FILE? (PLIMxxx) \c'
   read INPT
   if
      [ "$INPT" != "" ]
   then
      if
         [ $INPT = "stop" -o $INPT = "STOP" ]
      then
         echo 'TERMINATING POOL... PLEASE WAIT'
         exit
      fi
      if
         test -r $INPT
      then
         IN1=$INPT
         break
      else
         echo 'pool user input file not found'
      fi
   fi
done
while
   true
do
   echo 'ENTER POOL UNIT 8 INPUT FILE? (FSQMxxx) \c'
   read INPT
   if
      [ "$INPT" != "" ]
   then
      if
         [ $INPT = "stop" -o $INPT = "STOP" ]
      then
         echo 'TERMINATING POOL... PLEASE WAIT'
         exit
      fi
      if
         test -r $INPT
      then
         IN2=$INPT
         break
      else
         echo 'pool unit 8 input file not found'
      fi
   fi
done
while
   true
do
   echo 'ENTER POOL UNIT 9 INPUT FILE? (FSXMxxx) \c'
   read INPT
   if
      [ "$INPT" != "" ]
   then
      if
         [ $INPT = "stop" -o $INPT = "STOP" ]
      then
         echo 'TERMINATING POOL... PLEASE WAIT'
         exit
      fi
      if
         test -r $INPT
      then
         IN3=$INPT
         break
      else
         echo 'pool unit 9 input file not found'
```

Driver File to Run SCL POOL Code
Used to Determine Decay Heat LOad


```
      fi
   fi
done
#
#  FILE 6 = LIST OUTPUT FILE
#
echo 'ENTER LIST OUTPUT FILE? <POOL6> \c'
read OU1
if
   test "$OU1" = ""
then
   OU1=POOL6
fi
if
   [ $OU1 = "stop" -o $OU1 = "STOP" ]
then
   echo 'TERMINATING POOL... PLEASE WAIT'
   exit
fi
#
#  PLOT FILE
#
echo 'ENTER PLOT FILE? <CGMETA> \c'
read OU2
if
   test "$OU2" = ""
then
   OU2=CGMETA
fi
if
   [ $OU2 = "stop" -o $OU2 = "STOP" ]
then
   echo 'TERMINATING POOL... PLEASE WAIT'
   exit
fi
#
#  EXECUTE POOL
#
echo 'dayfile name is: daypool.'$$
#at now + 1 minute <<EOF
at now <<EOF
pool.proc -i $IN1 -j $IN2 -k $IN3 -o $OU1 -p $OU2 2>daypool.$$
cat daypool.$$ >> $OU1
grep "TOTAL POWER IN" $OU1 > $OU1.sum
EOF
```

pool.proc
Procedure File to Run the SCL POOL Code


```
#! /bin/ksh
set -x
#
# ++==================================++==================================++
# ||                                  ||                                  ||
# ||  SCRIPT NAME    :  pool.proc     ||  YANKEE ATOMIC ELECTRIC COMPANY  ||
# ||                                  ||                                  ||
# ||  SCRIPT VERSION :  1.00          ||  EXECUTE pool.e                  ||
# ||  SCRIPT DATE    :  09/30/91      ||                                  ||
# ||                                  ||                                  ||
# ++==================================++==================================++
#
#
#-------------------------------------------------------o  PROCESS OPTIONS
#
IFL=0
JFL=0
KFL=0
OFL=0
PFL=0
EFL=1
while getopts i:j:k:o:p: OPTION
do
   case $OPTION in
   i)   IN1=$OPTARG
        IFL=1;;
   j)   IN2=$OPTARG
        JFL=1;;
   k)   IN3=$OPTARG
        KFL=1;;
   o)   OU1=$OPTARG
        OFL=1;;
   p)   OU2=$OPTARG
        PFL=1;;
   \?)  EFL=0;;
   esac
done
if
   [ $IFL -eq 1 -a $JFL -eq 1 -a $KFL -eq 1 -a $OFL -eq 1 -a $PFL -eq 1 -a $EFL -eq 1 ]
then
   ERR=0
else
   ERR=1
fi
#
#--------------------------------------------------------o OPTION ERRORS
#
if
   [ $ERR -ne 0 ]
then
   cat <<EOF

   USAGE: pool.proc [-i file -j file -k file -o file -p file]

   OPTION   DESCRIPTION                  I/O

     -i     POOL USER INPUT FILE          I
     -j     POOL UNIT 8 INPUT FILE        I
     -k     POOL UNIT 9 INPUT FILE        I
     -o     POOL OUTPUT FILE              O
     -p     POOL PLOT FILE                O

EOF
   exit 64
fi
#
#--------------------------------------------------------o FILE ENVIRONMENT
#
#  SET UP TARGET DIR TO GET INPUT AND DEPOSIT OUTPUT
#
TDIR=`pwd`
```

pool.proc
Procedure File to Run the SCL POOL Code


```
#
#  SET UP TEMPORARY DIR FOR EXECUTION ONLY
#
RUND=/tmp/pool.$$
mkdir $RUND
cd $RUND
ln -s $TDIR/$IN1 POOL5
ln -s $TDIR/$IN2 POOL8
ln -s $TDIR/$IN3 POOL9
ln -s $TDIR/$OU1 BANNER
ln -s $TDIR/$OU2 CGMETA
#
#-----------------------------------------------------o EXECUTE APPLICATION
#
#  EXECUTE POOL
#
. /SCL/scladmin/sclproc
sclproc pool > BANNER
pool
cat POOL6 >> BANNER
STATUS=$?
#
#-------------------------------------------------------o CLEAN UP
#
cd $TDIR
rm -r $RUND
exit $STATUS
```

input and output file names, date, time after shutdown, and decay heat load for each case run. This table is a QuatroPro spreadsheet. Time after shutdown in days assumes shutdown was December 6, 1996. Time after shutdown in days is then calculated based on the unload date for each POOL code run, which as mentioned earlier is the date the POOL code calculates the existing decay heat on. The total power (in MW) in the spent fuel pool is also taken from each POOL code run. The spread sheet then calculates the power in BTU/hr as follows:

> Power in MW from column E is multiplied by the conversion from MW to BTU/hr. An example from the sheet is shown below:
>
> $$1.74773 \text{ MW} \times (3.412 \times 10^6 \text{ BTU/hr})/1\text{MW} = \mathbf{5.96 \times 10^6 \text{ BTU/hr}}$$ ✓

The results of decay heat load vs time are plotted in Figure 5.3.1-1. This plot is from the data in the QuatroPro spreadsheet.

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TABLE 5.3.1-1 Deay Heat Load vs Time

QuatroPro Version 6.0 for Windows

Input File Name	Output File Name	Date	Days After Shutdown	Total Power in SFP (MW)	Total Power in SFP (BTU/hr)
plimc92.oct15.97	plomc92.oct15.97	10/15/97	313	1.74773 ✓	5.96E+06 ✓
plimc92.oct30.97	plomc92.oct30.97	10/30/97	328	1.71064 ✓	5.84E+06
plimc92.nov29.97	plomc92.nov29.97	11/29/97	358	1.64511 ✓	5.61E+06 ✓
plimc92.dec29.97	plomc92.dec29.97	12/29/97	388	1.58915 ✓	5.42E+06
plimc92.jan28.98	plomc92.jan28.98	01/28/98	418	1.5409 ✓	5.26E+06 ✓
plimc92.feb27.98	plomc92.feb27.98	02/27/98	448	1.49892 ✓	5.11E+06
plimc92.mar29.98	plomc92.mar29.98	03/29/98	478	1.46207 ✓	4.99E+06 ✓
plimc92.apr28.98	plomc92.apr28.98	04/28/98	508	1.42946 ✓	4.88E+06
plimc92.may28.98	plomc92.may28.98	05/28/98	538	1.40037 ✓	4.78E+06 ✓
plimc92.jun27.98	plomc92.jun27.98	06/27/98	568	1.37425 ✓	4.69E+06
plimc92.jul27.98	plomc92.jul27.98	07/27/98	598	1.35065 ✓	4.61E+06 ✓
plimc92.aug26.98	plomc92.aug26.98	08/26/98	628	1.32921 ✓	4.54E+06
plimc92.sep25.98	plomc92.sep25.98	09/25/98	658	1.30962 ✓	4.47E+06 ✓
plimc92.oct25.98	plomc92.oct25.98	10/25/98	688	1.29166 ✓	4.41E+06
plimc92.nov24.98	plomc92.nov24.98	11/24/98	718	1.27513 ✓	4.35E+06 ✓
plimc92.dec24.98	plomc92.dec24.98	12/24/98	748	1.25985 ✓	4.30E+06
plimc92.jun22.99	plomc92.jun22.99	06/22/99	928	1.18815 ✓	4.05E+06 ✓
plimc92.dec19.99	plomc92.dec19.99	12/19/99	1108	1.13931 ✓	3.89E+06
plimc92.jun16.00	plomc92.jun16.00	06/16/00	1288	1.10412 ✓	3.77E+06 ✓
plimc92.dec13.00	plomc92.dec13.00	12/13/00	1468	1.07743 ✓	3.68E+06
plimc92.dec13.01	plomc92.dec13.01	12/13/01	1833	1.03783 ✓	3.54E+06 ✓
plimc92.dec13.02	plomc92.dec13.02	12/13/02	2198	1.00773 ✓	3.44E+06
plimc92.dec13.07	plomc92.dec13.07	12/13/07	4024	0.89079 ✓	3.04E+06 ✓

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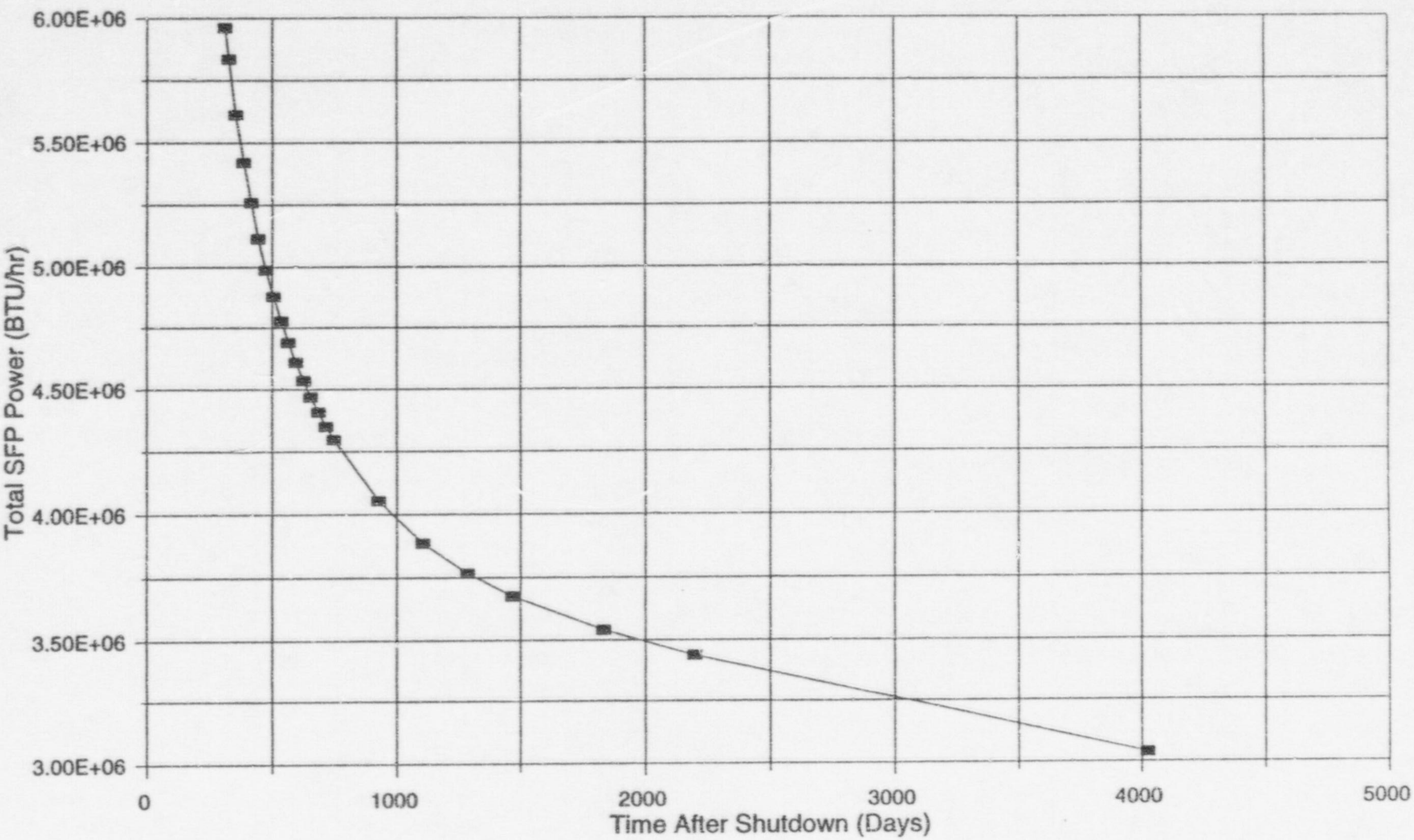
FIGURE 5.3.1-1

Total SFP Power vs Time After Shutdown



5.3.2 Time to Boil for Loss of Two SFP Pumps

The second calculation was performed to determine time to boil for a loss of two SFP pumps as a function of time, initial temperature, and initial level. These calculations were performed with a QuatroPro spreadsheet. The decay heat loads calculated in the POOL code runs and converted to BTU/hr in the QuatroPro spreadsheet developed in 5.3.1 were entered in the new spreadsheet. Initial temperature range studied was from 80°F to 154°F. Pool water level was run at three points 23.5, 32.5, and 35.5 feet. The three levels are approximately as follows:

23.5 ft - minimum level for a pipe break on the discharge side of the heat exchanger
32.5 ft - minimum level for a pipe break on the suction side of the heat exchanger
35.5 ft - nominal level

Thirty-two and a half feet was used in a previous calculation of time to boil in the SFP in MYC-1562 (pages 85 - 87). A conservative mass of 2.48×10^6 lb_m was calculated in MYC-1562 for this level at 154°F. Masses at the other levels were determined in the spreadsheet as follows:

A water volume was calculated for the difference in level for example at the 23.5 ft level:

Minimum pool dimensions from MYC-1562 are 41.4 ft by 36.89 ft and the water volume for the difference in level is given by:

$$41.4 \text{ ft} \times 36.89 \text{ ft} \times (32.5 \text{ ft} - 23.5 \text{ ft}) = 13{,}742.2 \text{ ft}^3$$ ✓

The mass for this volume was calculated using the specific volume of water at 32°F to maximize the reduction in mass since minimum mass will allow for shorter time to boil. The specific volume of water at 32°F is 0.01602 ft^3/lb_m. The mass at the 23.5 ft level was then calculated as:

$$2.48 \times 10^6 \text{ lb}_m - ((41.4\text{ft} \times 36.89 \text{ ft}) \times (32.5 \text{ ft} - 23.5 \text{ ft}))/0.01602 \text{ ft}^3/\text{lb}_m =$$
$$\mathbf{1.62 \times 10^6 \ lb_m}$$ ✓

[(SFP water mass) x ($T_{boiling}$ - $T_{initial}$)/(SFP decay heat load)] x specific heat of water

with a SFP water mass of 1.62×10^6 lb_m , an initial SFP temperature of 80°F, and an initial heat load of 5.84×10^6 BTU/hr (the heat load is taken from the POOL code calculations for October 30, 1997), time to boil is then:

$$[1.62 \times 10^6\ lb_m \times (212°F - 80°F)/5.84 \times 10^6\ BTU/hr] \times 1BTU/lb_m°F = 36.7\ hr$$ ✓

Time to boil for a loss of two SFP pumps as a function of time, initial temperature, and initial level results are provided in Table 5.3.2-1 and Figures 5.3.2-1 through 5.3.2-3.

Mass at the 35.5 ft level was determined in the spreadsheet as follows:

The mass for this volume was calculated using the specific volume of water at 32°F. The specific volume of water at 32°F is 0.01602 ft^3/lb_m . The mass at the 35.5 ft level was then calculated as:

$$2.48 \times 10^6\ lb_m - ((41.4ft \times 36.89\ ft) \times (32.5\ ft - 35.5\ ft))/0.01602\ ft^3/lb_m = 2.77 \times 10^6\ lb_m$$ ✓

TABLE 5.3.2-1 Time to Boil vs Time, Initial Temperature, Level

Quattro Pro for Windows version 6.0 MNS 11/19/97

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
5.84E+06 ✓	80	32.5	2.48E+06 ✓	56.05 ✓	Oct 30 1997
5.84E+06	100	32.5	2.48E+06	47.56	Oct 30 1997
5.84E+06	120	32.5	2.48E+06	39.07	Oct 30 1997
5.84E+06	140	32.5	2.48E+06	30.58	Oct 30 1997
5.84E+06	154	32.5	2.48E+06	24.63 ✓	Oct 30 1997
5.84E+06	80	23.5	1.62E+06 ✓	36.66 ✓	Oct 30 1997
5.84E+06	100	23.5	1.62E+06	31.11	Oct 30 1997
5.84E+06	120	23.5	1.62E+06	25.55	Oct 30 1997
5.84E+06	140	23.5	1.62E+06	20.00	Oct 30 1997
5.84E+06	154	23.5	1.62E+06	16.11 ✓	Oct 30 1997
5.84E+06	80	35.5	2.77E+06	62.52	Oct 30 1997
5.84E+06	100	35.5	2.77E+06	53.05	Oct 30 1997
5.84E+06	120	35.5	2.77E+06	43.57	Oct 30 1997
5.84E+06	140	35.5	2.77E+06	34.10	Oct 30 1997
5.84E+06	154	35.5	2.77E+06	27.47	Oct 30 1997
5.42E+06 ✓	80	32.5	2.48E+06 ✓	60.40 ✓	Dec 29 1997
5.42E+06	100	32.5	2.48E+06	51.25	Dec 29 1997
5.42E+06	120	32.5	2.48E+06	42.10	Dec 29 1997
5.42E+06	140	32.5	2.48E+06	32.94	Dec 29 1997
5.42E+06	154	32.5	2.48E+06	26.54	Dec 29 1997
5.42E+06	80	23.5	1.62E+06 ✓	39.50	Dec 29 1997
5.42E+06	100	23.5	1.62E+06	33.52	Dec 29 1997
5.42E+06	120	23.5	1.62E+06	27.53 ✓	Dec 29 1997
5.42E+06	140	23.5	1.62E+06	21.55	Dec 29 1997
5.42E+06	154	23.5	1.62E+06	17.36	Dec 29 1997
5.42E+06	80	35.5	2.77E+06	67.36	Dec 29 1997
5.42E+06	100	35.5	2.77E+06	57.16	Dec 29 1997
5.42E+06	120	35.5	2.77E+06	46.95	Dec 29 1997
5.42E+06	140	35.5	2.77E+06	36.74	Dec 29 1997
5.42E+06	154	35.5	2.77E+06	29.60	Dec 29 1997
4.99E+06 ✓	80	32.5	2.48E+06 ✓	65.60	Mar 29 1998
4.99E+06	100	32.5	2.48E+06	55.66	Mar 29 1998
4.99E+06	120	32.5	2.48E+06	45.72	Mar 29 1998
4.99E+06	140	32.5	2.48E+06	35.78 ✓	Mar 29 1998
4.99E+06	154	32.5	2.48E+06	28.83	Mar 29 1998
4.99E+06	80	23.5	1.62E+06 ✓	42.91	Mar 29 1998
4.99E+06	100	23.5	1.62E+06	36.41	Mar 29 1998
4.99E+06	120	23.5	1.62E+06	29.90	Mar 29 1998
4.99E+06	140	23.5	1.62E+06	23.40	Mar 29 1998
4.99E+06	154	23.5	1.62E+06	18.85 ✓	Mar 29 1998
4.99E+06	80	35.5	2.77E+06	73.17	Mar 29 1998

TABLE 5.3.2-1 Time to Boil vs Time, Initial Temperature, Level

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Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding tc Heat Load
4.99E+06	100	35.5	2.77E+06	62.08	Mar 29 1998
4.99E+06	120	35.5	2.77E+06	51.00	Mar 29 1998
4.99E+06	140	35.5	2.77E+06	39.91	Mar 29 1998
4.99E+06	154	35.5	2.77E+06	32.15	Mar 29 1998
4.69E+06 ✓	80	32.5	2.48E+06 ✓	69.80	Jun 27 1998
4.69E+06	100	32.5	2.48E+06	59.22 ✓	Jun 27 1998
4.69E+06	120	32.5	2.48E+06	48.65	Jun 27 1998
4.69E+06	140	32.5	2.48E+06	38.07	Jun 27 1998
4.69E+06	154	32.5	2.48E+06	30.67	Jun 27 1998
4.69E+06	80	23.5	1.62E+06 ✓	45.65	Jun 27 1998
4.69E+06	100	23.5	1.62E+06	38.73	Jun 27 1998
4.69E+06	120	23.5	1.62E+06	31.82	Jun 27 1998
4.69E+06	140	23.5	1.62E+06	24.90 ✓	Jun 27 1998
4.69E+06	154	23.5	1.62E+06	20.06	Jun 27 1998
4.69E+06	80	35.5	2.77E+06	77.85	Jun 27 1998
4.69E+06	100	35.5	2.77E+06	66.05	Jun 27 1998
4.69E+06	120	35.5	2.77E+06	54.26	Jun 27 1998
4.69E+06	140	35.5	2.77E+06	42.46	Jun 27 1998
4.69E+06	154	35.5	2.77E+06	34.21	Jun 27 1998
4.47E+06 ✓	80	32.5	2.48E+06 ✓	73.23	Sep 25 1998
4.47E+06	100	32.5	2.48E+06	62.14	Sep 25 1998
4.47E+06	120	32.5	2.48E+06	51.04 ✓	Sep 25 1998
4.47E+06	140	32.5	2.48E+06	39.95	Sep 25 1998
4.47E+06	154	32.5	2.48E+06	32.18	Sep 25 1998
4.47E+06	80	23.5	1.62E+06 ✓	47.90	Sep 25 1998
4.47E+06	100	23.5	1.62E+06	40.64	Sep 25 1998
4.47E+06	120	23.5	1.62E+06	33.38	Sep 25 1998
