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GENERAL ELECTRIC

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TITLE

K-PILE WATER SHUT OFF

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[redacted] WATER SHUTOFF

HW-56817 RD
Page 1
7-17-58

$a = .0775'$
$b = .625'$
$V = .365$
$A_o = 0.490$

K-PILE

This document consists of 28 pages, No. 1 of 1 copies. [redacted]

CASE	Type	%He	Power	α	h	A	B	h_1	t_{f_a}	λ	G_o	R_T	t_f	$(t_{f_a}-t_f)_c$
Ia	W	100	300	.37	2.0	.69	11.9	1.45	182	2	30,600	.128	11	.66
b				.37	1.81	.72	11.4	1.40	—		30,600	.133	11	.66
IIa	W	100	600	.37	2.0	.69	11.9	1.45	288	2	61,200	.128	11	.66
b				.37	1.81	.72	11.4	1.40	—		61,200	.135	11	.66
IIIa	W	100	1200	.37	2.0	.69	11.9	1.45	505	2	122,000	.128	11	.66
b				.37	1.81	.72	11.4	1.40	—		122,000	.133	11	.66
IVa	W	60	300	.29	1.32	.73	8.9	1.37	290	2.5	30,600	.171	8.7	.66
b				.26	1.02	.81	7.2	1.24	—		30,600	.212	7.8	.66
Va	W	60	600	.29	1.32	.73	8.9	1.37	490	2.5	61,200	.171	8.7	.66
b				.26	1.02	.81	7.2	1.24	—		61,200	.212	7.8	.66
VI	D	100	300	.37	2.0	2.4	5.1	0.42	200	2	30,600	.44	11	.45
VII	D	100	600	.37	2.0	2.4	5.1	0.42	310	2	61,200	.44	11	.45
VIII	D	100	1200	.37	2.0	2.4	5.1	0.42	530	2	122,000	.44	11	.45
IX	D	60	300	.29	1.32	2.3	5.2	0.43	320	2.5	30,600	.49	8.7	.45
X	D	60	600	.29	1.32	2.3	5.2	0.43	490	2.5	61,200	.49	8.7	.45

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July 17, 1958

For Interpolation procedure see Appendix I pg - 29

[redacted]

θ = [illegible] NW-56817 RD
T = time [illegible] Page 2

K-PILE

CASE-I SINGLE TUBE, WATER FILLED

(100% He, 300 Kw/Tube)

α	a	k	b	A	B	k_1	t_{G_0}	t_{w_0}	λ	Q_0	R_T	V	k_G	A_0 (wg.
.37	.077	2.0	.625	.69	11.9	1.45	182	27	2	30,600	.128	.37	11	.49	.66
							.15	15							

Values of θ → (hrs) .1 .2 .4 .6 1 1.5 2 4 8 16

at different values (Time H_2O off 2 hrs)

of T f_T t_w $t_{s.s.}$ t_x ↓ 150° Limit

	T (hrs)	f_T	t_w	$t_{s.s.}$										
	.05	.039	20	263	120	225	271	273	269	265	264	263	263	263
	.1	.030		207	84.5	150	221	221	214	210	207	207	207	207
Method I	.2	.024		169	62.9	150	186	185	178	173	171	170	170	170
	.5	.019		138	50.0	123	153	152	146	141	140	139	138	138
	1	.0155		116	46.1	104	128	127	122	119	117	117	117	117
	2	.0125		98	48.0	85.8	102	103	100	99	98	98	98	98
	4	.010		82	52.0	70	80	81	82	82	82	82	82	82
	6	.0090	15	73	61.5	72	77	76	75	74	74	73	73	73
	10	.0082		70	58	68	72	72	70	69	68	68	68	68
Method II	15	.0072		62	54	70	66	66	66	63	63	62	62	62
	20	.0066		58	62	60	63	62	60	59	58	58	58	58
	24	.0062		55	50	58	61	60	57	56	55	55	55	55
	36	.0056		51	47	55	57	56	54	52	52	51	51	51
	48	.0049		46	45	51	53	52	49	48	47	47	47	47

↑ Time after shutdown - hrs

α	a	k	b	A	B	k_1	t_{G_0}	t_w	λ	Q_0	R	k_G	A_0 (wg.
.37	.077	1.81	.625	.72	11.4	1.40	—	15	—	30,600	.133	.37	11	.49

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X

K-PILE

CASE-II SINGLE TUBE WATER FILLED

(100% He, 600 Kw/Tube)

α	a	h	b	A	B	h_1	t_{f_0}	t_{w_0}	λ	Q_0	R	V	k_f	A_0	(wt.)
.37	.077	2.0	.625	.69	11.9	1.45	320	(39) 15	2	61200	.128	.37	11	.49	.66

Values of θ → .1 .2 .4 .6 1 1.5 2 4 8 16

at different values of η

	η	f_η	t_w	$t_{s.s.}$										
Method I	.05	.039	22	508	231	430	520	526	517	512	510	508	508	508
	.10	.030		396	161	341	418	419	409	401	398	396	396	396
	.2	.024		321	117	280	349	348	335	327	324	321	321	321
	.5	.019		259	91	228	285	283	272	264	261	259	259	25[illegible]
	1	.0155		215	81	189	234	234	225	219	217	215	215	21[illegible]
	2	.0125		178	82	153	184	186	182	180	179	178	178	178
	4	.010		147	87	123	142	145	146	146	147	147	147	147
	6	.0090		134	89	111	125	128	131	133	134	134	134	134
Method II	10	.0082	16	122	94	111	121	122	122	122	122	122	122	122
	15	.0072		109	85	101	109	110	110	110	109	109	109	109
	20	.0066		101	80	95	102	103	102	102	101	101	101	101
	24	.0062		96	77	91	98	98	97	97	96	96	96	96
	36	.0056		88	72	85	91	91	90	89	89	88	88	88
	48	.0049		79	66	78	83	83	81	80	80	79	79	79

α	a	h	b	A	B	h_1	t_{f_0}	t_w	λ	Q_0	R	k_f	A_0	(wt.
.37	.077	1.81	.625	.72	11.4	1.40	—	16	←	61,200	.133	.37	11	.49	.66

[redacted]

[redacted]

K-Pile

CASE - III SINGLE TUBE, WATER FILLED

(100% He 1200 Kw/ft)

α	a	h	b	A	B	h_1	t_{G_0}	t_w	λ	Q_0	R	V	k_G	A_0	(wet
.37	.077	2.0	.625	.69	11.9	1.45	563"	63 (15)	2	122,000	.128	.37	11	.49	.66

