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Cavitation and Multiphase Flow Laboratory

Report No. UMICH 306090-1-F

CAVITATION - EROSION RESISTANCE FOR CAST AND WELD DEPOSITED CORROSION RESISTING STEELS FOR BIRDSBORO CORPORATION

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N. R. Bhatt
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Financial Support Provided by:

Birdsboro Corporation
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ABSTRACT

Cavitation - corrosion tests have been conducted in a vibratory facility (20 kHz, 2 mil double amplitude) upon cast and weld deposited corrosion resisting steels at a water temperature of 120^{o}F and a pressure of 1 atm to provide damage rates for the different materials provided by Birdsboro in terms of MDPR and incubation period. Correlations of loss rates with mechanical properties are also shown with correlation coefficient and factorial standard error.

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I. INTRODUCTION

The objective of this project was to provide cavitation damage test data for various stainless-steel type materials (supplied by Birdsboro Corporation) of interest for use in applications where intense cavitation exists. Our modified cavitation damage vibratory system, using a baffle-plate around the vibrating specimen was used to obtain more uniformity in damage and greater repeatability of damage rate. It was found in preliminary tests[1] that increased repeatability was in fact achieved with this method as compared to the conventional vibratory test arrangement. The tests were run at 120°F rather than at room-temperature since damage rates are considerably greater at that temperature and hence test time is minimized.

The properties of the materials tested are listed in Table I along with damage rates and MDPR*. The modified cavitation damage vibratory system provides 2 mil double amplitude at 20 kHz. The test conditions and test procedure used are specified in Table II.

II. EXPERIMENTS AND RESULTS

A. Experimental Facilities

The modified experimental facility[1] differs from that used in the conventional vibratory test[2, 3, e.g.] only in that the specimen is positioned within and concentric with a circular hole in a baffle-plate. The radial clearance with the baffle plate must be a minimum (3 mils was used in the present test). The arrangement is shown in Fig. 1. The horn, transducer assembly, and flange are unchanged from the conventional arrangement, but the baffle-plate is mounted firmly to the flange to maintain the required parallelism and flushness with the specimen face, the

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*MDPR = Mean Depth of Penetration Rate = Vol. Loss Rate/Spec. Ar desired distance from the flange, and the concentricity with the horn and specimen axis. It was found that optimum uniformity of damage occurs in the flush condition (measured when horn is not operatting). Water level in the test vessel is maintained 1-1/2 in. above the top surface of the baffle-plate.

The specific vibratory facility, to which the baffle-plate arrangement was later added, was designed for high-temperature tests with various fluids[3] and hence includes a sealed flange which also supports the horn. Hence, tests at higher than atmospheric temperature and pressure are not inconvenient if this were desired for future work.

Horn amplitude is monitored by a power meter provided in the driver unit. This unit in turn is calibrated for each specimen with a Fotonic Sensor (MTI Inc., Latham, New York) accurate to about 5% of the desired amplitude. Frequent measurements indicate that frequency remains constant to the order of 0.1% of the desired value. Temperature is automatically controlled by the heater power control to the water bath surrounding the vessel. Air content of the test water (distilled) was maintained at an approximately constant value, somewhat less than saturation at STP, by using a 30-minute pre-run with a dummy specimen to achieve an equilibrium air content somewhat less than saturated. Experience has shown that an air content so obtained remains relatively constant throughout a test. For each weighing of specimens, a wash and dry procedure is used as explained in Table II, where other facility procedures and parameters are listed.

B. Experimental Results

The raw data for all 99 specimens are tabulated in the Appendix, and have been plotted in terms of weight loss vs. time of exposure. Fig 2 through 31 comprise a separate curve sheet

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for each material, with separate curves for each specimen.

The materials have been stamped from A-1, 2, 3, to Z-1, 2, 3 and A'-1, 2, 3 to C'-1, 2, 3. The corresponding material name and number can be found in Table I where all other pertinent information is included. Of the materials tested, A'-1, 2, 3, AM355 stainless steel was found to be most resistant to cavitation and G-1, 2, 3, 25CN carbon steel was found to be least resistant. The factor between these extremes is about x5 in terms of maximum MDPR. The materials are rearranged accordingly to resistance ranking in Table III. The materials have been numbered 1 through 30 according to increasing order of maximum MDPR, i. e., volume loss rate. The most resistant is No. 1 (AM 355 Stainless steel)* etc. This numbering system has been used throughout all the Tables and Figures.

The raw data has been plotted on each of the individual material curve sheets (Fig. 2-31) as weight loss vs. time of exposure. For each specimen, the test has been continued until the maximum weight loss rate had been reached, as determined by subsequent reduction in rate. Normally, seven hours sufficed for all the materials. Hourly measurements of weight loss were made. The maximum weight loss rate and MDPR are taken from these averaged curves. Individual incubation periods are found for each specimen by extrapolating the maximum damage rate portion of the curve to zero loss. The reciprocal of the average maximum MDPR (or weight loss rate) considering all specimens tested is taken as the unit of merit for each material on which the individual listing of the material from 1 to 30 is based. The pertinent individual specimen values and averaged values are listed in Tables I and III.

As is well known, the damage rate usually follows a characteristic S-type curve for tests of this sort, characterized by an initial period of small or zero measurable weight loss followed by a period of relatively constant weight loss rate, and then

* It is interesting to note that there is a factor of more than 3 in MDPR between the various types of <u>stainless steel</u> themselves (excluding carbon steel).

a period of decreasing weight loss rate. Eventual fluctuations of the weight loss rate may occur,. or the rate may continue to decrease with additional exposure. It is our belief, generally shared by most investigators at the present time, that the maximum volume loss rate is the most significant parameter for comparison of specimens. The incubation period may also be of prime importance in applications where it is more desirable that little or no cavitation damage be incurred than that an eventual minimum damage rate exist. Hence, incubation period has also been tabulated. The most and least resistent materials are the same according either to MDPR or Incubation Period. Some of the relative rankings are quite similar as #6 and 8, #21, 22, 23, and 25 for example, and perhaps others. Others, however, are very different. The reasons for these differences at the present time are unknown, but perhaps later more detailed study of the photomicrographs and test results may shed some light (Tables I and II).

Fig 32 to 37 are photographs of typical specimens of each material at or near the conclusion of the test. The MDP value and time of exposure at the time of the photograph are shown in the figure legends. Some differences in uniformity and pitting and damage patterns are evident from an examination of these photos, though a direct comparison is not possible, since the accumulated volume loss is less for the more resistant materials. Fig. 38 through 61 are photomicrographs of the grain structure for each material supplied by Birdsboro.

One classical goal of cavitation damage research is to find a usable correlation between cavitation damage resistance (1/MDPR) and easily measurable mechanical properties of the material. This goal appears elusive, perhaps because cavitation attack is on a micro-scale and involves very high rates of loading (duration is order or one microsecond) whereas the conventional mechanical properties involve macro-failures of the materials, and the loading is relatively very gradual compared to cavitation attack. Due to the apparent lack of a good correlation with standard mechanical properties, it appears that a more detailed consideration of the surface reaction to cavitation must be made if an ability to predict cavitation resistance is to be attained, or the capability of designing materials specifically for this purpose. A more detailed study of the grain structures (Fig. 38--61) may be useful for this purpose. Of course it may well be more feasible to simply test the cavitation resistance directly as was done in the present instance.

C. Data Correlations

Computer correlations have been made wherein the present materials, as well as a group of tool steels and another of miscellaneous metallic alloys which we had previously tested are included. The results are shown in Table IV (A. B. C.) and in Fig. 62--63. Table IV-A is for the Birdsboro materials alone, IV-B for all materials (including Birdsboro) and IV-C for all materials excepting Birdsboro.

The best correlation of damage resistance for the Birdsboro materials alone is with Brinell hardness (BHN). This parameter has often been used in the past for predicting purposes and has the strong advantage of simplicity. Recent tests have often shown that ultimate resilience (UR) or a combination between (UR) and strain energy (SE) or (BHN) was the most successful (4, e.g.). It is noted (Table IV-C) that this is still the case for the materials we have tested excluding the Birdsboro materials, i.e. a set of predominently stainless steels. It is also interesting to note that while the correlation coefficients for the Birdsboro materials are not particularly impressive, the scatter is very small (factorial standard error of estimate = 1.26), compared with the other data sets, i.e. the total material set and that excluding the Birdsboro materials (Tables IV-B, C).

Finally, it should be mentioned that Strain Energy (SE)*, which has often been suggested in the past as a correlating parameter, is considerably worse in all regards than the other possibilities which are included in these tables.

*Area under conventional stress-strain curve

III. CONCLUSIONS

The minimum cavitation volume loss rate (MDPR) was found for material AM 355 Stainless Steel and the maximum for material 25 CM Carbon Steel. The factor in MDPR between these materials is about 5. The same relative ranking for these two end materials is maintained for incubation period, and the factor is about 6. The relative rankings for some of the materials with either of these two merit parameters is quite similar, and for others it is quite different (Table III).

Although the mechanical properties of these materials cover only a relatively small range, the reciprocal volume loss rates can be quite accurately correlated in terms of Brinell Hardness. Ultimate resilience, which had been quite successful for other material sets, is much less so for the present set which is composed predominently of stainless steels. The reason for this difference is not known but may be disclosed by further study of the results along with the photomicrographs. This may allow the development of an even more useful grading parameter for these materials, perhaps involving grain size as well as hardness.

ACKNOWLEDGEMENTS

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TABLE I

U of M No.	Material No. and Name	Hardness (Rockwell-C) R_c	Hardness (Brinell) BHN	Tensile Strength T.S. psi	Yield Strength Y.S. psi	% Elongation 2 in.	%Area Reduction	Density gm/cm^3 at 70^oF	Elastic Modulus E psi	Weight Loss Rate mg/hr	MDPR mils/hr	Incubation Period hr.	Ave. WLR Ave. MDPR
A-1	Grad CF 8									23.00	0.7728	1.00	
A-2	Heat E - 4012		150	82700	52600	53%		7.75		19.00	0.6384	1.00	21.83
A-3	A-1, A-2, A-3; A-4, A-5, A-6, A-7, A-8, A-9, A-10.									23.50	0.7896	1.00	.7336
A-4	Grad CF-8									19.50	0.6552	1.00	
A-5			150	82700	52600	53%				19.00	0.6384	1.00	20.33
A-6										22.25	0.7560	1.00	.6832
A-8	Grad CF-8									21.75	0.7308	1.00	
A-9			150	82700	52600	53%		7.75		23.50	0.7896	1.00	22.66
A-10										22.75	0.7644	1.00	.7616
C-1	CA7M									14.347	0.4670	0.9	
C-2	Stainless		160	66800	33150	44.0%		8.00		15.642	0.5091	0.65	15.35
C-3	Heat # C-808 Sol. quenched from 2000^o									16.071	0.5231	0.35	.4997
CA15#1	CA-15									19.90	0.6808	0.70	
CA15#2								7.612		20.80	0.7116	0.65	20.35
D-1	CA6NM									12.666	0.4329	0.35	
D-2	Stainless		241	118950	105950	18.0%	53.8%	7.620		8.783	0.3001	0.90	10.05
D-3	Heat #E-4967									8.712	0.2977	0.70	0.3435
E-1	CF 8									22.00	0.7392	0.70	
E-2	Stainless		150	73220	39850	63.5%		7.75		29.60	0.9906	1.25	23.70
E-3	Heat # E 4957									19.50	0.6552	1.00	.7950
F-1	CF 8									22.70	0.7627	0.75	26.511
F-2	Stainless		150	77750	41150	57.0%		7.75		30.32	1.0188	0.9	.8907
F-3	Heat #88406									--	--	--	
G-1	25 CM									42.62	1.4121	0.5	
G-2	Carbon Steel		140	76450	43500	33.0%	51.3%	7.859		34.60	1.146	0.00	38.21
G-3	Heat # E 4945									37.42	1.2365	0.25	1.264
H-1	45 A 7									10.40	0.3445	1.00	
H-2	Carbon		311	1500850	121250	12.5%	41.2%	7.86		15.02	0.4976	1.35	12.71
H-3	Heat # F-5144									11.00	0.900	0.80	.4221
I-1	CA - 15	23_o								18.00	0.6158	0.85	
I-2	Heat # F-5144		220	103200	83500	21.0%	43.3%	7.612		19.40	0.6637	0.55	18.63
I-3										18.50	0.6329	0.65	.6374

TABLE I (cont.)

J-1	CA-15							14.00	0.5097	0.65	
J-2	LO CR, LO ST	187	91550	75300	29.0%	60.3%	7.612	12.68	0.4338	0.75	15.22
J-3	Heat F-5264							14.09	0.4820	0.00	.4751
K-1	CA-15							12.10	0.4139	0.875	
K-2	CO CR, LO SF	285	133950	120900	17.0%	51.1%	7.612	11.33	0.3876	0.95	11.37
K-3	Heat E 5036							10.70	0.3660	0.5	0.3891
L-1	CF 8							15.74	0.5288	0.85	
L-2	Stainless	150	80000	45000	42.5%		7.75	15.20	0.5107	1.25	16.44
L-3	Heat # F-5580							18.40	0.6183	0.95	.5526
M-1	CF-8							18.46	0.6202	0.5	
M-2	Sol. quench.	150	79000	49950	45.0%		7.75	17.32	0.5819	0.65	18.26
M-3	2000°F							19.01	0.6387	0.70	.6136
N-1	Arcos Stainlend							14.72	0.4946	0.30	
N-2	13-4 Ni	240	145550	115850	3.5%	10.6%	7.62	16.36	0.5497	0.5	15.79
N-3	(For welding GAGNM as weld.							16.30	0.5477	0.00	.5306
O-1	Arcos Stainlend							18.24	0.6223	0.5	
O-2	13-4 Ni	240	132550	70650	17.0%	45.3%	7.62	16.38	0.5598	0.75	16.29
O-3	Stress Relieved 1175°F							14.26	0.4873	0.60	.5564
P-1	304-L Sol)							17.60	0.5800	0.40	
P-2	Quenched 2050°F	156	72700	43800	68.0%		7.90	17.50	0.5767	0.00	17.60
P-3								17.70	0.5833	0.60	.5800
Q-1	304-L									0.25	
Q-2	Sensitized	156	77450	37450	64.00%		7.90	20.20	0.6657	0.25	
Q-3	1250°F							--		0.25	
R-1	CF 8 M							16.00	0.5376	0.70	
R-2	Sol. quenched	160	78200	47950	50.00%		7.75	17.00	0.5712	0.55	0.5514
R-3	2050							16.25	0.5456	0.75	16.41
S-1	CF 8 M							16.10	0.5409	0.80	
S-2	As cast	160	78250	44250	36.00%		7.75	16.10	0.5809	0.625	16.31
S-3								15.75	0.5292	0.625	.5370
T-1	CE 30							14.80	0.5025	0.75	
T-2	Water quenched	225	91700	60600	24.5%		7.67	14.80	0.5025	0.75	14.41
T-3	2000°F							13.65	0.4635	0.75	.4903
U-1	CE 30							15.15	0.5144	0.60	
U-2	As cast	225	88.250	52600	28.0%		7.67	15.70	0.5331	0.50	15.42
U-3								Broken	--	--	0.5230
V-1	308-L							17.00	0.550	0.51	19.00
V-2	Water quenched	160	72850	42350	54.0%		8.00	20.00	.650	0.00	.616
V-3	2000°F							20.00	.650	0.60	
W-1	308-L							16.50	.5439	0.49	16.50
W-2	As welded	160	73900	52500	49.0%		8.00	16.50	.5439	1.00	.543
W-3								16.50	.5439	0.75	

TABLE I (cont.)

X-1	308 Wire							17.50	.552	0.75	18.25
X-2	As welded	160	90250	66650	34.0%		8.00	19.00	.620	1.51	.585
X-3								Broken	--	--	
Y-1	308 Wire							18.50	.6010	0.60	18.50
Y-2	Sol. quenched	160	83500	53050	44.0%		8.00	18.50	.6010	0.60	.6010
Y-3	2000°F							18.50	.6010	0.60	
Z_1-1	E 410 Sta inless							10.00	.340	0.75	10.40
Z_1-2	As welded	230	150000	92250	2.5%	7.0%	7.70	10.50	.340	0.50	.337
Z_1-3								10.70	.348	0.60	
Z_2-1	E 410							20.00	.679	0.40	17.50
Z_2-2	Stress Relieved	230	112200	95750	18.0%	52.7%	7.70	19.00	.645	0.60	.593
Z_2-3	1300°F							13.50	.457	0.40	
A'-1	AM 355							7.50	.247	1.00	7.66
A'-2	Stainless	350	179900	154300	17.0%	52.2	7.92	6.00	.198	1.75	.253
A'-3			(ultimate)					9.50	.314	1.50	
B'-1	CF 8 C							18.50	.665	0.90	
B'-2	Sol. quenched	150	77550	43450	50.0%		7.75	16.00	.555	1.00	16.66
B'-3	Heat 2050°F							15.50	.539	1.10	.586
C'-1	CF 8 C							13.00	.437	0.75	
C'-2	As cast	150	77050	39400	47.0%		7.75	13.00	.437	0.75	13.00
C'-3								13.00	.437	0.75	0.437

TABLE II

TEST PROCEDURE

1. Baffle-plate installed with axial clearances so that baffle-plate and specimen surface are flush with power off.
2. 4-1/2" distilled water depth, fresh each day with a 30 minute deareation run (with dummy specimen) before start of actual tests to achieve equilibrium air content conditions for actual tests.
3. $120^{o}F \pm 3^{o}F$ water temperature attained.
4. 1.69 psig (16.69 psia) air pressure in vessel.
5. Run at power settings to attain 2 mil double amplitude at 20 kHz.
6. Run in 1 hour increments to a cumulative time of 7 hours, or at least until maximum damage rate is attained.
7. Wash in acetone, then in methanol, then dry 5 minutes in vacuum at ambient temperature.
8. Torque applied to specimen is 90 in. lb., to achieve uniform and snug fit.

TABLE III

NUMBERING SYSTEM

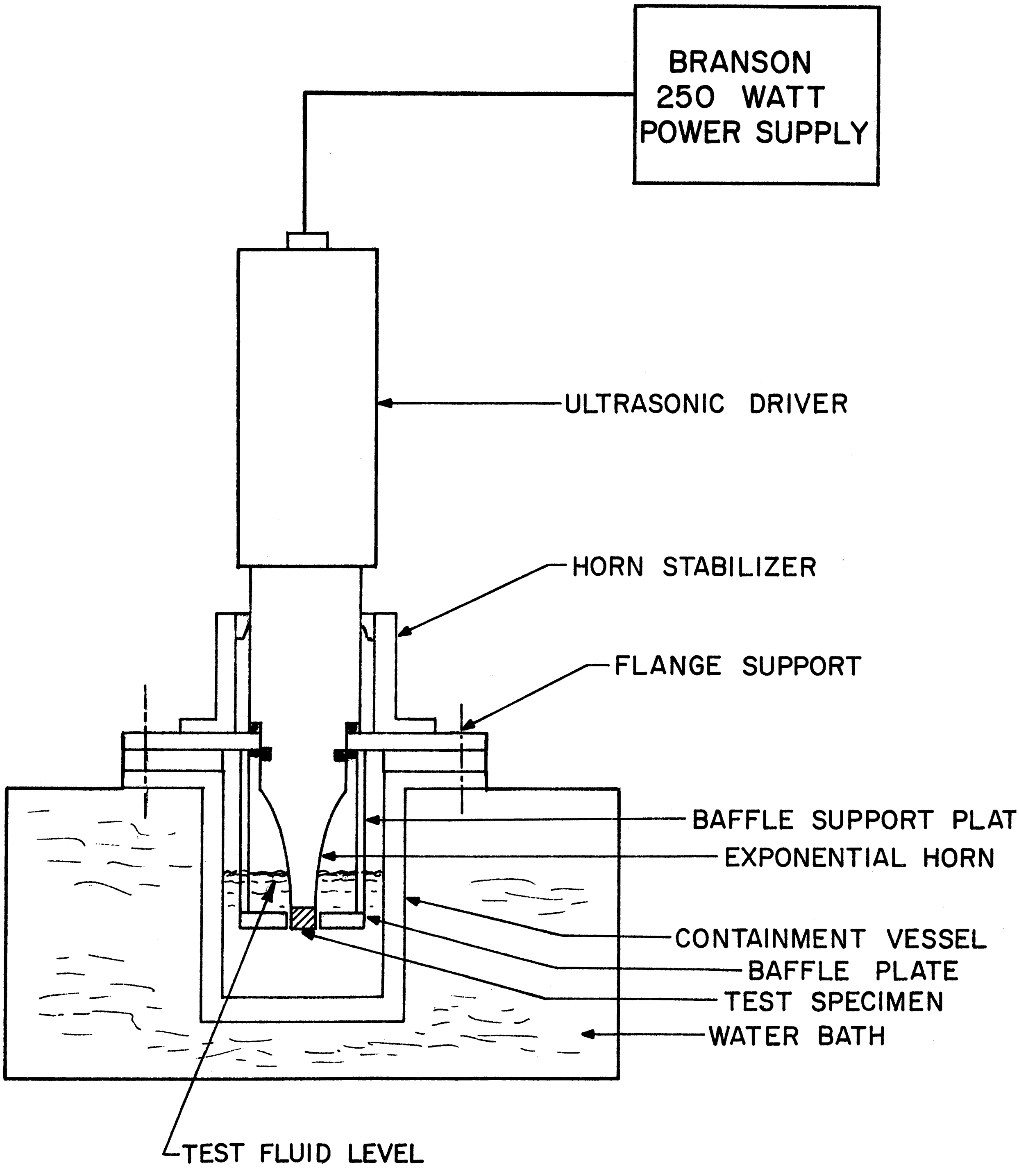
Relative Ranking MDPR	Relative Ranking Incubation Period	Material Name and No.	MDPR* (mils/hr)	WLR* (mg/hr)	Incubation* Period (hrs)
1	1	A'1, 2, 3	0.253	7.66	1.625
2	18	Z_1-1, 2, 3	0.337	10.40	0.500
3	15	D-1, 2, 3	0.3435	10.05	0.65
4	27	K-1, 2, 3	0.3891	11.37	0.625
5	19	H-1, 2, 3	0.4221	12.71	0.715
6	28	C'-1, 2, 3	0.437	13.00	0.750
7	29	J-1, 2, 3	0.4751	15.22	0.700
8	6	T-1, 2, 3	0.4903	14.41	0.750
9	8	C-1, 2, 3	0.4997	15.35	0.632
10	13	U-1, 2, 3	0.5230	15.42	0.550
11	5	S-1, 2, 3	0.5306	15.79	0.673
12	7	N-1, 2, 3	0.5370	16.31	0.400
13	24	W-1, 2, 3	0.5439	16.50	0.746
14	26	R-1, 2, 3	0.5514	16.41	0.625
15	11	L-1, 2, 3	0.5526	16.44	1.070
16	3	O-1, 2, 3	0.5564	16.29	0.616
17	9	P-1, 2, 3	0.5800	17.60	0.500
18	4	X-1, 2, 3	0.5850	18.25	1.130
19	14	B'-1, 2, 3	0.5860	16.66	0.950
20	16	Z_2-1, 2, 3	0.5930	17.50	0.460
21	23	Y-1, 2, 3	0.6010	18.50	0.600
22	21	V-1, 2, 3	0.6136	18.20	0.550
23	25	M-1, 2, 3	0.6160	19.00	0.613
24	10	I-1, 2, 3	0.6374	18.36	0.683
25	22	Q-1, 2, 3	0.6657	20.20	0.600
26	2	CA15	0.6962	20.35	0.675
27	17	A-1-10	0.7250	21.60	1.000
28	20	E-1, 2, 3	0.7950	23.70	0.950
29	12	F-1, 2, 3	0.8907	26.511	0.825
30	30	G-1,2 ,3	1.264	38.21	0.250

*Average Values of several Specimens

TABLE IV (A. B. C.)

Correlation Relation	Sample Correlation Coefficient On Log Scale	Sample Correlation Coefficient On Linear Scale	Factorial Standard Error of Estimate	Constant C	Exponent n
A. Birdsboro materials only					
$1/MDPR = C\,(UR)^n$	0.439	0.378	1.33	1.087	0.146
$1/MDPR = C\,(UR \times E^2)^n$	0.439	0.378	1.33	0.73×10^{-2}	0.145
$1/MDPR = C\,(UR \times BHN)^n$	0.511	0.446	1.31	0.530	0.142
$1/MDPR = C\,(BHN)^n$	0.672	0.718	1.26	0.238×10^{-1}	0.876
$1/MDPR = C\,(SE)^n$	0.224	0.203	1.36	0.744	0.113
B. For all materials (U of M, Tool Steels and Birdsboro)					
$1/MDPR = C\,(UR)^n$	0.636	0.006	3.05	0.478×10^{-1}	0.795
$1/MDPR = C\,(UR \times E^2)^n$	0.677	0.041	2.90	0.453×10^{-9}	0.576
$1/MDPR = C\,(UR \times BHN)^n$	0.701	0.063	2.76	0.52×10^{-2}	0.576
$1/MDPR = C\,(BHN)^n$	0.748	0.364	2.61	0.38×10^{-3}	0.602
$1/MDPR = C\,(SE)^n$	0.072	0.174	4.20	0.964	4.08
C. For all other materials (excluding Birdsboro)					
$1/MDPR = C\,(UR)^n$	0.743	0.077	3.75	0.11×10^{-1}	1.11
$1/MDPR = C\,(UR \times E^2)^n$	0.771	0.139	3.51	0.25×10^{-11}	0.72
$1/MDPR = C\,(UR \times BHN)^n$	0.780	0.127	3.43	0.16×10^{-2}	0.74
$1/MDPR = C\,(BHN)^n$	0.761	0.338	3.60	0.32×10^{-3}	1.76
$1/MDPR = C\,(SE)^n$	0.188	0.100	6.95	0.114	0.35

UR = Ultimate Resilience
E = Elasticity
BHN = Brinell Hardness
SE = Strain Energy



