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Hanford Atomic Products Operation,
Richland, Washington

May 13, 1954

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 S.E. Gylesen 4-16-90
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SLUG AND TUBE FACTORS

INTRODUCTION:

A common and useful assumption is that the front-to-rear power distribution is a shortened cosine curve. This fact led to the calculation of "slug factors" for the longer charges to be used at K-Pile.

It is hoped that the publication of these numbers will save time and prevent duplication of effort by those concerned in any way with slug power, surface temperatures, reactivity effects, etc. For the sake of completeness, slug factors for the older piles are included.

Another useful idea is that tube power distributions can be approximated by the assumption of a cylindrical pile and a cosine distribution of power outside of a central flattened region. This led to another double set of numbers since the values for the 2004 tube piles were again included for completeness.

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DETAILS:

(1)

I. The K-Pile charge length has been set at 38 - 8" slugs. The augmentation distance was assumed to be two standard 8" slugs. (The current length of an 8" slug is approximately 8.9".) With these two assumptions the following values were calculated as noted: (See Table I)

1. Slug number (N) with No. 1 at upstream end.
2. Cosine value = $\cos\left(\frac{X}{L}\right) 90^\circ$ where X varies in steps of 1.0 from 18.5 to 0.5 and L is taken as 21; the values are then repeated in reverse order for the other half of the column.
3. f value = cosine value * $\sum_1^{38}$ cosine values. This gives "factors" which are proportional to slug power and which total unity for the whole column. Since the gamma heating of the graphite is about 6% of the tube power some have chosen to use factors which total 0.94 when calculating slug power and surface temperature. The difference is of little consequence since the cosine assumption and the heat transfer coefficient have a larger probable error.
4. $\sum_1^N f$ = accumulative sum of factors. This value can be used quite conveniently to find local water temperature.
5. f^2 values = values in column 3 squared.
6. F^2 values = $f^2 * \sum_1^{38} f^2$. This gives a set of factors proportional to slug power squared and which total unity for the whole column. These are useful for some reactivity calculations or for calculating the buildup of Pu^{240} .
7. $\sum_1^N F^2$ = accumulative sum of F^2
8. $\sum_1^N F^2 * \sum_1^N f$ = ratio of summation of squared values to first power values. One use of this value is to determine the percent of Pu^{240} in slugs 1-N when the percent Pu^{240} for the column is known:

$$\left(\frac{\text{Pu}^{240}}{\text{Pu-Total}} \right)_{1-N} = \left(\frac{\text{Pu}^{240}}{\text{Pu-Total}} \right)_{\text{col.}} \left(\frac{\sum_1^N F^2}{\sum_1^N f} \right)$$
9. - 10. These columns are left blank so that the user may insert any other factors, ratios or combination of factors of interest for a particular application.

(1) HW-31143, "Minutes of Meeting No. 1 - K-Pile Startup Council", R. E. Johnson, 3-16-54.

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II. The standard change length for all piles except KE and KW is 32 - 8" slugs. The augmentation distance was assumed to be two standard slugs. All calculations were similar to those discussed above except "X" varied from 15.5 to 0.5 and "L" was taken as 18. The values are presented on Table II.

III. and IV. In some cases half-column factors are more convenient than full-column factors. This is particularly true when considering a few slugs at the column center or equal numbers of slugs taken from either end of the column. These are provided in Tables III and IV and are similar to Tables I and II except that the values are normalized to unity for a half column (19 - 8" slugs for K-File and 16 - 8" slugs for the other piles.)

V. The next set of calculations were performed in the following manner:

A. Assume: -

- (1) Total active area = $3220 (L.U.)^2$
- (2) This can be represented by a cylinder with a radius of $\sim 32.0 L.U.$
- (3) Augmentation distance = 50 cm (19.7" or 2.6 L.U.); this is for the $7\frac{1}{2}$ inch K-File lattice.
- (4) Flattened zone radii (R_f) of 0, 10, 12, 14, 16, 18, 20, 22, 24, 26, and 28 L.U.

