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NOV 77 T V O'HARA, J B HENRY, W A STEPHEN F04611-76-C-0010

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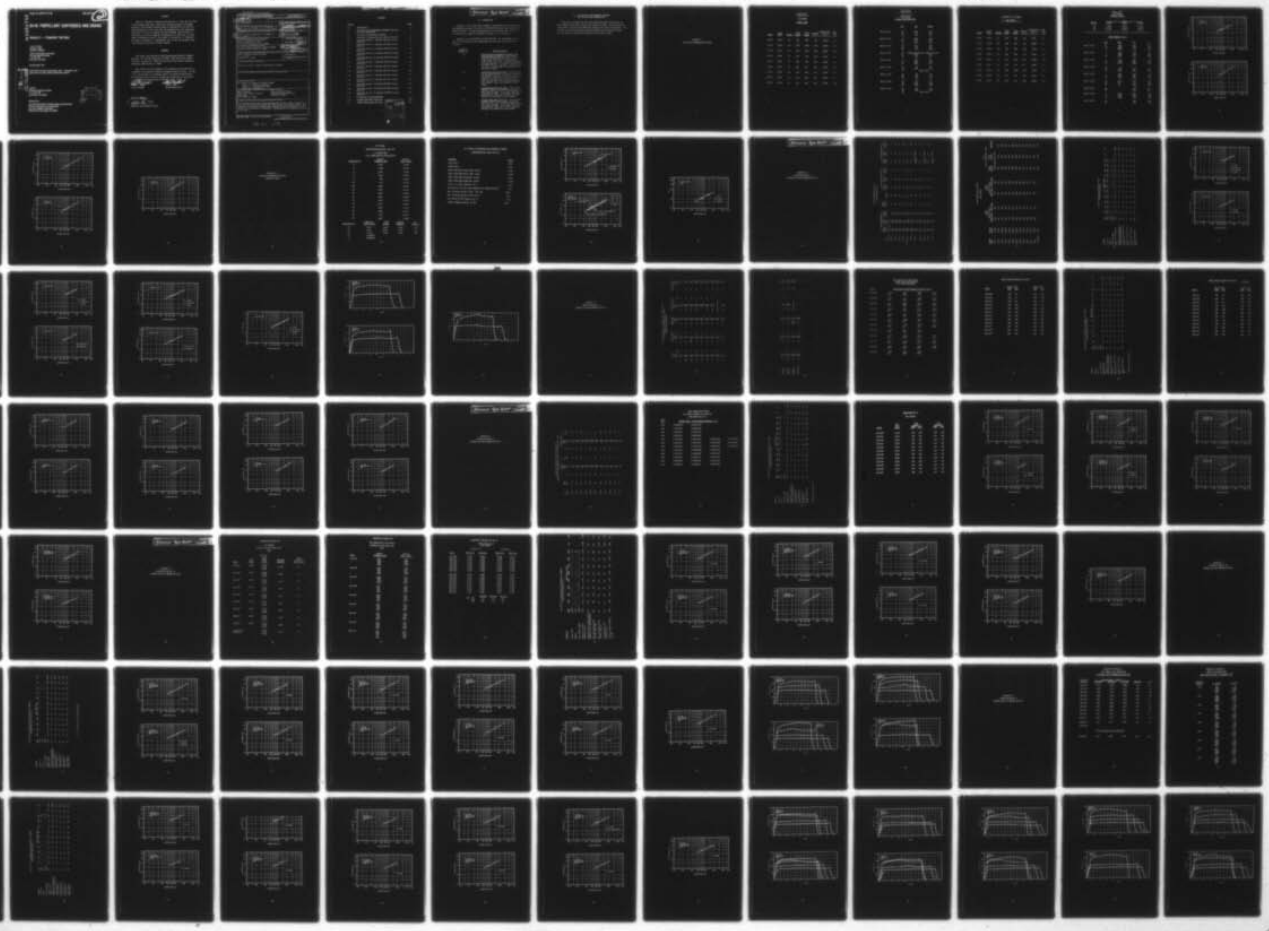

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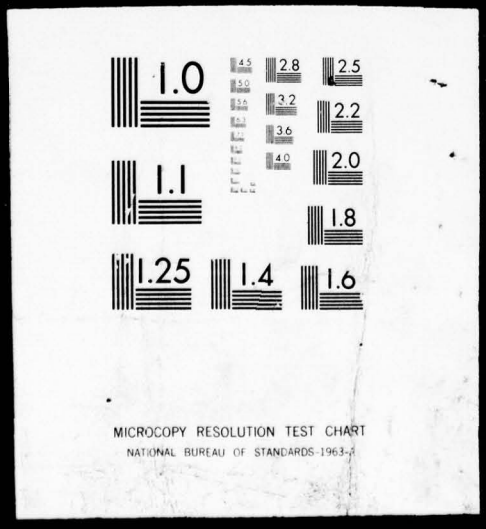

Report No. AFRPL-TR-77-92

CSD 2579-FR

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84-IN. PROPELLANT CARTRIDGES AND GRAINS

Volume II — Propellant Test Data

A051133
Vol 3

Terry V. O'Hara
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United Technologies Corporation
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P. O. Box 358
Sunnyvale, CA 94088

30 November 1977

Final Report for Period November 1975 — November 1977
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AIR FORCE ROCKET PROPULSION LABORATORY
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Edwards Air Force Base, CA 93523

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FOREWARD

This report was submitted by United Technologies/Chemical Systems Division, P.O. Box 358, Sunnyvale, CA 94086, under Contract No. F04611-76-C-0010, Job Order No. 305909 JM with the Air Force Rocket Propulsion Laboratory, Edwards AFB, CA 93523.

This report has been reviewed by the Information Office/XOJ and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations. This technical report has been reviewed and is approved for publication; it is unclassified and suitable for general public release.

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FOR THE COMMANDER

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Director, Solid Rocket Division

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18. SUPPLEMENTARY NOTES

This report is presented in three volumes:
Volume I - Technical Discussion
Volume II - Propellant Test Data
Volume III - Appendices

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

HTPB Propellant
High Solids Loaded Propellant
UTP-18,803A
ELSH Loaded Cartridges
CHAR Loaded Cartridges
Propellant Characterization
84-Inch Cartridge

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document reports the results obtained from casting a total of 30 84-inch cartridges with UTP-18,803A propellant (90% solids, 21% aluminum, HTPB). Both ballistic and mechanical property data obtained during the production of over 730,000 lbs of propellant is presented. Documentation for propellant production is provided.

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1.0 INTRODUCTION

Volume II of the final report presents a compilation of all the ballistic and mechanical property test data for UTP-18,803A obtained under contract No. F04611-76-C-0010. The data presented here are those which were used in the statistical data summaries presented in section 4.2.1 of Volume I.

Because of the large amount of data available, the presentation of the data in this volume has been categorized into four main topics for ease of reference.

Volume II Section No.	Data Description
2.0	CSD Ballistic and Mechanical Property Test Data and Data Correlation - This section presents the test data obtained by CSD for each batch of propellant. Both ballistic (LSBR, CSBR, 4-lb motor) and physical property data are presented. Correlations between CSD and AFRPL test data are given. All test data are given by batch number and grouped by production run number.
3.0	AP Particle Size Distribution - The AP particle size distributions in terms of cumulative percentages are given for both the ground and unground AP. These data were used to establish the AP grind ratio for those batches where D_{43} was used as the propellant burning rate control. Data are presented by batch number.
4.0	Fifteen-Pound BATES Test Data - This section presents a plot of the pressure and thrust duty cycles for each of the 15-lb BATES motors test fired by AFRPL. The primary ballistic parameters for each test are also tabulated. The data are presented by batch number.
5.0	Seventy-Pound BATES Test Data - This section presents a plot of the pressure and thrust duty cycles for each of the 70-lb BATES motors test fired by AFRPL. The primary ballistic parameters for each test are also tabulated. The data are presented by batch number.

2.0 CSD BALLISTIC AND MECHANICAL PROPERTY TEST DATA AND DATA CORRELATIONS

This section presents the test data obtained by CSD for each batch of UTP-18,803A produced under contract No. F04611-76-C-0010. Both the ballistic (LSBR, CSBR, 4-lb motor) and mechanical property test data are presented. The ballistic correlations between the CSD and AFRPL test data are also given. All test data are presented by production run and batch number.

SECTION 2.1

FIVE-GALLON PREPRODUCTION BATCHES

Five Gallon
Preproduction

4-LB MOTOR

18803A DATA

Batch	Grind Ratio	NCO/OH	r_{1000} in/sec	r_{1400} in/sec	Exponent η	Burning Rate Constant a	One Sigma %
5-1711	65/35	.86	.415	.487	.472	.01591	1.8
5-1712	60/40	.86	.439	.538	.603	.00682	1.8
5-1713	55/45	.86	.489	.594	.583	.00867	2 pt
5-1714	65/35	.83	.411	.490	.522	.01116	2.2
5-1715	60/40	.83	.442	.530	.543	.01038	1.2
5-1716	55/45	.83	.482	.577	.534	.01209	2 pt
5-1717	65/35	.80	.413	.496	.547	.00943	3.2
5-1718	60/40	.80	.457	.554	.573	.00872	3.6
5-1719	55/45	.80	.473	.581	.610	.00700	2 pt

Five Gallon
Preproduction

Project 2579
UTP 18803A
4# Motor Burn Rate Data

	S/N	psi	in/sec
Batch 5-1711	13	1428	.495
	09	757	.369
	19	951	.397
Batch 5-1712	11	1920	.655
	17	831	.398
	12	1103	.456
Batch 5-1714	22	1472	.508
	01	956	.392
	20	751	.360
Batch 5-1713	15	Overpressurization, nozzle ejected	
	27	1483	.614
	23	969	.479
Batch 5-1715	5	827	.402
	24	1061	.450
	25	1843	.618
Batch 5-1716	21	934	.465
	10	1395	.576
	3	Motor blew	
Batch 5-1717	08	721	.354
	02	906	.377
	06	1493	.520
Batch 5-1718	18	825	.421
	26	1072	.456
	16	2034	.694
Batch 5-1719	07	962	.462
	04	1342	.566
	14	Motor blew	

2C MICRO (2 X 4) MOTOR

UTP 18803A

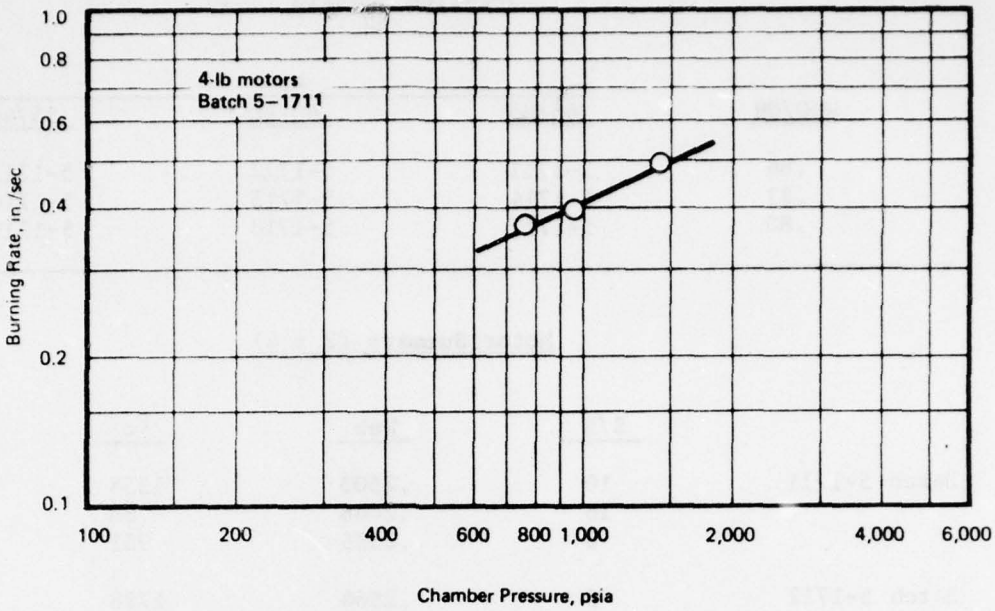
Batch	Grind Ratio	NCO/OH	r_{1000} in/sec	r_{1400} in/sec	Exponent η	Burning Rate Constant a	One Sigma %
5-1711	65/35	.86	.445	.508	.397	.0287	2.4
5-1712	60/40	.86	.482	.593	.615	.00688	2.1
5-1713	55/45	.86	.522	.686	.814	.00189	3.1
5-1714	65/35	.83	.484	.586	.573	.00926	2 pt
5-1715	60/40	.83	.467	.580	.641	.00560	4.61
5-1716	55/45	.83	.499	.723	1.11	.00024	9.4
5-1717	65/35	.80	.442	.5096	.423	.02385	2 pt
5-1718	60/40	.80	.477	.573	.543	.01123	0.3
5-1719	55/45	.80	.531	.772	1.106	.00026	2 pt

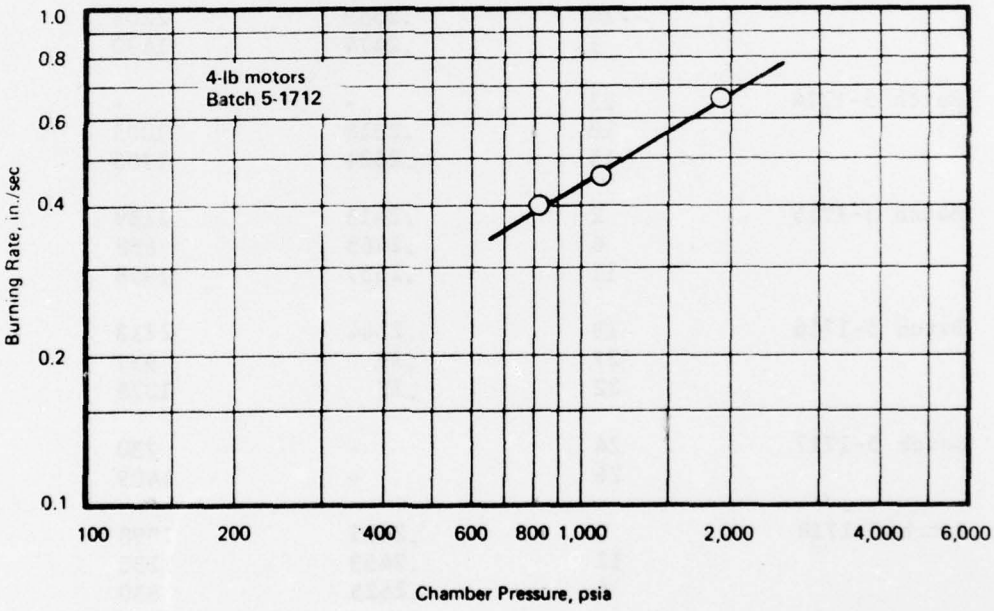
Project 2579
UTP 18803A
5-Gallon Matrix

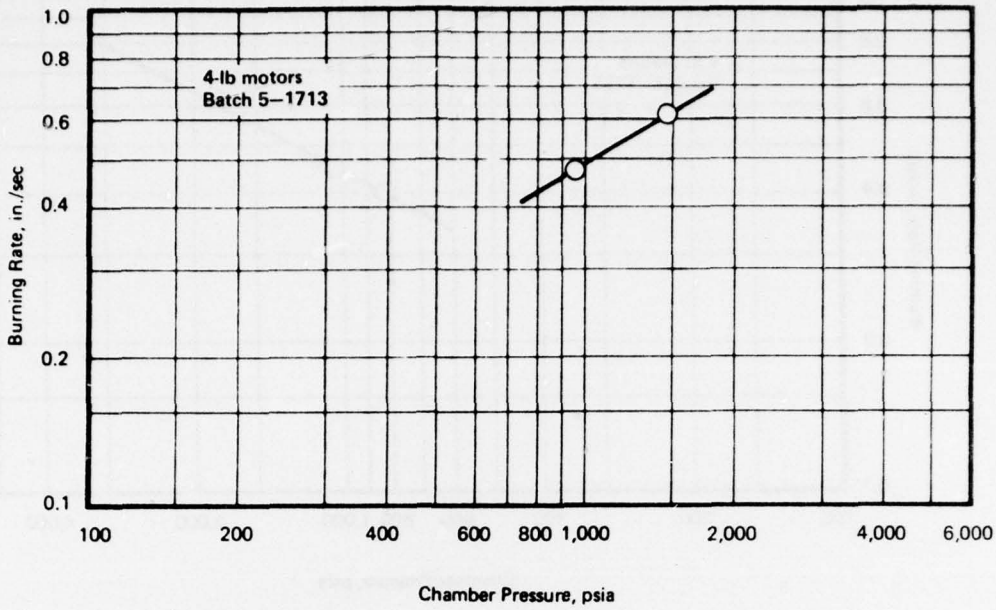
NCO/OH	AP 65/35	AP 60/40	AP 55/45
.86	5-1711	5-1712	5-1713
.83	5-1714	5-1715	5-1716
.80	5-1717	5-1718	5-1719

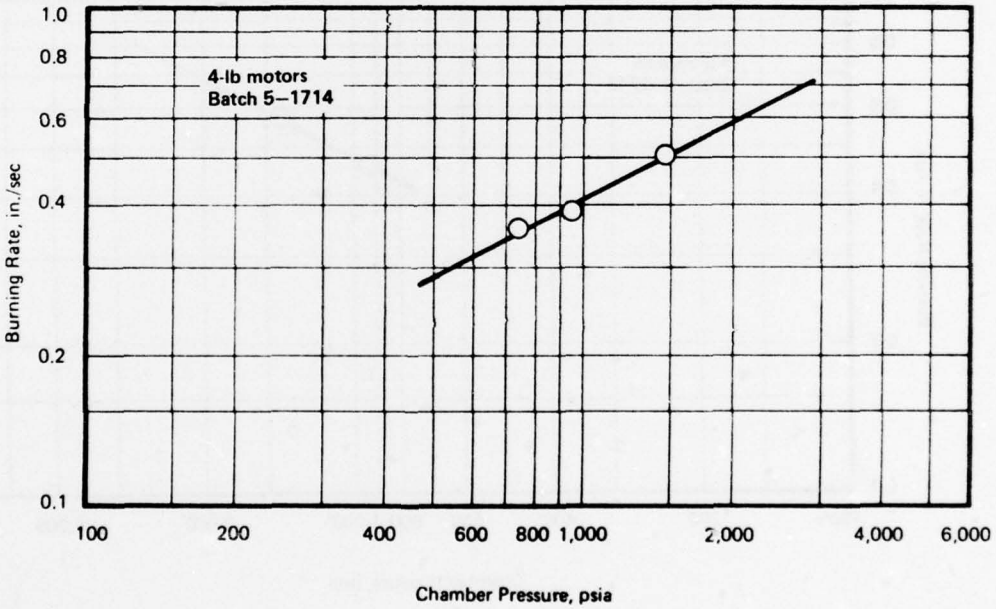
Motor Summary (2 x 4)

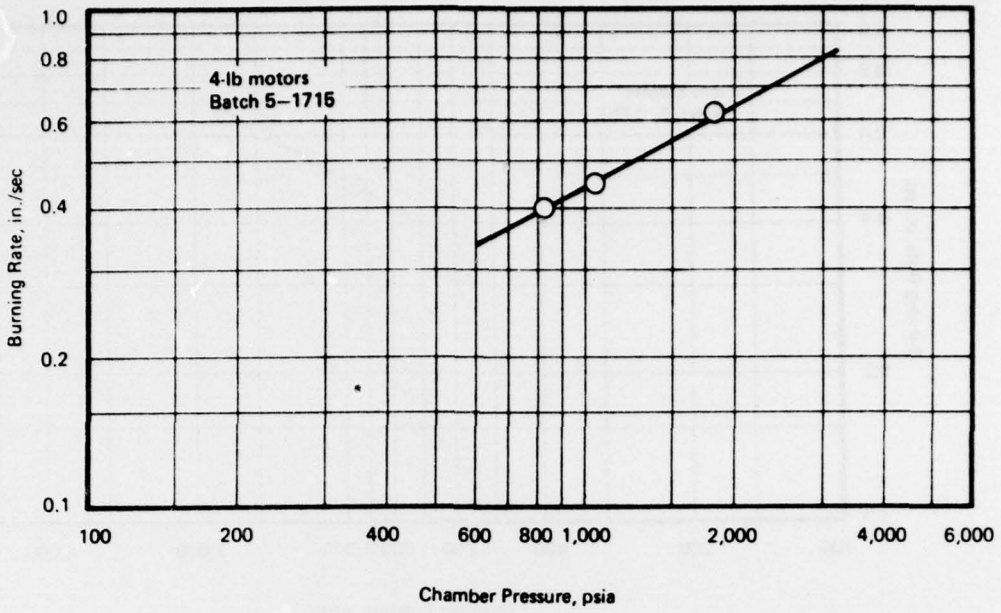
	S/N	Web	P_c	$\dot{r}$
Batch 5-1711	10	.2503	1358	.507
	18	.2446	788	.412
	8	.2585	951	.424
Batch 5-1712	5	.2564	1798	.697
	3	.2481	895	.458
	16	.2437	1110	.502
Batch 5-1713	7	.2545	1067	.561
	14	.2559	2208	1.011
	9	.2474	1490	.697
Batch 5-1714	13	-	-	-
	10	.2518	1005	.485
	15	.2524	1703	.656
Batch 5-1715	2	.2415	1189	.495
	6	.2465	888	.448
	11	.2537	1998	.742
Batch 5-1716	19	.2544	2213	1.259
	27	.25	957	.506
	22	.25	1375	.635
Batch 5-1717	24	-	730	.387
	26	-	1409	.511
Batch 5-1718	1	.2455	1098	.504
	12	.2453	1235	.534
	4	.2525	830	.431
Batch 5-1719	20	-	986	.523
	21	-	1544	.859