4.47E+06	140	23.5	1.62E+06	26.13	Sep 25 1998
4.47E+06	154	23.5	1.62E+06	21.05 ✓	Sep 25 1998
4.47E+06	80	35.5	2.77E+06	81.68	Sep 25 1998
4.47E+06	100	35.5	2.77E+06	69.30	Sep 25 1998
4.47E+06	120	35.5	2.77E+06	56.93	Sep 25 1998
4.47E+06	140	35.5	2.77E+06	44.55	Sep 25 1998
4.47E+06	154	35.5	2.77E+06	35.89	Sep 25 1998
4.30E+06 ✓	80	32.5	2.48E+06 ✓	76.13	Dec 24 1998
4.30E+06	100	32.5	2.48E+06	64.60	Dec 24 1998
4.30E+06	120	32.5	2.48E+06	53.06	Dec 24 1998
4.30E+06	140	32.5	2.48E+06	41.53	Dec 24 1998
4.30E+06	154	32.5	2.48E+06	33.45	Dec 24 1998
4.30E+06	80	23.5	1.62E+06 ✓	49.79	Dec 24 1998
4.30E+06	100	23.5	1.62E+06	42.25	Dec 24 1998
4.30E+06	120	23.5	1.62E+06	34.70	Dec 24 1998

TABLE 5.3.2-1 Time to Boil vs Time, Initial Temperature, Level

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AR

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
4.30E+06	140	23.5	1.62E+06	27.16	Dec 24 1998
4.30E+06	154	23.5	1.62E+06	21.88	Dec 24 1998
4.30E+06	80	35.5	2.77E+06	84.91	Dec 24 1998
4.30E+06	100	35.5	2.77E+06	72.04	Dec 24 1998
4.30E+06	120	35.5	2.77E+06	59.18	Dec 24 1998
4.30E+06	140	35.5	2.77E+06	46.31	Dec 24 1998
4.30E+06	154	35.5	2.77E+06	37.31	Dec 24 1998
4.05E+06 ✓	80	32.5	2.48E+06 ✓	80.83	Jun 22 1999
4.05E+06	100	32.5	2.48E+06	68.58	Jun 22 1999
4.05E+06	120	32.5	2.48E+06	56.34	Jun 22 1999
4.05E+06	140	32.5	2.48E+06	44.09	Jun 22 1999
4.05E+06	154	32.5	2.48E+06	35.52	Jun 22 1999
4.05E+06	80	23.5	1.62E+06 ✓	52.87	Jun 22 1999
4.05E+06	100	23.5	1.62E+06	44.86	Jun 22 1999
4.05E+06	120	23.5	1.62E+06	36.85	Jun 22 1999
4.05E+06	140	23.5	1.62E+06	28.84	Jun 22 1999
4.05E+06	154	23.5	1.62E+06	23.23	Jun 22 1999
4.05E+06	80	35.5	2.77E+06	90.15	Jun 22 1999
4.05E+06	100	35.5	2.77E+06	76.49	Jun 22 1999
4.05E+06	120	35.5	2.77E+06	62.83	Jun 22 1999
4.05E+06	140	35.5	2.77E+06	49.17	Jun 22 1999
4.05E+06	154	35.5	2.77E+06	39.61	Jun 22 1999
3.89E+06 ✓	80	32.5	2.48E+06 ✓	84.15	Dec 19 1999
3.89E+06	100	32.5	2.48E+06	71.40	Dec 19 1999
3.89E+06	120	32.5	2.48E+06	58.65	Dec 19 1999
3.89E+06	140	32.5	2.48E+06	45.90	Dec 19 1999
3.89E+06	154	32.5	2.48E+06	36.98	Dec 19 1999
3.89E+06	80	23.5	1.62E+06 ✓	55.04	Dec 19 1999
3.89E+06	100	23.5	1.62E+06	46.70	Dec 19 1999
3.89E+06	120	23.5	1.62E+06	38.36	Dec 19 1999
3.89E+06	140	23.5	1.62E+06	30.02	Dec 19 1999
3.89E+06	154	23.5	1.62E+06	24.18	Dec 19 1999
3.89E+06	80	35.5	2.77E+06	93.86	Dec 19 1999
3.89E+06	100	35.5	2.77E+06	79.64	Dec 19 1999
3.89E+06	120	35.5	2.77E+06	65.42	Dec 19 1999
3.89E+06	140	35.5	2.77E+06	51.20	Dec 19 1999
3.89E+06	154	35.5	2.77E+06	41.24	Dec 19 1999
3.77E+06 ✓	80	32.5	2.48E+06 ✓	86.83	Jun 16 2000
3.77E+06	100	32.5	2.48E+06	73.68	Jun 16 2000
3.77E+06	120	32.5	2.48E+06	60.52	Jun 16 2000
3.77E+06	140	32.5	2.48E+06	47.36	Jun 16 2000
3.77E+06	154	32.5	2.48E+06	38.15	Jun 16 2000

TABLE 5.3.2-1 Time to Boil vs Time, Initial Temperature, Level

QuattroPro for Windows Version 6.0 11/19/97 MMS

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Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
3.77E+06	80	23.5	1.62E+06 ✓	56.79 ✓	Jun 16 2000
3.77E+06	100	23.5	1.62E+06	48.19	Jun 16 2000
3.77E+06	120	23.5	1.62E+06	39.58	Jun 16 2000
3.77E+06	140	23.5	1.62E+06	30.98	Jun 16 2000
3.77E+06	154	23.5	1.62E+06	24.95	Jun 16 2000
3.77E+06	80	35.5	2.77E+06	96.85	Jun 16 2000
3.77E+06	100	35.5	2.77E+06	82.17	Jun 16 2000
3.77E+06	120	35.5	2.77E+06	67.50	Jun 16 2000
3.77E+06	140	35.5	2.77E+06	52.83	Jun 16 2000
3.77E+06	154	35.5	2.77E+06	42.55	Jun 16 2000
3.68E+06 ✓	80	32.5	2.48E+06 ✓	88.96	Dec 13 2000
3.68E+06	100	32.5	2.48E+06	75.48 ✓	Dec 13 2000
3.68E+06	120	32.5	2.48E+06	62.00	Dec 13 2000
3.68E+06	140	32.5	2.48E+06	48.52	Dec 13 2000
3.68E+06	154	32.5	2.48E+06	39.09	Dec 13 2000
3.68E+06	80	23.5	1.62E+06 ✓	58.18	Dec 13 2000
3.68E+06	100	23.5	1.62E+06	49.37	Dec 13 2000
3.68E+06	120	23.5	1.62E+06	40.55 ✓	Dec 13 2000
3.68E+06	140	23.5	1.62E+06	31.73	Dec 13 2000
3.68E+06	154	23.5	1.62E+06	25.56	Dec 13 2000
3.68E+06	80	35.5	2.77E+06	99.22	Dec 13 2000
3.68E+06	100	35.5	2.77E+06	84.18	Dec 13 2000
3.68E+06	120	35.5	2.77E+06	69.15	Dec 13 2000
3.68E+06	140	35.5	2.77E+06	54.12	Dec 13 2000
3.68E+06	154	35.5	2.77E+06	43.59	Dec 13 2000
3.54E+06 ✓	80	32.5	2.48E+06 ✓	92.47	Dec 13 2001
3.54E+06	100	32.5	2.48E+06	78.46	Dec 13 2001
3.54E+06	120	32.5	2.48E+06	64.45	Dec 13 2001
3.54E+06	140	32.5	2.48E+06	50.44 ✓	Dec 13 2001
3.54E+06	154	32.5	2.48E+06	40.63	Dec 13 2001
3.54E+06	80	23.5	1.62E+06 ✓	60.48	Dec 13 2001
3.54E+06	100	23.5	1.62E+06	51.32	Dec 13 2001
3.54E+06	120	23.5	1.62E+06	42.15	Dec 13 2001
3.54E+06	140	23.5	1.62E+06	32.99	Dec 13 2001
3.54E+06	154	23.5	1.62E+06	26.58 ✓	Dec 13 2001
3.54E+06	80	35.5	2.77E+06	103.14	Dec 13 2001
3.54E+06	100	35.5	2.77E+06	87.51	Dec 13 2001
3.54E+06	120	35.5	2.77E+06	71.88	Dec 13 2001
3.54E+06	140	35.5	2.77E+06	56.26	Dec 13 2001
3.54E+06	154	35.5	2.77E+06	45.32	Dec 13 2001
3.44E+06 ✓	80	32.5	2.48E+06 ✓	95.16	Dec 13 2002

TABLE 5.3.2-1 Time to Boil vs Time, Initial Temperature, Level

QuattroPro for windows version 6.0 11/19/97

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Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
3.44E+06	100	32.5	2.48E+06	80.74	Dec 13 2002
3.44E+06	120	32.5	2.48E+06	66.33	Dec 13 2002
3.44E+06	140	32.5	2.48E+06	51.91 ✓	Dec 13 2002
3.44E+06	154	32.5	2.48E+06	41.81	Dec 13 2002
3.44E+06	80	23.5	1.62E+06 ✓	62.24	Dec 13 2002
3.44E+06	100	23.5	1.62E+06	52.81	Dec 13 2002
3.44E+06	120	23.5	1.62E+06	43.38 ✓	Dec 13 2002
3.44E+06	140	23.5	1.62E+06	33.95	Dec 13 2002
3.44E+06	154	23.5	1.62E+06	27.35	Dec 13 2002
3.44E+06	80	35.5	2.77E+06	106.14	Dec 13 2002
3.44E+06	100	35.5	2.77E+06	90.06	Dec 13 2002
3.44E+06	120	35.5	2.77E+06	73.97	Dec 13 2002
3.44E+06	140	35.5	2.77E+06	57.89	Dec 13 2002
3.44E+06	154	35.5	2.77E+06	46.64	Dec 13 2002
3.04E+06 ✓	80	32.5	2.48E+06 ✓	107.68 ✓	Dec 13 2007
3.04E+06	100	32.5	2.48E+06	91.37	Dec 13 2007
3.04E+06	120	32.5	2.48E+06	75.05	Dec 13 2007
3.04E+06	140	32.5	2.48E+06	58.74	Dec 13 2007
3.04E+06	154	32.5	2.48E+06	47.32	Dec 13 2007
3.04E+06	80	23.5	1.62E+06 ✓	70.43	Dec 13 2007
3.04E+06	100	23.5	1.62E+06	59.76 ✓	Dec 13 2007
3.04E+06	120	23.5	1.62E+06	49.09	Dec 13 2007
3.04E+06	140	23.5	1.62E+06	38.42	Dec 13 2007
3.04E+06	154	23.5	1.62E+06	30.95	Dec 13 2007
3.04E+06	80	35.5	2.77E+06	120.10	Dec 13 2007
3.04E+06	100	35.5	2.77E+06	101.91	Dec 13 2007
3.04E+06	120	35.5	2.77E+06	83.71	Dec 13 2007
3.04E+06	140	35.5	2.77E+06	65.51	Dec 13 2007
3.04E+06	154	35.5	2.77E+06	52.77	Dec 13 2007

FIGURE 5.3.2-1

Quatro Pro for Windows version 6.0 11/19/97 mws

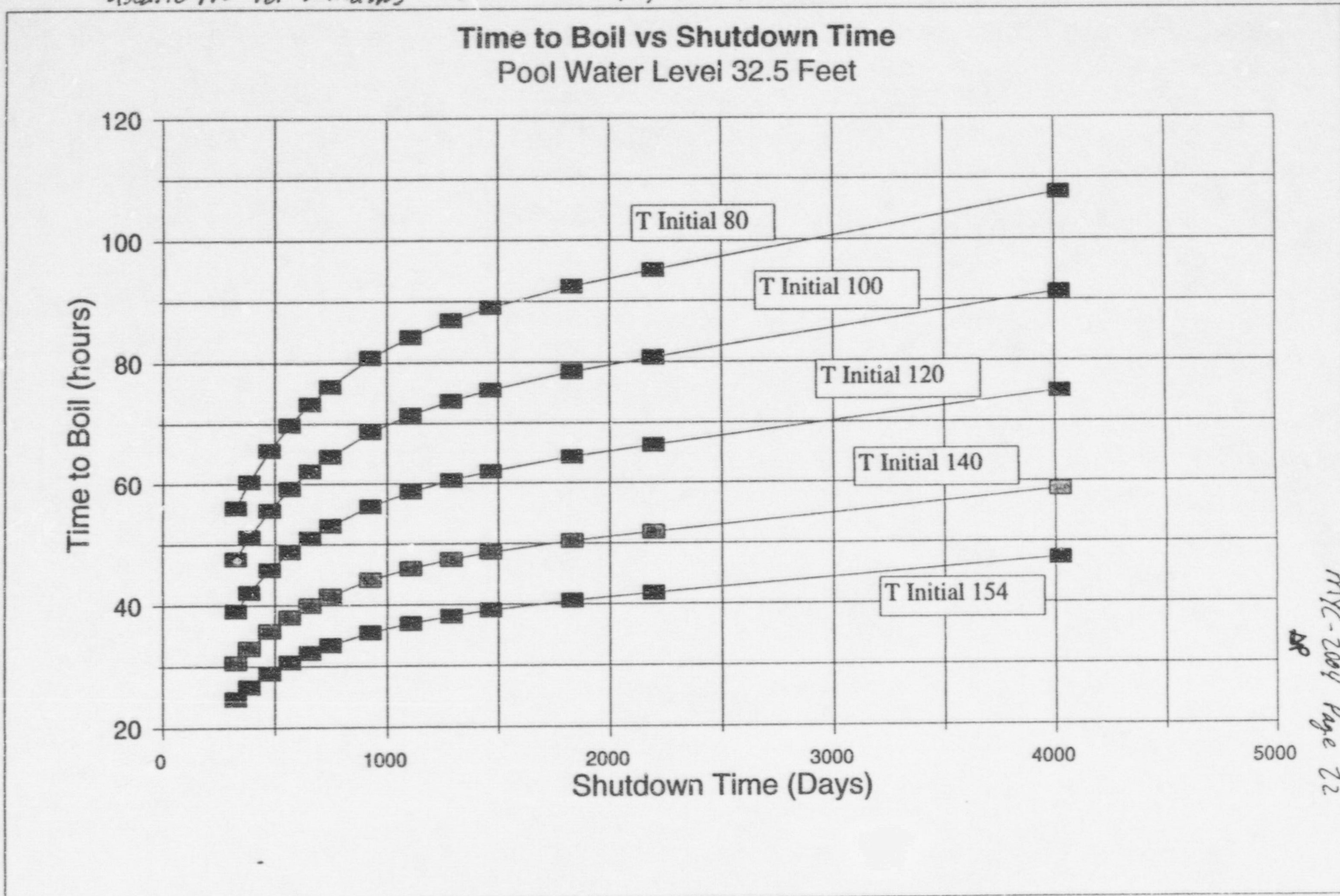

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FIGURE 5.3.2-2

Quato Pro for Windows Version 6.0 11/19/97 AWS

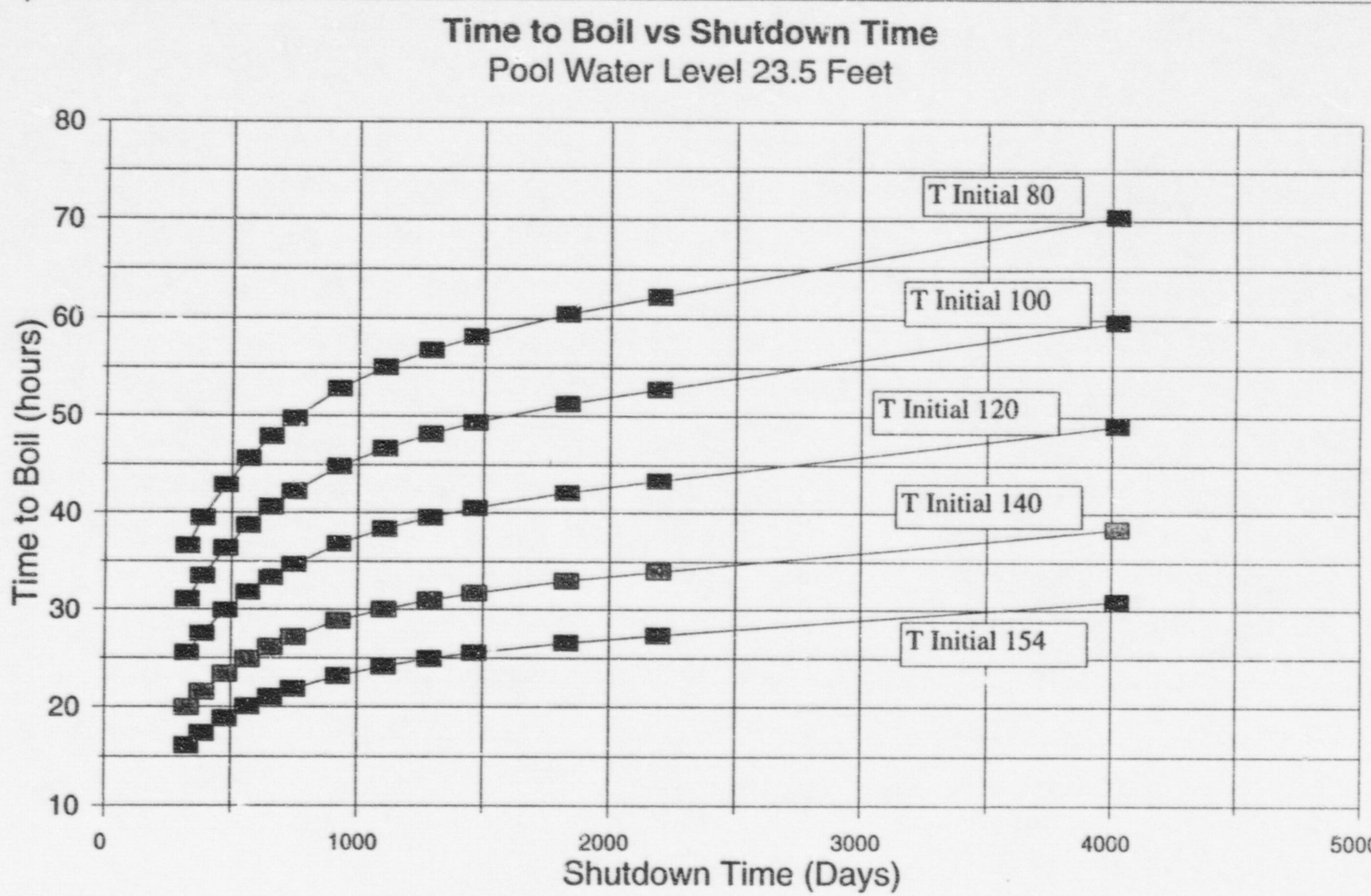

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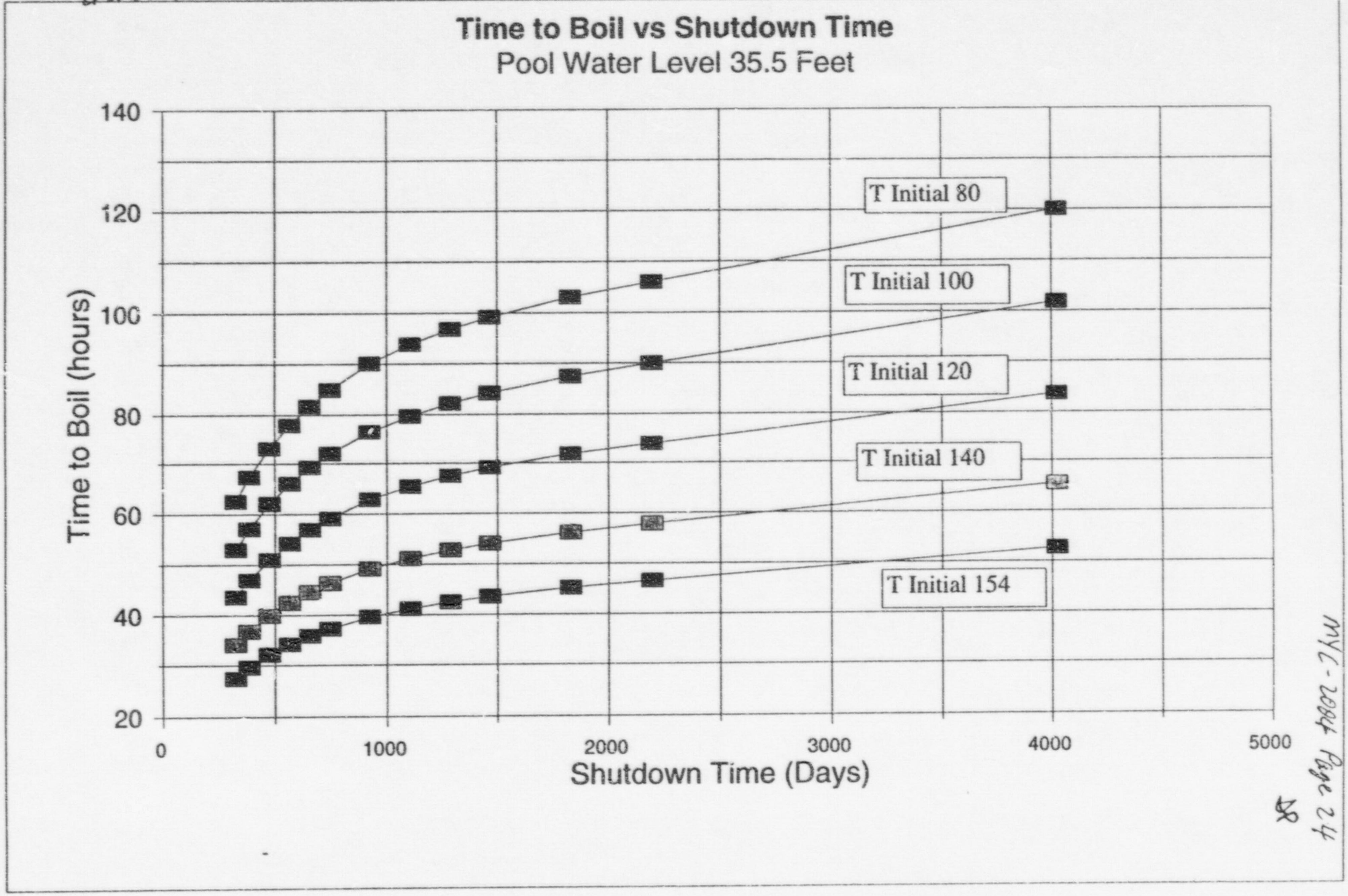
FIGURE 5.3.2-3

Quattro Pro for Windows Version 6.0 MWS 11/19/97



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5.3.3 Boil Off Rate

A QuatroPro spreadsheet was also used to calculate boil off rate as a function of heat load (time) and time to reach various levels in the pool as a function of heat load (time). The boil off rate for a total loss of cooling is given by:

boil off rate = q/h_{fg} @ 212°F

for example from the spreadsheet on October 30, 1997 the decay heat level was 5.84 x 10^6 BTU/hr , this yields a boil off rate of

$(5.84 \times 10^6$ BTU/hr)/970.3 BTU/lb_m = **6.02 x 10^3 lb_m/hr** ✓

The spreadsheet calculates boil off rate in gpm:

$(6.02 \times 10^3$ lb_m/hr) x (1 hr/60 min) x (0.0167 ft^3/lb_m) x (7.481 gal/ft^3) = **12.53 gpm** ✓

The spreadsheet calculates level drop due to boil off in inches per hour:

(12.53 gal/min) x (1 ft^3/7.481 gal) x (60 min/hr) ÷ (41.4 ft x 36.89 ft) x (12 in/ft)

= 0.79 in/hr ✓

The spreadsheet calculates level drop due to boil off in feet per day:

(12.53 gal/min) x (1 ft^3/7.481 gal) x (60 min/hr) ÷ (41.4 ft x 36.89 ft) x (24 hr/day)

= 1.58 ft/day ✓

The results for these calculations are provided in Table 5.3.3-1. Figure 5.3.3-1 provides a plot of boil off rate in gpm versus shutdown time in days.

The spreadsheet also calculates for a given boil off rate; time to boil off from several initial levels to several final levels. All of these calculations are performed in the same fashion as follows:

For time to drop from 35.5 ft to 20 ft, the level change is calculated:

35.5 ft - 20 ft = 15.5 ft

The level change is then divided by the level drop due to boil off in feet per day:

15.5 ft/(1.58 ft/day) = **9.81 days** ✓

This is the time to boil off from 35.5 feet to 20 feet for the heat load on October 30, 1997. All of the other calculations are done in the same fashion. The results of these calculations are presented in Table 5.3.3-2.

Quattro Pro for Windows version 6.0 MWS 11/19/97

TABLE 5.3.3-1 Boil Off Rate vs Time, Deay Heat Load

Date	Days After Shutdown	Total Power in SFP (MW)	Total Power in SFP (BTU/hr)	Boil Off Rate (lbm/hr)	Boil Off Rate (gpm)	Loss in Pool Level (in/hr)	Loss in Pool Level (ft/day)
10/15/97	313	1.74773	5.96E+06	6.15E+03	12.80	0.81	1.61
10/30/97	328	1.71064	5.84E+06	6.02E+03	12.53	0.79	1.58
11/29/97	358	1.64511	5.61E+06	5.78E+03	12.05	0.76	1.52
12/29/97	388	1.58915	5.42E+06	5.59E+03	11.64	0.73	1.47
01/28/98	418	1.5409	5.26E+06	5.42E+03	11.28	0.71	1.42
02/27/98	448	1.49892	5.11E+06	5.27E+03	10.98	0.69	1.38
03/29/98	478	1.46207	4.99E+06	5.14E+03	10.71	0.68	1.35
04/28/98	508	1.42946	4.88E+06	5.03E+03	10.47	0.66	1.32
05/28/98	538	1.40037	4.78E+06	4.92E+03	10.25	0.65	1.29
06/27/98	568	1.37425	4.69E+06	4.83E+03	10.06	0.63	1.27
07/27/98	598	1.35065	4.61E+06	4.75E+03	9.89	0.62	1.25
08/26/98	628	1.32921	4.54E+06	4.67E+03	9.73	0.61	1.23
09/25/98	658	1.30962	4.47E+06	4.61E+03	9.59	0.60	1.21
10/25/98	688	1.29166	4.41E+06	4.54E+03	9.46	0.60	1.19
11/24/98	718	1.27513	4.35E+06	4.48E+03	9.34	0.59	1.18
12/24/98	748	1.25985	4.30E+06	4.43E+03	9.22	0.58	1.16
06/22/99	928	1.18815	4.05E+06	4.18E+03	8.70	0.55	1.10
12/19/99	1108	1.13931	3.89E+06	4.01E+03	8.34	0.53	1.05
06/16/00	1288	1.10412	3.77E+06	3.88E+03	8.08	0.51	1.02
12/13/00	1468	1.07743	3.68E+06	3.79E+03	7.89	0.50	1.00
12/13/01	1833	1.03783	3.54E+06	3.65E+03	7.60	0.48	0.96
12/13/02	2198	1.00773	3.44E+06	3.54E+03	7.38	0.47	0.93
12/13/07	4024	0.89079	3.04E+06	3.13E+03	6.52	0.41	0.82

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TABLE 5.3.3-2 Time from Initial to Final Level vs Time, Deay Heat Load

QuattroPro for Windows Version 6 MVHS 11/19/97

Date	Total Power in SFP (MW)	Total Power in SFP (BTU/hr)	Boil Off Rate (lbm/hr)	Boil Off Rate (gpm)	Loss In Pool Level (ft/day)	35.5 to 20 ft (days)	35.5 to 15 ft (days)	35.5 to 13 ft (days)	32.5 to 20 ft (days)	32.5 to 15 ft (days)	32.5 to 13 ft (days)	23.5 to 20 ft (days)	23.5 to 15 ft (days)	23.5 to 13 ft (days)
10/15/97	1.74773	5.96E+06	6.15E+03	12.89	1.61	9.60	12.70	13.94	7.74	10.84	12.08	2.17	5.27	6.50
10/30/97	1.71064	5.84E+06	6.02E+03	12.53	1.58	9.81	12.97	14.24	7.91	11.07	12.34	2.21	5.38	6.64
11/29/97	1.64511	5.61E+06	5.78E+03	12.05	1.52	10.20	13.49	14.81	8.23	11.52	12.83	2.30	5.59	6.91
12/29/97	1.58915	5.42E+06	5.59E+03	11.64	1.47	10.56	13.97	15.33	8.52	11.92	13.28	2.38	5.79	7.15
01/28/98	1.5409	5.26E+06	5.42E+03	11.28	1.42	10.89	14.40	15.81	8.78	12.29	13.70	2.46	5.97	7.38
02/27/98	1.49892	5.11E+06	5.27E+03	10.98	1.38	11.19	14.81	16.25	9.03	12.64	14.08	2.53	6.14	7.58
03/29/98	1.46207	4.99E+06	5.14E+03	10.71	1.35	11.48	15.18	16.66	9.26	12.96	14.44	2.59	6.29	7.77
04/28/98	1.42946	4.88E+06	5.03E+03	10.47	1.32	11.74	15.53	17.04	9.47	13.25	14.77	2.65	6.44	7.95
05/28/98	1.40037	4.78E+06	4.92E+03	10.25	1.29	11.98	15.85	17.39	9.66	13.53	15.07	2.71	6.57	8.12
06/27/98	1.37425	4.69E+06	4.83E+03	10.06	1.27	12.21	16.15	17.72	9.85	13.79	15.36	2.76	6.70	8.27
07/27/98	1.35065	4.61E+06	4.75E+03	9.89	1.25	12.42	16.43	18.03	10.02	14.03	15.63	2.81	6.81	8.42
08/26/98	1.32921	4.54E+06	4.67E+03	9.73	1.23	12.62	16.70	18.33	10.18	14.25	15.88	2.85	6.92	8.55
09/25/98	1.30962	4.47E+06	4.61E+03	9.59	1.21	12.81	16.95	18.60	10.33	14.47	16.12	2.89	7.03	8.68
10/25/98	1.29166	4.41E+06	4.54E+03	9.46	1.19	12.99	17.18	18.86	10.48	14.67	16.34	2.93	7.12	8.80
11/24/98	1.27513	4.35E+06	4.48E+03	9.34	1.18	13.16	17.40	19.10	10.61	14.86	16.56	2.97	7.22	8.91
12/24/98	1.25985	4.30E+06	4.43E+03	9.22	1.16	13.32	17.62	19.33	10.74	15.04	16.76	3.01	7.30	9.02
06/22/99	1.18815	4.05E+06	4.18E+03	8.70	1.10	14.12	18.68	20.50	11.39	15.95	17.77	3.19	7.74	9.57
12/19/99	1.13931	3.89E+06	4.01E+03	8.34	1.05	14.73	19.48	21.38	11.88	16.63	18.53	3.33	8.08	9.98
06/16/00	1.10412	3.77E+06	3.88E+03	8.08	1.02	15.20	20.10	22.06	12.26	17.16	19.12	3.43	8.33	10.30
12/13/00	1.07743	3.68E+06	3.79E+03	7.89	1.00	15.57	20.60	22.61	12.56	17.58	19.59	3.52	8.54	10.55
12/13/01	1.03783	3.54E+06	3.65E+03	7.60	0.96	16.17	21.38	23.47	13.04	18.25	20.34	3.65	8.87	10.95
12/13/02	1.00773	3.44E+06	3.54E+03	7.38	0.93	16.65	22.02	24.17	13.43	18.80	20.95	3.76	9.13	11.28
12/13/07	0.89079	3.04E+06	3.13E+03	6.52	0.82	18.84	24.91	27.34	15.19	21.27	23.70	4.25	10.33	12.76

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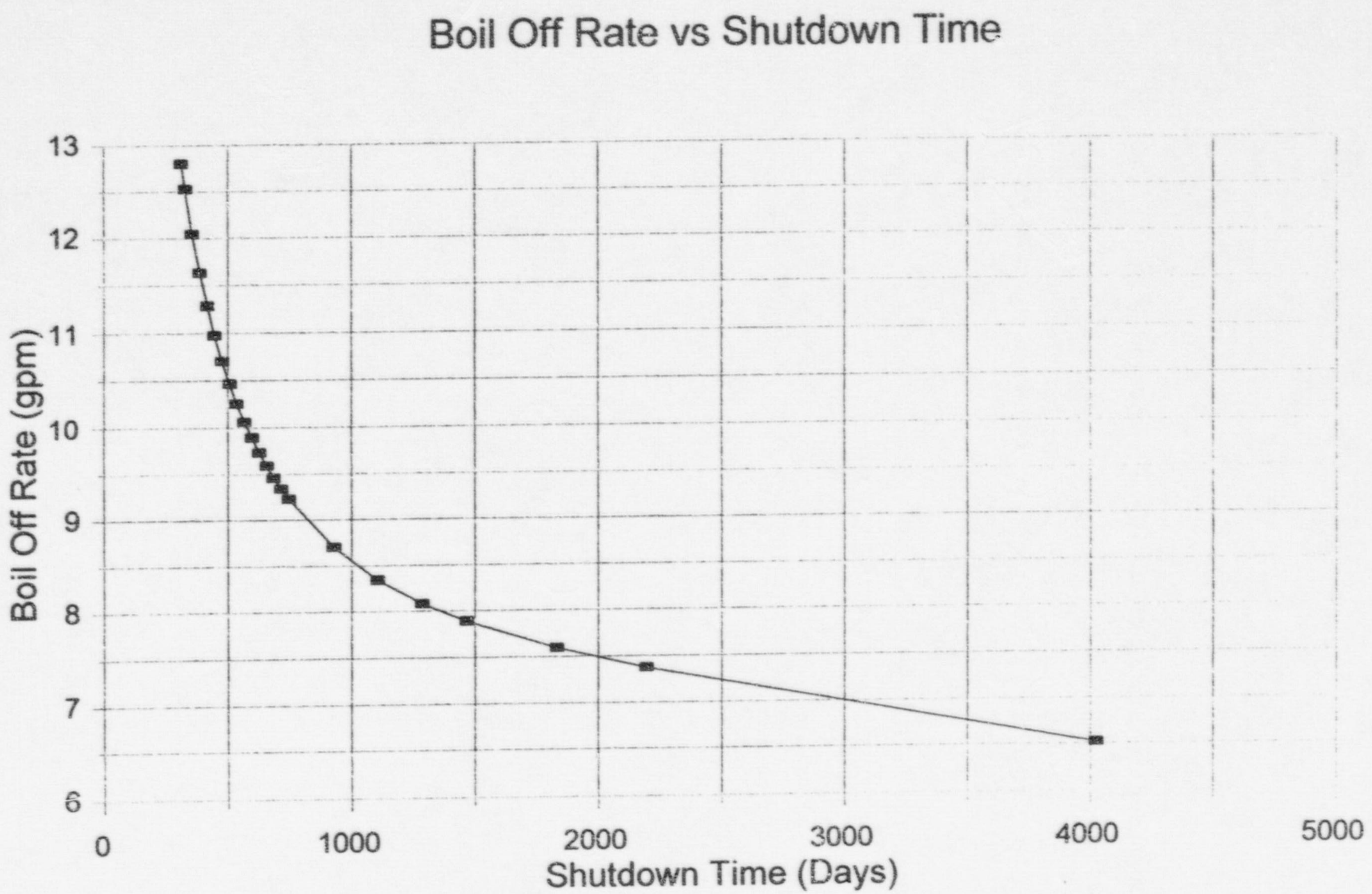
FIGURE 5.3.3-1

QuattroPro for Windows Version 6.0 MWS 11/19/97



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5.3.4 Operation with One SFP Cooling Pump

The purpose of this calculation was to determine if spent fuel pool cooling with one pump, as a normal operating mode, was acceptable. Normal operation with one pump would be considered acceptable if the pool water does not increase significantly in temperature when going from two to one pump operation.