B. Calculate: -

- (1) Area = areas of annular rings one L.U. thick from the center of the cylinder outward. When the pile is flattened the first area value is the area of the flattened zone.
- (2) Cosine value = $\cos\left(\frac{X}{L}\right) 90^\circ$ where X varies from 0.5 to 31.5 ($R_f = 0$) and L is taken as 34.6. As R_f takes on successive values then L is reduced from 34.6 to $34.6 - R_f$; similarly X takes on values 0, 0.5, 1.5 ... N-1, N where N is $31.5 - R_f$.
- (3) F value = $\frac{\text{Cosine value}}{\text{Avg. cosine value}}$ where the average cosine value is found by $\sum_1^N \frac{(\text{Area})(\text{Cosine Value})}{3220}$. Note that this definition of F will produce a $\sum_1^{3220} F$ that is equal to 3220 for any flattened zone radius. F is then the ratio of tube power to average tube power, to the extent that the cosine assumption and cylindrical approximation are valid.
- (4) F^2 value = value of F-squared. This value is useful for reactivity calculations and determining the degree of flattening⁽²⁾.

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- (5) F^3 value is value of F raised to the third power. The ratio (3)
of $\sum_{\text{pile}} F^3$ to $\sum_{\text{pile}} F^2$ can be used for Xenon calculations
and probably for other fission-product reactivity effects.

Note I: The summations at the bottom of the columns are also useful and the plotted curves at the end of this report show some useful relationships.

Note II: No attempt has been made to present all possible useful factors or to present those calculated in the most useful form for every purpose. Innumerable curves may be drawn which would be helpful or essential to a particular study. In general they can be obtained quickly from the tabulated values shown.

VI. This set of calculations is similar to the above set except that the assumptions are a 2004 tube pile leading to:

1. Total active area = 2004 (L.U.)²
2. This can be represented by a cylinder with a radius of 25.26 L.U.
3. Augmentation distance = 50 cm (19.7" or 2.35 L.U.) this is for the 8.375 inch lattice.
4. Flattened zone radii R_f of 0, 6, 10, 12, 14, 16, 18, 20 L.U.

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TABLE I

38-SLUG COLUMN

SLUG FACTORS

Slug No.	Cos. Value	f	$\Sigma N, f$	f^2	F^2	$\Sigma N, F^2$	$\Sigma N, F^2 / \Sigma N, f$
1	0.1858	.0070	.0070	.00005	.0017	.0017	.2429
2	0.2588	.0098	.0168	.00010	.0033	.0050	.2976
3	0.3305	.0125	.0293	.00016	.0053	.0103	.3515
4	0.3999	.0151	.0444	.00023	.0077	.0180	.4054
5	0.4672	.0177	.0621	.00031	.0103	.0283	.4557
6	0.5320	.0201	.0822	.00040	.0134	.0417	.5073
7	0.5938	.0225	.1047	.00051	.0170	.0587	.5606
8	0.6524	.0247	.1294	.00061	.0204	.0791	.6113
9	0.7061	.0267	.1561	.00071	.0237	.1028	.6586
10	0.7579	.0287	.1848	.00082	.0274	.1302	.7045
11	0.8047	.0304	.2152	.00092	.0307	.1609	.7477
12	0.8468	.0320	.2472	.00102	.0340	.1949	.7884
13	0.8841	.0334	.2806	.00112	.0374	.2323	.8279
14	0.9166	.0347	.3153	.00120	.0401	.2724	.8639
15	0.9439	.0357	.3510	.00127	.0424	.3148	.8969
16	0.9659	.0365	.3875	.00133	.0444	.3592	.9270
17	0.9826	.0372	.4247	.00138	.0461	.4053	.9543
18	0.9937	.0376	.4623	.00141	.0471	.4524	.9786
19	0.9993	.0378	.5001	.00143	.0477	.5001	1.000
20	0.9993	.0378	.5379	.00143	.0477	.5478	1.018
21	0.9937	.0376	.5755	.00141	.0471	.5949	1.034
22	0.9826	.0372	.6127	.00138	.0461	.6410	1.046
23	0.9659	.0365	.6492	.00133	.0444	.6854	1.056
24	0.9439	.0357	.6849	.00127	.0424	.7278	1.063
25	0.9166	.0347	.7196	.00120	.0401	.7679	1.067
26	0.8841	.0334	.7530	.00112	.0374	.8053	1.069
27	0.8468	.0320	.7850	.00102	.0340	.8393	1.069
28	0.8047	.0304	.8154	.00092	.0307	.8700	1.067
29	0.7579	.0287	.8441	.00082	.0274	.8974	1.063
30	0.7061	.0267	.8708	.00071	.0237	.9211	1.058
31	0.6524	.0247	.8955	.00061	.0204	.9415	1.051
32	0.5938	.0225	.9180	.00051	.0170	.9585	1.044
33	0.5320	.0201	.9381	.00040	.0134	.9719	1.036
34	0.4672	.0177	.9558	.00031	.0103	.9822	1.028
35	0.3999	.0151	.9709	.00023	.0077	.9899	1.020
36	0.3305	.0125	.9834	.00016	.0053	.9952	1.012
37	0.2588	.0098	.9932	.00010	.0033	.9985	1.005
38	0.1858	.0070	1.000	.00005	.0017	1.000	1.000