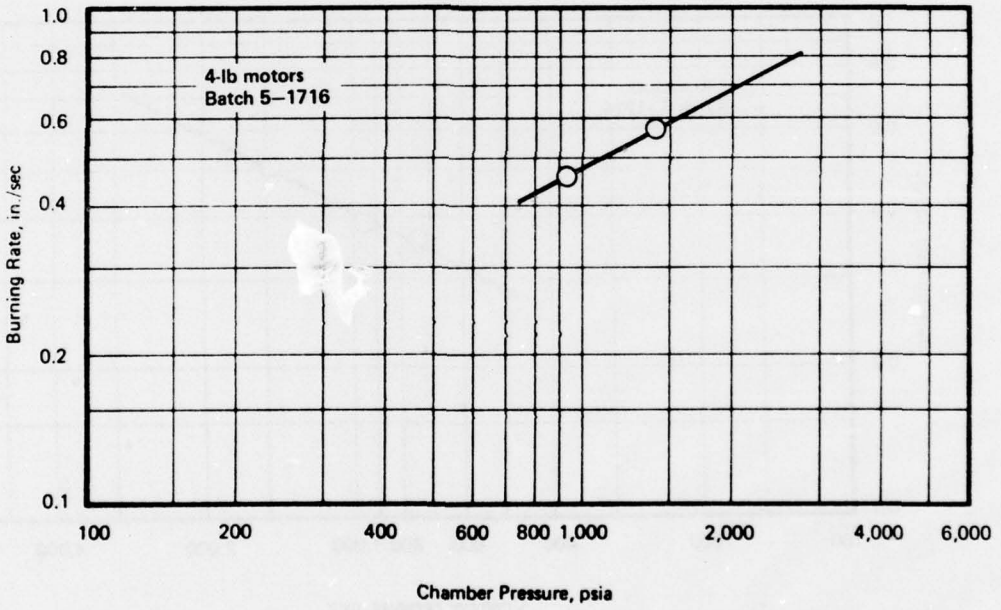

4-lb motors
Batch 5–1711
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

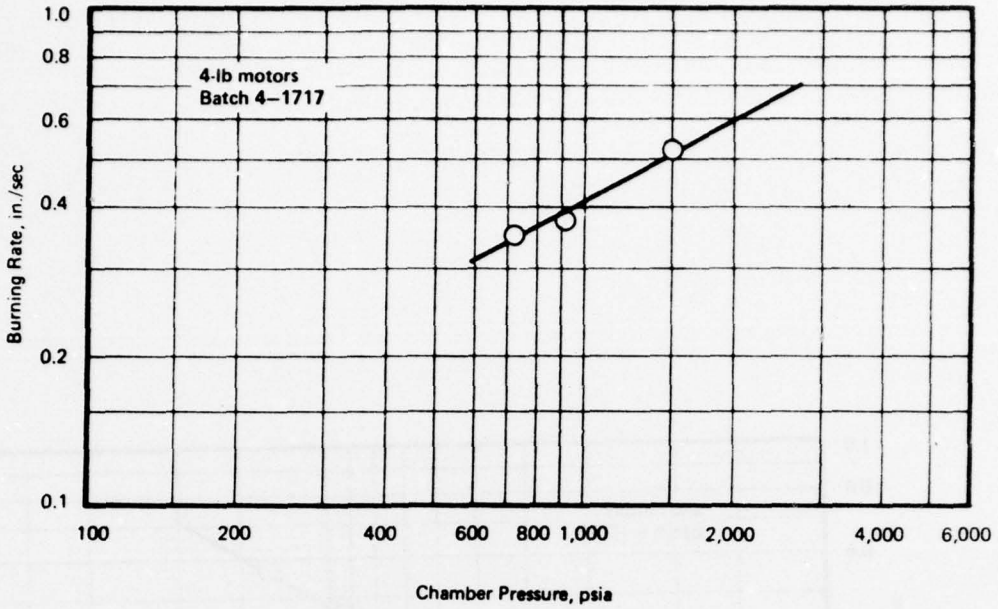

4-lb motors
Batch 5-1712
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

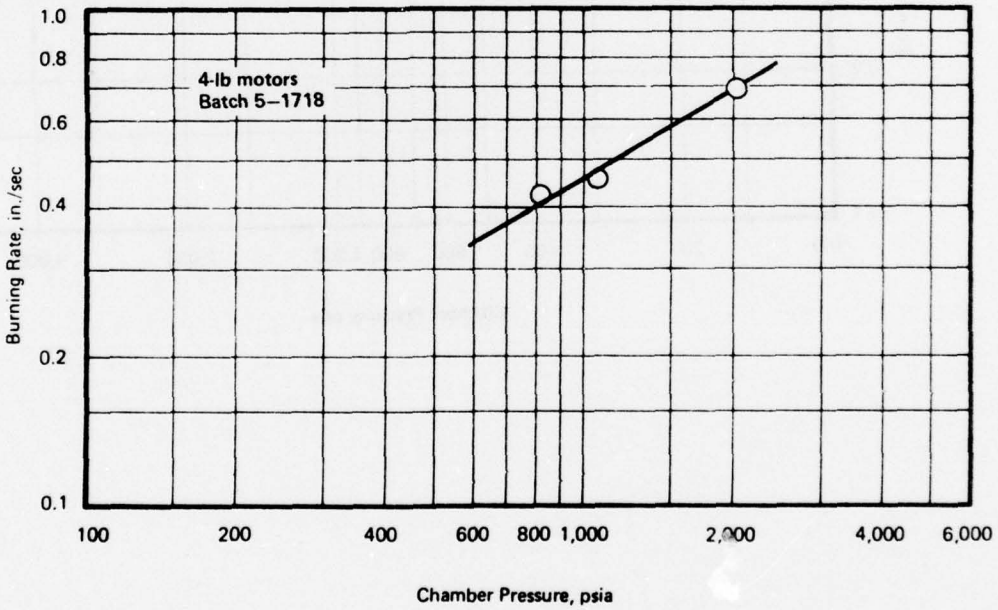

4-lb motors
Batch 5–1713
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

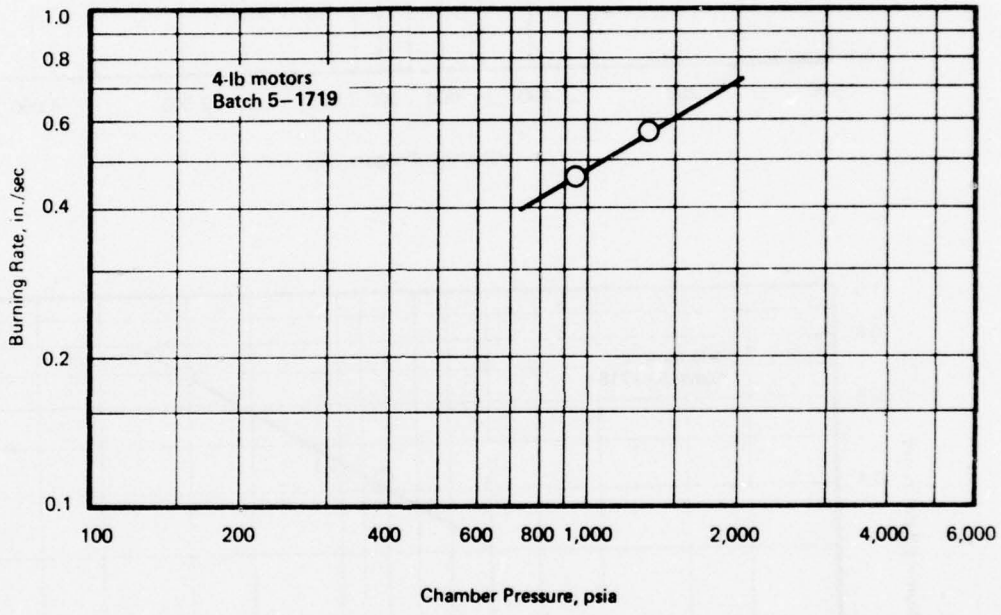

4-lb motors
Batch 5–1714
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 5–1715
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 5–1716
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 4–1717
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 5–1718
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 5–1719
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.2
400-GALLON PREPRODUCTION BATCH
(BATCH 400-1450)

UTP 18803A

CHARACTERIZATION BATCH, 400-1450

4 LB MOTOR DATA

65/35 GRIND RATIO,85 NCO/OH RATIO

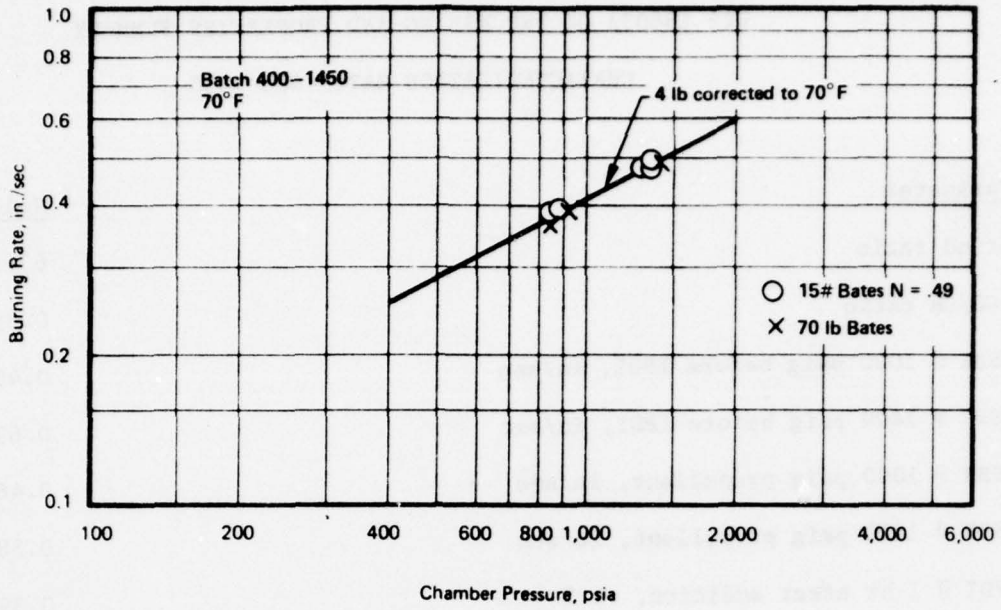
Temperature, F	Chamber Pressure, psia	Burning Rate, in/sec
32	2,165	0.6104
32	1,580	0.5339
32	1,276	0.4562
32	1,012	0.4110
32	789	0.3649
128	947	0.4148
128	1,299	0.4923
128	1,655	0.5675
128	1,989	0.6219
85	2,043	0.5950
85	1,895	0.5837
85	1,437	0.4906
85	1,238	0.4230
85	1,004	0.4177
85	802	0.3735
85	1,595	0.5358

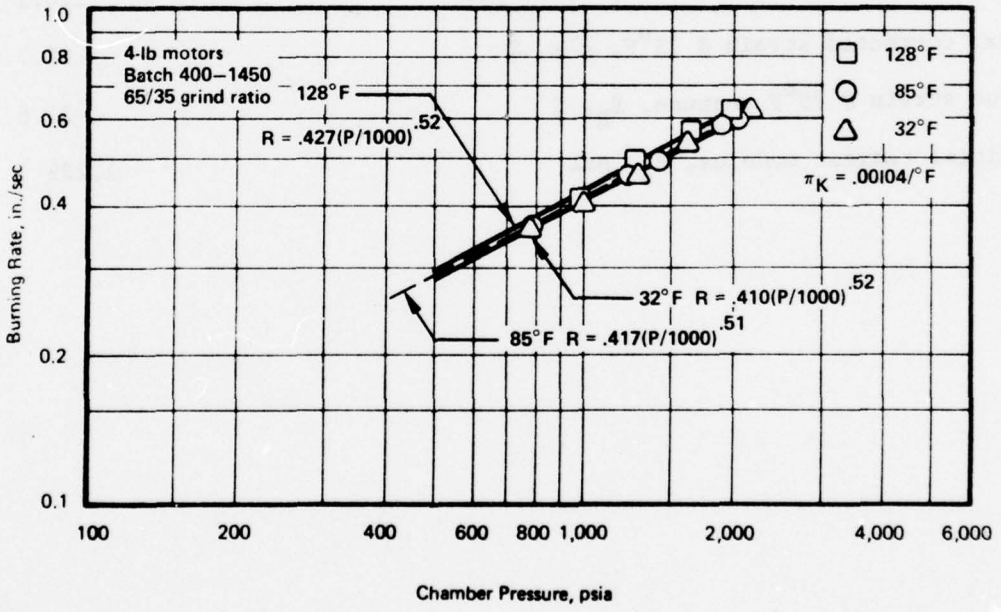
Temperature, F	Composite r_{1000}, in/sec	r_{1400}, in/sec	Pressure Exponent	One Sigma, %
32	0.410	0.489	0.522	1.70
128	0.427	0.514	0.550	0.44
85	0.416	0.494	0.510	1.19
π_K	0.104%/°F			
π_P	0.0498/°F			

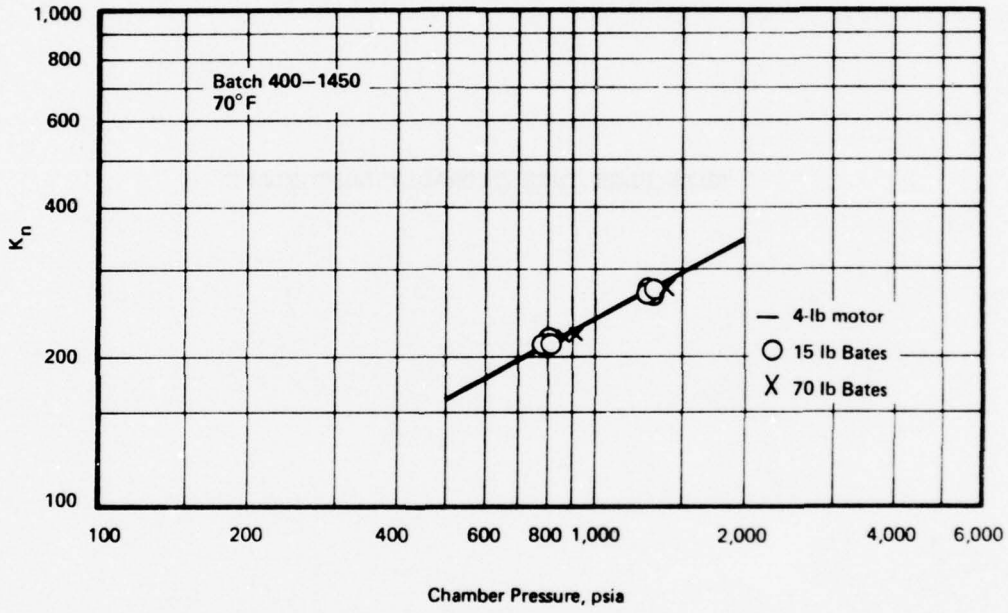
UTP 18803A QC PROCESSING AND PROPERTIES SUMMARY

CHARACTERIZATION BATCH 400-1450

Parameter	Value
Grind ratio	65/35
NCO/OH ratio	0.85
LSBR @ 1000 psig before IPDI, in/sec	0.499
LSBR @ 1400 psig before IPDI, in/sec	0.638
LSBR @ 1000 psig propellant, in/sec	0.467
LSBR @ 1400 psig propellant, in/sec	0.589
IPDI @ 1 hr after addition, wt %	0.39
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	6.98
Max. corrected stress @ 75°F, $\sigma^c m$, psi	120.1
Max. corrected strain @ 75°F, $\varepsilon^c m$, %	30.7
True strain @ 75°F rupture, E_R, %	31.6
Initial tangent modulus, E_o, psi	1,229


Batch 400–1450
70° F
4 lb corrected to 70° F
15# Bates N = .49
70 lb Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1450
65/35 grind ratio
128° F
R = .427(P/1000)^.52
128° F
85° F
32° F
π_K = .00104/° F
32° F R = .410(P/1000)^.52
85° F R = .417(P/1000)^.51
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1,000
800
600
400
200
100
K_n
Batch 400–1450
70° F
4-lb motor
15 lb Bates
70 lb Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

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SECTION 2.3

PRODUCTION RUN NO. 1

(BATCHES 400-1454 THROUGH 400-1465)

FIRST PRODUCTION CASTING

UTP-18,803A DATA

Batch	Four Pound Motor Data			Burning Rate @ 1400 psia, in/sec	Exponent	15 Lb Motor Bates Motor Data			70 Pound Bates Motor Data		
	Chamber Pressure, psia	Burning Rate in/sec	Test Temperature, F			Chamber Pressure, psia	Burning Rate in/sec	Test Temperature, F	Chamber Pressure, psia	Burning Rate in/sec	Test Temperature F
1400-1454	Questionable P_c Data										
400-1455	1062 1469	.4036 .4633	90 90	.454	.425	1162	.419	70	1231	.435	70
400-1456	1061 1556	.4011 .4831	90 90	.459	.486	800	.361	70	N/A	N/A	N/A
400-1457	1021 1403	.3943 .4612	90 90	.461	.493	1253	.479	70	1313	.471	70
400-1458	1046 1633	.410 .524	90 90	.481	.55	831	.365	70	N/A	N/A	N/A
400-1459	1001 1570	.3994 .4977	90 90	.471	489	1268	.453	70	1371	.477	70
400-1460	1054 1622	.4161 .5170	90 90	.480	.504	895	.407	70	N/A	N/A	N/A
400-1461	1083 1572	.4137 .4991	90 90	.471	.504	1243 817	.444 .373	70	Test motor hardware failed		70
400-1462	1058 1706	.4162 .5287	90 90	.479	.501	799	.374	70	N/A	N/A	N/A
400-1463	966 1653	.4049 .520	90 90	.481	.466	1230	.446	70	Test motor hardware failed		70
400-1464	1015 1651	.4031 .520	90 90	.477	.523	833	.381	70	N/A	N/A	N/A
400-1465	1033 1804	.4172 .5547	90 90	.487	.511	1251	.458	70	Test motor hardware failed		70

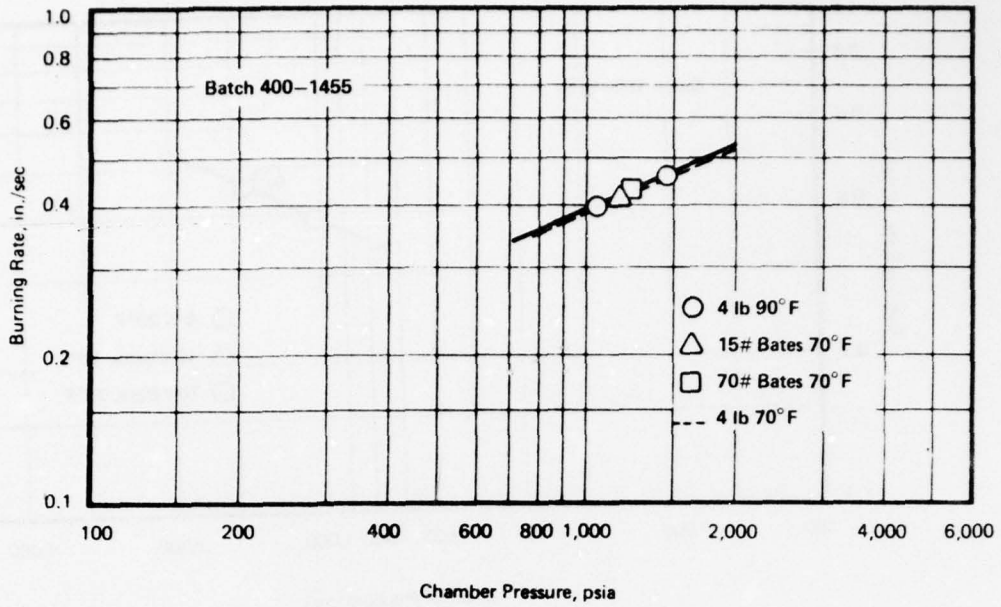
FIRST PRODUCTION CASTING

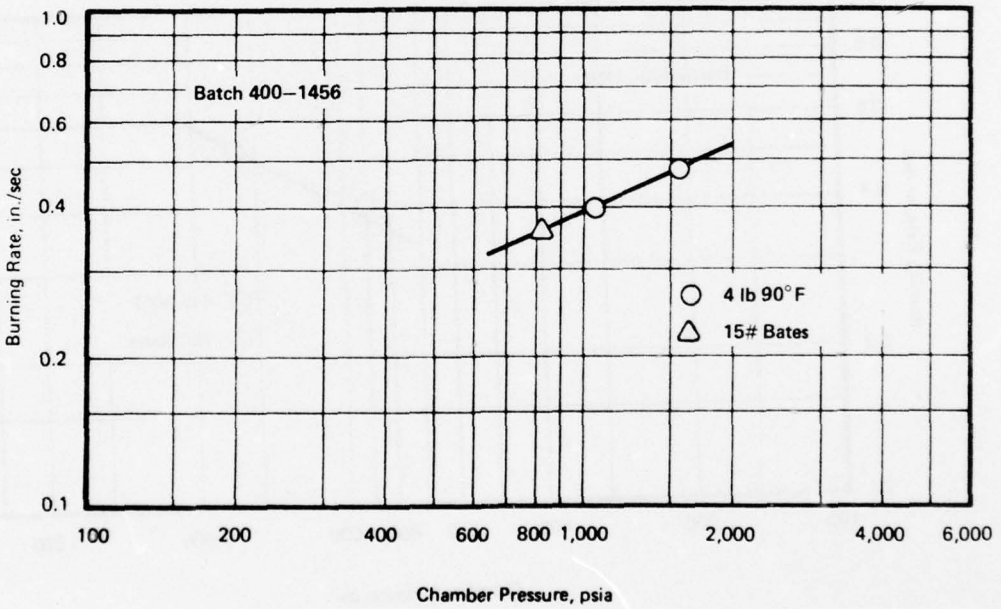
UTP 18803A

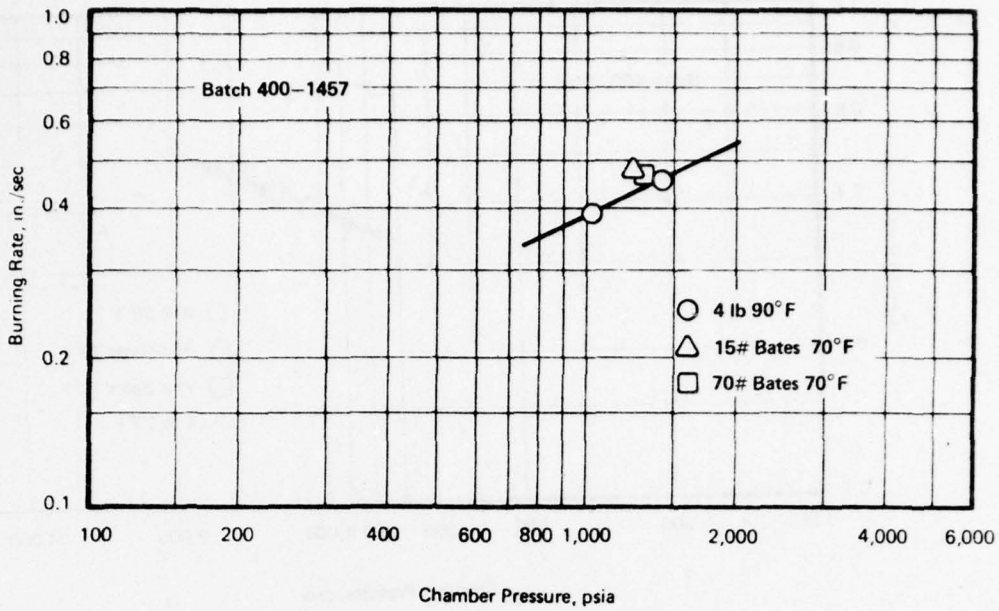
Batch 400-	Grind Ratio	LSBR Before IPDI, in/sec 1000 psig	LSBR Before IPDI, in/sec 1400 psig	LSBR After IPDI, in/sec 1000 psig	LSBR After IPDI, in/sec 1400 psig	90 F Four Pound Motor Data r_{1000}, in/sec	r_{1400} in/sec	Exponent
1454	70/30	.467	.589	.444	.558	Questionable pc data		
1455	70/30	.467	.595	.445	.554	.393	.454	.425
1456	68/32	.473	.600	.447	.564	.390	.459	.486
1457	68/32	.469	.598	.445	.559	.390	.461	.493
1458	66/34	.473	.607	.449	.568	.400	.481	.55
1459	66/34	.476	.617	.455	.572	.399	.471	.489
1460	66/34	.483	.619	.460	.587	.405	.480	.504
1461	66/34	.483	.617	.456	.583	.397	.471	.504
1462	65/35	.483	.631	.459	.587	.405	.479	.501
1463	65/35	.481	.624	.456	.581	.411	.481	.466
1464	66/34	.482	.614	.457	.576	.400	.477	.523
1465	66/34	.488	.620	.459	.587	.410	.487	.511
6 batches	66/34	---	---	---	---	.402	.478	.518

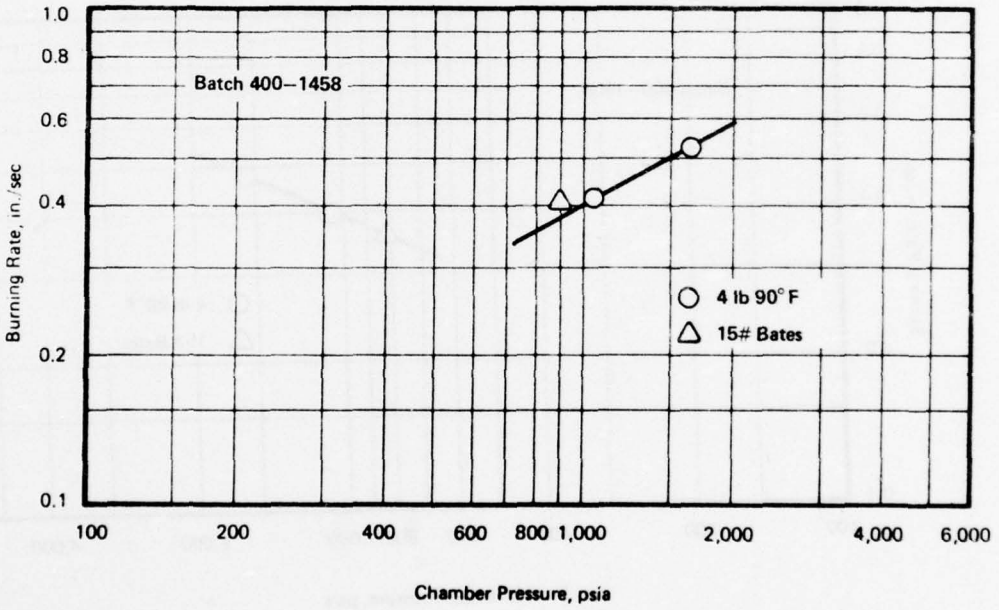
UTP 18803A QC PROCESSING AND PROPERTIES SUMMARY
FIRST PRODUCTION CASTING

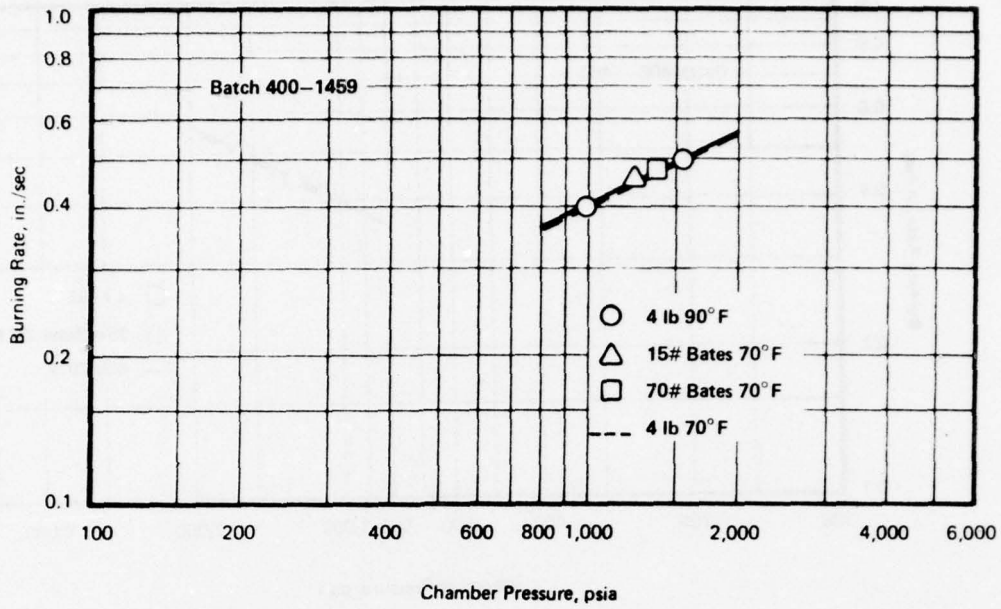
Parameter	400 Gallon Batch 1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	$\bar{X}$	Sx
Grind ratio	70/30	70/30	68/32	68/32	66/34	66/34	66/34	66/34	65/35	65/35	66/34	66/34		
NCO/OH	0.85 →													
Fuel premix number	3500-1 →													
IPDI @ 1 hr after addition, wt %	0.38	0.38	0.40	0.37	0.38	0.37	0.37	0.37	0.38	0.38	0.37	0.38	0.38	0.0087
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	5.0	4.7	4.2	4.1	4.5	4.8	4.8	4.8	5.7	5.5	6.5	5.3	4.99	0.0067
Max. corrected stress @ 75^{o}F, $\sigma^{c}m$, psi	126	128	123	115	90	118	131	131	120	107	110	135	120	12.8
Max. corrected strain @ 75^{o}F, $\epsilon^{c}m$, %	43	40	40	37	28	37	40	38	40	32	38	33	37.2	4.22
True strain @ 75^{o}F rupture, E_r, %	44	41	42	38	29	38	41	39	41	32	39	34	38.2	4.41
Initial tangent modulus, E_o, psi	408	587	432	658	312	399	393	460	526	411	555	468	467	97.3