The calculation was performed by first determining the heat exchanger conditions for the present situation for two pumps running. Then the conditions for one pump operation were determined. So that one and two pump operation can be compared under the present conditions. The present conditions are the most limiting since decay heat load will continue to decrease with time. Decay heat load for the present condition was taken from Section 5.3.1 for October 30, 1997. The decay heat load at that point was calculated to be 5.84×10^6 BTU/hr.

5.3.4.1 Calculation of Heat Exchanger Conditions for the Present Decay Heat Load with Two Pumps Running

Heat exchanger conditions will be determined based on calculations performed in MYC-1562 (Reference 4, page 56). As discussed above in Section 5.3.4, the heat load used herein was the present heat load of 5.84×10^6 BTU/hr.

The overall heat transfer coefficient for this condition was assumed the same as Condition 1 in MYC-1562, or 264. $BTU/lb_m \cdot ft^2 \cdot {}^\circ F$ (a reasonable assumption considering U only varies slightly under the condition evaluated here).

The other inputs that are known (taken from MYC-1562) for this condition include:

Shell side inlet temperature which is fixed at	85°F
Primary Component Cooling (PCC) mass flow rate (850 gpm at 85°F, atmospheric pressure)	4.237×10^5 lb_m/hr
Spent Fuel Pool Cooling Pump flow rate	1500 gpm

The values to be determined are shell side outlet temperature, and tube side inlet and outlet temperatures.

Calculation of Shell Side Temperatures

For the shell side of the tubes:

$$q = \dot{m}\, c_p \Delta T_c$$

solving for ΔT_c yields:

$$\Delta T_c = \frac{q}{\dot{m}\, c_p}$$

$$\Delta T_c = \frac{5.84x10^6 BTU/hr}{(4.237x10^5 lb_m/hr)(1 BTU/lb_m \cdot {}^\circ F)}$$

$$\Delta T_c = 13.8^\circ F$$ ✓

T_{c2} the shell inlet temperature is fixed at 85°F so:

$$T_{c1} = 85^\circ F + 13.8^\circ F = 98.8^\circ F$$ ✓

On the tube side:

$$q = \dot{m}\, c_p \Delta T_h$$

$$\rightarrow \Delta T_h = \frac{q}{\dot{m}\, c_p}$$

The mass flow rate for the spent fuel pool cooling pumps is not known, since the inlet temperature is not known for this condition. However, the mass flow rate does not vary greatly for the temperature range under consideration. To maximize the value of ΔT_h and thus the pool temperature for this condition the lower mass flow rate for conditions calculated in MYC-1562, was used. From Condition 2 in MYC-1562 (Reference 4):

$$\dot{m} = 7.354x10^5 lb_m/hr \ @154F, \ atmospheric\ pressure$$ ✓

and solving for ΔT_h:

$$\Delta T_h = \frac{q}{\dot{m}\, c_p}$$

$$\Delta T_h = \frac{5.84x10^6 BTU/hr}{(7.354x10^5 lb_m/hr)(1 BTU/lb_m \cdot {}^\circ F)}$$

$$\Delta T_h = 7.9^\circ F$$ ✓

and

$$\Delta T_h = T_{h1} - T_{h2}$$

$$\rightarrow T_{h1} = T_{h2} + \Delta T_h$$

$$T_{h1} = T_{h2} + 7.9^\circ F$$

Now we can use the LMTD form of the heat transfer equation to solve for the tube side temperatures:

$$q = U_o A_o \Delta T_m$$

$$\Rightarrow \Delta T_m = \frac{q}{U_o A_o}$$

$$\frac{5.84 \times 10^6\ BTU/hr}{\left(\frac{264.\ BTU}{hr \cdot ft^2 \cdot {}^\circ F}\right)(2980\ ft^2)} = \frac{(T_{h_2} - 85^\circ F) - (T_{h_2} + 7.9^\circ F - 98.8^\circ F)}{\ln[(T_{h_2} - 85^\circ F)/(T_{h_2} + 7.9^\circ F - 98.8^\circ F)]}$$

$$7.4^\circ F = \frac{5.9^\circ F}{\ln[(T_{h_2} - 85^\circ F)/(T_{h_2} - 90.9^\circ F)]}$$

Iterating yields:

$$T_{h_2} = 95.7^\circ F$$

$$T_{h_1} = 95.7^\circ F + 7.9^\circ F = 103.6^\circ F$$

Now summarizing for operation with two spent fuel pool cooling pumps and a heat load of 5.84×10^6 BTU/hr:

Shell Side (cooling water)		Tube Side (pool water)	
Inlet	Outlet	Inlet	Outlet
85°F (T_{c2})	98.8°F (T_{c1})	103.6°F (T_{h1})	95.7°F (T_{h2})
5.84 x 10^6 BTU/hr heat transfer			

5.3.4.2 Calculation of Heat Exchanger Conditions for the Present Decay Heat Load with One Pump Running

This calculation is done in three steps:

1. With U already calculated for two pump flow, calculate the individual heat transfer coefficients, h_i and h_o for two pump flow.

2. Determine the effect on h_i in going from 2 pump flow to 1 pump flow and the effect on the overall heat transfer coefficient as a result of the change in h_i.

3. Calculate the new tube side temperatures, T_{h1} and T_{h2}, that result from reducing the flow from 2 pumps to 1 pump.

Step 1: Calculation of h_i and h_o

For flow inside the heat exchanger tubes the Nusselt number can be defined in the conventional manner as:

$$Nu = \frac{h_i d_i}{k}$$

$$\Rightarrow \quad h_i = Nu \frac{k}{d_i}$$

$$Nu = \frac{h_i d_i}{k}$$

$$\Rightarrow \quad h_i = Nu \frac{k}{d_i}$$

To determine the flow regime for this situation the Reynolds number was determined from mean fluid properties as follows:

$$Re = \frac{\rho_f v d_i}{\mu_f}$$

where: ρ_f = mean fluid density

μ_f = mean fluid viscosity

v = fluid velocity

The average fluid temperature is:

$$T_{av} = \frac{T_{h_1} + T_{h_2}}{2}$$

$$T_{av} = \frac{103.6°F + 95.7°F}{2} = 99.7°F \checkmark$$

The inside tube diameter d_i is:

$$d_i = 0.527\ in \times \frac{1\ ft}{12\ in} = 0.0439\ ft \checkmark$$

At $T_{av} = 99.7°F$:

$$c_p = 1.0\ BTU/lb_m \cdot °F$$

$$\mu_f = 143.1 \times 10^{-7}\ lb_f \cdot sec/ft^2 \times 32.174\ \frac{lb_m \cdot ft}{lb_f \cdot sec^2}$$

$$\mu_f = 4.60 \times 10^{-4}\ lb_m/ft \cdot sec$$ ✓

$$k = 0.3615\ BTU/hr \cdot ft \cdot °F$$ ✓

$$Pr = 4.57 \quad (Prandtl\ Number)$$ ✓

$$\rho = \frac{1}{0.01613\ ft^3/lb_m} = 62.0\ lb_m/ft^3$$ ✓

The spent fuel pool cooling pump flow rate is 750 gpm/pump or a total of 1500 gpm for two pumps. The flow velocity for this flow rate is:

$$v = 1500\frac{gal}{min} \times \frac{1\ ft^3}{7.481\ gal} \times \frac{1\ min}{60\ sec} \times \frac{1}{\pi\frac{(0.0439\ ft)^2}{4}} \times \frac{1}{950\ tubes}$$

$$v = 2.32\ ft/sec$$ ✓

The Reynolds Number is then:

$$Re = \frac{(62.0\,lb_m/ft^3)(2.32\,ft/sec)(0.0439\,ft)}{4.60 \times 10^{-4}\,lb_m/ft \cdot sec}$$

$$Re = 1.37 \times 10^4$$ ✓

For a Reynolds number of this magnitude the flow is turbulent and the heat transfer coefficient can be calculated with the following empirical equation (from *Principles of Heat Transfer*, Ref 8, p. 445) :

$$Nu = 0.023\,Re^{0.8}\,Pr^{0.33}$$ ✓

Substituting for Nu we get:

$$\frac{h_i d_i}{k} = 0.023 Re^{0.8} Pr^{0.33}$$

$$\rightarrow h_i = (0.023 Re^{0.8} Pr^{0.33}) \frac{k}{d_i}$$

$$h_i = \left[0.023 (1.37 \times 10^4)^{0.8} (4.57)^{0.33}\right] \frac{0.3615 \, BTU/hr \cdot ft \cdot {}^\circ F}{0.0439 \, ft}$$

$$h_i = 638. \, BTU/hr \cdot ft^2 \cdot {}^\circ F \quad \checkmark$$

Now that we've solved for h_i and the overall heat transfer coefficient, U, we can calculate h_o using the overall heat transfer equation. From Holman (Reference 9, p. 388) the overall heat transfer coefficient based on the outside area of the tubes is given by:

$$U_o = \frac{1}{\frac{A_o}{A_i}\frac{1}{h_i} + \frac{A_o \ln(r_o/r_i)}{2\pi k L} + \frac{1}{h_o}} \quad \checkmark$$

Solving for h_o :

$$\frac{1}{U_o} = \frac{A_o}{A_i}\frac{1}{h_i} + \frac{A_o \ln(r_o/r_i)}{2\pi kL} + \frac{1}{h_o}$$

$$\frac{1}{h_o} = \frac{1}{U_o} - \frac{A_o}{A_i}\frac{1}{h_i} - \frac{A_o \ln(r_o/r_i)}{2\pi kL}$$

$$h_o = \frac{1}{\frac{1}{U_o} - \frac{A_o}{A_i}\frac{1}{h_i} - \frac{A_o \ln(r_o/r_i)}{2\pi kL}}$$

All parameters in this equation are known including k which is the thermal conductivity of stainless steel = 10. BTU/hr•ft^2•°F (Reference 10). As in the previous calculation, the overall heat transfer coefficient for this condition was assumed the same as Condition 1 in MYC-1562 (Reference 4), or 264. BTU/lb$_m$•ft^2•°F (a reasonable assumption considering U only varies slightly under the condition evaluated here). Solving for h_o :

$$h_o = \frac{1}{\frac{1}{\frac{264.\ BTU}{hr\cdot ft^{2}\cdot{}^\circ F}} - \frac{2980\,ft^2}{2516\,ft^2}\cdot\frac{1}{\frac{638.\ BTU}{hr\cdot ft^{2}\cdot{}^\circ F}} - \frac{2980\,ft^2\cdot \ln(0.625in/0.527in)}{2\pi\left(\frac{10\,BTU}{hr\cdot ft\cdot{}^\circ F}\right)\left(20\,\frac{ft}{tube}\ x\ 950\ tubes\right)}}$$

$$h_o = \frac{1}{3.79\ x\ 10^{-3}\,\frac{hr\cdot ft^{2}\cdot{}^\circ F}{BTU} - 1.86\ x\ 10^{-3}\,\frac{hr\cdot ft^{2}\cdot{}^\circ F}{BTU} - 4.26\ x\ 10^{-4}\,\frac{hr\cdot ft^{2}\cdot{}^\circ F}{BTU}}$$ ✓

$$h_o = \frac{1}{1.50\ x\ 10^{-3}\,\frac{hr\cdot ft^{2}\cdot{}^\circ F}{BTU}}$$ ✓

$$h_o = 665.\ BTU/hr\cdot ft^{2}\cdot{}^\circ F$$ ✓

where: A_o , and A_i and other values (except h_i , calculated earlier)are taken from MYC-1562, Reference 4

Now that h_i and h_o have been calculated for flow with two pumps, the calculation can proceed to step 2.

Step 2: Determine the effect on h_i and U in going from 2 pump flow to 1 pump flow.

Operation with 1 pump will conservatively half the flow velocity (actually the remaining pump will provide additional flow). To determine the effect on h_i of halving the flow velocity we return to the h_i equation developed earlier:

$$h_i = \left(0.023 Re^{0.8}\, Pr^{0.33}\right)\frac{k}{d_i}$$

and with:

$$Re = \frac{\rho v d}{\mu}$$

h_i can be written as:

$$h_i \propto \left[0.023\left(\frac{\rho v d}{\mu}\right)^{0.8} Pr^{0.33}\right]\frac{k}{d}$$

$$\therefore \; h_i \propto v^{0.8}$$

Thus if the velocity is halved:

$$\frac{h_i(v_{new} = 0.5v)}{h_i(v)} = \left(\frac{0.5v}{v}\right)^{0.8}$$

$$h_i(v_{new} = 0.5v) = 0.574\,h_i(v)$$

$$h_i(v_{new} = 0.5v) = 0.574 \times 638\,BTU/lb_m \cdot ft^2 \cdot {}^\circ F$$

$$h_i(v_{new} = 0.5v) = 366.\,BTU/hr\,ft^2 \cdot {}^\circ F$$ ✓

The effect on the overall heat transfer coefficient based on this reduction in h_i is then:

$$U_o = \frac{1}{\frac{2980\,ft^2}{2516\,ft^2}\left(\frac{1}{366.\,\frac{BTU}{hr\,ft^2 \cdot {}^\circ F}}\right) + 4.26 \times 10^{-4}\,\frac{hr\,ft^2 \cdot {}^\circ F}{BTU} + \frac{1}{665.\,\frac{BTU}{hr\,ft^2 \cdot {}^\circ F}}}$$

$$U_o = 194.\,BTU/hr\,ft^2 \cdot {}^\circ F$$ ✓

The fraction that U_o is reduced in going from 2 pump flow to 1 pump flow is:

$$\frac{U_o(1\ pump)}{U_o(2\ pump)} = \frac{194.\,BTU/hr\,ft^2 \cdot {}^\circ F}{264.\,BTU/hr\,ft^2 \cdot {}^\circ F}$$

$$U_o(1\ pump) = 0.73\,U_o(2\ pump)$$ ✓

Step 3: Calculate the new tube side temperatures T_{h1} and T_{h2}

Heat transfer on the tube side is given by:

$$q = \dot{m}\, c_p (T_{h_1} - T_{h_2})$$

Assuming the same heat transfer and of 1 pump operation:

$$\dot{m}\, c_p (T_{h_1} - T_{h_2})_{full\ flow} = \frac{\dot{m}}{2} c_p (T_{h_1} - T_{h_2})_{half\ flow}$$

$$\rightarrow\ 2(T_{h_1} - T_{h_2})_{full\ flow} = (T_{h_1} - T_{h_2})_{half\ flow}$$

Therefore, for heat load of 5.84×10^6 BTU/hr and operation with 1 spent fuel pool cooling pump:

$$(T_{h_1} - T_{h_2}) = 2(103.6°F - 95.7°F) = 15.8°F \ ✓$$

$$\rightarrow\ T_{h_1} = T_{h_2} + 15.8°F \ ✓$$

Now reiterating the LMTD heat transfer equation:

$$\frac{q}{U_o A_o} = \frac{(T_{h_2} - T_{c_2}) - (T_{h_1} - T_{c_1})}{\ln[(T_{h_2} - T_{c_2}/(T_{h_1} - T_{c_1})]} \ ✓$$

Substituting for T_{h1} gives:

$$\frac{q}{U_o A_o} = \frac{(T_{h_2} - T_{c_2}) - (T_{h_2} + 15.8°F - T_{c_1})}{\ln[(T_{h_2} - T_{c_2})/(T_{h_2} + 15.8°F - T_{c_1})]}$$

$$\frac{5.84 \times 10^6 BTU/hr}{\frac{194.BTU}{hr \cdot ft^2 \cdot °F}(2980\,ft^2)} = \frac{(T_{h_2} - 85°F) - (T_{h_2} + 15.8°F - 98.8°F)}{\ln[T_{h_2} - 85°F)/(T_{h_2} + 15.8°F - 98.8°F)]}$$

$$10.1°F = \frac{-2.0°F}{\ln[(T_{h_2} - 85°F)/(T_{h_2} - 83.0°F)]}$$

Iterating yields:

$$T_{h_2} = 94.1°F$$

and:

$$T_{h_1} = 94.1°F + 15.8°F$$

$$T_{h_1} = 109.9°F$$

Now summarizing for operation with one spent fuel pool cooling pump with heat load equal to 5.84×10^6 BTU/hr:

Shell Side (cooling water)		Tube Side (pool water)	
Inlet	Outlet	Inlet	Outlet
85°F (T_{c2}) ✓	98.8°F (T_{c1}) ✓	109.9°F (T_{h1}) ✓	94.1°F (T_{h2}) ✓
5.84 x 10 BTU/hr heat transfer			

Thus operation with one spent fuel pool cooling pump versus two results in the pool temperature on the inlet side increasing from 103.6 °F to 109.9 °F or an increase of 6.3 °F for the conditions analyzed. This change in temperature is not significant. Operation with one spent fuel cooling pump, as a normal mode of operation is acceptable from a pool temperature standpoint.

6.0 Results/Conclusions

6.1 VS Objectives

The objectives of this calculation were:

1. To determine the heat load as a function of time in the SFP.

2. To determine time to boil for a loss of two SFP pumps as a function of time, initial temperature, and initial level.

3. To determine boil off rate as a function of heat load (time) and time to reach various levels in the pool as a function of heat load (time).

4. To determine if normal operation with one spent fuel pool cooling pump is acceptable from a pool temperature standpoint.

All the objectives of this calculation were met as follows:

1. The heat load in the SFP as a function of time was determined. The results are presented in Section 5.3.1.

2. The time to boil for a loss of two SFP pumps as a function of time, initial temperature, and initial level was determined. The results are presented in Section 5.3.2.

3. The boil off rate as a function of heat load (time) and time to reach various levels in the pool as a function of heat load (time) were determined. The results are presented in Section 5.3.3.

4. Normal operation with one spent fuel pool cooling pump was determined to be acceptable from a pool temperature standpoint. The results are presented in Section 5.3.4.

7.0 References

1. MY Service Request M-97-27, "Post - Shutdown Safety Analysis," dated September 4, 1997.

2. MYC-481, Revs 0 - 6, "POOL Computer Code," date of most recent revision January 15, 1993.

3. MYC-1755, "End of Cycle 14 Allowable Fuel Removal Rate," dated February 2, 1995.

4. MYC-1562, Revs. 0, 1, 2, "Spent Fuel Pool Rerack Analysis," dated January 1993, June 1993, and February 1995 respectively.

5. MYC-1253, Revs 0,1, "End of Cycle 11 Allowable Fuel Removal Rate," dated April 19, 1990.

6. MYC-1463, "End of Cycle 12 Allowable Fuel Removal Rate," dated February 7, 1992.

7. RP-MY-97-33, "Maine Yankee Fuel Cycle Information for End of Cycle 15," dated September 19, 1997.

8. Principles of Heat Transfer, Kreith, p.445, Harper & Row, Publishers, Third Edition

9. Heat Transfer, J. P. Holman, McGraw-Hill, Fourth Edition, Copyright 1976.

10. Introduction to Nuclear Engineering, J. R. Lamarsh, Addison - Wesley Publishing Co., First Edition, Copyright 1975.

8.0 Attachments

The attachments are as follows:

- 8.1 Results Transmittal Memo
- 8.2 Evaluation of Computer Code Use Form
- 8.3 Calculation/Analysis Review Form
- 8.4 NED WE-103 Review Checklist
- 8.5 NED Analysis Process Checklist

8.1 Results Transmittal Memo

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MEMORANDUM

YANKEE ATOMIC - BOLTON

To	P. L. Anderson	Date	December 1, 1997
		Group #	TAG MY 97-051
From	M. W. Scott	W.O.#	5377
Subject	SFP Thermal-Hydraulic Calculation Results	I.M.S.#	
		File #	

REFERENCES

1. Maine Yankee Service Request M-97-27, "Post-Shutdown Safety Analysis," dated September 4, 1997.

2. MYC-2004, "Spent Fuel Pool Thermal-Hydraulic Calculations," dated November 1997.

DISCUSSION

The Transient Analysis Group has performed calculations that provide a portion of the response to Maine Yankee Service Request M-97-27 (Reference 1). The first, second, and fourth TAG items in this service request asked the following:

- "Spent Fuel Pool Heat Load: Calculate the heat load in the SFP as a function of time."

- "Loss of Two Spent Fuel Pool Cooling Pumps - Time to Boil: Calculate the time to boil in the spent fuel pool as a function of time and initial temperature."

- "Operation with One Spent Fuel Pool Pump: Calculate the temperature in the SFP as a function of time with one spent fuel pool pump in operation."

This memo provides the results of these calculations (Reference 2) as follows:

1. The heat load in the spent fuel pool as a function of time was calculated. The results are presented in Table 1 and Figure 1.

2. Time to boil for a loss of two spent fuel pool cooling pumps was calculated. This calculation was done as a function of time, initial spent fuel pool temperature and, as requested by W. Henries, an additional parametric was added on initial level. The results are presented in Table 2 and Figures 2, 3, and 4. As requested by D. Boynton boil off rate as a function of heat load (time) and time to reach various

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levels in the pool as a function of heat load (time) were also calculated. The results are presented in Tables 3 and 4 and Figure 5.

3. Operation with one spent fuel pool cooling pump was assessed. Normal operation with one pump rather than two resulted in an increase of 6.3°F in the pool temperature. This change in temperature is not significant. As a result normal operation with one spent fuel pool cooling pump is acceptable from a pool temperature standpoint.

SAFETY EVALUATION

This calculation is safety related. It provides information to be used in the Defueled Safety Analysis Report.