2691

Figure 1. Schematic of Baffled Test Configuration

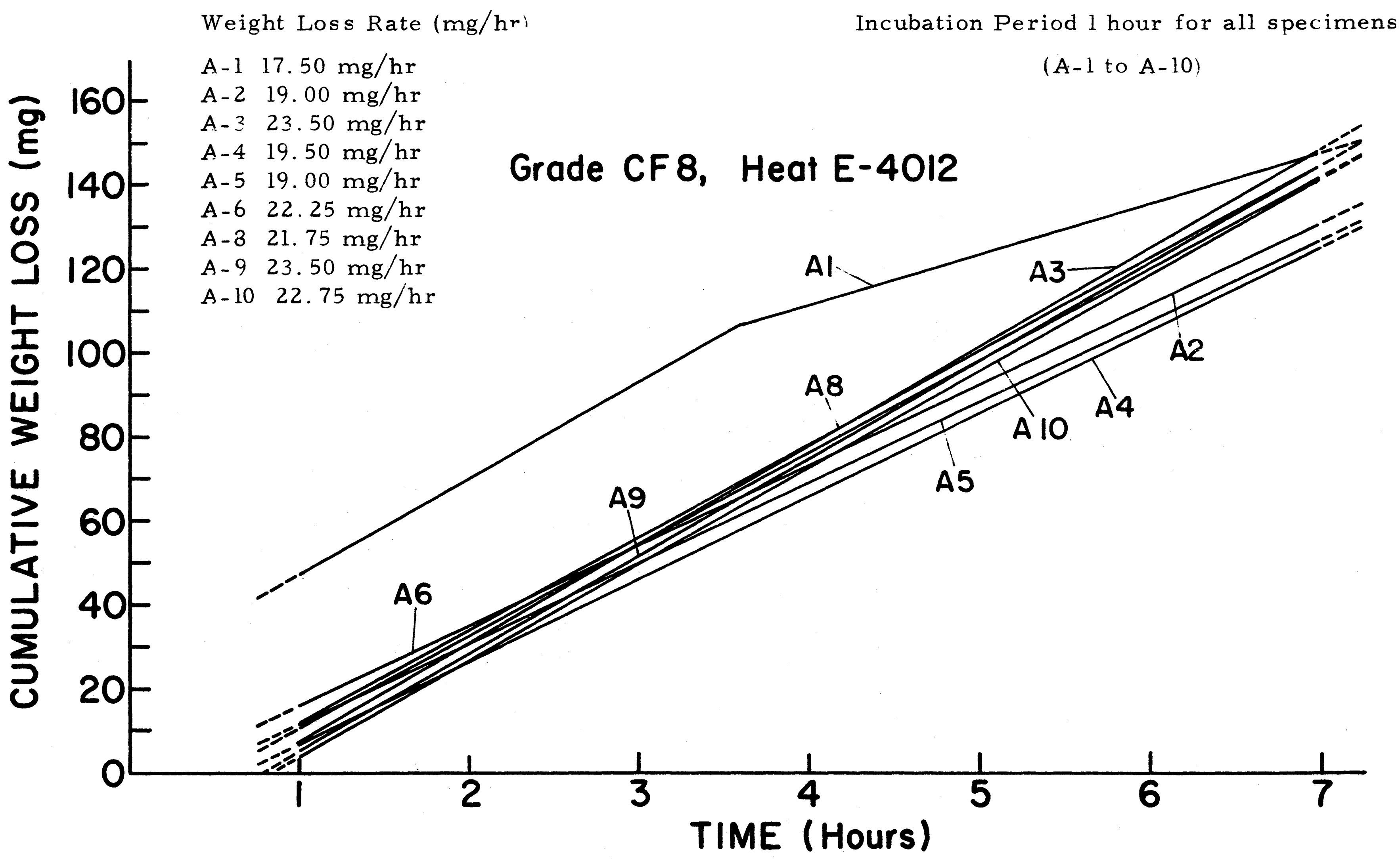


Figure 2. Weight Loss vs. Exposure Time

3265

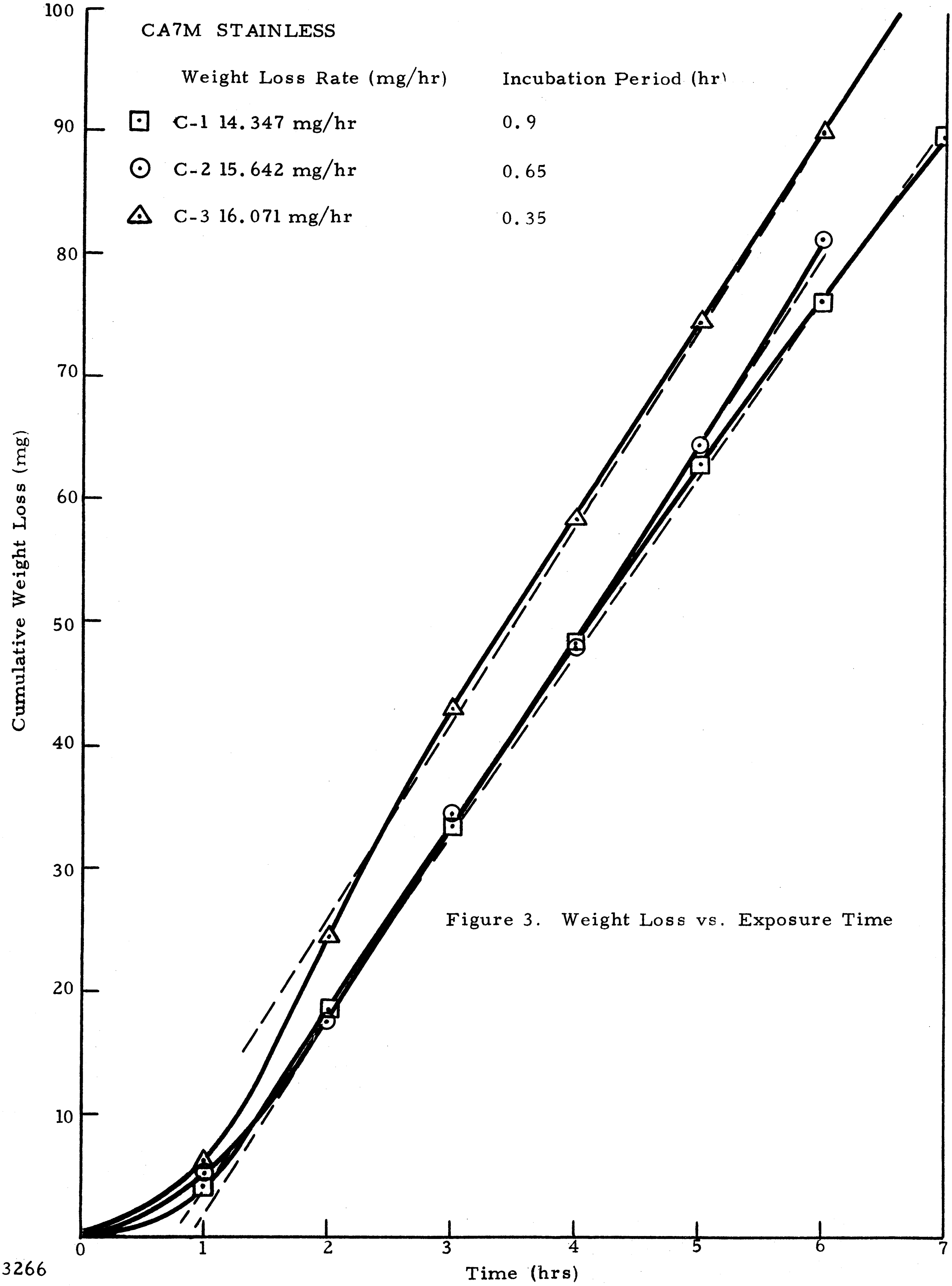


Figure 3. Weight Loss vs. Exposure Time

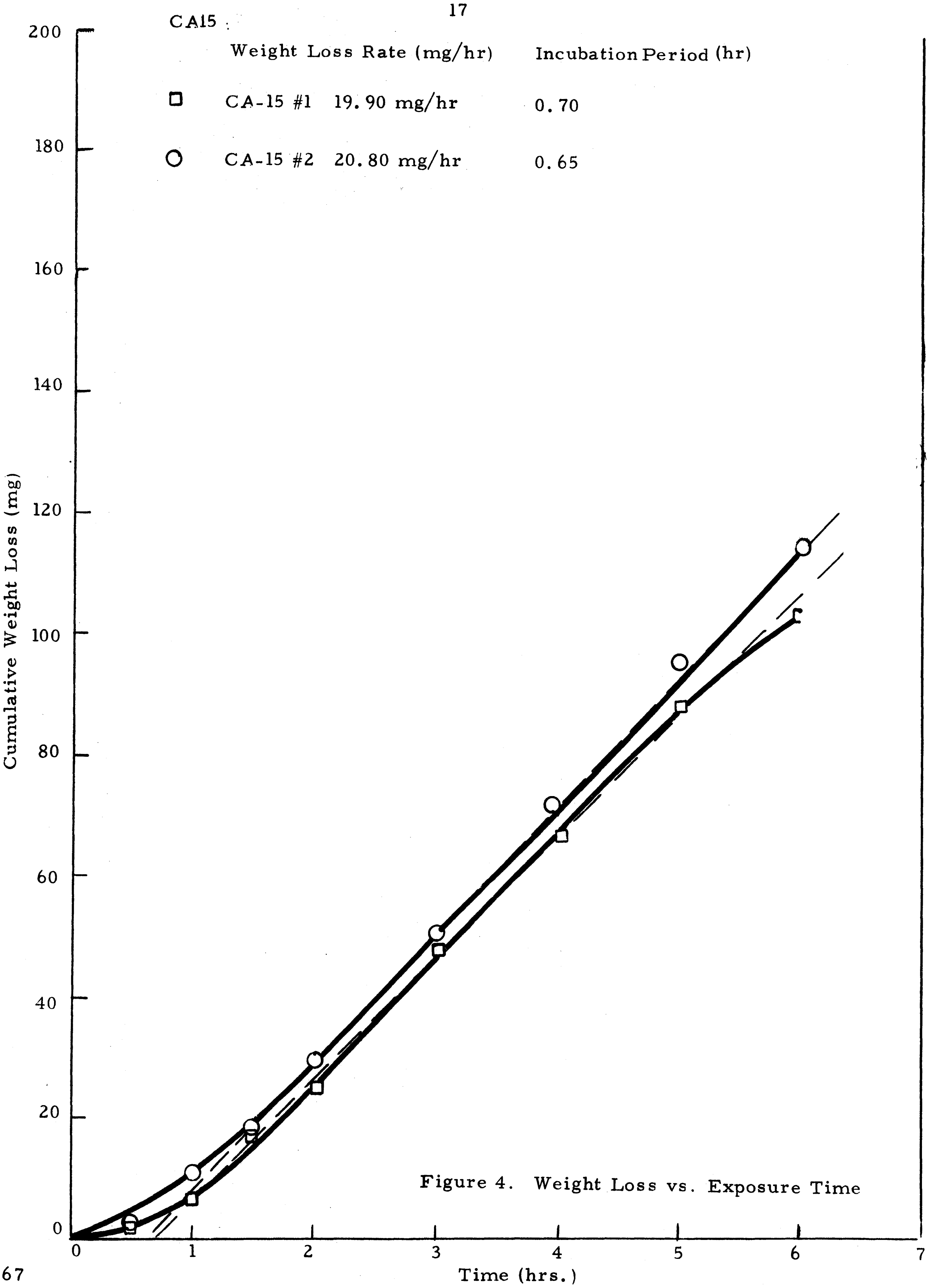


Figure 4. Weight Loss vs. Exposure Time

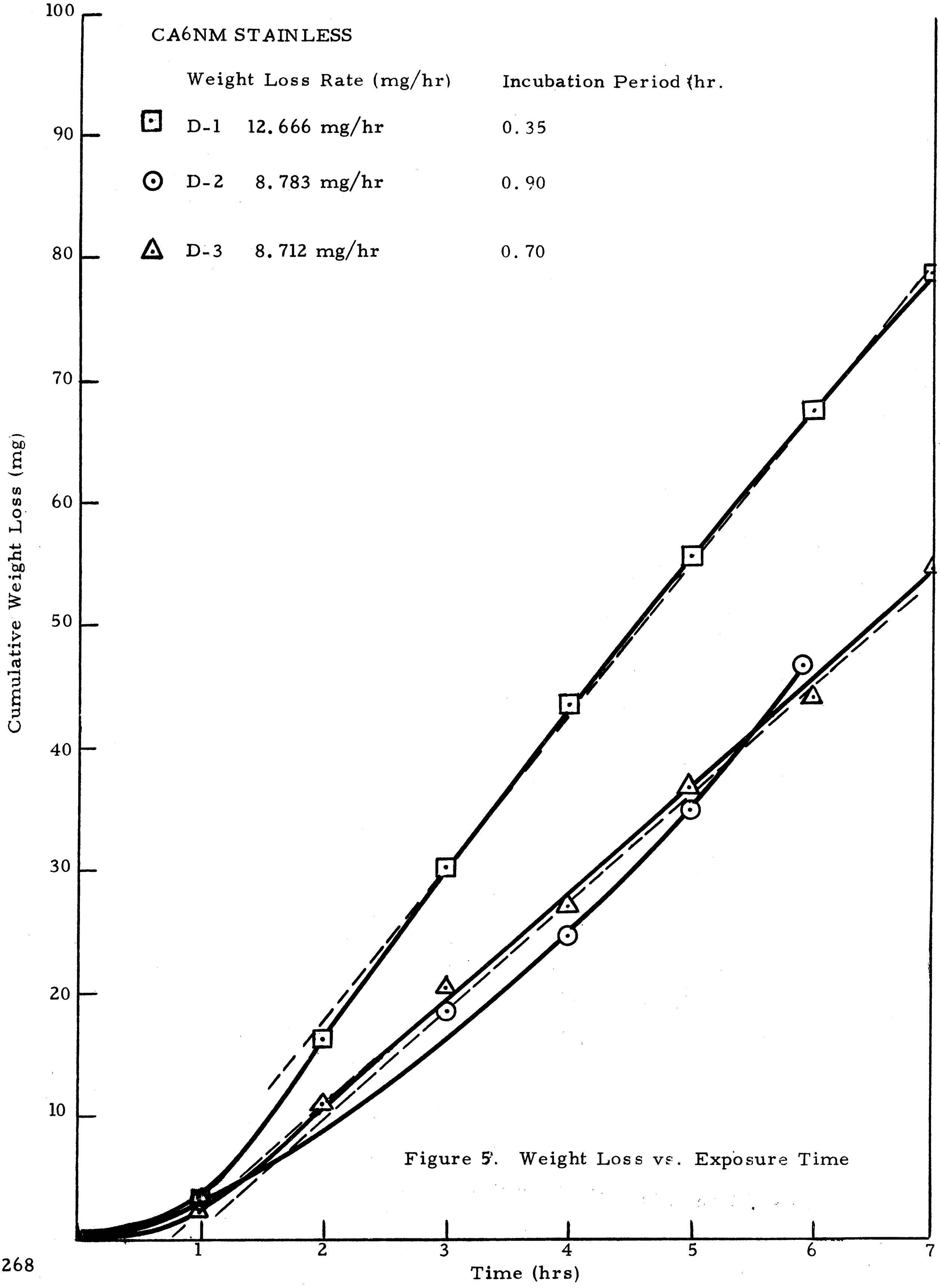


Figure 5. Weight Loss vs. Exposure Time

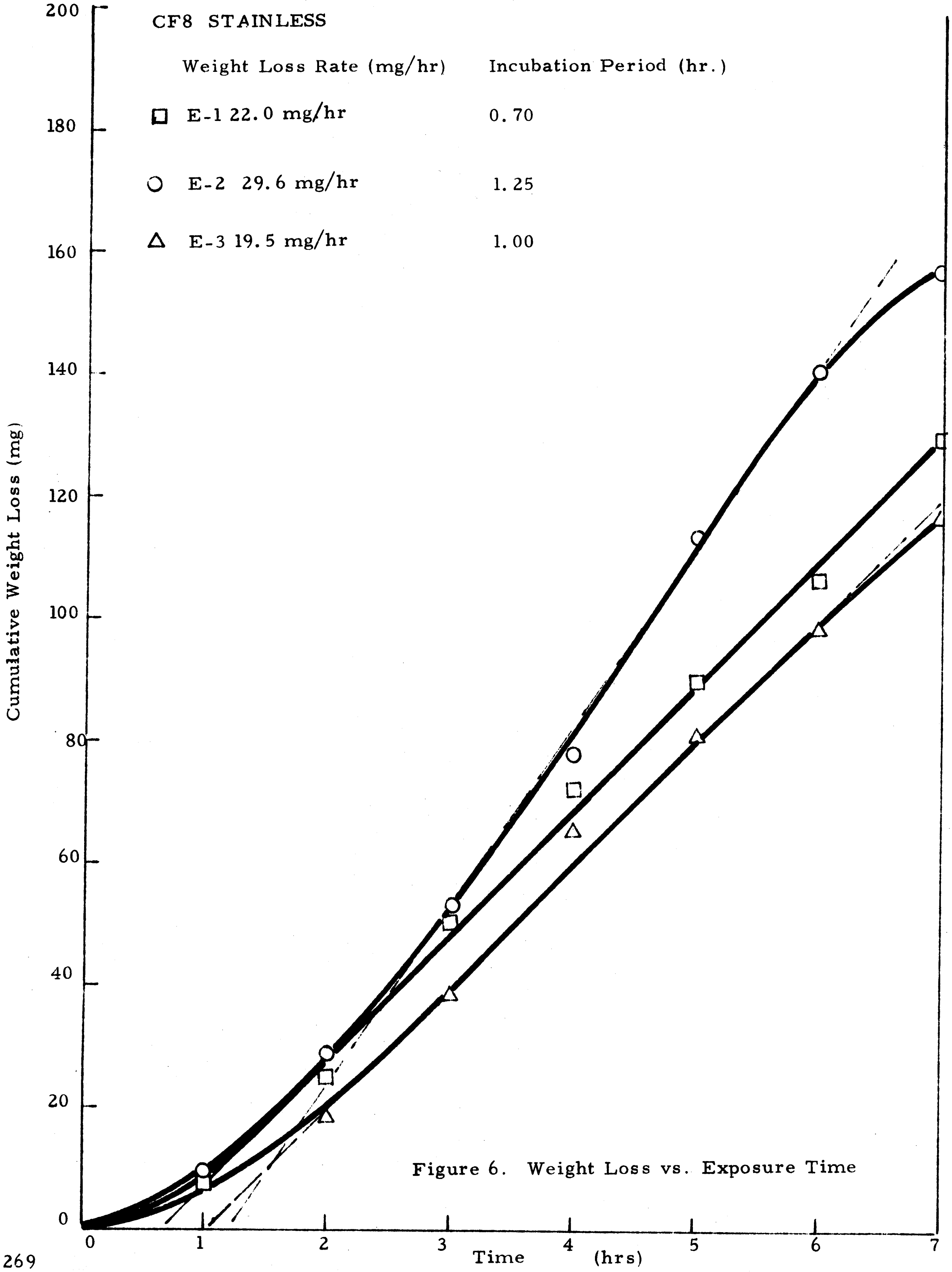


Figure 6. Weight Loss vs. Exposure Time

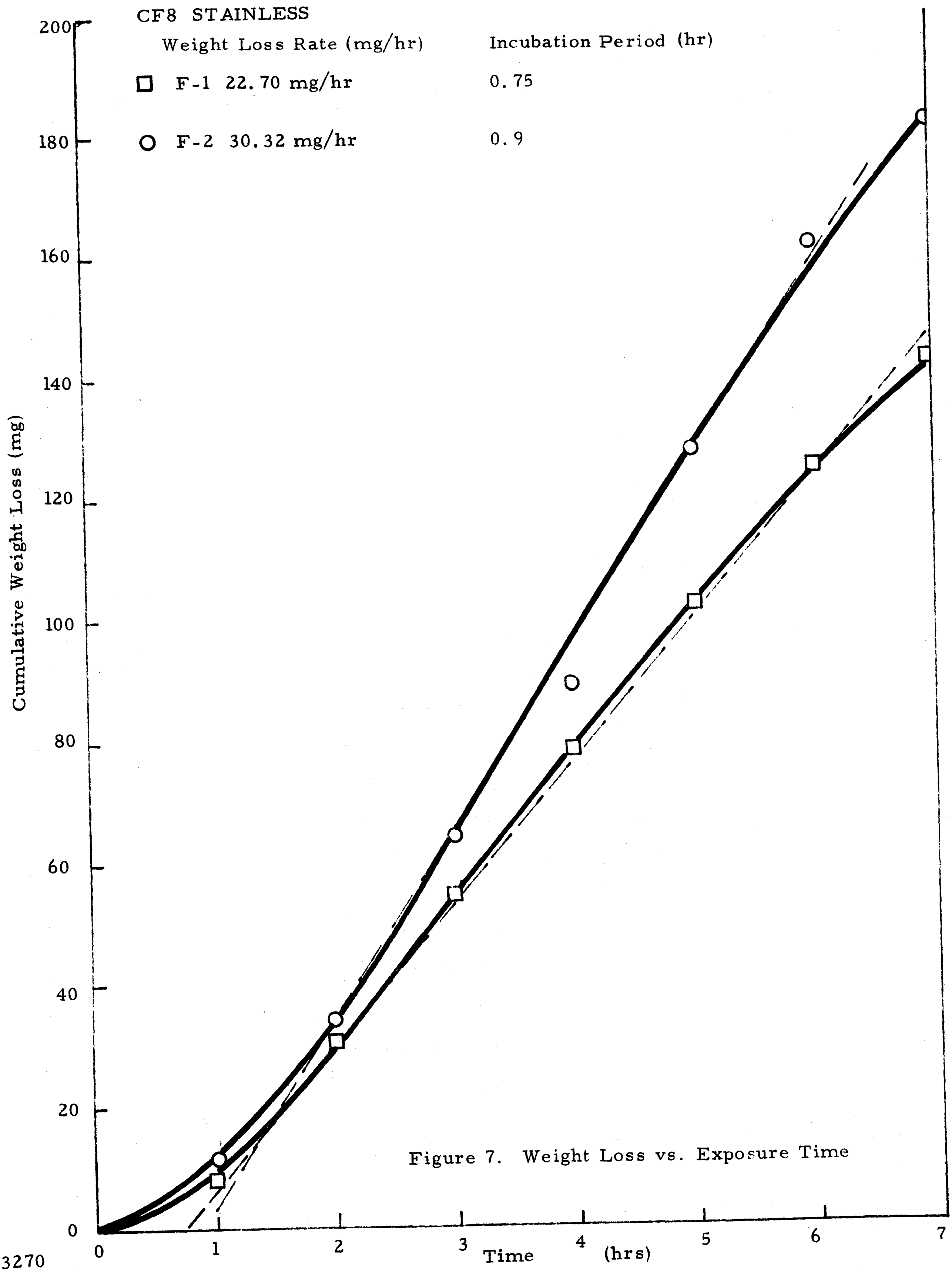


Figure 7. Weight Loss vs. Exposure Time

3270

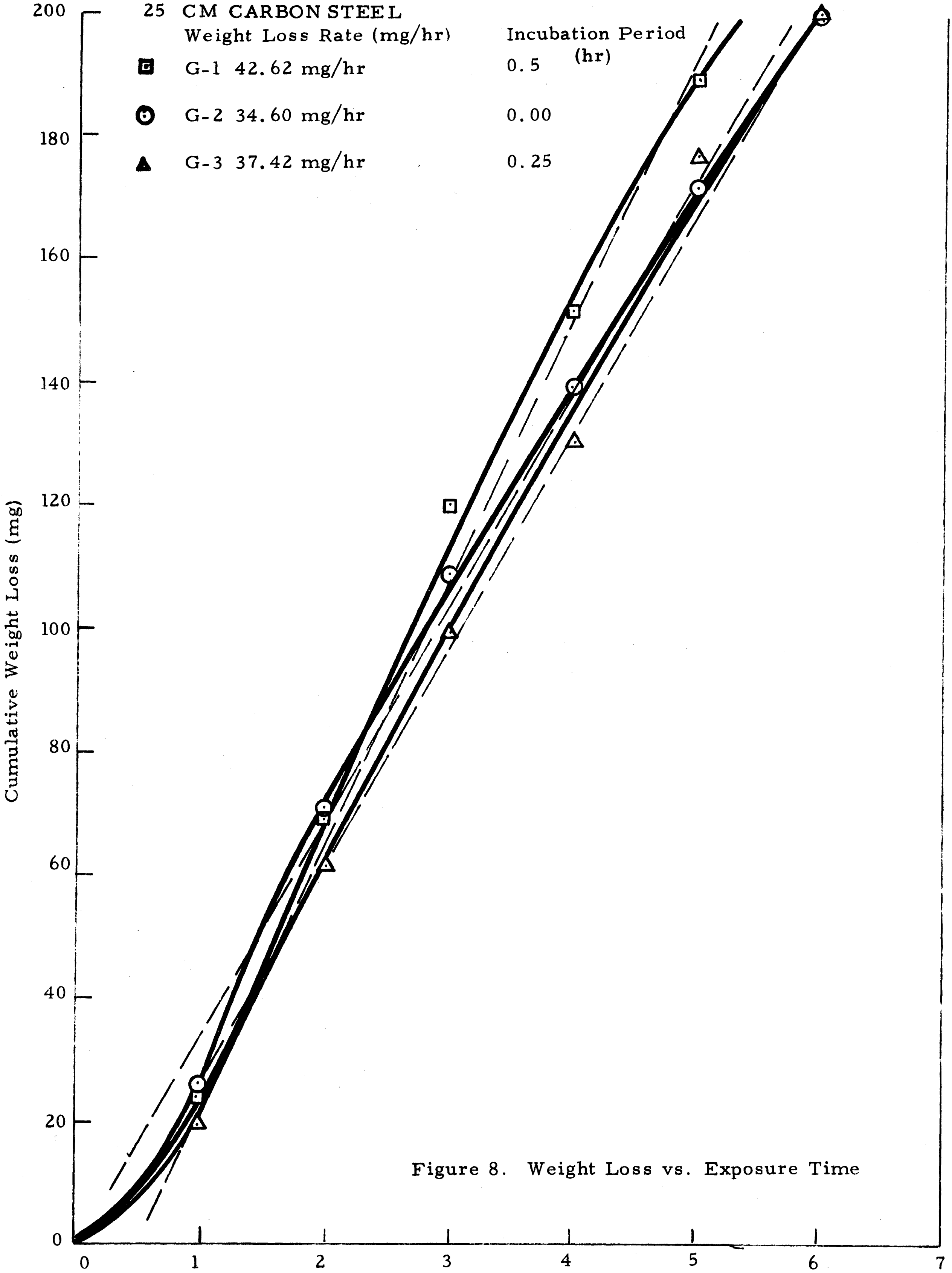


Figure 8. Weight Loss vs. Exposure Time

3271

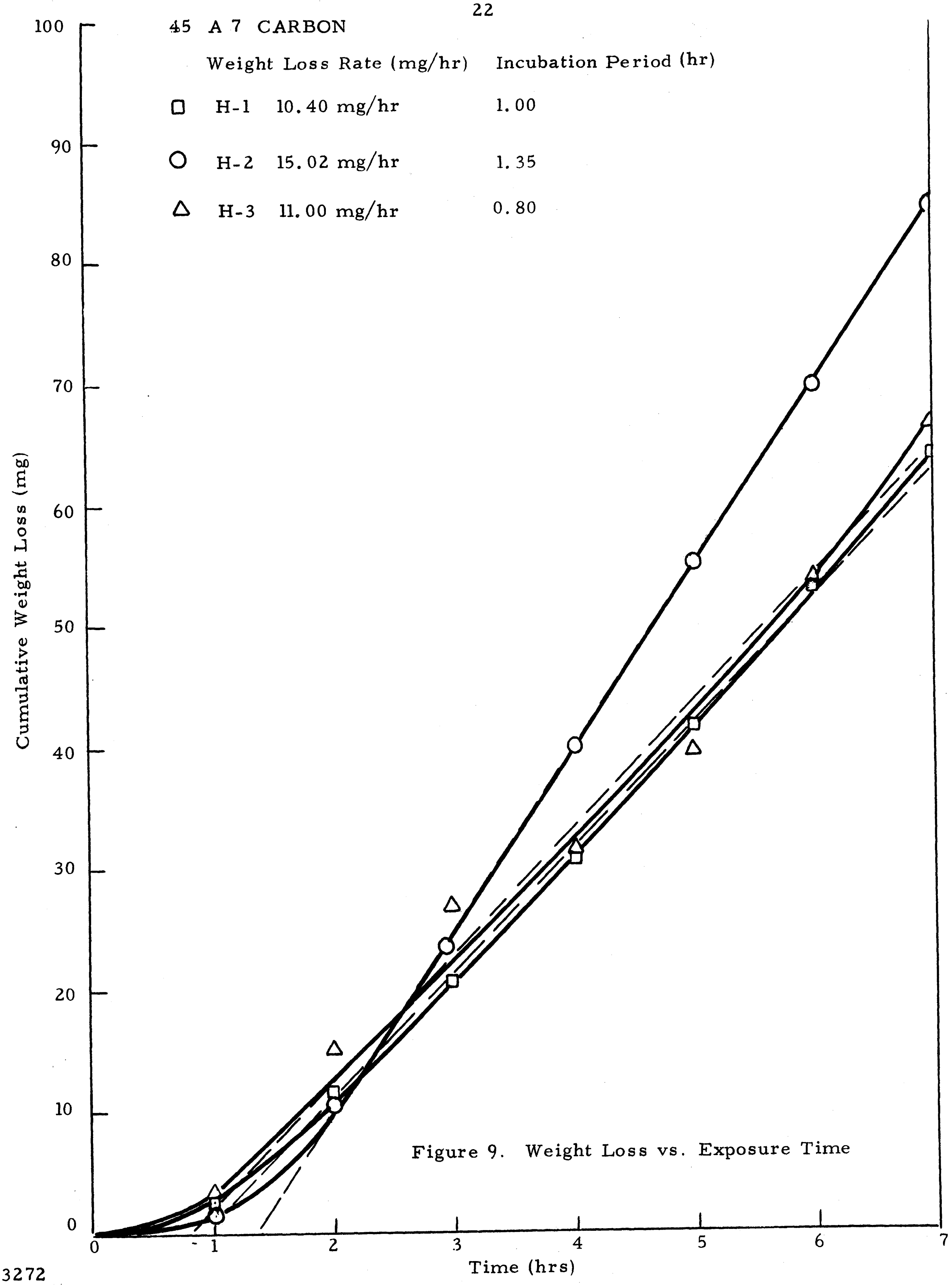


Figure 9. Weight Loss vs. Exposure Time

3272

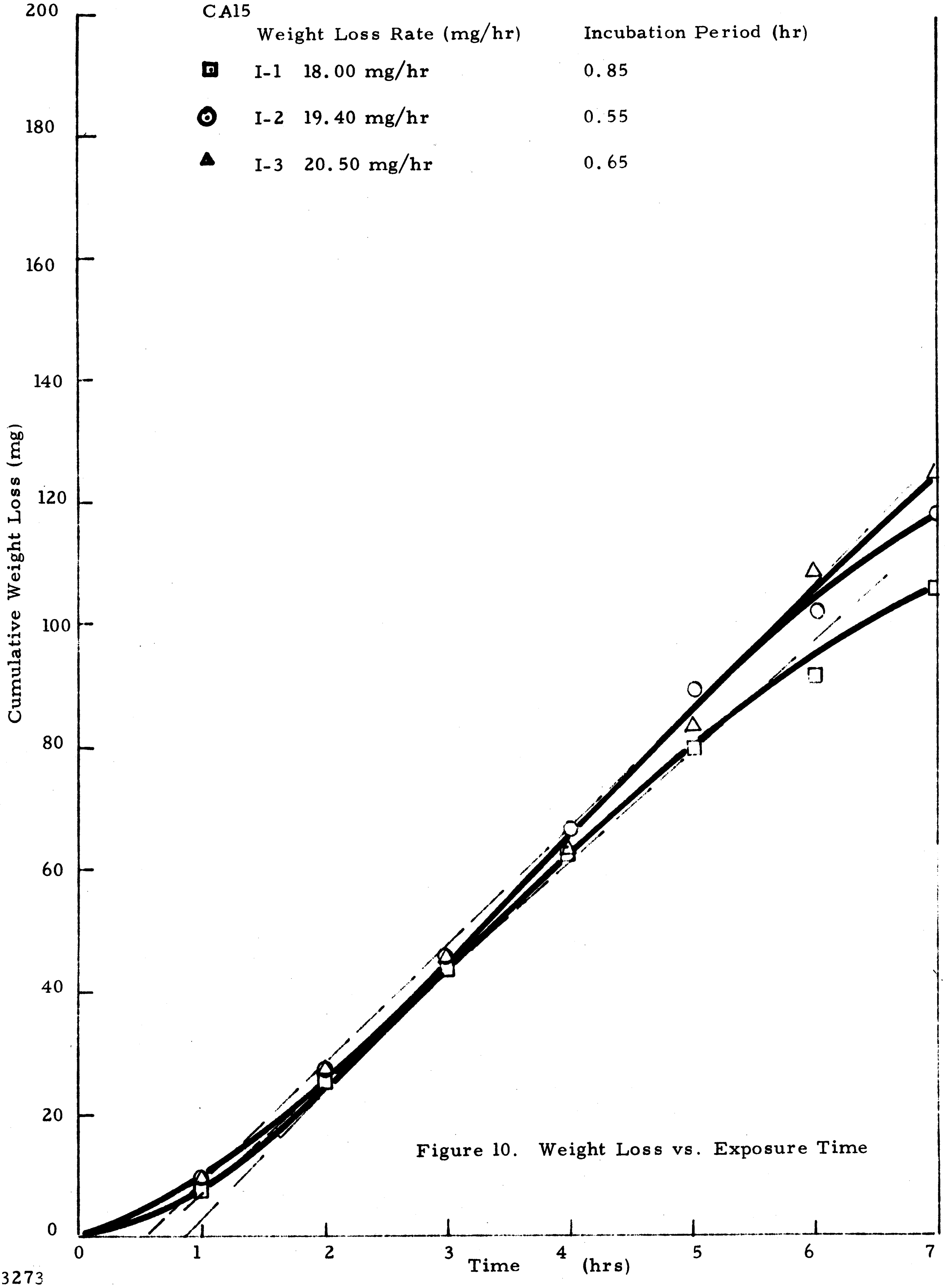


Figure 10. Weight Loss vs. Exposure Time

3273

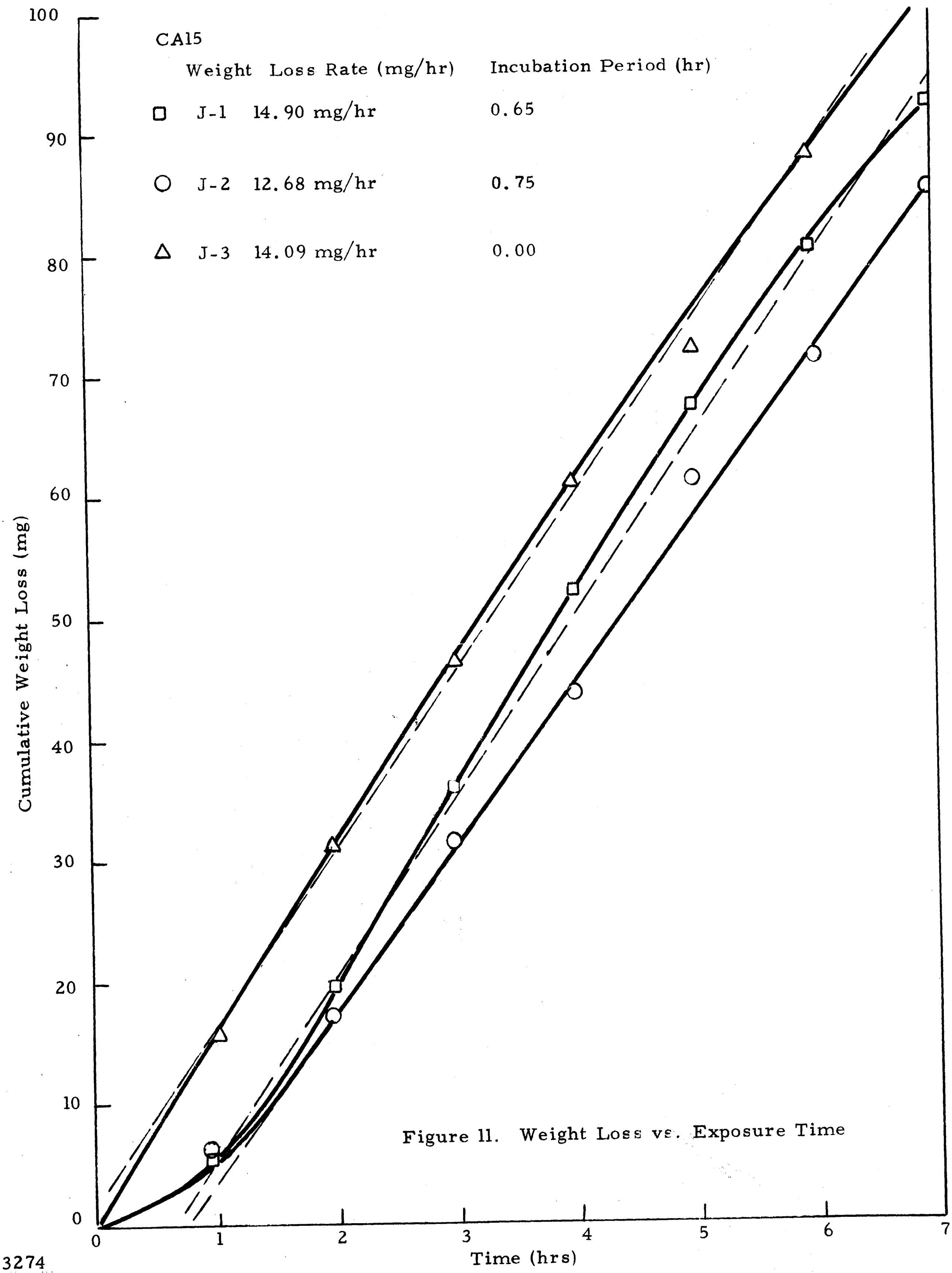


Figure 11. Weight Loss vs. Exposure Time

3274

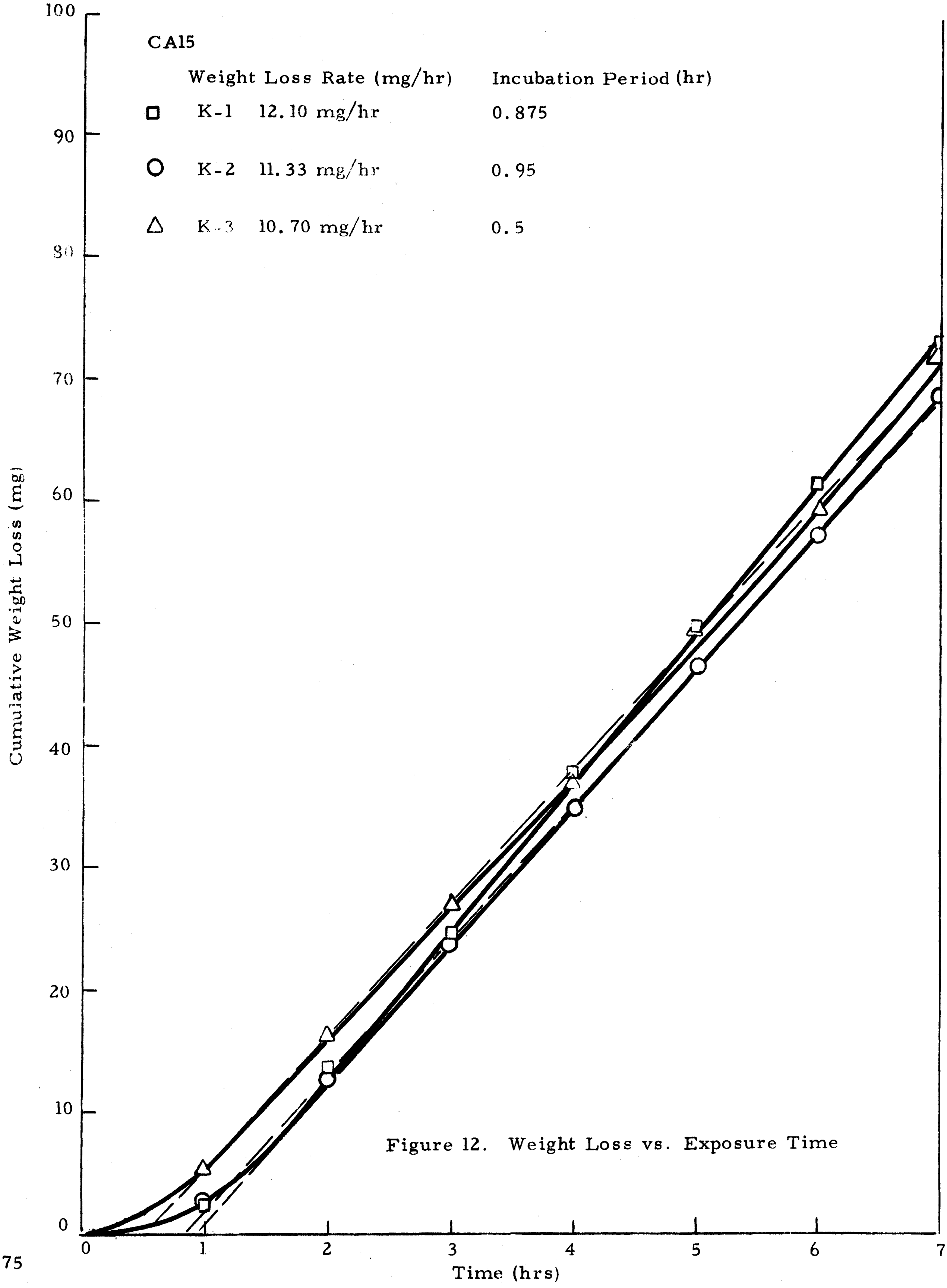


Figure 12. Weight Loss vs. Exposure Time

3275

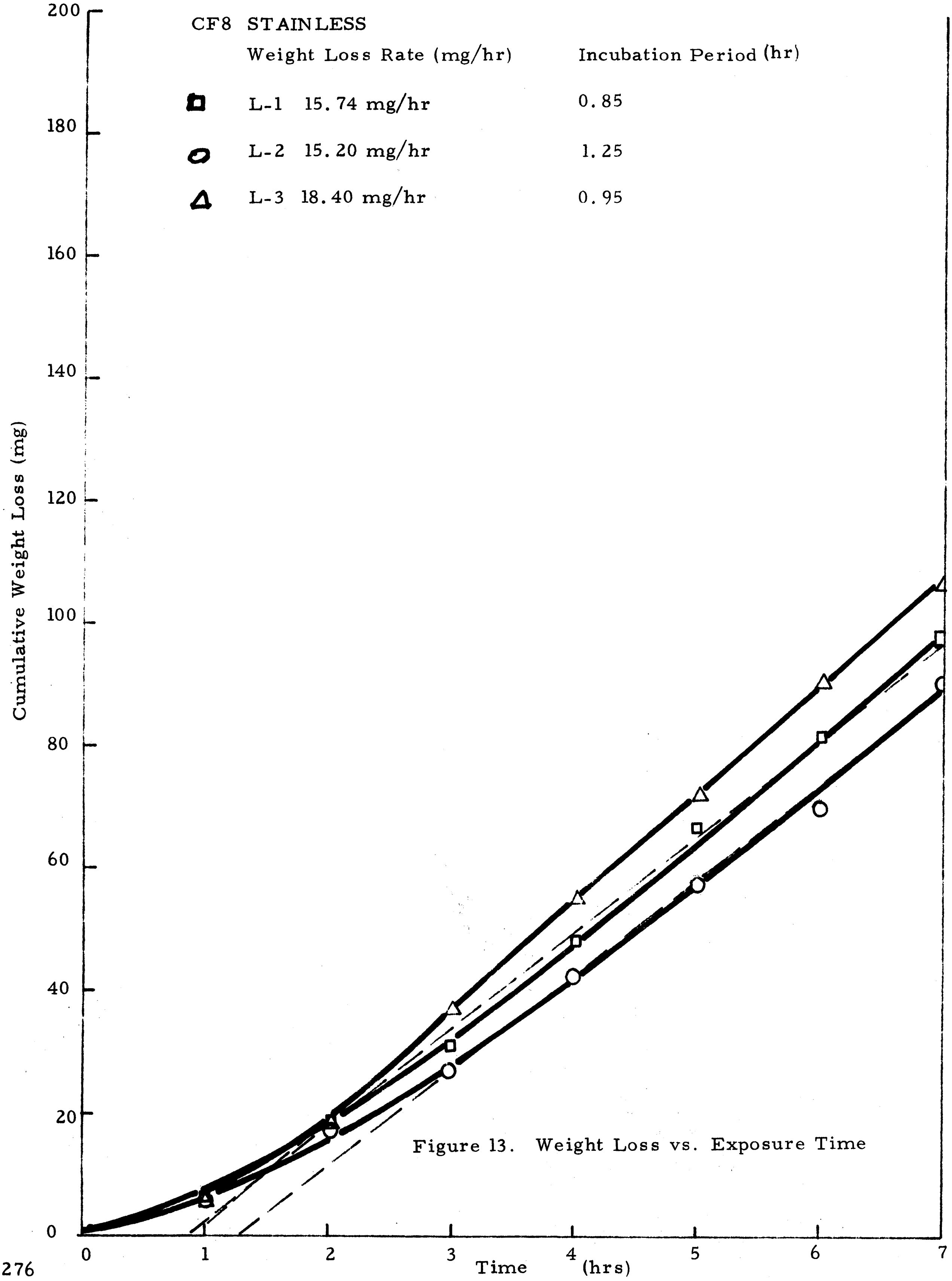


Figure 13. Weight Loss vs. Exposure Time

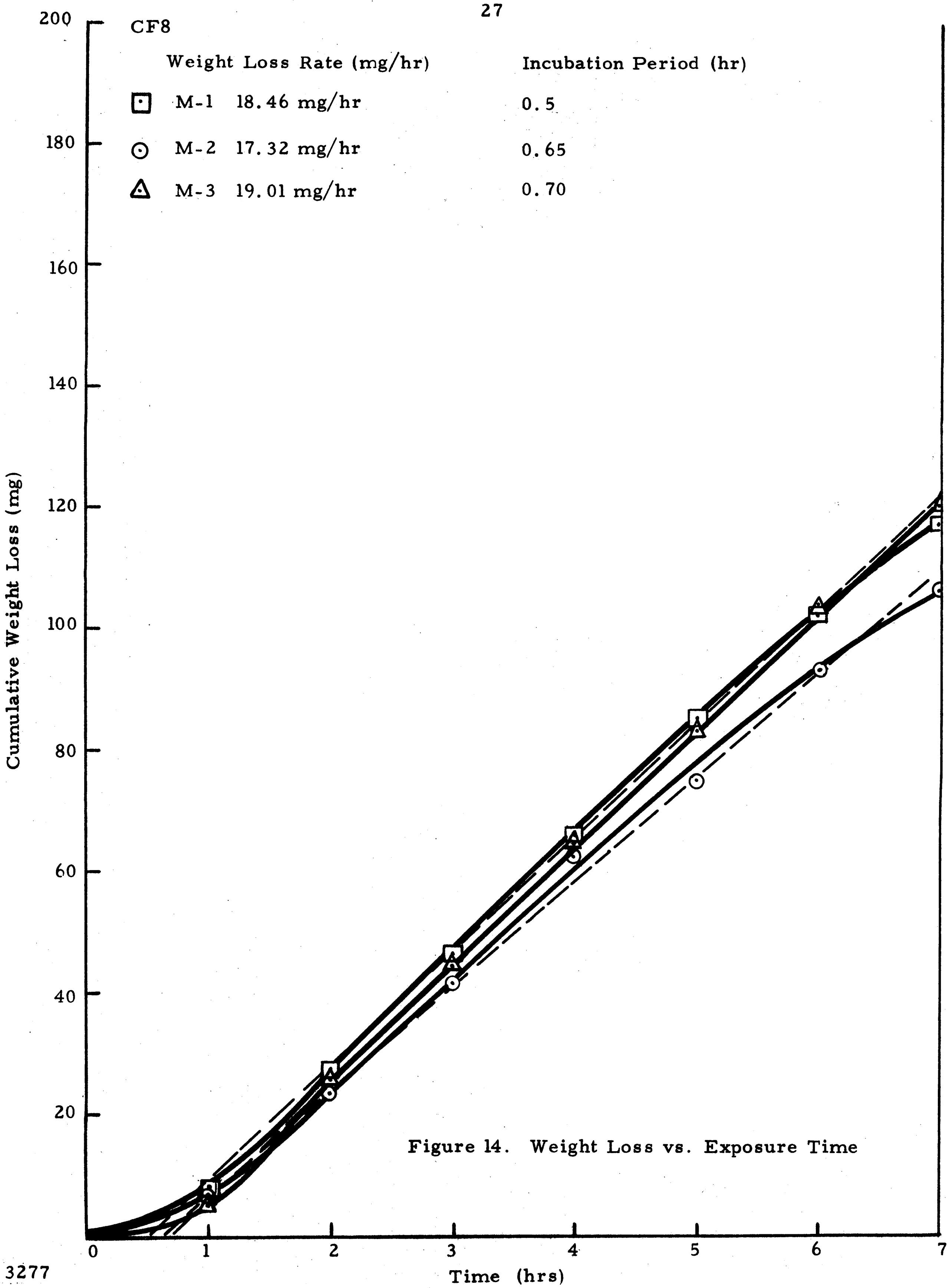


Figure 14. Weight Loss vs. Exposure Time

3277

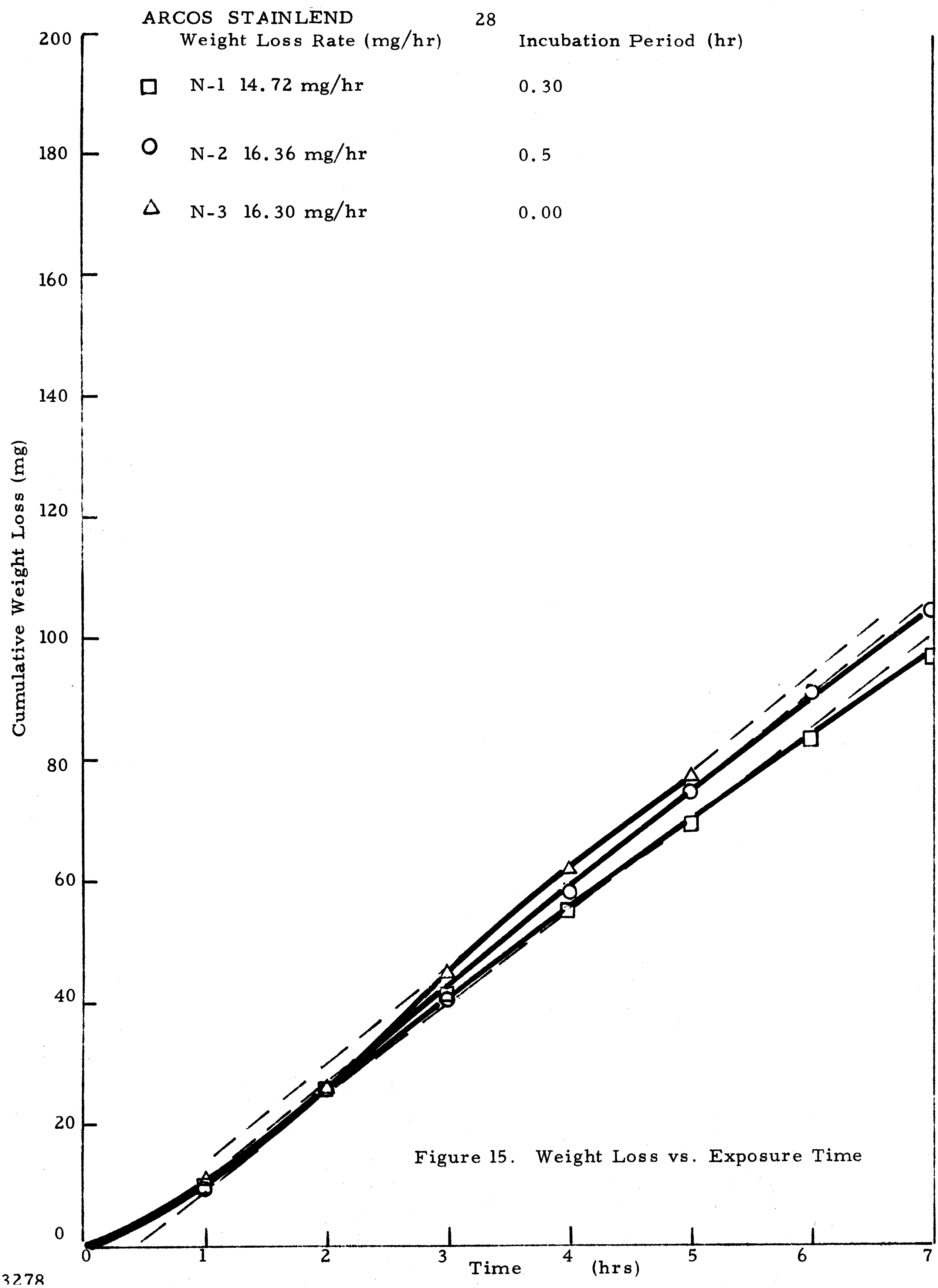


Figure 15. Weight Loss vs. Exposure Time