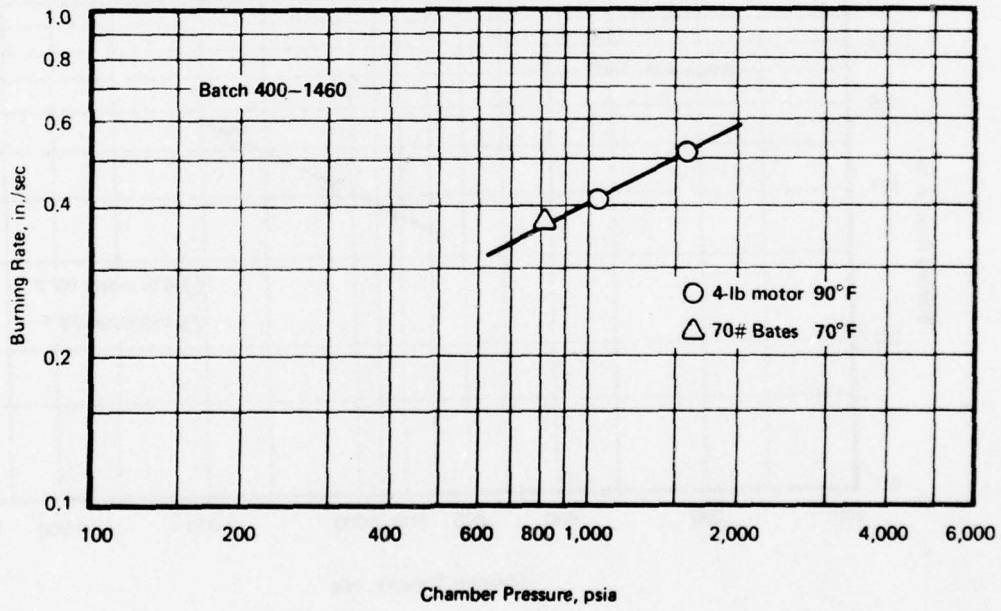

Batch 400–1455
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90° F
15# Bates 70° F
70# Bates 70° F
4 lb 70° F

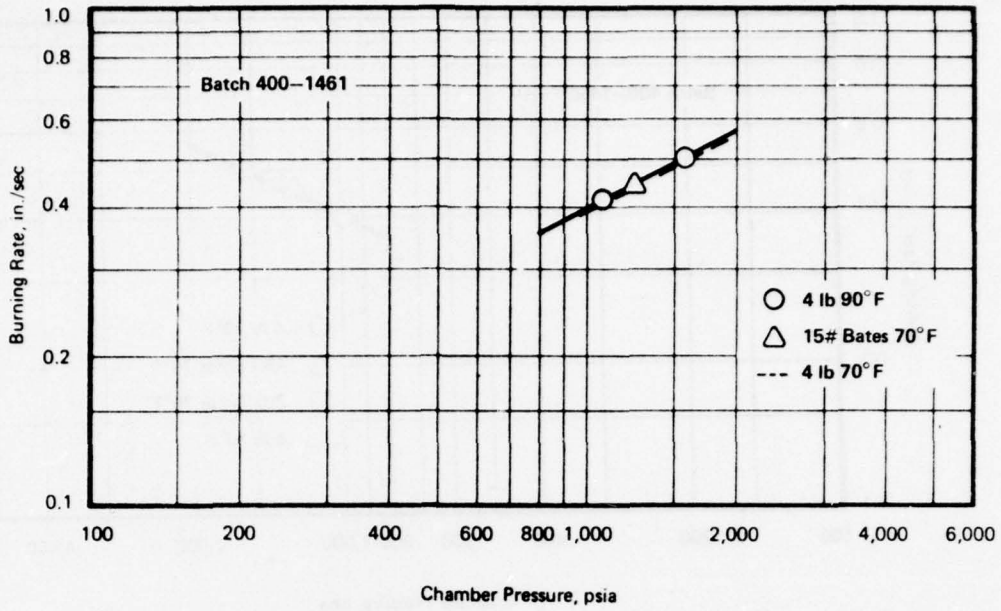

Batch 400–1456
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90° F
15# Bates

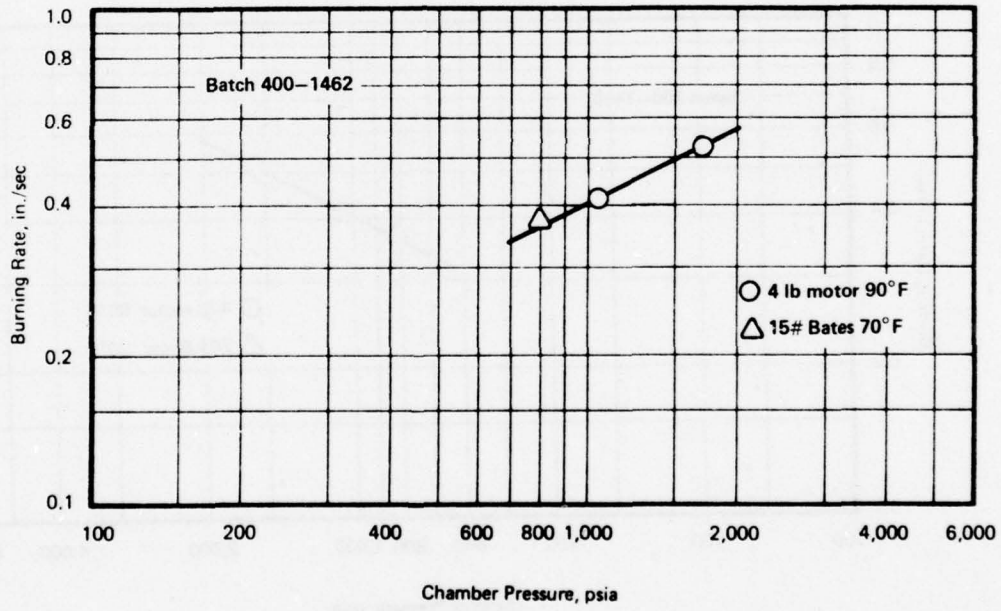

Batch 400–1457
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90° F
15# Bates 70° F
70# Bates 70° F

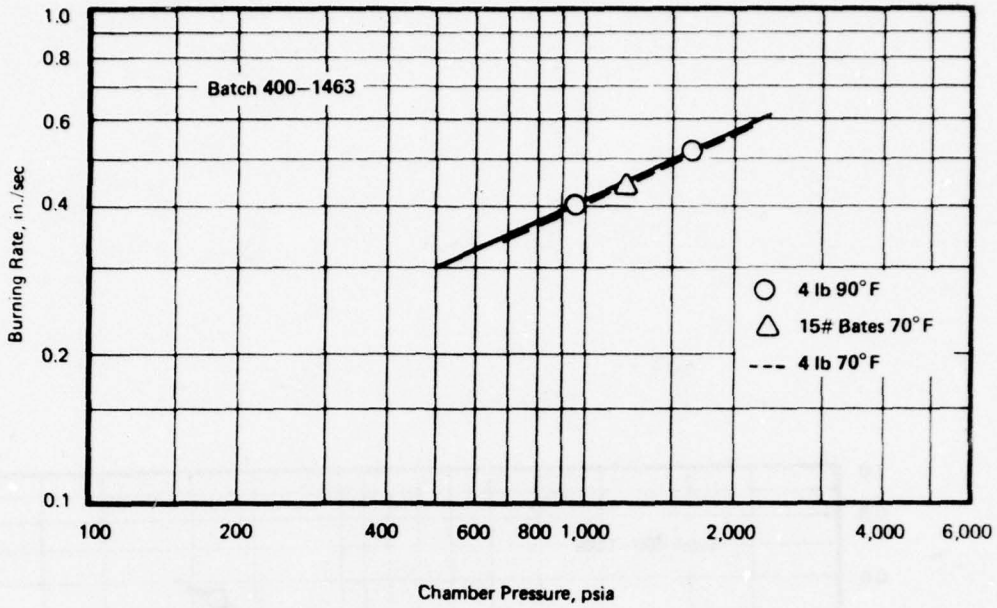

Batch 400–1458
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90° F
15# Bates

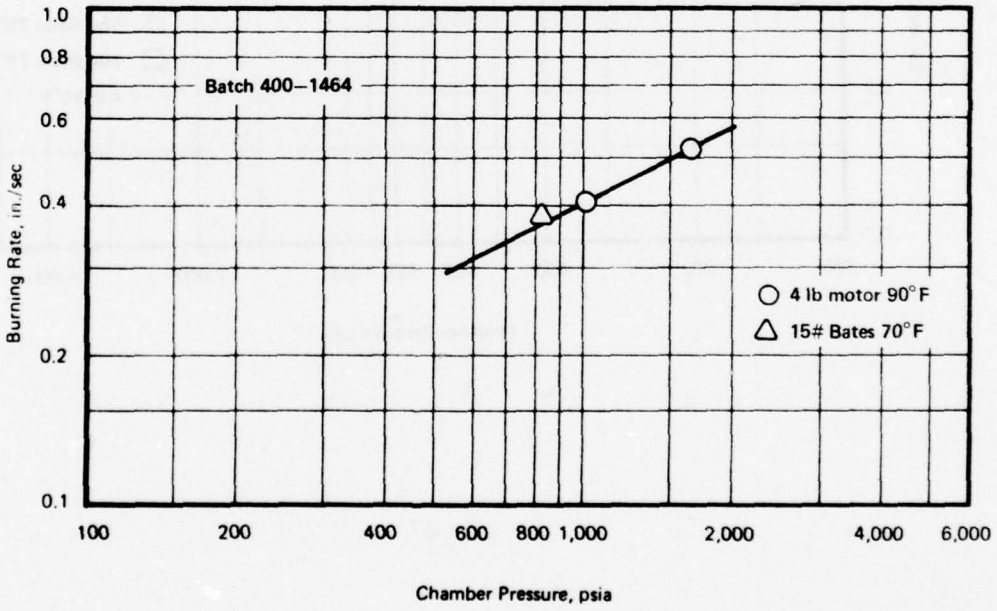

Batch 400–1459
4 lb 90°F
15# Bates 70°F
70# Bates 70°F
4 lb 70°F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

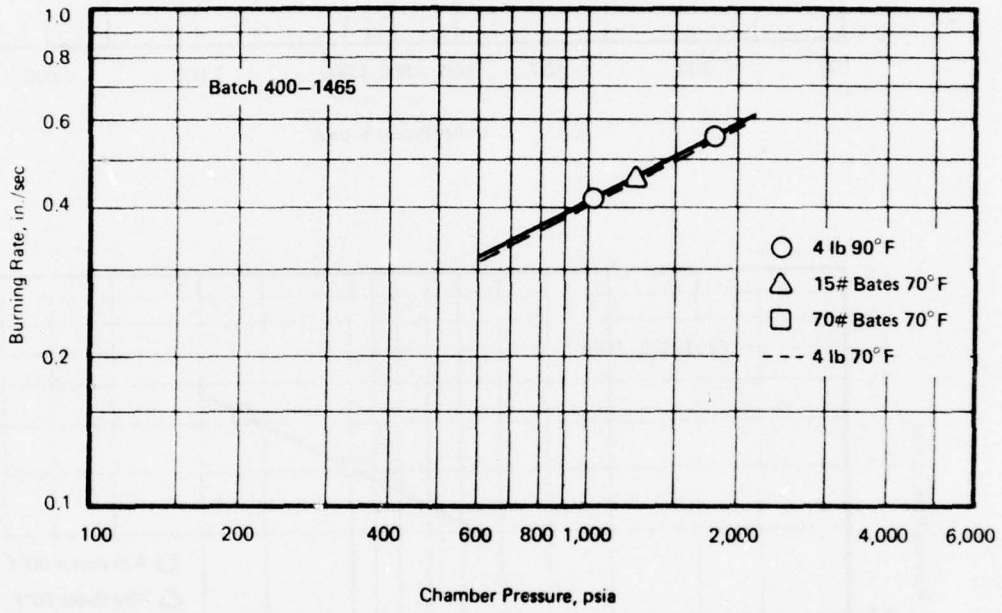

Batch 400–1460
4-lb motor 90°F
70# Bates 70°F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

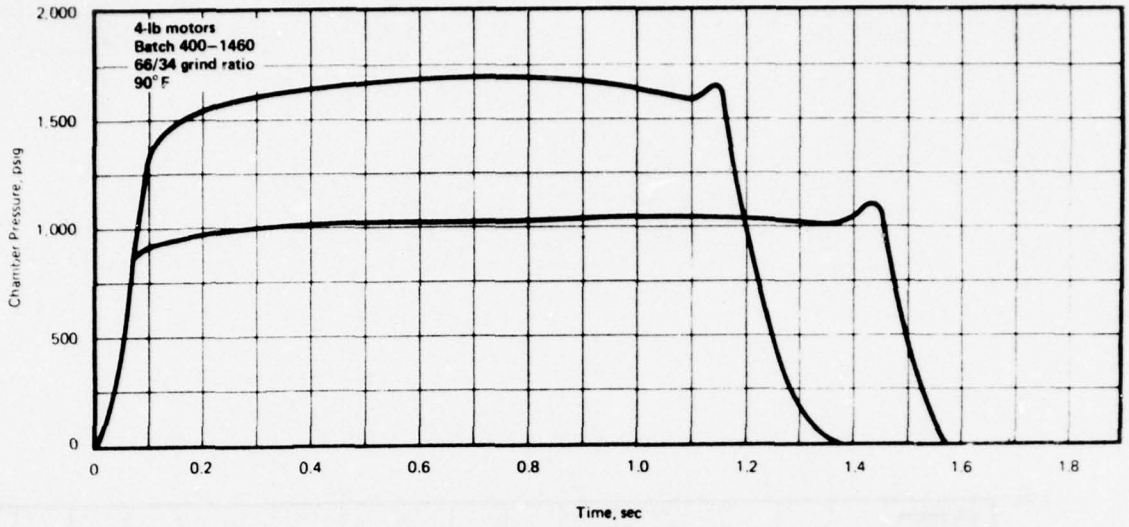

Batch 400–1461
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90° F
15# Bates 70° F
4 lb 70° F

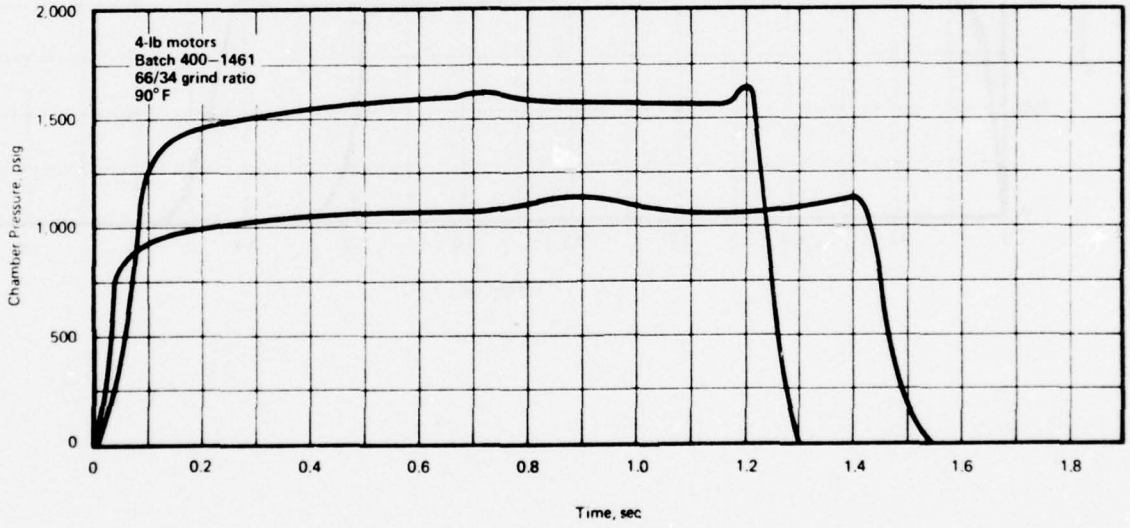

Batch 400–1462
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb motor 90° F
15# Bates 70° F

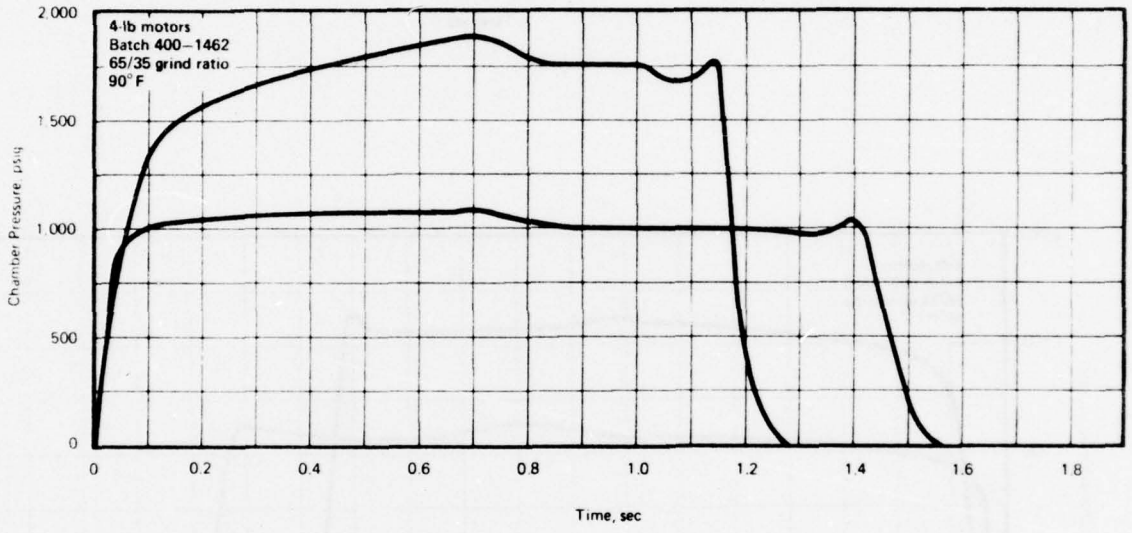

Batch 400–1463
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90°F
15# Bates 70°F
4 lb 70°F


Batch 400–1464
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb motor 90°F
15# Bates 70°F


Batch 400–1465
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia
4 lb 90° F
15# Bates 70° F
70# Bates 70° F
4 lb 70° F


4-lb motors
Batch 400–1460
66/34 grind ratio
90° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1461
66/34 grind ratio
90° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400—1462
65/35 grind ratio
90° F
2,000
1,500
1,000
500
0
Chamber Pressure, psig
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

SECTION 2.4

PRODUCTION RUN NO. 2

(BATCHES 400-1468 THROUGH 400-1479)

SECOND PRODUCTION CASTING, 65/35 GRIND RATIO
UTP-18,803A 4-LB MOTOR DATA, 90°F
AVERAGE WEB THICKNESS

All Data				800 thru 1800 Psia Three Points				1000 & 1500 Two Data Pts			1000 Psia to 2200 Psia Three Points			800 & 1000 Psia Two Data Pts	
n	r_{1000} r_{1400} r_{1700}	σ,%		n	r_{1000} r_{1400} r_{1700}	σ,%		n	r_{1000} r_{1400} r_{1700}		n	r_{1000} r_{1400} r_{1700}	σ,%	n	r_{1000} r_{1400} r_{1700}
	.416				.415				.397			.398			.403
.513	.494	3.1		.488	.490	3.5		.602	.487		.602	.486	0.4	.214	.433
	.546				.538				.547			.545			.451
	.412				.412				.408			.407			.408
.564	.498	1.0		.55	.496	1.0		.58	.495		.584	.496	0.1	.451	.475
	.556				.552				.554			.556			.519
	.421				.420				.408			.409			.416
.561	.508	1.9		.547	.505	2.2		.618	.507		.604	.501	0.4	.37	.472
	.566				.562				.566			.564			.507
	.421				.421				.420			.419			.420
.526	.503	0.5		.515	.500	0.2		.524	.501		.536	.501	0.3	.50	.497
	.557				.553				.554			.557			.548
	.419				.418				.405			.404			.410
.516	.499	2.6		.470	.490	2.4		.568	.490			.492	0.5		.455
	.551				.537				.548			.552			.483
	.414				.415				.403			.404			.405
.567	.502	2.0		.569	.502	2.4		.633	.499		.612	.497	0.9	.315	.450
	.560				.561				.564			.559			.478
	.410				.409				.403			.402			.403
.551	.494	1.9		.512	.486	1.3		.55	.486		.586	.489	1.1	.404	.460
	.549				.536				.540			.548			.498
	.415				.415				.406						.410
.491	.490	1.8		.491	.490	1.8		.54	.487		Only Three Points			.362	.463
	.539				.539				.541						.496
	.417				.417				.413			.417			.415
.465	.488	1.1		.489	.492	0.7		.518	.492		.466	.488	1.3	.441	.482
	.534				.541				.544			.534			.525

		.419			.418			.409					.413
400-1477	.55	.504	3.1	.481	.492	1.8	.543	.491	.612	.495	1.9	.353	.467
84 In Char		.561			.540			.545		.558			.501
		.417			.417			.409		.404			.412
400-1478	.569	.505	3.1	.496	.493	1.4	.542	.491	.625	.498	2.5	.381	.468
84 In Char		.565			.542			.546		.563			.504
		.425			.425			.412					.419
400-1479	.514	.505	2.1	.514	.505	2.1	.588	.502	Only Two Points			.378	.476
84 In Char		.558			.558			.562					.512
		.416			.416			.406					
400-1468-1476	.537	.498	2.1	.516	.494	2.14	.574	.493					
		.554			.547			.552					

UTP-18803A 65/35 GRIND RATIO
SECOND PRODUCTION CASTING
90°F FOUR POUND MOTOR

Batch	Burning Rate In/Sec/Chamber Pressure (psia)			
400-1468	.3854 812	.406 1036	.5389 1657	.6106 2070
400-1469	.3761 833	.411 1014	.5432 1640	.6525 2235
400-1470	.393 856	.4292 1086	.5757 1747	.6749 2301
400-1471	.3768 804	.435 1071	5322 1574	.6299 2133
400-1472	.3807 790	.415 1043	.5206 1555	.6145 2032
400-1473	.3827 838	.4060 1011	.568 1717	.6178 2024
400-1474	.3616 771	.3971 972	.5215 1594	.6472 2229
400-1475	.3783 803	4163 1046	.5646 1843	
400-1476	.3781 808	.4294 1078	.5334 1639	.5974 2002
400-1477	.3815 804	.4221 1062	.5405 1674	.6780 2289
400-1478	.3828 823	.4175 1037	.5392 1662	.6686 2176
400-1479	.3878 814	.4331 1090	.5666 1722	

18803A SECOND PRODUCTION CASTING

Batch	Before IPDI 1000	Before IPDI 1400	After IPDI 1000	After IPDI 1400
400-1468	.495	.63	.462	.589
400-1469	.492	.63	.562	.586
400-1470	.494	.63	.464	.586
400-1471	.487	.623	.458	.577
400-1472	.496	638	.463	.587
400-1473	.495	638	.468	.598
400-1474	.495	641	.464	.595
400-1475	.486	626	.462	.583
400-1476	.488	630	.460	.585
400-1477	.487	628	.465	.585
400-1478	.487	630	.457	.587
400-1479	.490	639	.465	.596