Michael W. Scott Date: 12/1/97
M. W. Scott, Senior Nuclear Engineer
Transient Analysis Group

Reviewed by: Suzanne Palmer Date: 12/1/97
S. Palmer, Nuclear Engineer
Transient Analysis Group

Approved by: P.A. Bergeron Date: 12/1/97
P. A. Bergeron, Manager
Transient Analysis Group

c:

J. R. Chapman
W. E. Henries
R. P. Jordan (Maine Yankee)

TABLE 1 Decay Heat Load vs Time

Date	Days After Shutdown	Total Power in SFP (MW)	Total Power in SFP (BTU/hr)
10/15/97	313	1.74773	5.96E+06
10/30/97	328	1.71064	5.84E+06
11/29/97	358	1.64511	5.61E+06
12/29/97	388	1.58915	5.42E+06
01/28/98	418	1.5409	5.26E+06
02/27/98	448	1.49892	5.11E+06
03/29/98	478	1.46207	4.99E+06
04/28/98	508	1.42946	4.88E+06
05/28/98	538	1.40037	4.78E+06
06/27/98	568	1.37425	4.69E+06
07/27/98	598	1.35065	4.61E+06
08/26/98	628	1.32921	4.54E+06
09/25/98	658	1.30962	4.47E+06
10/25/98	688	1.29166	4.41E+06
11/24/98	718	1.27513	4.35E+06
12/24/98	748	1.25985	4.30E+06
06/22/99	928	1.18815	4.05E+06
12/19/99	1108	1.13931	3.89E+06
06/16/00	1288	1.10412	3.77E+06
12/13/00	1468	1.07743	3.68E+06
12/13/01	1833	1.03783	3.54E+06
12/13/02	2198	1.00773	3.44E+06
12/13/07	4024	0.89079	3.04E+06

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TABLE 2 Time to Boil vs Time, Initial Temperature, Level

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
5.84E+06	80	32.5	2.48E+06	56.05	Oct 30 1997
5.84E+06	100	32.5	2.48E+06	47.56	Oct 30 1997
5.84E+06	120	32.5	2.48E+06	39.07	Oct 30 1997
5.84E+06	140	32.5	2.48E+06	30.58	Oct 30 1997
5.84E+06	154	32.5	2.48E+06	24.63	Oct 30 1997
5.84E+06	80	23.5	1.62E+06	36.66	Oct 30 1997
5.84E+06	100	23.5	1.62E+06	31.11	Oct 30 1997
5.84E+06	120	23.5	1.62E+06	25.55	Oct 30 1997
5.84E+06	140	23.5	1.62E+06	20.00	Oct 30 1997
5.84E+06	154	23.5	1.62E+06	16.11	Oct 30 1997
5.84E+06	80	35.5	2.77E+06	62.52	Oct 30 1997
5.84E+06	100	35.5	2.77E+06	53.05	Oct 30 1997
5.84E+06	120	35.5	2.77E+06	43.57	Oct 30 1997
5.84E+06	140	35.5	2.77E+06	34.10	Oct 30 1997
5.84E+06	154	35.5	2.77E+06	27.47	Oct 30 1997
5.42E+06	80	32.5	2.48E+06	60.40	Dec 29 1997
5.42E+06	100	32.5	2.48E+06	51.25	Dec 29 1997
5.42E+06	120	32.5	2.48E+06	42.10	Dec 29 1997
5.42E+06	140	32.5	2.48E+06	32.94	Dec 29 1997
5.42E+06	154	32.5	2.48E+06	26.54	Dec 29 1997
5.42E+06	80	23.5	1.62E+06	39.50	Dec 29 1997
5.42E+06	100	23.5	1.62E+06	33.52	Dec 29 1997
5.42E+06	120	23.5	1.62E+06	27.53	Dec 29 1997
5.42E+06	140	23.5	1.62E+06	21.55	Dec 29 1997
5.42E+06	154	23.5	1.62E+06	17.36	Dec 29 1997
5.42E+06	80	35.5	2.77E+06	67.36	Dec 29 1997
5.42E+06	100	35.5	2.77E+06	57.16	Dec 29 1997
5.42E+06	120	35.5	2.77E+06	46.95	Dec 29 1997
5.42E+06	140	35.5	2.77E+06	36.74	Dec 29 1997
5.42E+06	154	35.5	2.77E+06	29.60	Dec 29 1997
4.99E+06	80	32.5	2.48E+06	65.60	Mar 29 1998
4.99E+06	100	32.5	2.48E+06	55.66	Mar 29 1998
4.99E+06	120	32.5	2.48E+06	45.72	Mar 29 1998
4.99E+06	140	32.5	2.48E+06	35.78	Mar 29 1998
4.99E+06	154	32.5	2.48E+06	28.83	Mar 29 1998
4.99E+06	80	23.5	1.62E+06	42.91	Mar 29 1998
4.99E+06	100	23.5	1.62E+06	36.41	Mar 29 1998
4.99E+06	120	23.5	1.62E+06	29.90	Mar 29 1998
4.99E+06	140	23.5	1.62E+06	23.40	Mar 29 1998
4.99E+06	154	23.5	1.62E+06	18.85	Mar 29 1998
4.99E+06	80	35.5	2.77E+06	73.17	Mar 29 1998

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TABLE 2 Time to Boil vs Time, Initial Temperature, Level

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
4.99E+06	100	35.5	2.77E+06	62.08	Mar 29 1998
4.99E+06	120	35.5	2.77E+06	51.00	Mar 29 1998
4.99E+06	140	35.5	2.77E+06	39.91	Mar 29 1998
4.99E+06	154	35.5	2.77E+06	32.15	Mar 29 1998
4.69E+06	80	32.5	2.48E+06	69.80	Jun 27 1998
4.69E+06	100	32.5	2.48E+06	59.22	Jun 27 1998
4.69E+06	120	32.5	2.48E+06	48.65	Jun 27 1998
4.69E+06	140	32.5	2.48E+06	38.07	Jun 27 1998
4.69E+06	154	32.5	2.48E+06	30.67	Jun 27 1998
4.69E+06	80	23.5	1.62E+06	45.65	Jun 27 1998
4.69E+06	100	23.5	1.62E+06	38.73	Jun 27 1998
4.69E+06	120	23.5	1.62E+06	31.82	Jun 27 1998
4.69E+06	140	23.5	1.62E+06	24.90	Jun 27 1998
4.69E+06	154	23.5	1.62E+06	20.06	Jun 27 1998
4.69E+06	80	35.5	2.77E+06	77.85	Jun 27 1998
4.69E+06	100	35.5	2.77E+06	66.05	Jun 27 1998
4.69E+06	120	35.5	2.77E+06	54.26	Jun 27 1998
4.69E+06	140	35.5	2.77E+06	42.46	Jun 27 1998
4.69E+06	154	35.5	2.77E+06	34.21	Jun 27 1998
4.47E+06	80	32.5	2.48E+06	73.23	Sep 25 1998
4.47E+06	100	32.5	2.48E+06	62.14	Sep 25 1998
4.47E+06	120	32.5	2.48E+06	51.04	Sep 25 1998
4.47E+06	140	32.5	2.48E+06	39.95	Sep 25 1998
4.47E+06	154	32.5	2.48E+06	32.18	Sep 25 1998
4.47E+06	80	23.5	1.62E+06	47.90	Sep 25 1998
4.47E+06	100	23.5	1.62E+06	40.64	Sep 25 1998
4.47E+06	120	23.5	1.62E+06	33.38	Sep 25 1998
4.47E+06	140	23.5	1.62E+06	26.13	Sep 25 1998
4.47E+06	154	23.5	1.62E+06	21.05	Sep 25 1998
4.47E+06	80	35.5	2.77E+06	81.68	Sep 25 1998
4.47E+06	100	35.5	2.77E+06	69.30	Sep 25 1998
4.47E+06	120	35.5	2.77E+06	56.93	Sep 25 1998
4.47E+06	140	35.5	2.77E+06	44.55	Sep 25 1998
4.47E+06	154	35.5	2.77E+06	35.89	Sep 25 1998
4.30E+06	80	32.5	2.48E+06	76.13	Dec 24 1998
4.30E+06	100	32.5	2.48E+06	64.60	Dec 24 1998
4.30E+06	120	32.5	2.48E+06	53.06	Dec 24 1998
4.30E+06	140	32.5	2.48E+06	41.53	Dec 24 1998
4.30E+06	154	32.5	2.48E+06	33.45	Dec 24 1998
4.30E+06	80	23.5	1.62E+06	49.79	Dec 24 1998
4.30E+06	100	23.5	1.62E+06	42.25	Dec 24 1998
4.30E+06	120	23.5	1.62E+06	34.70	Dec 24 1998

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TABLE 2 Time to Boil vs Time, Initial Temperature, Level

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
4.30E+06	140	23.5	1.62E+06	27.16	Dec 24 1998
4.30E+06	154	23.5	1.62E+06	21.88	Dec 24 1998
4.30E+06	80	35.5	2.77E+06	84.91	Dec 24 1998
4.30E+06	100	35.5	2.77E+06	72.04	Dec 24 1998
4.30E+06	120	35.5	2.77E+06	59.18	Dec 24 1998
4.30E+06	140	35.5	2.77E+06	46.31	Dec 24 1998
4.30E+06	154	35.5	2.77E+06	37.31	Dec 24 1998
4.05E+06	80	32.5	2.48E+06	80.83	Jun 22 1999
4.05E+06	100	32.5	2.48E+06	68.58	Jun 22 1999
4.05E+06	120	32.5	2.48E+06	56.34	Jun 22 1999
4.05E+06	140	32.5	2.48E+06	44.09	Jun 22 1999
4.05E+06	154	32.5	2.48E+06	35.52	Jun 22 1999
4.05E+06	80	23.5	1.62E+06	52.87	Jun 22 1999
4.05E+06	100	23.5	1.62E+06	44.86	Jun 22 1999
4.05E+06	120	23.5	1.62E+06	36.85	Jun 22 1999
4.05E+06	140	23.5	1.62E+06	28.84	Jun 22 1999
4.05E+06	154	23.5	1.62E+06	23.23	Jun 22 1999
4.05E+06	80	35.5	2.77E+06	90.15	Jun 22 1999
4.05E+06	100	35.5	2.77E+06	76.49	Jun 22 1999
4.05E+06	120	35.5	2.77E+06	62.83	Jun 22 1999
4.05E+06	140	35.5	2.77E+06	49.17	Jun 22 1999
4.05E+06	154	35.5	2.77E+06	39.61	Jun 22 1999
3.89E+06	80	32.5	2.48E+06	84.15	Dec 19 1999
3.89E+06	100	32.5	2.48E+06	71.40	Dec 19 1999
3.89E+06	120	32.5	2.48E+06	58.65	Dec 19 1999
3.89E+06	140	32.5	2.48E+06	45.90	Dec 19 1999
3.89E+06	154	32.5	2.48E+06	36.98	Dec 19 1999
3.89E+06	80	23.5	1.62E+06	55.04	Dec 19 1999
3.89E+06	100	23.5	1.62E+06	46.70	Dec 19 1999
3.89E+06	120	23.5	1.62E+06	38.36	Dec 19 1999
3.89E+06	140	23.5	1.62E+06	30.02	Dec 19 1999
3.89E+06	154	23.5	1.62E+06	24.18	Dec 19 1999
3.89E+06	80	35.5	2.77E+06	93.86	Dec 19 1999
3.89E+06	100	35.5	2.77E+06	79.64	Dec 19 1999
3.89E+06	120	35.5	2.77E+06	65.42	Dec 19 1999
3.89E+06	140	35.5	2.77E+06	51.20	Dec 19 1999
3.89E+06	154	35.5	2.77E+06	41.24	Dec 19 1999
3.77E+06	80	32.5	2.48E+06	86.83	Jun 16 2000
3.77E+06	100	32.5	2.48E+06	73.68	Jun 16 2000
3.77E+06	120	32.5	2.48E+06	60.52	Jun 16 2000
3.77E+06	140	32.5	2.48E+06	47.36	Jun 16 2000
3.77E+06	154	32.5	2.48E+06	38.15	Jun 16 2000

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TABLE 2 Time to Boil vs Time, Initial Temperature, Level

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
3.77E+06	80	23.5	1.62E+06	56.79	Jun 16 2000
3.77E+06	100	23.5	1.62E+06	48.19	Jun 16 2000
3.77E+06	120	23.5	1.62E+06	39.58	Jun 16 2000
3.77E+06	140	23.5	1.62E+06	30.98	Jun 16 2000
3.77E+06	154	23.5	1.62E+06	24.95	Jun 16 2000
3.77E+06	80	35.5	2.77E+06	96.85	Jun 16 2000
3.77E+06	100	35.5	2.77E+06	82.17	Jun 16 2000
3.77E+06	120	35.5	2.77E+06	67.50	Jun 16 2000
3.77E+06	140	35.5	2.77E+06	52.83	Jun 16 2000
3.77E+06	154	35.5	2.77E+06	42.55	Jun 16 2000
3.68E+06	80	32.5	2.48E+06	88.96	Dec 13 2000
3.68E+06	100	32.5	2.48E+06	75.48	Dec 13 2000
3.68E+06	120	32.5	2.48E+06	62.00	Dec 13 2000
3.68E+06	140	32.5	2.48E+06	48.52	Dec 13 2000
3.68E+06	154	32.5	2.48E+06	39.09	Dec 13 2000
3.68E+06	80	23.5	1.62E+06	58.18	Dec 13 2000
3.68E+06	100	23.5	1.62E+06	49.37	Dec 13 2000
3.68E+06	120	23.5	1.62E+06	40.55	Dec 13 2000
3.68E+06	140	23.5	1.62E+06	31.73	Dec 13 2000
3.68E+06	154	23.5	1.62E+06	25.56	Dec 13 2000
3.68E+06	80	35.5	2.77E+06	99.22	Dec 13 2000
3.68E+06	100	35.5	2.77E+06	84.18	Dec 13 2000
3.68E+06	120	35.5	2.77E+06	69.15	Dec 13 2000
3.68E+06	140	35.5	2.77E+06	54.12	Dec 13 2000
3.68E+06	154	35.5	2.77E+06	43.59	Dec 13 2000
3.54E+06	80	32.5	2.48E+06	92.47	Dec 13 2001
3.54E+06	100	32.5	2.48E+06	78.46	Dec 13 2001
3.54E+06	120	32.5	2.48E+06	64.45	Dec 13 2001
3.54E+06	140	32.5	2.48E+06	50.44	Dec 13 2001
3.54E+06	154	32.5	2.48E+06	40.63	Dec 13 2001
3.54E+06	80	23.5	1.62E+06	60.48	Dec 13 2001
3.54E+06	100	23.5	1.62E+06	51.32	Dec 13 2001
3.54E+06	120	23.5	1.62E+06	42.15	Dec 13 2001
3.54E+06	140	23.5	1.62E+06	32.99	Dec 13 2001
3.54E+06	154	23.5	1.62E+06	26.58	Dec 13 2001
3.54E+06	80	35.5	2.77E+06	103.14	Dec 13 2001
3.54E+06	100	35.5	2.77E+06	87.51	Dec 13 2001
3.54E+06	120	35.5	2.77E+06	71.88	Dec 13 2001
3.54E+06	140	35.5	2.77E+06	56.26	Dec 13 2001
3.54E+06	154	35.5	2.77E+06	45.32	Dec 13 2001
3.44E+06	80	32.5	2.48E+06	95.16	Dec 13 2002

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TABLE 2 Time to Boil vs Time, Initial Temperature, Level

Heat Load (BTU/hr)	Initial Temperature (Degrees F)	Pool Water Level (ft)	Water Mass (lbm)	Time to Boil (hrs)	Date Corresponding to Heat Load
3.44E+06	100	32.5	2.48E+06	80.74	Dec 13 2002
3.44E+06	120	32.5	2.48E+06	66.33	Dec 13 2002
3.44E+06	140	32.5	2.48E+06	51.91	Dec 13 2002
3.44E+06	154	32.5	2.48E+06	41.81	Dec 13 2002
3.44E+06	80	23.5	1.62E+06	62.24	Dec 13 2002
3.44E+06	100	23.5	1.62E+06	52.81	Dec 13 2002
3.44E+06	120	23.5	1.62E+06	43.38	Dec 13 2002
3.44E+06	140	23.5	1.62E+06	33.95	Dec 13 2002
3.44E+06	154	23.5	1.62E+06	27.35	Dec 13 2002
3.44E+06	80	35.5	2.77E+06	106.14	Dec 13 2002
3.44E+06	100	35.5	2.77E+06	90.06	Dec 13 2002
3.44E+06	120	35.5	2.77E+06	73.97	Dec 13 2002
3.44E+06	140	35.5	2.77E+06	57.89	Dec 13 2002
3.44E+06	154	35.5	2.77E+06	46.64	Dec 13 2002
3.04E+06	80	32.5	2.48E+06	107.68	Dec 13 2007
3.04E+06	100	32.5	2.48E+06	91.37	Dec 13 2007
3.04E+06	120	32.5	2.48E+06	75.05	Dec 13 2007
3.04E+06	140	32.5	2.48E+06	58.74	Dec 13 2007
3.04E+06	154	32.5	2.48E+06	47.32	Dec 13 2007
3.04E+06	80	23.5	1.62E+06	70.43	Dec 13 2007
3.04E+06	100	23.5	1.62E+06	59.76	Dec 13 2007
3.04E+06	120	23.5	1.62E+06	49.09	Dec 13 2007
3.04E+06	140	23.5	1.62E+06	38.42	Dec 13 2007
3.04E+06	154	23.5	1.62E+06	30.95	Dec 13 2007
3.04E+06	80	35.5	2.77E+06	120.10	Dec 13 2007
3.04E+06	100	35.5	2.77E+06	101.91	Dec 13 2007
3.04E+06	120	35.5	2.77E+06	83.71	Dec 13 2007
3.04E+06	140	35.5	2.77E+06	65.51	Dec 13 2007
3.04E+06	154	35.5	2.77E+06	52.77	Dec 13 2007

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TABLE 3 Boil Off Rate vs Time, Decay Heat Load

Date	Days After Shutdown	Total Power In SFP (MW)	Total Power in SFP (BTU/hr)	Boil Off Rate (lbm/hr)	Boil Off Rate (gpm)	Loss in Pool Level (in/hr)	Loss in Pool Level (ft/day)
10/15/97	313	1.74773	5.96E+06	6.15E+03	12.80	0.81	1.61
10/30/97	326	1.71064	5.84E+06	6.02E+03	12.53	0.79	1.58
11/29/97	358	1.64511	5.61E+06	5.78E+03	12.05	0.76	1.52
12/29/97	388	1.58915	5.42E+06	5.59E+03	11.64	0.73	1.47
01/28/98	418	1.5409	5.26E+06	5.42E+03	11.28	0.71	1.42
02/27/98	448	1.49892	5.11E+06	5.27E+03	10.98	0.69	1.38
03/29/98	478	1.46207	4.99E+06	5.14E+03	10.71	0.68	1.35
04/28/98	508	1.42943	4.88E+06	5.03E+03	10.47	0.66	1.32
05/28/98	538	1.40037	4.78E+06	4.92E+03	10.25	0.65	1.29
06/27/98	568	1.37425	4.69E+06	4.83E+03	10.06	0.63	1.27
07/27/98	598	1.35065	4.61E+06	4.75E+03	9.89	0.62	1.25
08/26/98	628	1.32021	4.54E+06	4.67E+03	9.73	0.61	1.23
09/25/98	658	1.30962	4.47E+06	4.61E+03	9.59	0.60	1.21
10/25/98	688	1.29166	4.41E+06	4.54E+03	9.46	0.60	1.19
11/24/98	718	1.27513	4.35E+06	4.48E+03	9.34	0.59	1.18
12/24/98	748	1.25985	4.30E+06	4.43E+03	9.22	0.58	1.16
06/22/99	928	1.18815	4.05E+06	4.18E+03	8.70	0.55	1.10
12/19/99	1108	1.13931	3.89E+06	4.01E+03	8.34	0.53	1.05
06/16/00	1288	1.10412	3.77E+06	3.88E+03	8.08	0.51	1.02
12/13/00	1468	1.07743	3.68E+06	3.79E+03	7.89	0.50	1.00
12/13/01	1833	1.03783	3.54E+06	3.65E+03	7.60	0.48	0.96
12/13/02	2198	1.00773	3.44E+06	3.54E+03	7.38	0.47	0.93
12/13/07	4024	0.89079	3.04E+06	3.13E+03	6.52	0.41	0.82

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TABLE 4 Time from Initial to Final Level vs Time, Heat Load

Date	Total Power In SFP (MW)	Total Power In SFP (BTU/hr)	Boil Off Rate (lbm/hr)	Boil Off Rate (gpm)	Loss in Pool Level (ft/day)	35.5 to 20 ft (days)	35.5 to 15 ft (days)	35.5 to 13 ft (days)	32.5 to 20 ft (days)	32.5 to 15 ft (days)	32.5 to 13 ft (days)	23.5 to 20 ft (days)	23.5 to 15 ft (days)	23.5 to 13 ft (days)
10/15/97	1.74773	5.96E+06	6.15E+03	12.80	1.61	9.60	12.70	13.94	7.74	10.84	12.08	2.17	5.27	6.50
10/30/97	1.71064	5.84E+06	6.02E+03	12.53	1.58	9.81	12.97	14.24	7.91	11.07	12.34	2.21	5.38	6.64
11/29/97	1.64511	5.61E+06	5.78E+03	12.05	1.52	10.20	13.49	14.81	8.23	11.52	12.83	2.30	5.59	6.91
12/29/97	1.58915	5.42E+06	5.59E+03	11.64	1.47	10.56	13.97	15.33	8.52	11.92	13.28	2.38	5.79	7.15
01/28/98	1.5409	5.26E+06	5.42E+03	11.28	1.42	10.89	14.40	15.81	8.78	12.29	13.70	2.46	5.97	7.38
02/27/98	1.49892	5.11E+06	5.27E+03	10.98	1.38	11.19	14.81	16.25	9.03	12.64	14.08	2.53	6.14	7.58
03/29/98	1.46207	4.99E+06	5.14E+03	10.71	1.35	11.48	15.18	16.66	9.26	12.96	14.44	2.59	6.29	7.77
04/28/98	1.42946	4.88E+06	5.03E+03	10.47	1.32	11.74	15.53	17.04	9.47	13.25	14.77	2.65	6.44	7.95
05/28/98	1.40037	4.78E+06	4.92E+03	10.25	1.29	11.98	15.85	17.39	9.66	13.53	15.07	2.71	6.57	8.12
06/27/98	1.37425	4.69E+06	4.83E+03	10.06	1.27	12.21	16.15	17.72	9.85	13.79	15.36	2.76	6.70	8.27
07/27/98	1.35065	4.61E+06	4.75E+03	9.89	1.25	12.42	16.43	18.03	10.02	14.03	15.63	2.81	6.81	8.42
08/2[illegible]/98	1.32921	4.54E+06	4.67E+03	9.73	1.23	12.62	16.70	18.33	10.18	14.25	15.88	2.85	6.92	8.55
09/25/98	1.30962	4.47E+06	4.61E+03	9.59	1.21	12.81	16.95	18.60	10.33	14.47	16.12	2.89	7.03	8.68
10/25/98	1.29166	4.41E+06	4.54E+03	9.46	1.19	12.99	17.18	18.86	10.48	14.67	16.34	2.93	7.12	8.80
11/24/98	1.27513	4.35E+06	4.48E+03	9.34	1.18	13.16	17.40	19.10	10.61	14.86	16.56	2.97	7.22	8.91
12/24/98	1.25985	4.30E+06	4.43E+03	9.22	1.16	13.32	17.62	19.33	10.74	15.04	16.76	3.01	7.30	9.02
06/22/99	1.18815	4.05E+06	4.18E+03	8.70	1.10	14.12	18.68	20.50	11.39	15.95	17.77	3.19	7.74	9.57
12/19/99	1.13931	3.89E+06	4.01E+03	8.34	1.05	14.73	19.48	21.38	11.88	16.63	18.53	3.33	8.08	9.98
06/16/00	1.10412	3.77E+06	3.88E+03	8.08	1.02	15.20	20.10	22.06	12.26	17.16	19.12	3.43	8.33	10.30
12/13/00	1.07743	3.68E+06	3.79E+03	7.89	1.00	15.57	20.60	22.61	12.56	17.58	19.59	3.52	8.54	10.55
12/13/01	1.03783	3.54E+06	3.65E+03	7.60	0.96	16.17	21.38	23.47	13.04	18.25	20.34	3.65	8.67	10.95
12/13/02	1.0[illegible]73	3.44E+06	3.54E+03	7.38	0.93	16.65	22.02	24.17	13.43	18.80	20.95	3.76	9.13	11.28
12/13/07	0.[illegible]907[illegible]	3.04E+06	3.13E+03	6.52	0.82	18.84	24.91	27.34	15.19	21.27	23.70	4.25	10.33	12.76

FIGURE 1

Total SFP Power vs Time After Shutdown

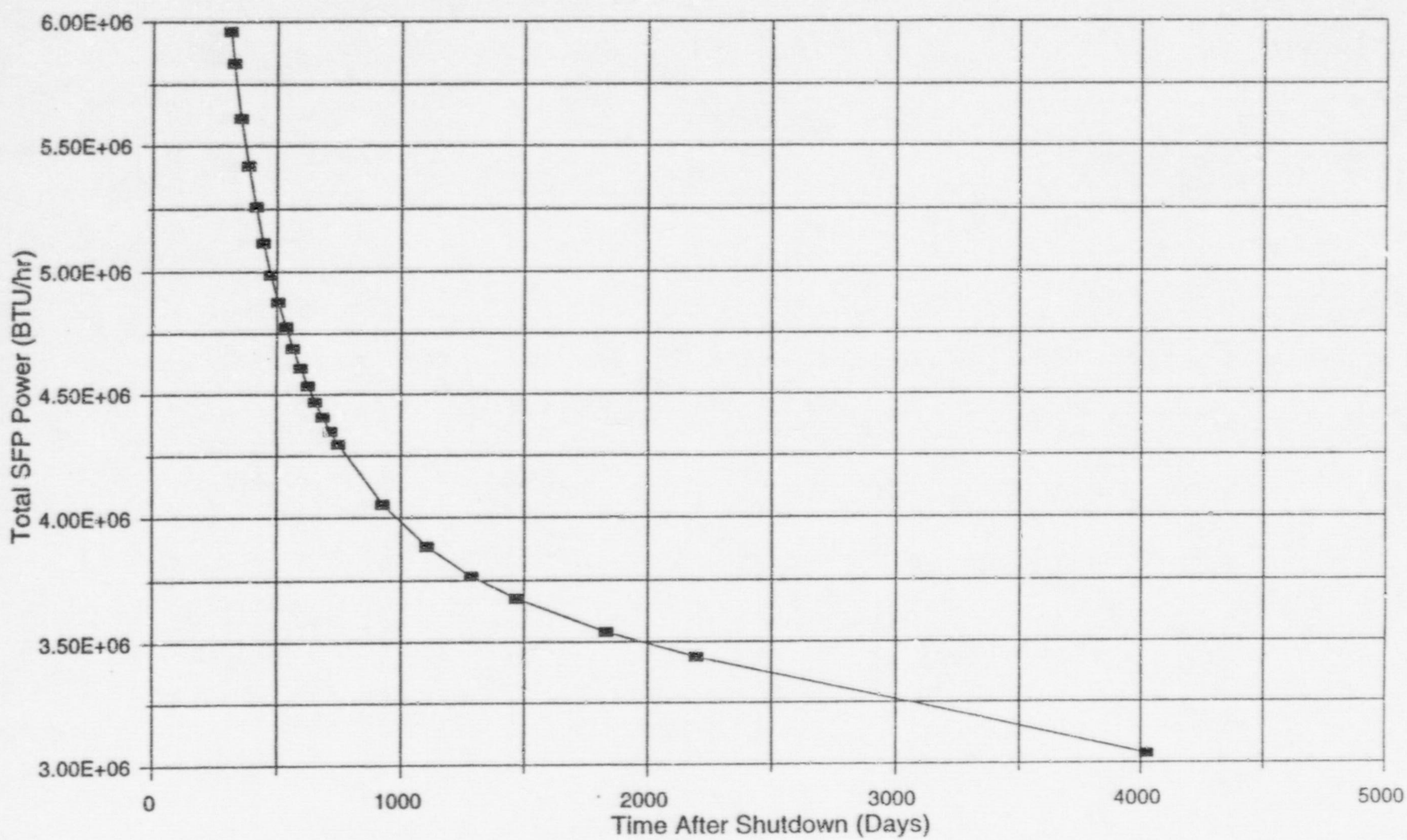

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FIGURE 2 Time to Boil vs Shutdown Time

Pool Water Level 32.5 Feet

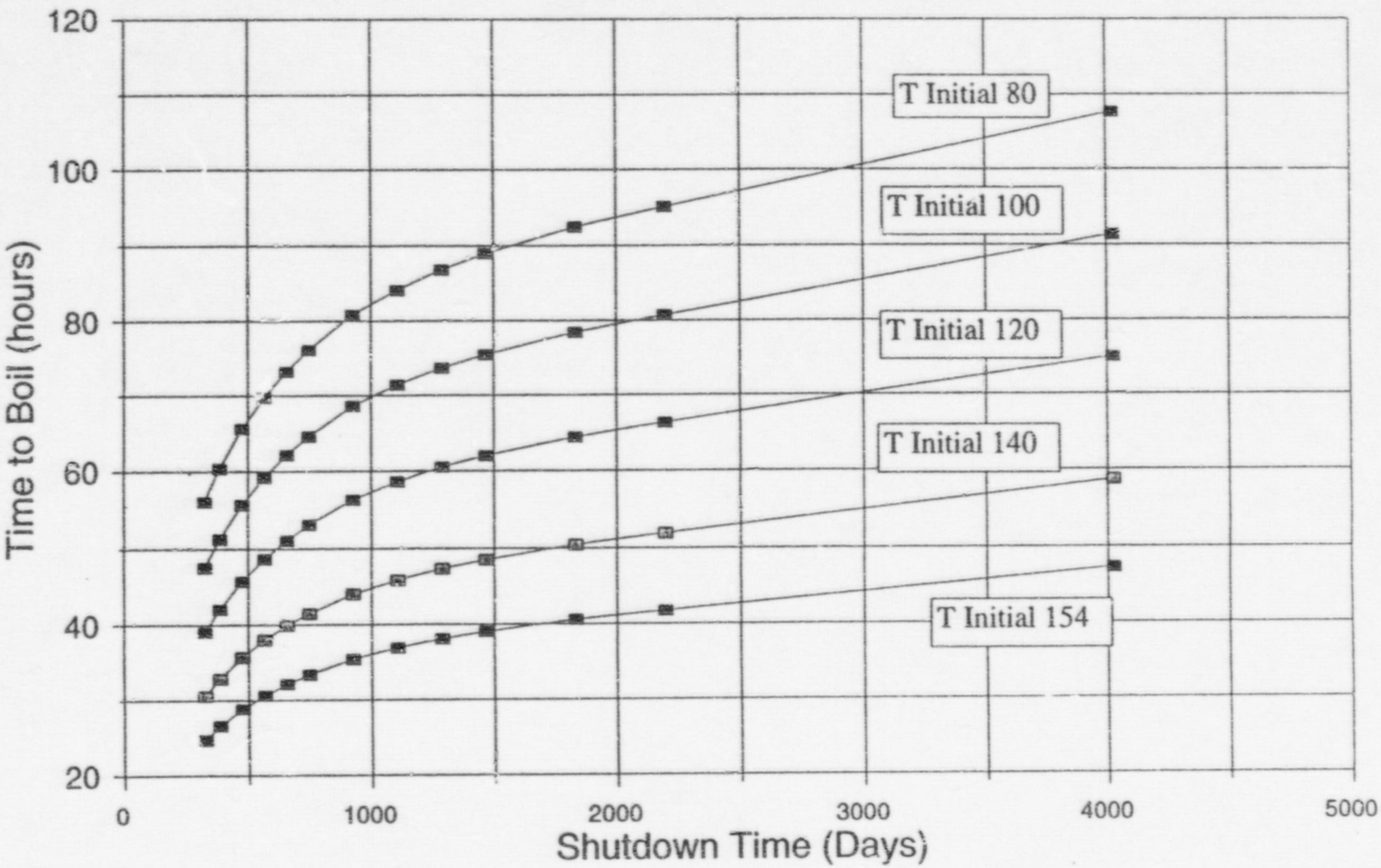

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FIGURE 3 Time to Boil vs Shutdown Time

Pool Water Level 23.5 Feet

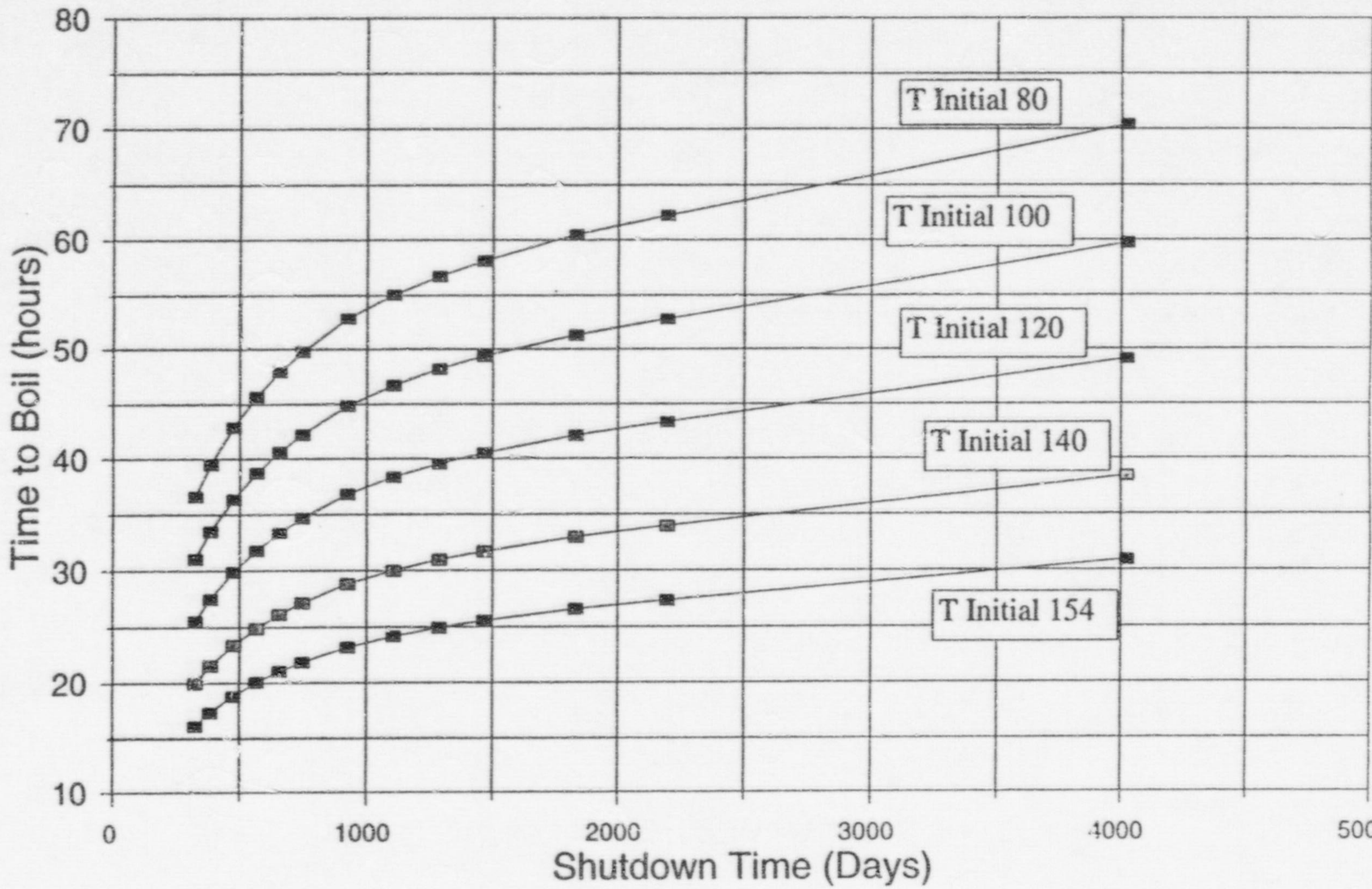

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FIGURE 4 Time to Boil vs Shutdown Time

Pool Water Level 35.5 Feet

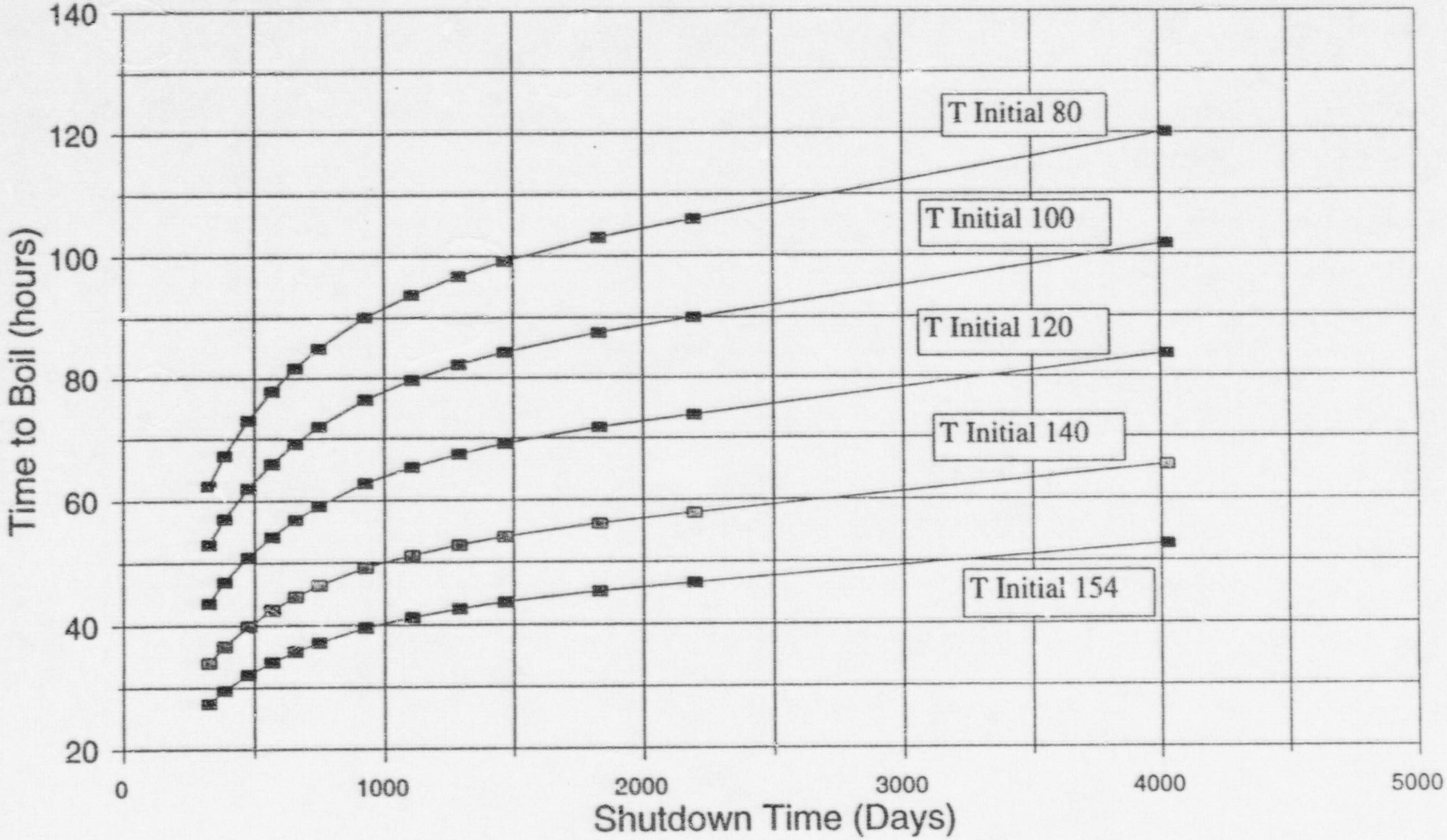