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TABLE II

32-SLUG COLUMN

SLUG FACTORS

Slug No.	Cos. Value	f	$\sum N, f$	f^2	F^2	$\sum N, F^2$	$\sum N, F^2 / \sum N, f$
1	.2164	.0095	.0095	.00009	.0026	.00026	.2737
2	.3007	.0133	.0228	.00018	.0052	.00078	.3421
3	.3827	.0169	.0397	.00029	.0083	.00161	.4056
4	.4617	.0204	.0601	.00042	.0120	.00281	.4676
5	.5373	.0237	.0838	.00056	.0160	.00441	.5263
6	.6088	.0268	.1106	.00072	.0206	.00647	.5850
7	.6756	.0298	.1404	.00089	.0255	.00902	.6425
8	.7373	.0325	.1729	.00106	.0304	.01206	.6975
9	.7934	.0350	.2079	.00123	.0352	.01558	.7494
10	.8434	.0372	.2451	.00138	.0395	.01953	.7968
11	.8860	.0391	.2842	.00152	.0435	.02388	.8403
12	.9239	.0407	.3249	.00166	.0475	.02863	.8812
13	.9537	.0420	.3669	.00176	.0504	.03367	.9177
14	.9763	.0430	.4099	.00185	.0530	.03897	.9507
15	.9914	.0437	.4536	.00191	.0547	.04444	.9797
16	.9990	.0440	.4976	.00194	.0556	.5000	1.005
17	.9990	.0440	.5416	.00194	.0556	.5556	1.026
18	.9914	.0437	.5853	.00191	.0547	.6103	1.043
19	.9763	.0430	.6283	.00185	.0530	.6633	1.056
20	.9537	.0420	.6703	.00176	.0504	.7137	1.065
21	.9239	.0407	.7110	.00166	.0475	.7612	1.071
22	.8860	.0391	.7501	.00152	.0435	.8047	1.073
23	.8434	.0372	.7873	.00138	.0395	.8442	1.072
24	.7932	.0350	.8223	.00123	.0352	.8794	1.069
25	.7373	.0325	.8548	.00106	.0304	.9098	1.064
26	.6756	.0298	.8846	.00089	.0255	.9353	1.057
27	.6088	.0268	.9114	.00072	.0206	.9559	1.049
28	.5373	.0237	.9351	.00056	.0160	.9719	1.039
29	.4617	.0204	.9555	.00042	.0120	.9839	1.030
30	.3827	.0169	.9724	.00029	.0083	.9922	1.020
31	.3007	.0133	.9857	.00018	.0052	.9974	1.012
32	.2164	.0095	.9952	.00009	.0026	1.000	1.005