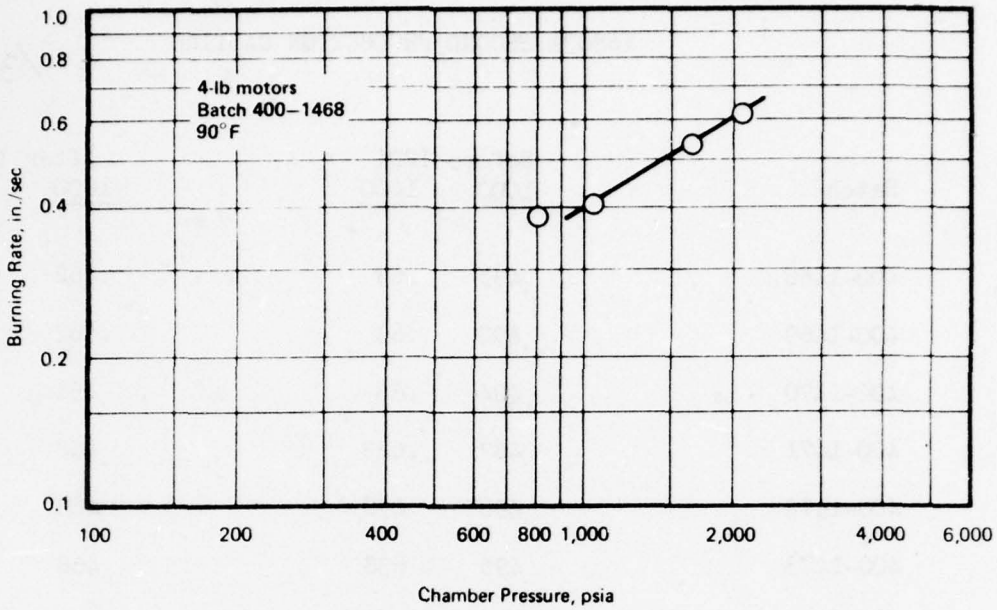
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
SECOND PRODUCTION CASTING

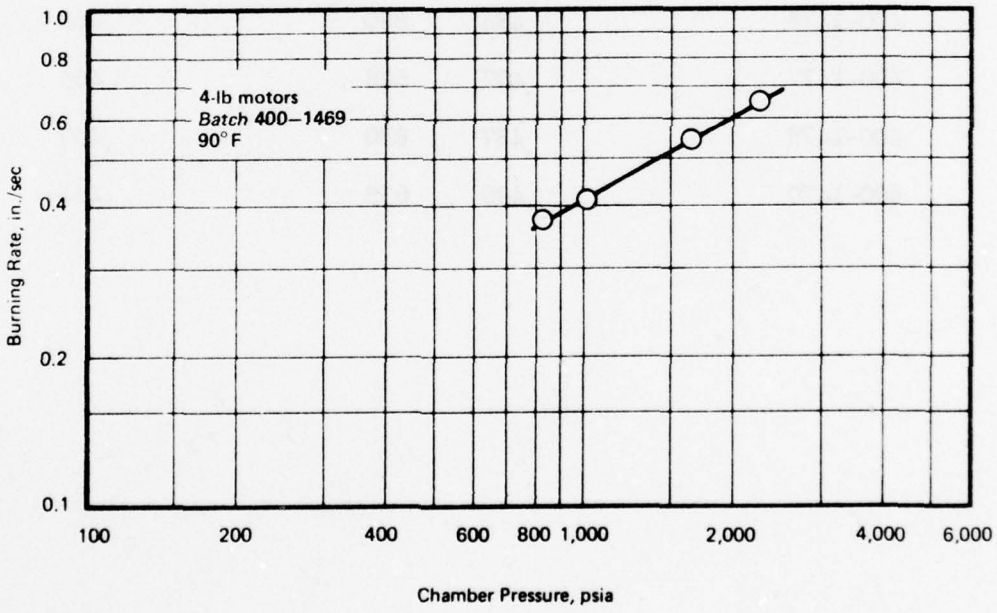
Parameter	400 Gallon Batch 1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	$\bar{X}$	Sx
Grind ratio	65/35	←	←	←	←	←	←	←	←	←	←	→		
NCO/OH	0.85	←	←	←	←	←	←	←	←	←	←	→		
Fuel premix number	3500-2	←	←	←	←	←	←	←	←	←	←	→		
IPDI @ 1 hr after addition, wt %	0.37	0.37	0.38	0.37	0.37	0.37	0.37	0.38	0.37	0.38	0.38	0.38	0.374	0.005
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	7.8	6.4	5.8	6.0	9.0	7.9	6.6	5.6	5.5	5.8	5.6	6.8	6.57	1.12
Max. corrected stress @ 75°F, σ^c_m, psi	133	137	141	126	122	121	124	114	120	112	127	117	125.0	8.90
Max. corrected strain @ 75°F, ε^c_m, %	29	29	35	29	24	25	32	29	27	30	34	25	29.8	3.61
True strain @ 75°F rupture, E_r, %	30	30	36	30	26	25	32	29	28	31	35	26	29.8	3.41
Initial tangent modulus, E_o, psi	999	1081	833	779	967	925	720	846	570	740	572	816	821	158.0

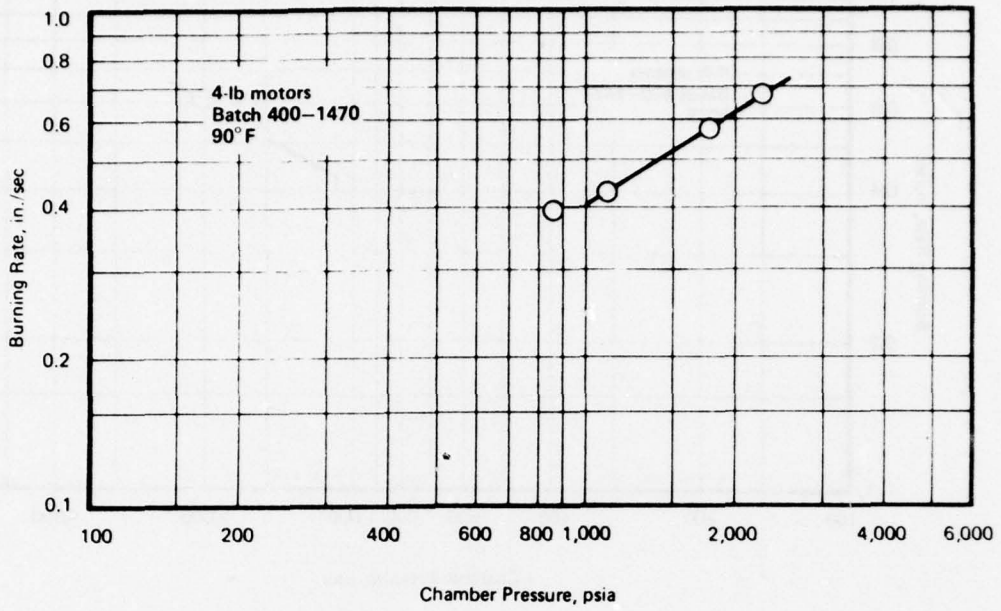
Cartridges lost in 23 May 76 fire

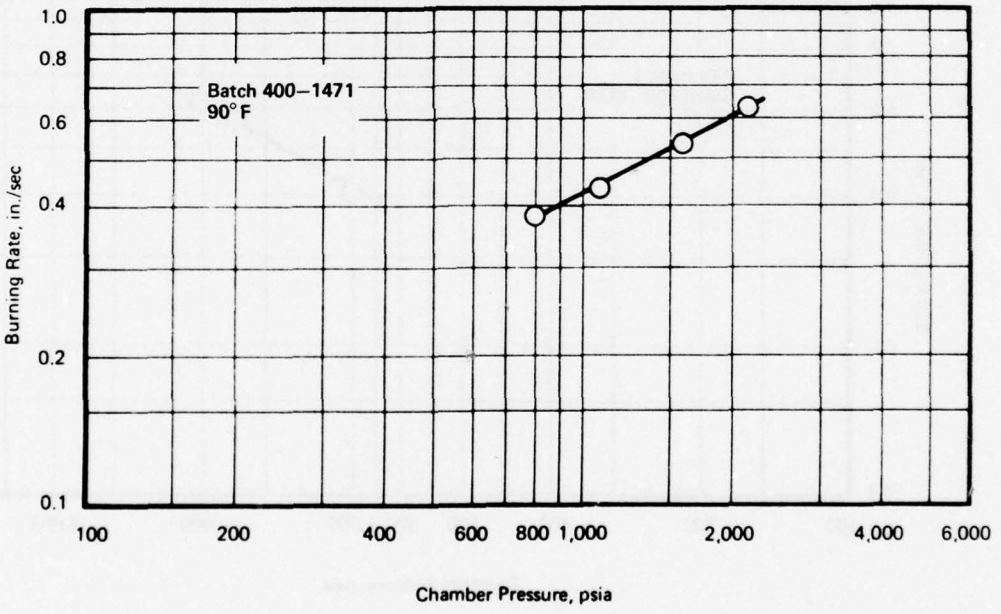
18803A SECOND PRODUCTION CASTING 65/35

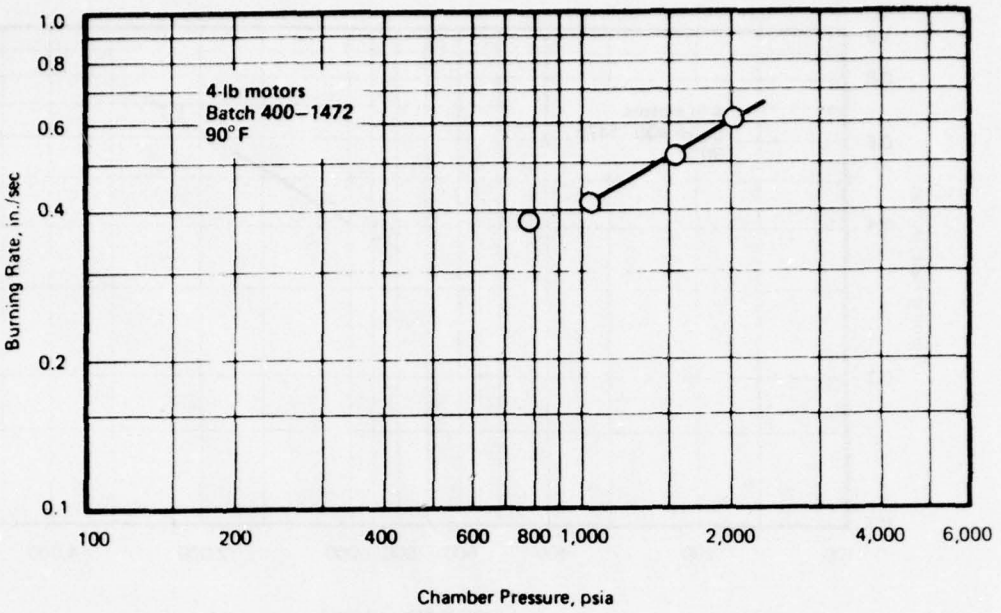
Batch	Before IPDI 1000	Before IPDI 1400	After IPDI 1000	After IPDI 1400
400-1468	.495	.63	.462	.589
400-1469	.492	.63	.462	.586
400-1470	.494	.63	.464	.586
400-1471	.487	.623	.458	.577
400-1472	.496	638	.463	.587
400-1473	.495	638	.468	.598
400-1474	.495	641	.464	.595
400-1475	.486	626	.462	.583
400-1476	.488	630	.460	.585
400-1477	.487	628	.465	.585
400-1478	.487	630	.457	.587
400-1479	.490	639	.465	.596

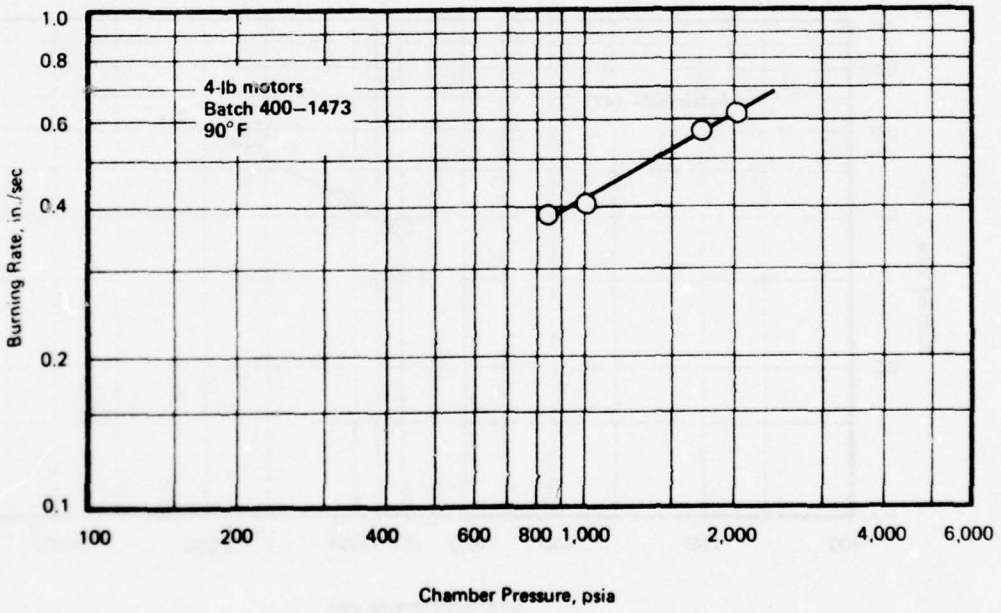

4-lb motors
Batch 400–1468
90°F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

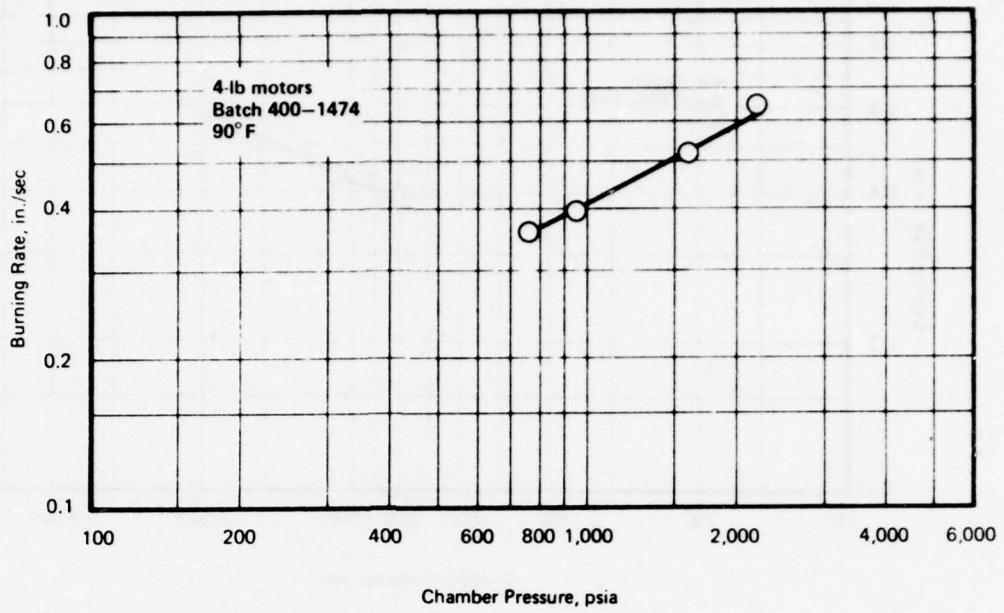

4-lb motors
Batch 400–1469
90°F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

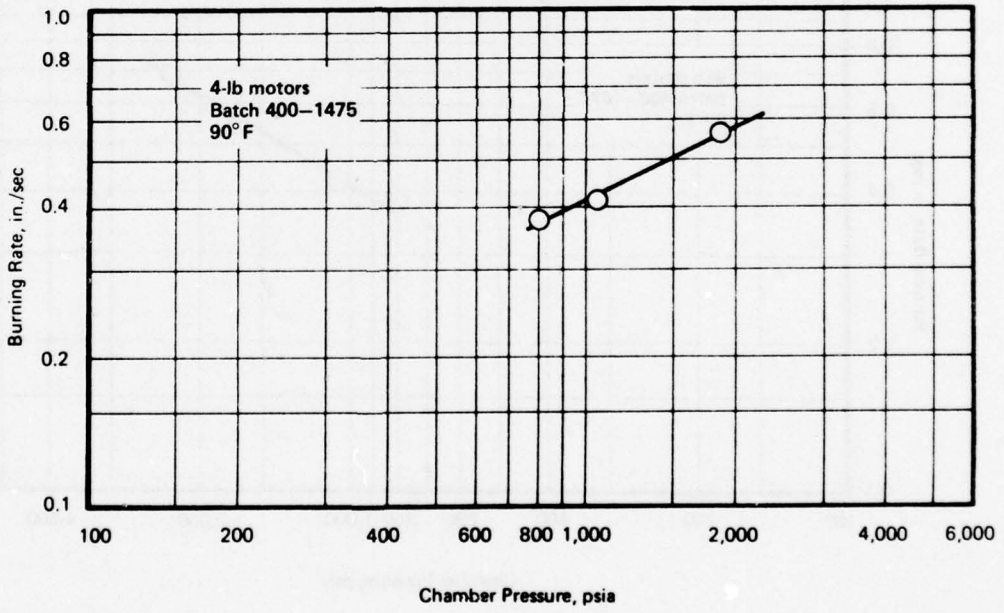

4-lb motors
Batch 400–1470
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

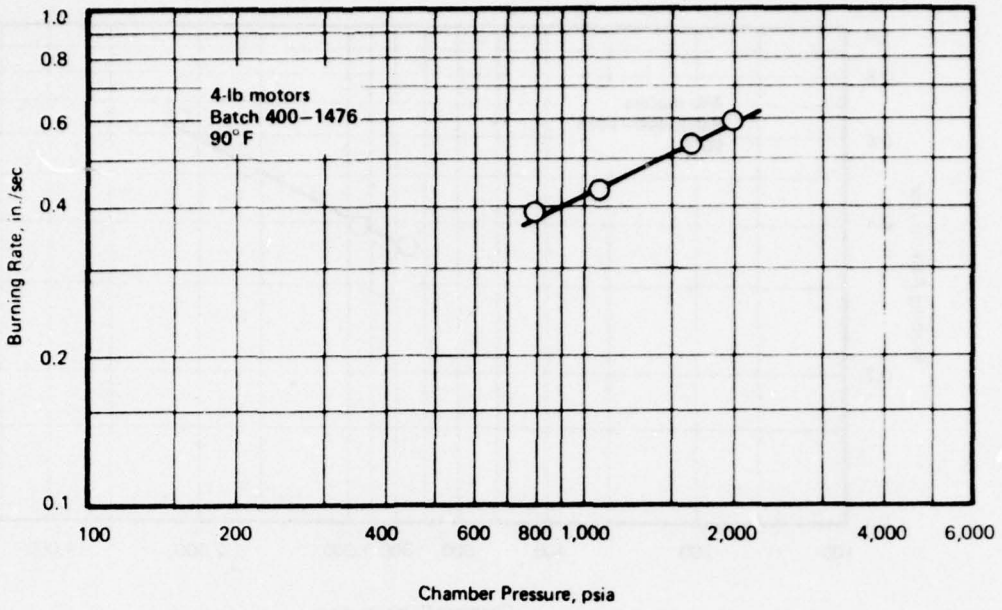

Batch 400–1471
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

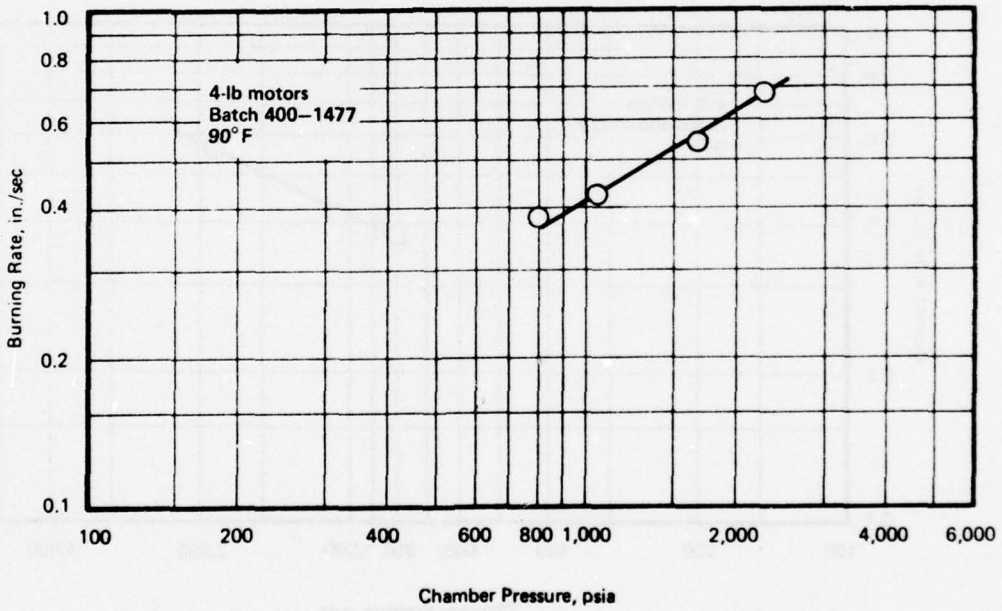

4-lb motors
Batch 400–1472
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

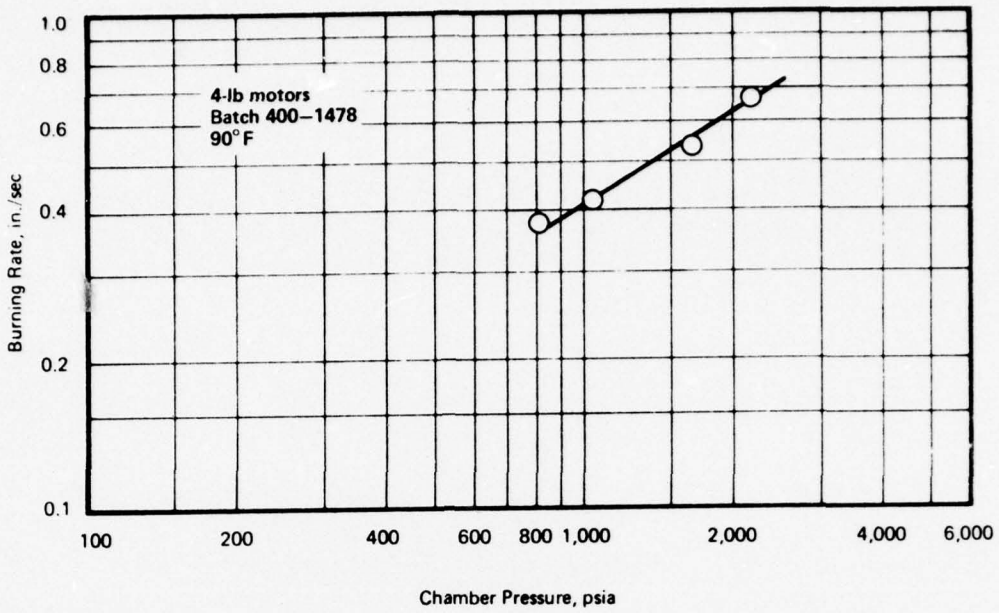

4-lb motors
Batch 400–1473
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

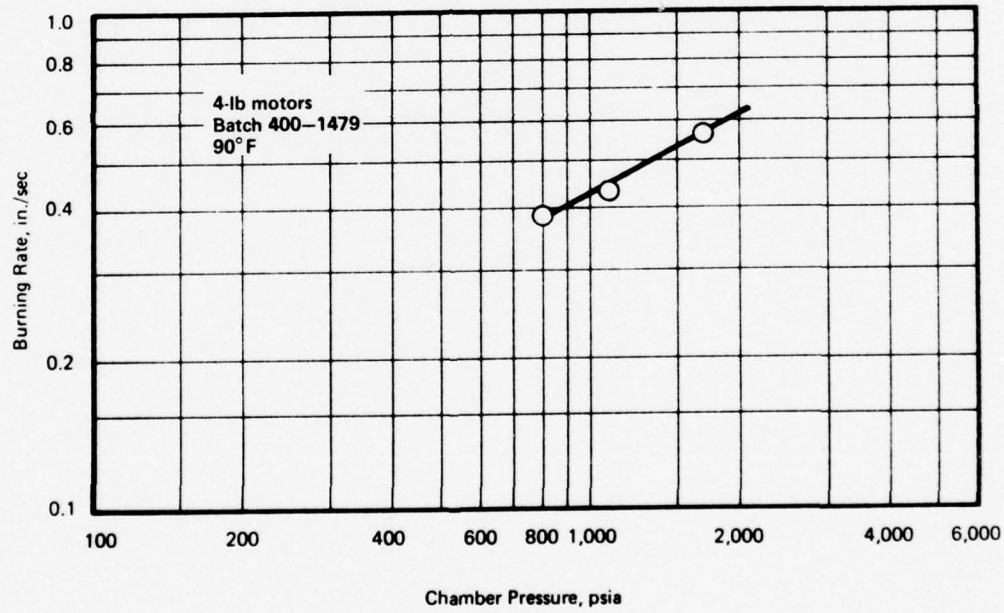

4-lb motors
Batch 400–1474
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1475
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1476
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1477
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1478
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1479
90° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