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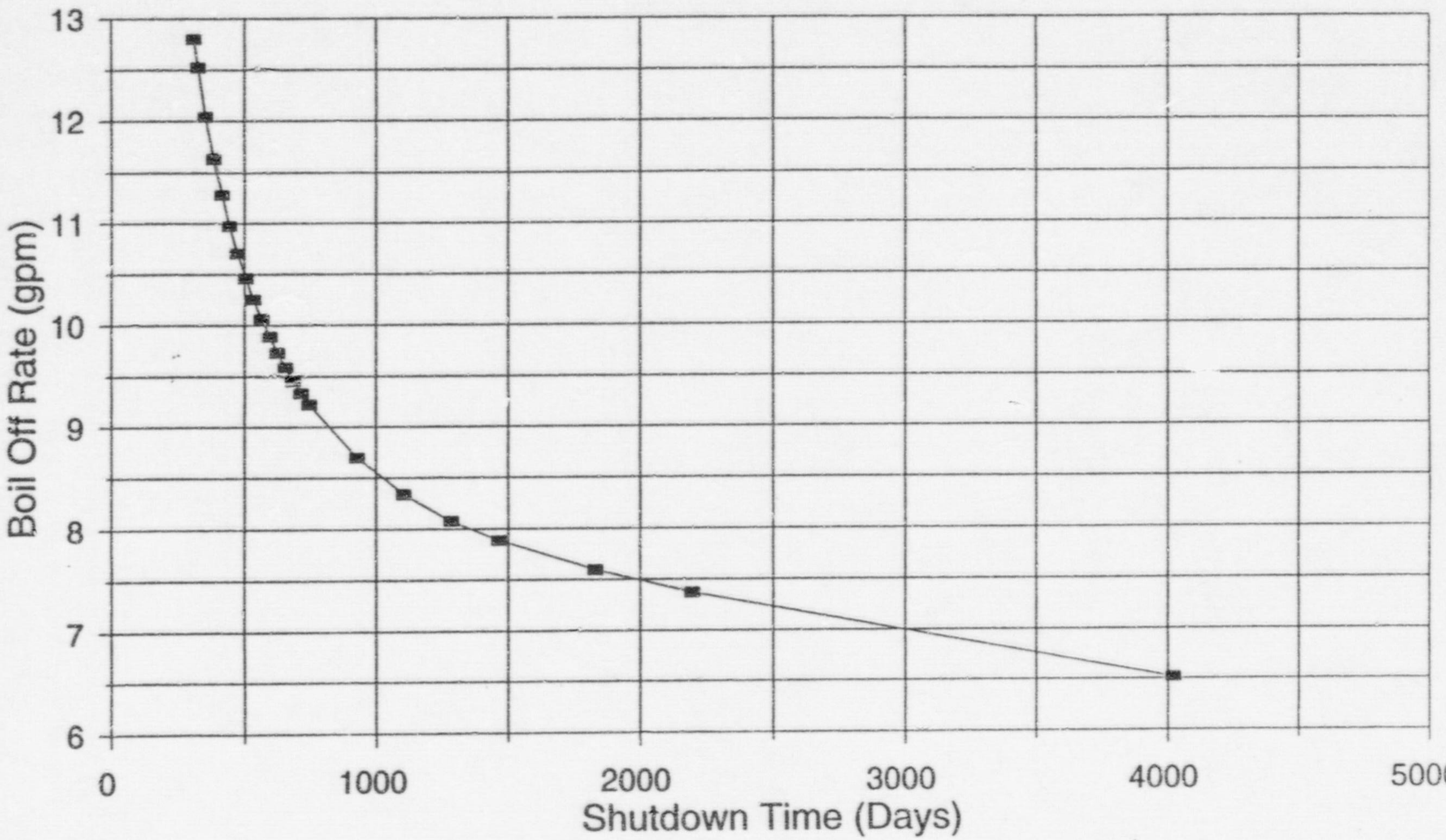
FIGURE 5

Boil Off Rate vs Shutdown TIme



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8.2 Evaluation of Computer Code Use Form

P. 53
AP

EVALUATION OF COMPUTER CODE USE

CALCULATION NO. MYC-2004 REVISION NO. 0

List the computer codes used, and complete the following:

Code Name/Version and/or Script File	Approved per WE-108[1]		Appropriateness Verified[2]		Outstanding SPRs[3]	
	Yes	No	Yes	No	Yes	No
POOL	✓		✓			✓
QuatroPro for Windows						
Version 6.0		✓	✓			✓

[1] Refer to Section 4.1.4.4, Bullet 3, of this procedure.

[2] Refer to Section 4.1.4.4, Bullet 2, of this procedure.

[3] Refer to WE-108, Section 4.4.

If a computer code was not verified per WE-108, or if there are outstanding SPRs, state below why it is appropriate.

Code Name/Script File	Appropriateness
QuatroPro for Windows	Spreadsheets verified in calculation.
Version 6.0	

FORM WE-103-2
Revision 3

8.3 Calculation/Analysis Review Form

CALCULATION/ANALYSIS REVIEW FORM

P.55

CALCULATION NO. MYC-2004 REVISION NO. 0

COMMENTS	RESOLUTION
Section 4.5 - It isn't clear in this section that BTP ASB 9-2 w/ 10% uncertainty is a user option in the POOL code.	Added Statement
Section 5.3.1 (pg 6) - provide justification for using 1.00 as uncertainty multiplier for burnup & power on old fuel.	Added statement
Section 5.3.1 (pgs 6-8) - your documentation for Card 2, 9th-11th entries, doesn't match input file on page 7. Also there are 12 inputs on Card 2, not 11.	Corrected documentation for Card 2
Pg 8 - Reference 7 states that it must be attached to any WE-103 calculation that uses the information it contains. Please attach.	Attached Reference 7
Section 5.3.1 - you need to add instruction on how to run the POOL code (command line for example).	Added missing pool driver and procedure files.
Section 5.3.1 - if RPG input files from Reference 7 are modified in order to	

Identify method(s) of review:

- [x] Calculation/analysis review
- [ ] Alternative calculational method
- [ ] Qualification testing

Resolution By: Michael W. Scott 11/26/97
Preparer/Date

Comments Continued on Page: 55A

Concurrence with Resolution Suzanne Palmer 11/26/97
Reviewer/Date

FORM WE-103-3
Revision 4

P. 55A

CALCULATION/ANALYSIS REVIEW FORM

CALCULATION NO. MYC-2004 REVISION NO. 0

COMMENTS	RESOLUTION
run POOL code, specific modifications should be documented. The figures on pages 9-11 don't match Reference 7.	Added notes
Section 5.3.1 - Quattro Pro spreadsheet output should be labeled with spreadsheet name and Q.P. version #.	done see text.
Page 13 - I don't know how you calculated "days after shutdown". I don't get the same number of days assuming shutdown on 12/12/96.	The shutdown date is corrected in the text. It was actually 12/6/96
Section 5.3.2 (pg 15) - 32½ ft of water is the minimum water level under normal conditions per MYC-1562. Please add this and basis for other levels.	Bases for levels added See text.
Section 5.3.2 - Provide justification for using Cp = 1.000 for all cases.	Cp = 1.0 for all cases. It does vary in the third decimal place.
Section 5.3.2 - Show calculation of mass at 35.5 ft. Using the specific	You are right. But the difference in overall mass at 35.5 feet

Identify method(s) of review:

- ☒ Calculation/analysis review
- ☐ Alternative calculational method
- ☐ Qualification testing

Resolution By: Michael [signature] 11/26/97
Preparer/Date

Comments Continued on Page: 55B

Concurrence with Resolution Suzanne Palmer 11/26/97
Reviewer/Date

FORM WE-103-3
Revision 4

CALCULATION/ANALYSIS REVIEW FORM P:55B

CALCULATION NO. MYC-2004 REVISION NO. 0

COMMENTS	RESOLUTION
volume at 32°F is non-conservative for levels > 32.5 ft.	, as a result of the non-conservative specific volume, is 0.2% and can be neglected.
Section 5.3.2 and 5.3.3 - The plots would be more useful, I think, with an x-scale of "date" rather than time after shutdown.	The figures are consistent with Maine Yankee needs.
Section 5.3.4 - The information obtained from MYC-1562 should be more detailed - specifically, identify the pressure, temp etc. for the mass flow rates.	Pressures and temps for mass flow rates have been added to text.
On page 40 you state U=264. Btu/lb·ft²°F is reasonable considering U only varies slightly under the conditions evaluated. I believe you need more detail in order to make this statement.	U was calculated for several different conditions in MYC-1562 also from other conditions not documented. Under these varied conditions U did not change significantly.
Page 41 - every input to these equations should be documented in this calculation or referenced to another calculation.	done

Identify method(s) of review:

- ☒ Calculation/analysis review
- ☐ Alternative calculational method
- ☐ Qualification testing

Resolution By: [signature] 11/26/97
Preparer/Date

Comments Continued on Page: N/A

Concurrence with Resolution Suzanne Palmer 11/26/97
Reviewer/Date

FORM WE-103-3
Revision 4

8.4 NED WE-103 Review Checklist

NED WE-103 REVIEW CHECKLIST

Reviewer		Compliance Reviewer	
Name (please print)	Suzanne Palmer	Name (please print)	STEPHEN PETERSON
Organization	YAEC	Organization	YAEC
Signature	Suzanne Palmer	Signature	Stephen Peterson
Date	11/26/97	Date	12/1/97

Requirement	Reviewer	Compliance Reviewer
Ensure the title page is appropriately filled out. • Correct number of pages. ✓ • QA Record filled out. ✓ • IMS number filled out. N/A • Record number filled out (13.C09.001 included if microfiche or hard copy of computer runs are attached to the calculation). ✓ • Descriptive title. ✓ • Plant, cycle number and calculation number included. "N/A" ✓ can be used for plant and cycle number. • Signatures and dates are included, and are in correct chronological order. Print the name and individuals' organization (if other than YAEC) below the signature. The title page reviewer and approver dates do not pre-date any date in the calculation except for changes containing that individual's initials and date. • All WE-108 computer codes and other keywords not in the title which can be used to retrieve the calculation are listed in the keyword field.	SP	SPete ①
Ensure the Form WE-103-2 is included and properly completed when a computer code is used.	SP	SPete
Ensure Form WE-103-3 is included, and has signatures/dates from both the preparer and the reviewer and that all comments have been addressed. If no comments, use the following statement: "Reviewed in accordance with WE-103 with no comments".	SP	SPete
Ensure review of the calculation can be done without recourse to the originator.	SP	N/A
Ensure computer codes are used in accordance with WE-103 Steps 4.1.4.4 through 4.1.4.6.	SP	SPete ②

① Not yet approved. SPete 12/1/97
② Fiche not yet available SPete 12/1/97

NED-WE-103 REVIEW CHECKLIST
(continued)

Requirement	Reviewer	Compliance Reviewer
Ensure the calculation includes a title page, objective, method, inputs, assumptions, calculations, results, conclusions and references.	DR	Slete
Ensure the inputs are referenced to formal documents, e.g., WE-103. The reference can not be a YAEC report unless formal QA records are checked and also referenced.	DR	N/A
Ensure design input internal and external correspondence is prepared and reviewed, and is, therefore, a QA record. If there is only one signature on the correspondence, verify that it is a QA record.	DR	N/A
Ensure that if design specifications were used as input to the calculation, the performance characteristics are verified in writing by the provider of the component/product or by cognizant YAEC/plant personnel.	DR	N/A
Ensure that input and modeling uncertainties are explicitly addressed in the calculation.	DR	N/A
Ensure that the applicable input considerations from WE-100, Table 1 have been incorporated and are explicitly addressed within the calculation.	DR	N/A
Ensure individuals responsible for each portion of the calculation are identified when multiple preparers and/or reviewers are utilized. Page initialing is optional, even in the cases where initial boxes are provided on the pages.	DR	Slete
Ensure each page has a page number and the calculation number and revision number if applicable. Dates on each page are optional.	DR	Slete
Ensure that every page of every attachment (or Appendix) contains its attachment (or Appendix) number.	DR	Slete
Ensure a conclusion is stated in a supplemental Revision.	DR	Slete
Ensure corrections are addressed in one of the following approaches: • Retyped and identified by a vertical line with revision number, if applicable, in the right margin; OR • Lined out, initialed and dated by preparer; OR • Photocopy of original to eliminate any previous correction tape, whiteout, or erasures.	DR	Slete
Ensure enhancements and clouding are initialed and dated.	DR	Slete

NED-WE-103 REVIEW CHECKLIST
(continued)

Requirement	Reviewer	Compliance Reviewer
Confirm legibility meets WE-103, Attachment A. Specific pages can be exempt if they are: (1) documents received from another organization who is the original QA custodian, or (2) supplemental pages included for information only. In these two cases, make sure a memo was issued to RMS per WE-002 Section 3.4.3.	DR	Slete
Review of 10CFR50.46 reporting requirements has been documented for analyses which assess conformance with 10CFR50.46.	DR	N/A
Ensure computer codes are validated for the computing environment.	DR	N/A
Ensure script files are included in the calculation or referenced to another calculation. Also, ensure the preparer identifies how the code/script was run.	DR	N/A
Ensure applicable outstanding Engineeri[illegible]ficiency Reports (EDRs) have been reviewed for influence on the c[illegible]ation and note review in calculation.	DR	N/A
Ensure relevant SER conditions/limitations have been reviewed for their effect on this calculation and the review is noted in the calculation.	DR	Slete

8.5 NED Analysis Process Checklist

Table 1
NED ANALYSIS PROCESS CHECKLIST

Preparer		Reviewer	
Name (please print)	Michael W. Scott	Name (please print)	Suzanne Palmer
Organization	YAEC	Organization	YAEC
Signature	Michael W. Scott	Signature	Suzanne Palmer
Date	12/1/97	Date	11/26/97

Requirement	Preparer	Reviewer	
Ensure that the method described in the MOM, if applicable, and the base calculation, if one exists, has been followed	mws	SP	
If not, ensure lead engineer/manager is consulted and document variation in calculation	mws	SP	
Ensure that other applicable NED Procedures are implemented	mws	SP	
Ensure inputs/assumptions are obtained from appropriate sources	mws	SP	
Ensure any change to an input/assumption is consistent with operating practice at the plant	mws	SP	
Ensure that the safety analysis conforms to applicable requirements	mws	SP	
Ensure that intermediate results that would require a change to plant operating practice are dispositioned and documented	mws	N/A	Rev 2
Ensure, if reporting preliminary results, that the standard memorandum clearly states the results are preliminary and provides the status of the final analysis	mws	N/A	Rev. 2
Ensure that issues found when performing an analysis are dispositioned and documented	mws	N/A	Rev. 2
Ensure a standard memorandum is written describing the analysis performed and containing the following elements:	mws	SP	
- Any documents affected by the analysis are updated	mws	SP	
- Recommend updates be incorporated in the affected documents and include an action taken feedback block	mws	SP	

NED ANALYSIS PROCESS CHECKLIST
(continued)

Requirement	Preparer	Reviewer	
- If the memorandum recommends updates to affected documents, copy the NED Administrative Assistant	MD	DR	Rev 1
- Provide a list of personnel for distribution at YNSD and the sponsor	MD	DR	
- Notify project and sponsor licensing groups of any known NRC reporting requirements	MD	DR	
- Include a safety evaluation, if a plant operating practice is known to be affected	MD	DR	
Ensure that this checklist has been filled out and is attached to both the memorandum, placed in department chronological files, and the calculation. [NOTE: The checklist does not need to be attached to distributed copies of the memorandum.]	MD	DR	Rev 1

8.6 Selected References

MYC-2004
Attachment 8.6
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Principles of HEAT TRANSFER
third edition

Frank Kreith
University of Colorado

Thomas Y. Crowell
HARPER & ROW, PUBLISHERS
New York   Hagerstown   San Francisco   London

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$$f_{\text{heat transfer}} = f_{\text{isothermal}} \left(\frac{T_s}{T_b}\right)^{0.14} \tag{8-33}$$

8-5. Forced convection in transition flow

The mechanisms of heat transfer and fluid flow in the transition region (Re_D between 2100 and 10,000) vary considerably from system to system. In this region the flow may be unstable, and fluctuations in pressure drop and heat transfer have been observed. There exists a large uncertainty in the basic heat-transfer and flow-friction performance, and consequently the designer is advised to design equipment, if possible, to operate outside this region. For the purpose of estimating the Nusselt number in the transition region, the curves of Fig. 8-15 may be used, but the actual performance may deviate considerably from that predicted on the basis of these curves.

8-6. Closure

To aid in the rapid selection of an appropriate relation to obtain the heat-transfer coefficient for flow in a duct, some of the most commonly

Table 8-1. Summary of useful equations for forced convection heat transfer inside tubes and ducts.

System	Equation	Eq. No. in Text
Long Ducts, Liquids and Gases, Laminar Flow ($Re_D < 2,100$, $Pr > 0.7$)	$\overline{Nu}_{D_H} = 1.86(Re_{D_H} Pr\, D_H/L)^{0.33} (\mu_b/\mu_s)^{0.14}$	8-28*
Short Ducts, Liquids and Gases Laminar Flow $100 < Re_D Pr\, D_H/L < 1500$ ($Pr > 0.7$)	$\overline{Nu}_{D_H} = \frac{Re_D Pr\, D_H}{4L} \ln\left[\frac{1}{1 - \frac{2.6}{Pr^{0.167}(Re_{D_H} Pr\, D_H/L)^{0.5}}}\right]$	8-27*
Long Ducts, Turbulent Flow, Liquid Metals Constant Heat Flux ($Pr < 0.1$)	$\overline{Nu}_{D_H} = 5.0 + 0.025(Re_{D_H} Pr)^{0.8}$	8-24*
Long Ducts, Turbulent Flow Liquid Metals. Constant Wall Temperature ($Pr < 0.1$)	$\overline{Nu}_{D_H} = 4.0 + 0.025(Re_{D_H} Pr)^{0.8}$	8-25*
Long Ducts, Liquids and Gases in Turbulent Flow ($Re_D > 6,000$, $Pr > 0.7$)	$\overline{Nu}_{D_H} = 0.023\, Re_{D_H}^{0.8} Pr^{0.33}$	8-20*
Short Ducts, Liquids and Gases in Turbulent Flow ($2 < L/D_H < 20$, $Pr > 0.7$)	$\overline{Nu}_{D_H} = 0.023[1 + (D_H/L)^{0.7}]\, Re_{D_H}^{0.8} Pr^{0.33}$	8-23*
Liquid Metals, Laminar Flow	See Reference 26.	

*All physical properties should be evaluated at the mean film temperature, $(T_s + T_b)/2$.

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MEMORANDUM

YANKEE ATOMIC - BOLTON

To P. L. Anderson/J. T. McCumber

Date September 19, 1997

From G. M. Solan

Group # RP-MY-97-33
S.R. # Reload Task 04.01
W.O. # 5366
I.M.S.# MY.K.1.1.1
FUELSC8.MEM

Subject Maine Yankee Fuel Cycle Information for End-of-Cycle 15

SUMMARY

Fuel cycle information for Maine Yankee operation through the End-of-Cycle 15 is provided in Attachment A. The information is updated from Reference 1 to reflect the early shutdown of Cycle 15 as the last operating cycle. This memorandum fulfills the reload task indicated above and is for transmittal to R. P. Jordan and D. B. Boynton at Maine Yankee.

DISCUSSION

The fuel schedule in Figure A of Attachment A is contained in the file *fsxm042*. The batch information lines from Figure A are contained in the file *fsqm042*. These files are available to the Fuel Management Department for economics evaluations.