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TABLE III

HALF COLUMN SLUG FACTORS

19 - SLUGS

Slug No.	Cos. Value	f	$\Sigma_{N,f}$	f^2	F^2	Σ_{N,F^2}	$\Sigma_{N,F^2} / \Sigma_{N,f}$
1	.1858	.0141	.0141	.00020	.0033	.0033	.2340
2	.2588	.0196	.0337	.00038	.0063	.0096	.2849
3	.3305	.0250	.0587	.00063	.0105	.0201	.3424
4	.3999	.0302	.0889	.00091	.0152	.0353	.3971
5	.4672	.0353	.1242	.00125	.0208	.0561	.4517
6	.5320	.0402	.1644	.00162	.0270	.0831	.5055
7	.5938	.0449	.2093	.00202	.0337	.1168	.5581
8	.6524	.0493	.2586	.00243	.0405	.1573	.6083
9	.7061	.0534	.3120	.00285	.0475	.2048	.6564
10	.7579	.0573	.3693	.00328	.0547	.2595	.7027
11	.8047	.0609	.4302	.00371	.0618	.3213	.7469
12	.8468	.0640	.4942	.00410	.0683	.3896	.7883
13	.8841	.0669	.5611	.00448	.0747	.4643	.8275
14	.9166	.0693	.6304	.00480	.0800	.5443	.8634
15	.9439	.0714	.7018	.00510	.0850	.6293	.8967
16	.9659	.0731	.7749	.00534	.0890	.7183	.9270
17	.9826	.0743	.8492	.00552	.0920	.8103	.9542
18	.9937	.0752	.9244	.00566	.0943	.9046	.9786
19	.9993	.0756	1.000	.00572	.0953	.9999	.9999

TABLE IV

HALF COLUMN SLUG FACTORS

16 - SLUGS

Slug No.	Cos. Value	f	$\Sigma_{N,f}$	f^2	F^2	Σ_{N,F^2}	$\Sigma_{N,F^2} / \Sigma_{N,f}$
1	.2614	.0192	.0192	.00037	.0052	.0052	.2728
2	.3007	.0266	.0458	.00071	.0100	.0153	.3332
3	.3827	.0339	.0797	.00115	.0162	.0317	.3975
4	.4617	.0409	.1206	.00167	.0236	.0553	.4583
5	.5373	.0476	.1682	.00227	.0321	.0873	.5193
6	.6088	.0539	.2221	.00291	.0411	.1285	.5783
7	.6756	.0599	.2820	.00358	.0506	.1790	.6349
8	.7373	.0653	.3473	.00427	.0603	.2394	.6892
9	.7934	.0703	.4176	.00494	.0698	.3092	.7403
10	.8434	.0747	.4923	.00558	.0788	.3880	.7881
11	.8860	.0785	.5708	.00616	.0870	.4750	.8322
12	.9239	.0819	.6526	.00700	.0989	.5740	.8795
13	.9537	.0845	.7371	.00714	.1009	.6748	.9155
14	.9763	.0865	.8236	.00748	.1057	.7805	.9477
15	.9914	.0878	.9114	.00771	.1089	.8895	.9759
16	.9990	.0885	.9999	.00783	.1106	1.000	1.000

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TABLE V

TUBE-POWER FACTORS - K-PILE

$$R_f = 0$$

<u>Radius</u> <u>R</u>	<u>Area</u> <u>(L.U.)²</u>	<u>Cos. Value</u>	<u>F</u>	<u>F²</u>	<u>F³</u>
1	3.14	.9997	1.881	3.538	7.076
2	9.42	.9977	1.877	3.523	7.046
3	15.71	.9936	1.869	3.493	6.986
4	22.00	.9874	1.858	3.452	6.414
5	28.27	.9793	1.843	3.396	6.259
6	34.56	.9691	1.823	3.323	6.058
7	40.84	.9569	1.800	3.240	5.832
8	47.12	.9506	1.789	3.200	5.725
9	53.41	.9265	1.743	3.038	5.295
10	59.69	.9086	1.710	2.924	5.000
11	65.97	.8887	1.672	2.796	4.675
12	72.26	.8670	1.631	2.660	4.338
13	78.54	.8435	1.587	2.519	3.998
14	84.82	.8184	1.540	2.372	3.653
15	91.11	.7914	1.489	2.217	3.301
16	97.39	.7629	1.435	2.059	2.955
17	103.67	.7327	1.379	1.902	2.623
18	109.96	.7012	1.319	1.740	2.295
19	116.24	.6671	1.255	1.575	1.977
20	122.52	.6337	1.192	1.421	1.694
21	128.87	.5979	1.125	1.266	1.428
22	135.09	.5601	1.054	1.111	1.171
23	141.37	.5229	.9838	.9679	.9522
24	147.65	.4837	.9101	.8283	.7538
25	153.94	.4437	.8348	.6969	.5818
26	160.22	.4023	.7569	.5729	.4336
27	166.50	.3605	.6783	.4601	.3121
28	172.79	.3178	.5979	.3575	.2137
29	179.07	.2745	.5165	.2668	.1378
30	185.35	.2306	.4339	.1883	.0817
31	191.64	.1864	.3507	.1230	.0431
32	197.92	.1416	.2664	.0710	.0189
$\sum_{1}^{3220}$			3220.36	3959.88	5498.73
			F =		