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SECTION 2.5

PRODUCTION RUN NO. 3

(BATCHES 400-1480 THROUGH 400-1491)

THIRD PRODUCTION CASTING, UTP-18,803A
BATCHES 400-1480 THROUGH 1491, 4-LB MOTOR DATA, 90°F

Batch	Grind Ratio	All Data			1000 thru 1700 psia		
		n	r_{1000} r_{1400} r_{1700}	G, %	n	r_{1000} r_{1400} r_{1700}	G, %
400-1480	65/35	.569	.394 .478 .533	2 pts	.569	.394 .478 .533	2 pts
400-1481	65/35	.523	.411 .490 .543	2 pts	.523	.411 .490 .543	2 pts
400-1482	65/35	.593	.409 .499 .560	2 pts	.593	.409 .499 .560	2 pts
400-1483	65/35	.497	.414 .489 .539	2 pts	.497	.414 .489 .539	2 pts
400-1484	65/35	.484	.415 .489 .537	2.1	.56	.404 .488 .544	1.2
400-1485	66/34	.472	.415 .486 .533	1.4	.536	.405 .485 .538	0.3
400-1486	66/34	.499	.419 .496 .546	0.8	.535	.413 .494 .548	0.2
400-1487	66/34	.442	.412 .478 .521	1.3	.527	.402 .481 .532	2 pts
400-1488	66/34	.457	.417 .486 .531	0.1	.457	.417 .486 .531	2 pts
400-1489	66/34	.437	.417 .484 .526	0.46	.466	.414 .484 .530	2 pts
400-1490	66/34	.495	.416 .492 .542	1.2	.585	.406 .494 .554	2 pts
400-1491	66/34	.419	.420 .484 .525	2.3	.553	.403 .486 .541	2 pts

THIRD PRODUCTION CASTING

UTP 18803A BATCHES 400-1480-1491

FOUR MOTOR DATA 90 F

Batch 400-	BURNING RATE, IN/SEC/CHAMBER PRESSURE, psia			
1480	0.3998/1024	0.5007/1521		
1481	0.4037/966	0.4809/1350		
1482	0.4024/974	0.4962/1387		
1483	0.4039/952	0.4863/1383		
1484	0.3714/768	0.4091/1014	0.4809/1398	0.5377/1638
1485	0.3681/759	0.4214/1074	0.4829/1398	0.5366/1683
1486	0.3615/736	0.4379/1118	0.5165/1512	0.5538/1738
1487	0.3792/816	0.4207/1088	0.4869/1436	
1488	0.3747/792	0.4323/1085	0.4979/1475	
1489	0.3821/812	0.436/1118	0.4971/1481	
1490	0.3862/848	0.4348/1124	0.5022/1438	
1491	0.4025/872	0.4282/1115	0.5026-1490	

UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
THIRD PRODUCTION CASTING

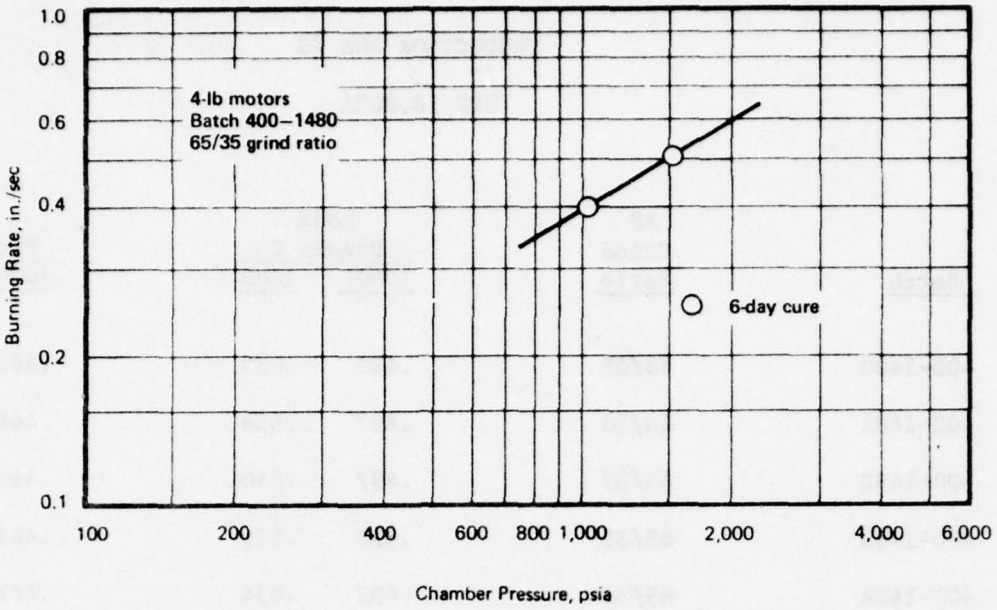
Parameter	400 Gallon Batch													
	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	$\bar{X}$	Sx
Grind ratio	65/35	65/35	65/35	65/35	65/35	66/34	66/34	66/34	66/34	66/34	66/34	66/34		
NCO/OH	0.85													
Fuel premix number	3500-3													
IPDI @ 1 hr after addition, wt %	0.38	0.38	0.38	0.36	0.36	0.37	0.37	0.36	0.37	0.38	0.37	0.38	0.372	0.0084
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	4.6	4.1	4.9	5.6	5.7	6.5	2.6	6.9	6.1	5.9	7.7	7.1	5.64	1.42
Max. corrected stress at 75°F, $\sigma^c m$, psi	160	149	156	135	147	145	152	144	142	142	151	154	148	6.99
Max. corrected strain at 75°F, $\varepsilon^c m$, %	31	33	32	31	38	36	37	37	37	31	35	38	34.7	2.87
True strain @ 75°F rupture, E_r, %	32	34	33	31	39	37	38	38	37	32	36	39	35.5	2.94
Initial tangent modulus, E_o, psi	844	933	1092	1036	880	1124	1100	1000	918	1104	808	836	973	117

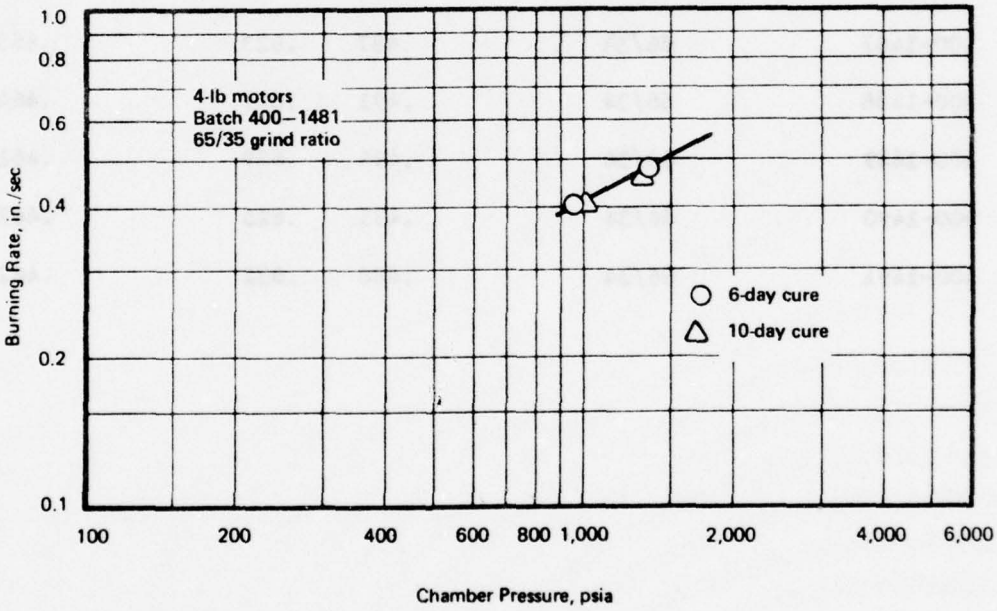
Cartridge lost in 23 May 76 fire

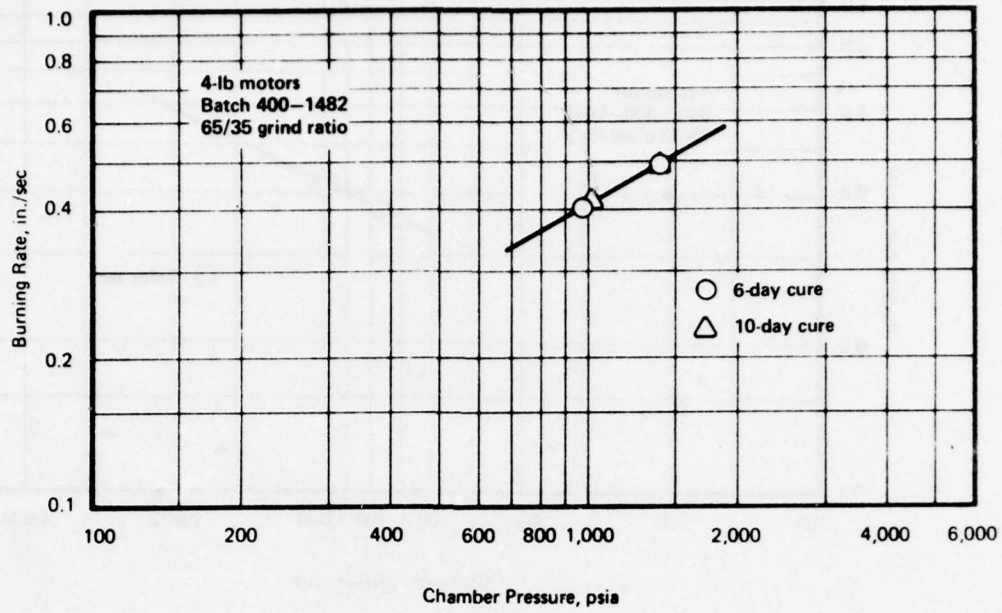
PRODUCTION RUN #3

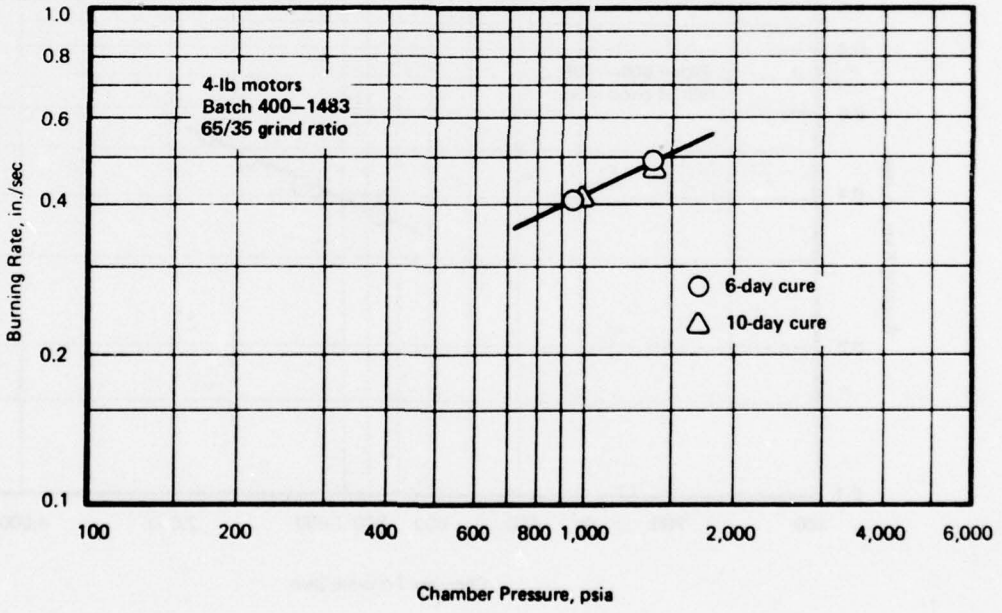
UTP 18,803A

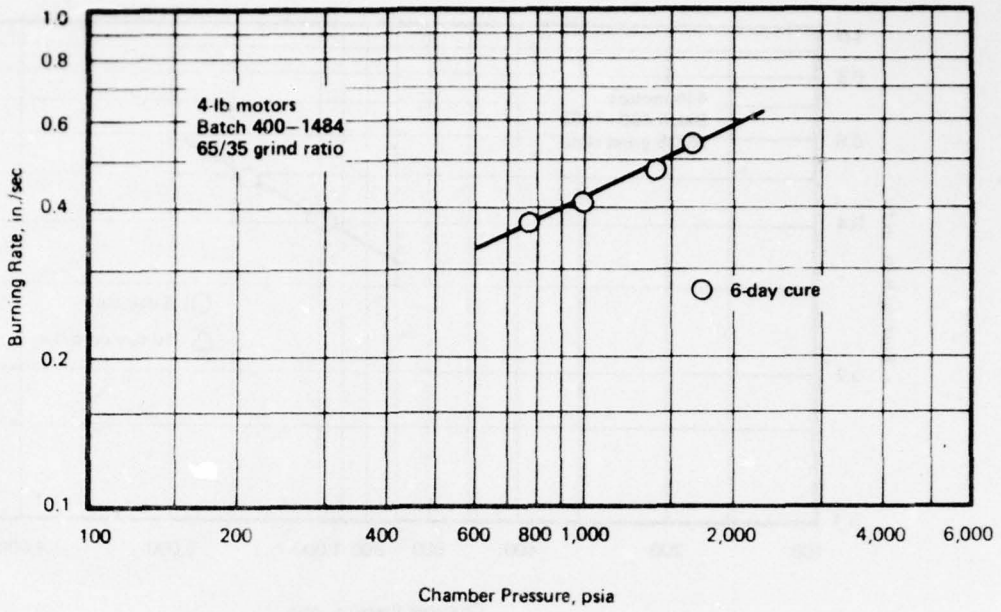
Batch	AP Grind Ratio	LSBR Premix C		LSBR Propellant	
		1000	1400	1000	1400
400-1480	65/35	.493	.632	.462	.588
400-1481	65/35	.497	.634	.464	.588
400-1482	65/35	.497	.640	.468	.592
400-1483	65/35	.493	.635	.462	.587
400-1484	65/35	.492	.634	.461	.588
400-1485	66/34	.485	.623	.463	.589
400-1486	66/34	.487	.621	.461	.581
400-1487	66/34	.487	.623	.463	.581
400-1488	66/34	.491	.627	.464	.587
400-1489	66/34	.494	.629	.461	.579
400-1490	66/34	.491	.625	.462	.580
400-1491	66/34	.488	.632	.462	.589

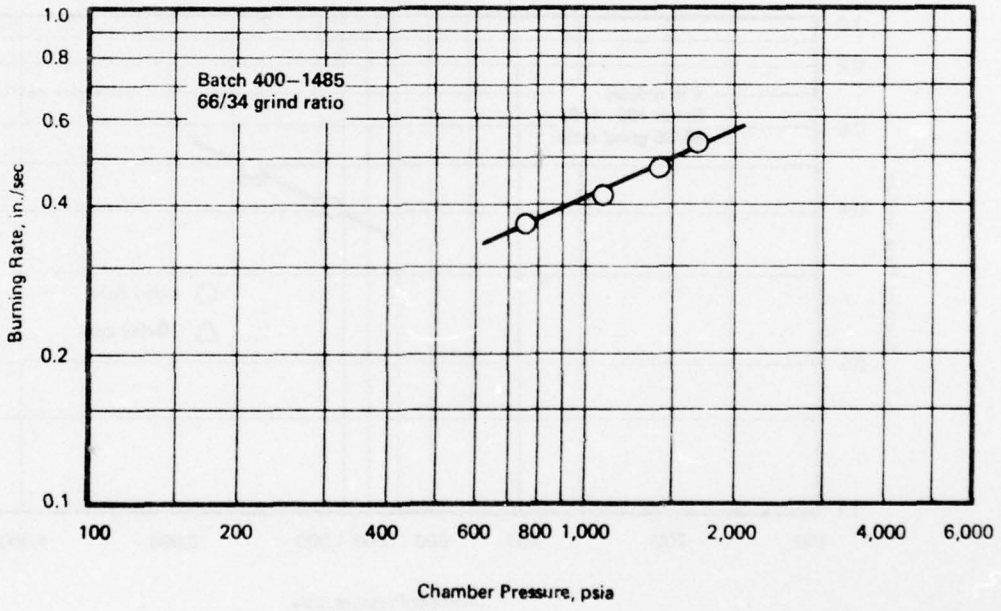

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1480
65/35 grind ratio
6-day cure
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

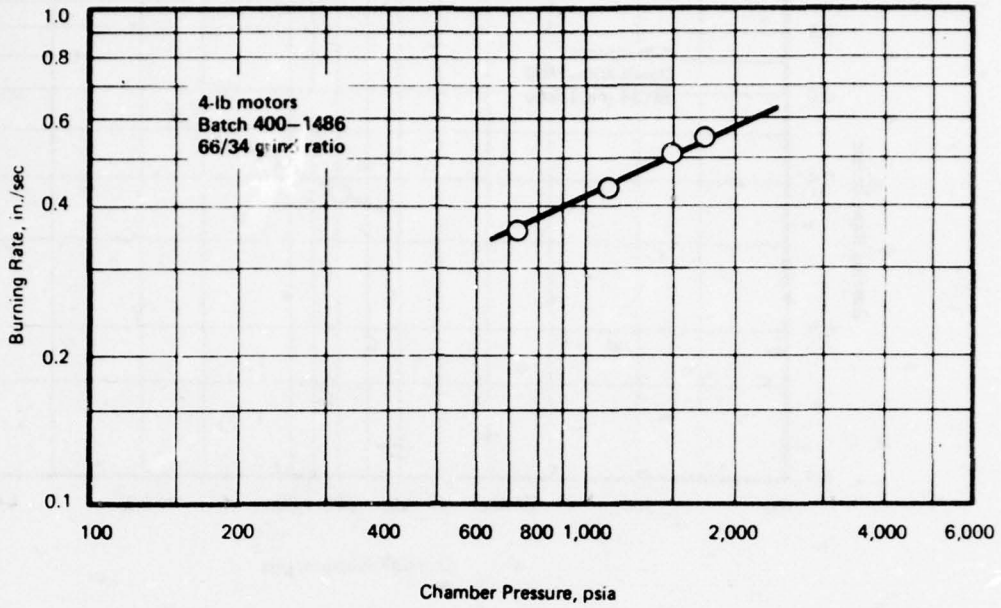

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1481
65/35 grind ratio
6-day cure
10-day cure
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

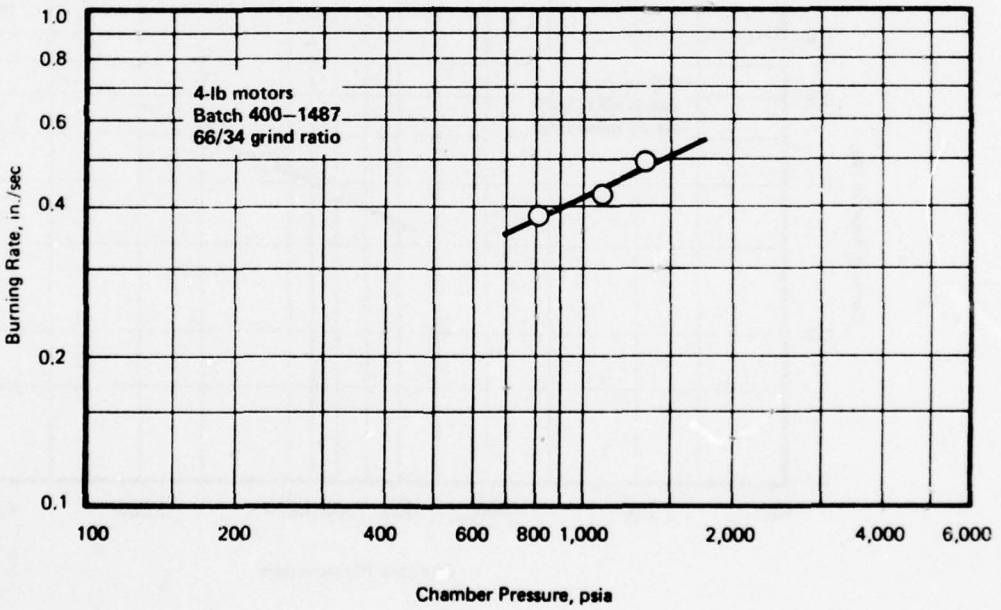

4-lb motors
Batch 400–1482
65/35 grind ratio
6-day cure
10-day cure
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

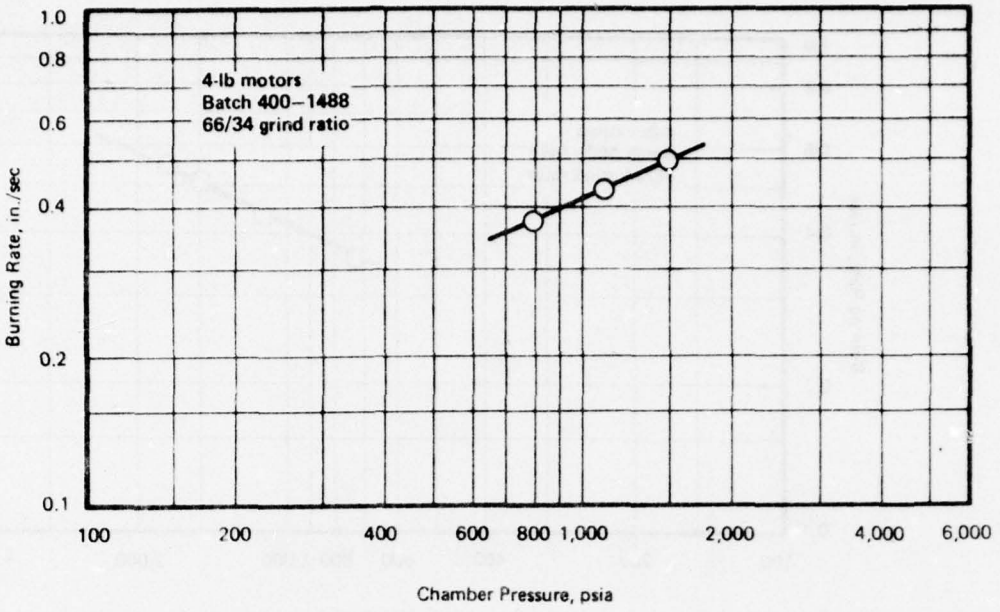

4-lb motors
Batch 400–1483
65/35 grind ratio
6-day cure
10-day cure
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

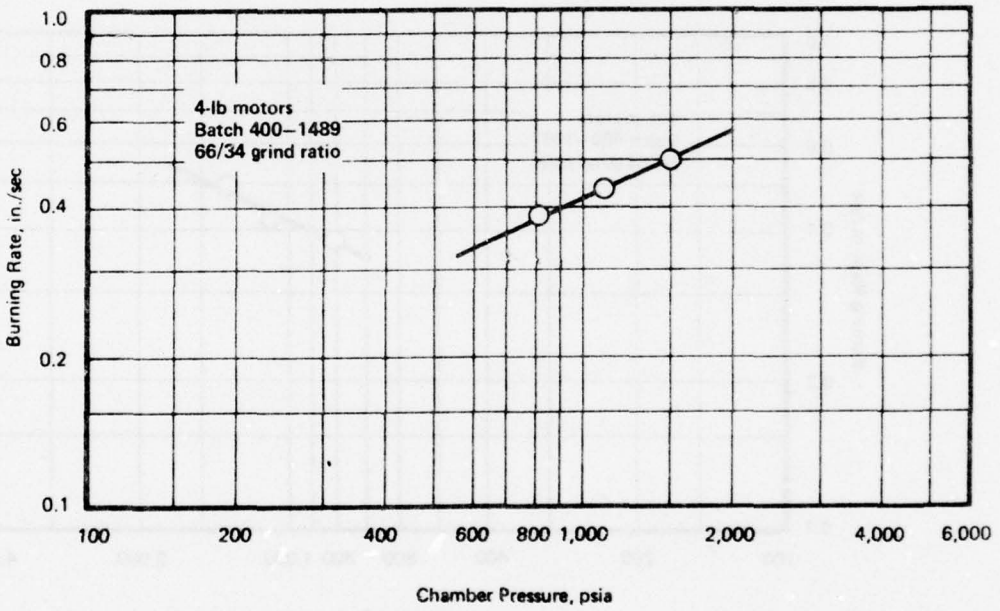

4-lb motors
Batch 400–1484
65/35 grind ratio
6-day cure
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