Values of θ → 0.1 0.2 0.4 0.6 1 1.5 2 4 8 16

at different values of T ↓

	↓	f_T	t_w	$t_{s.c.}$										
Method I	0.05	.039	26	995	465	836	1007	1020	1009	1001	998	996	995	995
	0.1	.030		772	323	658	805	810	792	780	775	772	772	772
	0.2	.024		623	236	538	666	667	646	632	627	623	623	623
	0.5	.019		498	180	434	540	539	520	507	502	498	498	498
	1.	.0155		411	157	357	442	442	428	418	414	411	411	411
	2	.0125		337	155	288	347	350	344	340	338	337	337	337
	4	.010		274	160	228	263	270	272	274	274	275	275	275
	6	.009		250	161	205	231	238	244	247	249	250	250	250
Method II	10	.0082	18	229	164	198 (211)	217	222	226	228	228	229	229	229
	15	.0072		203	147	177 (191)	194	198	201	202	203	203	203	203
	20	.0066		188	138	165 (176)	181	184	186	187	188	188	188	188
	24	.0062		178	131	157 (167)	172	175	176	177	177	178	178	178
	36	.0056		162	121	145 (154)	158	160	161	162	162	162	162	162
	48	.0049		144	110	131 (139)	142	144	144	144	144	144	144	144

α	a	h	b	A	B	h_1	t_{G_0}	t_w	λ	Q_0	R	V	k_G	A_0	(wet
.37	.077	1.81	.625	.72	11.4	1.40	—	18	—	122,000	.133	.37	11	.49	.66

[redacted]

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X

K-PILE

CASE III — SINGLE TUBE, WATER FILLED

(60% Helium, 300 Kw/ft.)

α	a	h	b	A	B	h_1	t_{f_0}	t_{w_0}	λ	Q_0	R	V	k_f	A_0	$(wc_p)_s$
.29	.077	1.32	.625	.73	8.9	1.37	290	27	2.5	30,600	.171	.37	8.7	.49	.66

Values of δ → .1 .2 .3 .4 .5 1 1.5 2 4 ∞ 16

at different values of

	T	f_T	t_w	$t_{s.s.}$										
Method I	0.05	.039	20	361	65	230	339	361	366	364	363	362	361	361
	.1	.030		283	22	174	272	291	293	289	286	283	283	283
	.2	.024		230	24	137	227	244	243	238	235	231	230	230
	.5	.019		186	12	109	187	201	199	194	191	187	186	186
	1	.0155		156	6	92	156	167	166	162	160	156	156	156
	2	.0125		129	12	82	126	135	135	133	131	130	129	129
	4	.010		108	38	75	99	105	107	107	107	107	108	108
Method II	6	.0090	15	113	75	92	105	110	112	112	112	113	113	113
	10	.0082		104	70	86	98	102	104	104	104	104	104	104
	15	.0072		93	64	78	90	93	94	94	94	94	94	93
	20	.0066		87	61	74	85	87	88	88	88	87	87	87
	24	.0062		83	58	71	81	84	84	84	83	83	83	83
	36	.0056		76	55	67	76	78	78	78	77	76	76	76
	48	.0049		68	51	62	70	72	72	71	70	69	68	68

α	a	h	b	A	B	h_1	t_{f_0}	t_w	λ	Q_0	R	V	k_f	A_0	$(wc_p)_s$
.26	.077	1.02	.625	.81	7.2	1.24	—	15	—	30,600	.212	.37	7.8	.49	.66

[redacted]

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K-Plc

CASE V — SINGLE TUBE, WATER FILLED

(60% Helium, 600 Kw/Tube)

α	a	h	b	A	B	h_1	t_{c_0}	t_{w_0}	λ	Q_0	R	V	h_f	A_0	(w_{c_0}
.29	.077	1.32	.625	.73	8.9	1.37	490	(39) 15	2.5	61,200	.171	.37	7.7	.49	.66

Values of δ → .1 .2 .4 .6 1 1.5 2 4 ∞ 16

at different values of f_f, t_w, t_{ss}

	f_f	t_w	t_{ss}											
Method I	.05	.039	22	705	154	452	651	694	706	706	705	705	705	705
	.1	.030		547	68	339	518	555	559	555	552	548	547	547
	.2	.024		442	17	226	428	459	460	454	449	443	442	442
	.5	.019		355	6	209	349	375	374	367	362	356	355	355
	1	.0155		293	2	175	289	310	309	303	299	294	293	293
	2	.0125		241	27	151	231	247	248	245	244	241	241	241
	4	.010		197	68	134	180	190	194	195	196	197	197	197
	6	.0090		180	88	129	158	166	172	175	177	179	180	180
Method II	10	.0082	16	195	120	148	172	180	185	188	190	194	195	195
	15	.0072		173	108	133	154	161	166	168	170	172	173	173
	20	.0066		160	101	124	144	150	154	156	157	159	160	161
	24	.0062		151	97	118	137	143	146	148	149	151	151	151
	36	.0056		138	90	110	126	132	135	136	136	138	138	138
	46	.0049		123	81	99	114	119	121	122	122	123	123	123

α	a	h	b	A	B	h_1	t_{c_0}	t_w	λ	Q_0	R	V	h_f	A_0	(w_{c_0}
.26	.077	1.02	.625	.81	7.2	1.24	—	16	—	61,200	.212	.37	7.7	.49	.66

[redacted]

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K-PILE

$R_2 = .39$ all Cases

CASE: ~~VI~~ - SINGLE TUBE, DRY (100% He, 300 Kw/ft

α	a	h	b	A	B	h_1	t_{s_0}	t_{w_0}	λ	Q_0	R	V	h_{fg}	A_0	$(wc_p)_s$
.37	.077	2.0	.625	2.4	5.1	.42	182	27 (15)	2	30,600	.44	.37	11	.49	.45

Values of θ → 0.1 hrs. 0.2 .4 .6 1 1.5 2 4 6 16

at different values of → 12 24 36 60 Mins.