3278

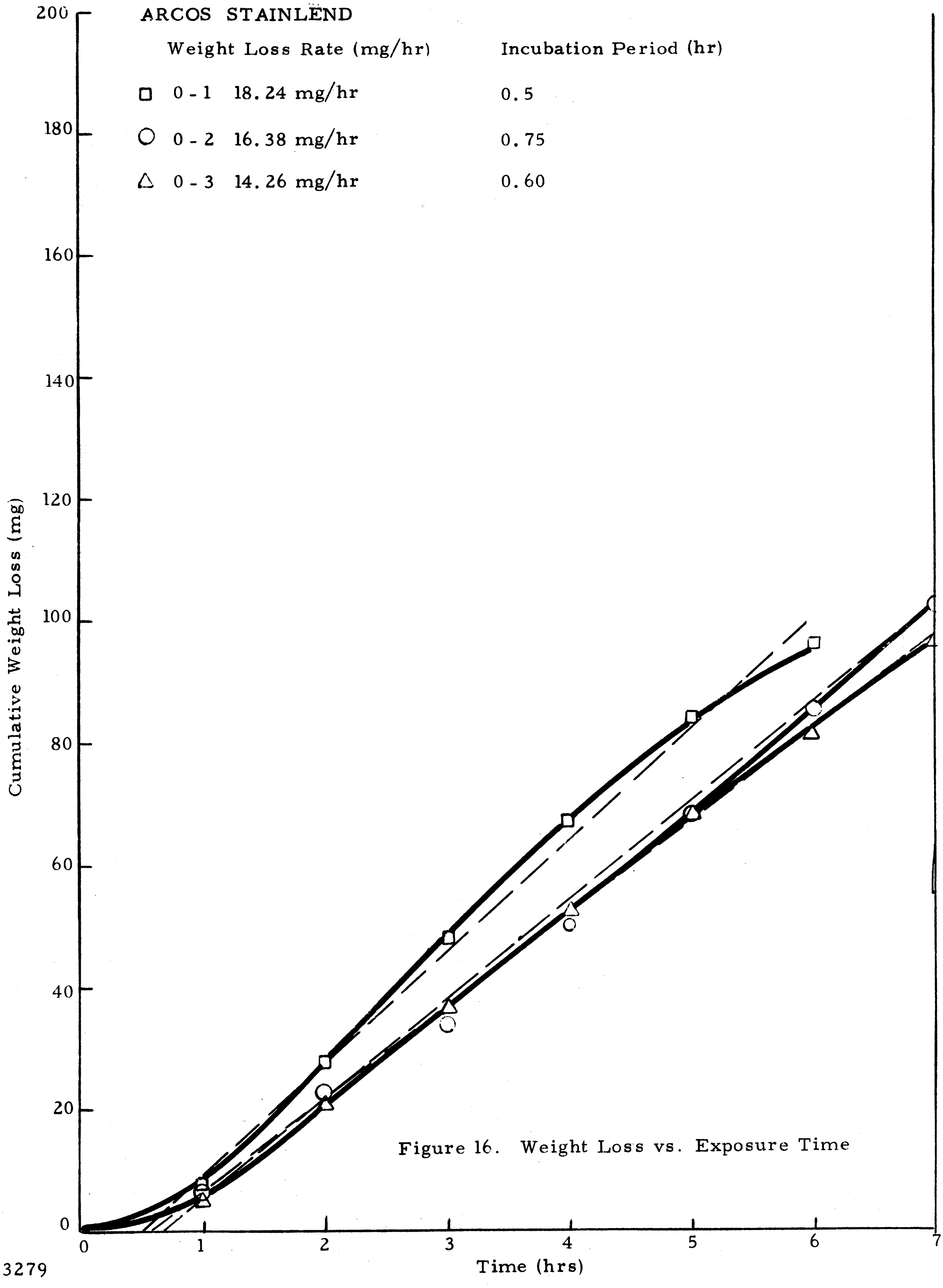


Figure 16. Weight Loss vs. Exposure Time

3279

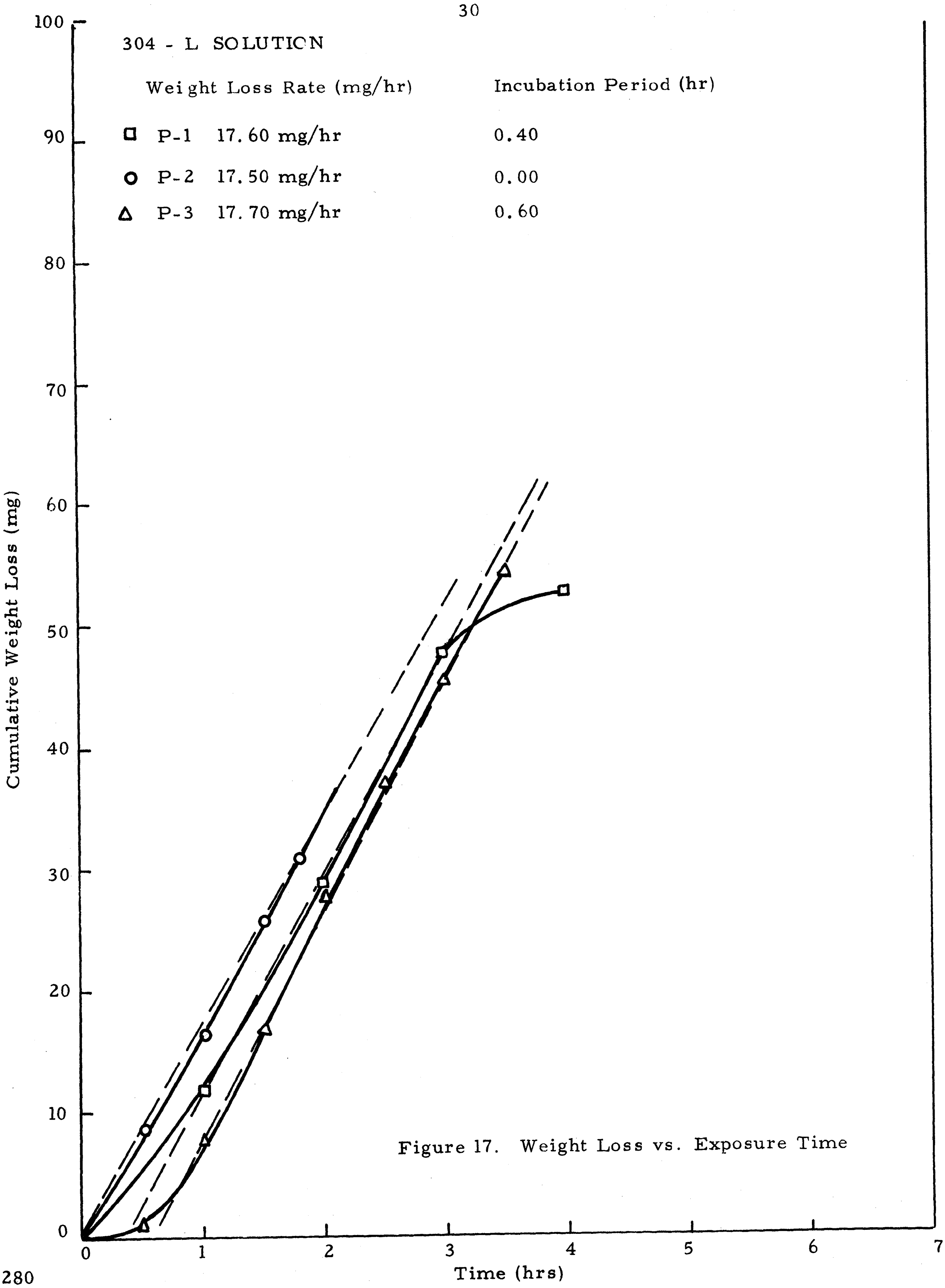


Figure 17. Weight Loss vs. Exposure Time

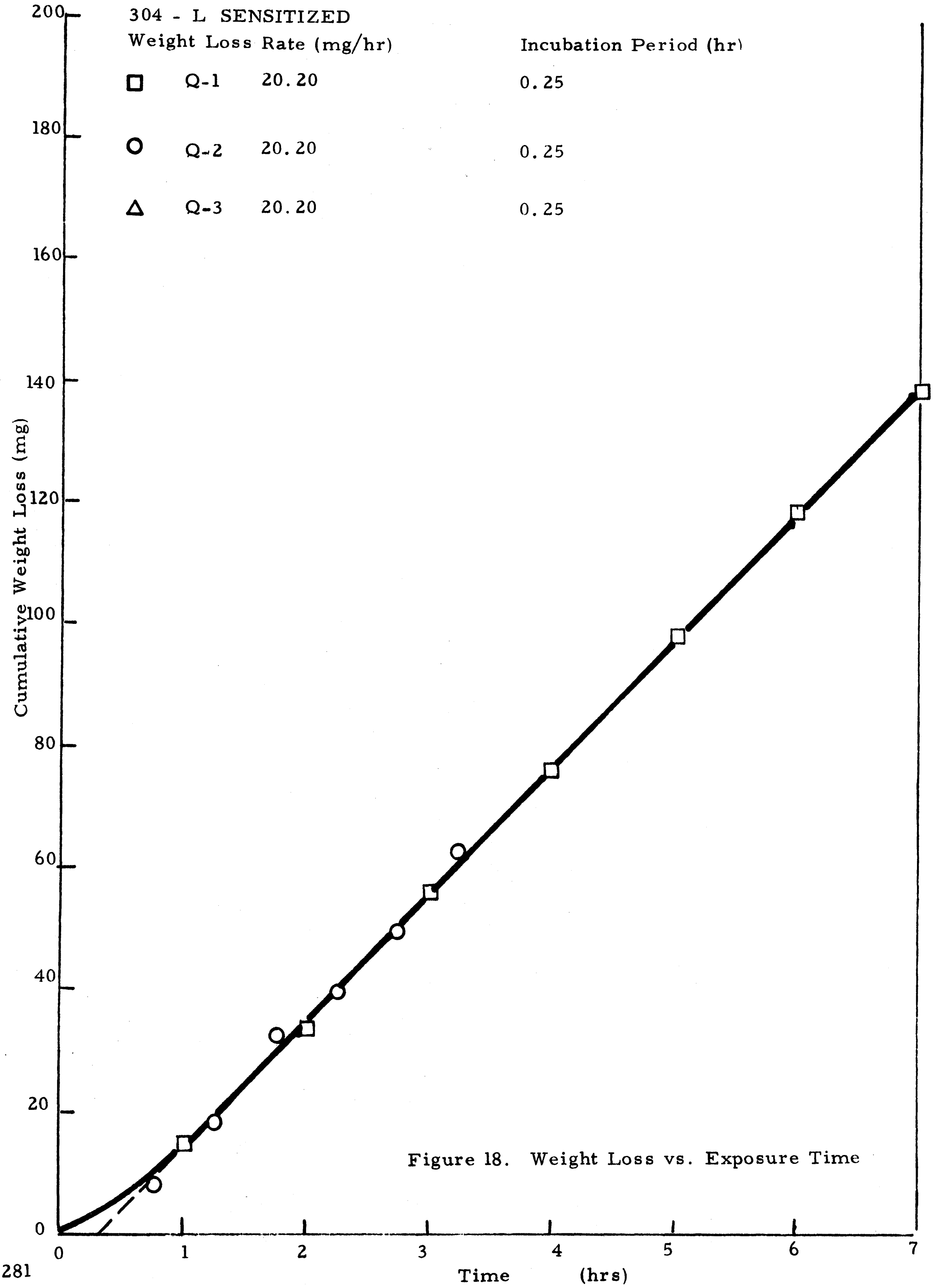


Figure 18. Weight Loss vs. Exposure Time

3281

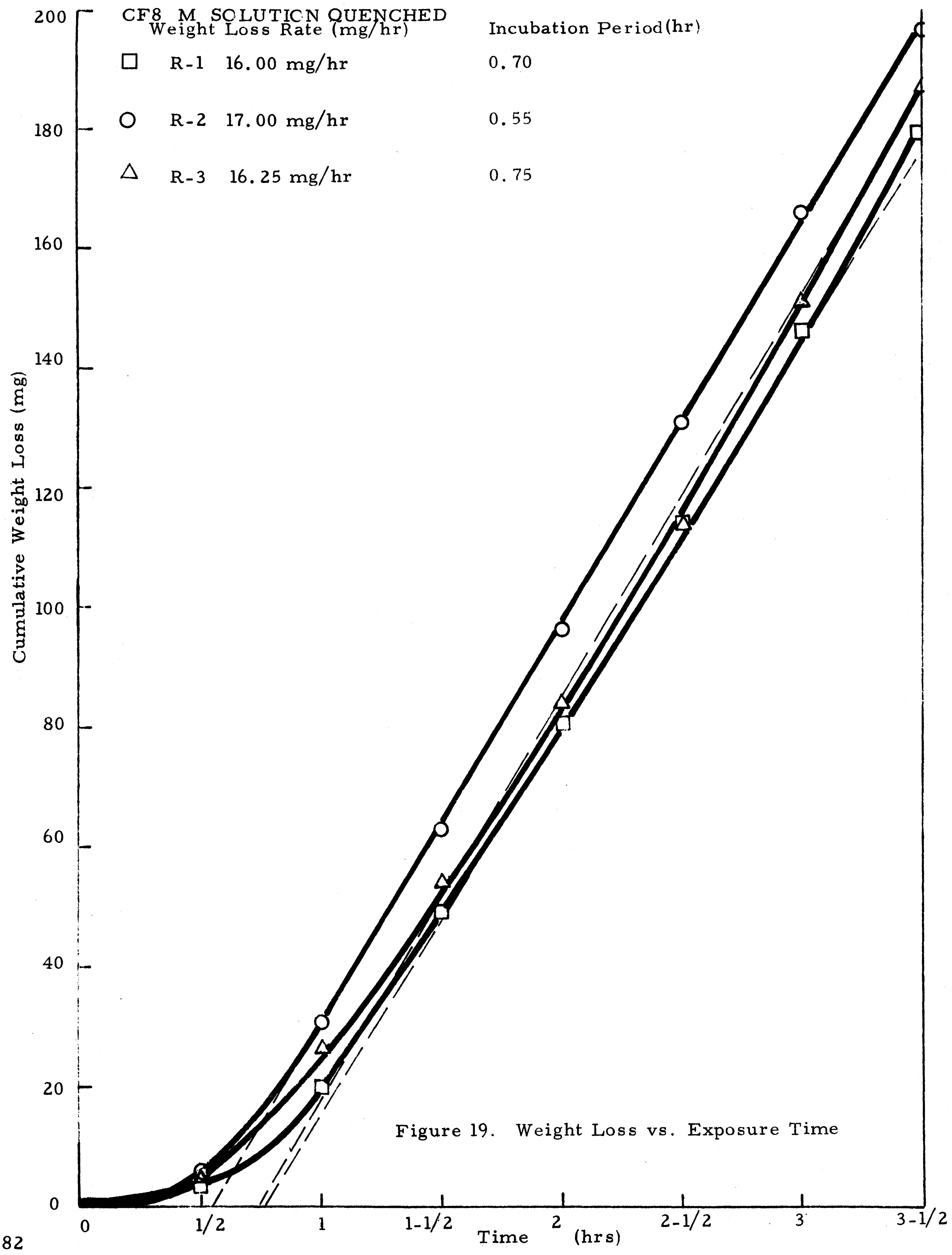


Figure 19. Weight Loss vs. Exposure Time

3282

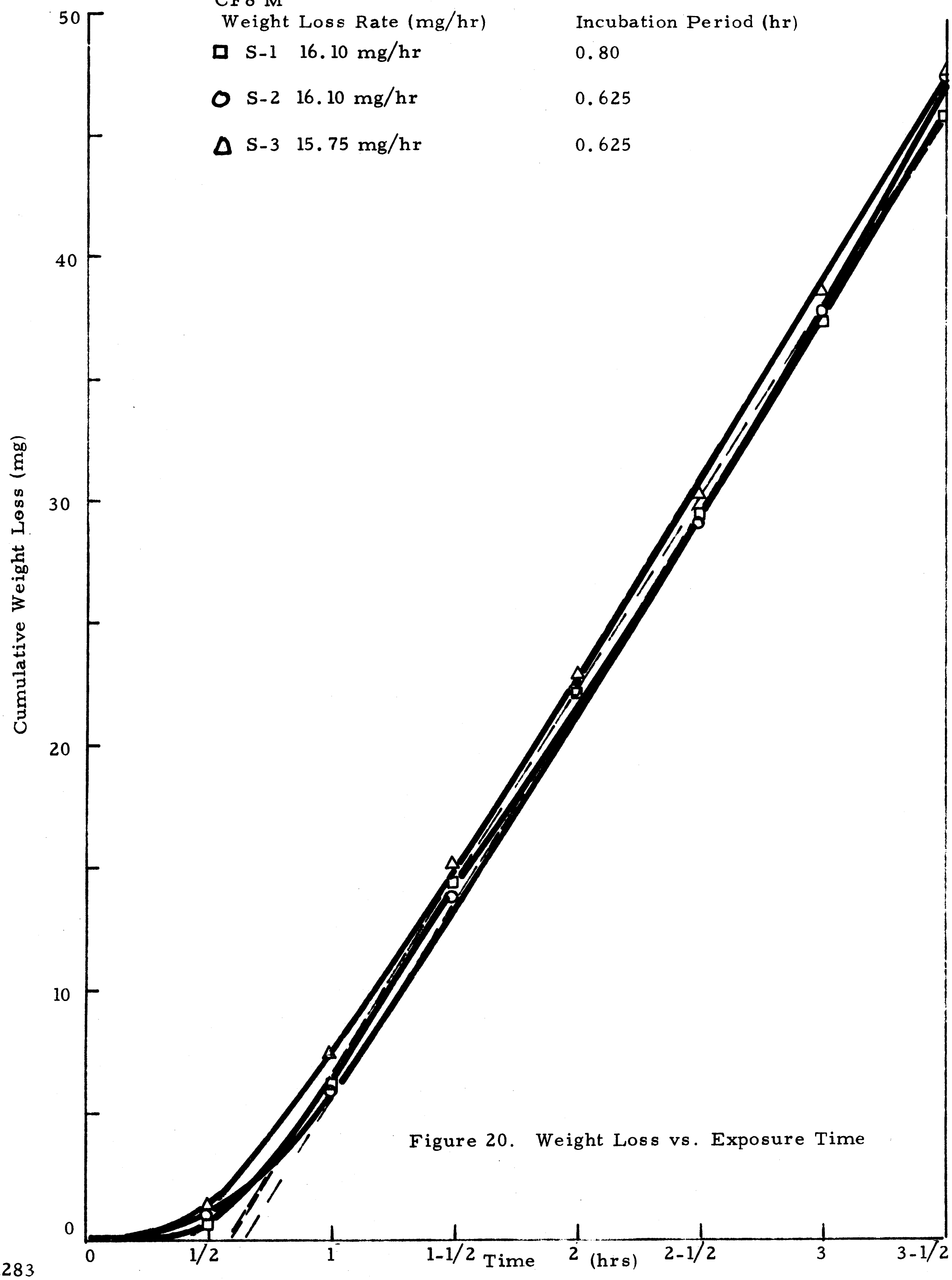


Figure 20. Weight Loss vs. Exposure Time

3283

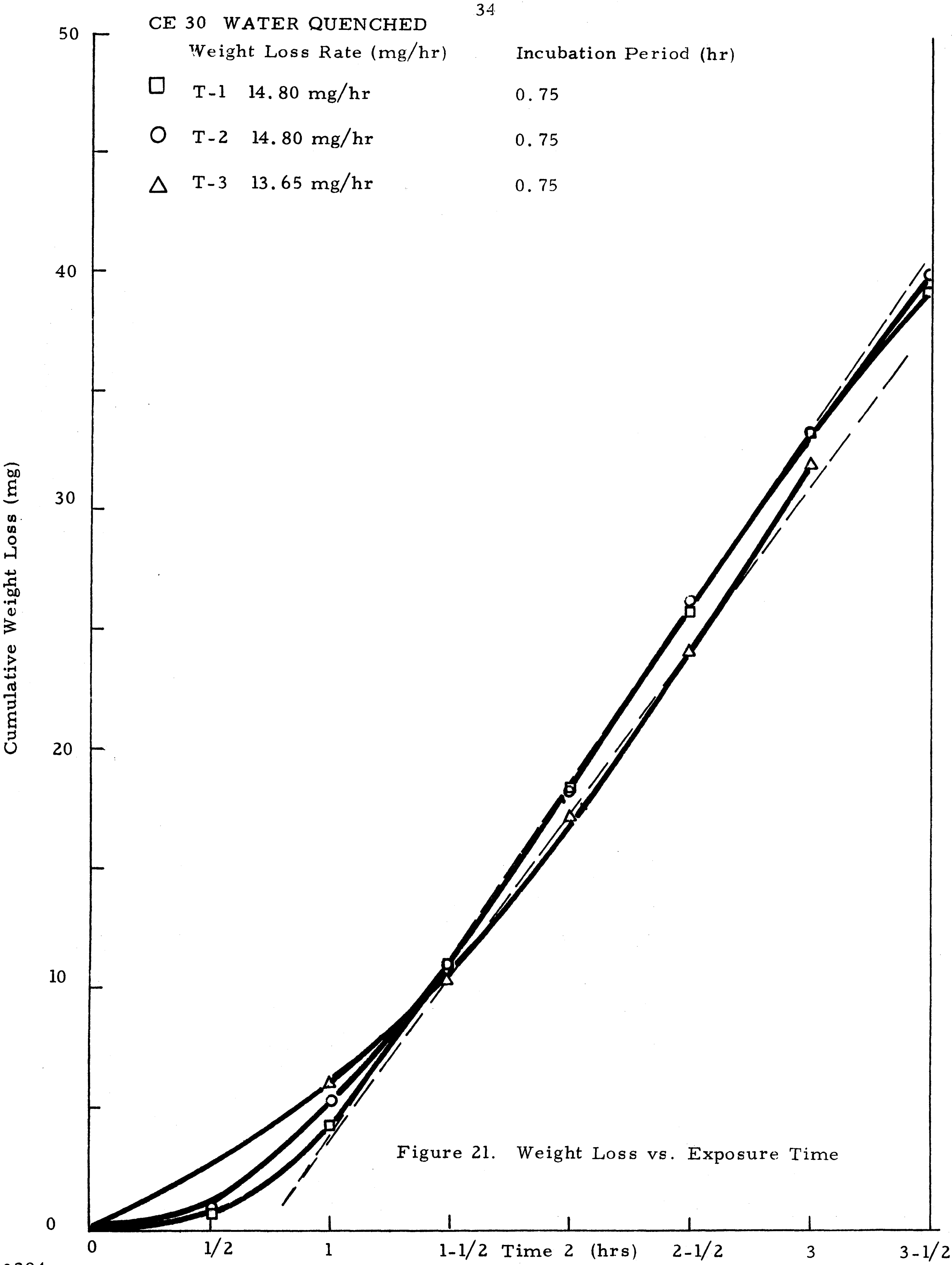


Figure 21. Weight Loss vs. Exposure Time

3284

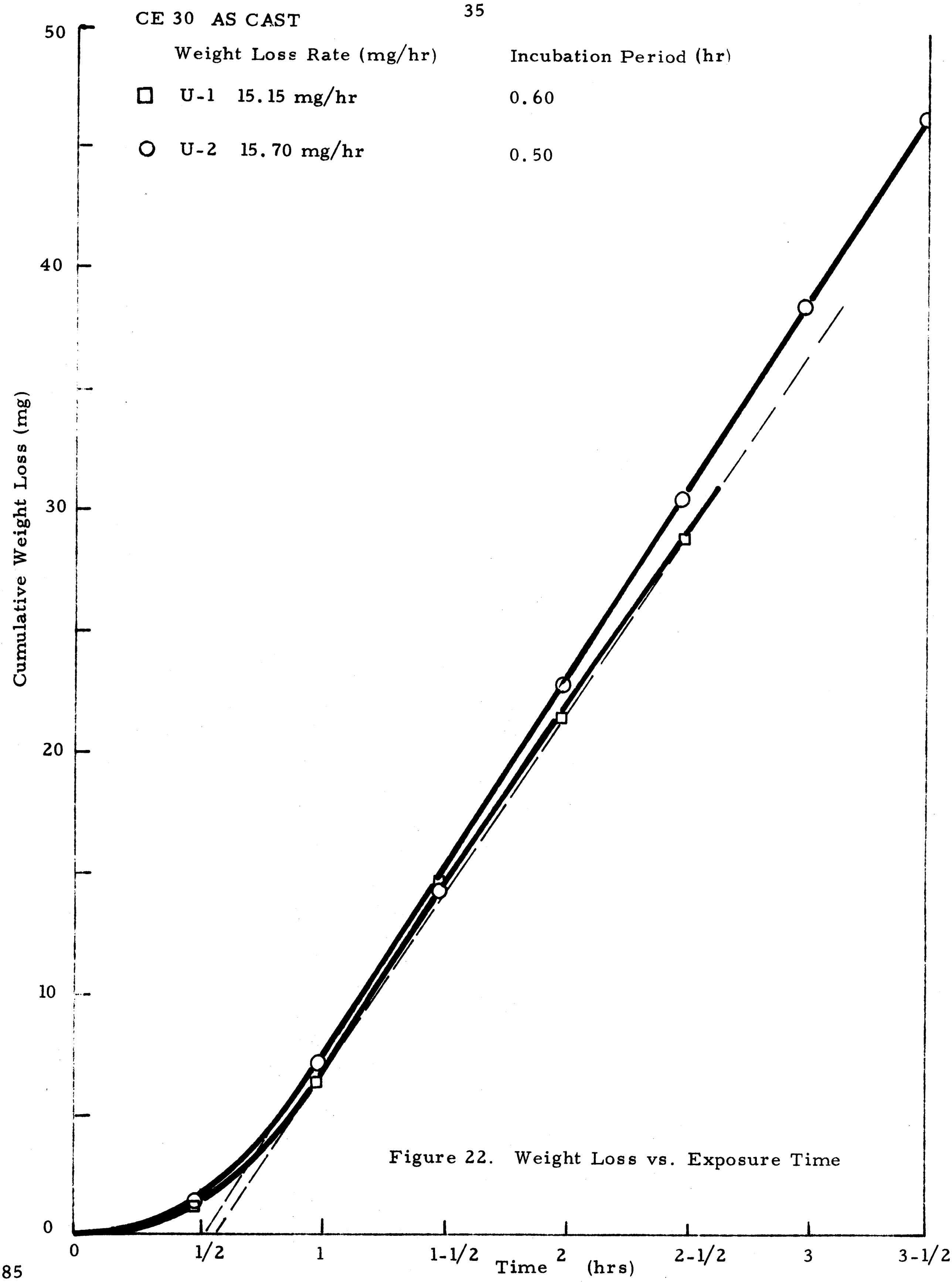


Figure 22. Weight Loss vs. Exposure Time

3285

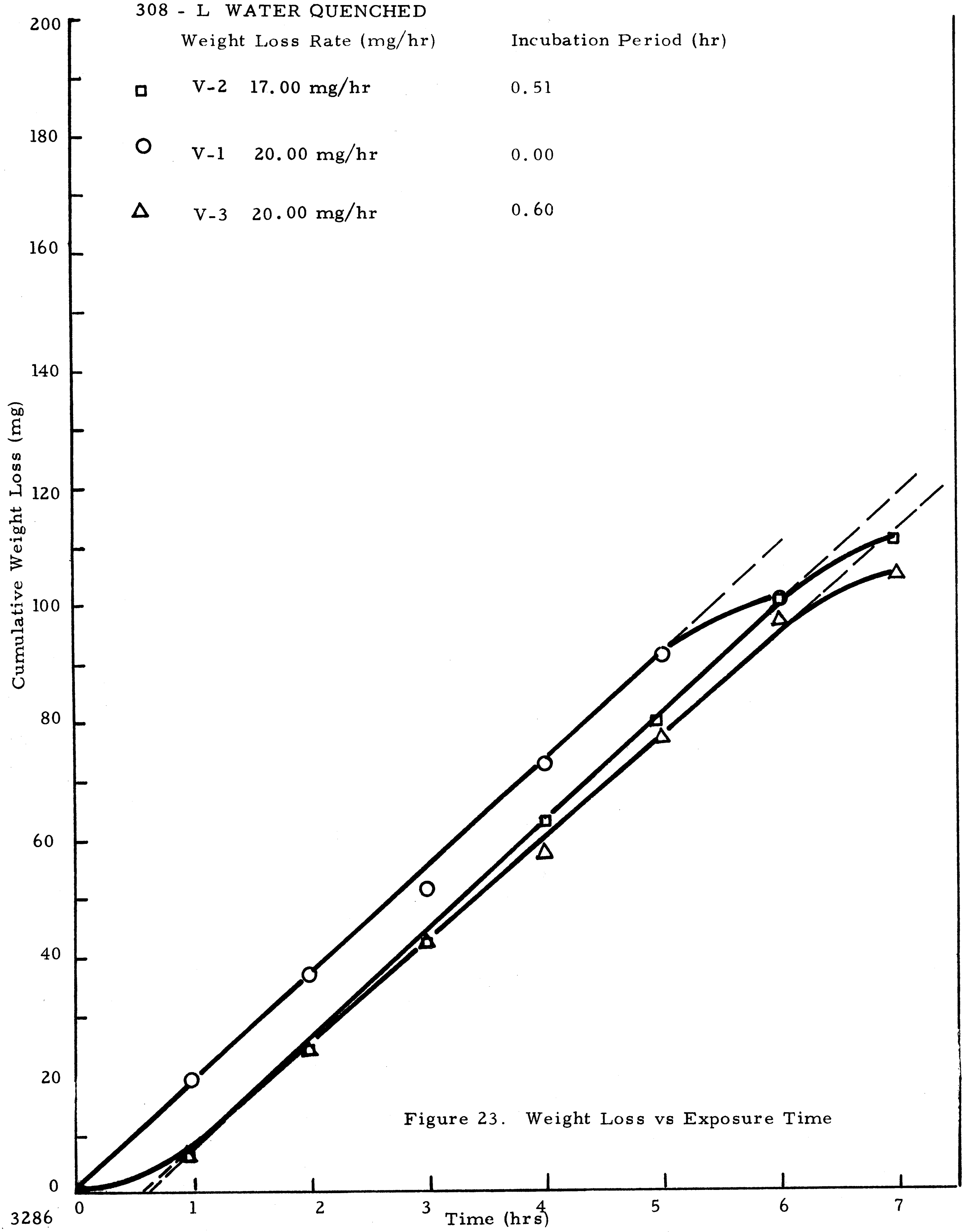


Figure 23. Weight Loss vs Exposure Time

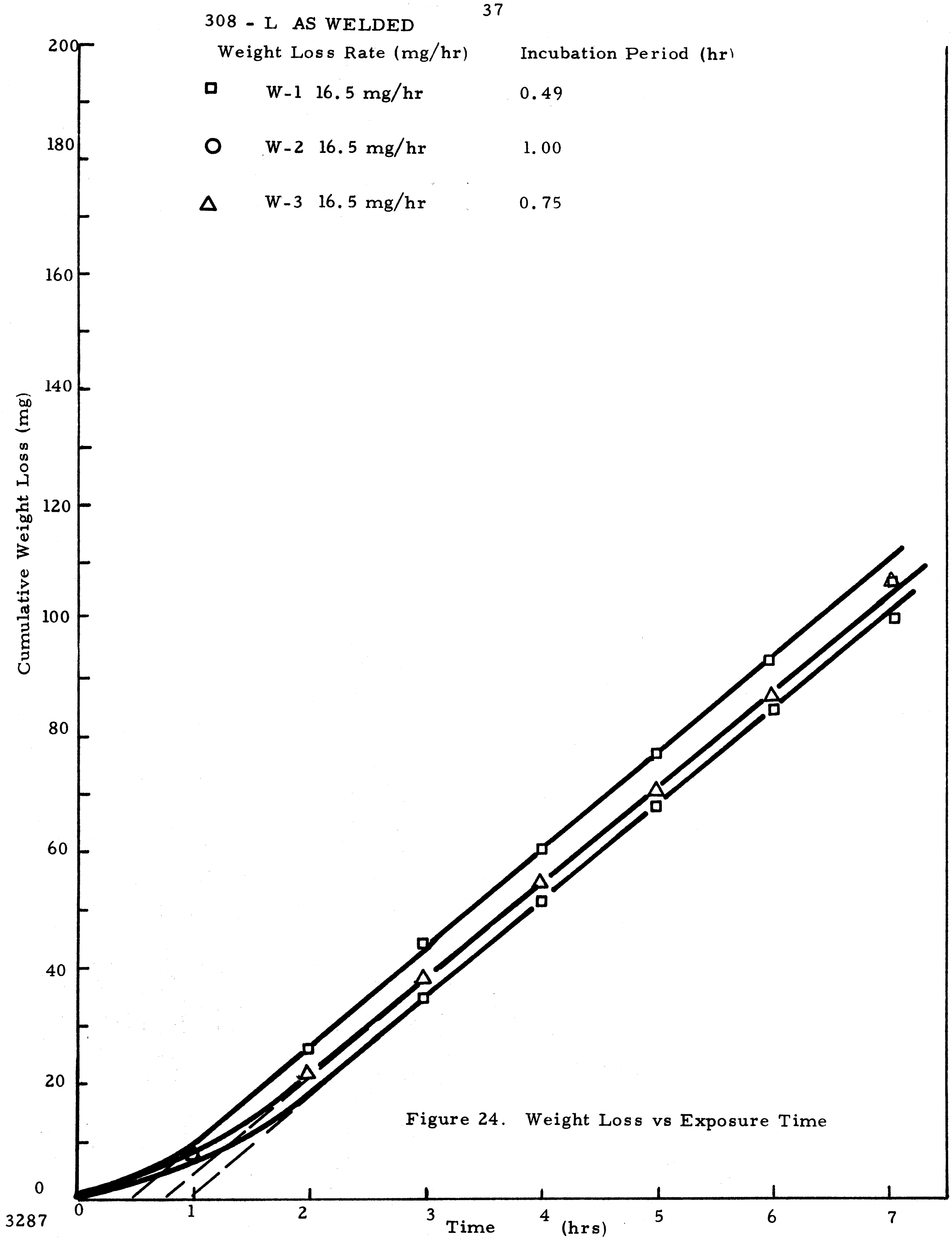


Figure 24. Weight Loss vs Exposure Time

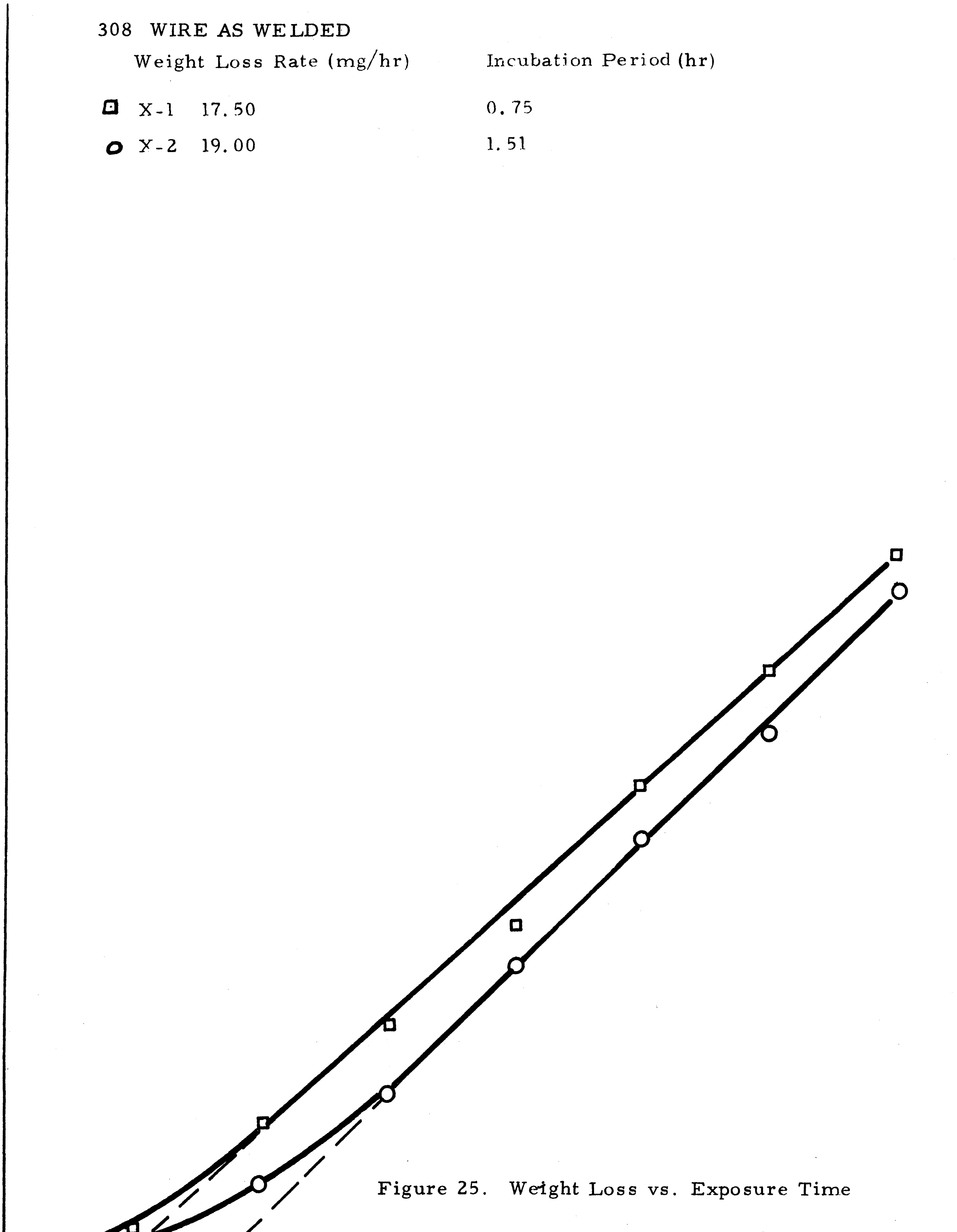


Figure 25. Weight Loss vs. Exposure Time

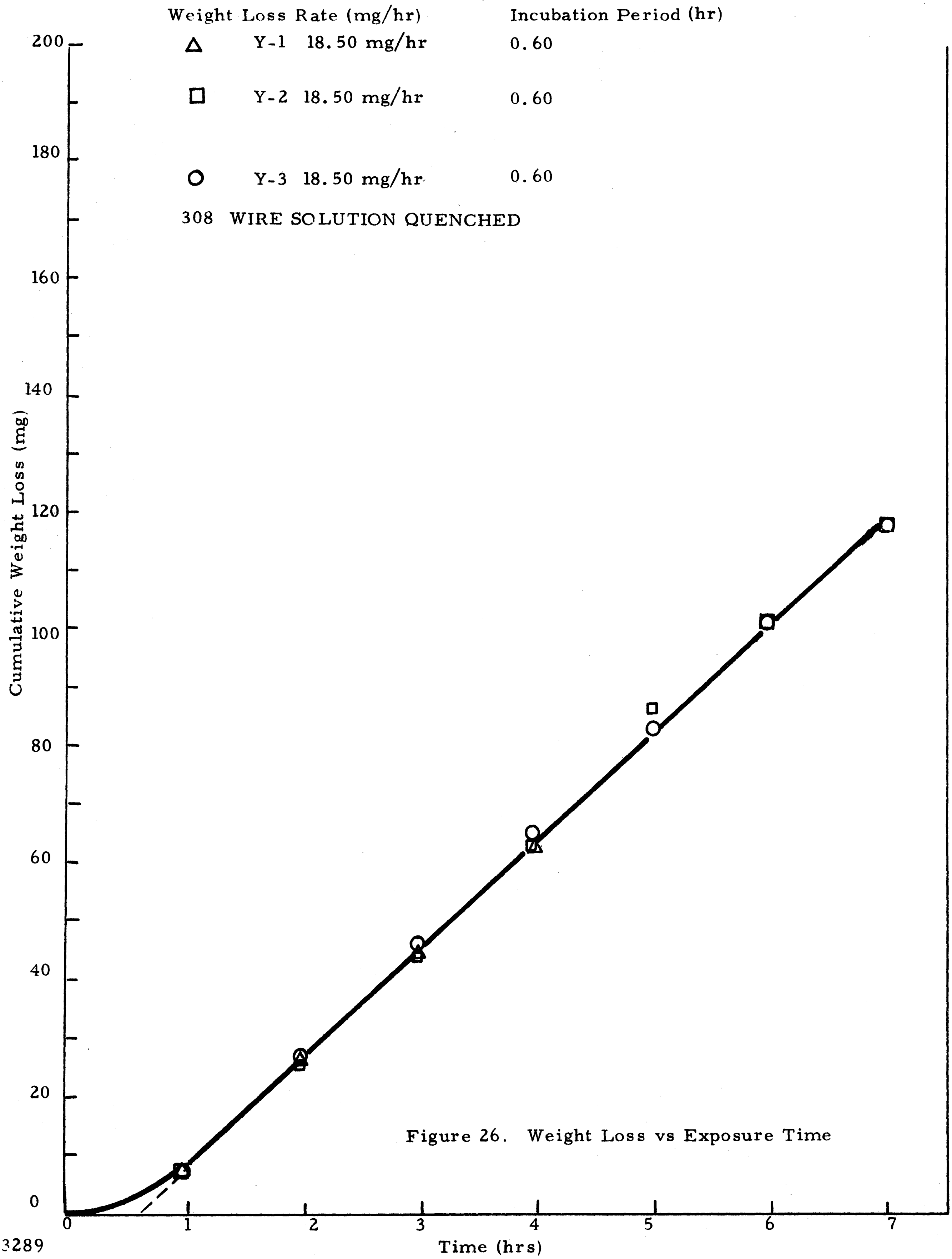


Figure 26. Weight Loss vs Exposure Time

3289

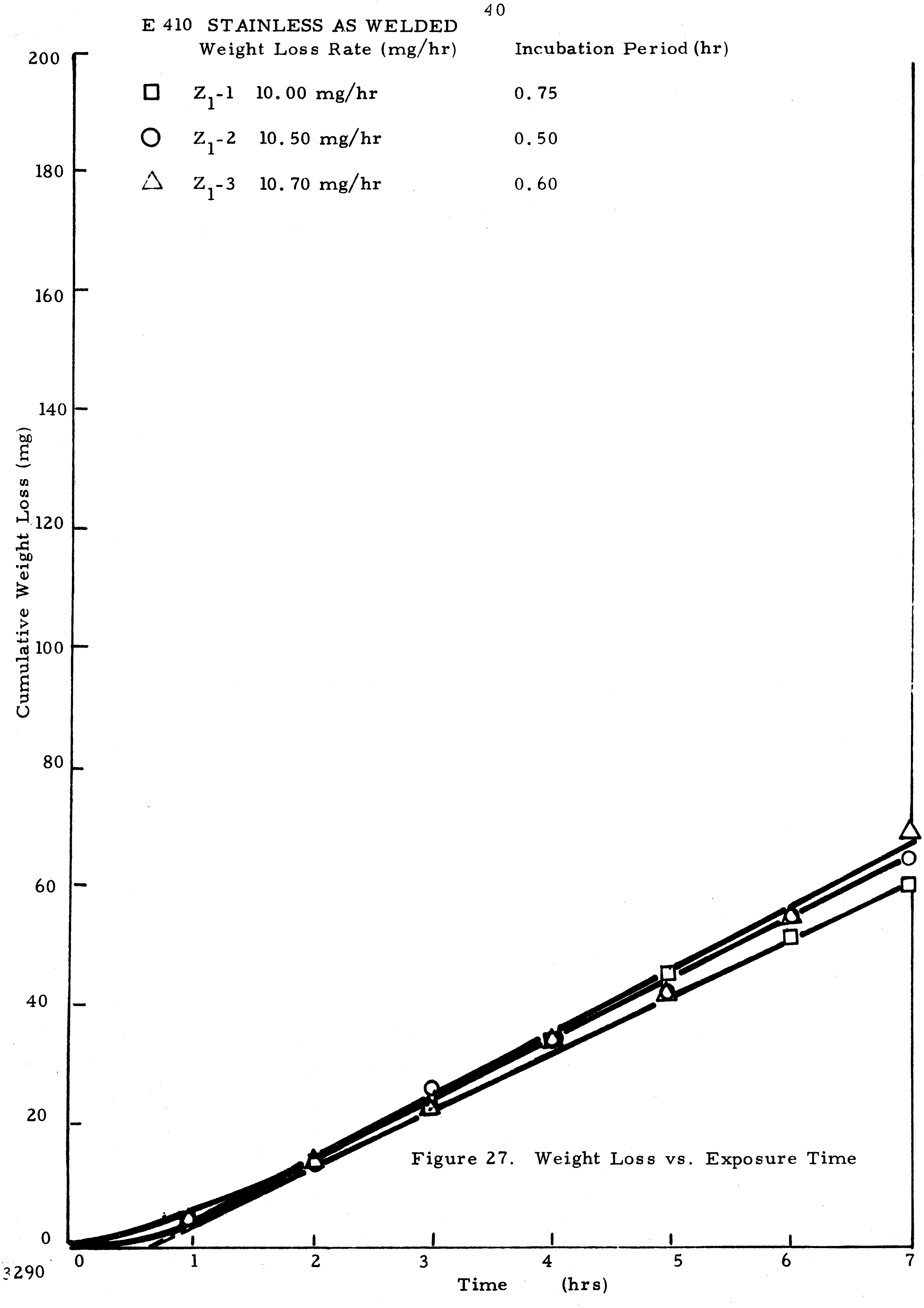


Figure 27. Weight Loss vs. Exposure Time

3290

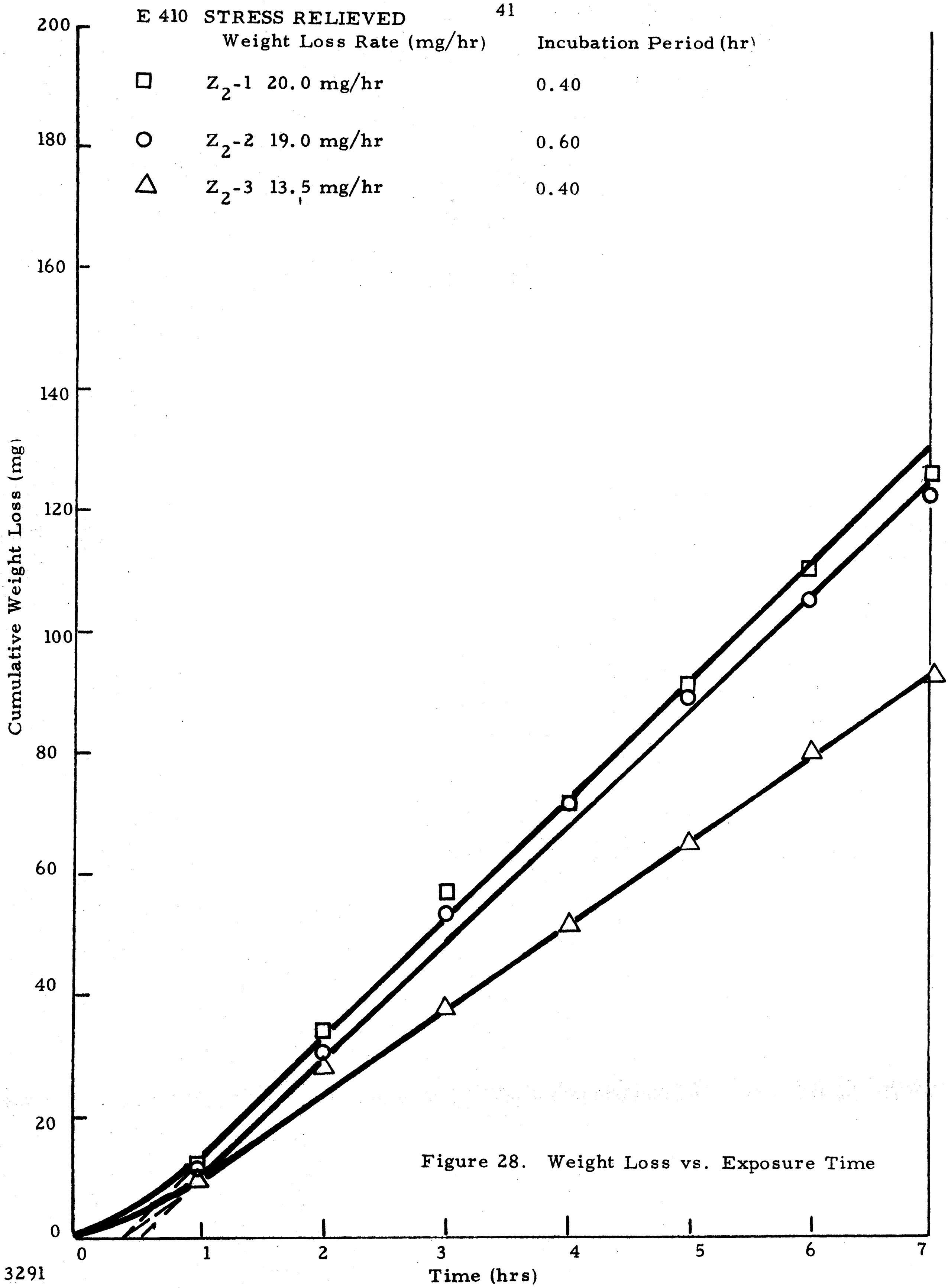


Figure 28. Weight Loss vs. Exposure Time

3291

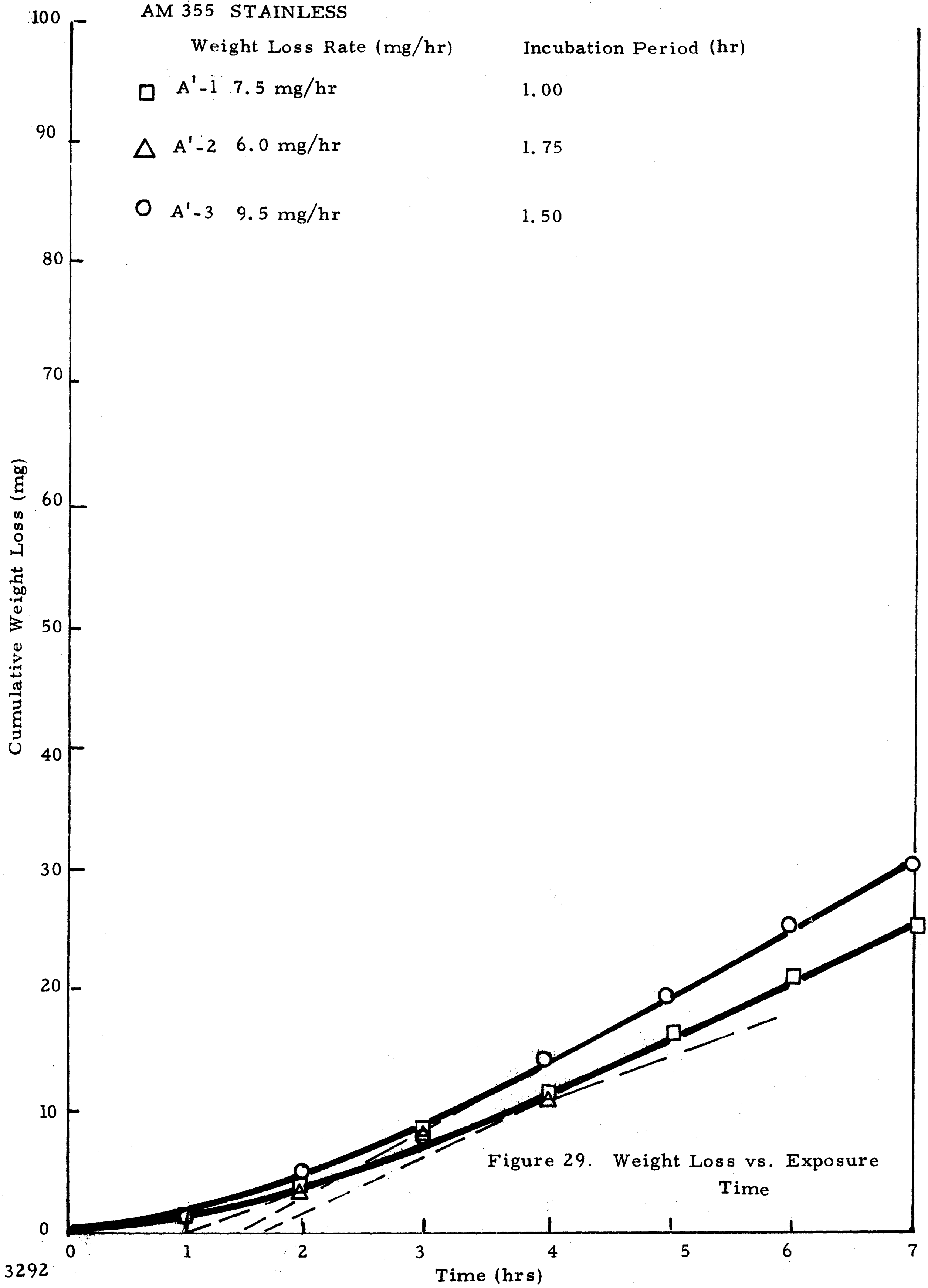


Figure 29. Weight Loss vs. Exposure Time

3292

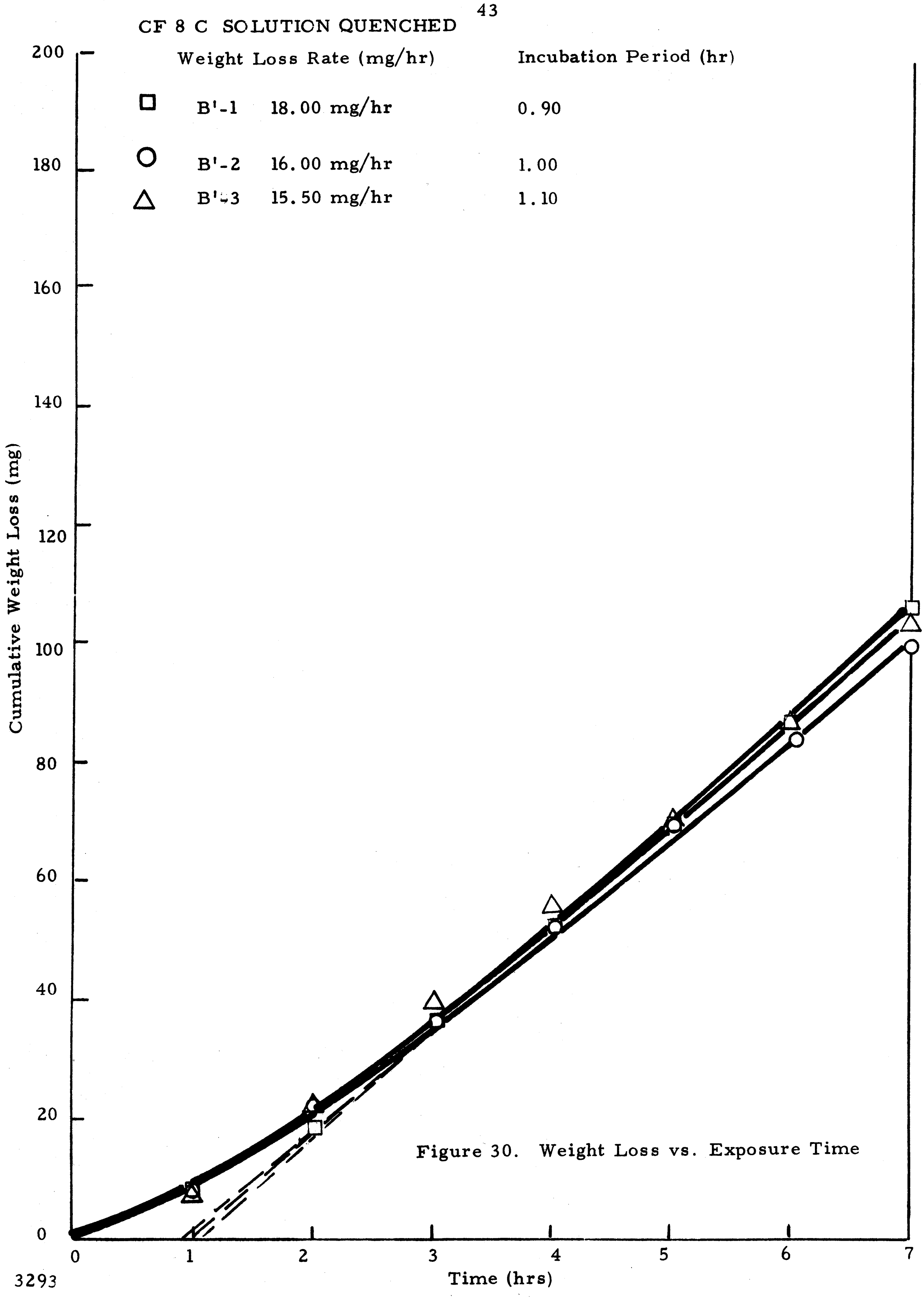