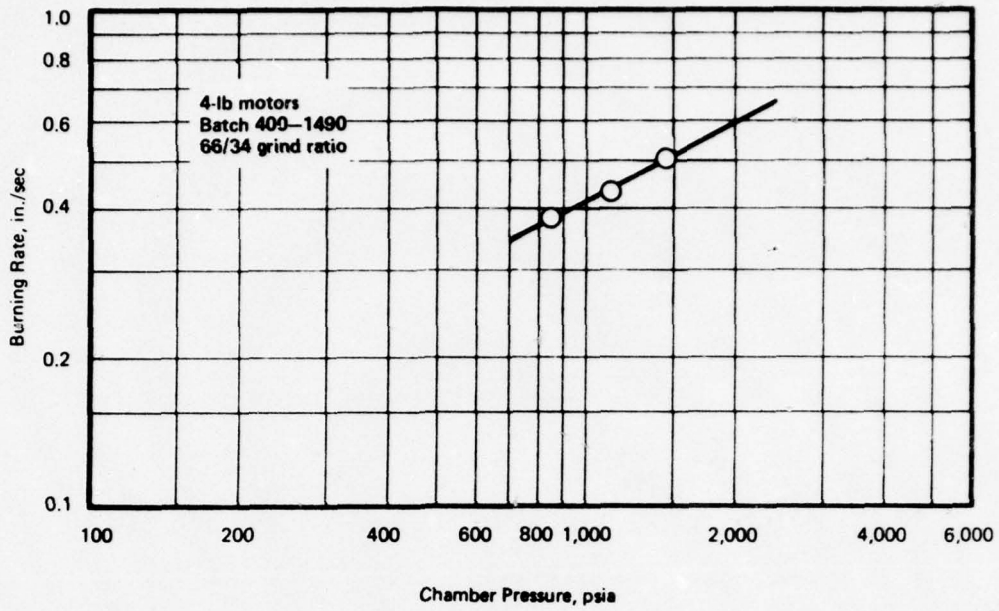

Batch 400–1485
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

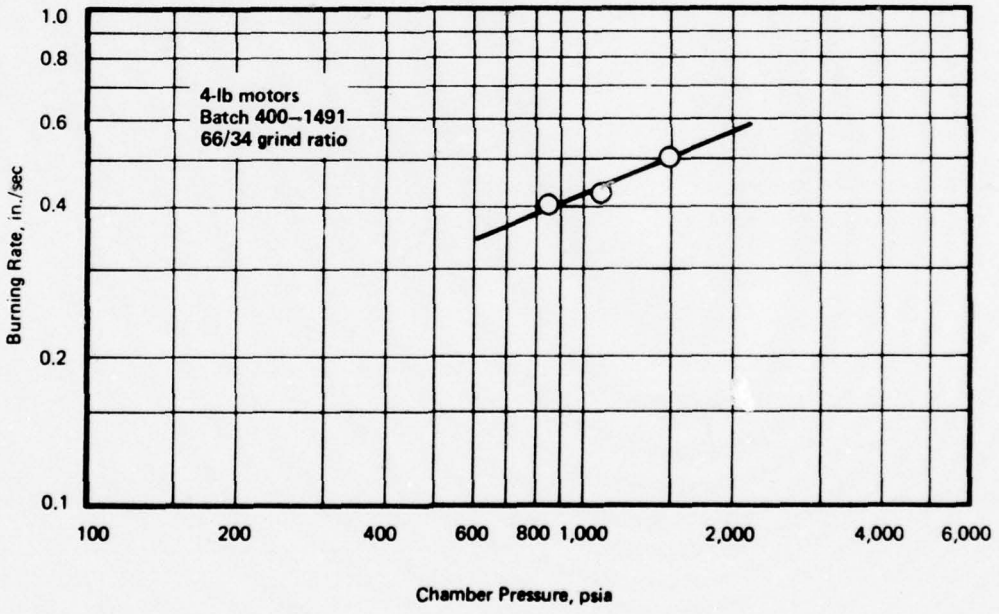

4-lb motors
Batch 400–1486
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1487
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1488
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1489
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1490
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1491
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

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SECTION 2.6

PRODUCTION RUN NO. 2A

(BATCHES 400-1495 THROUGH 400-1503)

PRODUCTION CASTING #2A

UTP 18803A

BATCHES 400-1495 THROUGH 1503

76°F

Batch	Grind Ratio	All Data r_{1000} r_{1400} r_{1700}	Pressure Exponent	One Standard Deviation, %
400-1495	66/34	0.423 0.507 0.563	0.538	0.4
400-1496	66/34	0.426 0.508 0.563	0.529	1.0
400-1497	66/34	0.419 0.502 0.557	0.540	0.8
400-1498	66/34	0.416 0.499 0.554	0.538	2.1
400-1499	66/34	0.413 0.488 0.537	0.493	1.6
400-1500	66/34	0.416 0.491 0.540	0.492	1.3
400-1501	66/34	0.413 0.482 0.528	0.465	2.1
400-1502	66/34	0.417 0.499 0.553	0.529	1.6
400-1503	66/34	0.418 0.493 0.543	0.490	2.0
Composite of 1495-1503		0.418 0.497 0.550	0.517	2.1

PRODUCTION CASTING #2A

UTP 18803A 66/34 Grind Ratio

BATCHES 400-1495 Thru 1503

76°F

Batch	Chamber Pressure, psia	Burning Rate, in/sec
400-1495	1451	.520
	1830	.5829
	879	.3937
	1263	.4793
400-1496	1490	.5297
	1781	.5761
	905	.4068
	1082	.4378
400-1497	1498	.5251
	1789	.5711
	901.5	.3976
	1122	.4411
400-1498	1470	.5229
	1711	.5507
	861	.3893
	1036	.4140
400-1499	1406	.4872
	1682	.5378
	876	.3933
	1037	.4116
400-1500	1450	.4950
	1760	.5546
	902	.4003
	1070	.4243
400-1501	1434	.4818
	1710	.5378
	849	.390
	1023	.4074
400-1502	1457	.4983
	1782	.576
	869	.3895
	1040	.4270
400-1503	1383	.4839
	1730	.555
	861	.3966
	1024	.4143

PRODUCTION CASTINGS #2A AND 3A

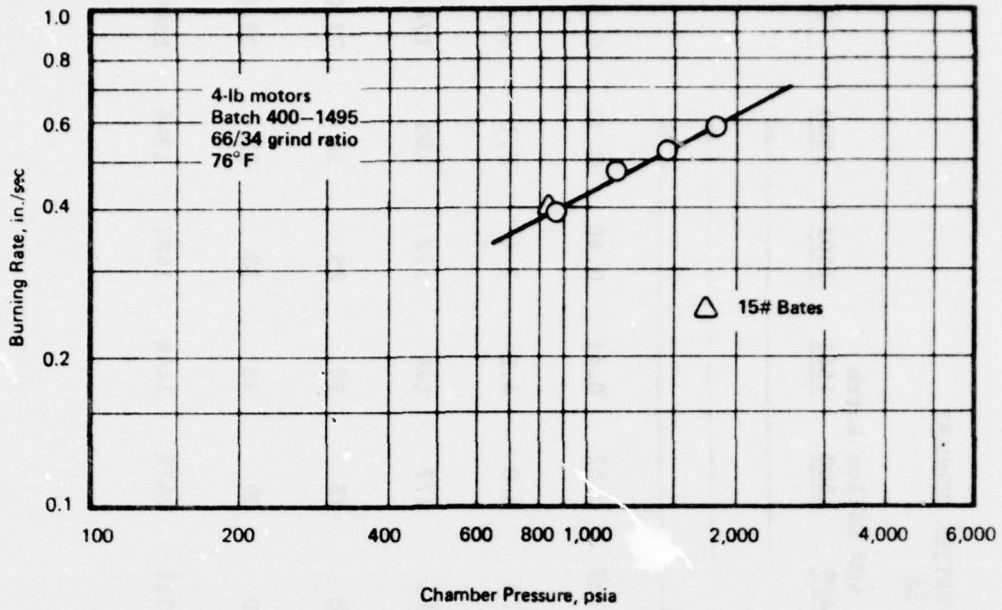
ELSH LSBR Results
UTP 18803A

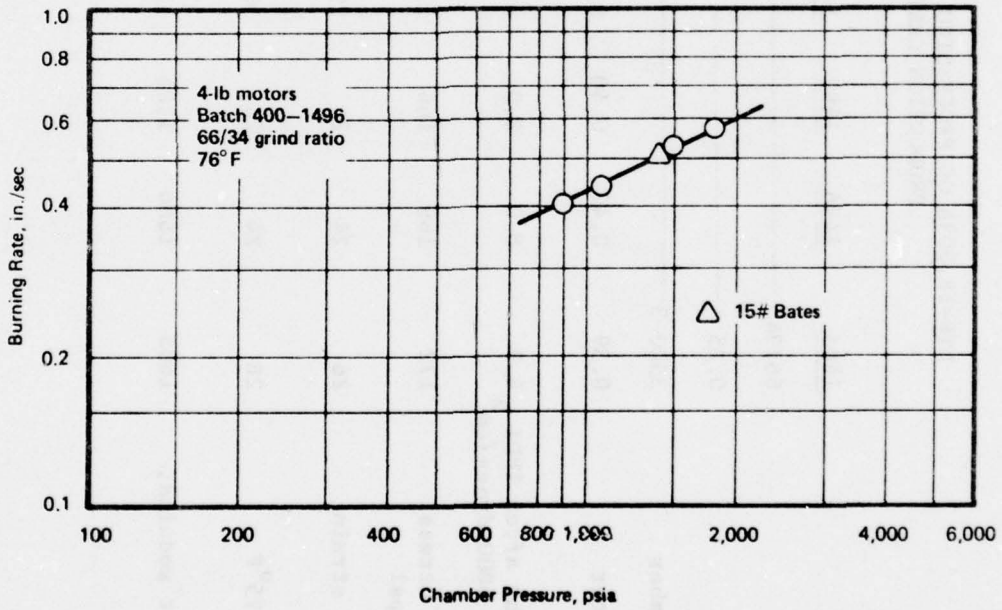
	Premix "C"		Propellant	
Batch	1000 psig	1400 psig	1000 psig	1400 psig
400-1495	0.490	0.632	0.464	0.591
400-1496	0.493	0.639	0.468	0.612
400-1497	0.497	0.644	0.472	0.603
400-1498	0.501	0.642	0.470	0.602
400-1499	0.483	0.623	0.463	0.584
400-1500	0.495	0.634	0.470	0.595
400-1501	0.495	0.632	0.465	0.589
400-1502	0.495	0.638	0.468	0.602
400-1503	0.489	0.639	0.464	0.597
400-1505	0.482	0.620	0.460	0.584
400-1506	0.496	0.634	0.472	0.591
400-1507	0.495	0.634	0.468	0.595
400-1508	0.492	0.650	0.462	0.594
400-1509	0.487	0.632	0.461	0.591
400-1510	0.491	0.635	0.463	0.593
400-1511	0.485	0.618	0.460	0.585
400-1512	0.495	0.628	0.472	0.593
400-1513	0.492	0.632	0.464	0.593
400-1514	0.494	0.632	0.466	0.585
400-1515	0.494	0.643	0.467	0.599

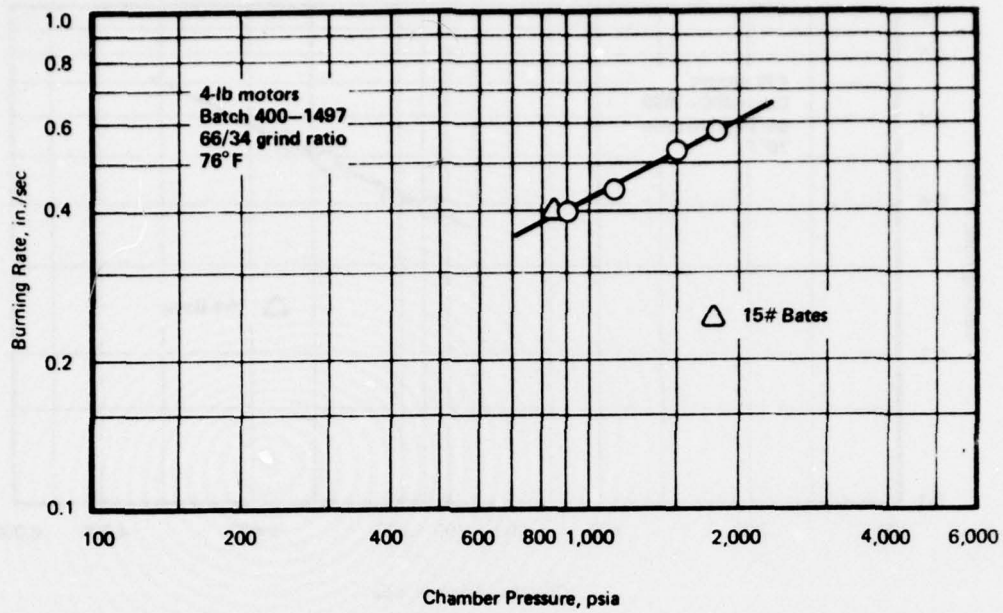
		400-1495	400-1499	400-1503
MSA	10%	3.0	3.7	3.2
	50%	9.2	11.0	9.8
	90%	24	27	26

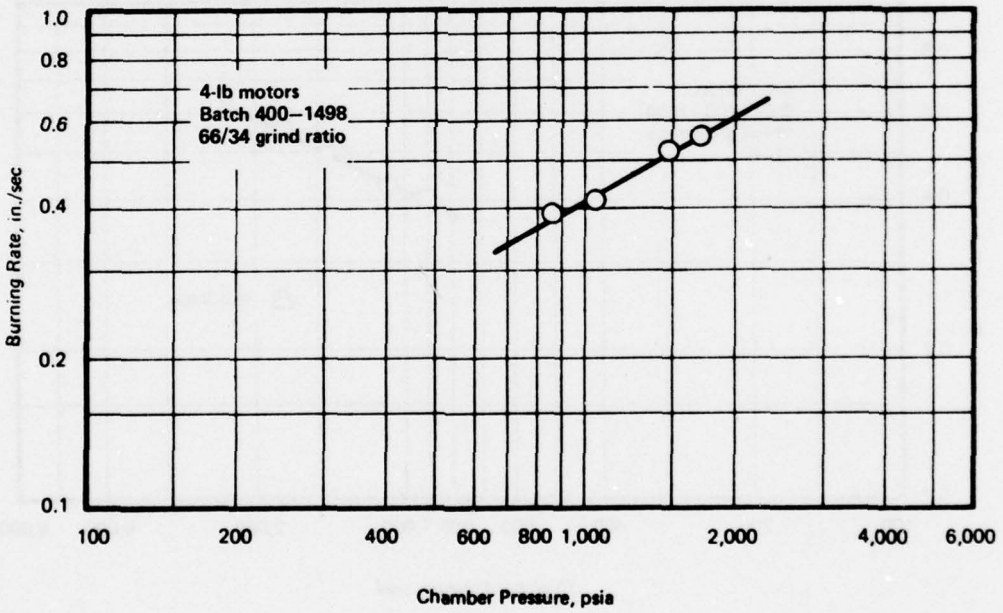
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 2A

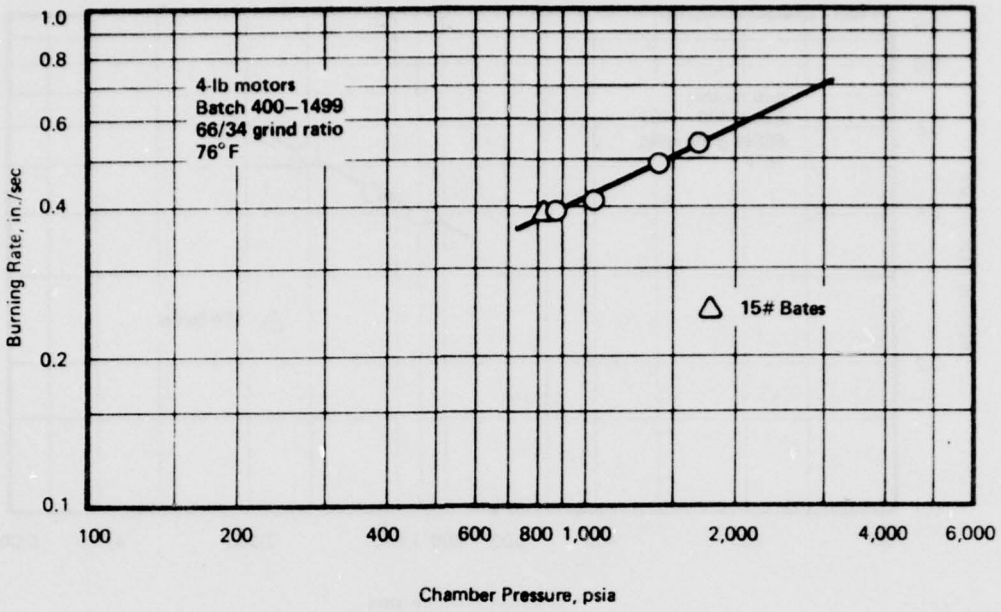
Parameter	400 Gallon Batch 1495	1496	1497	1498	1499	1500	1501	1502	1503	$\bar{X}$	Sx
Grind ratio	66/34 →										
NCO/OH	0.85 →										
Fuel premix number	3500-3 →										
IPDI @ 1 hr after addition, wt %	0.39	0.42	0.40	0.40	0.39	0.42	0.41	0.40	0.30	0.403	0.011
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	4.9	8.0	8.0	6.5	5.5	6.0	6.0	7.4	7.1	6.6	1.1
Max. corrected stress at 75^{o}F, $\sigma^{c}m$, psi	172	169	166	179	181	177	174	172	180	174	5.17
Max. correctes strain @ 75^{o}F, $\varepsilon^{c}m$, %	26	24	24	29	28	28	28	25	31	27.0	2.4
True strain @ 75^{o}F rupture, E_r, %	28	24	24	30	30	30	30	30	33	28.8	2.99
Initial tangent modulus, E_o, psi	1605	1666	1764	1577	1536	1479	1444	1482	1346	1540	125

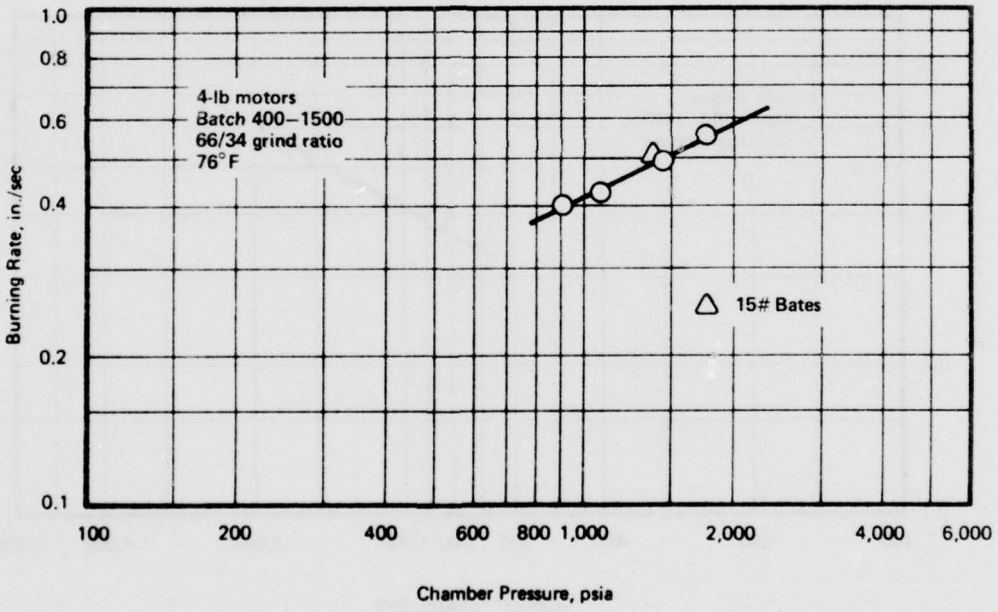

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1495
66/34 grind ratio
76° F
△ 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

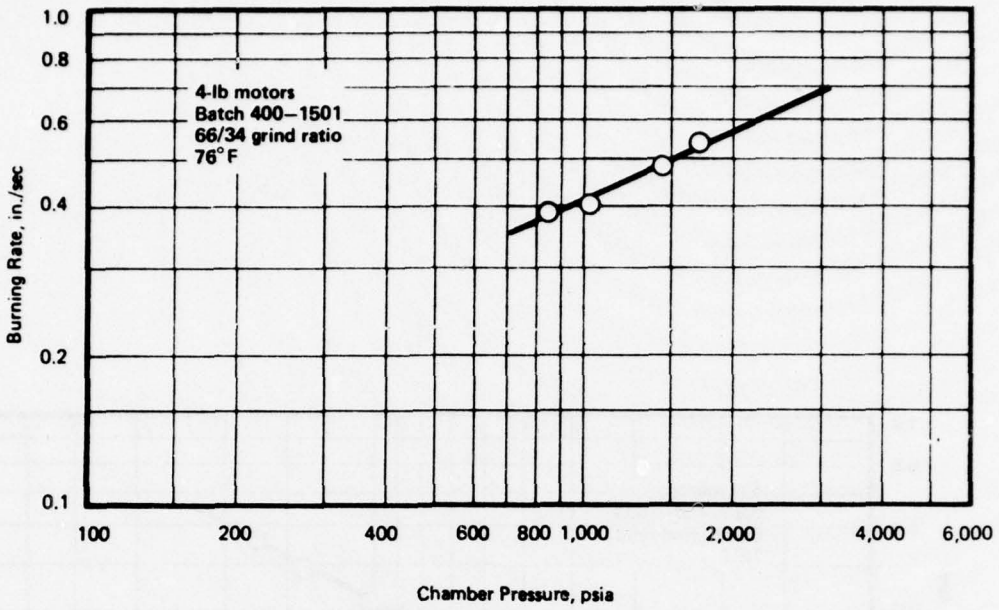

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1496
66/34 grind ratio
76° F
△ 15# Bates
100
200
400
600
800
2,000
4,000
6,000
Chamber Pressure, psia

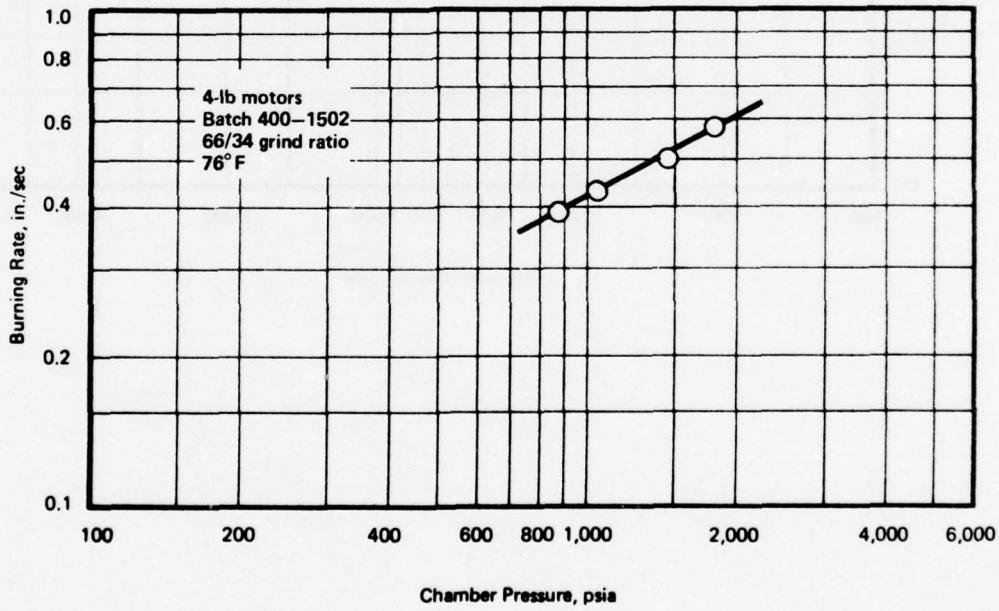

4-lb motors
Batch 400–1497
66/34 grind ratio
76°F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

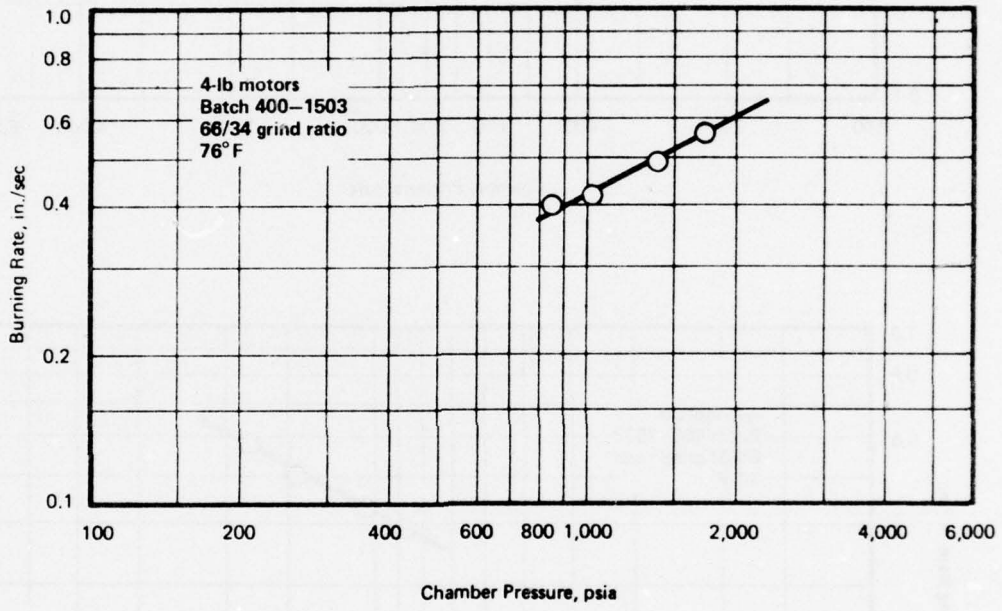

4-lb motors
Batch 400–1498
66/34 grind ratio
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1499
66/34 grind ratio
76°F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1500
66/34 grind ratio
76°F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1501
66/34 grind ratio
76°F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1502
66/34 grind ratio
76°F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1503
66/34 grind ratio
76°F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.7