Min	θ	T_{hvg}	f_T/t_w	$t_{s.s.}$										
3	.05	.039	16	557	72	214	372	447	510	539	550	557	557	55
6	.10	.03		432	20	138	270	334	390	416	425	432	432	43
12	.2	.024		349	9	92	205	261	310	334	343	349	349	34
	.5	.019		280	16	66	159	206	247	267	274	279	280	28
	1	.0135		231	5	61	136	173	206	221	227	231	231	23
	2	.0125		189	22	71	124	150	173	183	187	189	189	189
	4	.010		155	52	83	118	134	146	151	153	155	155	15
	6	.009		141	62	88	115	127	136	139	140	141	141	14
	10	.0082		130	66	87	110	119	126	128	129	130	130	13
	15	.0073		116	60	79	99	107	113	115	115	116	116	116
	20	.0066		107	57	74	92	100	105	107	107	108	108	108
	24	.0062		102	54	71	87	94	99	101	102	102	102	102
	36	.0056		94	50	65	80	87	91	93	93	94	94	94
	48	.0049		84	46	59	72	78	82	83	84	84	84	84

[redacted]

[redacted]

K-PILE

CASE - VII SINGLE TUBE, DRY
(100% He, 600 Kw/T)

α	a	h	b	A	B	h_1	t_{f_0}	t_{w_0}	λ	Q_0	R	V	k_f	A_0 (wg
.37	.077	2.0	.625	2.3	5.2	.43	320	(39) 15	2	61,200	.43	.37	11	.29	.45
Values of δ →						.1	.2	.4	.6	1	1.5	2	4	∞	.16
at different values of T hrs for t_w $t_{s.s.}$						Time H.P off									
						6	12	24	36	60					
	Min					δt									
TIME AFTER SCRAM	3	.05	.039	22		.147	.430	.736	.880	.999	1051	1071	1085	1085	1085
	6	.1	.030			.47	.280	.536	.658	.762	.809	.827	.839	.840	.841
	12	.2	.024			.9	.189	.407	.513	.606	.648	.665	.676	.676	.676
	30	.5	.019			.25	.137	.316	.404	.481	.516	.530	.540	.540	.541
		1	.0155			.6	.123	.267	.337	.398	.426	.437	.444	.444	.444
		2	.0125			.42	.137	.241	.290	.332	.351	.358	.363	.363	.363
		4	.010			.94	.158	.225	.255	.279	.288	.292	.294	.295	.295
		6	.009			.112	.164	.217	.241	.257	.264	.266	.267	.267	.267
		10	.0082			.118	.162	.207	.226	.238	.243	.244	.245	.246	.246
		15	.0072			.108	.146	.185	.201	.212	.216	.217	.218	.218	.218
		20	.0066			.101	.136	.172	.186	.196	.200	.201	.202	.202	.202
		24	.0062			.96	.129	.163	.176	.186	.189	.190	.191	.191	.191
		36	.0056			.89	.119	.149	.161	.170	.173	.174	.175	.175	.175
		48	.0049			.80	.106	.133	.144	.151	.154	.155	.156	.156	.156

[redacted]

[redacted]

K-PILE

CASE - VIII SINGLE TUBE, DRY
(100% He, 1200 Kw/ft

α	a	h	b	A	B	L_1	t_{f_o}	t_{w_o}	λ	G_o	R	V	t_f	A_o	$(wc_p$
.37	.077	2.0	.625	2.3	5.2	.43	563	(63) 15	2	122,000	.43	.37	11	.49	.4

Values of δ → .1 .2 .4 .6 1 1.5 2 4 ∞ 16
at different values ↑ hrs water off
of T f_T t_w °C $t_{s.s.}$ °C ↑ Mins Water Off FUEL TEMPS
min hrs ↓ b/x

T	3	.05	.039	26		343	893	1483	1759	1964	2092	2119	2144	2145	2145
I	6	.1	.030			141	592	1083	1316	1512	1599	1633	1655	1656	1656
M	12	.2	.024			26	407	825	1027	1200	1278	1309	1329	1330	1330
E	30	.5	.019			14	296	639	805	949	1015	1040	1058	1058	1058
A	60	1	.0155			12	261	535	668	782	834	854	868	868	868
F		2	.0125 =	↓		92	276	(475)	569	648	683	696	705	705	705
T		4	.0100	18		171	296	427	476	532	550	557	561	561	561
E		6	.0090			202	304	410	455	488	500	504	507	507	507
R		10	.0082			211	298	387	425	450	459	462	463	464	464
S		15	.0072			191	267	344	376	398	405	408	409	409	409
C		20	.0066			177	246	317	346	366	373	375	377	377	377
R		24	.0062			167	232	299	326	345	351	352	355	355	355
A		36	.0056			152	211	272	297	313	319	321	322	322	322
M		48	.0049	↓		135	187	240	262	276	281	283	284	284	284

[redacted]

[redacted]

K-PILE

CASE-TX - SINGLE TUBE, DRY (60% He) 300 Kw/T

α	a	h	b	A	B	h_1	t_{G_0}	t_{w_0}	λ	Q_0	R	V	k_G	A_0	$(w_{G_0})_{ss}$
.29	.077	1.32	.625	2.1	4.5	.48	290	(27) 15	2.5	30,000	.49	.37	8.7	.49	.45
Values of Θ →						0.1	.2	.4	.6	1	1.5	2	4	8	16
at different values of T	f_T	t_w	$t_{s.s.}$												
.05	.039	16				−25	145	342	443	538	591	619	656	662	662
.1	.030					−80	63	230	316	400	447	474	508	513	513
.2	.024					−109	14	159	235	309	353	377	409	413	413
.5	.019					−111	−8	113	177	241	278	299	326	331	331
1	.0155 =					88	−4	94	147	199	230	245	269	273	273
2	.0125					40	23	96	134	171	193	205	221	223	223
4	.0100					20	61	108	131	154	166	172	180	182	182
6	.0090					48	79	115	132	148	155	159	164	165	165
10	.0082					65	90	118	131	141	146	148	151	152	152
15	.0072					63	84	108	119	127	131	133	135	135	135
20	.0066					59	79	100	110	118	121	123	125	125	125
24	.0062					57	75	95	104	112	115	117	118	119	119
36	.0056					53	69	87	96	103	105	107	108	109	109
48	.0049					48	62	78	86	92	94	95	97	97	97

[redacted]

[redacted]

K-PILE

CASE ~~XI~~ SINGLE TUBE, DRY

(60% He) 600 Kw/T

α	a	h	b	A	B	t_f	t_{f_0}	t_{w_0}	λ	Q_0	R	V	t_y	A_0	ω_0
.29	.077	1.32	.625	2.0	4.6	.50	490	(39) 15	2.5	61,200	.48	.37	8.7	.49	.45

Values of θ → hrs .01 .02 .04 .06 .1 .15 .2 .4 .6 1

for different values of:

* T hrs	f_T	t_w °C	$t_{s.s.}$ → °C								
0,05	.039	22	2	331	209	499	1072	1167	1218	1284	1294	1294
.1	.030		109	169	487	649	800	885	931	992	1000	1001
.2	.024		166	72	346	487	622	699	741	797	805	805
.5	.019		174	23	251	370	482	550	587	635	642	642
1	.0155		140	22	208	305	398	453	483	522	528	528
2	.0125		60	61	200	271	339	377	398	426	430	430
4	.0100		29	122	213	258	298	320	331	346	348	348
6	.0090		88	151	221	255	284	298	305	314	316	316
10	.0082		117	168	223	249	270	279	283	289	290	290
15	.0072		113	156	203	225	241	248	252	256	257	257
20	.0066		106	145	188	208	223	230	233	237	237	237
24	.0062		101	138	178	197	211	217	220	224	224	224
36	.0056		93	126	163	180	193	198	201	204	205	205
48	.0049	↓	84	113	145	160	171	176	178	181	182	182

[redacted]

[redacted]

WATER SHUT OFF

K-PILE

SINGLE TUBES - TUBE TEMP.