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TABLE V (continued)

$R_f = 10$

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1 - 10	314.16	1.000	1.508	2.274	3.429
11	65.97	.9995	1.507	2.271	3.422
12	72.26	.9954	1.501	2.253	3.382
13	78.54	.9873	1.488	2.214	3.294
14	84.82	.9752	1.470	2.161	3.177
15	91.11	.9591	1.446	2.091	3.024
16	97.39	.9391	1.416	2.005	2.839
17	103.67	.9153	1.380	1.904	2.628
18	109.96	.8877	1.338	1.790	2.395
19	116.24	.8566	1.291	1.667	2.152
20	122.52	.8210	1.238	1.533	1.898
21	128.87	.7830	1.180	1.392	1.643
22	135.09	.7429	1.120	1.254	1.404
23	141.37	.6981	1.052	1.107	1.165
24	147.65	.6517	0.9825	0.9653	0.9484
25	153.94	.6011	.9062	.8212	.7442
26	160.22	.5499	.8290	.6872	.5697
27	166.50	.4956	.7472	.5583	.4172
28	172.79	.4383	.6608	.4367	.2886
29	179.07	.3812	.5747	.3303	.1898
30	185.35	.3214	.4845	.2347	.1137
31	191.64	.2603	.3924	.1540	.0604
32	197.92	.1983	.2990	.0894	.0273
$\sum_{1}^{3220}$	=		3219.88	3748.39 3740.18	4749.41

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TABLE V (continued)

 $R_F = 14$

(This table corrected 4-22-55)

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1 - 14	615.75	1.0000	1.380	1.904	2.628
15	91.11	.9993	1.379	1.902	2.623
16	97.39	.9985	1.371	1.880	2.577
17	103.67	.9819	1.355	1.836	2.488
18	109.96	.9646	1.331	1.772	2.359
19	116.24	.9417	1.299	1.687	2.191
20	122.52	.9134	1.260	1.588	2.001
21	128.87	.8797	1.214	1.474	1.789
22	135.09	.8409	1.160	1.346	1.561
23	141.37	.7972	1.100	1.210	1.331
24	147.65	.7490	1.033	1.067	1.102
25	153.94	.6963	.9606	.9228	.8864
26	160.22	.6394	.8822	.7783	.6866
27	166.50	.5790	.7988	.6381	.5097
28	172.79	.5153	.7109	.5054	.3593
29	179.07	.4485	.6188	.3829	.2369
30	185.35	.3792	.5231	.2736	.1431
31	191.64	.3076	.4244	.1801	.0764
32	197.92	.2343	.3232	.1045	.0338
$\sum_{1}^{3220} =$			3220.40	3639.81	4401.30

 $R_F = 16$

1 - 16	804.25	1.0000	1.319	1.740	2.295
17	103.67	.9991	1.318	1.737	2.289
18	109.96	.9910	1.307	1.708	2.232
19	116.24	.9779	1.290	1.664	2.147
20	122.52	.9568	1.262	1.593	2.010
21	128.87	.9289	1.225	1.501	1.839
22	135.09	.8944	1.180	1.392	1.643
23	141.37	.8526	1.125	1.266	1.424
24	147.65	.8067	1.064	1.132	1.204
25	153.94	.7539	.9946	.9892	.9839
26	160.22	.6950	.9169	.8407	.7708
27	166.50	.6321	.8339	.6954	.5799
28	172.79	.5655	.7460	.5565	.4151
29	179.07	.4931	.6505	.4232	.2753
30	185.35	.4183	.5518	.3045	.1680
31	191.64	.3402	.4488	.2014	.0904
32	197.92	.2608	.3441	.1184	.0407
$\sum_{1}^{3220} =$			3219.78	3576.64*	4211.40