Figure 30. Weight Loss vs. Exposure Time

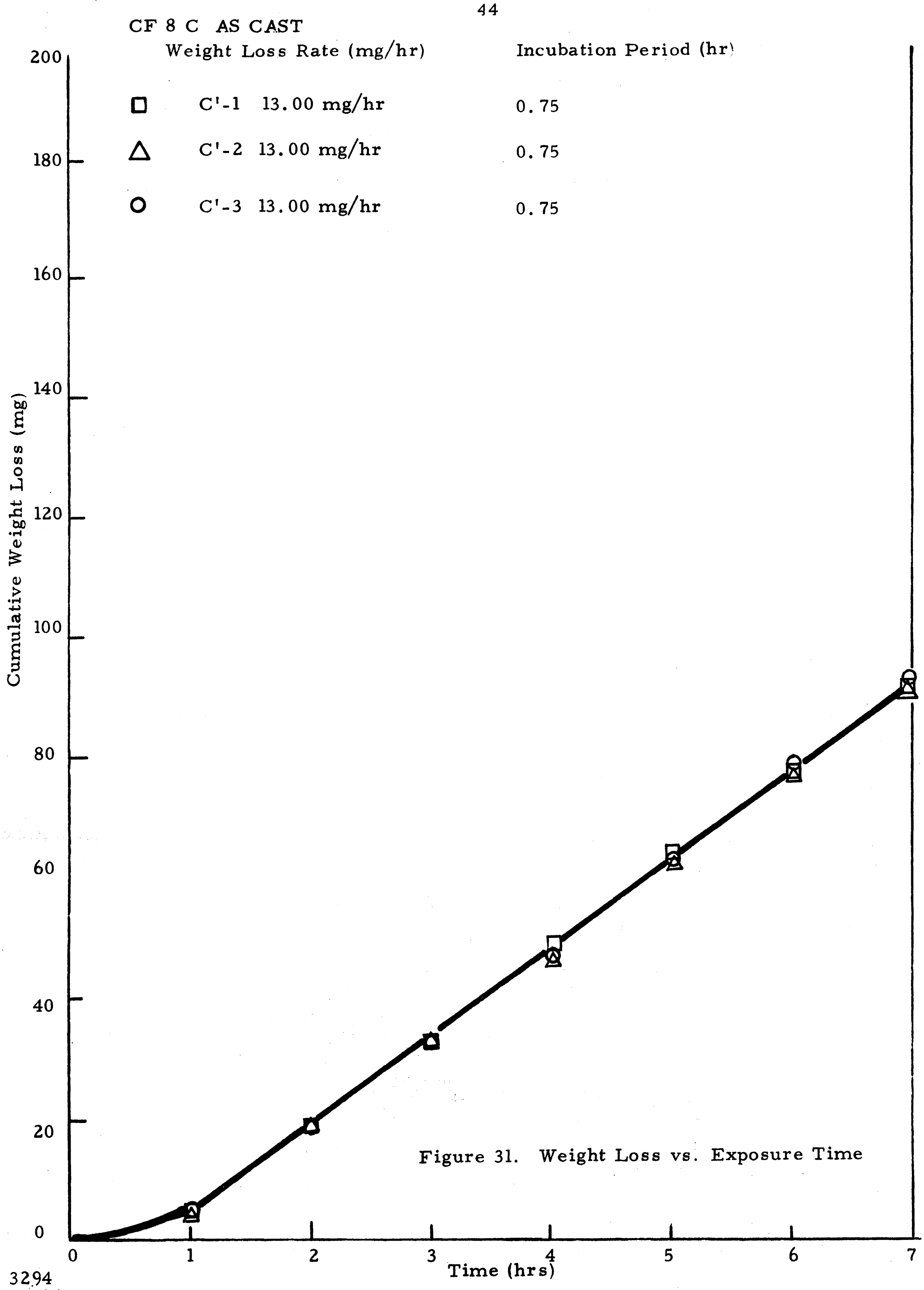
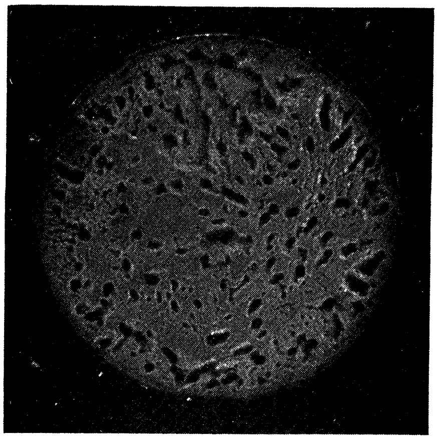
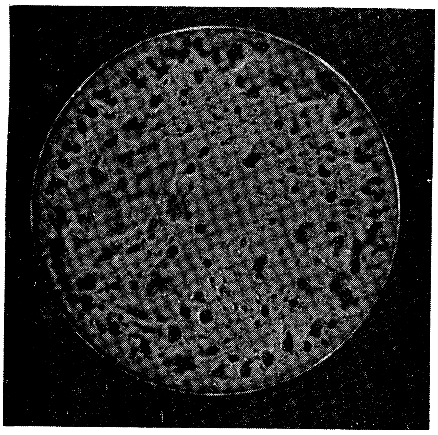


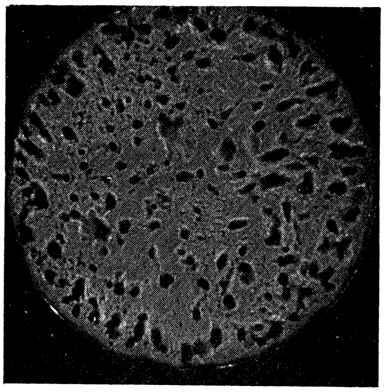
Figure 31. Weight Loss vs. Exposure Time



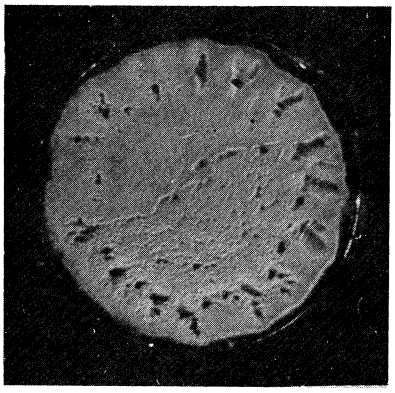
A-2 Grad CF 8
WLR 23.00 mg/hr
7 hr. exposure



A-4 Grad CF 8
WLR 19.50 mg/hr
7 hr. exposure

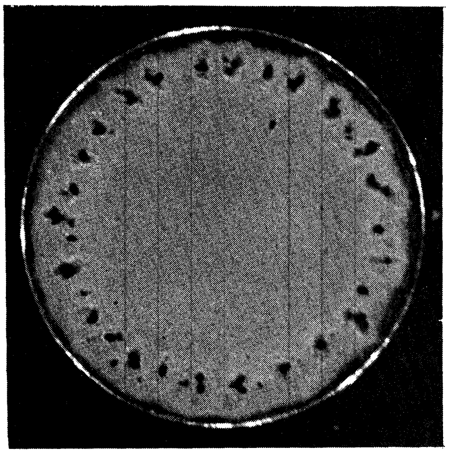


A-10 Grad CF 8
WLR 22.75 mg/hr
7 hr. exposure

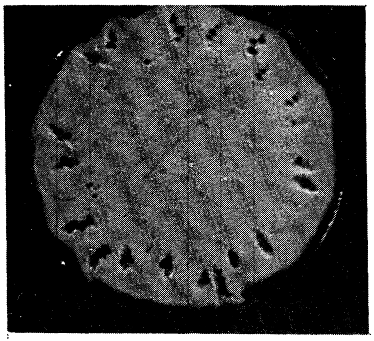


C-2 CA7M Stainless
WLR 15.642 mg/hr
7 hr. exposure

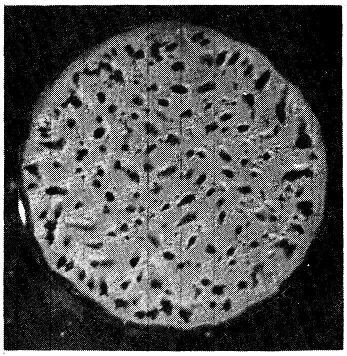
Figure 32. Photographs of Damaged Specimens A-C



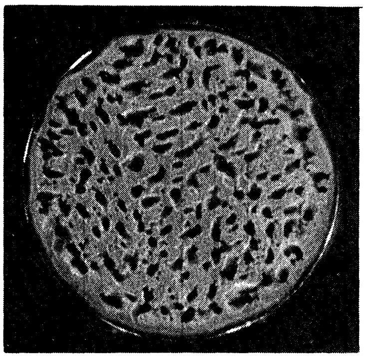
CA 15 #1
WLR 19.90 mg/hr.
7 hr. exposure



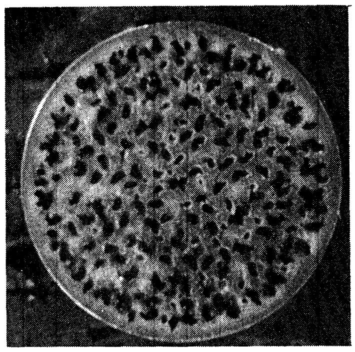
D-1 CA6NM Stainless
WLR 12.666 mg/hr.
7 hr exposure



E-1 CF 8 Stainless
WLR 22.00 mg/hr
7 hr. exposure

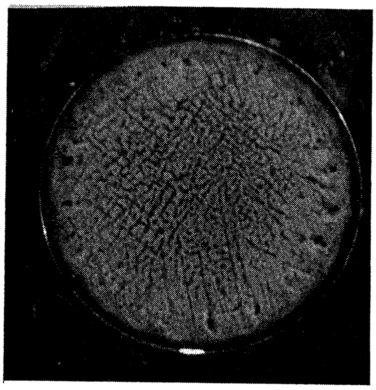


F-1 CF 8 Stainless
WLR 22.70 mg/hr
7 hr exposure

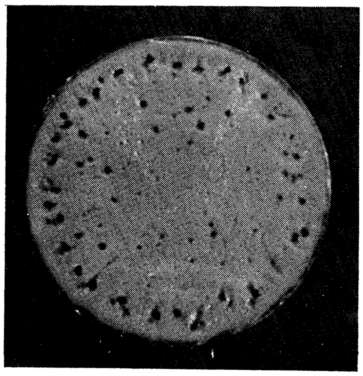


G-2 25 CN Carbon Steel
WLR 34.60 mg/hr
7 hr. exposure

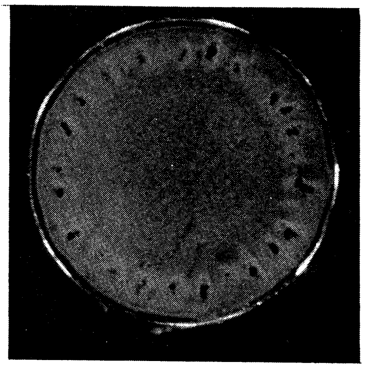
Figure 33. Photographs of Damaged Specimens CA-G



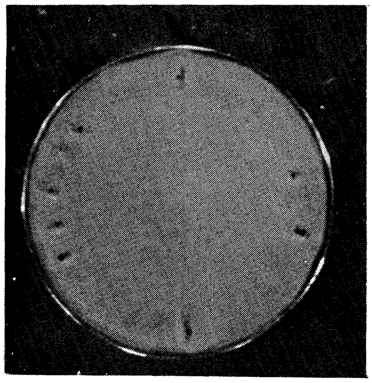
H-2 45 A 7 Carbon
WLR 15.02 mg/hr
7 hr. exposure