CASE-VI (100% He, 300 Kw/ft)

α	a	h	b	A	B	h_1	t_{θ_0}	t_{w_0}	λ	Q_0	R	V	t_6	A_0 (wc)
.37	.077	2.0	.625	2.4	5.1	.42	182	(27) 15	2	30,600	.44	.37	11	.49	.45

Values of θ → 0.1 .2 .4 .6 1 1.5 2 4 8 16

at different values of T for t_w

T										
.05	11	43	92	122	154	172	180	185	185	185
.1	9	19	61	88	118	134	141	146	146	146
.2	20	5	43	67	95	109	116	120	120	120
.5	19	2	33	54	77	89	95	98	98	98
1	10	7	32	48	66	76	80	83	83	83
2	8	19	36	47	59	66	68	70	70	70
4	26	33	42	48	54	57	58	59	59	59
6	33	38	44	48	52	54	54	55	55	55
10	35	39	44	47	49	51	51	51	51	51
15	33	37	41	43	45	46	47	47	47	47
20	32	35	39	41	43	44	44	45	45	45
24	31	34	37	39	41	42	43	43	43	43
36	29	32	35	37	39	40	40	40	40	40
48	27	30	33	34	36	37	37	37	37	37

θ = Time after water shut off

T = Time " " shut off

[redacted]

[redacted]

WATER SHUT OFF

K PILE

SINGLE TUBES — TUBE TEMP.

CASE - VII (100% He, 600 Kw/T)

α	a	h	b	A	B	h_1	t_{f_0}	t_{w_0}	λ	Q_c	R	V	k_c	A_0	wc
.37	.077	2.0	.625	2.3	5.2	.43	320	39 (15)	2	61,200	.43	.37	11	.49	.45

Values of α → .1 .2 .4 .6 1 1.5 2 4 8 16 at different values of T ↓

T ↓										
.05	21	80	168	223	284	317	331	340	340	340
.1	17	34	112	161	216	246	258	267	267	267
.2	36	8	77	122	171	199	210	218	218	218
.5	36	.9	59	96	138	161	170	177	177	177
1	20	9	55	85	118	136	143	149	149	149
2	11	31	62	82	104	116	121	124	124	124
4	43	55	72	82	94	99	102	104	104	104
6	54	63	75	82	89	93	94	95	95	95
10	58	66	75	80	85	87	88	89	89	89
15	55	61	69	73	77	79	80	81	81	81
20	52	58	65	69	73	75	75	76	76	76
24	50	56	62	66	70	71	72	73	73	73
36	47	52	58	62	65	67	67	68	68	68
48	44	48	54	57	60	61	62	62	62	62

[redacted]

[redacted]

WATER SHOT OFF

K-PILE

SINGLE TUBES ; DRY ; TUBE TEMP

CASE VIII (100% He, 1202 Kw/T)

α	a	h	b	A	B	h_1	t_{f_0}	t_{w_0}	λ	Q	R	V	k_f	A_0	w_c
.37	.077	2.0	.625	2.3	5.2	.43	563	63 (15)	2	122,000	.43	.37	11	.49	.45

Values of δ → .1 .2 .4 .6 1 1.5 2 4 8 16

at different values of ↓ τ

TUBE TEMPS

τ										
.05	60	172	339	443	556	618	643	660	661	661
.1	16	80	226	318	420	476	498	514	514	514
.2	56	27	156	239	331	381	402	416	417	417
.5	60	9	116	186	263	305	323	335	335	335
1	35	20	106	160	221	255	268	278	278	278
2	18	56	115	151	192	214	223	229	229	229
4	64	88	121	141	162	173	177	181	181	181
6	84	102	125	139	152	160	162	164	164	164
10	92	106	124	133	143	148	150	151	151	151
15	84	97	112	120	128	132	134	135	135	135
20	79	90	104	112	119	123	124	125	125	125
24	75	86	99	106	113	116	118	119	119	119
36	70	79	91	97	104	107	108	109	109	109
48	63	71	82	87	93	96	97	98	98	98

[redacted]

[redacted]

WATER SHOT OFF

K-PILE

SINGLE TUBES — DRY — TUBE TEMP.

CASE - TX (60% He, 300 Kev/T)

α	a	h	b	A	B	h_1	t_{e_0}	t_{w_0}	λ	a_1	R	V	t_e	A_0	wc
.29	.077	1.32	.625	2.1	4.5	.48	290	27 (15)	2.5	30,60	.99	37	0.7	.49	.45

Values of δ → .1 .2 .4 .6 1 1.5 2 4 8 16

at different values of → T

.105	32	17	89	136	192	231	254	285	289	290
.1	61	18	45	86	137	173	194	222	226	226
.2	75	37	18	56	102	135	155	180	184	184
.5	72	41	6	38	78	107	123	146	149	149
1	56	31	7	33	66	90	104	122	125	125
2	26	-7	21	40	63	79	89	102	104	104
4	12	23	41	51	64	73	78	85	86	86
6	29	38	50	57	66	71	74	78	79	79
10	40	47	56	61	66	67	71	73	74	74
15	39	45	52	56	61	63	64	66	66	66
20	37	43	50	53	57	59	60	62	62	62
24	36	41	48	51	54	57	58	59	59	59
36	34	39	44	48	51	53	54	55	55	55
48	32	36	41	43	46	48	49	50	50	50

[redacted]

[redacted]