These fuel schedule files have also been requested by the Transient Analysis Group for spent fuel pool heat load calculations which may be safety-related. The recent cycle sub-batch burnups from Cycles 14 and 15 have been checked to assure that they match the cycle burnups from the final plant INCA burnup blocks (95-14-58 for Cycle 14 and 96-15-41 for Cycle 15). These burnups are the significant inputs to the heat load calculations and the fuel schedule files are therefore considered acceptable for use in such calculations. *If this data is incorporated in safety-related WE-103 calculations, this memorandum and the relevant parts of Attachment A should be included as an attachment to the calculations for documentation as a QA record.*

G. M. Solan, Principal Engineer — 9/19/97 Date
Reactor Physics Group

Reviewed by: P. A. Theriault, Senior Engineer — 9/19/97 Date
Reactor Physics Group

Approved by: R. J. Cacciapouti, Manager — 9/19/97 Date
Reactor Physics Group

c: J. R. Chapman, P. A. Bergeron, M. W. Scott, K. E. St.John, R. M. Grube, R. P. Barna, F. X. Quinn, J. M. Buchheit, R. T. Yee, E. E. Pilat, J. E. Rivera, J. A. Mayer, P. S. Littlefield, J. DiStefano, J. Hamawi, S. Van Volkinburg

REFERENCE

1. YAEC Memorandum RP-MY-96-24, "Maine Yankee Fuel Cycle Information for Cycles 15 and 16," G. M. Solan/M. C. Beganski to P. L. Anderson/W. J. Metevia, May 30, 1996

Attachment A

MAINE YANKEE FUEL CYCLE INFORMATION FOR END-OF-CYCLE 15

Summary

Fuel cycle information for Maine Yankee operation through the end-of-Cycle 15 is provided in this attachment. The information is updated from Reference 1 to reflect the early shutdown of Cycle 15 as the last operating cycle. The fuel cycle information is contained in the following tables and figures:

Table	*Description*
1.1	Operating History Summary
1.2	Core Loading History Summary
1.3	Thermal Generation History Comparison
1.4	Cycle Burnup History Summary
1.5	Thermal Generation in Effective Full Power Years
2.1	Fuel Assembly Types by Cycle
2.2	Fuel Assembly Types by Cycle and Total
2.3	Fuel Assembly Types by Cycle - Sub-Batch Detail
2.4	Design and As-Built Enrichments and Loadings by Assembly Type
2.5	Type UX and V Enrichment and Uranium Loadings
2.6.1	Number of Assemblies, Spent Fuel Pool Storage Capacity and Requirements
2.6.2	Discharged Assemblies on Site with Storage Restricted to Region I Only
3.1	Cycles 1-15 Fuel Cycle Information
3.2	Cycles 1-15 Discharge Burnup History vs. Industry Average

Figure	*Description*
1.1	Cycles 1-15 Length of Outages, Full Power Operation and Coastdowns in Days
1.2	Cycles 1-15 Length of Full Power Operation and Coastdown in EFPDs
1.3	Cycles 1-15 Thermal Capacity Factor, Excluding and Including Prior Outage
1.4	Cycles 1-15 Fresh Fuel and Core Average Enrichment
1.5	Cycles 1-15 Average and Maximum Discharged Assembly Burnups
1.6	Cycles 1-15 Discharged Assembly Average Burnups vs. U.S. Industry Average for PWRs
A	Fuel Schedule for EOC 15 (FSXM042)

Operating, Core Loading and Thermal Generation Histories

The operating history of Maine Yankee Cycles 1 through 15 is contained in Table 1.1, providing dates of startup and shutdown, licensed and operated power levels and cycle burnups. The core loading history is presented in Table 1.2. The core loadings are based on the assembly design weights from the fuel vendor, the as-modeled weights used in the current physics methods analysis, or the as-built assembly weights. Two as-built core loa[illegible] are provided in the table. One uses the individual assembly as-built data, while the other uses the average as-builts of all fabricated assemblies of that sub-batch.

The gross thermal generation history is contained in Table 1.3, comparing the gross thermal generation from the monthly statistical reports to the gross thermal generation used in the incore analysis, which determines the incremental and final assembly burnups for the cycle. Cycle burnups are shown in Table 1.4, illustrating the differences resulting from the use of different sources of gross thermal generation and core loadings. The gross thermal energy generation from the monthly statistical reports is converted to effective full-power years (EFPYs) in Table 1.5.

Fuel Assembly Types

The number of fuel assembly types by cycle through Cycle 15 is provided in Table 2.1. The number of fuel assembly types by cycle is provided in Table 2.2, including the cumulative number of irradiated assemblies by cycle. The number of fuel assembly types by cycle with sub-batch details is provided in Table 2.3. [illegible]formation includes assembly types, fuel vendors (Combustion Engineering (CE), Exxon Nuclear Company (ENC) and Westinghouse (W)), fuel designs, as-modeled assembly average enrichments and weights, and number of assemblies by cycle.

Additional enrichment and loading information by sub-batch is provided in Table 2.4. Assembly enrichment zoning was introduced in Type T fuel for Cycle 14. Axial blankets were introduced in the Type U fuel for Cycle 15. The assembly design enrichments for the low enrichment regions, the high enrichment regions and the blanket regions are specified for each sub-batch. The average assembly design and as-built U-235 enrichments are indicated for each sub-batch. The assembly average design, as-modeled and as-built uranium loadings are also provided for each sub-batch.

Cycle 15 was the first cycle for insertion of Westinghouse fuel, designated Type U. Cycle 15's early shutdown required a redesign of Cycle 16 without reinsertion of the failed Type U fuel. The redesigned Cycle 16 fresh fuel consisted of 8 Type UX assemblies from Siemens Power Corporation (SPC, formerly Exxon Nuclear Company) and 84 Type V assemblies from Combustion Engineering (CE). The fresh Type UX assemblies are currently at the plant in the new fuel vault and the fresh Type V assemblies remain at CE. The redesigned Cycle 16 and the fresh fuel types were described in Reference 2. Table 2.5 provides the design and as-built enrichments and loadings for these fuel types.

Spent Fuel Pool Storage

A summary of the number of fabricated and irradiated assemblies and the spent fuel pool storage requirements are provided in Table 2.6.1. There have been 1530 assemblies fabricated for Maine Yankee, with the detailed assembly information contained in a library file which was provided to the plant in Reference 3. Of these assemblies, 1434 have been irradiated. Of these irradiated assemblies, 144 require storage in Region I of the spent fuel pool based on criticality criteria, as detailed in Table 2.6.2, taken from Reference 4. The unirradiated assemblies are comprised of 4 spare assemblies no longer on-site (Types A, B, C and D), 8 Type UX assemblies currently in the new fuel vault and 84 Type V assemblies currently at Combustion Engineering.

The spent fuel pool capacity after reracking is 2019 locations when all the new racks are inserted. There are a total of 228 assembly locations in Region I and 1791 assembly locations in Region II.

Fuel Schedule

An updated fuel schedule for Cycles 1 through 15 is provided in Figure A. The fuel schedule in Figure A is contained in the file *fsxm042*. The batch lines from Figure A are contained in the file *fsqm042*. These files are available to the Fuel Management Department for economics and the Transient Analysis Group for spent fuel pool evaluations. Table 3.1 provides a summary of fuel schedule information.

The fuel schedules include cycle information for days of outage, days of total operation, days of coastdown, rated power levels, cycle exposures to end-of-full-power-life (EOFPL) and end-of-cycle (EOC), and capacity factors. The core loadings, sub-batch loadings and enrichments in the fuel schedule are based on individual assembly as-built loadings and enrichments by cycle. The cycle burnups in the fuel schedules are based on an individual assembly sub-batch average weighting of the assembly burnups.

The fuel schedule contains the following major changes since the last fuel schedule provided in Reference 1:

- Cycle 15 actual startup and shutdown on 1/16/96 and 12/6/96, with as-built loadings and enrichments for Type U fuel, a measured cycle burnup of 7859 MWd/Mt and measured sub-batch average burnups.

- Elimination of cycle projections beyond Cycle 15.

As a result of these major changes, the sub-batch numbering and designations have changed as follows:

Sub-Batch	*Change*
0800090	The number of Type M-8 assemblies, discharged after Cycles 8 and 9 with no planned reinsertions, has been increased from 2 to 3 assemblies. Assembly M860 had been planned for Cycle 16. Two of these assemblies were not reinserted for mechanical reasons. Assembly M839 was damaged during the Cycle 9-10 refueling and Assembly M850 had metallic debris in its lower grid.
0900100	The 8 Type N-8 assemblies discharged after Cycles 9 and 10 have no planned reinsertion (Assemblies N836, N838, N839, N842, N845, N859, N862, N872).
1100120	The 4 Type Q-4 assemblies discharged after Cycles 11 and 12 have no planned reinsertion (Assemblies Q442, Q457, Q459, Q463).
1300140	The 4 Type S-0 assemblies discharged after Cycles 13 and 14 have no planned reinsertion (Assemblies S008, S009, S011, S012).
1300150	The 16 Type S-0 assemblies discharged after Cycles 13, 14 and 15 have no planned reinsertion.
1301150	The 28 Type S-4 assemblies discharged after Cycles 13, 14 and 15 have no planned reinsertion and are condensed into a single sub-batch.
1302150	The 20 Type S-8 assembly sub-batch is renumbered due to the above changes.
1400150 - 1402150	The Type T-0, T-4 and T-8 assemblies are condensed into single sub-batches which are renumbered for no planned reinsertion.
1500150 - 1502150	The Type U-0, U-24 and U-48 assemblies are condensed into single sub-batches which are renumbered for no planned reinsertion.

Core Performance and Fuel Management Trends

Core performance and fuel management trends from Cycles 1 through 15 are shown in Figures 1.1 through 1.6. The lengths of outages, full-power operation and coastdown in days are shown in Figure 1.1. The length of full-power operation and coastdown in effective full-power days (EFPDs) are shown in Figure 1.2. Recent cycles are in the range of 400 EFPDs, which is effectively 18-month operating cycles. Thermal capacity factors, both excluding and including the refueling outage, are shown in Figure

1.3. The trends towards higher assembly enrichments and higher discharged assembly burnups in recent cycles are shown in Figures 1.4 and 1.5, respectively.

A comparison of the average discharge burnup at Maine Yankee to the industry average is shown in Figure 1.6, based on the data in Table 3.2. Since Cycle 5, Maine Yankee's average discharge burnup has been consistently above the U. S. PWR industry average. For fully completed cycles since 1987, Maine Yankee's discharged burnups have averaged greater than 10% above the industry average.

References

1. YAEC Memorandum RP-MY-96-24, "Maine Yankee Fuel Cycle Information for Cycles 15 and 16," G. M. Solan/M. C. Beganski to P. L. Anderson/W. J. Metevia, May 30, 1996

2. YAEC Memorandum RP-MY-97-13, "Maine Yankee Cycle 16 Redesign Depletion, Power, Burnup, Census and Kinetics Data - Case R," M. C. Beganski/G. M. Solan to S. Palmer/K. E. St.John/P. S. Littlefield, May 16, 1997

3. YAEC Memorandum RP-MY-97-32, "Maine Yankee Assembly Library File," G. M. Solan to P. L. Anderson/J. T. McCumber, September 12, 1997

4. YAEC Memorandum RP-MY-97-25, "Maine Yankee Cycle 15-16 Spent Fuel Pool and New Fuel Storage Vault Criticality Evaluation," G. M. Solan to P. L. Anderson/J. T. McCumber, June 13, 1997

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TABLE 1.1

Maine Yankee Operating History Summary

	Dates		Core Power Level		
Cycle	Startup[1]	Shutdown	Maximum Licensed (MWt)	Operated (%)	Cycle Burnup (MWd/Mt)
1	11/8/72	6/29/74	2440	50-80[2]	10,367
1A	10/12/74	5/2/75	2440	80[2]	4,492
2	6/29/75	4/9/77	2440	100	17,365
3	6/11/77	7/14/78	2630[3]	93	11,105
4	8/28/78	1/11/80	2630	97[4]	10,500
5	3/17/80	5/8/81	2630	97[4]	10,799
6	7/20/81	9/24/82	2630	97[4]	11,585
7	12/12/82	3/31/84	2630	100	12,483
8	6/20/84	8/17/85	2630	100	12,504
9	10/25/85	3/28/87	2630	100	14,424
10	6/18/87	10/15/88	2630	100	12,675
11	12/16/88	4/7/90	2700[5]	97-98[4]	13,786
12	6/30/90	2/14/92	2700	100	15,364
13	4/19/92	7/30/93	2700	100	13,668
14	10/14/93	1/14/95	2700	100	13,075
15	1/16/96	12/6/96	2440[6]	100	7,859

---

1) Date of power escalation with initial phasing onto power grid
2) Power restrictions due to leaking fuel and rodded operation for moderator temperature coefficient control. Primary system pressure decrease to 1800-2000 psia for leaking fuel.
3) Licensed power increase on 6/20/78 from 2440 MWt/2100 psia to 2630 MWt/2250 psia operation during Cycle 3
4) Power restriction due to secondary plant limitations
5) Licensed power increase on 7/10/89 from 2630 to 2700 MWt operation during Cycle 11
6) Licensed power restricted to 2440 MWt due to small-break LOCA and containment analysis issues. Operation terminated near mid-cycle due to cable separation and fuel failure issues.

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TABLE 1.2

Maine Yankee
Core Loading History Summary

Cycle	with Assembly Design Weights(1) (kg U)	with Assembly As-Modeled Weights(2) (kg U)	with Assembly As-Built Weights(3) (kg U)	with Sub-Batch As-Built Weights(4) (kg U)
1	81,544	81,549	81,434	81,434
1A	83,113	83,119	83,084	83,086
2	80,885	80,953	81,027	81,027
3	83,065	83,118	83,130	83,128
4	81,843	81,908	81,822	81,817
5	83,034	83,076	83,006	83,008
6	82,248	82,264	82,220	82,222
7	81,013	80,872	80,905	80,905
8	80,528	80,257	80,231	80,232
9	80,467	80,221	80,120	80,119
10	81,450	81,362	81,227	81,231
11	82,354	82,554	82,389	82,385
12	82,910	83,135	83,051	83,050
13	82,863	83,075	83,028	83,024
14	82,627	82,700	82,819	82,813
15	82,801	83,044	83,062	83,064
16*	82,601	82,648	82,887	82,891

1) with assembly design weights from the fuel vendor, prior to fabrication
2) with assembly as-modeled weights from the current physics methods analyses
3) with assembly as-built weights for each individual assembly in the core
4) with assembly as-built weights for each sub-batch, taken as the average of all assembly as-built weights fabricated in the sub-batch

* Cycle 16 never loaded into the core

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TABLE 1.3

Maine Yankee
Thermal Generation History Comparison

Cycle	Cycle Gross Thermal Energy Generation: Incore Analysis (MWt-hours)	Cycle Gross Thermal Energy Generation: Monthly Reports (MWt-hours)	Cycle Gross Thermal Energy Generation: Diff. (%)	Cumulative Gross Thermal Energy Generation: Incore Analysis (MWt-hours)	Cumulative Gross Thermal Energy Generation: Monthly Reports (MWt-hours)	Cumulative Gross Thermal Energy Generation: Diff. (%)
1	20,262,525	20,262,525	0.00	20,262,525	20,262,525	0.00
1A	8,957,090	8,938,891	-0.20	29,219,615	29,201,416	-0.06
2	33,768,971	33,768,963	0.00	62,988,586	62,970,379	-0.03
3	22,155,743	22,079,033	-0.35	85,144,329	85,049,412	-0.11
4	20,617,175	20,635,170	0.09	105,761,504	105,684,582	-0.07
5	21,512,949	21,494,940	-0.08	127,274,453	127,179,522	-0.07
6	22,860,352	22,860,355	0.00	150,134,805	150,039,877	-0.06
7	24,238,404	24,238,449	0.00	174,373,209	174,278,326	-0.05
8	24,076,381	24,076,380	0.00	198,449,590	198,354,706	-0.05
9	27,734,848	27,734,847	0.00	226,184,438	226,089,553	-0.04
10	24,710,464	24,759,471	0.20	250,894,902	250,849,024	-0.02
11	27,258,678	27,258,678	0.00	278,153,580	278,107,702	-0.02
12	30,623,741	30,624,238	0.00	308,777,321	308,731,940	-0.01
13	27,234,376	27,231,970	-0.01	336,011,697	335,963,910	-0.01
14	25,987,464	25,980,181	-0.03	361,999,161	361,944,091	-0.02
15	15,667,857	15,667,061	-0.01	377,667,018	377,611,152	-0.01