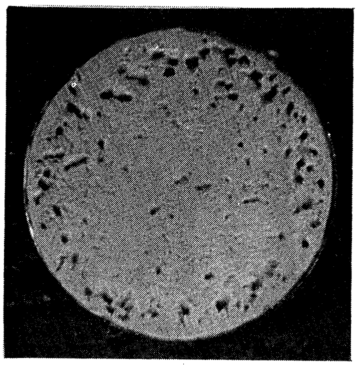
I-3 CA 15
WLR 18.50 mg/hr
7 hr. exposure



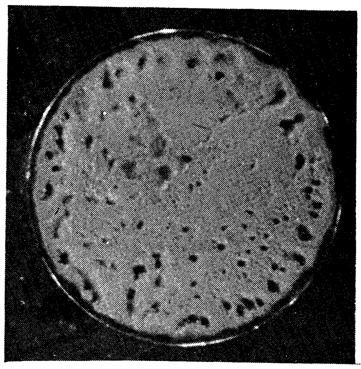
J-3 CA 15
WLR 14.09 mg/hr
7 hr. exposure



K-3 CA 15
WLR 10.70 mg/hr
7 hr. exposure

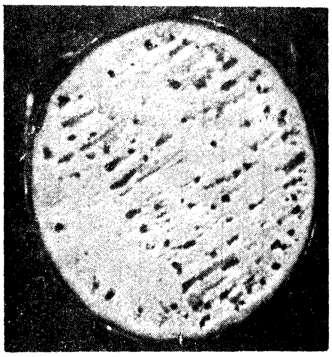


L-2 CF 8 Stainless
WLR 15.20 mg/hr
7 hr. exposure

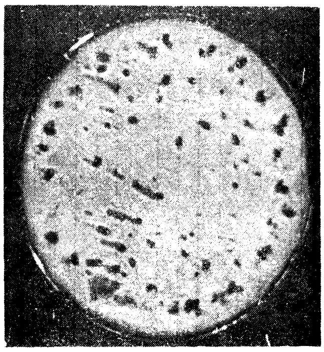


M-2 CF 8
WLR 17.32 mg/hr
7 hr. exposure

Figure 34. Photographs of Damaged Specimens H-M

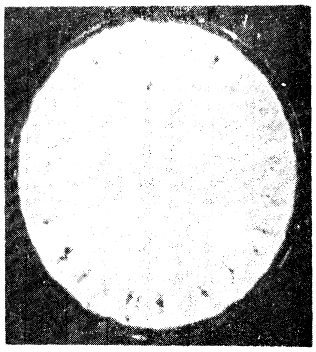


N-2 Arcos Stainlend
WLR 16.36 mg/hr
7 hr. exposure

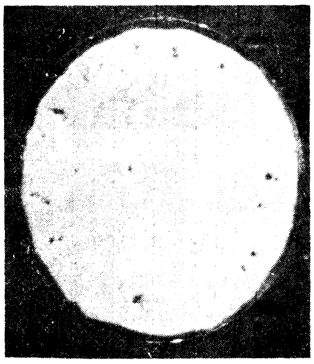


O-2 Arcos Stainlend
WLR 16.38 mg/hr
7 hr. exposure

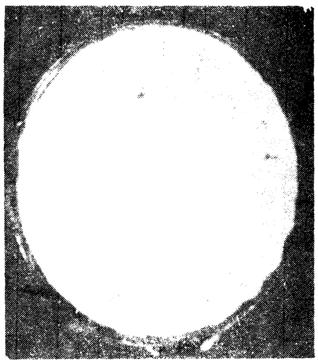
P-3 304-L Sol.
WLR 17.70 mg/hr
7 hr. exposure



Q-2 304-L Sensitized
WLR 20.20 mg/hr
7 hr. exposure

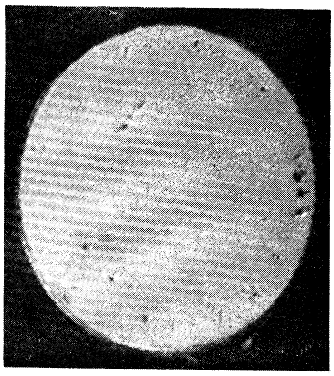


R-3 CF 8 M Sol. quenched
WLR 16.25 mg/hr
7 hr. exposure

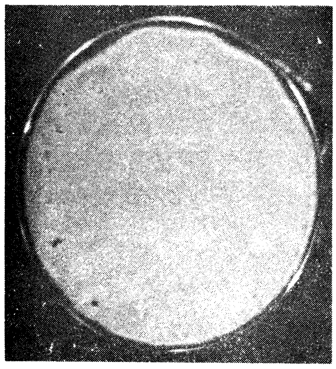


S-2 CF 8 M
WLR 16.10 mg/hr
7 hr. exposure

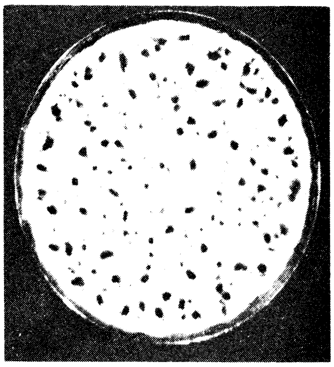
Figure 35. Photographs of Damaged Specimens N-S



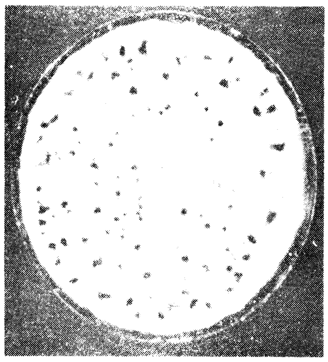
T-2 CE 30 Water quenched
WLR 14.80 mg/hr
7 hr. exposure



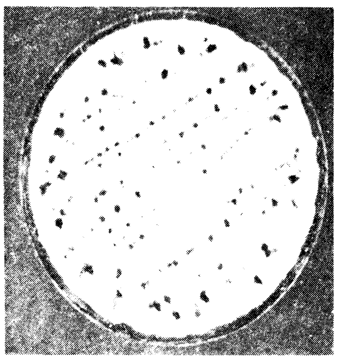
U-1 CE 30 As cast
WLR 15.15 mg/hr
7 hr. exposure



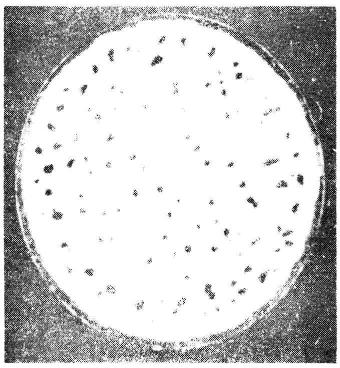
V-2 308-L Water quenched
WLR 20.00 mg/hr
7 hr. exposure



W-2 308-L As welded
WLR 16.50 mg/hr
7 hr. exposure

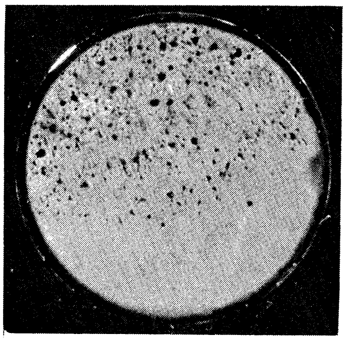


X-1 308 Wire as welded
WLR 17.50 mg/hr
7 hr. exposure

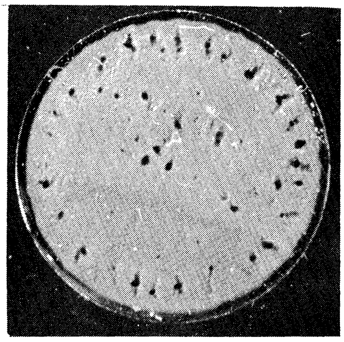


Y-2 308 Wire sol. quenched
WLR [illegible] mg/hr
7 hr. exposure

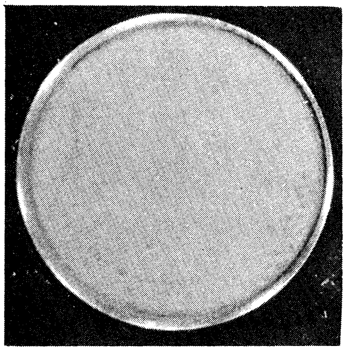
Figure 36. Photographs of Damaged Specimens [illegible]



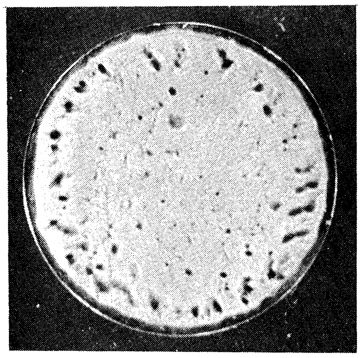
Z_1-3 E 410 Stainless as welded
WLR 10.70 mg/hr
7 hr. exposure



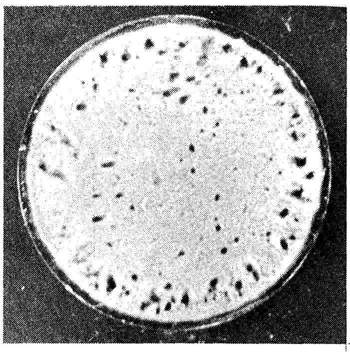
Z_2-3 E 410 Stress relieved
WLR 13.50 mg/hr
7 hr. exposure



A'-1 AM 355 Stainless
WLR 7.50 mg/hr
7 hr. exposure



B'-2 CF 8 C Sol. quenched
WLR 16.00 mg/hr
7 hr. exposure



C'-2 CF 8 C As cast
WLR 13.00 mg/hr
7 hr. exposure

Figure 37. Photographs of Damaged Specimens Z_1- C'

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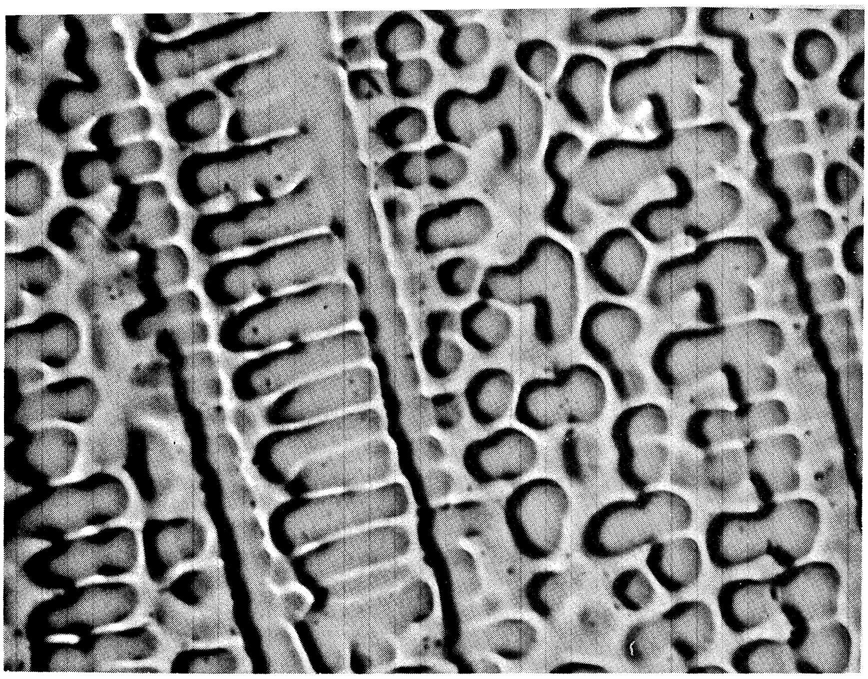
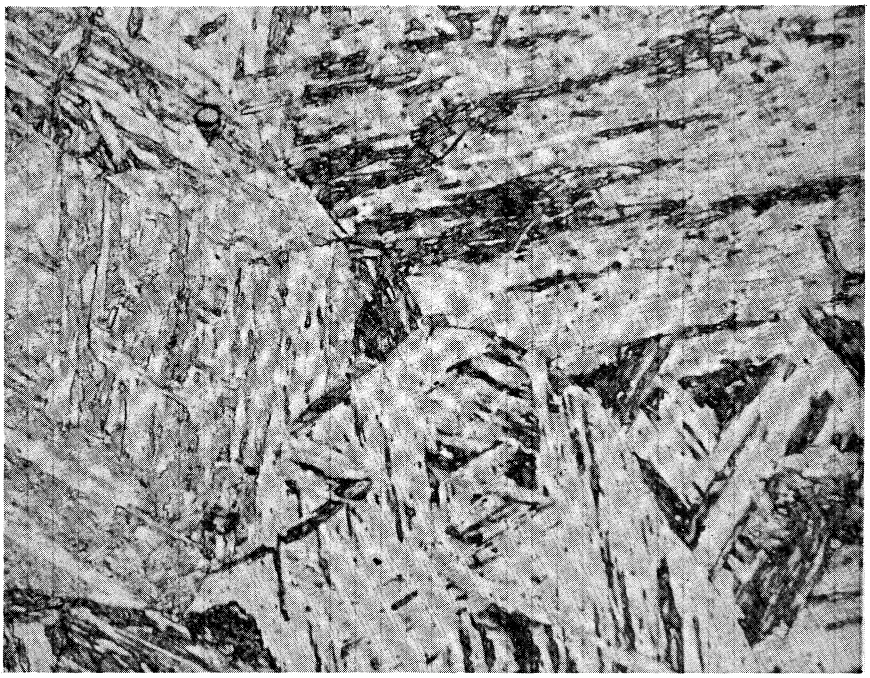


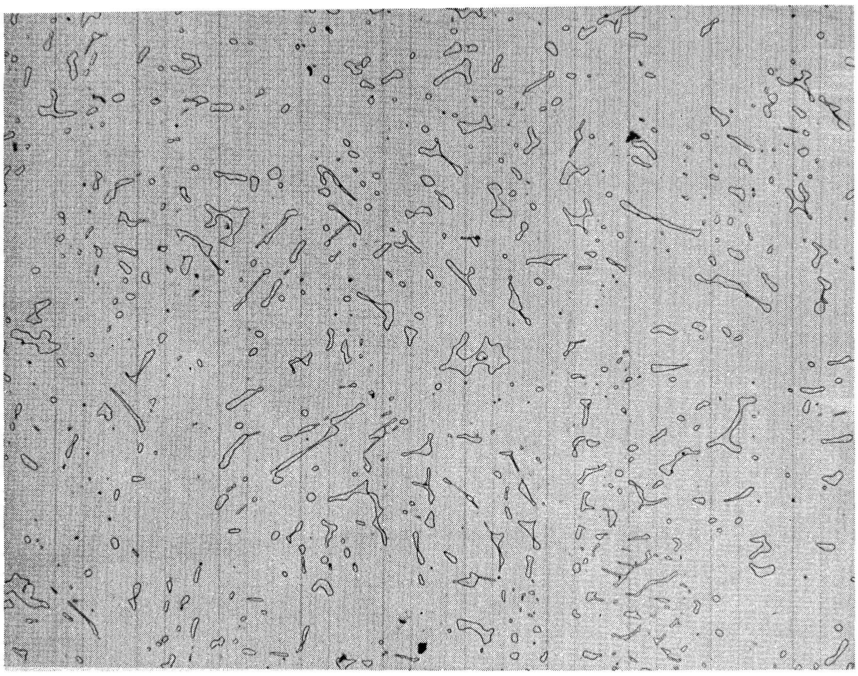
U of M No. C-1 CN7M - Stainless Heat # C-808
C-2 Solution Quenched - 2000° F
C-3 X100 Electrolytic Etch



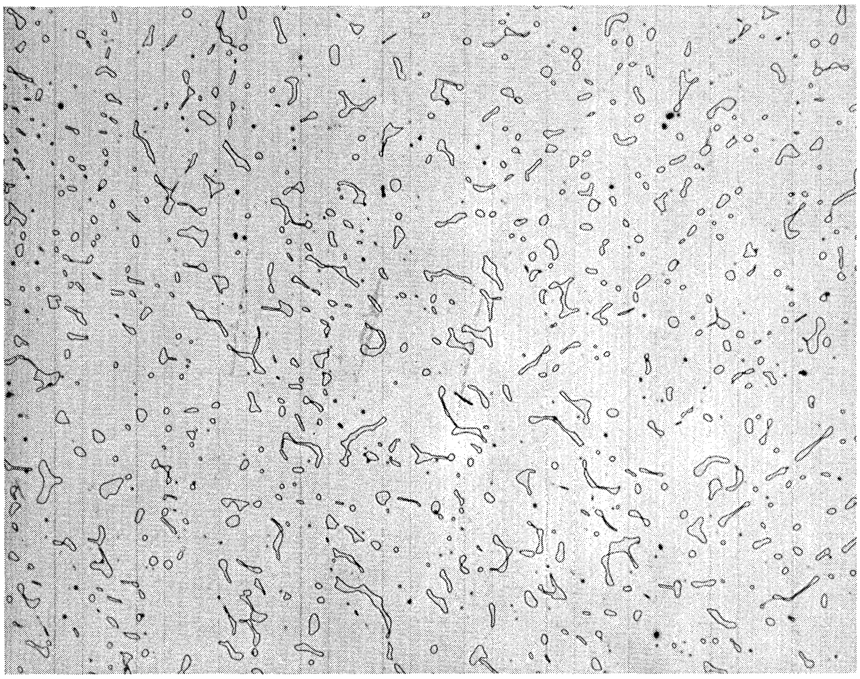
U of M No. D-1 CA6NM (12 Cr 4 Ni) Heat #E4967
D-2 Normalized and Tempered
D-3 X 500 Ferric Chloride Etch

Figure 38. Photomicrograph of material C-1, 2, 3, and D-1, 2, 3

3295



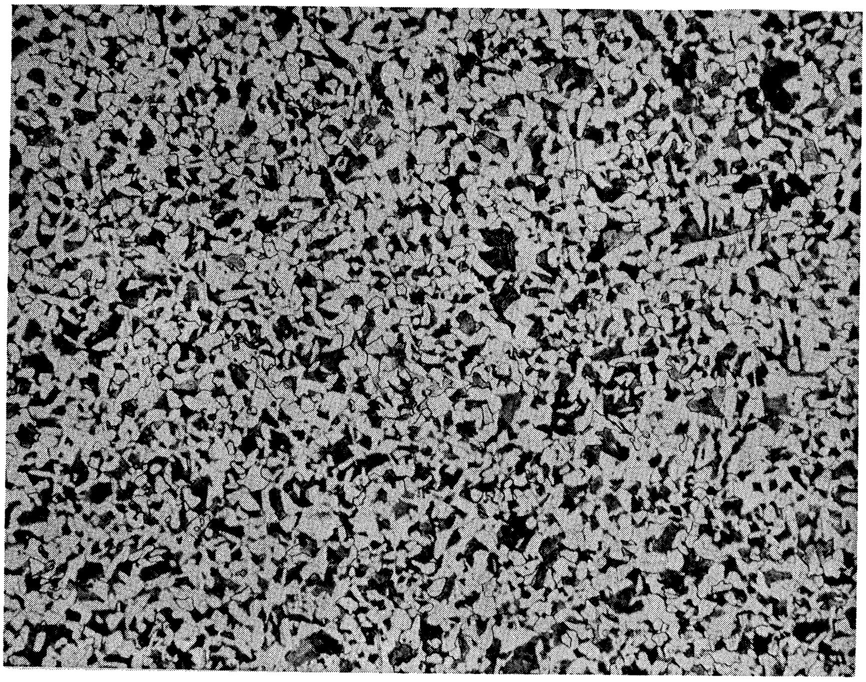
U of M No. F-1 CF8 Stainless (Vacuum Melted)
F-2 Solution quenched from 2000°F
F-3 X100 Electrolytic Etch



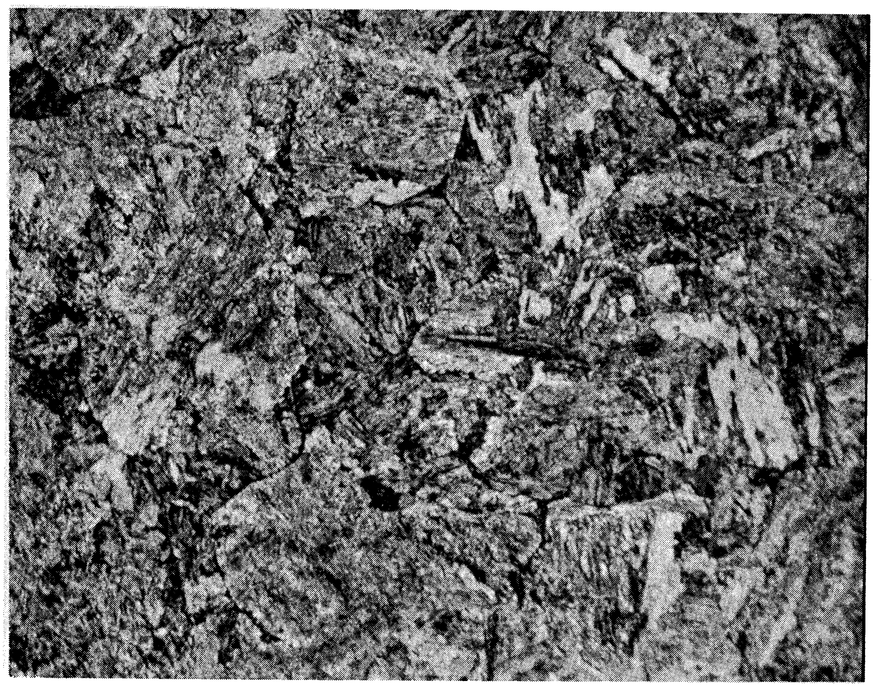
U of M No. E-1 CF8 Stainless (Air Melted)
E-2 Solution quenched from 2000°F
E-3 X100 Electrolytic Etch

Figure 39. Photomicrograph of material F-1, 2, 3 and E-1, 2, 3

3296

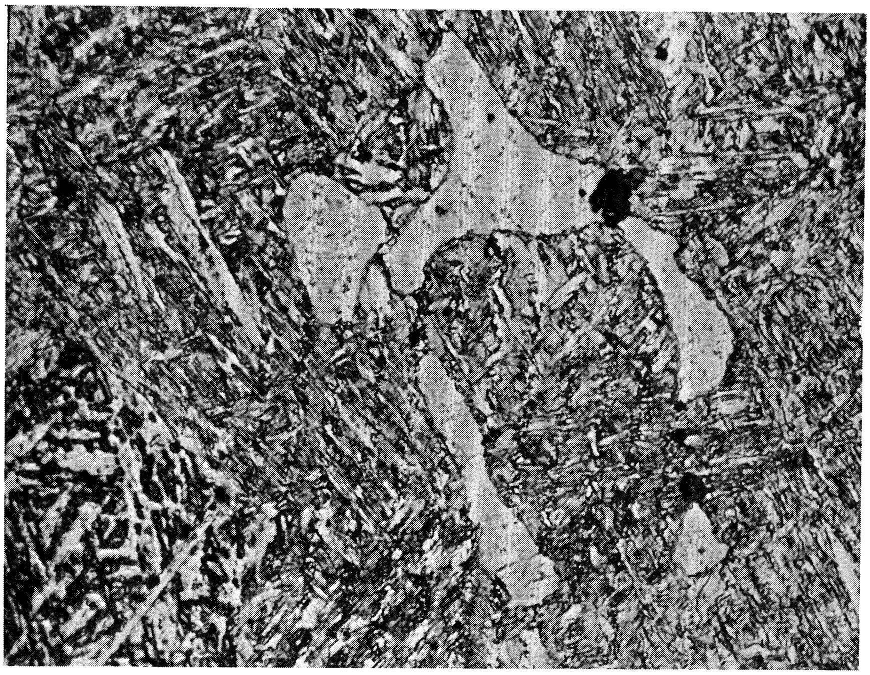


U of M No. G-1   25CN (Carbon Steel) Normalized and Tempered X100 2% Nital Etc
G-2
G-3

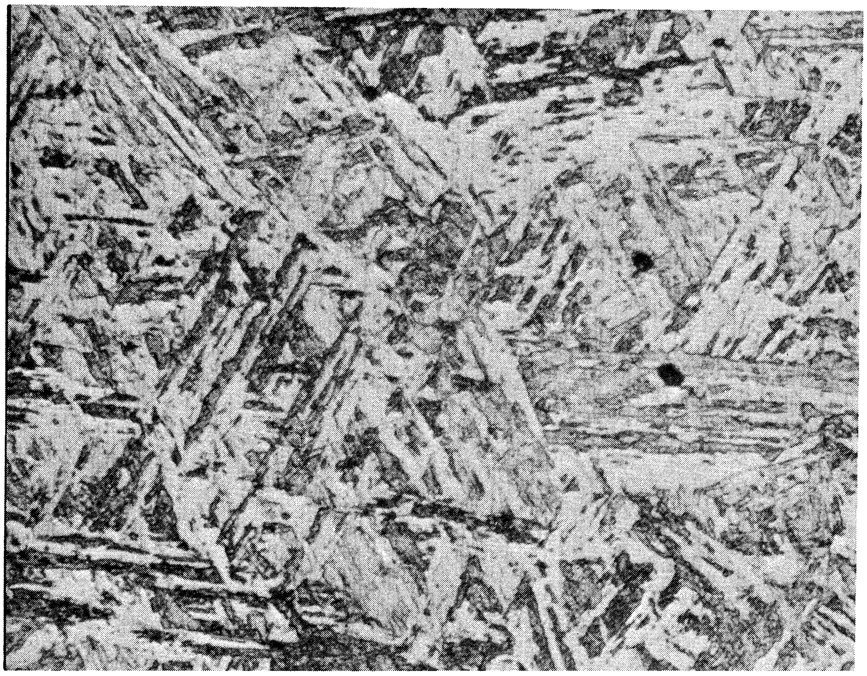


U of M No. H-1   45A7 (Carbon Chrome Moly Steel) Normalized and Tempered X500 2% Nital Etch
H-2
H-3

Figure 40. Photomicrograph of material G-1, 2, 3 and H-1, 2, 3



U of M No I-1 CA-15 High Cr, High Si, structure containing Ferrite. Normal propertie
I-2
I-3 X500 Ferric Chloride Etch.

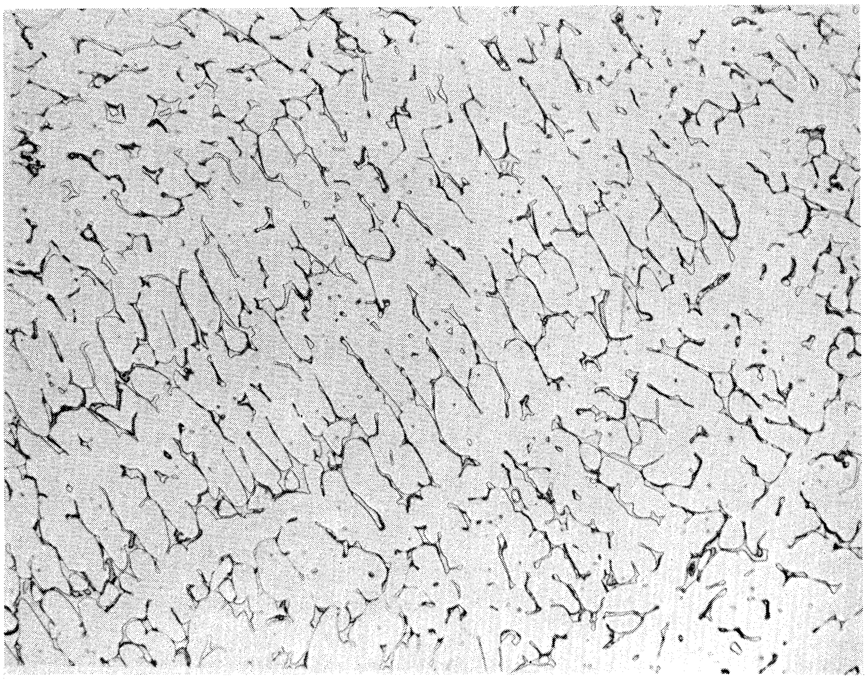


U of M No. J-1 CA15 - Low Cr, Low Si, structure containing no Ferrite. Normal pro-
J-2
J-3 perties X500 Ferric Chloride Etch

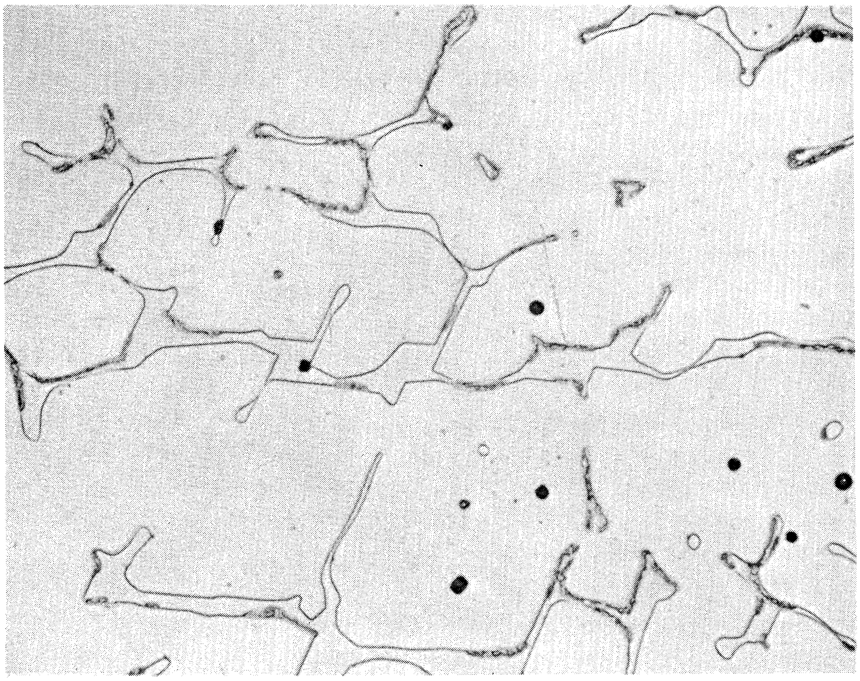
Figure 41. Photomicrograph of material I-- 1, 2, 3 and J-1, 2, 3

U of M No. K-1 K-2 K-3	CA15 - Low Cr, Low Si Structure con containing no Ferrite. Heat treated to 248 - 302 BHN. (A. C. and BLH Impellers) X500 Ferric Chloride.

Figure 42. Photomicrograph of Material K-1, 2, 3



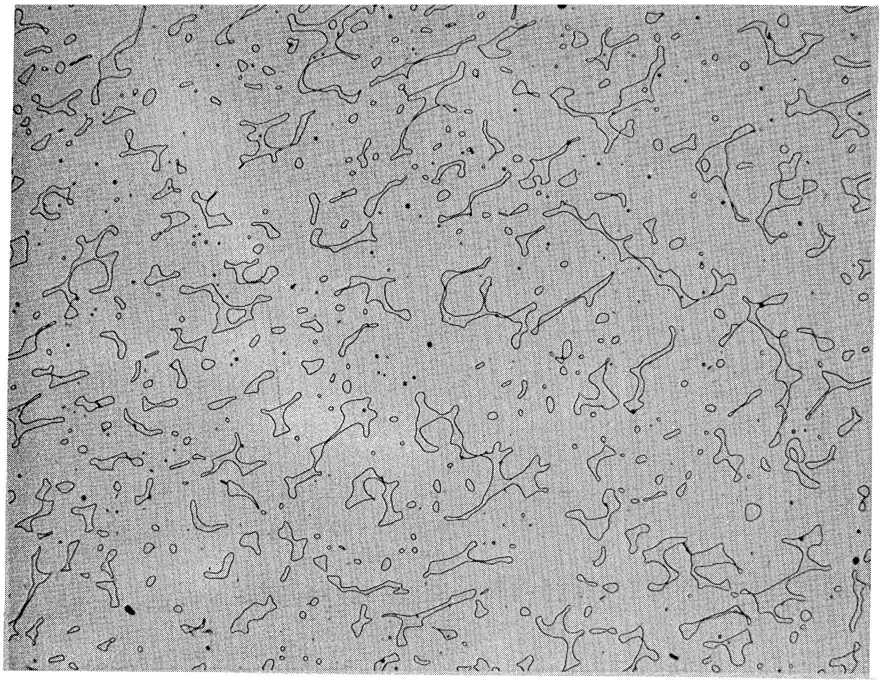
U of M No. L-1 L-2 L-3 — CF 8 Stainless - High Ferrite (17%) As Cast X100 Electrolytic Etch



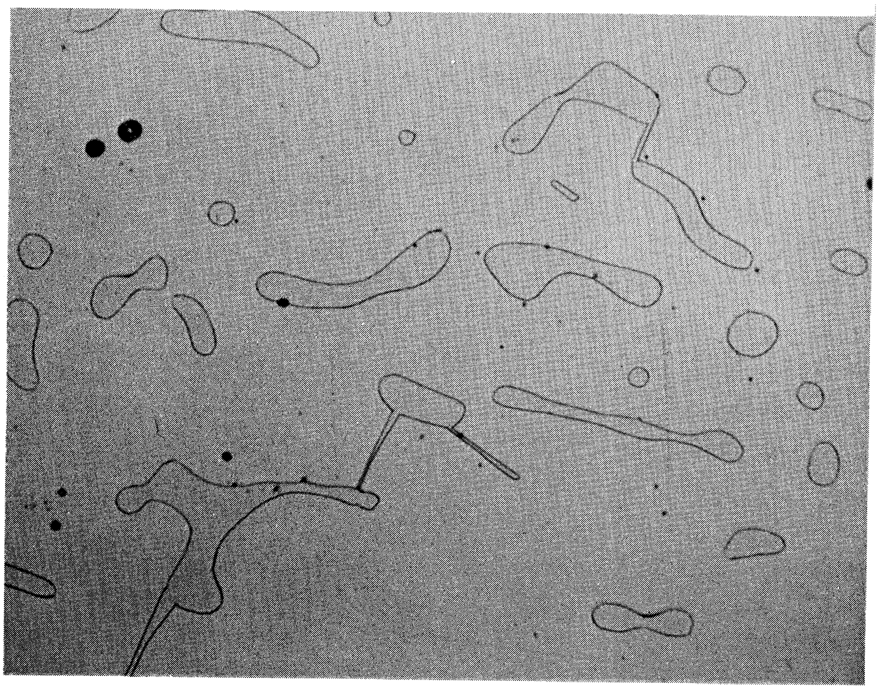
U of M No. L-1 L-2 L-3 — CF8 Stainless - High Ferrite (17%) As Cast X500 Electrolytic Etch

Figure 43. Photomicrograph of Material L-1, 2, 3

3300



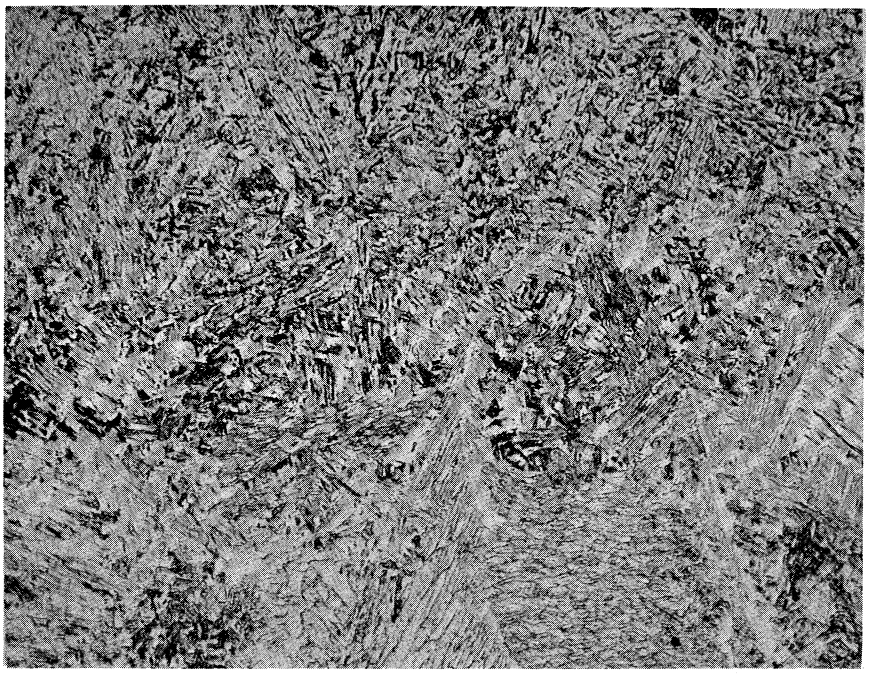
U of M No. M-1 CF8 Stainless - High Ferrite
M-2 (17%) Sol. Quenched X100
M-3 Electrolytic Etch



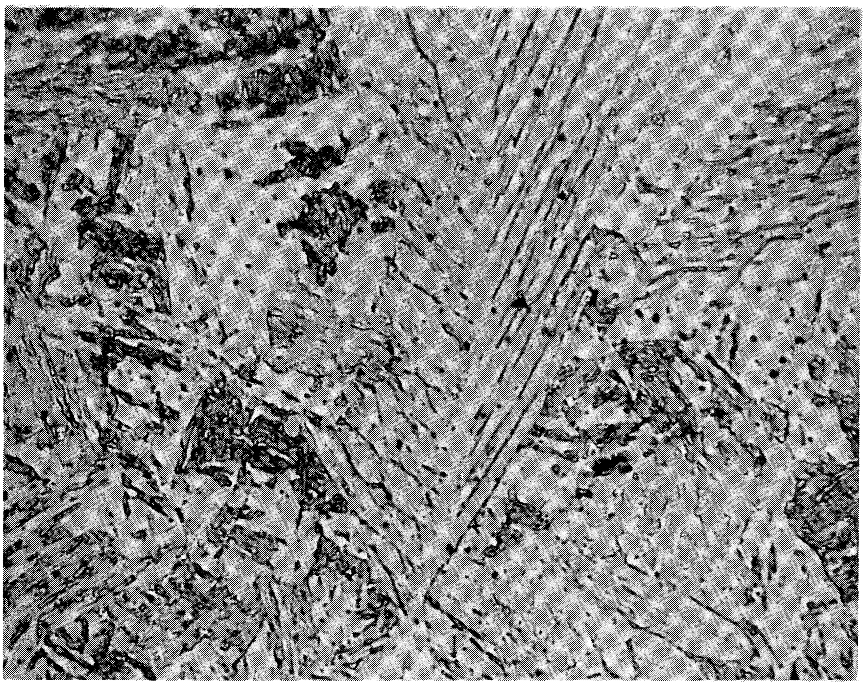
U of M No. M-1 CF8 Stainless - High Ferrite
M-2 (17%) Sol. Quenched X500
M-3 Electrolytic Etch

Figure 44. Photomicrograph of Material M-1, 2, 3

3301



U of M No. N-1 N-2 N-3 — Arcos Stainlend 134 Ni As welded Deposit X100 Fe Cl Etch

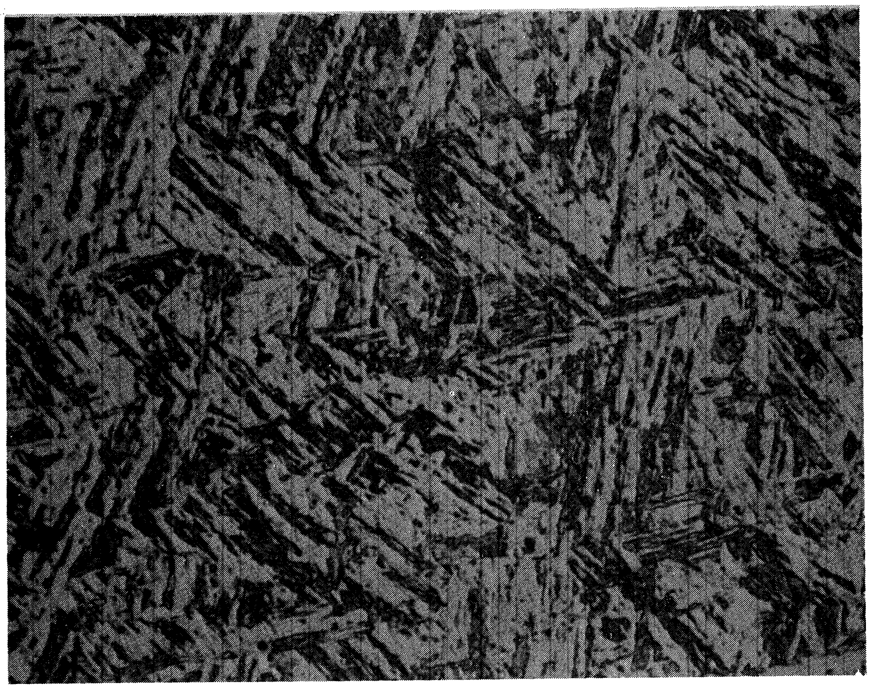


U of M No. N-1 N-2 N-3 — Arcos Stainlend 134 Ni Deposit As welded X500 Fe Cl Etch

3302

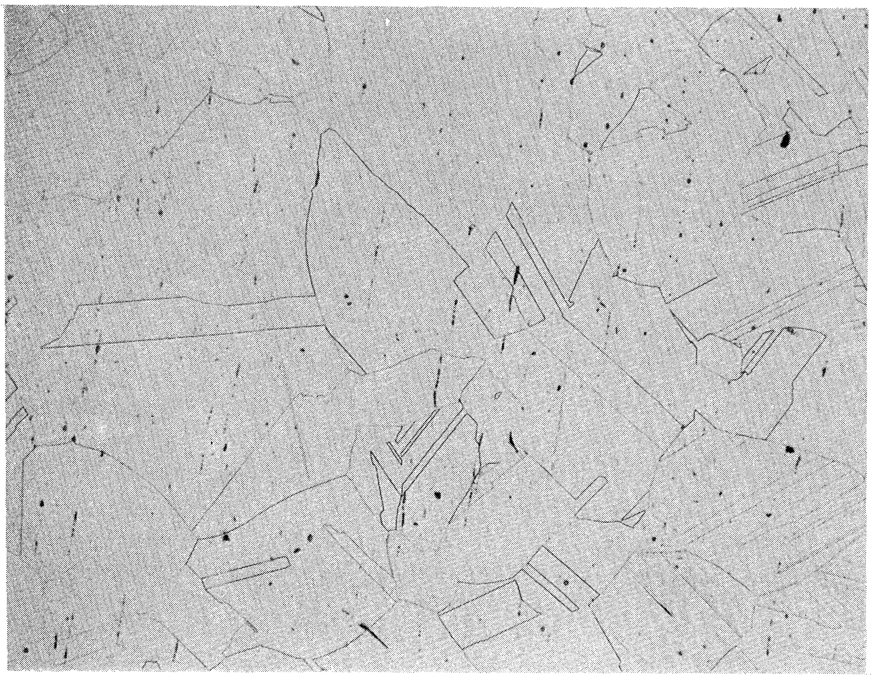
Figure 45. Photomicrograph of Material N-1, 2, 3.