WATER SHOT OFF

K-PILE

SINGLE TUBES DRY TUBE TEMP

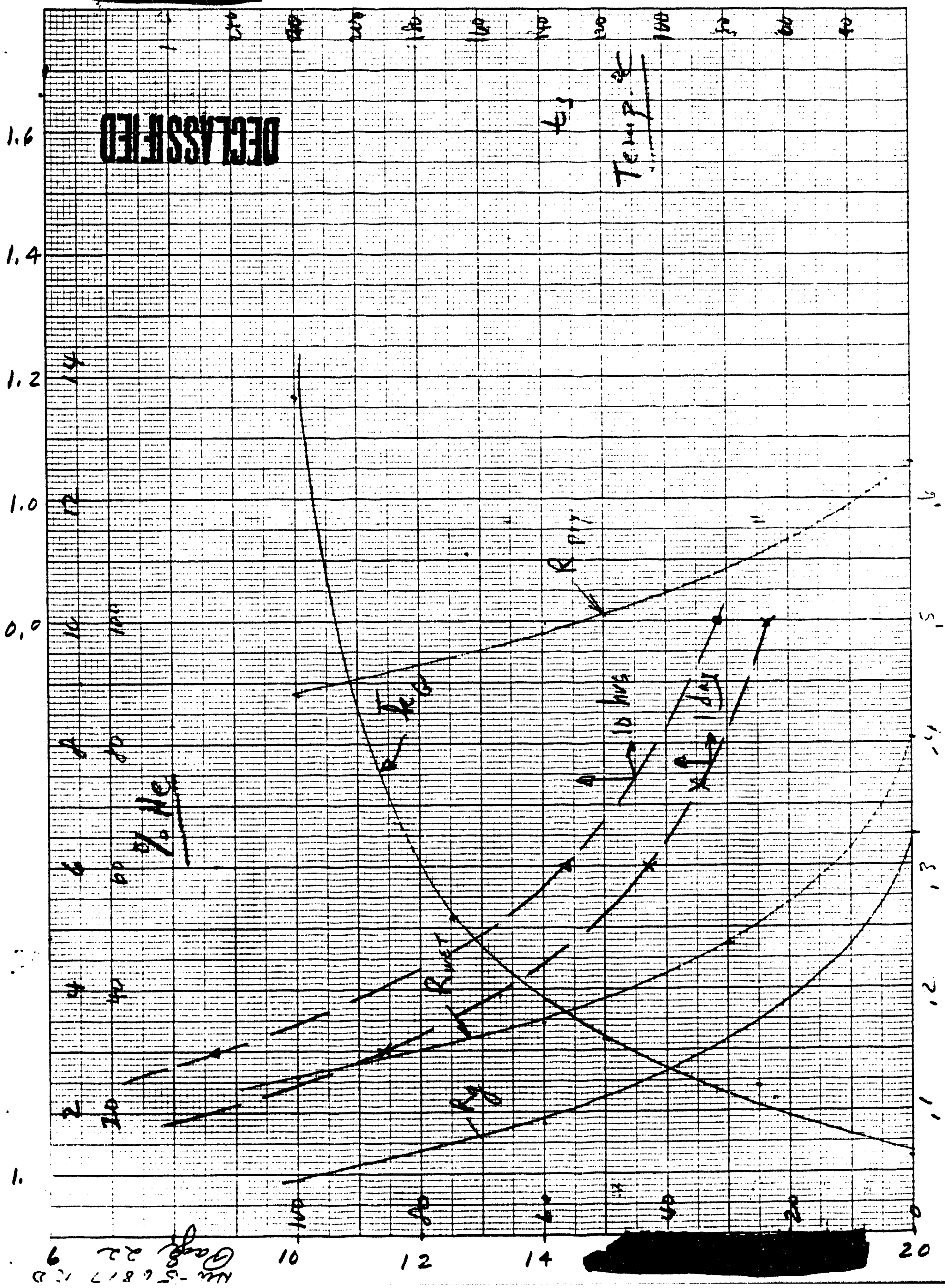
CASE X (60% He, 600 Kw/T)

α	a	h	b	A	B	L_1	t_{b_0}	t_w	λ	Q_0	R	V	k_f	A_0	wc
.29	.077	1.32	.625	2.0	4.6	.50	490	39 (15)	2.5	61,200	.48	.37	.47	.49	.45
Values of θ →						.1	.2	.4	.6	1	1.5	2	4	8	16
for different values of ↓ T for t_w															
.05						32	60	191	275	375	446	497	542	550	550
.1						85	8	106	180	269	333	371	420	428	428
.2						113	46	54	120	202	260	294	340	347	347
.5					=	113	57	28	84	154	204	234	273	279	279
1						89	43	26	72	129	170	195	227	232	232
2						39	5	45	78	120	148	165	188	191	191
4						13	45	76	95	118	134	143	155	157	157
6						51	68	91	104	119	129	135	143	144	144
10						69	82	98	108	108	124	128	132	133	133
15						67	79	92	100	108	113	115	119	119	119
20						64	74	87	94	101	105	108	111	111	111
24						62	71	83	89	96	100	102	105	106	106
36						58	66	77	83	89	93	95	97	98	98
48						53	61	70	75	80	84	86	88	88	88

[redacted]

[redacted]

DECLASSIFIED



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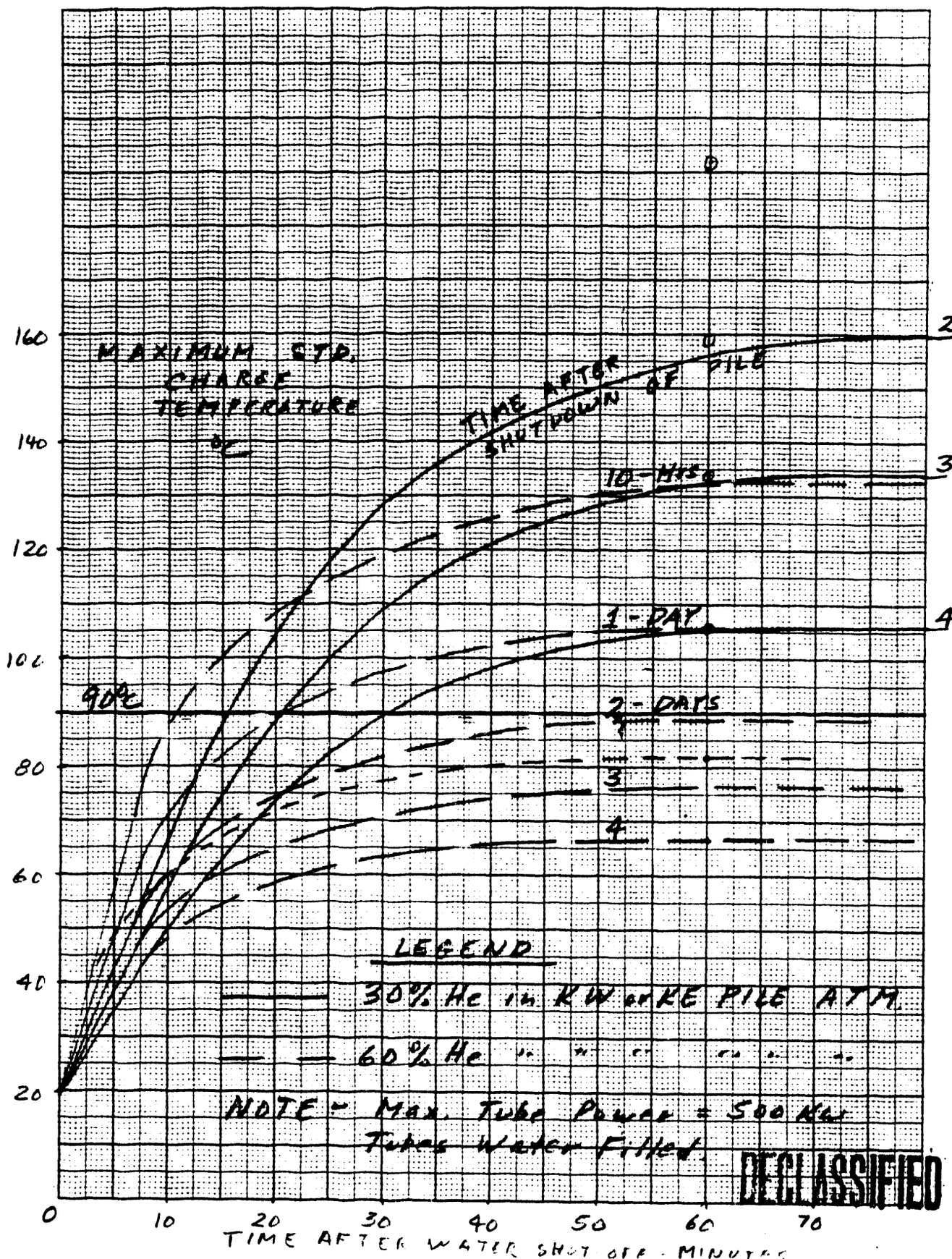