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TABLE 1.4

Maine Yankee
Cycle Burnup History Summary

Information					
Cycle Energy:	Incore Analysis	Monthly Reports	-	-	-
Core Loading:	Sub-Batch Average As-Builts	Individual Assembly As-Builts	-	-	-
Sub-Batch Burnups:	-	-	-	Incore Analysis	-
Sub-Batch Loadings:	-	-	-	Individual Assembly As-Builts	-
Cycle	Cycle Burnup (MWd/Mt)	Cycle Burnup (MWd/Mt)	Difference (%)	Cycle Burnup (MWd/Mt)	Difference (%)
1	10,367	10,367	0.00	10,336	-0.30
1A	4,492	4,483	-0.20	4,509	0.38
2	17,365	17,365	0.00	17,396	0.18
3	11,105	11,067	-0.34	11,076	-0.26
4	10,500	10,508	0.08	10,495	-0.05
5	10,799	10,790	-0.08	10,795	-0.04
6	11,585	11,585	0.00	11,582	-0.03
7	12,483	12,483	0.00	12,465	-0.14
8	12,504	12,504	0.00	12,455	-0.39
9	14,424	14,424	0.00	14,361	-0.44
10	12,675	12,701	0.21	12,647	-0.22
11	13,786	13,786	0.00	13,798	0.09
12	15,364	15,364	0.00	15,423	0.38
13	13,668	13,666	-0.01	13,668	0.00
14	13,075	13,071	-0.03	13,075	0.00
15	7,859	7,859	0.00	7,859	0.00

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TABLE 1.5

Maine Yankee
Thermal Generation In Effective Full Power Years

	Gross Thermal Energy Generation from Monthly Statistical Reports		Effective Full-Power Years			
			at 2630 MWt		at 2700 MWt	
Cycle	Cycle (MWt-hours)	Cumulative (MWt-hours)	Cycle (EFPY)	Total (EFPY)	Cycle (EFPY)	Total (EFPY)
1	20,262,525	20,262,525	0.879	0.879	0.856	0.856
1A	8,938,891	29,201,416	0.388	1.267	0.378	1.234
2	33,768,963	62,970,379	1.465	2.731	1.427	2.661
3	22,079,033	85,049,412	0.958	3.689	0.933	3.593
4	20,635,170	105,684,582	0.895	4.584	0.872	4.465
5	21,494,940	127,179,522	0.932	5.516	0.908	5.373
6	22,860,355	150,039,877	0.992	6.508	0.966	6.339
7	24,238,449	174,278,326	1.051	7.559	1.024	7.363
8	24,076,380	198,354,706	1.044	8.604	1.017	8.381
9	27,734,847	226,089,553	1.203	9.807	1.172	9.552
10	24,759,471	250,849,024	1.074	10.881	1.046	10.599
11	27,258,678	278,107,702	1.182	12.063	1.152	11.750
12	30,624,238	308,731,940	1.328	13.391	1.294	13.044
13	27,231,970	335,963,910	1.181	14.572	1.151	14.195
14	25,980,181	361,944,091	1.127	15.699	1.098	15.292
15	15,667,061	377,611,152	0.680	16.379	0.662	15.954

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TABLE 2.1

Maine Yankee
Fuel Assembly Types by Cycle

Fuel Type	Average Initial Enrichment (w/o U^{235})	Fuel Vendor and Assembly Mechanical Design Type	Number of Fuel Assemblies by Cycle															
			1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	2.01	CE-Core 1	69	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	2.40	CE-Core 1	80	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	2.95	CE-Core 1	68	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RF	2.33	CE-RF	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RF	1.93	CE-RF	-	70	-	65	-	-	-	-	-	-	-	-	-	-	-	-
D	1.95	CE-Core 2	-	-	69	-	-	-	-	-	-	-	-	-	-	-	-	-
E	2.52	CE-Core 2	-	-	80	12	61	1	1	1	1	1	1	-	-	-	-	-
F	2.90	CE-Core 2	-	-	68	68	12	-	-	-	-	-	-	-	-	-	-	-
G	2.73	CE-Core 2	-	-	-	32	32	32	-	-	-	-	-	-	-	-	-	-
H	3.03	CE-Core 2	-	-	-	40	40	40	-	-	-	-	-	-	-	-	-	-
I	3.03	CE-Core 2	-	-	-	-	72	72	72	-	-	-	-	-	-	-	-	-
J	3.00	ENC	-	-	-	-	-	72	72	72	-	-	-	-	-	-	-	-
K	3.00	ENC	-	-	-	-	-	-	72	72	72	-	-	-	-	-	-	-
L	3.30	ENC	-	-	-	-	-	-	-	72	72	72	8	8	-	-	-	-
M	3.30	ENC	-	-	-	-	-	-	-	-	72	72	64	1	1	1	1	9
N	3.30	CE-Core 2	-	-	-	-	-	-	-	-	-	72	72	64	-	-	-	-
P	3.50	CE-Core 2	-	-	-	-	-	-	-	-	-	-	72	72	72	8	8	-
Q	3.70	CE-Core 2	-	-	-	-	-	-	-	-	-	-	-	72	72	68	-	-
R	3.70	CE-Core 2	-	-	-	-	-	-	-	-	-	-	-	-	72	72	68	4
S	3.70	CE-Core 2	-	-	-	-	-	-	-	-	-	-	-	-	-	68	68	64
T	3.90	CE-Core 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72	72
U	3.74	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68

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TABLE 2.2

MAINE YANKEE
FUEL ASSEMBLY TYPES BY CYCLE AND TOTAL

Assembly Type	Fuel Vendor and Design	Average Initial Enrichment (w/o U-235)	Number of Assemblies by Type	Total*		Assemblies in Core by Cycle 1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	CE-1	2.01	69	69		69	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	CE-1	2.40	80	149		80	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	CE-1	2.95	68	217		68	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RF	CE-RF	1.93	69	286		-	69	-	65	-	-	-	-	-	-	-	-	-	-	-	-
RF	CE-RF	2.01	1	287		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RF	CE-RF	2.33	2	289		-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	CE-2	1.95	69	358		-	-	69	-	-	-	-	-	-	-	-	-	-	-	-	-
E	CE-2	2.52	80	433		-	-	80	12	61	1	1	1	1	1	1	-	-	-	-	-
F	CE-2	2.90	68	506		-	-	68	68	12	-	-	-	-	-	-	-	-	-	-	-
G	CE-2	2.73	32	538		-	-	-	32	32	32	-	-	-	-	-	-	-	-	-	-
H	CE-2	3.03	40	578		-	-	-	40	40	40	-	-	-	-	-	-	-	-	-	-
I	CE-2	3.03	72	650		-	-	-	-	72	72	72	-	-	-	-	-	-	-	-	-
J	ENC	3.00	72	722		-	-	-	-	-	72	72	72	-	-	-	-	-	-	-	-
K	ENC	3.00	72	794		-	-	-	-	-	-	72	72	72	-	-	-	-	-	-	-
L	ENC	3.30	72	866		-	-	-	-	-	-	-	72	72	72	8	8	-	-	-	-
M	ENC	3.30	72	938		-	-	-	-	-	-	-	-	72	72	64	1	1	1	1	9
N	CE-2	3.30	72	1010		-	-	-	-	-	-	-	-	-	72	72	64	-	-	-	-
P	CE-2	3.50	72	1082		-	-	-	-	-	-	-	-	-	-	72	72	72	8	8	-
Q	CE-2	3.70	72	~~[illegible]~~	1154	-	-	-	-	-	-	-	-	-	-	-	72	72	68	-	-
R	CE-2	3.70	72	1226	mma	-	-	-	-	-	-	-	-	-	-	-	-	72	72	68	4
S	CE-2	3.70	68	1294	11/10/97	-	-	-	-	-	-	-	-	-	-	-	-	-	68	68	64
T	CE-2	3.90	72	1366		-	-	-	-	-	-	-	-	-	-	-	-	-	-	72	72
U	W	3.74	68	1434	This	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68

value was not used as input to any computer code mma 12/1/97 AP 12/1/97

* Total spent fuel pool locations: 2019

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TABLE 2.3

MAINE YANKEE
FUEL ASSEMBLY TYPES BY CYCLE - SUB-BATCH DETAIL

Assembly Type and Number of Poison Rods	Fuel Vendor and Design	Assembly As-Modeled Enrichment (w/o U-235)	Assembly As-Modeled Weights (kg U)	Number of Assemblies	Assemblies in Core by Cycle															
					1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A-0	CE-1	2.03	394.82	69	69	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B-16	CE-1	2.40	358.93	80	80	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-0	CE-1	2.95	394.82	24	24	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-12	CE-1	2.95	367.90	36	36	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-16	CE-1	2.95	358.93	8	8	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RF-0	CE-RF	1.95	394.82	14	-	14	-	12	-	-	-	-	-	-	-	-	-	-	-	-
RF-4	CE-RF	1.95	385.85	55	-	55	-	53	-	-	-	-	-	-	-	-	-	-	-	-
RF-0	CE-RF	2.33	394.82	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RF-5	CE-RF	2.01	383.60	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D-0	CE-2	1.95	389.03	69	-	-	69	-	-	-	-	-	-	-	-	-	-	-	-	-
E-16	CE-2	2.52	353.66	80	-	-	80	12	61	1	1	1	1	1	1	-	-	-	-	-
F-0	CE-2	2.90	389.03	40	-	-	40	40	12	-	-	-	-	-	-	-	-	-	-	-
F-8	CE-2	2.90	371.34	12	-	-	12	12	-	-	-	-	-	-	-	-	-	-	-	-
F-12	CE-2	2.90	362.50	16	-	-	16	16	-	-	-	-	-	-	-	-	-	-	-	-
G-0	CE-2	2.74	389.03	16	-	-	-	15	16	16	-	-	-	-	-	-	-	-	-	-
G-4	CE-2	2.74	380.19	16	-	-	-	16	16	16	-	-	-	-	-	-	-	-	-	-
H-0	CE-2	3.03	389.03	40	-	-	-	40	40	40	-	-	-	-	-	-	-	-	-	-
I-0	CE-2	3.03	389.03	48	-	-	-	-	48	48	48	-	-	-	-	-	-	-	-	-
I-4	CE-2	3.03	380.19	24	-	-	-	-	24	24	24	-	-	-	-	-	-	-	-	-
J-0	ENC	3.00	381.07	48	-	-	-	-	-	48	48	48	-	-	-	-	-	-	-	-
J-4	ENC	3.00	372.41	4	-	-	-	-	-	4	4	4	-	-	-	-	-	-	-	-
J-8	ENC	3.00	363.75	20	-	-	-	-	-	20	20	20	-	-	-	-	-	-	-	-
K-0	ENC	3.00	381.07	48	-	-	-	-	-	-	48	48	48	-	-	-	-	-	-	-
K-4	ENC	3.00	372.41	4	-	-	-	-	-	-	4	4	4	-	-	-	-	-	-	-
K-8	ENC	3.00	363.75	20	-	-	-	-	-	-	20	20	20	-	-	-	-	-	-	-

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TABLE 2.3
(CONTINUED)
MAINE YANKEE
FUEL ASSEMBLY TYPES BY CYCLE - SUB-BATCH DETAIL

Assembly Type and Number of Poison Rods	Fuel Vendor and Design	Assembly As-Modeled Enrichment (w/o U-235)	Assembly As-Modeled Weights (kg U)	Number of Assemblies	Assemblies in Core by Cycle															
					1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L-0	ENC	3.30	379.21	16	-	-	-	-	-	-	-	16	16	16	8	8	-	-	-	-
L-4	ENC	3.30	370.59	12	-	-	-	-	-	-	-	12	12	12	-	-	-	-	-	-
L-8	ENC	3.30	361.97	40	-	-	-	-	-	-	-	40	40	40	-	-	-	-	-	-
L-12	ENC	3.30	353.35	4	-	-	-	-	-	-	-	4	4	4	-	-	-	-	-	-
M-0	ENC	3.30	379.21	8	-	-	-	-	-	-	-	-	8	8	8	-	-	-	-	8
M-4	ENC	3.30	370.59	28	-	-	-	-	-	-	-	-	28	28	28	-	-	-	-	-
M-8	ENC	3.30	361.97	36	-	-	-	-	-	-	-	-	36	36	28	1	1	1	1	1
N-0	CE-2	3.30	389.03	4	-	-	-	-	-	-	-	-	-	4	4	4	-	-	-	-
N-4	CE-2	3.30	380.19	24	-	-	-	-	-	-	-	-	-	24	24	24	-	-	-	-
N-8	CE-2	3.30	371.35	44	-	-	-	-	-	-	-	-	-	44	44	36	-	-	-	-
P-0	CE-2	3.50	389.03	28	-	-	-	-	-	-	-	-	-	-	28	28	28	-	8	-
P-4	CE-2	3.50	380.19	20	-	-	-	-	-	-	-	-	-	-	20	20	20	-	-	-
P-8	CE-2	3.50	371.35	24	-	-	-	-	-	-	-	-	-	-	24	24	24	8	-	-
Q-0	CE-2	3.70	391.14	28	-	-	-	-	-	-	-	-	-	-	-	28	28	28	-	-
Q-4	CE-2	3.70	382.25	36	-	-	-	-	-	-	-	-	-	-	-	36	36	32	-	-
Q-8	CE-2	3.70	373.36	8	-	-	-	-	-	-	-	-	-	-	-	8	8	8	-	-
R-0	CE-2	3.70	391.14	36	-	-	-	-	-	-	-	-	-	-	-	-	36	36	36	-
R-4	CE-2	3.70	382.25	16	-	-	-	-	-	-	-	-	-	-	-	-	16	16	12	4
R-8	CE-2	3.70	373.36	20	-	-	-	-	-	-	-	-	-	-	-	-	20	20	20	-
S-0	CE-2	3.70	389.85	20	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	16
S-4	CE-2	3.70	380.99	28	-	-	-	-	-	-	-	-	-	-	-	-	-	28	28	28
S-8	CE-2	3.70	372.13	20	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	20
T-0	CE-2	3.91	389.85	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8
T-4	CE-2	3.91	380.99	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	28
T-8	CE-2	3.90	372.13	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36	36
U-0	W	3.74	391.00	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
U-24	W	3.74	391.00	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32
U-48	W	3.74	391.00	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28

TABLE 2.4

MAINE YANKEE
DESIGN AND AS-BUILT ENRICHMENTS AND LOADINGS BY ASSEMBLY TYPE

Assembly Type and Number of Poison Rods	Fuel Vendor and Design	Number of Assemblies	Assembly Design Enrichments (w/o U-235)			Average Enrichment (w/o U-235)		Assembly Average Loading (kg U)		
			Low Region	High Region	Blanket Region	Assembly Design	Assembly As-Built	Design	As-Modeled	As-Built
A-0	CE-1	69	2.03	2.03	2.03	2.03	2.023	394.8	394.82	393.975
B-16	CE-1	80	2.40	2.40	2.40	2.40	2.408	358.9	358.93	358.267
C-0	CE-1	24	2.95	2.95	2.95	2.95	2.946	394.8	394.82	394.706
C-12	CE-1	36	2.95	2.95	2.95	2.95	2.950	367.9	367.90	367.991
C-16	CE-1	8	2.95	2.95	2.95	2.95	2.953	358.9	358.93	358.460
RF-0	CE-RF	14	1.95	1.95	1.95	1.95	1.938	394.8	394.82	395.280
RF-4	CE-RF	55	1.95	1.95	1.95	1.95	1.935	385.8	385.85	386.426
RF-0	CE-RF	2	2.33	2.33	2.33	2.33	2.341	394.8	394.82	395.455
RF-5	CE-RF	1	2.01	2.01	2.01	2.01	2.006	383.6	383.60	380.050
D-0	CE-2	69	1.95	1.95	1.95	1.95	1.950	388.7	389.03	389.669
E-16	CE-2	80	2.52	2.52	2.52	2.52	2.517	353.4	353.66	353.693
F-0	CE-2	40	2.90	2.90	2.90	2.90	2.888	388.7	389.03	389.142
F-8	CE-2	12	2.90	2.90	2.90	2.90	2.884	371.0	371.34	372.158
F-12	CE-2	16	2.90	2.90	2.90	2.90	2.884	362.2	362.50	363.271
G-0	CE-2	16	2.74	2.74	2.74	2.74	2.741	388.7	389.03	388.814
G-4	CE-2	16	2.74	2.74	2.74	2.74	2.740	379.9	380.19	380.286
H-0	CE-2	40	3.03	3.03	3.03	3.03	3.036	388.7	389.03	387.765
I-0	CE-2	48	3.03	3.03	3.03	3.03	3.035	388.7	389.03	388.812
I-4	CE-2	24	3.03	3.03	3.03	3.03	3.032	379.9	380.19	378.882
J-0	ENC	48	3.00	3.00	3.00	3.00	3.003	381.1	381.07	381.481
J-4	ENC	4	3.00	3.00	3.00	3.00	3.003	372.5	372.41	372.852
J-8	ENC	20	3.00	3.00	3.00	3.00	3.003	363.8	363.75	363.991
K-0	ENC	48	3.00	3.00	3.00	3.00	3.002	381.1	381.07	380.831
K-4	ENC	4	3.00	3.00	3.00	3.00	3.004	372.5	372.41	371.499
K-8	ENC	20	3.00	3.00	3.00	3.00	3.002	363.8	363.75	363.157
L-0	ENC	16	3.30	3.30	3.30	3.30	3.288	381.1	379.21	379.489
L-4	ENC	12	3.30	3.30	3.30	3.30	3.288	372.5	370.59	371.060
L-8	ENC	40	3.30	3.30	3.30	3.30	3.288	363.8	361.97	362.447
L-12	ENC	4	3.30	3.30	3.30	3.30	3.288	355.1	353.35	354.176

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TABLE 2.4
(CONTINUED)
MAINE YANKEE
DESIGN AND AS-BUILT ENRICHMENTS AND LOADINGS BY ASSEMBLY TYPE

Assembly Type and Number of Poison Rods	Fuel Vendor and Design	Number of Assemblies	Assembly Design Enrichments (w/o U-235)			Average Enrichment (w/o U-235)		Assembly Average Loading (kg U)		
			Low Region	High Region	Blanket Region	Assembly Design	Assembly As-Built	Design	As-Modeled	As-Built
M-0	ENC	8	3.30	3.30	3.30	3.30	3.301	381.1	379.21	378.931
M-4	ENC	28	3.30	3.30	3.30	3.30	3.303	372.5	370.59	370.051
M-8	ENC	36	3.30	3.30	3.30	3.30	3.302	363.8	361.97	361.572
N-0	CE-2	4	3.30	3.30	3.30	3.30	3.307	388.7	389.03	388.183
N-4	CE-2	24	3.30	3.30	3.30	3.30	3.303	379.9	380.19	378.365
N-8	CE-2	44	3.30	3.30	3.30	3.30	3.302	371.0	371.35	370.078
P-0	CE-2	28	3.50	3.50	3.50	3.50	3.502	388.7	389.03	389.332
P-4	CE-2	20	3.50	3.50	3.50	3.50	3.501	379.9	380.19	379.850
P-8	CE-2	24	3.50	3.50	3.50	3.50	3.499	371.0	371.35	371.216
Q-0	CE-2	28	3.70	3.70	3.70	3.70	3.690	388.7	391.14	390.712
Q-4	CE-2	36	3.70	3.70	3.70	3.70	3.693	379.9	382.25	380.581
Q-8	CE-2	8	3.70	3.70	3.70	3.70	3.695	371.0	373.36	372.789
R-0	CE-2	36	3.70	3.70	3.70	3.70	3.684	390.8	391.14	390.577
R-4	CE-2	16	3.70	3.70	3.70	3.70	3.682	381.9	382.25	382.223
R-8	CE-2	20	3.70	3.70	3.70	3.70	3.681	373.0	373.36	374.061
S-0	CE-2	20	3.70	3.70	3.70	3.70	3.702	389.5	389.85	390.635
S-4	CE-2	28	3.70	3.70	3.70	3.70	3.700	380.6	380.99	381.292
S-8	CE-2	20	3.70	3.70	3.70	3.70	3.702	371.8	372.13	372.285
T-0	CE-2	8	3.50	4.20	3.50/4.20	3.91	3.918	389.5	389.85	391.319
T-4	CE-2	28	3.50	4.20	3.50/4.20	3.91	3.906	380.6	380.99	381.947
T-8	CE-2	36	3.50	4.20	3.50/4.20	3.90	3.895	371.8	372.13	373.550
U-0	W	8	3.40	4.00	2.60	3.74	3.742	387.9	391.00	390.342
U-24	W	32	3.40	4.00	2.60	3.74	3.739	387.9	391.00	389.643
U-48	W	28	3.40	4.00	2.60	3.74	3.740	387.9	391.00	389.498

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TABLE 2.5

Maine Yankee
Type UX and V Enrichment and Uranium Loadings
Fresh Fuel Fabricated for Cycle 16

Parameter	Type UX-0	Type V-0	Type V-4	Type V-8	Total
Fuel Vendor	SPC	CE	CE	CE	-
Number of Assemblies	8	36	4	44	92
Number of Rods in Assembly					
2.40 w/o U-235 fuel[1]	176	0	0	0	-
3.50 w/o U-235 fuel[2]	0	72	72	72	-
4.20 w/o U-235 fuel[2]	0	104	100	96	-
31.4 mg B-10 per inch shims[3]	0	0	4	8	-
Total	176	176	176	176	-
Number of Rods in Batches					
2.40 w/o U-235 fuel	1408	0	0	0	1408
3.50 w/o U-235 fuel	0	2592	288	3168	6048
4.20 w/o U-235 fuel	0	3744	400	4224	8368
31.4 mg B-10 per inch shims	0	0	16	352	368
Total	1408	6336	704	7744	16192
Assembly Average Enrichment (w/o U-235)					
Design	2.400	3.914	3.907	3.900	-
As-Built	2.416	3.928	3.929	3.919	-
Assembly Average Uranium Loading (kg U)					
Design[4]	380.406	389.488	380.636	371.784	-
As-Built	380.2866	391.0953	382.2826	373.6973	-

1) Uniform fuel rod enrichments in 136.7 inch active fuel height for Type UX
2) Uniform fuel rod enrichments in 136.25 inch active fuel height for Type V
3) Uniform shim loading in central 122.7 inches of active fuel height for Type V
4) Design uranium loading of 2.1614 kg U per rod for Type UX
Design uranium loading of 2.213 kg U per rod for Type V

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TABLE 2.6.1

Maine Yankee
Number of Assemblies,
Spent Fuel Pool Storage Capacity and Requirements

Total Number of Assemblies Fabricated		1530
Number of Unirradiated Assemblies	Type A, Serial Number A003 (not on-site)	1
	Type B, Serial Number B068 (not on-site)	1
	Type C, Serial Number C210 (not on-site)	1
	Type D, Serial Number EF004B (not on-site)	1
	Type UX (currently in new fuel vault)	8
	Type V (currently at Combustion Engineering)	84
Total Number of Assemblies Irradiated		1434
Storage Requirements for Criticality	Required in Region I	
	Type C	46
	Type RF	2
	Type T	28
	Type U	68
	Total Region I	144
Total Number of Storage Locations	Region I	228
	Region II	1791
	Total	2019

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TABLE 2.6.2