PRODUCTION RUN NO. 3A

(BATCHES 400-1505 THROUGH 400-1515)

PRODUCTION CASTING #3A

UTP 18803A 66/34 GRIND RATIO

4 LB MOTOR 90 F BATCHES 400-1505-1515

400 Gallon Batch	Burning Rate, in/sec @ 1000 psia	@ 1400 psia	@ 1700 psia	Exponent	σ, %
1505	.4036	.4771	.5253	.497	1.4
1506	.4167	.4963	.5490	.520	2.0
1507	.4127	.4903	.5415	.512	1.6
1508	.4173	.4941	.5446	.502	0.6
1509	.4128	.4935	.5470	.531	1.6
1510	.4127	.4920	.5445	.523	0.3
1511	.4121	.4902	.5419	.516	0.8
1512	.4103	.5009	.5621	.594	2.3
1513	.4213	.5017	.5549	.519	2.0
1514	.4194	.5019	.5566	.534	1.7
1515	.4192	.5030	.5589	.542	0.2
Composite	.4142	.4949	.5484	.529	2.0

PRODUCTION CASTING #3A

UTP 18803A 66/34 GRIND RATIO

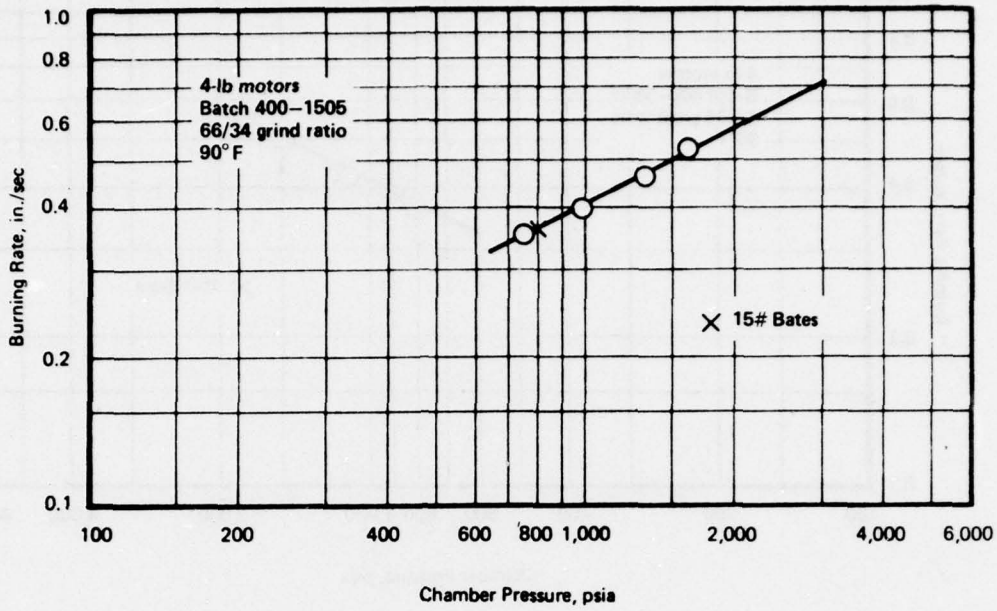
BATCH 400-1505-1515 4 LB MOTOR 90°F

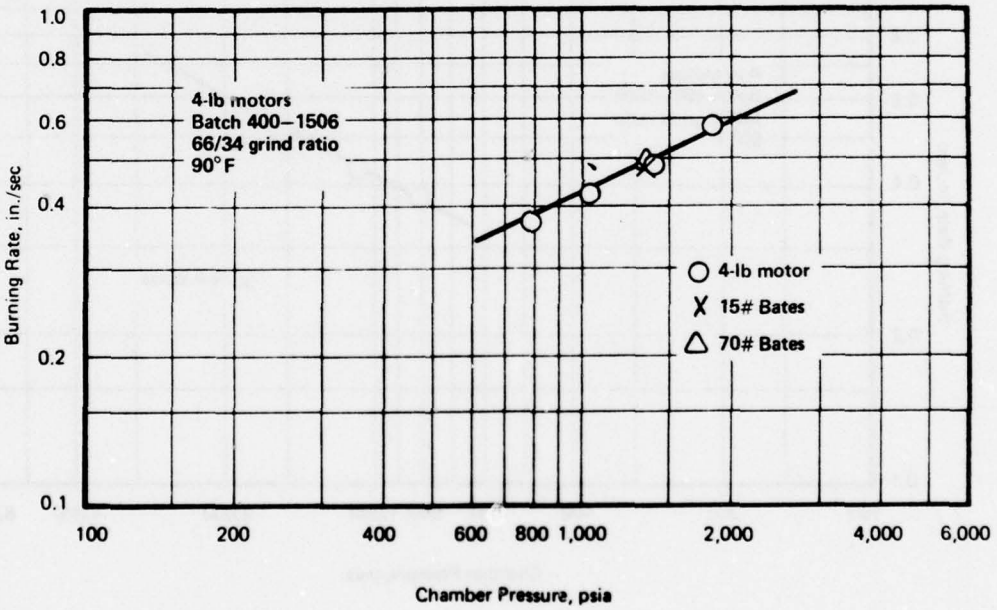
400 Gallon Batch					
1505	$\underline{r}$, in/sec	.3554	.3985	.4629	.5223
	P, psia	760	990	1361	1630
1506	$\underline{r}$, in/sec	.3769	.4209	.4864	.5812
	P, psia	801	1042	1404	1831
1507	$\underline{r}$, in/sec	.3731	.4238	.5033	.5558
	P, psia	800	1097	1487	1747
1508	$\underline{r}$, in/sec	.3806	.4324	.5159	.5538
	P, psia	826	1084	1544	1734
1509	$\underline{r}$, in/sec	.3727	.4214	.5075	.5605
	P, psia	813	1054	1528	1720
1510	$\underline{r}$, in/sec	.3718	.4318	.5201	.5457
	P, psia	823	1083	1552	1716
1511	$\underline{r}$, in/sec	.3717	.4260	.5064	.555
	P, psia	808	1088	1494	1764
1512	$\underline{r}$, in/sec	.3786	.415	.5060	.597
	P, psia	842	1064	1458	1826
1513	$\underline{r}$, in/sec	.3798	.4259	.5173	.5687
	P, psia	795	1065	1520	1721
1514	$\underline{r}$, in/sec	.3915	.4261	.5248	.5727
	P, psia	854	1071	1543	1752
1515	$\underline{r}$, in/sec	.3758	.4404	.5201	.5781
	P, psia	816	1097	1496	1802

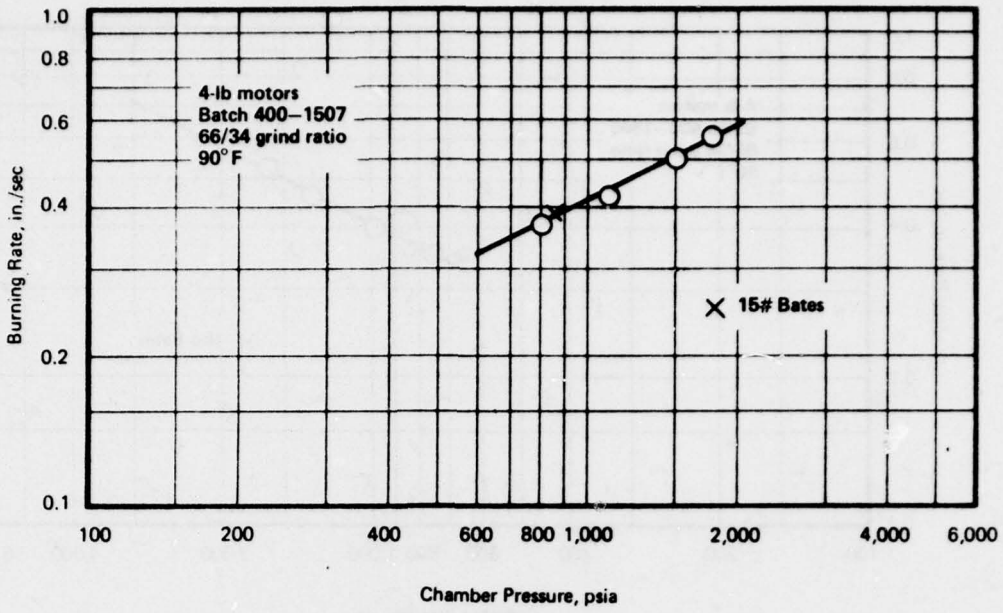
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 3A

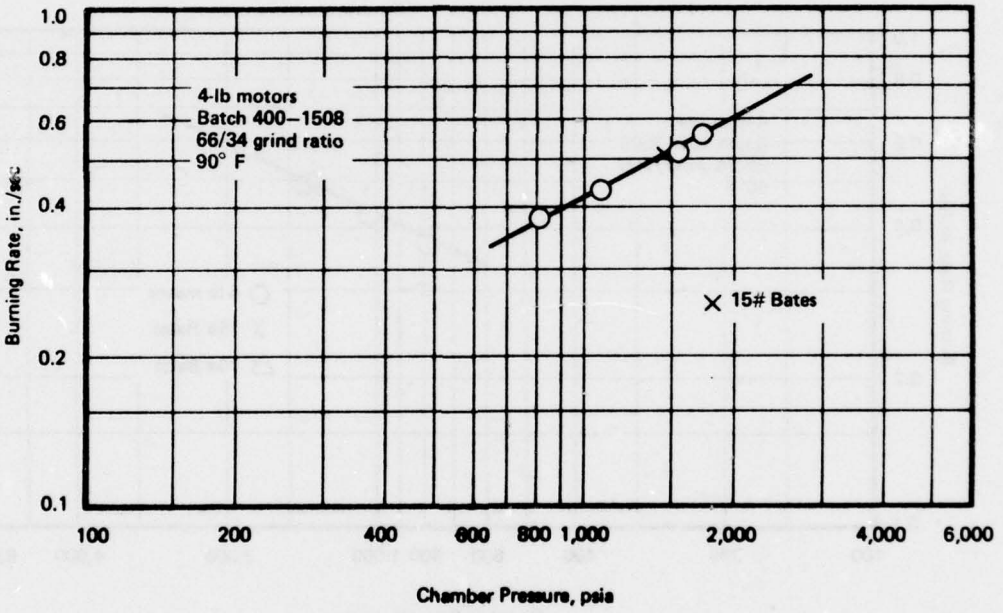
Parameter	400 Gallon Batch 1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	$\bar{X}$	Sx
Grind ratio	66/34	←	←	←	←	←	←	←	←	←	←		
NCO/OH	0.82	←	←	←	←	←	←	←	←	←	←		
Fuel premix number	3500-4	←	←	←	←	←	←	←	←	←	←		
IPDI @ 1 hr after addition, wt %	0.40	0.39	0.40	0.38	0.38	0.38	0.39	0.40	0.40	0.38	0.38	0.389	0.0094
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	3.8	5.7	8.5	5.5	4.8	4.5	6.4	8.3	5.3	6.1	5.3	5.84	1.46
Max. corrected stress @ 75°F, σ^c_m, psi	98	129	126	121	127	124	120	132	126	128	131	124	9.34*
Max. corrected strain @ 75°F, ε^c_m, %	36	31	31	27	35	35	32	34	35	36	30	32.9	2.91
True strain @ 75°F rupture, Er, %	38	32	32	30	36	36	33	34	36	37	30	34.0	2.79
Initial tangent modulus, E_o, psi	534	930	744	1057	894	822	669	717	670	732	786	778	144

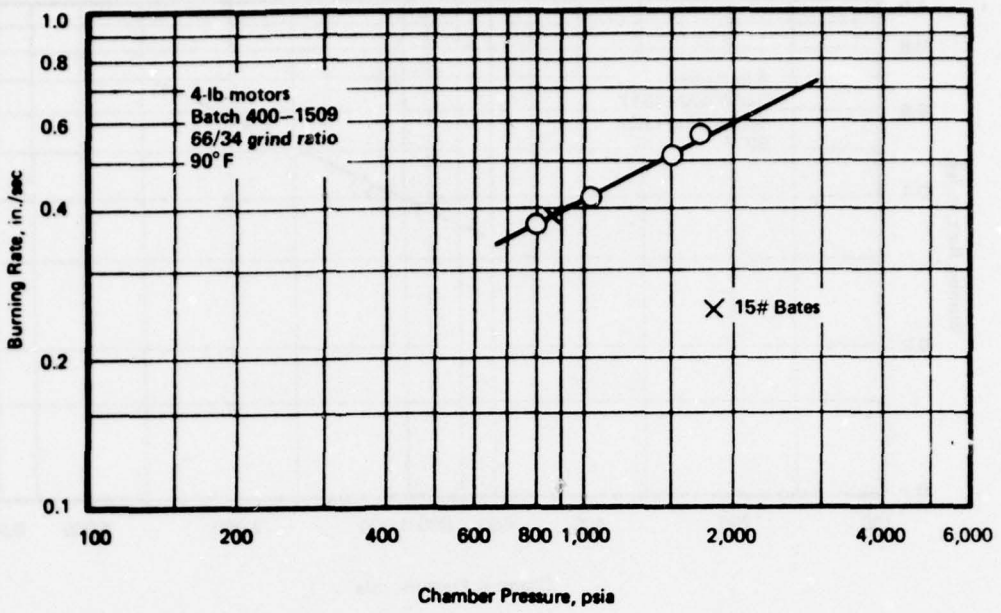
* $\bar{X}$ = 126 and S_x = 3.92 if eliminate 400-1505

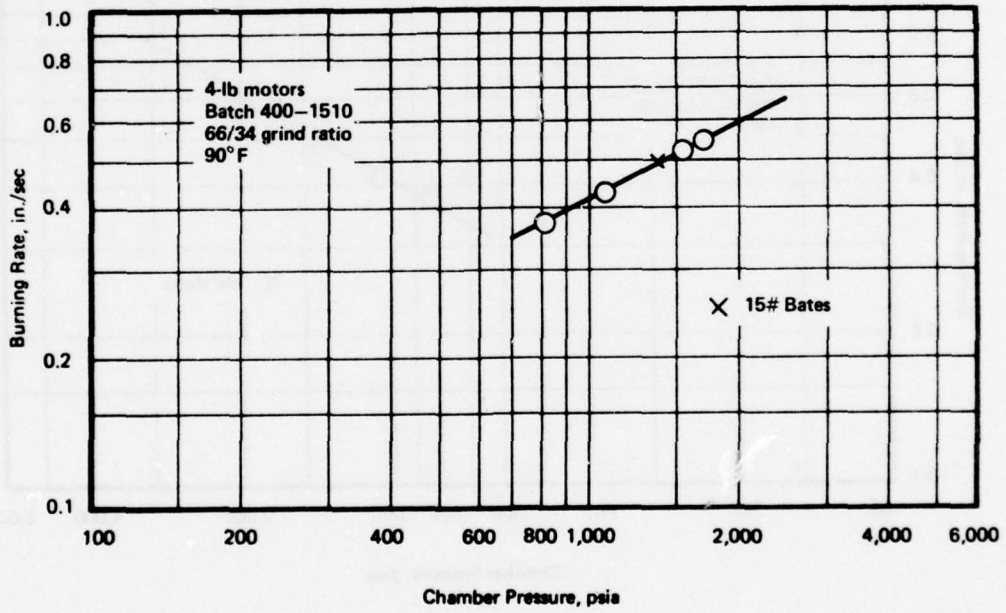

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1505
66/34 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

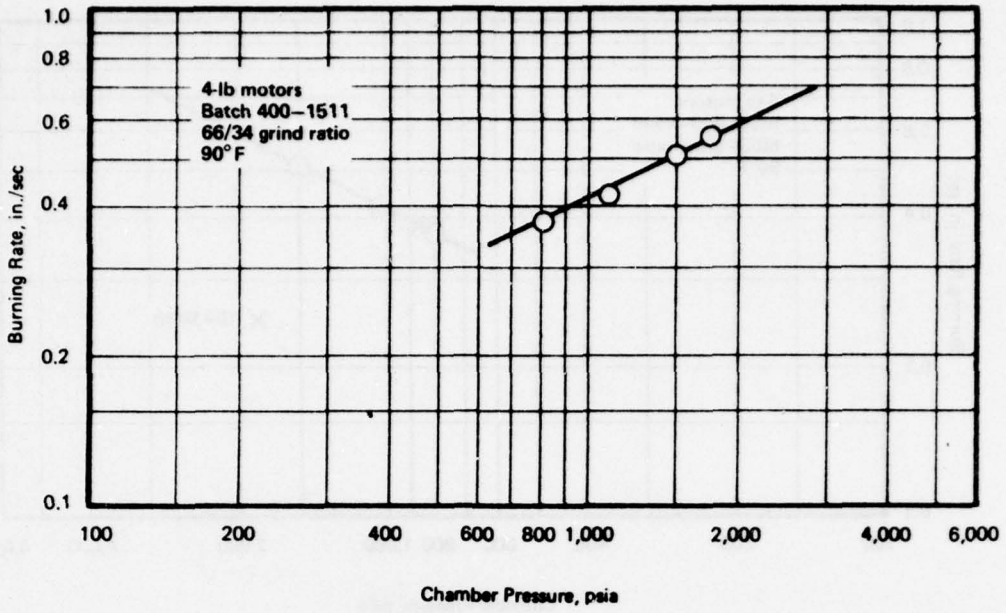

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1506
66/34 grind ratio
90° F
4-lb motor
15# Bates
70# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

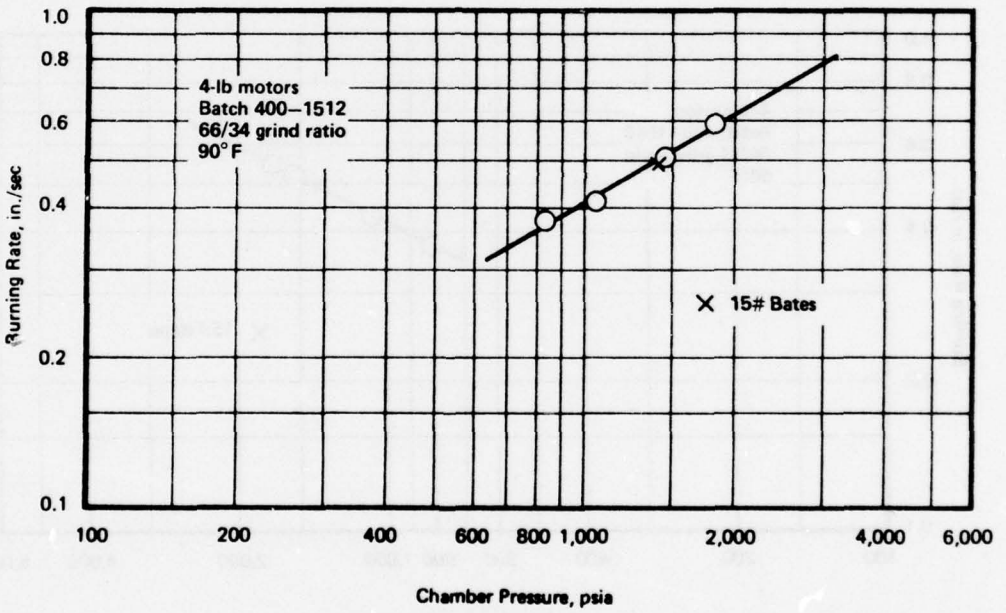

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1507
66/34 grind ratio
90° F
X 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

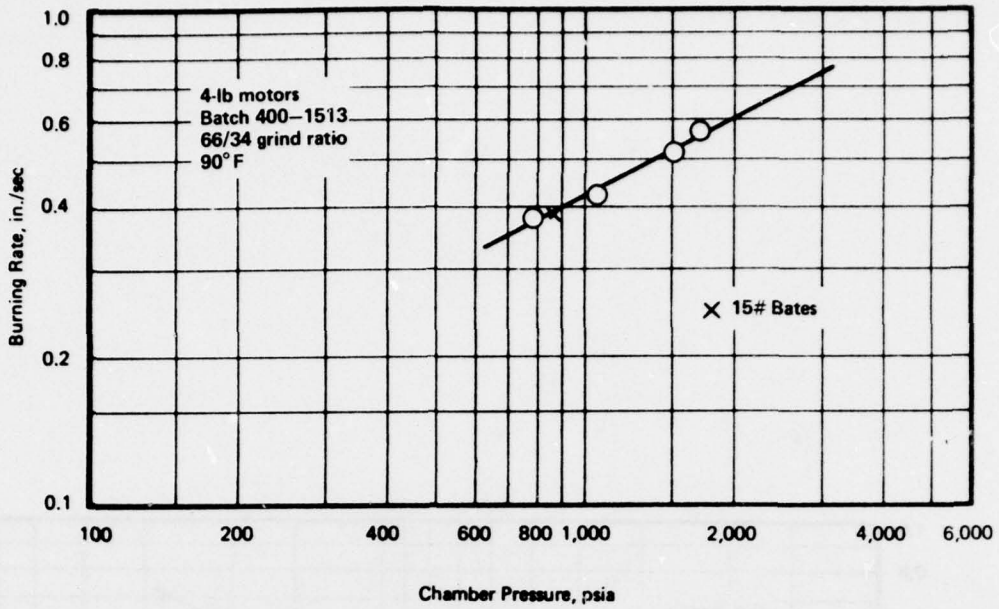

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1508
66/34 grind ratio
90° F
X 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

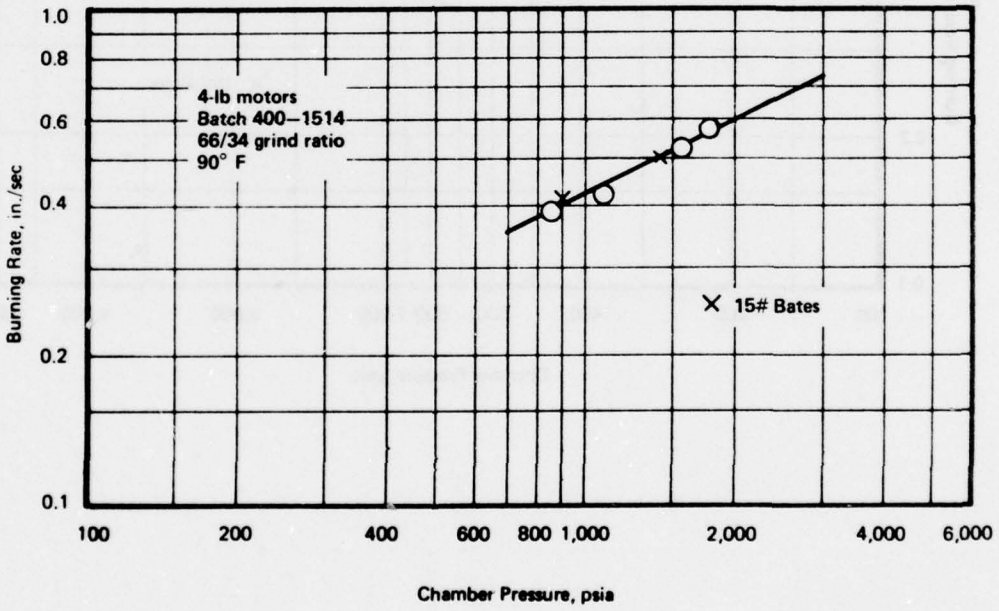

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1509
66/34 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