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FIGURE 2: CHARGE TEMPS, AFTER WATER SHUTOFF TO SINGLE OR ALTERNATE K-PILE [redacted]

[redacted] KW DRAINED

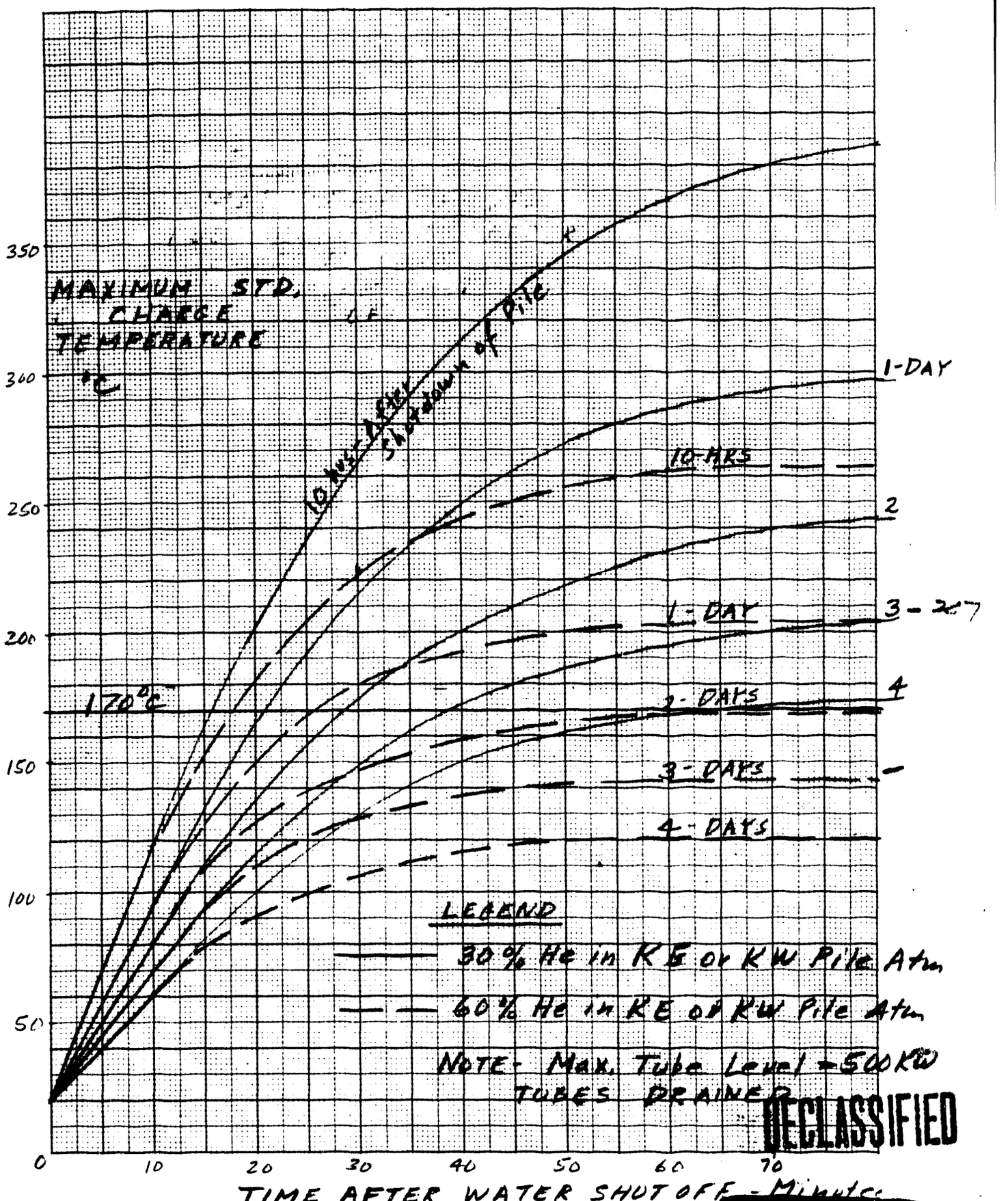


FIGURE 1: CHARGE TEMPS. AFTER WATER [redacted] TO SINGLE OR ALTERNATE K-PILE CROSS HEADER.

[redacted]

WATER SHUT OFF TO ALTERNAT
CROSS HEADERS AT K-PILE
EQUILIBRIUM TEMPS.

WATER FILLED

Power K-4 P	% He	Time After Shut Down T	Decay Factor f_T (1)	R (2)	Δt_a	Aver Lat. Cond. $\bar{k}_c$	$\frac{f_T P}{\bar{k}_c}$	Resistance Δt_b		R_g (3)
500	100	10	.0082	.128	43	13.7	0.30	27.9	8.4	.047
	60			.171	57	4	1.02	30.9	31.4	.100
	30			.24	80	2.2	1.86	35.8	66.6	.325
500	100	24	.0062	.128	32.5	13.7	0.23	27.9	6.4	.047
	60	(1-D)		.171	43	4	0.77	30.9	24	.100
	30			.24	60.5	2.2	1.41	35.8	50.5	.325
500	100	48	.005		26		0.18	27.9	5	.0
	60	(2-D)			35		0.62	30.9	19	
	30				49		1.13	35.8	41	
500	100	72	.0041		21.5		0.15		4	
	60	(3-D)			28.5		0.51		16	
	30				40		0.93		33	
	100	96	.0034		18		0.12		3	
	60	(4-D)			23.5		0.42		13	
	30				33		0.77		28	

(1) HW-33870, pg. 3, 1 yr. Exp.