U of M No. O-1 Stainlend 134 Ni Weld Deposit
O-2 Stress Relieved 1175°F A. C.
O-3 X100 FeCl Etch

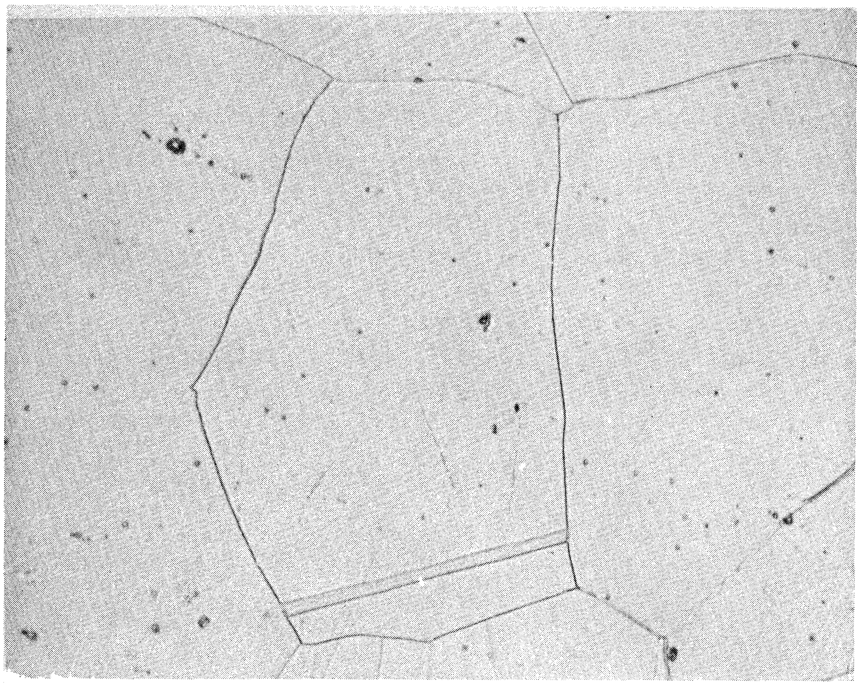


U of M No. O-1 Stainlend 134 Ni Weld Deposit
O-2 Stress Relieved 1175°F A. C.
O-3 X500 FeCl Etch

Figure 46. Photomicrograph of Material O-1, 2, 3



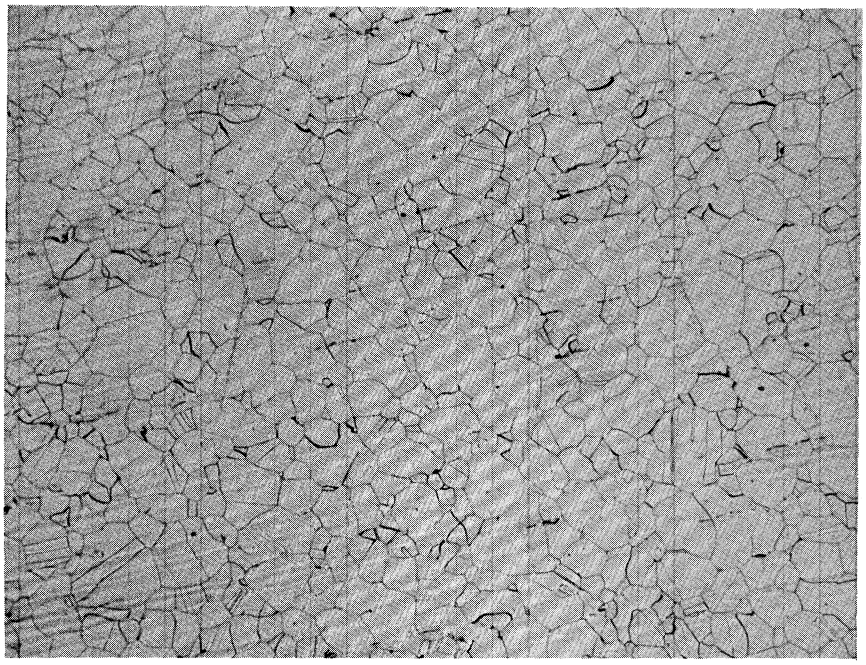
U of M No. P-1 Type 304-L Stainless Solution
P-2 Quenched 2050°F X100
P-3 Electrolytic Etch



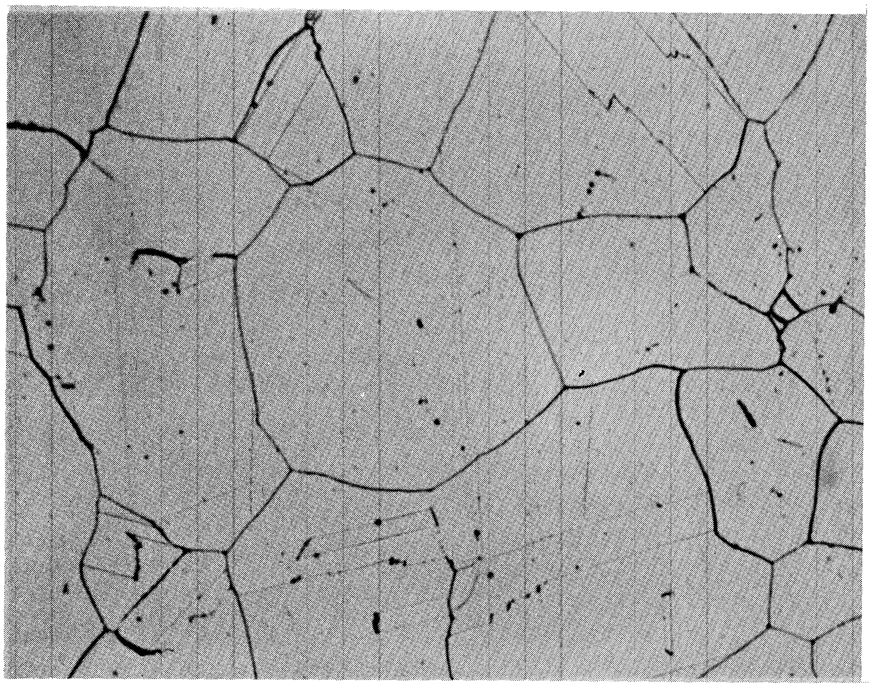
U of M No. P-1 Type 304-L Stainless Solution
P-2 Quenched 2050°F X500
P-3 Electrolytic Etch

3304

Figure 47. Photomicrograph of Material P-1, 2, 3



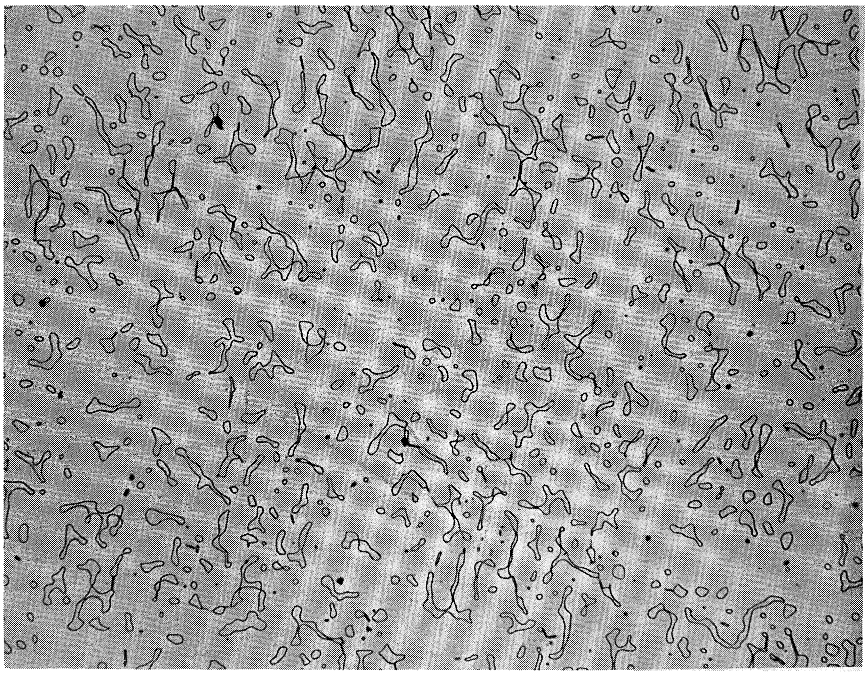
U of M No. Q-1   304-L Stainless Sensitized
Q-2   1250^{o}F 25 Hours X100
Q-3   Electrolytic Etch



U of M No. Q-1   304-L Stainless Sensitized
Q-2   1250^{o}F 25 Hours X500
Q-3   Electrolytic Etch

3305

Figure 48. Photomicrograph of Material Q-1, 2, 3



U of M No. R-1 R-2 R-3

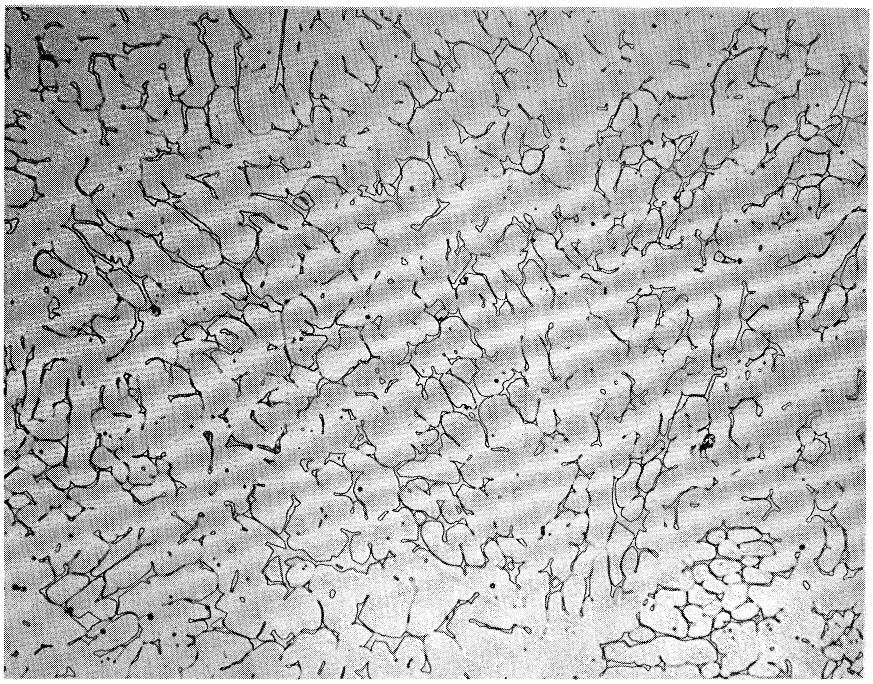
CF8M Stainless Solution Quenche from 2050^{o}F X100 Electrolytic Etch

U of M No. R-1 R-2 R-3

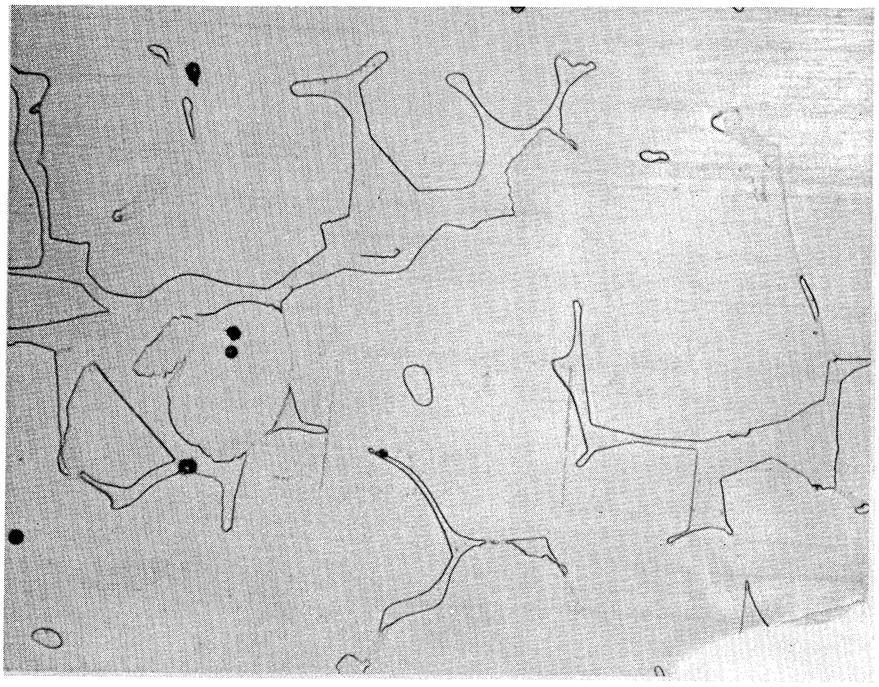
CF8M Stainless Solution Quenched from 2050^{o}F X500 Electrolytic Etch

Figure 49. Photomicrograph of Material R-1, 2, 3

3306

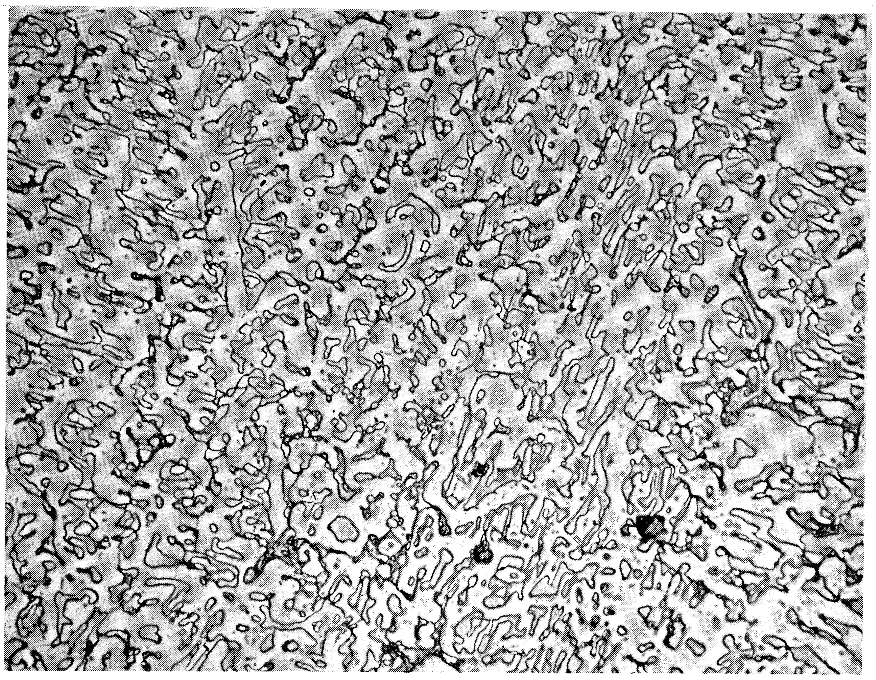


U of M No. S-1 S-2 S-3 — CF8M Stainless As Cast X100, Electrolytic Etch

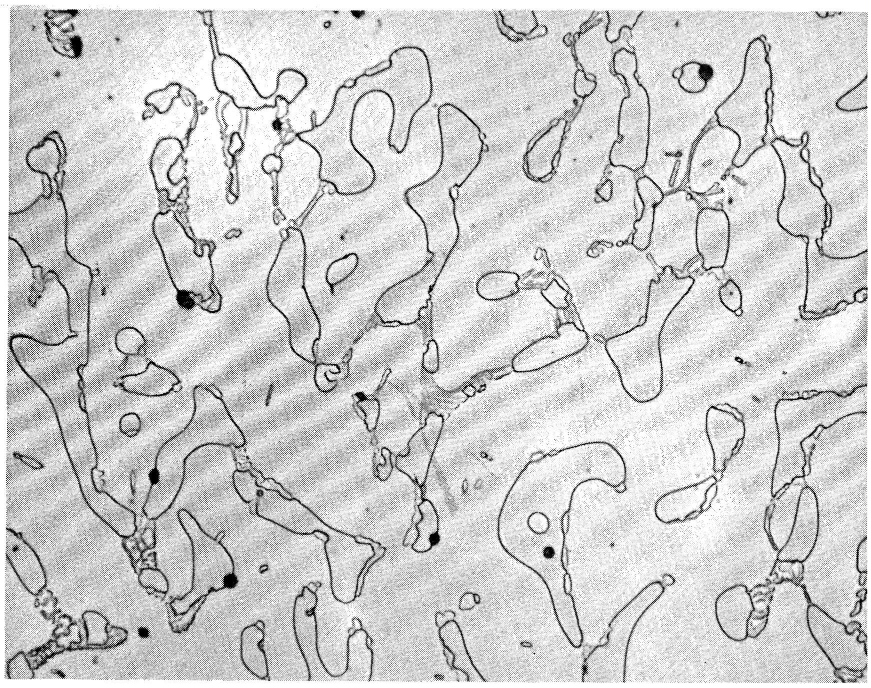


U of M No. S-1 S-2 S-3 — CF8M Stainless As Cast X500, Electrolytic Etch

3307 Figure 50. Photomicrograph of Material S-1, 2, 3



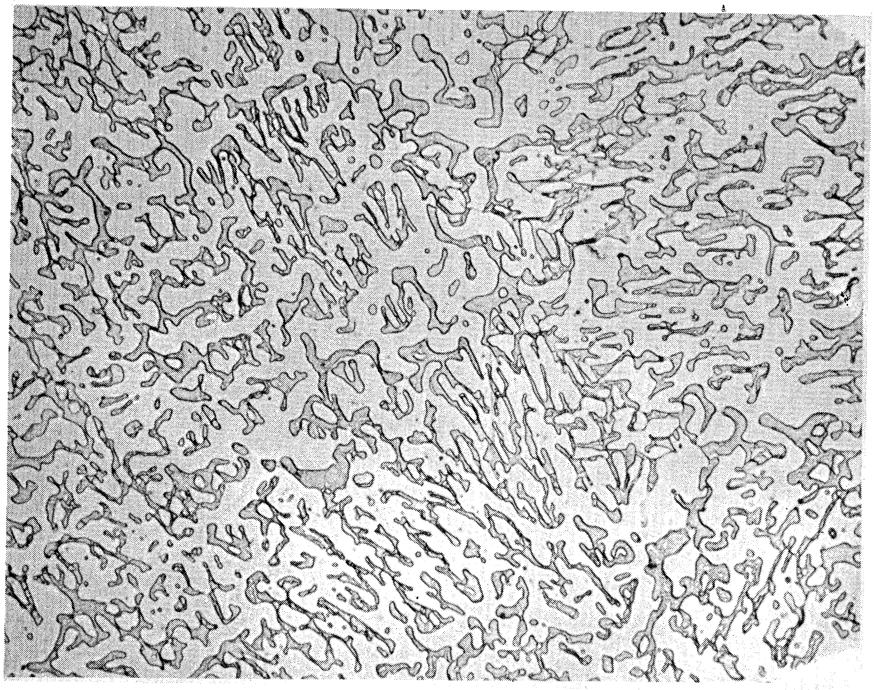
U of M No. T-1 T-2 T-3 — CE30 Stainless - Sol. Quenched $2000^{\circ}F$ X100 Electrolytic Etch



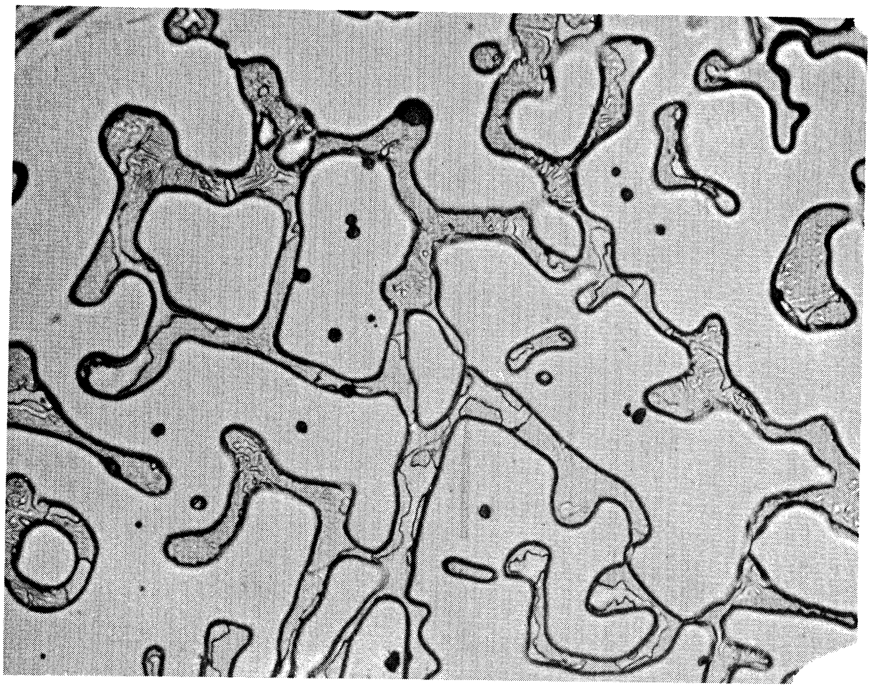
U of M No. T-1 T-2 T-3 — CE30 Stainless - Sol. Quenched $2000^{\circ}F$ X500 Electrolytic Etch

3308

Figure 51. Photomicrograph of Material T-1, 2, 3



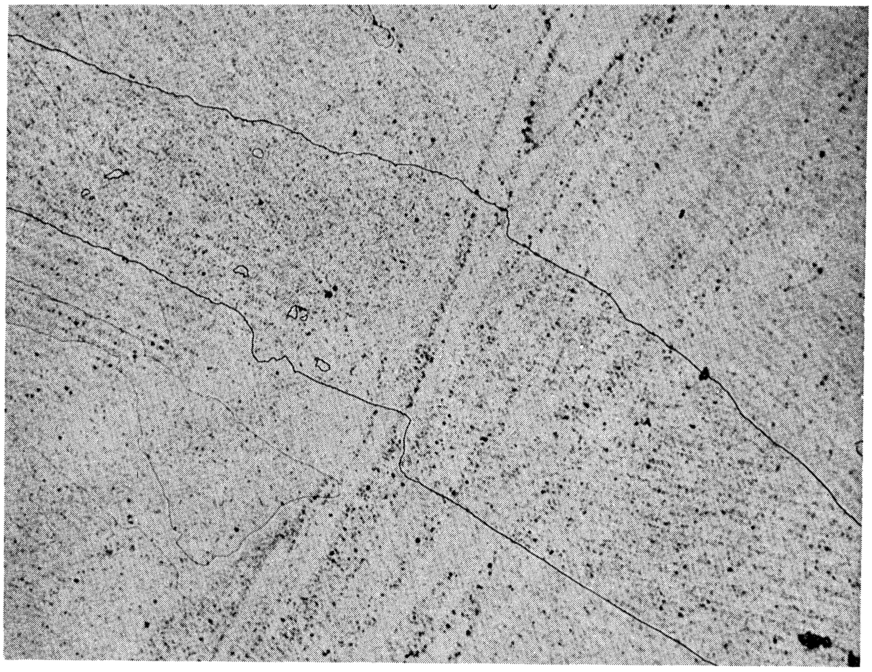
U of M No.	U-1	CE30 Stainless - As Cast X100
	U-2	Electrolytic Etch
	U-3	



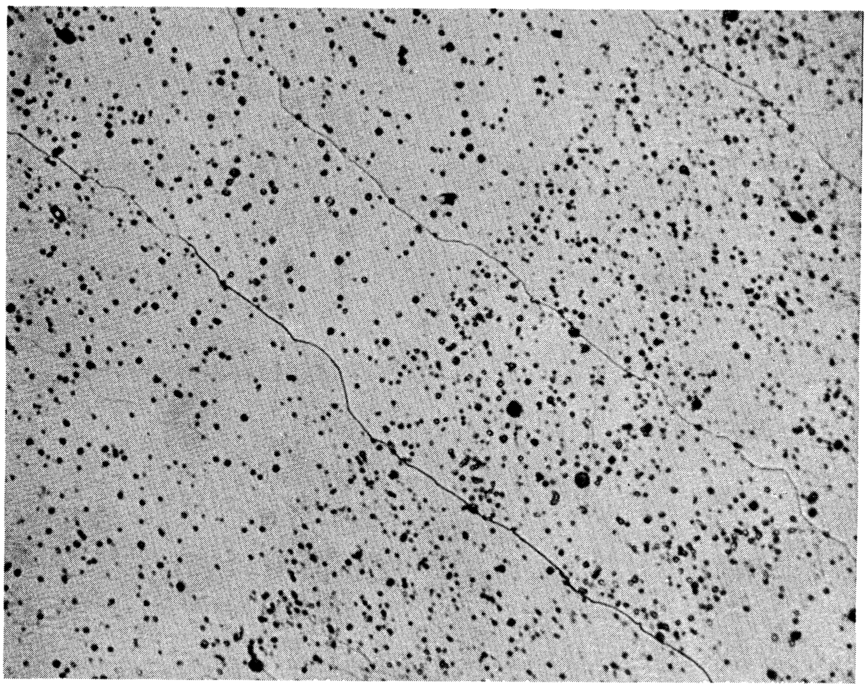
U of M No.	U-1	CE30 Stainless - As Cast X500
	U-2	Electrolytic Etch
	U-3	

3309

Figure 52. Photomicrograph of Material U-1, 2, 3



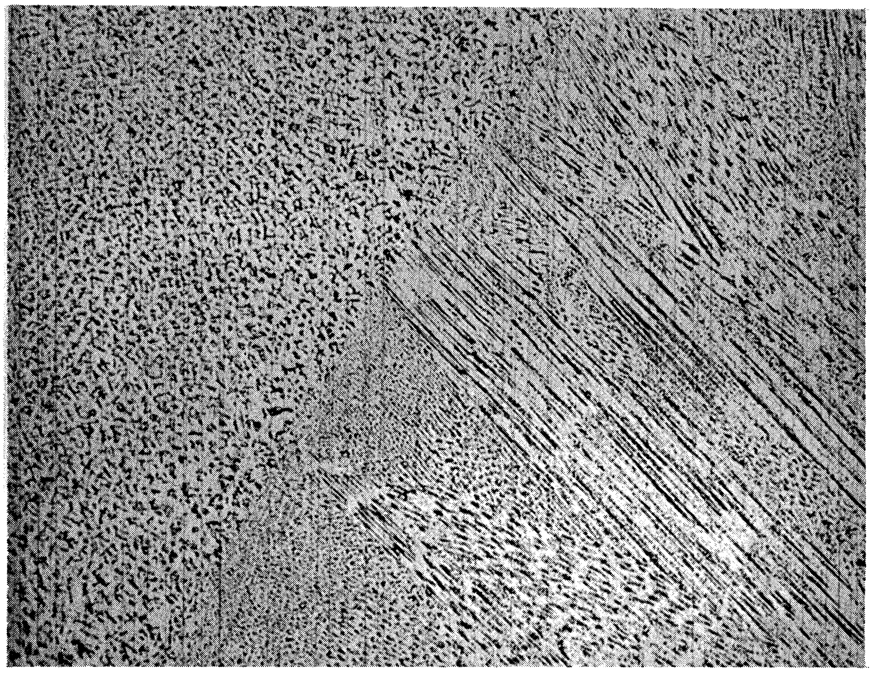
U of M No. V-1 V-2 V-3 — Weld Deposit 308 Stainless Solution Quenched 2000°F X100 Electrolytic Etch



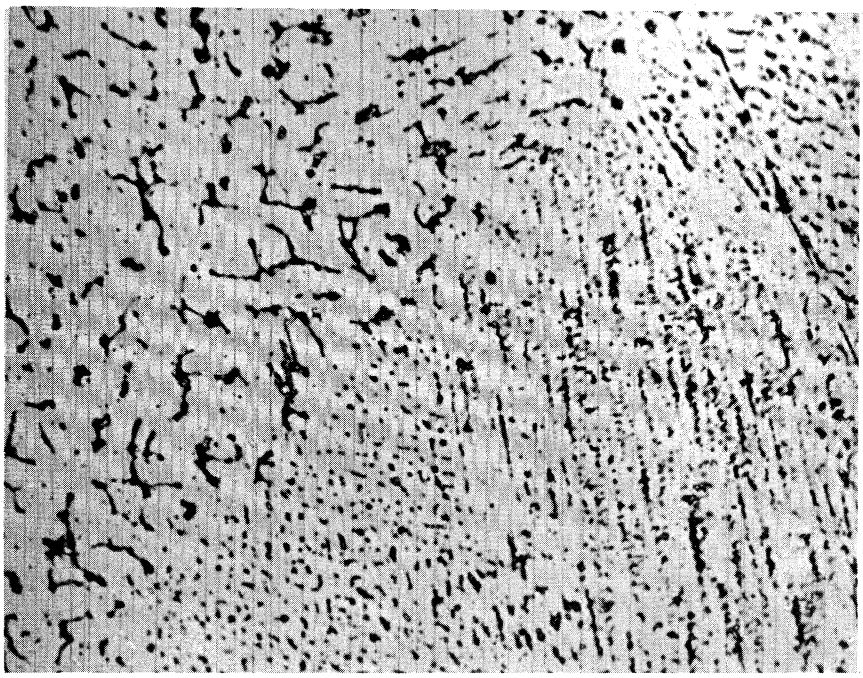
U of M No. V-1 V-2 V-3 — Weld Deposit 308 Stainless Solution Quenched 2000°F X500 Electrolytic Etch

3310

Figure 53. Photomicrograph of Material V-1, 2, 3



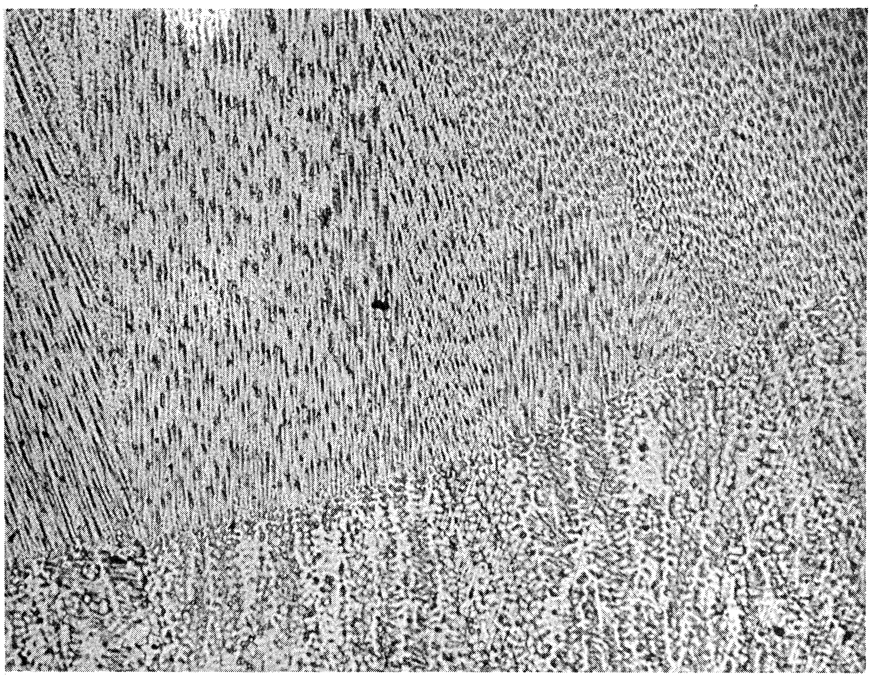
U of M No. W-1 W-2 W-3 — Weld Deposit 308-L Stainless As Welded X100 Electrolytic Etch