*This value corrected 4-22-55

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TABLE V (continued)

 $R_T = 18$

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1 - 18	1017.88	1.000	1.262	1.593	2.010
19	116.24	.9989	1.261	1.590	2.005
20	122.52	.9900	1.250	1.563	1.954
21	128.87	.9722	1.227	1.506	1.848
22	135.09	.9458	1.194	1.426	1.703
23	141.37	.9110	1.150	1.323	1.521
24	147.65	.8681	1.096	1.201	1.316
25	153.94	.8173	1.032	1.065	1.099
26	160.22	.7594	.9585	.9187	.8806
27	166.50	.6947	.8768	.7688	.6741
28	172.79	.6236	.7871	.6195	.4876
29	179.07	.5473	.6908	.4772	.3296
30	185.35	.4658	.5879	.3456	.2032
31	191.64	.3803	.4800	.2300	.1104
32	197.92	.2914	.3678	.1353	.0498
$\sum_1^{3220}$	=		3219.99	3515.43	4030.40

 $R_T = 20$

1 - 20	1256.64	1.000	1.209	1.462	1.768
21	128.87	.9986	1.207	1.457	1.759
22	135.09	.9871	1.194	1.426	1.703
23	141.37	.9642	1.166	1.360	1.523
24	147.65	.9302	1.125	1.266	1.424
25	153.94	.8856	1.071	1.147	1.228
26	160.22	.8307	1.004	1.008	1.012
27	166.50	.7662	.9265	.8584	.7953
28	172.79	.6930	.8380	.7022	.5884
29	179.07	.6117	.7397	.5472	.4048
30	185.35	.5232	.6326	.4002	.2532
31	191.64	.4291	.5189	.2693	.1397
32	197.92	.3297	.3987	.1590	.0634
$\sum_1^{3220}$	=		3219.92	3454.37	3848.05

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TABLE V (continued)

 $R_f = 22$

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1 - 22	1520.60	1.000	1.160	1.346	1.561
23	141.37	.9981	1.157	1.339	1.549
24	147.65	.9826	1.139	1.297	1.477
25	153.94	.9521	1.104	1.219	1.346
26	160.22	.9067	1.051	1.105	1.161
27	166.50	.8474	.9826	.9655	.9487
28	172.79	.7749	.8985	.8073	.7254
29	179.07	.6908	.8010	.6488	.5197
30	185.35	.5957	.6907	.4771	.3295
31	191.64	.4914	.5698	.3247	.1850
32	197.92	.3795	.4401	.1937	.0852
$\sum_1^{3220}$	=		3220.59	3397.64	3693.69

 $R_f = 24$

1 - 24	1809.62	1.000	1.114	1.241	1.382
25	153.94	.9973	1.111	1.234	1.371
26	160.22	.9755	1.086	1.179	1.280
27	166.50	.9325	1.039	1.080	1.122
28	172.79	.8692	.9680	.9370	.9070
29	179.07	.7869	.8764	.7681	.6732
30	185.35	.6875	.7657	.5863	.4489
31	191.64	.5730	.6382	.4073	.2599
32	197.92	.4462	.4969	.2469	.1227
$\sum_1^{3220}$	=		3220.71	3339.46	3538.41

 $R_f = 26$

1 - 26	2123.78	1.000	1.072	1.149	1.232
27	166.50	.9958	1.068	1.141	1.219
28	172.79	.9630	1.032	1.065	1.099
29	179.07	.8983	.9630	.9274	.8931
30	185.35	.8039	.8618	.7427	.6401
31	191.64	.6829	.7321	.5360	.3924
32	197.92	.5394	.5783	.3344	.1934
$\sum_1^{3220}$	=		3219.77	3286.85	3401.40

 $R_f = 28$

1 - 28	2463.07	1.000	1.036	1.073	1.112
29	179.07	.9930	1.029	1.059	1.090
30	185.35	.9375	.9715	.9438	.9169
31	191.64	.8296	.8597	.7391	.6354
32	197.92	.6755	.7000	.4900	.3430
$\sum_1^{3220}$	=		3219.37	3246.06	3293.72