INITIAL TEMP. RISE

Δt_c	t_4	t_s	$W\dot{c}_p$	$\frac{\delta I f_T P}{60}$	$\frac{dt}{d\theta}$ °c/min
12	20	83	.74	5.5	7.5
25	↓	133			
81		248			
9	20	68		4.2	5.7
19	↓	106			
61		192			
7	20	58		3.4	4.6
15	↓	89			
49		159			
4	20	52		2.8	3.8
12.5		77			
40.5		134			
5	20	46		2.3	3.1
10		67			
34		115			

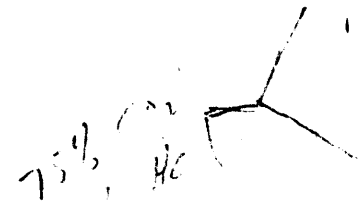
[redacted]

[redacted]

WATER SHUT OFF TO ALTERNA
CROSS HEADERS AT K-PILE
EQUIL. TEMPS

DRAINED TUBES

Power	%He	Time After Shut Down	Decay Factor								
P		T	f_T	R	Δt_n	T_c	$\frac{f_T}{t_c} PF_{CIRCUIT}$		Δt_c	R_o
500	100	10	.0052	.44	146	13.7	0.30	50.0	15	.047
	60			.49	163	4	1.02	53.6	55	.100
	30			.54	180	2.2	1.86	57.2	107	.325
500	100	24	.0062		110		0.23		11	
	60	(1-D)			123		.77		41	
	30				136		1.41		81	
500	100	48	.005		89		.18		9	
	60	(2-D)			99.5		.42		33	
	30				116		1.13		65	
500	100	72	.0041		73		.15		8	
		(3-D)			82		.51		28	
					90		.93		53	
500		96	.0039		61		.12		6	
		(4-D)			68		.42		23	
					75		.77		44	



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Note (1) F_c =

(2) $\overline{\omega\tau}_P \frac{dt}{d\theta} = \frac{\rho_o f_T PF}{60}$

TE

Δt_c	t_{in}	t_s	TUBE REQ. HEAT FLOW OUTPUT Kw	GPM (Δt=50)	INITIAL TEMP. RISE wc_p .	$\frac{.80 f_T P F_c}{60}$	$\frac{dt}{dw}$
						$(1.37 f_q P)$	°C/min
12	20	193	4.1	.31	.56	5.6	9.8
25		263					
81		388					
9	20	150	3.1	.23		4.3	7.5
19		203					
61		298					
7	20	125	2.5	.19		3.4	6.1
15		168					
49		274					
6	20	107	2.1	.16		2.9	5.0
12.5		143					
40.5		204					
5	20	92	1.7	.13		2.3	4.1
10		121					
34		173					

Conversion factor Kw/tube → heat gen./ft. central cross.
103 for K-Reactor

[redacted]

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[redacted]

NOMENCLATURE

a - Radius of graphite bore - ft.

b - Lattice dimension - ft.

f_T - Relative heat generation at T hours after pile shut-down.

h - Apparent gas gap at the surrounding tubes in reciprocal feet.

$$h = \frac{1}{\pi b R_g k_G}$$

h_1 - Apparent gas gap at the test tube in reciprocal feet.

$$h_1 = \frac{1}{A_0 R_T k_G}$$

k_G - Apparent overall thermal conductivity of the lattice graphite between tubes. Btu/hr, ft, °C.

t_{G_0} - Maximum graphite temperature at equilibrium operation °C

t_w - Local water temperature at center of [redacted] tube, °C

$(\rho c_p)_G$ - Heat capacity of the tube + charge. Btu/°C, ft.

α - Apparent graphite diffusivity $= \frac{k_G}{(\rho c_p)}$

(ρc_p) - Effective graphite density x heat capacity

θ - Time that the water is shut off - hours

τ - Time after pile shut-down - hours

Δa - Gap between centered tube and graphite - inch.

d_e - Equivalent diameter of this gap - inch.

[redacted]

$A = k_G A_0 R_T$

A_0 - surface area of graphite bore - ft^2/ft of length.

$B = \frac{1}{(\omega\rho)_s R_T}$

R_g - Resistance of bore gas annulus to heat transfer

$$R_g = \frac{(\Delta a) f_L}{k_g \pi d_e}$$

R_t - Thermal resistance of graphite annulus plus tube wall

$$R_T = \frac{1}{\frac{k_w \pi d_w}{\Delta r_w} + \frac{2 k_w w}{.003} + \frac{2 k_A w}{\Delta r_w}}$$

water (- ribs -)

R_T - Overall resistance of graphite

$$R_T = R_g + R_t$$

Δa - Gap between centered tube and graphite - inch
d_e - Equivalent diameter of gas gap - inch
d_w - Equivalent diameter of water annulus
f_L - Experimental factor for line contact tube
k_A - Thermal conductivity of aluminum
k_g - " " " gas
k_w - " " " water
Δr_w - Water annulus gap [redacted]