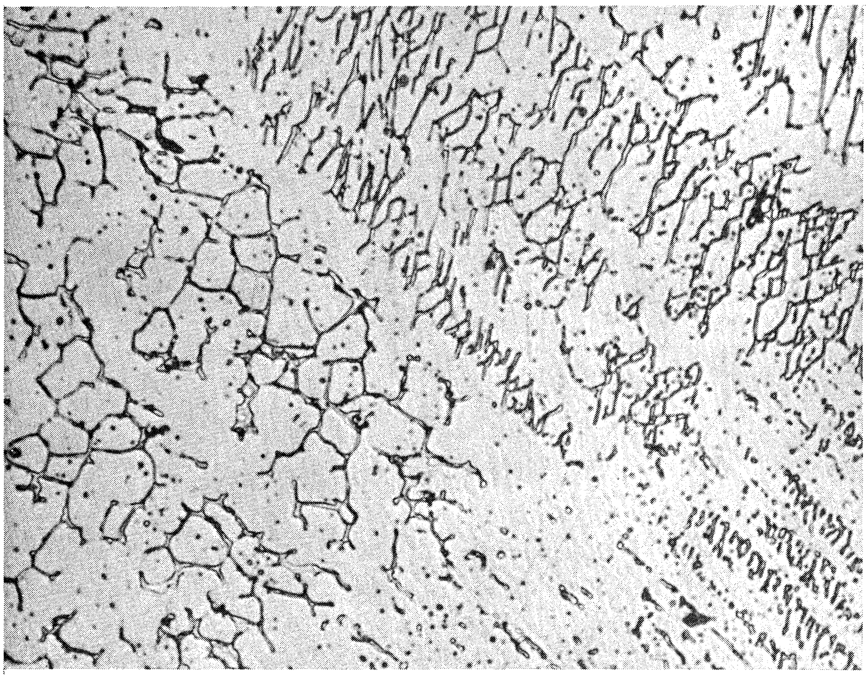
U of M No. W-1 W-2 W-3 — Weld Deposit 308-L Stainless As Welded X500 Electrolytic Etch

311

Figure 54. Photomicrograph of Material W-1, 2, 3



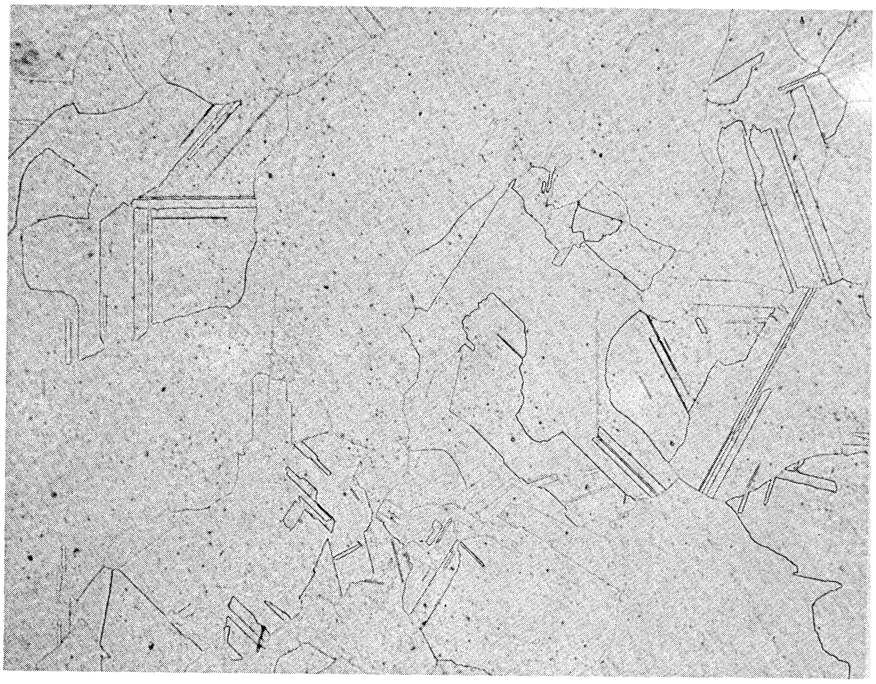
U of M No. X-1 X-2 X-3 — Weld Deposit Type 308 Stainless As Welded X100 Electrolytic Etch



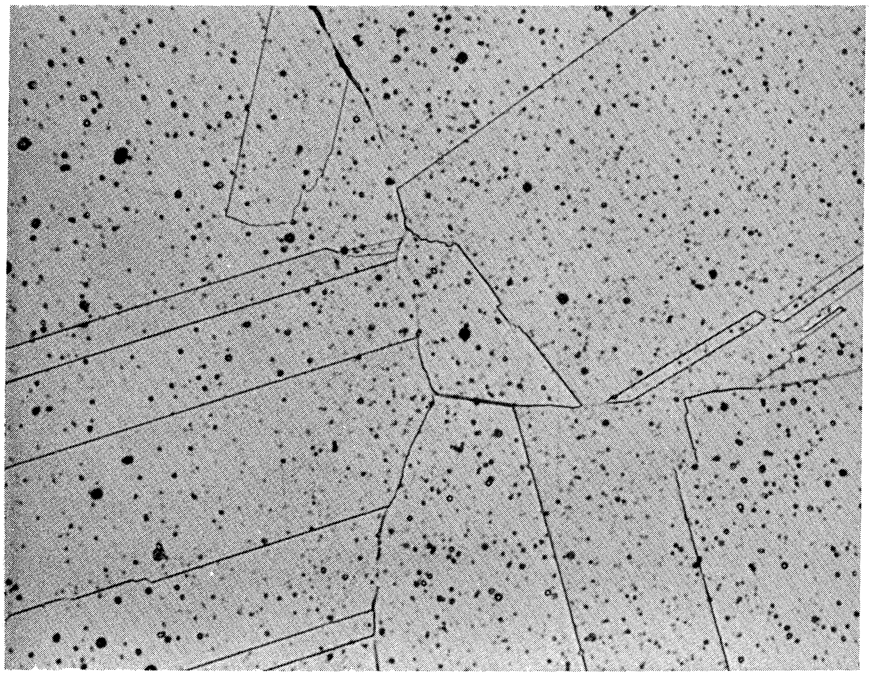
U of M No. X-1 X-2 X-3 — Weld Deposit Type 308 Stainless As Welded X500 Electrolytic Etch

Figure 55. Photomicrograph of Material X-1, 2, 3

3312

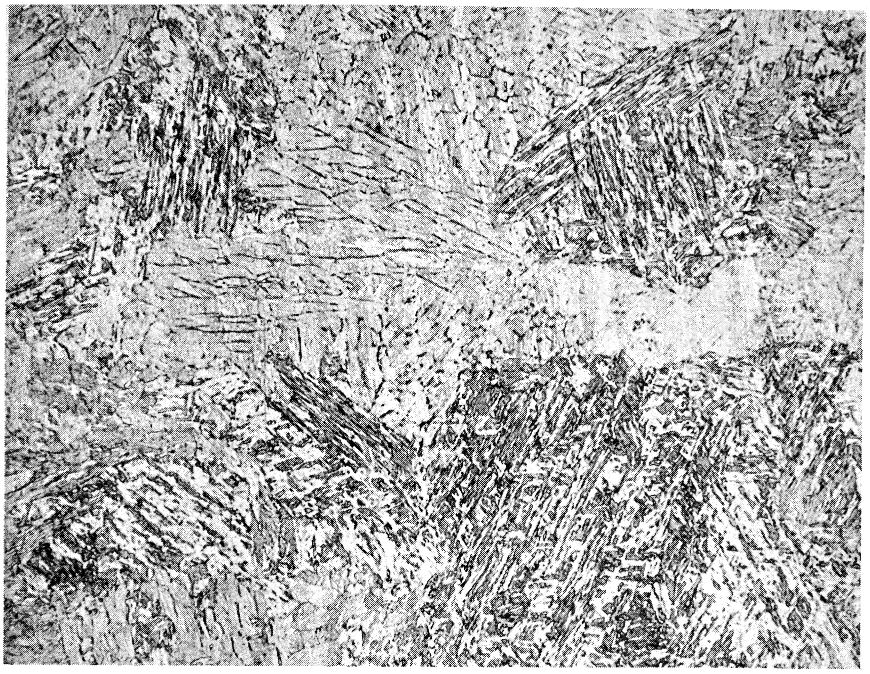


U of M No. Y-1 — Weld Deposit 308-L Stainless
Y-2 — Solution Quenched 2000°F X100
Y-3 — Electrolytic Etch

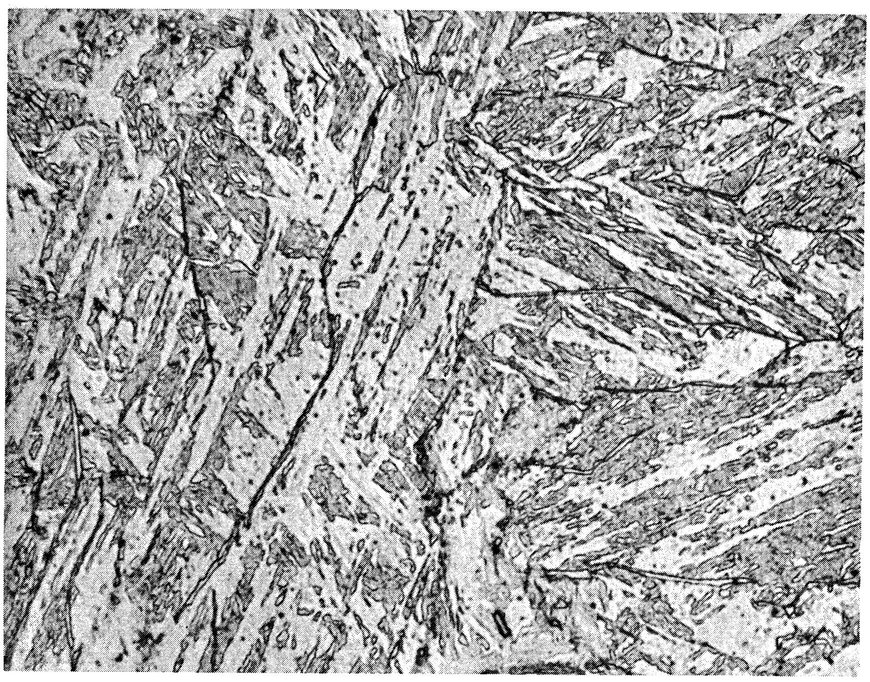


U of M No. Y-1 — Weld Deposit 308-L Stainless
Y-2 — Solution Quenched 2000°F X500
Y-3 — Electrolytic Etch

3313 Figure 56. Photomicrograph of Material Y-1, 2, 3



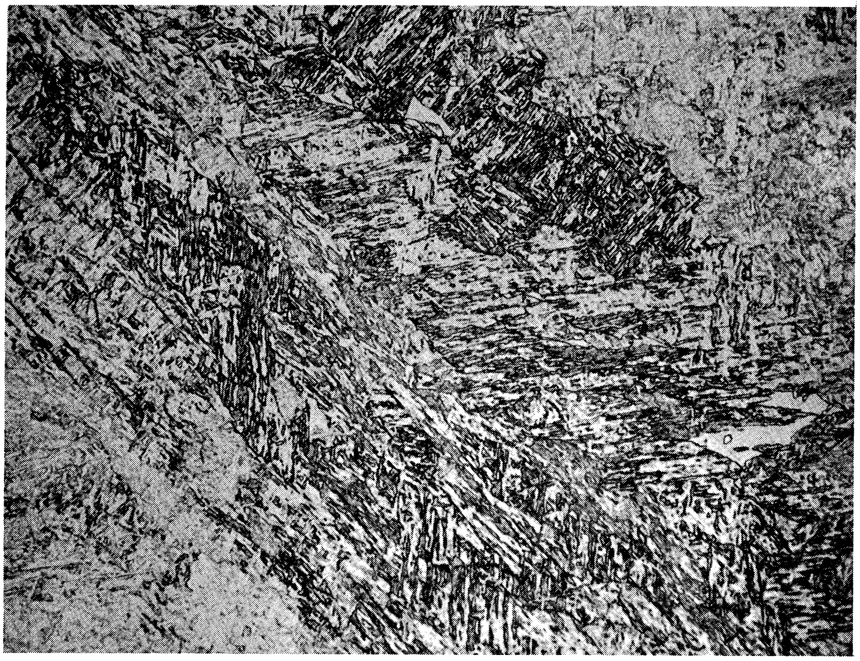
U of M No. Z_1-1, Z_1-2, Z_1-3 — Arcos 410-15 Weld Deposit As Welded
X100 FeCl Etch



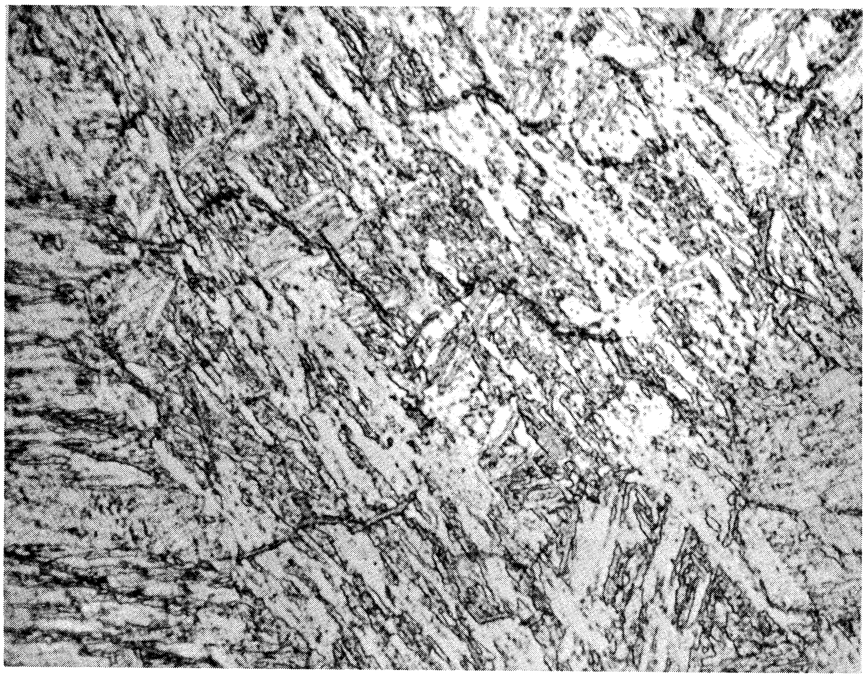
U of M No. Z_1-1, Z_1-2, Z_1-3 — Arcos 410-15 Weld Deposit As Welded
X500 FeCl Etch

Figure 57. Photomicrograph of Material Z_1-1, 2, 3

3314



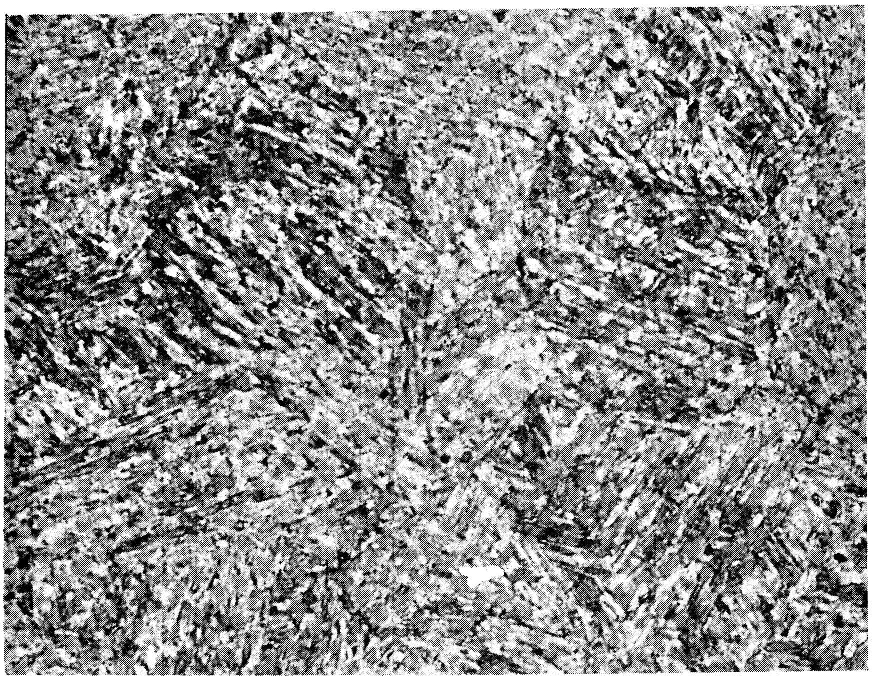
U of M No. Z_2-1 / Z_2-2 / Z_2-3 — Arcos 410-15 Weld Deposit Stress Relieved 1300°F A. C. X100 FeCl Etch



U of M No. Z_2-1 / Z_2-2 / Z_2-3 — Arcos 410-15 Weld Deposit Stress Relieved 1300°F A. C. X500 FeCl Etch

3315 Figure 58. Photomicrograph of Material Z_2-1, 2, 3

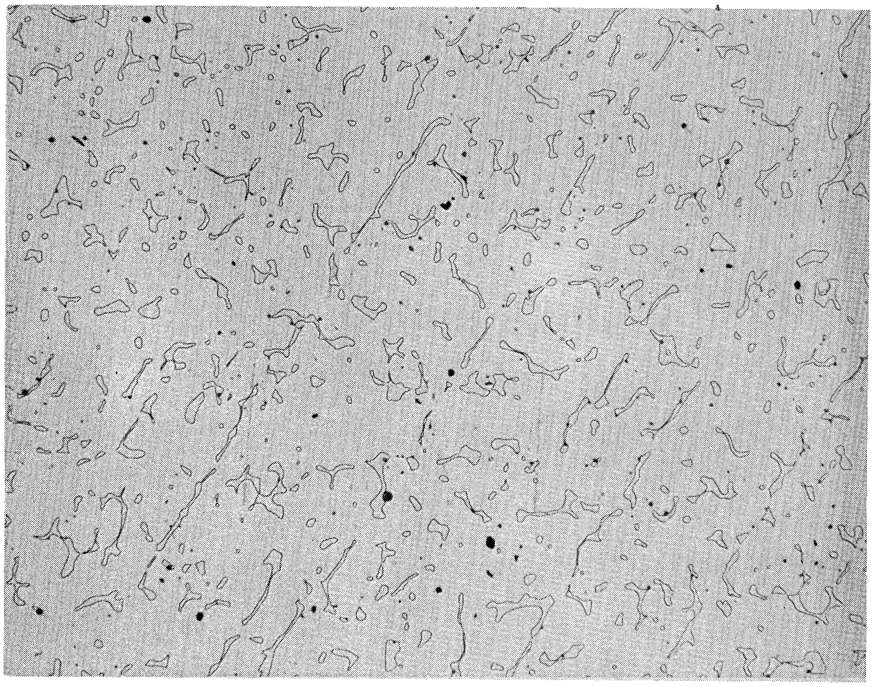
U of M No.	A'-1	AM-355 Stainless X100 Ferric Chloride
	A'-2	Etch Sample by Carpenter
	A'-3	Technology Corp., Reading, Penna.



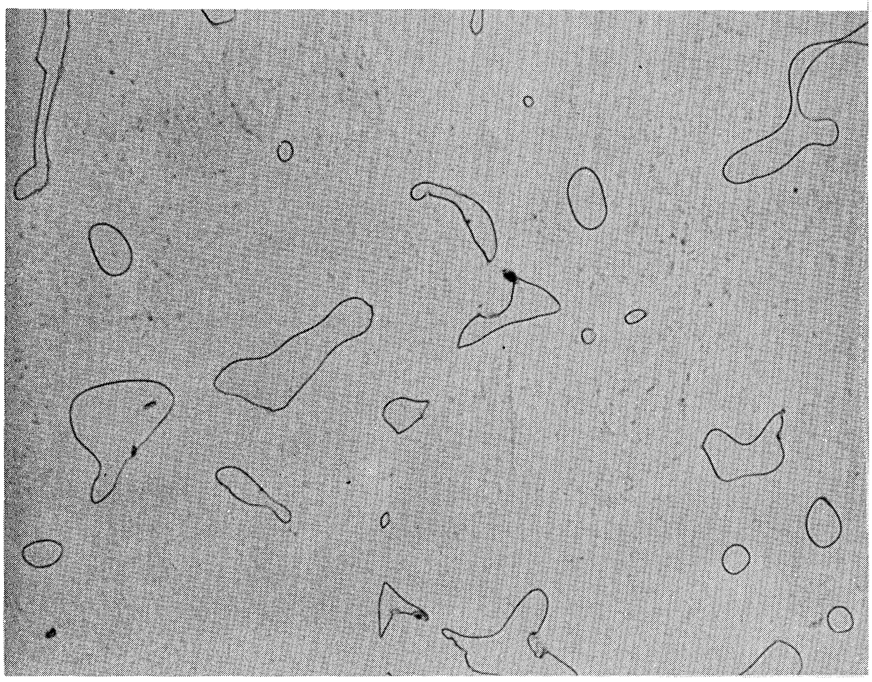
U of M No.	A'-1	Am-355 Stainless X500 Ferric Chloride
	A'-2	Etch Sample by Carpenter
	A'-3	Technology Corp., Reading, Penna.

3316

Figure 59. Photomicrograph of Material A'-1, 2, 3



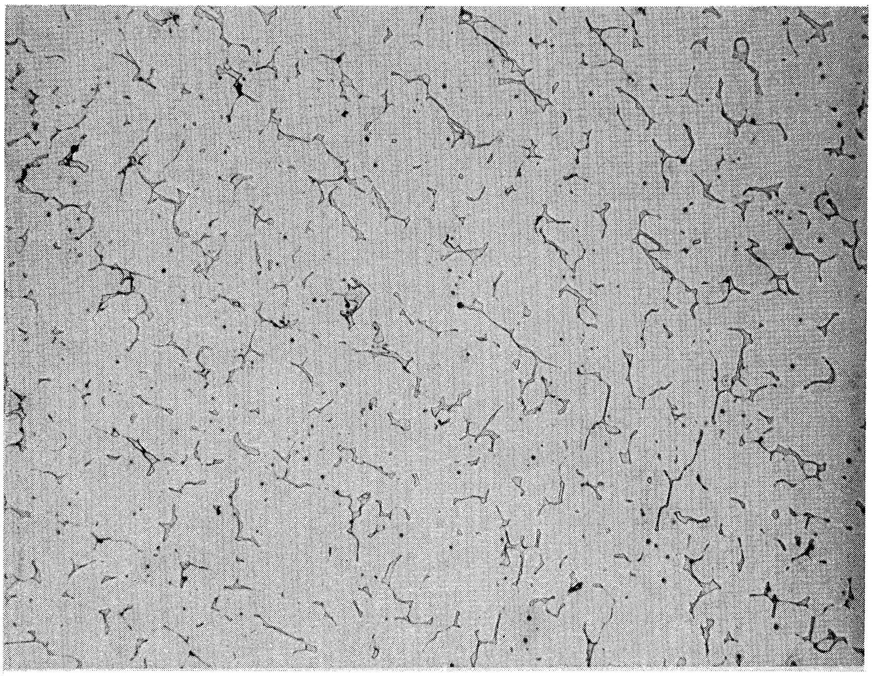
U of M No. B'-1 CF8C Cast Stainless Steel Sol.
B'-2 Quenched 2050°F X100
B'-3 Electrolytic Etch



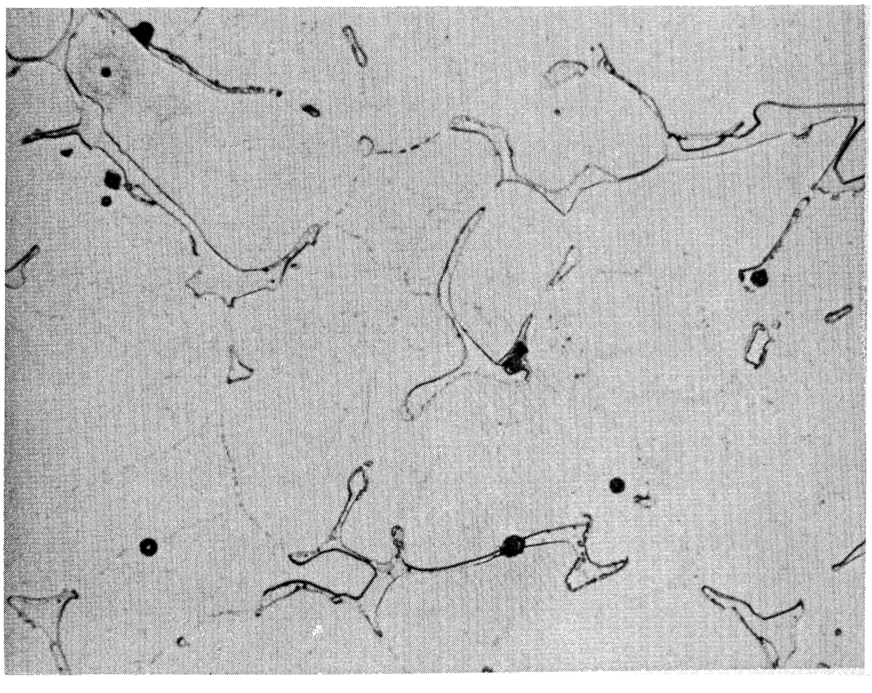
U of M No. B'-1 CF8C Cast Stainless Steel Sol.
B'-2 Quenched 2050°F X500
B'-3 Electrolytic Etch

3317

Figure 60. Photomicrograph of Material B'-1, 2, 3

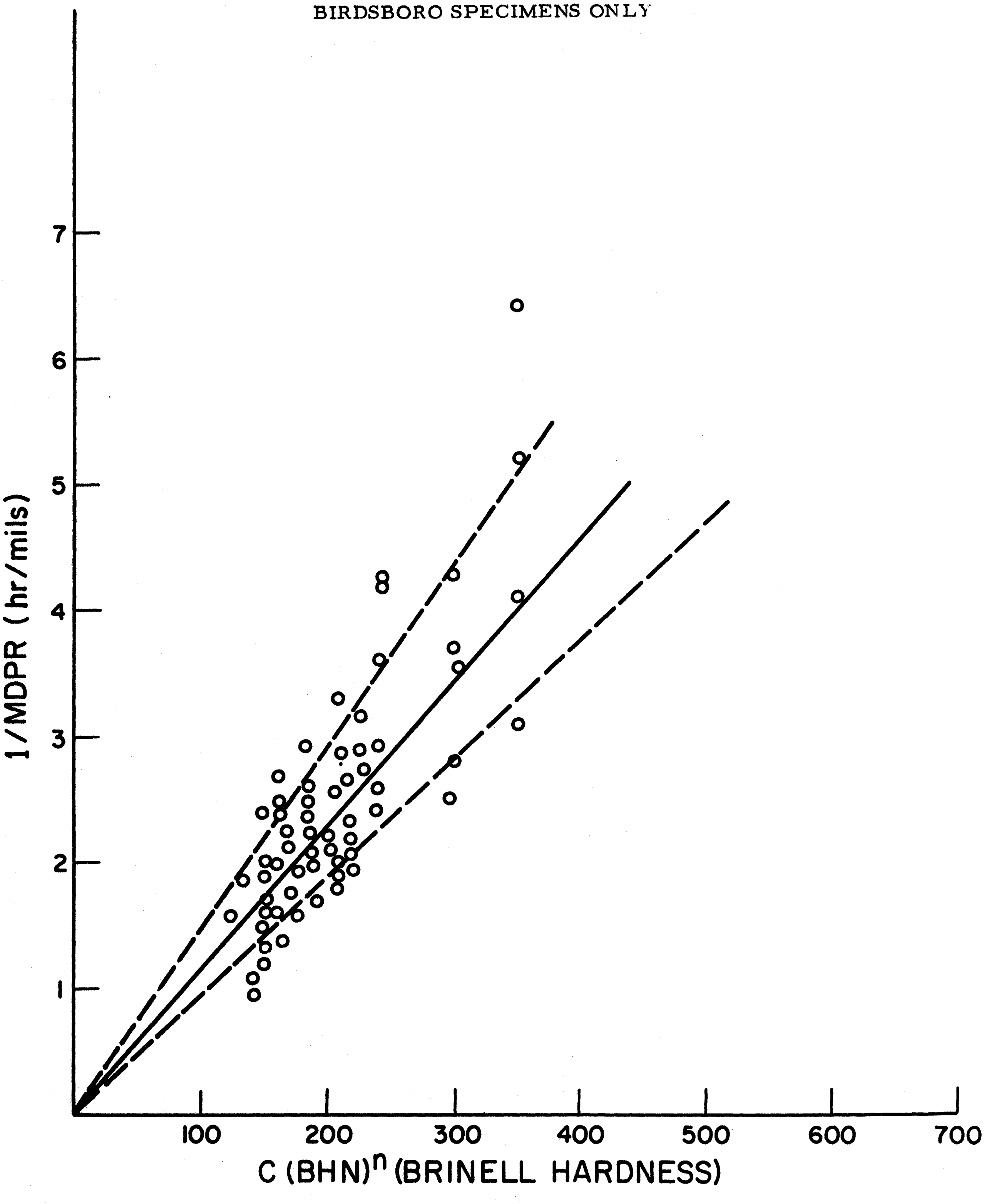


U of M No. C'-1 C'-2 C'-3 — CF8C Cast Stainless Steel As Cast, X100 Electrolytic Etch

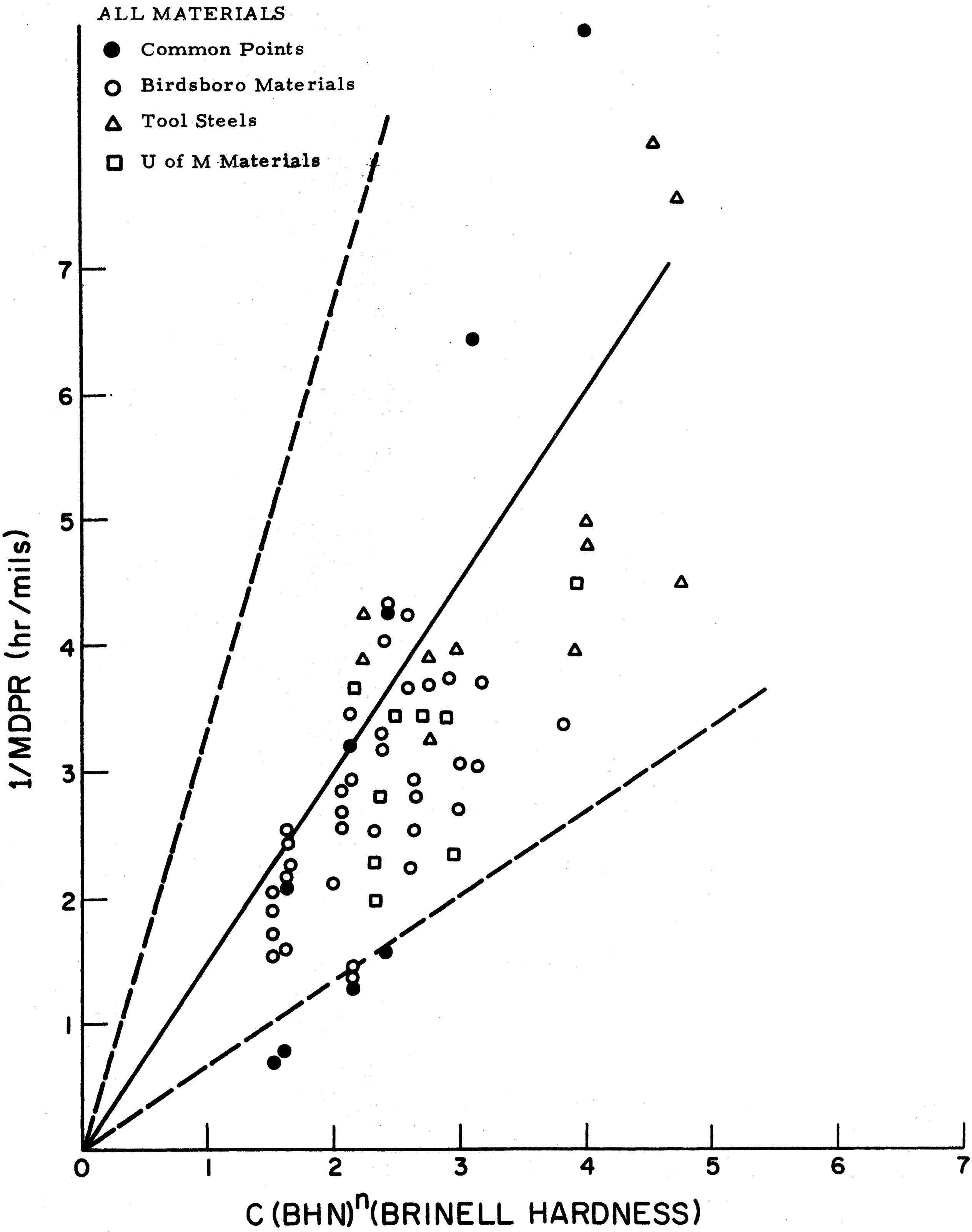


U of M No. C'-1 C'-2 C'-3 — CF8C Cast Stainless Steel As Cast, X500 Electrolytic Etch

3318 Figure 61. Photomicrograph of Material C'-1, 2, 3



62. **Best Fit Correlation and Standard Deviation for 98 Samples**



63. Best Fit Correlation and Standard Deviation for 198 Samples

APPENDIX

P

MATERIAL DAMAGE SHEET

Material Birdsboro Stainless Steel

(er CA-15 #1, ASTM A-296, GR CA 15

RUNNING CONDITIONS

Horn 55	Temperature 120°
% Power 61-62	Pressure 1.69 psig
Approx. Date 12/65	Torque 80-90

Prerun 15' Fresh H_2O

Surface Preparation Metallurgical

BASIS FOR CALCULATIONS

Density 7.612 gr/cm³ or .275 lb/in³	Area

MDP Factor

Comments Baffle

$$\frac{77.5 - 25.7}{270 - 120} = \frac{51.8}{150} = .345 \text{ mg/min}$$

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
30	30	1.67	1.67	.0571	.0571
30	60	6.02	7.69	.206	.263
30	90	9.61	17.30	.329	.592
30	120	8.39	25.69	.287	.878
60	180	21.94	47.63	.750	1.63
60	240	19.07	66.70	.652	2.28
60	300	21.90	88.60	.749	3.03
60	360	14.57	103.17	.498	3.52

MATERIAL DAMAGE SHEET

Material Birdsboro Stainless Steel
... er CA 15 #2, ASTM A296, GR CA15

RUNNING (ITIONS

Horn 55	...mperature 120°
% Power 55	Pressure 1.69
Approx. Date 1/69	Torque 80-90

Prerum 15' FRESH H2O

Surface Preparation METALLURGICAL

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments BAFFLE

$\frac{92.5 - 22.5}{297 - 102} = \frac{70.0}{195} = .359$ mg/min

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
30	30	2.80	2.80	.0958	.0958
30	60	7.58	10.38	.259	.355
30	90	8.17	18.55	.279	.634
30	120	10.55	29.10	.361	.995
60	180	21.70	50.80	.742	1.74
60	240	20.45	71.25	.699	2.44
60	300	23.89	95.14	.817	3.25
60	360	19.51	114.65	.667	3.92

MATERIAL DAMAGE SHEET

Material

Number E-1

RUNNING CONDITIONS

Horn Tc	...mperature 1200 F
% Power 40 %	Pressure 1.69 psig
Approx. Date 4-16-70	Torque 85 in-lb

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval hr	Cumulative Time hr	Wt. Loss mg	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	7.52	7.52	.253	.253
1	2	17.54	25.06	.589	.842
1	3	25.41	50.47	.854	1.69
1	4	22.32	72.79	.750	2.44
1	5	17.41	90.20	.585	3.03
1	6	16.94	107.14	.569	3.59
1	7	22.9	130.08	.769	4.37
(					

MATERIAL DAMAGE SHEET

Material CF-8, Stainless, Air Melted, [illegible] quenched from 2000°F	
Number E-2 Bordsboro	

RUNNING CONDITIONS

Horn Ti	Temperature 120°
% Power 48%	Pressure 169 PSIG
Approx. Date 2-19 - 3-16 70	Torque 8.4 in-lb
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area 0.236 in²
MDP Factor	

Comments

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	9.75	9.75 mg	.328	.328
—"—	2	19.11	28.86	.642	.970
—"—	3	23.90	52.76	.803	1.77
—"—	4	25.44	78.20	.855	2.63
—"—	5	35.10	113.30	1.18	3.80
—"—	6	27.50	140.80	.924	4.73
—"—	7	17.15	157.95	.576	5.31

MATERIAL DAMAGE SHEET

Material	
Number	E-3 Birchhead

RUNNING CONDITIONS

Horn	Ti	Temperature	120
% Power	40%	Pressure	1.7 PSIG
Approx. Date	3-21 — 3-24-70	Torque	85 inch-lb
Prerun			
Surface Preparation	polished		

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	8.50	8.50	.296	.296
1	2	10.01	18.51	.336	.632
1	3	19.99	38.50	.672	1.304
1	4	21.75	60.56	.731	2.03
1	5	20.75	81.30	.697	2.73
1	6	17.60	98.90	.591	3.32
1	7	18.55	117.45	.623	3.94
1	8	17.10	134.55	.574	4.52

MATERIAL DAMAGE SHEET

Material	
Number	F-1

RUNNING CONDITIONS

Horn	Ti	**Temperature**	120°
% Power	40%	**Pressure**	17. psig
Approx. Date	3-2[illegible] - 3.26 [illegible]	**Torque**	85 lbs-in
Prerun			
Surface Preparation	[illegible]		

BASIS FOR CALCULATIONS

Density		**Area**	
MDP Factor			

Comments:

DATA					
Time Interval	**Cumulative Time**	**Weight Loss**	**Cumulative Weight Loss**	**MDP**	**Cumulative MDP**
1	1	8.60	8.60	.289	.289
1	2	22.30	30.90	.749	1.04
1	3	23.60	54.50	.793	1.83
1	4	23.69	78.19	.796	2.63
1	5	23.48	101.67	.789	3.42
1	6	22.91	124.58	.770	4.18
1	7	18.06	142.64	.607	4.79
1	8	18.46	161.10	.620	5.41
1	9	19.30	180.40	.648	6.06

MATERIAL DAMAGE SHEET

Material	
Number F-2	

RUNNING CONDITIONS

Horn Ti	Temperature 120°F
% Power 48	Pressure 1.69
Approx. Date 2-21 - 2-24-70	Torque 8 [illegible]
Prerun	
Surface Preparation [illegible]	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

P_1 Q_1 R_1
P_2 Q_2 R_2

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	11.57	11.57	.389	.389
1	2	22.56	34.13	.758	1.15
1	3	30.44	64.57	1.02	2.17
1	4	24.79	89.36	.833	3.00
1	5	38.45	127.81	1.29	4.29
1	6	33.61	161.42	1.13	5.42
1	7	20.40	181.82	.685	6.11

MATERIAL DAMAGE SHEET

Material	
Number	G-1

RUNNING CONDITIONS

Horn	Ti	Temperature	120° F
% Power	48%	Pressure	1.69 PSIG
Approx. Date	2.24. — 2.25.70	Torque	8 in-lb
Prerun			
Surface Preparation	polished		

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1hr	1hr	22.51	22.51	.745	.745
1	2	46.90	69.41	1.55	2.29
1	3	49.93	119.34	1.65	3.95
1	4	37.16	156.50	1.23	5.18
1	5	32.93	189.43	1.09	6.27
1	6	29.53	218.96	.977	7.25
1 ?					