TABLE VI

TUBE POWER FACTORS B, C, D, DR, F, AND H PILES

$$R_f = 0$$

<u>Radius R</u>	<u>Area (L.U.)²</u>	<u>Cos. Value</u>	<u>F</u>	<u>F²</u>	<u>F³</u>
1	3.14	.9996	1.849	3.418	6.318
2	9.42	.9964	1.843	3.396	6.257
3	15.71	.9895	1.830	3.349	6.129
4	22.00	.9803	1.813	3.287	5.959
5	28.27	.9673	1.789	3.200	5.725
6	34.56	.9516	1.760	3.097	5.451
7	40.84	.9323	1.724	2.973	5.127
8	47.12	.9107	1.684	2.837	4.778
9	53.41	.8854	1.637	2.681	4.391
10	59.69	.8572	1.585	2.513	3.984
11	65.97	.8271	1.530	2.340	3.579
12	72.26	.7934	1.467	2.153	3.159
13	78.54	.7581	1.402	1.966	2.756
14	84.82	.7193	1.330	1.770	2.355
15	91.11	.6782	1.254	1.573	1.973
16	97.39	.6361	1.176	1.384	1.628
17	103.67	.5906	1.092	1.193	1.303
18	109.96	.5446	1.007	1.015	1.022
19	116.24	.4955	0.9163	0.8397	0.7694
20	122.52	.4446	0.8223	0.6762	0.5561
21	128.87	.3939	0.7286	0.5308	0.3867
22	135.09	.3404	0.6295	0.3963	0.2495
23	141.37	.2874	0.5315	0.2824	0.1501
24	147.65	.2318	0.4286	0.1837	0.0787
25	153.94	.1754	0.3243	0.1052	0.0341
25.26	41.00	.1547	0.2861	0.0819	0.0234
$\sum_1^{2004}$			2004	2433	3310

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TABLE VI (continued)

R_f 6

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1-6	113.10	1.0000	1.5666	2.451	3.838
7	40.84	.9993	1.565	2.448	3.831
8	47.12	.9941	1.556	2.422	3.770
9	53.41	.9836	1.540	2.372	3.652
10	59.69	.9677	1.515	2.296	3.478
11	65.97	.9472	1.483	2.200	3.262
12	72.26	.9212	1.442	2.080	3.001
13	78.54	.8902	1.394	1.943	2.708
14	84.82	.8554	1.339	1.794	2.472
15	91.11	.8151	1.276	1.629	2.079
16	97.39	.7705	1.206	1.455	1.756
17	103.67	.7230	1.132	1.281	1.450
18	109.67	.6704	1.050	1.102	1.157
19	116.24	.6143	0.9618	0.9251	0.8898
20	122.52	.5563	0.8710	0.7587	0.6608
21	128.87	.4939	0.7734	0.5981	0.4626
22	135.09	.4289	0.6716	.4511	0.3029
23	141.37	.3633	0.5688	3235	0.1840
24	147.65	.2940	0.4604	2120	0.0976
25	153.94	.2250	0.3522	1241	0.0437
25.26	41.00	.1977	0.3095	0958	0.0296

$$\sum_{1}^{2004}$$

2003

2338

2990

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TABLE VI (continued)

 $R_f = 10$

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1 - 10	314.16	1.000	1.401	1.964	2.752
11	65.97	.9990	1.400	1.960	2.744
12	72.26	.9910	1.389	1.929	2.678
13	78.54	.9752	1.367	1.868	2.552
14	84.82	.9516	1.334	1.778	2.372
15	91.11	.9205	1.290	1.664	2.147
16	97.39	.8821	1.236	1.528	1.889
17	103.67	.8368	1.173	1.375	1.612
18	109.96	.7848	1.100	1.210	1.330
19	116.24	.7266	1.018	1.037	1.056
20	122.52	.6626	0.9286	0.8623	0.8007
21	128.87	.5920	0.8296	0.6883	0.5710
22	135.09	.5180	0.7260	0.5270	0.3826
23	141.37	.4399	0.6165	0.3801	0.2343
24	147.65	.3584	0.5022	0.2522	0.1267
25	153.94	.2740	0.3839	0.1474	0.0566
25.26	41.00	.2199	0.3081	0.0949	0.0292
Σ			2004	2263	2742