Maine Yankee
Discharged Assemblies on Site with Storage Restricted to Region I Only

Type C (46)			Type RF (2)	Type T (28)			Type U (68)		
(24)	(21)	(1)	(2)	(8)	(16)	(4)	(8)	(32)	(28)
C-0	C-12	C-16	RF-0	T-0	T-4	T-8	U-0	U-24	U-48
C101	C202	C301	EF0041	T001	T409	T868	U01	U09	U41
C102	C203		EF0043	T002	T411	T869	U02	U10	U42
C103	C205			T003	T412	T870	U03	U11	U43
C104	C209			T004	T414	T871	U04	U12	U44
C105	C213			T005	T415		U05	U13	U45
C106	C216			T006	T419		U06	U14	U46
C108	C217			T007	T420		U07	U15	U47
C109	C218			T008	T421		U08	U16	U48
C110	C219				T422			U17	U49
C111	C221				T424			U18	U50
C112	C222				T426			U19	U51
C113	C223				T427			U20	U52
C114	C224				T428			U21	U53
C115	C230				T429			U22	U54
C116	C231				T431			U23	U55
C117	C232				T432			U24	U56
C118	C233							U25	U57
C119	C234							U26	U58
C120	C235							U27	U59
C121	C236							U28	U60
C122	C237							U29	U61
C123								U30	U62
C124								U31	U63
C125								U32	U64
								U33	U65
								U34	U66
								U35	U67
								U36	U68
								U37	
								U38	
								U39	
								U40	

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TABLE 3.1

Maine Yankee Cycles 1-15
Fuel Cycle Information

CYCLE	1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DATES																
Startup	11/ 8/72	10/12/74	6/29/75	6/11/77	8/28/78	3/17/80	7/20/81	12/12/82	6/20/84	10/25/85	6/18/87	12/16/88	6/30/90	4/19/92	10/14/93	1/16/96
Shutdown	6/29/74	5/ 2/75	4/ 9/77	7/14/78	1/11/80	5/ 8/81	9/24/82	3/31/84	8/17/85	3/28/87	10/15/88	4/ 7/90	2/14/92	7/30/93	1/14/95	12/ 6/96
DAYS																
Refueling and Testing	-	105	58	63	45	66	73	79	81	69	82	62	84	65	76	367
Power Operation																
Full Power	598	202	605	363	457	406	396	440	365	453	423	452	537	415	457	325
Coastdown	0	0	45	35	44	11	35	35	58	66	62	25	57	52	0	0
Total Power Operation	598	202	650	398	501	417	431	475	423	519	485	477	594	467	457	325
MONTHS																
Refueling and Testing	-	3.4	1.9	2.1	1.5	2.2	2.4	2.6	2.7	2.3	2.7	2.0	2.8	2.1	2.5	12.1
Power Operation	19.6	6.6	21.4	13.1	16.5	13.7	14.2	15.6	13.9	17.1	15.9	15.7	19.5	15.3	15.0	10.7
Cycle Total	19.6	10.0	23.3	15.1	17.9	15.9	16.6	18.2	16.6	19.3	18.6	17.7	22.3	17.5	17.5	22.7
GENERATION																
Power Level (MWt)	2440	2440	2440	2440	2560	2560	2560	2630	2630	2630	2630	2630	2700	2700	2700	2440
Thermal Capacity Factor																
Excluding Refueling (%)	58	76	89	95	67	84	86	81	90	84	81	91	80	90	88	82
Including Refueling (%)	58	50	82	82	61	72	74	69	75	74	69	80	70	79	75	39
CORE LOADINGS																
Uranium, As-Built (MTU)	81.434	83.084	81.026	83.130	81.822	83.006	82.220	80.905	80.231	80.120	81.227	82.389	83.051	83.028	82.819	83.062
Enrichment, As-Built																
Fresh Fuel (w/o U_{235})	2.44	1.94	2.45	2.90	3.03	3.00	3.00	3.29	3.30	3.30	3.50	3.69	3.68	3.70	3.91	3.74
Core Average (w/o U_{235})	2.44	2.30	2.45	2.59	2.84	2.98	3.01	3.10	3.20	3.29	3.36	3.50	3.62	3.68	3.75	3.76
BURNUPS (MWD/MT)																
Cycle Length																
End-of-Full Power Life	-	-	16300	10500	9800	10500	10700	11600	11000	12700	11400	13250	13900	12200	-	-
Coastdown	0	0	1096	576	695	295	882	865	1455	1661	1247	548	1523	1468	0	0
Total	10336	4509	17396	11076	10495	10795	11582	12465	12455	14361	12647	13798	15423	13668	13075	7859
Discharged Assemblies																
Number	72	152	70	133	73	73	73	73	73	68	65	73	61	77	81	217
Average	11475	13564	18073	21665	30319	31971	33003	33566	35662	37506	38386	40161	42078	43899	41912	24209
Maximum	12466	17209	20434	30493	33408	33882	36126	38235	38341	42882	44222	46045	47079	49241	48341	41372

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TABLE 3.2

Maine Yankee Cycles 1-15
Discharge Burnup History vs. Industry Average

Year of Discharge	Discharge Average Burnup (MWd/Mt) Industry Average* for PWRs	Maine Yankee	Difference (%)	Maine Yankee Discharge after Cycle
1974	18,900	11,475	-39.3	1
1975	18,100	13,564	-25.1	1A
1976	22,200	-	-	-
1977	25,100	18,073	-28.0	2
1978	26,400	21,665	-17.9	3
1979	27,000	-	-	-
1980	30,700	30,319	-1.2	4
1981	30,900	31,971	3.5	5
1982	32,300	33,003	2.2	6
1983	31,600	-	-	-
1984	32,100	33,566	4.6	7
1985	33,200	35,662	7.4	8
1986	33,900	-	-	-
1987	34,400	37,506	9.0	9
1988	35,400	38,386	8.4	10
1989	36,800	-	-	-
1990	36,000	40,161	11.6	11
1991	37,400	-	-	-
1992	38,700	42,078	8.7	12
1993	38,900	43,899	12.9	13
1994	40,800	-	-	-
1995	-	41,912	-	14
1996	-	-	-	-
1997	-	24,209	-	15

* Industry average data from SR/CNEAF/96-01, *Spent Nuclear Fuel Discharges from U.S. Reactors 1994*, Energy Information Administration, U. S. Department of Energy, February 1996, Table 5.
1974-1979 industry average data from *All Discharged Assemblies - PWR*
1980-1994 industry average data from *Equilibrium Cycle Discharges - PWR* (excluding discharge data from Cycles 1 and 2 of each reactor)

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Figure 1.1

Maine Yankee Fuel Information for Cycles 1-15

Length of Outages, Full Power Operation, and Coastdowns in Days

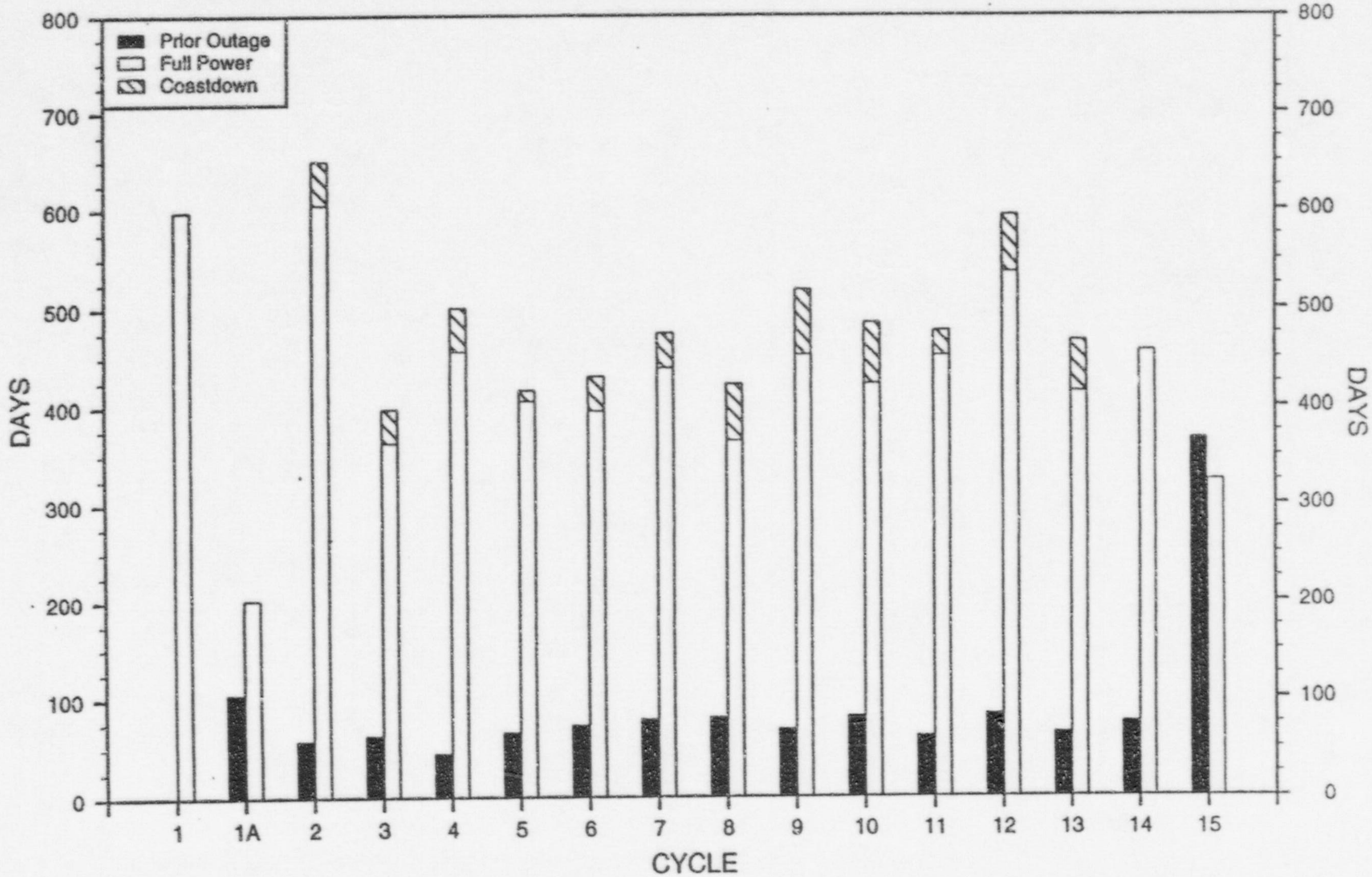

Figure 1.2

Maine Yankee Fuel Information for Cycles 1-15

Length of Full Power Operation and Coastdown in EFPDs

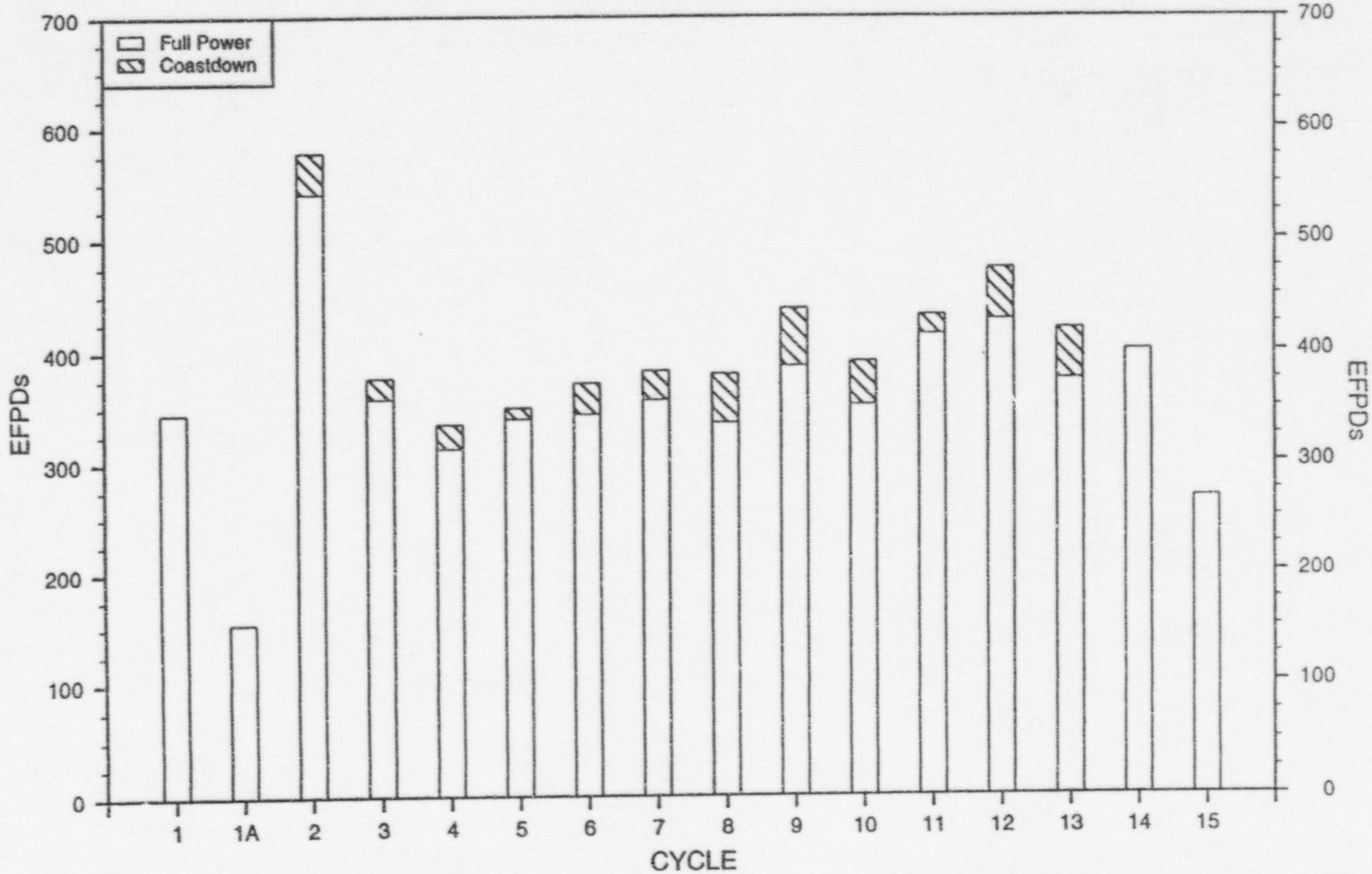

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Figure 1.3

Maine Yankee Fuel Information for Cycles 1-15

Thermal Capacity Factor, Excluding and Including Prior Outage

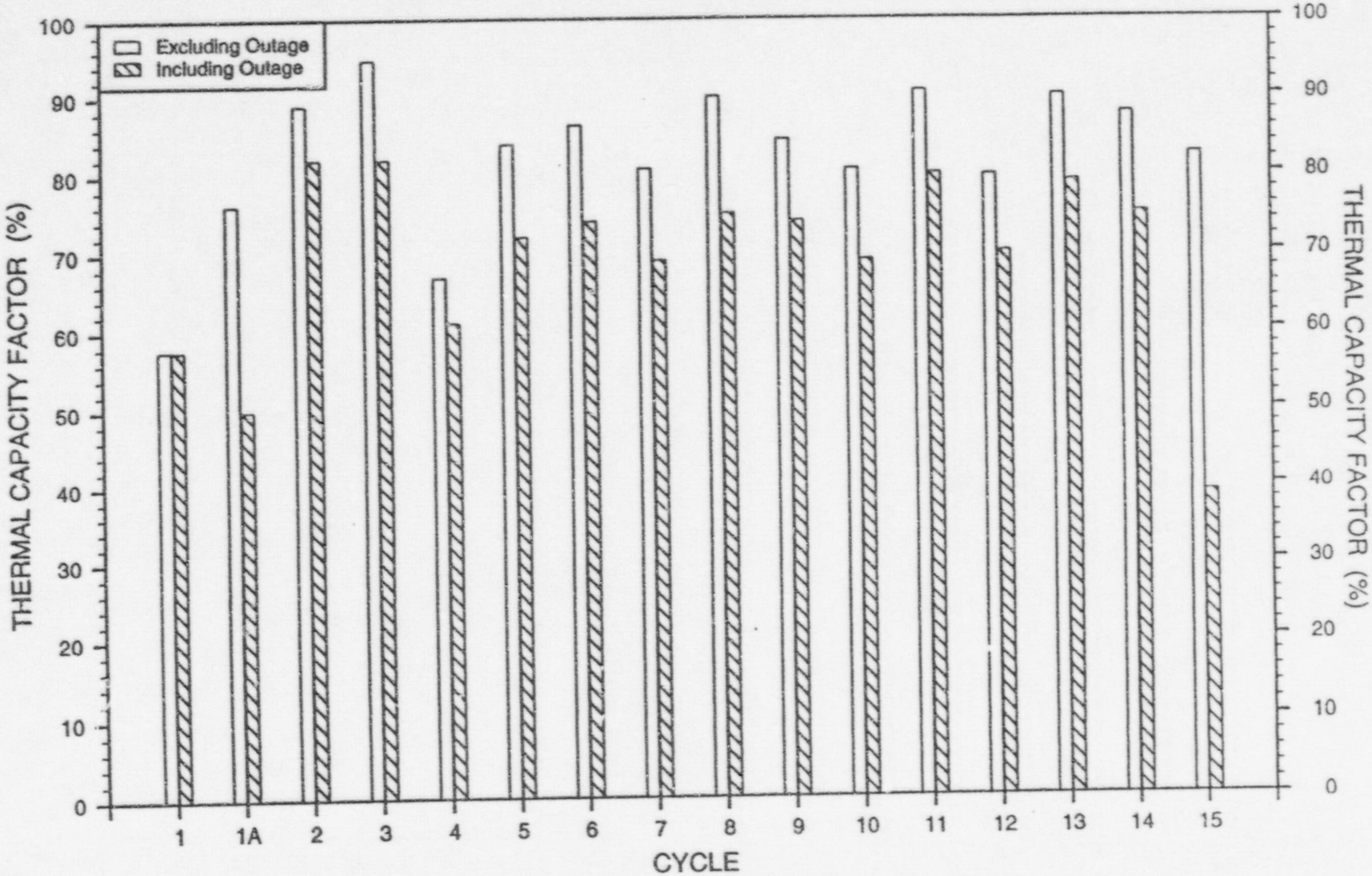

Figure 1.4

Maine Yankee Fuel Information for Cycles 1-15

Fresh Fuel and Core Average Enrichment

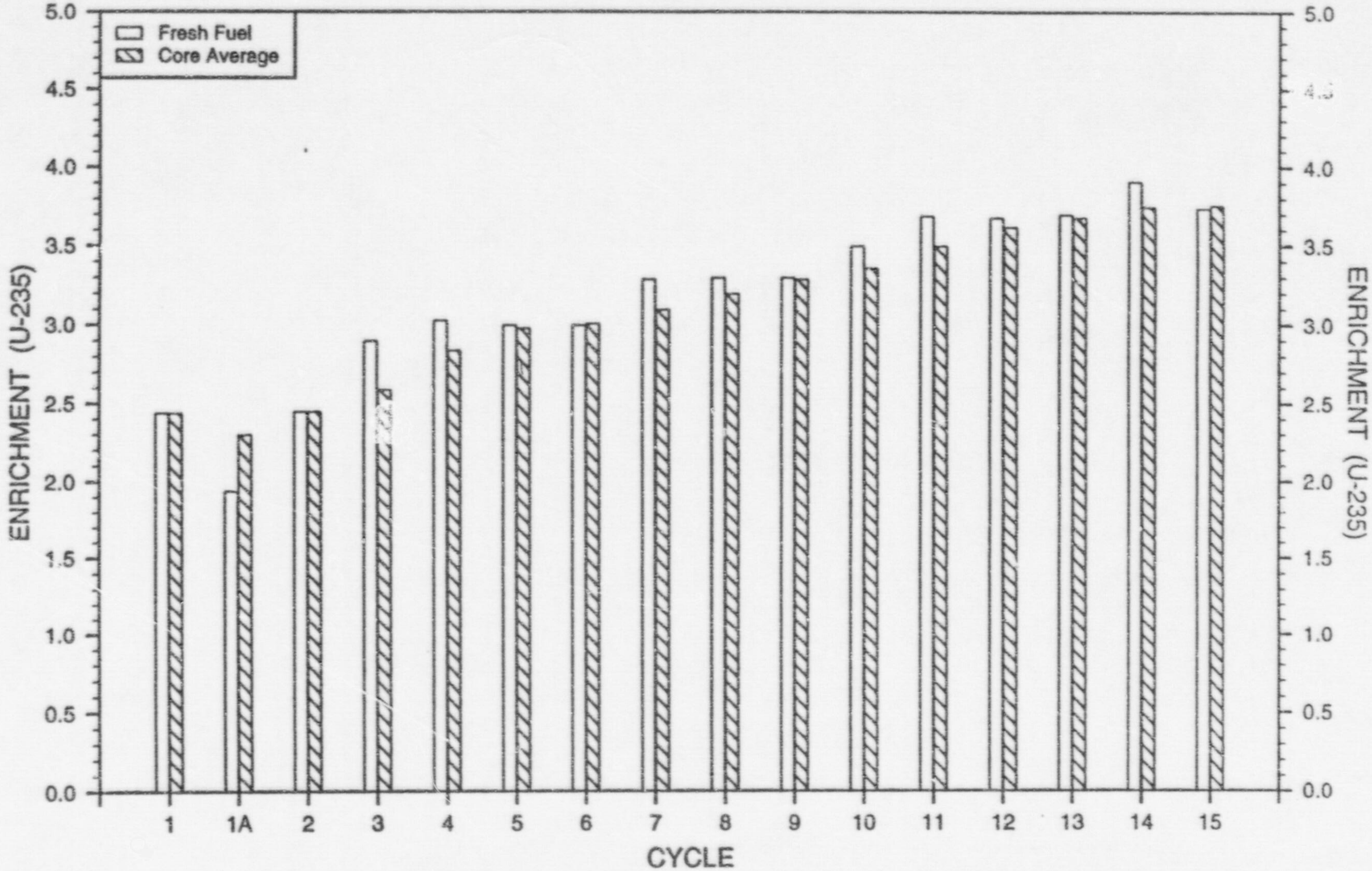

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Figure 1.5

Maine Yankee Fuel Information for Cycles 1-15

Average and Maximum Discharged Assembly Burnups

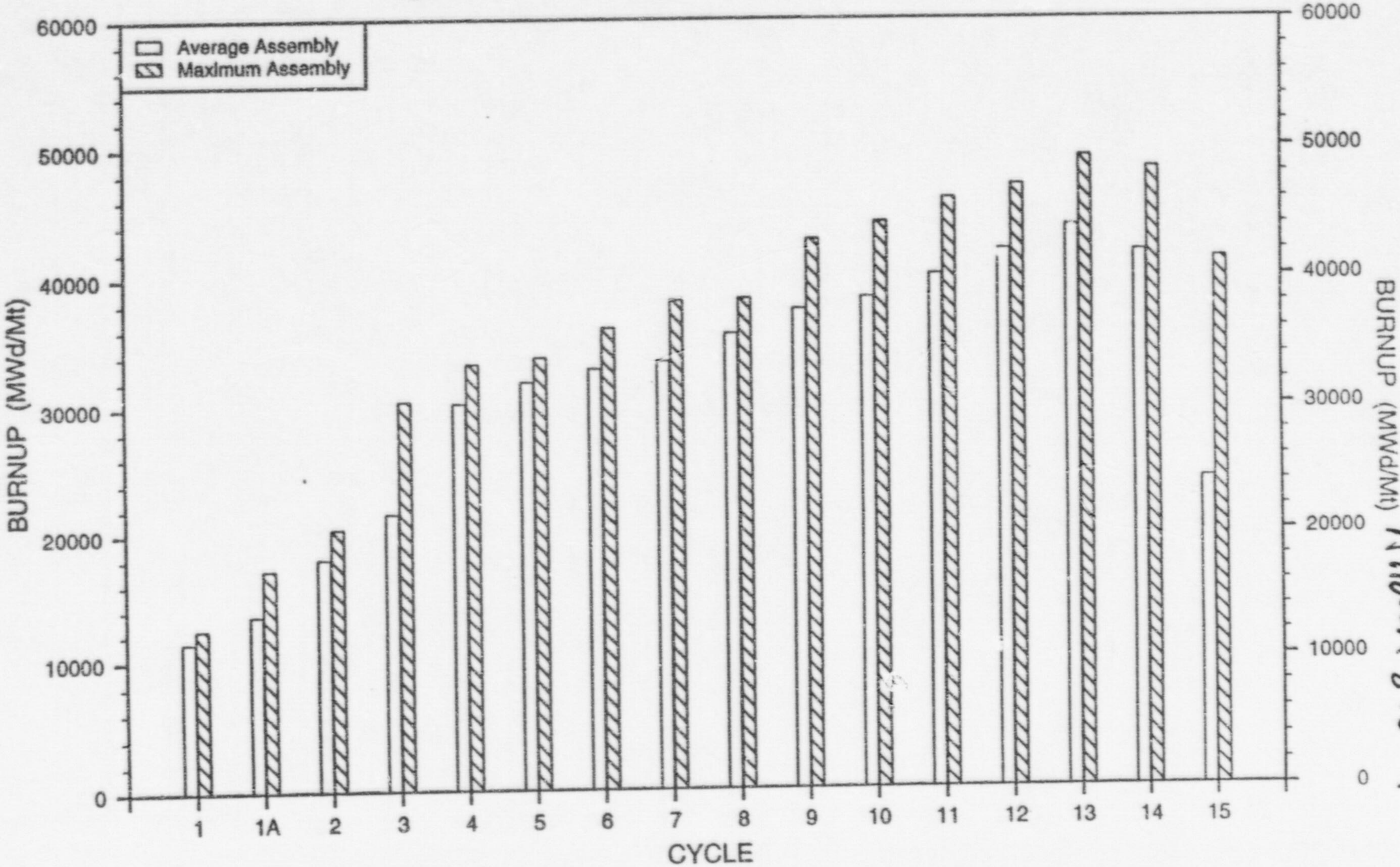

Figure 1.6

Maine Yankee Fuel Information for Cycles 1-15

Discharged Assembly Average Burnups vs. U.S. Industry Average for PWRs

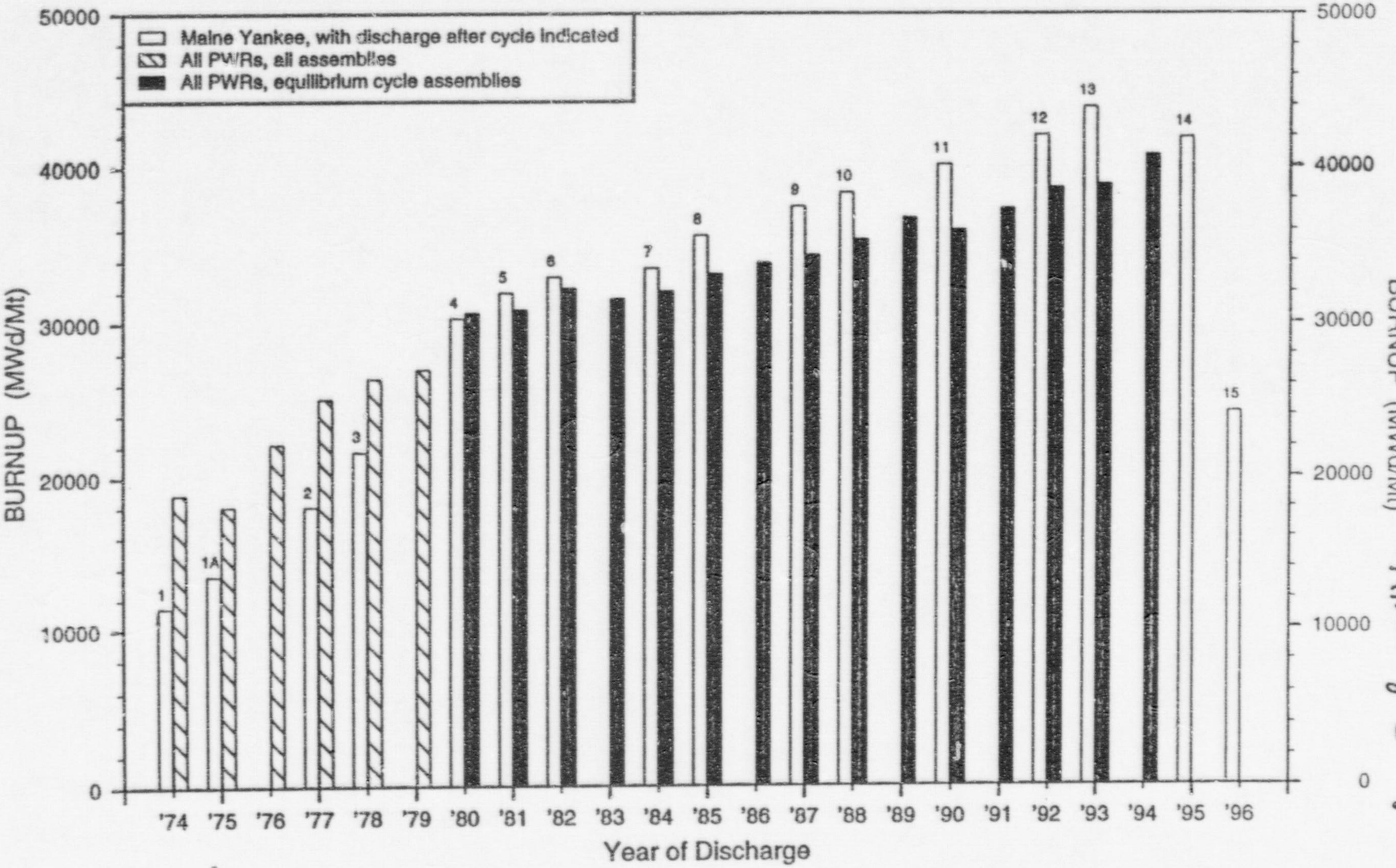

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FIGURE A

MAINE YANKEE FUEL SCHEDULE FOR EOC 15 (FSXM042)

CYCLES 1 THROUGH 15 (REVISED 08/11/97)

CYCLE PARAMETERS

CYCLE	DATES IN	DATES OUT	PRIOR OUTAGE	DAYS CYCLE TOTAL	DAYS COAST-DOWN	CYCLE LOADING (KGU) AS-MODELED	CYCLE LOADING (KGU) AS-BUILT	POWER LEVEL (MWt)	CYCLE LENGTH MWD/MT TO EOFPL	CYCLE LENGTH MWD/MT TO EOC	CYCLE LENGTH EFPDs TO EOFPL	CYCLE LENGTH EFPDs TO EOC	CAPACITY FACTOR TO EOFPL	CAPACITY FACTOR TO EOC
1	11/08/72	06/29/74	0	598	0	81549	81434	2440	-	10336	-	345	-	.577
1A	10/12/74	05/02/75	105	202	0	83119	83084	2440	-	4509	-	154	-	.762
2	06/29/75	04/09/77	58	650	45	80953	81026	2440	16300	17396	541	578	.894	.889
3	06/11/77	07/14/78	63	398	35	83118	83130	2440	10500	11076	358	377	.986	.948
4	08/28/78	01/11/80	45	501	44	81908	81822	2560	9800	10495	313	335	.685	.669
5	03/17/80	05/08/81	66	417	11	83076	83006	2560	10500	10795	340	350	.837	.839
6	07/20/81	09/24/82	73	431	35	82264	82220	2560	10700	11582	344	372	.869	.863
7	12/12/82	03/31/84	79	475	35	80872	80905	2630	11600	12465	357	383	.811	.807
8	06/20/84	08/17/85	81	423	58	80257	80231	2630	11000	12455	336	380	.921	.899
9	10/25/85	03/28/87	69	519	66	80221	80120	2630	12700	14361	387	438	.854	.844
10	06/18/87	10/15/88	82	485	62	81362	81227	2630	11400	12647	352	391	.832	.806
11	12/16/88	04/07/90	62	477	25	82554	82389	2630	13250	13798	415	432	.918	.906
12	06/30/90	02/14/92	84	594	57	83135	83051	2700	13900	15423	428	474	.797	.798
13	04/19/92	07/30/93	65	467	52	83075	83028	2700	12200	13668	375	420	.904	.900
14	10/14/93	01/14/95	76	457	0	82700	82819	2700	-	13075	-	401	-	.877
15	01/16/96	12/06/96	367	325	0	83044	83062	2440	-	7859	-	268	-	.825

BATCH NO.	FUEL TYPE	NO. OF ASSYS	WT./ASSY KGU	ENRICHMENT (%) IN	ENRICHMENT (%) OUT	RATIO TO U-INITIAL U-OUT	RATIO TO U-INITIAL FISS-PU(%)	CYCLES 1	CYCLES 2	CYCLES 3	CYCLES 4	CYCLES 5	BURNUPS (MWD/MT) 1	BURNUPS 2	BURNUPS 3	BURNUPS 4	BURNUPS 5	TOTAL
0100010	A0	12	393.887 *	2.027 *	1.117	.984	.378	1	-	-	-	-	10611	-	-	-	-	10611
0101010	B16	56	358.295 *	2.407 *	1.346	.982	.397	1	-	-	-	-	11912	-	-	-	-	11912
0102010	C0	2	395.219 *	2.944 *	2.271	.990	.261	1	-	-	-	-	6522	-	-	-	-	6522
0103010	C12	1	368.196 *	2.957 *	1.934	.985	.365	1	-	-	-	-	10470	-	-	-	-	10470
0104010	C16	1	358.808 *	2.957 *	1.945	.985	.364	1	-	-	-	-	10359	-	-	-	-	10359
0100011	A0	57	393.993 *	2.023 *	.830	.977	.456	1	1A	-	-	-	11059	4636	-	-	-	15695
0101011	B16	24	358.201 *	2.410 *	1.089	.977	.450	1	1A	-	-	-	10846	5148	-	-	-	15994
0102011	C0	22	394.659 *	2.947 *	2.090	.987	.317	1	1A	-	-	-	6056	2509	-	-	-	8565
0103011	C12	35	367.985 *	2.950 *	1.716	.981	.417	1	1A	-	-	-	9289	4041	-	-	-	13330
0104011	C16	7	358.410 *	2.953 *	1.602	.979	.440	1	1A	-	-	-	10359	4525	-	-	-	14884
0110011	RF0	2	395.455 *	2.341 *	1.735	.995	.145	1A	-	-	-	-	2769	-	-	-	-	2769
0111011	RF0	2	395.323 *	1.938 *	1.511	.993	.210	1A	-	-	-	-	4316	-	-	-	-	4316
0112011	RF4	2	386.173 *	1.930 *	1.449	.992	.241	1A	-	-	-	-	5058	-	-	-	-	5058
0113011	RF5	1	380.050 *	2.006 *	1.442	.992	.244	1A	-	-	-	-	5150	-	-	-	-	5150
0110030	RF0	12	395.273 *	1.938 *	.789	.978	.451	1A	3	-	-	-	5387	10463	-	-	-	15850
0111030	RF4	53	386.436 *	1.935 *	.776	.977	.454	1A	3	-	-	-	5079	11144	-	-	-	16223
0200020	D0	69	389.669 *	1.950 *	.715	.976	.466	2	-	-	-	-	18042	-	-	-	-	18042
0201020	E16	1	354.183 *	2.515 *	1.013	.973	.494	2	-	-	-	-	20434	-	-	-	-	20434
0200030	E16	12	353.782 *	2.517 *	.582	.962	.530	2	3	-	-	-	18697	10726	-	-	-	29423
0201030	F0	28	389.028 *	2.887 *	1.026	.968	.540	2	3	-	-	-	12368	12041	-	-	-	24409
0202030	F8	12	372.158 *	2.884 *	.810	.962	.554	2	3	-	-	-	17689	11153	-	-	-	28842
0203030	F12	16	363.271 *	2.884 *	.787	.962	.548	2	3	-	-	-	18124	11138	-	-	-	29262
0200040	E16	61	353.710 *	2.517 *	.575	.961	.530	2	4	-	-	-	19758	9938	-	-	-	29696
[illegible]1040	F0	12	389.409 *	2.888 *	.647	.957	.585	2	3	4	-	-	11134	12226	9833	-	-	33193
0200050	E16	1	351.636 *	2.506 *	.623	.963	.528	2	5	-	-	-	17697	10373	-	-	-	28070

not important mws 11/26/97

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Attach. 8.6

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MWS 12/1/97 not important

FIGURE A
MAINE YANKEE FUEL SCHEDULE FOR EOC 15 (FSXM042)
CYCLES 1 THROUGH 15 (REVISED 08/11/97)

ATCH NO.	FUEL TYPE	NO. OF ASSYS	WT./ASSY KGU	ENRICHMENT (%) IN	OUT	RATIO TO U-INITIAL U-OUT	FISS-PU(%)	CYCLES 1	2	3	4	5	BURNUPS (MWD/MT) 1	2	3	4	5	TOTAL
00060	E16	1	352.289 *	2.524 *	.617	.963	.528	2	6	-	-	-	17697	11115	-	-	-	28812
00070	E16	1	354.361 *	2.517 *	.554	.961	.531	2	7	-	-	-	17697	12779	-	-	-	30476
00080	E16	1	353.373 *	2.530 *	.522	.960	.532	2	8	-	-	-	20434	11431	-	-	-	31865
00090	E16	1	354.368 *	2.517 *	.469	.958	.533	2	9	-	-	-	20404	13415	-	-	-	33819
00100	E16	1	353.516 *	2.518 *	.466	.958	.533	2	10	-	-	-	20434	13242	-	-	-	33676
00050	G0	16	388.814 *	2.741 *	.595	.958	.576	3	4	5	-	-	11956	10726	9262	-	-	31944
01050	G41	4	379.997 *	2.744 *	.552	.957	.568	3	4	5	-	-	13294	10953	8788	-	-	33035
02050	G42	12	380.382 *	2.738 *	.533	.956	.570	3	4	5	-	-	13361	10492	9834	-	-	33687
03050	H0	40	387.765 *	3.036 *	.770	.959	.586	3	4	5	-	-	8959	11901	10601	-	-	31461
00060	I0	48	388.812 *	3.035 *	.775	.959	.586	4	5	6	-	-	8887	11782	11243	-	-	31912
01060	I4	24	378.882 *	3.032 *	.633	.955	.585	4	5	6	-	-	12823	11802	10780	-	-	35405
00070	J0	48	381.481 *	3.003 *	.713	.958	.577	5	6	7	-	-	9178	12752	10796	-	-	32726
01070	J4	4	372.852 *	3.003 *	.520	.952	.579	5	6	7	-	-	13293	12998	11944	-	-	38235
02070	J8	20	363.991 *	3.003 *	.619	.955	.566	5	6	7	-	-	13325	12926	8622	-	-	34873
00080	K0	48	380.831 *	3.002 *	.631	.955	.582	6	7	8	-	-	9536	14039	11934	-	-	35509
01080	K4	4	371.499 *	3.004 *	.531	.952	.578	6	7	8	-	-	13449	13845	11047	-	-	38341
02080	K8	20	363.157 *	3.002 *	.603	.955	.567	6	7	8	-	-	13658	13615	8412	-	-	35685
00090	L0	8	379.564 *	3.288 *	.651	.951	.610	7	8	9	-	-	11253	13808	14623	-	-	39684
01090	L4	12	371.060 *	3.288 *	.573	.948	.606	7	8	9	-	-	14123	13473	14121	-	-	41717
02090	L8	40	362.447 *	3.288 *	.764	.955	.585	7	8	9	-	-	13769	12718	9317	-	-	35804
03090	L12	4	354.176 *	3.288 *	.552	.948	.587	7	8	9	-	-	15236	13924	12828	-	-	41[illegible]
00110	L0	8	379.415 *	3.288 *	.712	.953	.606	7	8	9	10	11	10315	7276	7831	5101	6013	36[illegible]
00090	M8	3	362.029 *	3.303 *	.960	.960	.577	8	9	-	-	-	15703	16515	-	-	-	32218
01100	M4	28	370.051 *	3.303 *	.648	.951	.601	8	9	10	-	-	12935	14282	11935	-	-	39152
02100	M8	28	361.453 *	3.302 *	.616	.950	.594	8	9	10	-	-	15406	16215	7922	-	-	39543
00110	M8	1	362.537 *	3.299 *	.411	.942	.593	8	9	11	-	-	16373	16296	13376	-	-	46045
00120	M8	1	362.544 *	3.300 *	.408	.942	.593	8	9	12	-	-	16373	16296	14410	-	-	47079
00130	M8	1	361.651 *	3.30[illegible] *	.487	.945	.594	8	9	13	-	-	15234	15699	13324	-	-	44257
00140	M8	1	361.722 *	3.299 *	.476	.945	.594	8	9	14	-	-	15234	15699	12273	-	-	43206
00150	M0	8	378.931 *	3.301 *	.696	.952	.607	8	9	10	15	-	11899	16843	5772	2204	-	36718
01150	M8	1	361.382 *	3.302 *	.638	.951	.592	8	9	15	-	-	15234	15699	7204	-	-	38137
00100	N8	8	369.564 *	3.301 *	.943	.959	.588	9	10	-	-	-	18420	13885	-	-	-	32305
00110	N0	4	388.183 *	3.307 *	.602	.949	.627	9	10	11	-	-	14878	13079	12225	-	-	40182
01110	N4	24	378.365 *	3.303 *	.550	.947	.618	9	10	11	-	-	14956	14026	12799	-	-	41781
02110	N8	36	370.192 *	3.302 *	.603	.949	.607	9	10	11	-	-	17880	14035	7806	-	-	39721
00120	P0	20	389.140 *	3.502 *	.748	.950	.633	10	11	12	-	-	12754	15445	11393	-	-	39592
01120	P4	20	379.850 *	3.501 *	.559	.944	.629	10	11	12	-	-	15558	15360	14366	-	-	45284
02120	P8	16	370.907 *	3.500 *	.621	.946	.619	10	11	12	-	-	16819	15453	10667	-	-	42939
00130	P8	8	371.834 *	3.496 *	.582	.945	.619	10	11	12	13	-	16790	15364	6496	4951	-	43601
00140	P0	8	389.811 *	3.502 *	.711	.949	.636	10	11	12	14	-	13718	15348	5626	4709	-	39401
100120	Q4	4	380.873 *	3.694 *	1.131	.957	.617	11	12	-	-	-	16172	18078	-	-	-	34250
100130	Q0	28	390.712 *	3.690 *	.751	.947	.650	11	12	13	-	-	14347	17011	10997	-	-	42355
101130	Q4	32	380.545 *	3.693 *	.681	.945	.641	11	12	13	-	-	17783	17139	9118	-	-	44040
102130	Q8	8	372.789 *	3.695 *	.524	.939	.632	11	12	13	-	-	18150	17861	13230	-	-	49241
200140	R0	36	390.577 *	3.684 *	.826	.949	.647	12	13	14	-	-	16223	15309	7680	-	-	39212
201140	R4	12	382.465 *	3.682 *	.581	.941	.642	12	13	14	-	-	20215	14829	10984	-	-	46028
202140	R8	20	374.061 *	3.681 *	.520	.939	.632	12	13	14	-	-	20098	15369	12456	-	-	47923
200150	R4	4	381.497 *	3.681 *	.782	.948	.641	12	13	15	-	-	20180	12661	7399	-	-	402[illegible]
300140	S0	4	390.455 *	3.702 *	1.252	.960	.613	13	14	-	-	-	15341	14711	-	-	-	30[illegible]
300150	S0	16	390.680 *	3.702 *	1.118	.957	.624	13	14	15	-	-	14239	14992	3508	-	-	32739

MWS 11/24/97 not important

MWS 11/24/97 not important

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Attach 5.6 P. 96

FIGURE A

MAINE YANKEE FUEL SCHEDULE FOR EOC 15 (FSXM042)

CYCLES 1 THROUGH 15 (REVISED 08/11/97)

ATCH NO.	FUEL TYPE	NO. OF ASSYS	WT./ASSY KGU	ENRICHMENT (%) IN	ENRICHMENT (%) OUT	RATIO TO U-INITIAL U-OUT	RATIO TO U-INITIAL FISS-PU(%)	CYCLES 1	CYCLES 2	CYCLES 3	CYCLES 4	CYCLES 5	BURNUPS (MWD/MT) 1	BURNUPS (MWD/MT) 2	BURNUPS (MWD/MT) 3	BURNUPS (MWD/MT) 4	BURNUPS (MWD/MT) 5	TOTAL
01150	S4	28	381.292 *	3.701 *	.925	.952	.632	13	14	15	-	-	16568	14618	5678	-	-	36864
02150	S8	20	372.285 *	3.702 *	.769	.948	.632	13	14	15	-	-	18404	14830	7301	-	-	40535
00150	T0	8	391.319 *	3.918 *	1.969	.971	.535	14	15	-	-	-	12446	8776	-	-	-	21222
01150	T4	28	381.947 *	3.906 *	1.719	.966	.573	14	15	-	-	-	15780	9058	-	-	-	24838
02150	T8	36	373.550 *	3.895 *	1.666	.965	.578	14	15	-	-	-	16453	[illegible]190	-	-	-	25643
00150	U0	8	390.342 *	3.742 *	2.956	.989	.275	15	-	-	-	-	7340	-	-	-	-	7340
01150	U24	32	389.643 *	3.739 *	2.771	.986	.333	15	-	-	-	-	9340	-	-	-	-	9340
02150	U48	28	389.498 *	3.740 *	2.723	.985	.354	15	-	-	-	-	9905	-	-	-	-	9905

* AS-BUILT KGU AND ENRICHMENT

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REV MYC-2004,R0 SFP TH CALCS SB -13-C16-036
11/12/97 MY FINAL DECAY HEAT LOAD CALCS 1 K.02.01.01