MATERIAL DAMAGE SHEET

Material	
Number	G-2.

RUNNING CONDITIONS

Horn	Ti	**Temperature**	120°
% Power	100%	**Pressure**	17 PSIG
Approx. Date	3.26 – 3.28.70	**Torque**	35 inch-lb
Prerun			
Surface Preparation			

BASIS FOR CALCULATIONS

Density		**Area**	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	25.90	25.90	.857	.857
1	2	45.14	71.04	1.49	2.35
1	3	37.56	108.60	1.24	3.59
1	4	30.60	139.20	1.01	4.61
1	5	33.03	172.23	1.09	5.70
1	6	26.97	199.20	.893	6.59
1	7	21.31	220.51	.705	7.30
1	8.	20.19	240.70	.668	7.97
1	9	19.94	260.64	.660	8.63
1	10	18.90	279.54	.625	9.25

MATERIAL DAMAGE SHEET

Material	
Number G-3	

RUNNING CONDITIONS

Horn Ti	Temperature 120°
% Power 50%	Pressure 17 PSIG
Approx. Date 4/3/70	Torque 85 lb-cm
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	20.11	20.11	.666	.666
1	2	41.79	61.90	1.38	2.05
1	3	37.75	99.65	1.25	3.30
1	4	36.07	135.72	1.19	4.49
1	5	42.00	177.72	1.39	5.88
1	6	23.48	201.20	.777	6.66
1	7	19.72	220.92	.653	7.31

MATERIAL DAMAGE SHEET

Material	
Number	H-1

RUNNING CONDITIONS

Horn	Ti	Temperature	119° F
% Power	43%	Pressure	1.69 PSIG
Approx. Date		Torque	85 inc-lb
Prerun			
Surface Preparation	polished		

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	2.57	2.57		
1	2	9.00	11.57		
1	3	8.90	20.47		
1	4	10.33	30.80		
1	5	11.00	41.80		
1	6	10.70	52.50		
1	7	11.61	64.11		

MATERIAL DAMAGE SHEET

Material	
Number *H-2*	

RUNNING CONDITIONS

Horn *Ti*	Temperature *120°.*
% Power *40%*	Pressure
Approx. Date *3-26 —*	Torque
Prerun	
Surface Preparation [illegible]	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	1.87	[illegible]	.0619	.0619
1	2	8.[illegible]	10.65	.291	.352
1	3	14.20	24.95	.473	.826
1	4	15.12	40.07	.500	1.33
1	5	15.20	55.27	.503	1.83
1	6	14.66	69.93	.485	2.31
		14.22	84.15	.471	2.78

MATERIAL DAMAGE SHEET

Material	
Number	H3

RUNNING CONDITIONS

Horn 71	Temperature 120°F
% Power 47%	Pressure 1.9 PSIG
Approx. Date 4-1-70 — 4/3/70	Torque 85 lb.-cm
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	3.79	3.79	.125	.125
1	2	11.40	15.19	.377	.503
1	3	11.85	27.04	.392	.895
1	4	15.19	32.23	.503	1.07
1	5	7.50	39.70	.248	1.31
1	6	13.95	53.68	.462	1.78
1	7	13.00	66.68	.430	2.21

MATERIAL DAMAGE SHEET

Material	
Number	I-1 Birdsboro

RUNNING CONDITIONS

Horn	Ti	Temperature	119°.F
% Power	43%	Pressure	1.69 PSIG
Approx. Date	3.3. - 3.4.70	Torque	8.. inc-lb
Prerun			
Surface Preparation	polished		

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	7.5	7.5		
1	2	17.61	25.11		
1	3	18.59	43.70		
1	4	19.90	63.60		
1	5	16.10	79.70		
1	6	11.85	91.55.		
1	7	14.75	106.30		

MATERIAL DAMAGE SHEET

Material	
Number	I-2

RUNNING CONDITIONS

Horn	77	Temperature	120°
% Power	40%	Pressure	17 psig
Approx. Date	3-15 - 3.16.56	Torque	85 in-lb
Prerun			
Surface Preparation	Polished		

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr.	1 hr	8,59	8.59		
1	2	18,88	27.47		
1	3	19,17	46.64		
1	4	25,30	71,94		
1	5	17,91	89,85		
1	6	12,43	102,28		
1	7	16,46	118,74		

MATERIAL DAMAGE SHEET

Material

Number I - 3

RUNNING CONDITIONS

Horn Ti	...mperature 120°F
% Power 40%	Pressure 1.69 psig
Approx. Date 4-20-70	Torque 85 in-lb

Prerun

Surface Preparation polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval hr.	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
1	2	18.72	27.70		
1	3	18.45	46.15		
1	4	18.13	64.28		
1	5	19.32	83.60		
1	6	25.35	108.95		
1	7	16.20	125.15		
1	1	8.98	8.98		
(					

MATERIAL DAMAGE SHEET

Material	
Number	7-1 Birdsboro

RUNNING CONDITIONS

Horn	11	Temperature	120°
% Power	40% - 43%	Pressure	17 PSIG
Approx. Date	3·13 - 3.17·70	Torque	
Prerun			
Surface Preparation	Polished		

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1hr	1hr	5 41	5 41		
1	2	13.89	19.30		
1	3	17 00	36.30		
1	4	15.80	52.10		
1	5	14.83	66.93		
1	6	13.82	80.75		
1	7	14.25	95.00		
1	8	20.20	115.20		
1	9	14.80	130.00		
1	10	13.75	143.75		
1	11	12.90	156.75		

MATERIAL DAMAGE SHEET

Material	
Number J-2	

RUNNING CONDITIONS

Horn Ti	**Temperature** 120°
% Power 40%	**Pressure** 17 PSIG
Approx. Date 3.18 - 3.20.70	**Torque** [illegible]
Prerun	
Surface Preparation Polished	

BASIS FOR CALCULATIONS

Density	**Area**
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	5.86	5.86		
1	2	11.52	17.38		
1	3	15.07	32.45		
1	4	14.53	46.98		
1	5	14.30	61.28		
1	6	10.12	71.40		
1	7	13.72	85.12		

MATERIAL DAMAGE SHEET

Material	
Number	7-3

RUNNING CONDITIONS

Horn	11	Temperature	120°
% Power	40%	Pressure	17 PSIG
Approx. Date		Torque	85 in-lb
Prerun			
Surface Preparation			

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	16.06	16.06		
1	2	16.29	31.35		
1	3	15.51	46.86		
1	4	14.46	61.32		
1	5	10.69	72.01		
1	6	16.01	88.02		
1	7	14.40	102.42		

MATERIAL DAMAGE SHEET

Material	
Number K-1.	

RUNNING CONDITIONS

Horn Ti	Temperature 120°
% Power 40%	Pressure 16.9 Psia
Approx. Date 3.20 - 3.21.70	Torque 85 Inch-lb
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	2.54	2.54		
1	2	11.14	13.68		
1	3	10.99	24.67		
1	4	12.62	37.29		
1	5	12.20	49.49		
1	6	12.03	61.52		
1	7	11.99	73.51		

MATERIAL DAMAGE SHEET

Material	
Number	K-2

RUNNING CONDITIONS

Horn	Ti	Temperature	120°
% Power	40%	Pressure	17 PSIG
Approx. Date	11.3 – 15.3.70	Torque	85 inch-lb
Prerun			
Surface Preparation	Polished		

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1hr	1hr	2.74	2.74		
1	2	9.50	12.24		
1	3	11.30	23.54		
1	4	11.24	34.78		
1	5	11.81	46.59		
1	6	11.20	57.79		
1	7	11.20	68.99		

MATERIAL DAMAGE SHEET

Material	
Number	K-3

RUNNING CONDITIONS

Horn	Ti	Temperature	120°
% Power	40%	Pressure	1.7 PSIG
Approx. Date	4.8 - 4.9.70	Torque	85 in-lb
Prerun			
Surface Preparation			

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	5.02	5.02		
1	2	11.06	16.08		
1	3	10.42	26.50		
1	4	11.16	37.66		
1	5	10.34	48.00		
1	6	10.51	58.51		
1	7	14.02	72.53		

MATERIAL DAMAGE SHEET

Material CF-8	
Number 41 Birdsboro	

RUNNING CONDITIONS

Horn Ti	Temperature 118°F
% Power 45%	Pressure 1.69 PSIG
Approx Date 3.5 - 3.9.70	Torque 85 lb-in
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1hr	1hr	6.43	6.43	.216	.216
1	2	12.16	18.59	.408	.625
1	3	12.59	31.18	.423	1.05
1	4	17.04	48.22	.574	1.62
1	5	18.83	67.05	.633	2.25
1	6	14.71	81.76	.494	2.75
1	7	16.94	98.70	.569	3.32

MATERIAL DAMAGE SHEET

Material	
Number	L-2

RUNNING CONDITIONS

Horn	Ti	Temperature	120°
% Power	40%	Pressure	17 PSIG
Approx. Date	4/5/70 - 4/7/70	Torque	85 lb-inc
Prerun			
Surface Preparation	polished		

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	5.91	5.91	.198	.198
1	2	17.17	17.08	.577	.574
1	3	10.16	27.24	.341	.915
1	4	15.16	42.40	.509	1.42
1	5	15.43	57.83	.518	1.94
1	6	12.30	70.13	.413	2.35
1	7	20.87	91.00	.701	3.06

MATERIAL DAMAGE SHEET

Material	
Number	L-3 Birdsboro

RUNNING CONDITIONS

Horn	Ti	**Temperature**	118°
% Power	40%	**Pressure**	17 PSIG
Approx. Date	3.10 - 3.12.70	**Torque**	35 inch-lb
Prerun			
Surface Preparation	Polished		

BASIS FOR CALCULATIONS

Density		**Area**	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	6.57	6.57	.221	.221
1	2	11.77	18.34	.395	.616
1	3	19.01	37.35	.639	1.25
1	4	18.16	55.51	.610	1.86
1	5	16.63	72.14	.559	2.42
1	6	19.06	91.20	.640	3.06
1	7	16.79	107.99	.564	3.63

MATERIAL DAMAGE SHEET

Material	
Number M1	

RUNNING CONDITIONS

Horn Ti	Temperature 120°
% Power 40%	Pressure 1.7 PSIG
Approx. Date 3.17 - 3.18 70	Torque 85 inc-lb
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	8.67	8.67	.291	.291
1	2	18.70	27.37	.628	.919
1	3	18.40	45.77	.618	1.54
1	4	19.81	65.58	.666	2.20
1	5	19.73	75.31, 85.31	.663	2.87
1	6	16.63	91.94, 101.94	.559	3.42
1	7	15.78	~~107.72~~ 117.72	.530	3.95

MATERIAL DAMAGE SHEET

Material	
Number	M-2

RUNNING CONDITIONS

Horn	Ti	**Temperature**	120°F
% Power	40%	**Pressure**	17 PSIG
Approx. Date	3-9 - 3-10-70	**Torque**	85 in-lb
Prerun			
Surface Preparation	Polished		

BASIS FOR CALCULATIONS

Density		**Area**	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1 hr	1 hr	7.60	7.60	.255	.255
1	2	16.55	24.15	.556	.811
1	3	17.75	41.90	.596	1.41
1	4	20.65	62.55	.694	2.10
1	5	12.60	75.15	.423	2.52
1	6	18.00	93.15	.605	3.13
1	7	13.30	106.45	.447	3.58

MATERIAL DAMAGE SHEET

Material	
Number	M-3

RUNNING CONDITIONS

Horn Ti	Temperature 120°F.
% Power 40%	Pressure 17 PSIG
Approx. Date [illegible]	Torque 85 inch-[illegible]
Prerun	
Surface Preparation [illegible]	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	6.69	6.69	.224	.224
1	2	19.09	[illegible]	.641	.868
1	3	20.0[illegible]	45.86	.673	1.54
1	4	19.15	65.01	.643	2.18
1	5	18.72	83.73	.629	2.81
1	6	18.28	102.01	.614	3.43
1	7	17.23	119.24	.579	4.01

MATERIAL DAMAGE SHEET

Material	
Number	U-1

RUNNING CONDITIONS

Horn	77	Temperature	120°
% Power	45%	Pressure	17 PSIG
Approx. Date	3.29 – 3.30.70	Torque	85 [illegible]
Prerun			
Surface Preparation			

BASIS FOR CALCULATIONS

Density		Area	
MDP Factor			

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	9.04	9.04	.309	.309
1	2	16.10	26.14	.551	.860
1	3	16.66	40.80	.535	1.39
1	4	14.47	55.27	.495	1.89
1	5	14.12	69.39	.483	2.37
1	6	14.55	83.94	.498	2.87
1	7	14.63	98.47	.497	3.37

MATERIAL DAMAGE SHEET

Material	
Number	H-2

RUNNING CONDITIONS

Horn 11	Temperature 120°
% Power 46%	Pressure 1.9 PSIG
Approx. Date 4/15/70 – 4/5/70	Torque 85 lb-in
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	9.10	9.10	.311	.311
1	2	16.45	25.55	.562	.874
1	3	15.80	41.35	.540	1.41
1	4	17.10	58.45	.585	2.00
1	5	17.05	75.50	.583	2.58
1	6	15.85	91.35	.542	3.12
1	7	13.50	104.85	.462	3.58

MATERIAL DAMAGE SHEET

Material

Number N-3

RUNNING CONDITIONS

Horn Ti	Temperature 120°F
% Power 46%	Pressure 1.69 psig
Approx. Date 21-11-70	Torque [illegible]

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	10.62	10.62	.363	.363
1	2	15.12	25.74	.517	.880
1	3	19.43	45.17	.664	1.54
1	4	17.16	62.33	.587	2.13
1	5	15.34	77.67	.525	2.66
1	6				
(					

MATERIAL DAMAGE SHEET

Material	
Number	C-1

RUNNING CONDITIONS

Horn [illegible]	Temperature 120°
% Power 45%	Pressure 17 PSIG
Approx. Date 3.30 – 3.31.70	Torque
Prerun	
Surface Preparation [illegible]	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	8.17	8.17	.279	.279
1	2	19.94	28.11	.682	.961
1	3	19.91	48.01	.681	1.64
1	4	19.15	67.16	.655	2.30
1	5	18.66	85.82	.638	2.93
1	6	10.13	95.95	.346	3.28
1	7				

MATERIAL DAMAGE SHEET

Material	
Number	O-2

RUNNING CONDITIONS

Horn Ti	Temperature 170°
% Power 46%	Pressure 17PSIG
Approx. Date 4/4/70 - 4/5/70	Torque 85 lbs-ft
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	6.17	6.17	.211	.211
1	2	16.35	22.52	.559	.770
1	3	11.31	33.83	.387	1.15
1	4	16.15	49.98	.552	1.71
1	5	18.99	68.97	.649	2.36
1	6	16.95	85.92	.580	2.94
1	7	17.59	103.51	.601	3.54
1	8	16.49	119.92	.564	4.10

MATERIAL DAMAGE SHEET

Material	
Number	O-3

RUNNING CONDITIONS

Horn Ti	Temperature 120°
% Power 46%	Pressure 1.7 PSIG
Approx. Date 4/9/70 - 4/10/70	Torque 85 lb.ins
Prerun	
Surface Preparation polished	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	5.91	5.91	.202	.202
1	2	15.14	21.05	.518	.720
1	3	15.61	36.66	.534	1.25
1	4	15.81	52.47	.541	1.79
1	5	16.21	68.68	.554	2.35
1	6	12.77	81.45	.437	2.78
1	7	15.68	97.13	.536	3.32

MATERIAL DAMAGE SHEET

Material	
Number	P 1

RUNNING CONDITIONS

Horn	Ti	...mperature	180°F
% Power	86%	Pressure	1.64 psig
Approx. Date	2-27-70	Torque	85 in-lb

Prerun

Surface Preparation

Polished

BASIS FOR CALCULATIONS

Density		Area	

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss mg	MDP	Cumulative MDP
1	1	11.95	11.95	.393	.393
1	2	17.14	29.09	.564	.957
1	3	19.02	48.11	.626	1.58
1	4	4.65	52.76	.153	1.73

MATERIAL DAMAGE SHEET

Material

Number P 2

RUNNING CONDITIONS

Horn Ti	...mperature 120°
% Power 34%	Pressure 1.69 psig
Approx. Date 5-26-70	Torque 85 in-lb

Prerun

Surface Preparation

polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments Specimen

DATA

Time Interval min	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss mg.	MDP	Cumulative MDP
30	½	8.65	8.65	.284	.284
30	1	7.84	16.49	.258	.542
30	1½	9.33	25.82	.307	.849
18		4.29	30.11	.141	.991

MATERIAL DAMAGE SHEET

Material

Number P 3

RUNNING CONDITIONS

Horn Ti	...mperature 120°
% Power 34%	Pressure 1.69 psig
Approx. Date 5-25-70	Torque 85 in-lb

Prerun

Surface Preparation

polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

0329

DATA

Time Interval min	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
30	30 min	1.17	1.17	.0385	.0385
30	1 hr.	6.63	7.80	.218	.257
30	1 hr 30 min	9.37	17.17	.308	.565
30	2 hr	10.63	27.80	.350	.915
30	2 hr. 30 min	9.10	36.90	.301	1.21
30	3 hr	8.52	45.42	.280	1.40
30	3 hr. 30 min	9.15	54.57	.301	1.69

MATERIAL DAMAGE SHEET

Material Type 304-L SS,	
Number Q-1	

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque
Prerun	
Surface Preparation	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	14.21	14.21		
1	2	18.98	33.19		
1	3	22.42	55.61		
1	4	20.55	76.16		
1	5	21.40	97.56		
1	6	21.38	118.94		
1	7	19.77	138.71		

MATERIAL DAMAGE SHEET

Material

Number Q-2

RUNNING CONDITIONS

Horn Ti	Temperature 120°F
% Power 36 %	Pressure 1.69 psig
Approx. Date 5-21-70	Torque 85 in.lb.

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min.	Cumulative Time hr	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
15	.15	0.58	0.58	.0179	.0179
30	.45	7.49	8.07	.231	.249
30	1.15	10.55	18.62	.326	.575
30	1.45	11.60	30.22	.358	.934
30	2.15	8.83	39.05	.273	1.21
30	2.45	10.17	49.22	.314	1.52
30	3.15	14.54	63.76	.449	1.97

MATERIAL DAMAGE SHEET

Material

Number Q 3

RUNNING CONDITIONS

Horn TC	..mperature 1200°
% Power 38%	Pressure 1.69 psig.
Approx. Date 5 25 70	Torque 25 in lb

Prerun

Surface Preparation
polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments Specimen broken after 15 min of first run

DATA

Time Interval Mins.	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
30.	30 min	1.08	1.08	.0334	.0334

MATERIAL DAMAGE SHEET

Material

Number R 1

RUNNING CONDITIONS

Horn	Ti	...mperature	120°F
% Power	40%	Pressure	1.69 psig
Approx. Date	6-8-70	Torque	85 in lb.

Prerum

Surface Preparation

polished

BASIS FOR CALCULATIONS

Density		Area	

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time hr	Wt. Loss mg.	Cumulative Wt. Loss mg	MDP	Cumulative MDP
30	1/2	0.98	0.98	.0329	.0329
30	1	3.69	4.94	.124	.166
30	1 1/2	7.31	12.25	.246	.412
30	2	7.99	20.24	.268	.680
30	2 1/2	8.35	28.59	.281	.961
30	3	8.06	36.65	.271	1.23
30	3 1/2	8.20	44.85	.277	1.51

MATERIAL DAMAGE SHEET

Material

Number R 2

RUNNING CONDITIONS

Horn TC	...mperature 120°F
% Power 40%	Pressure 169 psig
Approx. Date 6-10-70	Torque 85 in-lb.

Prerun

Surface Preparation polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min.	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	1.12	1.12	.0376	.0376
30	1	6.58	7.70	.221	.259
30	1 1/2	8.15	15.85	.274	.532
30	2	8.31	24.16	.279	.812
30	2 1/2	8.61	32.77	.289	1.10
30	3	8.90	41.67	.299	1.40
30	3 1/2	7.83	49.50	.263	1.66

MATERIAL DAMAGE SHEET

Material

Number R 3

RUNNING CONDITIONS

Horn Ti	Temperature 120°F
% Power 40%	Pressure 1.69 psig.
Approx. Date 6 12-70	Torque 85 in-lb.

Prerun

Surface Preparation

polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min.	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	1.26	1.26	.0423	.0423
30	1	5.44	6.70	.183	.225
30	1 1/2	6.75	13.45	.227	.452
30	2	7.55	21.00	.254	.706
30	2 1/2	7.63	28.63	.256	.962
30	3	9.22	37.85	.309	1.27
30	3 1/2	9.05	46.90	.304	1.57

MATERIAL DAMAGE SHEET

Material

Number S1

RUNNING CONDITIONS

Horn Ti	Temperature 120°F
% Power 42%	Pressure 1.69 psig
Approx. Date 5 29-70	Torque 85 in-lb

Prerun

Surface Preparation polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time hrs	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	.55	.55	.0185	.0185
30	1	5.70	6.25	.191	.210
30	1 1/2	8.28	14.53	.278	.488
30	2	7.62	22.15	.256	.744
30	2 1/2	7.45	29.60	.250	.994
30	3	7.93	37.53	.264	1.26
30	3 1/2	8.52	46.05	.286	1.55

MATERIAL DAMAGE SHEET

Material

Number S 2

RUNNING CONDITIONS

Horn	Ti	...mperature	1200 F
% Power	42 %	Pressure	1.69 psia
Approx. Date	6-2-70	Torque	85 in lb

Prerun

Surface Preparation

polished

BASIS FOR CALCULATIONS

Density		Area	

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time h.	Wt. Loss mg.	Cumulative Wt. Loss mg.	MDP	Cumulative MDP
30	1/2	0.85	0.85	.0286	.0286
30	1	5.15	6.00	.173	.202
30	1 1/2	8.08	14.08	.271	.473
30	2	8.17	22.25	.274	.748
30	2 1/2	6.86	29.11	.230	.978
30	3	8.58	37.69	.288	1.26
30	3 1/2	7.96	47.65	.334	1.60

MATERIAL DAMAGE SHEET

Material

Number S 3

RUNNING CONDITIONS

Horn Tc	...mperature 120°
% Power 4290	Pressure 1.67 psig
Approx. Date 6-5-70	Torque 85 mil

Prerun

Surface Preparation
polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	1.29	1.29	.0433	.0433
30	1	6.25	7.54	.210	.253
30	1 1/2	7.69	15.23	.258	.512
30	2	7.84	23.07	.263	.775
30	2 1/2	7.45	30.52	.250	1.02
30	3	8.27	38.79	.278	1.30
30	3 1/2	9.24	48.03	.310	1.61

MATERIAL DAMAGE SHEET

Material

Number T1

RUNNING CONDITIONS

Horn TC	...mperature 1200°F
% Power 48%	Pressure 1.69 psig.
Approx. Date 6.25.70	Torque 85 in-lb

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time hr	Wt. Loss mg	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	0.53	0.53	.0179	.0179
30	1	3.86	4.39	.131	.149
30	1 1/2	6.71	11.10	.227	.376
30	2	7.45	18.55	.252	.629
30	2 1/2	7.27	25.82	.246	.875
30	3	7.53	33.35	.255	1.13
30	3 1/2	5.89	39.24	.200	1.33
(					

MATERIAL DAMAGE SHEET

Material

Number T2

RUNNING CONDITIONS

Horn Ti	Temperature 120 °F
% Power 48%	Pressure 1.69 psig.
Approx. Date 6-20-70	Torque 85 in-lb.

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	0.80	0.80	.0271	.0271
30	1	4.45	5.25	.151	.178
30	1 1/2	5.91	11.16	.200	.378
30	2	6.93	18.09	.235	.613
30	2 1/2	8.22	26.31	.279	.892
30	3	7.06	33.37	.239	1.13
30	3 1/2	7.43	40.80	.252	1.38

MATERIAL DAMAGE SHEET

Material

Number T 3

RUNNING CONDITIONS

Horn Ti	...mperature 120° F
% Power 81%	Pressure 1.69 psig
Approx. Date 7-6-70	Torque 85 in-lb

Prerun

Surface Preparation
polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval min.	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	0.59	0.59	.0200	.0200
30	1	5.54	6.13	.188	.208
30	1 1/2	4.32	10.45	.146	.354
30	2	6.94	17.39	.235	.589
30	2 1/2	6.65	24.04	.225	.815
30	3	8.10	32.14	.274	1.09
30	3 1/2				

MATERIAL DAMAGE SHEET

Material

Number u 1

RUNNING CONDITIONS

Horn Ti	Temperature 120°F
% Power 48%	Pressure 1.69 psig
Approx. Date 6 18-70	Torque 85 in lb.

Prerum

Surface Preparation
polished

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval ms	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	1.05	1.05	.0356	.0356
30	1	5.19	6.24	.176	.211
30	1 1/2	8.18	14.42	.277	.489
30	2	6.99	21.41	.237	.726
30	2 1/2	7.39	28.80	.250	.976

MATERIAL DAMAGE SHEET

Material

Number U 2

RUNNING CONDITIONS

Horn	Ti	Temperature	120°F
% Power	46%	Pressure	1.69 psig
Approx. Date	6-22-70	Torque	85 [illegible]

Prerun

Surface Preparation

polished

BASIS FOR CALCULATIONS

Density		Area	

MDP Factor

Comments

DATA

Time Interval min	Cumulative Time hr.	Wt. Loss mg.	Cumulative Wt. Loss	MDP	Cumulative MDP
30	1/2	1.45	1.45	.0491	.0491
30	1	5.71	7.16	.193	.243
30	1 1/2	7.37	14.53	.250	.492
30	2	8.29	22.82	.281	.773
30	2 1/2	7.55	30.37	.256	1.03
30	3	8.05	38.42	.273	1.30
30	3 1/2	7.84	46.26	.266	1.57

MATERIAL DAMAGE SHEET

Material 308-LWQ

Number V-1

RUNNING CONDITIONS

Horn	..mperature
% Power	Pressure
Approx. Date	Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	18.95	18.95		
1	2	16.05	35.00		
1	3	16.45	51.45		
1	4	20.63	72.08		
1	5	18.11	90.19		
1	6	9.89	100.08		

MATERIAL DAMAGE SHEET

Material Mutl 308 - L. WQ

Number V-2

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	7.96	7.96		
1	2	1684	24.80		
1	3	18.15	42.95		
1	4	19.05	62.00		
1	5	19.00	8100		
1	6	19.20	100.20		
1	7	10.70	110 90		

MATERIAL DAMAGE SHEET

Material 308 - LWQ.

Number V-3

RUNNING CONDITIONS

Horn

...mperature

% Power

Pressure

Approx. Date

Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density

Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	0.768	7.68		
1	2	17.15	24.83		
1	3	16.27	41.10		
1	4	16.75	57.85		
1	5	19.61	77.46		
1	6	19.64	97.10		
1	7	17.40	104.50		

MATERIAL DAMAGE SHEET

Material 308 - L AS

Number W - 1.

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	8.63	8.53		
1	2	16.94	25.47		
1	3	18.01	43.08		
1	4	17.70	60.78		
1	5	16.25	~~34.03~~	77.03	
1	6	15.34	~~49.37~~	92.37	
1	7	15.26	~~64.63~~	107.63	

MATERIAL DAMAGE SHEET

Material 308-1-WQ.

Number W-2

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	07.05	7.05		
1	2	13.24	20.29		
1	3	14.41	34.70		
1	4	16.84	51.54		
1	5	17.00	68.54		
1	6	16.03	84.57		
1	7	16.42	100.99		

MATERIAL DAMAGE SHEET

Material 308-L · AS -Weld

Number W-3

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	7.61	7.61		
1	2	14.59	2220		
1	3	16.00	38.20		
1	4	15.69	43 89		
1	5	15.80	[illegible]		
1	6	18.21	87. 90		
1	7	11.10	99 00		

MATERIAL DAMAGE SHEET

Material 308 – Wire

Number X-1

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque

Program

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	6.91	6.91		
1	2	15.29	22.20		
1	3	15.80	38.00		
1	4	16.85	54.85		
1	5	21.65	76.50		
1	6	17.94	94.44		
1	7	17.40	111.84		

MATERIAL DAMAGE SHEET

Material 308-Wire.

Number X-2.

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	1.30	1.30		
1	2	12.17	13.47		
1	3	13.68	27.15		
1	4	20.79	47.94		
1	5	19.66	67.60		
1	6	17.40	85.00		
1	7	11.15	96.15		

MATERIAL DAMAGE SHEET

Material Birosboro

Number Y - 1

RUNNING CONDITIONS

Horn

...mperature

% Power

Pressure

Approx. Date

Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density

Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	8.62	26.69		
1	2	18.07	26.69		
1	3	18.94	45.63		
1	4	17.65	63.28		

MATERIAL DAMAGE SHEET

Material	30 wire wa
Number	Y-2

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque
Prerun	
Surface Preparation	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	7.69	7.69		
1	2	16.38	24.07		
1	3	19.18	43.56		
1	4	18.61	62.17		
1	5	18.54	80.71		
1	6	20.08	100.79		
1	7	17.10	117.89		

MATERIAL DAMAGE SHEET

Material 208 wire wd.	
Number Y-3.	

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque
Prerun	
Surface Preparation	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	7.06	7.06		
1	2	19.75	26.80		
1	3	19.05	45.85		
1	4	18.97	64.82		
1	5	18.38	83.20		
1	6	17.35	100.55		
1	7	16.85	117.30		

MATERIAL DAMAGE SHEET

Material ~~[illegible]~~ E 410-STRESS	
Number E2-L	

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque
Prerun	
Surface Preparation	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	12.72	12.72		
1	2	21.63	34.35		
1	3	22.70	57.05		
1	4	13.96	71.00		
1	5	20.36	91.36		
1	6	18.82	110.18		
1	7	15.56	125.74		

MATERIAL DAMAGE SHEET

Material	E-410
Number	E1-2

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque
Prerun	
Surface Preparation	

BASIS FOR CALCULATIONS

Density	Area
MDP Factor	

Comments:

DATA					
Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	5.69	5.69		
1	2	10.44	16.13		
1	3	10.71	26.84		
1	4	9.16	36.00		
1	5	9.92	45.92		
1	6	10.00	55.92		
1	7	9.81	64.73		

MATERIAL DAMAGE SHEET

Material	E 416
Number	Z1-3

RUNNING CONDITIONS

Horn	**Temperature**
% Power	**Pressure**
Approx. Date	**Torque**
Prerun	
Surface Preparation	

BASIS FOR CALCULATIONS

Density	**Area**
MDP Factor	

Comments:

DATA

Time Interval	Cumulative Time	Weight Loss	Cumulative Weight Loss	MDP	Cumulative MDP
1	1	4.95	4.95		
1	2	9.82	14.77		
1	3	9.63	24.30		
1	4	10.55	34.85		
1	5	9.48	44.33		
1	6	12.02	56.35		
1	7	13.17	69.52		

MATERIAL DAMAGE SHEET

Material Birdsboro

Number Z_2-1

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	3.25	3.25		
1	2	10.19	13.44		
1	3	9.80	23.24		
1	4	10.06	33.30		
1	5	9.60	42.90		
1	6	8.90	51.80		
1	7	8.70	60.50		

MATERIAL DAMAGE SHEET

Material Birdsboro

Number Z_2-2

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	10.97	10.97		
1	2	18.99	29.96		
1	3	23.09	53.05		
1	4	18.38	71.43		
1	5	16.92	88.35		
1	6	16.35	104.70		
1	7	17.35	122.05		
(					

MATERIAL DAMAGE SHEET

Material Biedsboro

Number Z_2-3

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerum

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	9.51	9.51		
1	2	18.00	27.51		
1	3	10.05	37.56		
1	4	14.21	51.77		
1	5	12.72	64.49		
1	6	15.12	79.61		
1	7	12.45	92.06		
(					

MATERIAL DAMAGE SHEET

Material Birdsbord

Number A'-1

RUNNING CONDITIONS

Horn	..mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	00.48	00.48		
1	2	1.71	2.19		
1	3	7.20	9.39		
1	4	1.80	11.19		
1	5	4.85	16.04		
1	6	4.80	20.84		
1	7	4.19	25.03		
(					

MATERIAL DAMAGE SHEET

Material Birdsboro

Number A'-2

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	0.32	0.32		
1	2	3.61	3.93		
1	3	4.01	7.92		
1	4	2.61	10.55		

MATERIAL DAMAGE SHEET

Material Bildsboro

Number A'-3

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	0.54	0.54		
1	2	4.11	4.65		
1	3	4.20	8.85		
1	4	5.90	14.75		
1	5	5.11	19.86		
1	6	5.64	25.50		
1	7	5.10	30.60		

MATERIAL DAMAGE SHEET

Material BIRDSBORO

Number B'-1

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	6.03	6.03		
1	2	12.20	18.23		
1	3	16.37	34.60		
1	4	17.39	51.99		
1	5	18.11	70.10		
1	6	16.10	86.20		
1	7	18.00	104.00		

MATERIAL DAMAGE SHEET

Material Birdsbord

Number B'-2

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	6.75	6.75		
1	2	15.92	22.67		
1	3	16.72	39.39		
1	4	15.02	54.41		
1	5	16.49	70.90		
1	6	16.32	87.22		
1	7	16.33	103.55		

MATERIAL DAMAGE SHEET

Material Birdsboro

Number B'-3

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	8.24	8.24		
1	2	14.16	22.40		
1	3	14.30	36.70		
1	4	15.20	51.90		
1	5	16.30	68.20		
1	6	16.20	84.40		
1	7	16.30	100.70		

MATERIAL DAMAGE SHEET

Material BIROSBORD

Number C'-1

RUNNING CONDITIONS

Horn	..mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	4.41	4.41		
1	2	14.12	18.53		
1	3	14.77	33.30		
1	4	15.11	48.41		
1	5	16.57	64.98		
1	6	13.80	78.78		
1	7	12.31	91.09		

MATERIAL DAMAGE SHEET

Material: BIRDSBORO

Number: C'-2

RUNNING CONDITIONS

Horn	Temperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	5.24	5.24		
1	2	13.00	18.24		
1	3	13.61	31.85		
1	4	14.53	46.38		
1	5	15.22	61.60		
1	6	14.11	75.71		
1	7	16.28	91.99		

MATERIAL DAMAGE SHEET

Material BIRDSBORO

Number C'-3

RUNNING CONDITIONS

Horn	...mperature
% Power	Pressure
Approx. Date	Torque

Prerun

Surface Preparation

BASIS FOR CALCULATIONS

Density	Area

MDP Factor

Comments

DATA

Time Interval	Cumulative Time	Wt. Loss	Cumulative Wt. Loss	MDP	Cumulative MDP
1	1	4.90	4.90		
1	2	14.68	19.58		
1	3	15.12	34.70		
1	4	14.30	49.00		
1	5	15.06	64.06		
1	6	15.12	79.18		
1	7	15.02	94.20		