 $R_f = 12$

1 - 12	452.39	1.000	1.326	1.758	2.331
13	78.54	.9987	1.324	1.753	2.322
14	84.82	.9888	1.311	1.719	2.253
15	91.11	.9686	1.284	1.649	2.118
16	97.39	.9385	1.244	1.548	1.926
17	103.67	.8996	1.193	1.422	1.696
18	109.96	.8508	1.128	1.272	1.435
19	116.24	.7934	1.052	1.106	1.164
20	122.52	.7290	0.9665	0.9341	0.9028
21	128.87	.6561	0.8698	0.7566	0.6581
22	135.09	.5764	0.7643	0.5841	0.4464
23	141.37	.4924	0.6529	0.4262	0.2783
24	147.65	.4020	0.5329	0.2840	0.1513
25	153.94	.3074	0.4075	0.1661	0.0677
25.26	41.00	.2113	0.3275	0.1072	0.0351
Σ			2004	2219	2607

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TABLE VI (continued)

$R_f = 14$

Radius R	Area (L.U.) ²	Cos. Value	F	F ²	F ³
1 - 14	615.75	1.0000	1.255	1.576	1.978
15	91.11	.9983	1.253	1.571	1.968
16	97.39	.9851	1.237	1.529	1.891
17	103.67	.9588	1.204	1.449	1.744
18	109.97	.9198	1.155	1.333	1.540
19	116.24	.8678	1.089	1.187	1.293
20	122.52	.8049	1.010	1.021	1.032
21	128.87	.7314	0.9181	0.8429	0.7739
22	135.09	.6481	0.8136	0.6620	0.5386
23	141.37	.5563	0.6984	0.4877	0.3406
24	147.65	.4571	0.5738	0.3293	0.1890
25	153.94	.3518	0.4417	0.1951	0.0862
25.26	41.00	.2823	0.3544	0.1256	0.0445
$\sum_{1}^{2004}$			2004	2173	2472

$R_f = 16$

1 - 16	804.25	1.0000	1.190	1.416	1.685
17	103.67	.9977	1.187	1.409	1.673
18	109.97	.9796	1.166	1.359	1.584
19	116.24	.9432	1.122	1.260	1.414
20	122.52	.8902	1.059	1.122	1.189
21	128.87	.8202	0.9760	0.9525	0.9296
22	135.09	.7361	0.8760	0.7673	0.6721
23	141.37	.6374	0.7585	0.5754	0.4364
24	147.65	.5284	0.6288	0.3954	0.2487
25	153.94	.4083	0.4859	0.2361	0.1147
25.26	41.00	.3398	0.4044	0.1635	0.0661
$\sum_{1}^{2004}$			2004	2128	2342

$R_f = 18$

1 - 18	1017.88	1.0000	1.131	1.278	1.445
19	116.24	.9966	1.127	1.270	1.431
20	122.52	.9703	1.097	1.204	1.320
21	128.87	.9178	1.038	1.077	1.117
22	135.09	.8406	0.9504	0.9032	0.8584
23	141.37	.7420	0.8389	0.7038	0.5904
24	147.65	.6225	0.7038	0.4954	0.3486
25	153.94	.4879	0.5516	0.3042	0.1675
25.26	41.00	.3939	0.4454	0.1984	0.0884
$\sum_{1}^{2004}$			2004	2085	2223

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TABLE VI (continued)

 $R_f = 20$

<u>Radius</u> <u>R</u>	<u>Area</u> <u>(L.U.)²</u>	<u>Cos. Value</u>	<u>F</u>	<u>F²</u>	<u>F³</u>
1 - 20	1256.64	1.0000	1.078	1.161	1.252
21	128.87	.9947	1.072	1.149	1.232
22	135.09	.9527	1.027	1.054	1.082
23	141.37	.8695	0.9371	0.8781	0.8228
24	147.65	.7501	0.8084	0.6535	0.5283
25	153.94	.5990	0.6456	0.4168	0.2691
25.26	41.00	.4894	0.5274	0.2782	0.1467
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$\sum_{1}^{2004}$			2004	2046	2120

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