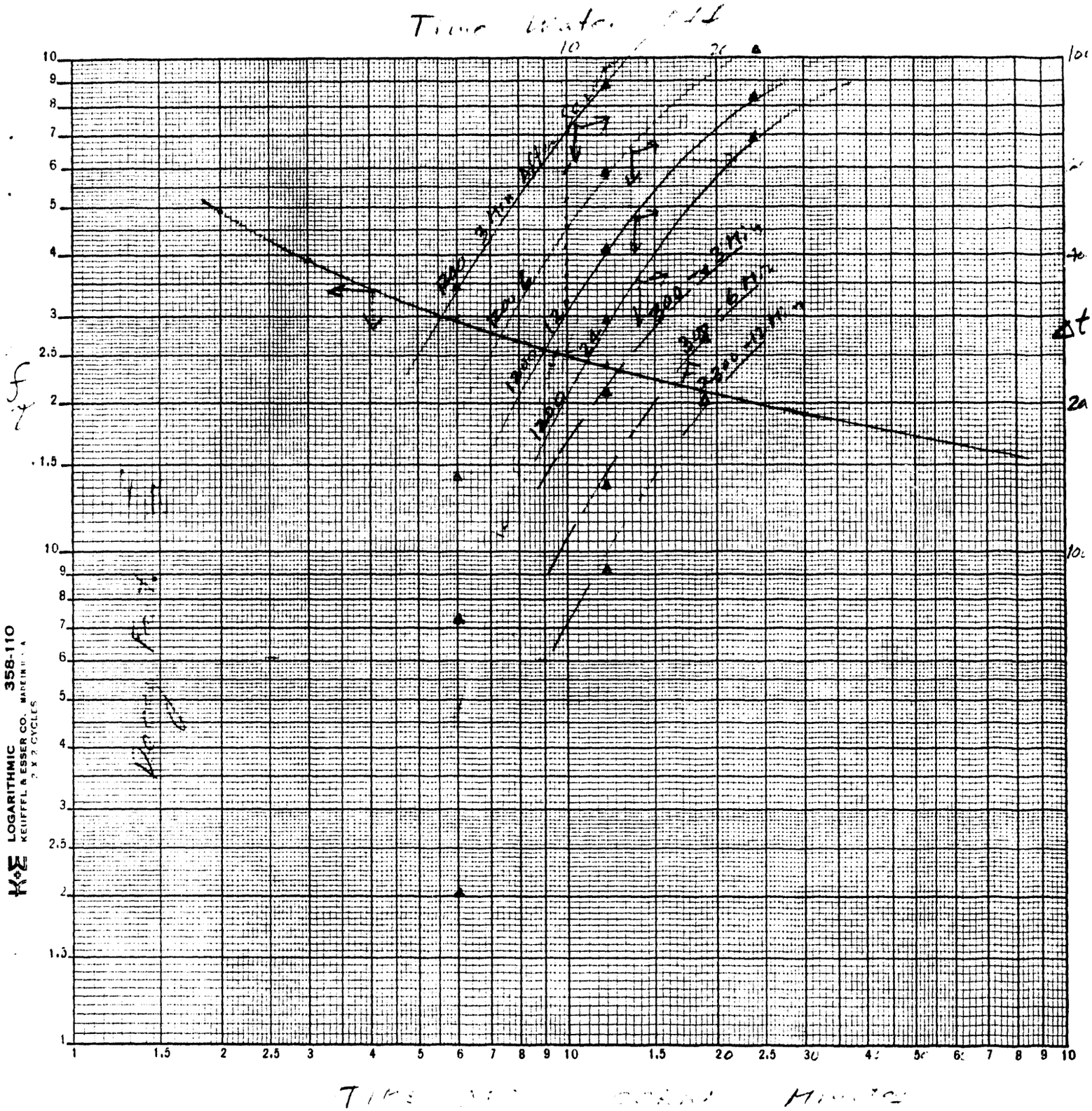
Appendix
HW-56P17-Ri
Mj-29

TIME AFTER SCRAM TO PREVENT MELTING (i.e. - 500°C)

	P Oper Power Kw	τ Time After Scram Min	θ Time H$_2$O Off Min	Δt Temp Rise °C	t_f Fuel Temp °C	f_τ Decay Fraction	τ Time After Scram
Base	1200	12	14	475	500	.023	14
I	1400	?	10	475	500	.0197	26
	1200	?	10	475	500	.028	7
	600	?	10	475	500	.046	2.3
	1600	?	10	475	500	.0172	50

To find H$_2$O shut off time for other than base case

$$f_\tau = \frac{\dot{m}}{\dot{m}_0} \frac{P_x}{P_0}$$



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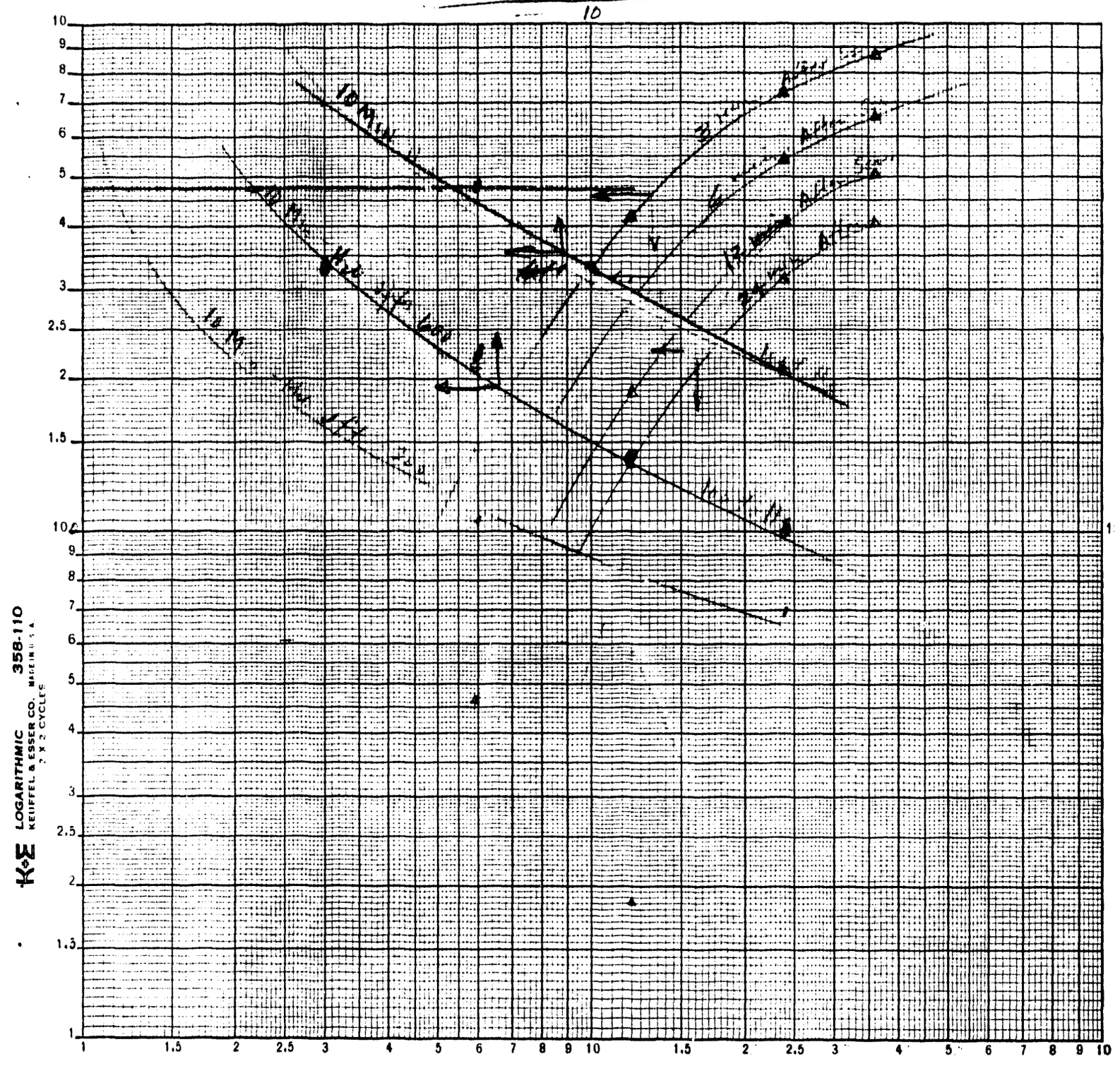

DATE
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