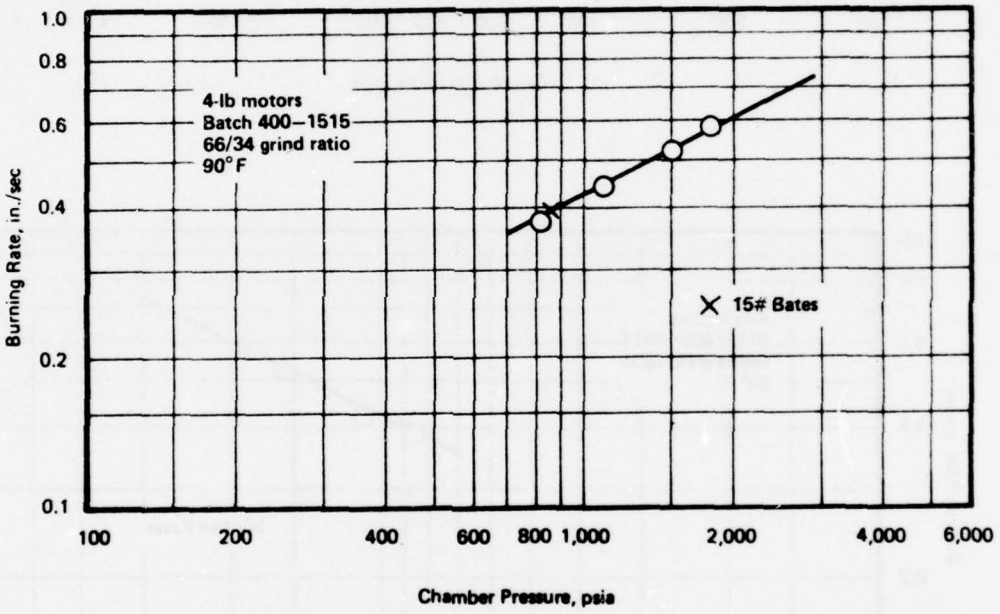

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1510
66/34 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

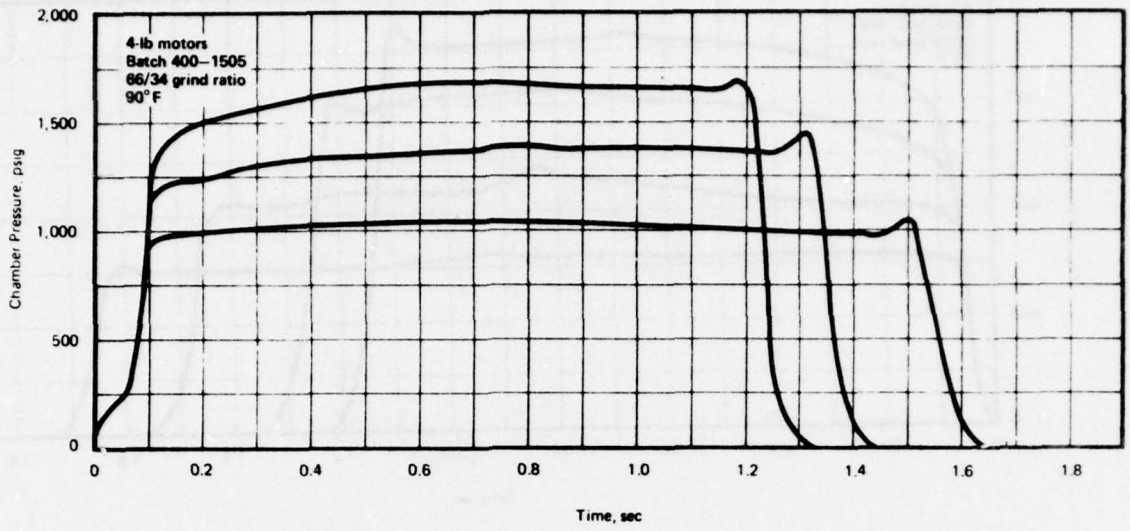

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1511
66/34 grind ratio
90° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

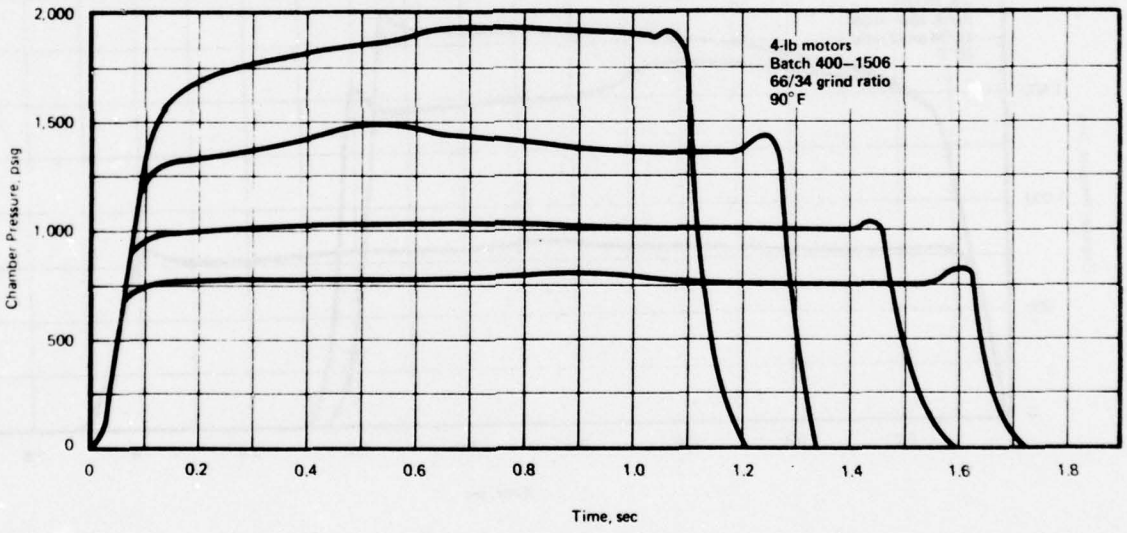

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1512
66/34 grind ratio
90° F
X 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

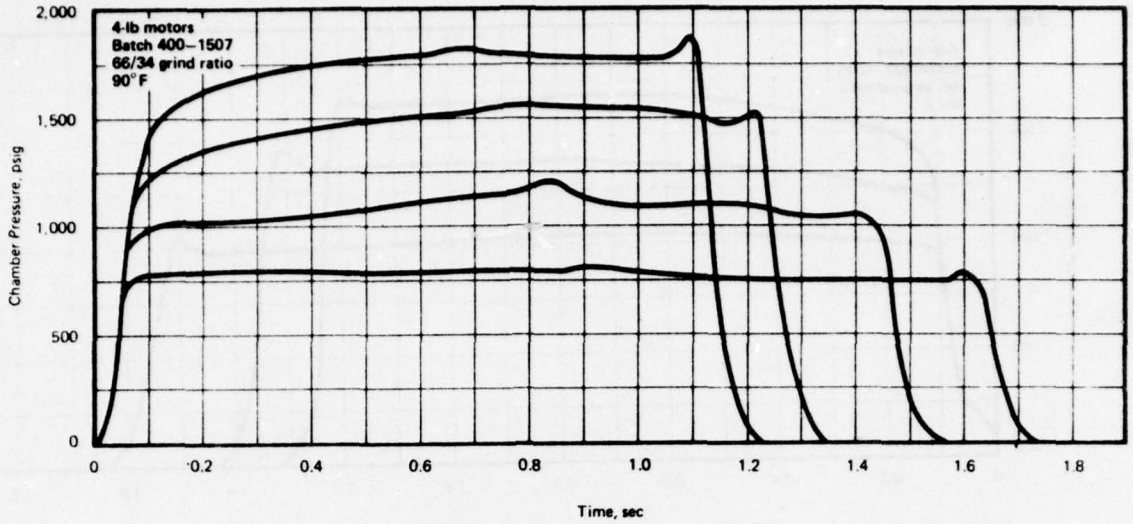

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1513
66/34 grind ratio
90° F
× 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

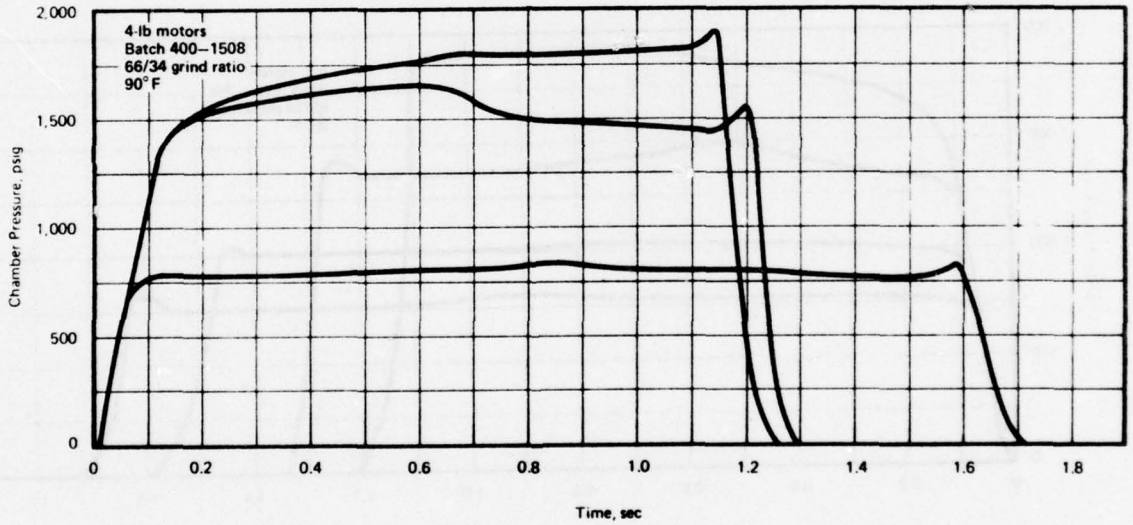

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1514
66/34 grind ratio
90° F
× 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1515
66/34 grind ratio
90° F
X 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1505
66/34 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1506
66/34 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1507
66/34 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1508
66/34 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

SECTION 2.8

PRODUCTION RUN NO. 4

(BATCHES 400-1516 THROUGH 400-1526)

PRODUCTION CASTING #4

UTP 18803A 68/32 GRIND RATIO

4-LB MOTOR, 90°F, BATCHES 400-1516-1524

400-Gallon Batch	Burning Rate, in/sec			Exponent	σ, %
	1000 psia	1400 psia	1700 psia		
400-1516	.4014	.4665	.5088	.446	1.2
400-1517	.4046	.4728	.5173	.463	.51
400-1518	.4001	.4762	.5266	.517	.80
400-1519	.4006	.4710	.5171	.481	.28
400-1520	.4061	.4711	.5133	.441	1.1
400-1521	.4034	.4766	.5248	.496	1.2
400-1522	.4022	.4688	.5122	.456	.96
400-1523	.4020	.4720	.5178	.477	.82
400-1524	.4014	.4728	.5197	.487	1.7
400-1525	.3989	.4693	.5154	.483	.29
Composite 1516-1525	.4021	.4715	.5168	.473	1.30

90°F UTP 18803A 66/34 GRIND RATIO

400-1526	.4123	.4879	.5377	.500	1.52

PRODUCTION CASTING #4

18803 68/32 GRIND RATIO

BATCH 400-1516-1524, 4-LB MOTOR, 90°F

400-Gallon Batch	$\dot{r}$, in/sec	P, psia
1516	.3652	792
	.3964	1,001
	.4624	1,409
	.4914	1,521
1517	.3675	802
	.4060	1,030
	.4666	1,357
	.4882	1,490
1518	.3663	834
	.3914	978
	.4625	1,297
	.4780	1,425
1519	.3651	820
	.4026	1,019
	.4719	1,410
	.4898	1,510
1520	.3649	769
	.4010	996
	.4598	1,360
	.4995	1,551
1521	.3683	820
	.4000	1,016
	.4786	1,366
	.4983	1,555
1522	.3558	755
	.3997	984
	.4436	1,293
	.5159	1,680
1523	.3657	802
	.3964	1,005
	.4848	1,467
	.5100	1,642
1524	.3599	767
	.3881	985
	.4550	1,316
	.5178	1,638

400-Gallon Batch	$\dot{r}$, in/sec	P, psia
1525	.5100	1,650
	.4772	1,460
	.4039	1,031
	.3558	786
	66/34 Grind Ratio	
1526	.558	1,778
	.489	1,449
	.411	1,016
	.3699	787

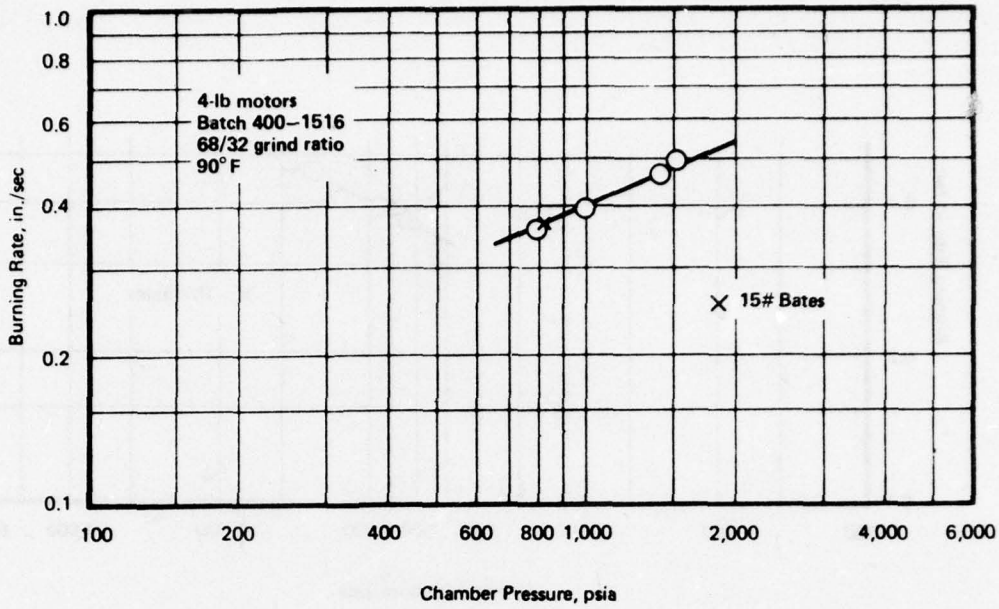
PRODUCTION CASTING #4

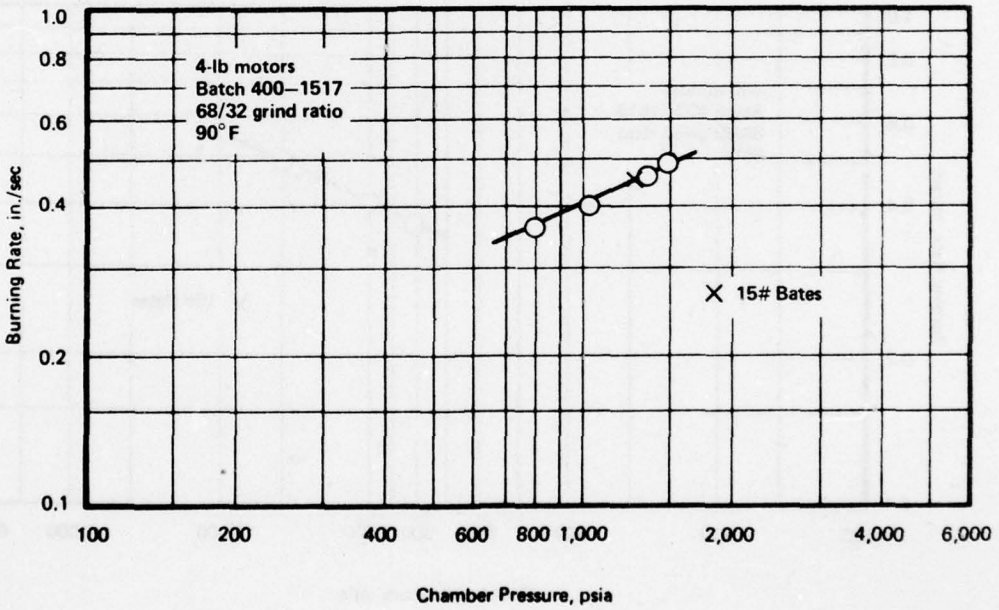
LSBR - UTP.18,803A

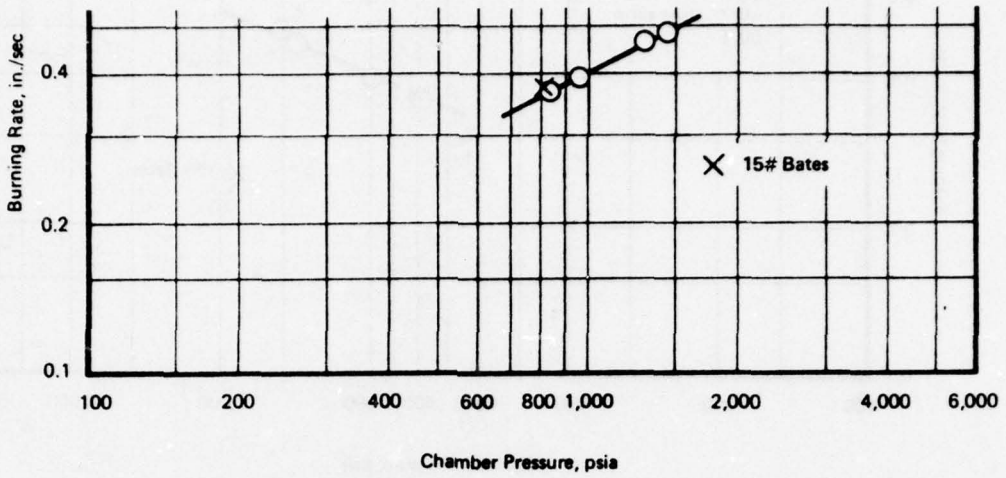
Batch	Pressure	Premix C	Propellant	Ratio	Curative Ratio
400-1516	1000	.480	.453	68/32	0.82
	1400	.621	.572		
400-1517	1000	.481	.454	68/32	0.82
	1400	.613	.575		
400-1518	1000	.482	.456	68/32	0.82
	1400	.613	.578		
400-1519	1000	.481	.448	68/32	0.82
	1400	.605	.564 & .560		
400-1520	1000	.475	.447	68/32	0.82
	1400	.603	.565		
400-1521	1000	.472	.445	68/32	0.82
	1400	.603	.562		
400-1522	1000	.464	.442	68/32	0.82
	1400	.598	.557		
400-1523	1000	.473	.448	68/32	0.82
	1400	.600	.562		
400-1524	1000	.473	.444	68/32	0.82
	1400	.598	.560		
400-1525	1000	.472	.446	68/32	0.82
	1400	.601	.565		
400-1526	1000	.487	.444 & .443	66/34	0.82
	1400	.627	.561 & .555		

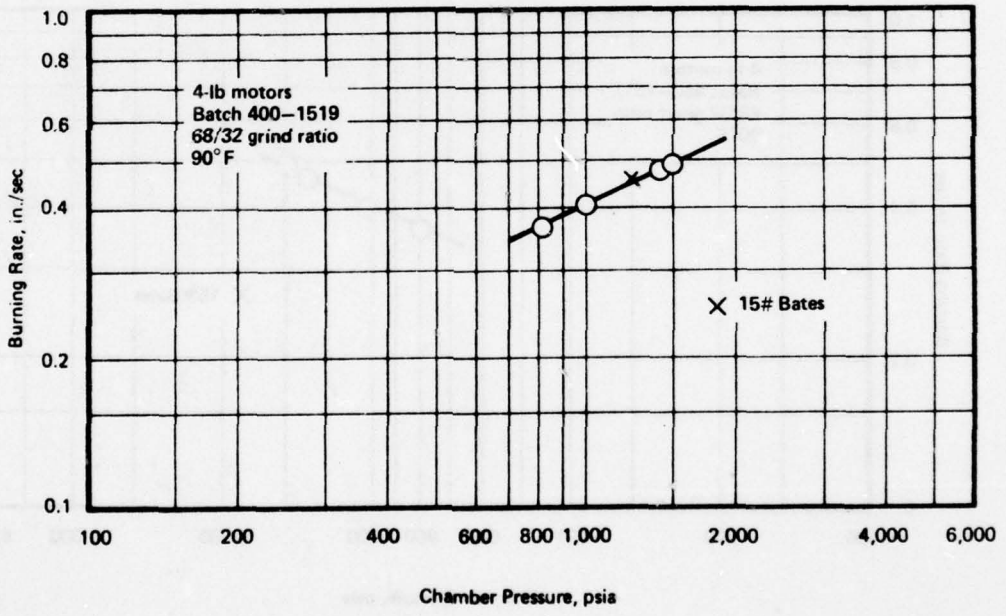
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 4

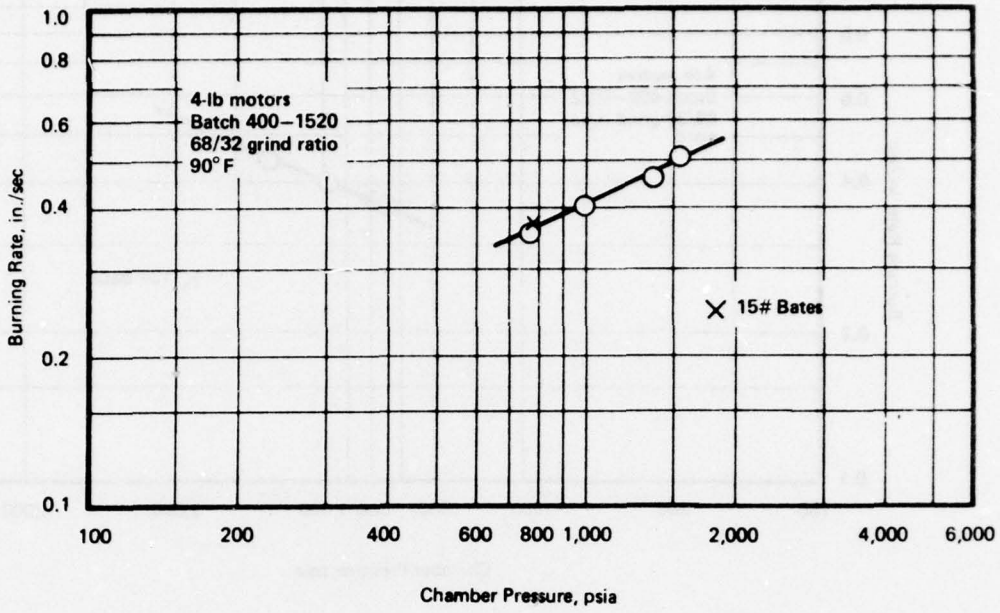
Parameter	400 Gallon Batches 1516	1517	1518	1519	1520	1521	1522	1523	1524	1525	1526	$\bar{X}$	Sx
Grind ratio	68/32 →										66/34		
NCO/OH	0.82 →												
Fuel premix number	3500-5 →												
IPDI @ 1 hr after addition, wt %	0.37	0.38	0.37	0.35	0.37	0.34	0.37	0.38	0.37	0.37	0.28	0.359	0.0029
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	5.3	4.65	4.28	3.43	4.14	4.40	5.57	4.55	4.45	4.42	4.93	4.56	0.0058
Max corrected stress @ 75°F, $\sigma^c m$, psi	112	116	120	114	115	110	113	114	113	115	114	114	2.52
Max corrected strain @ 75°F, $\varepsilon^c m$, %	34	31	40	36	42	34	38	33	36	40	40.	36.7	3.52
True strain @ 75°F rupture, Er, %	35	32	41	38	43	36	39	34	37	41	42	38.0	3.55
Initial tangent Modulus, E_o, psi	561	649	651	488	468	536	508	653	594	636	568	575	69.5

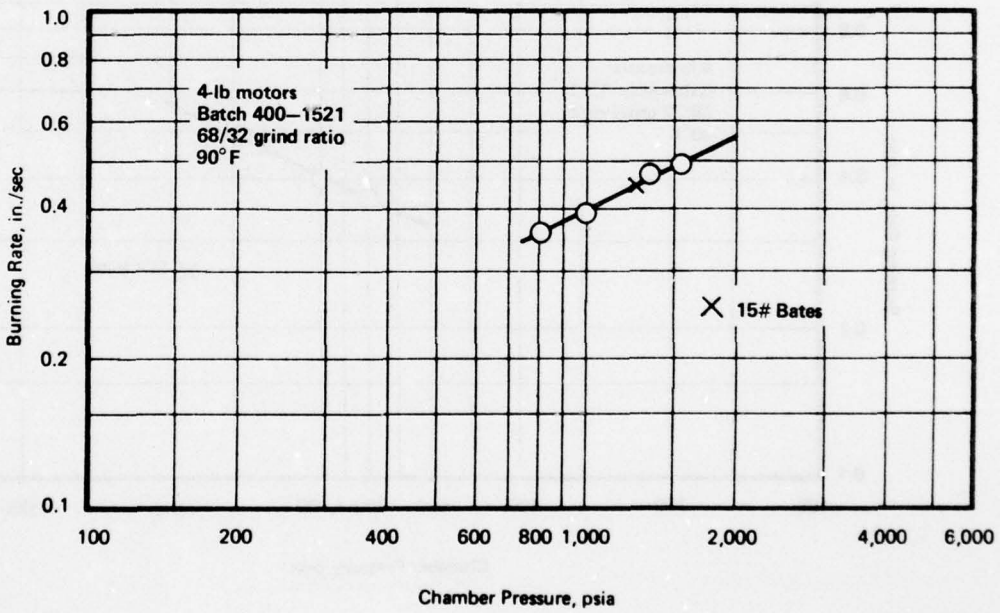

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1516
68/32 grind ratio
90° F
× 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

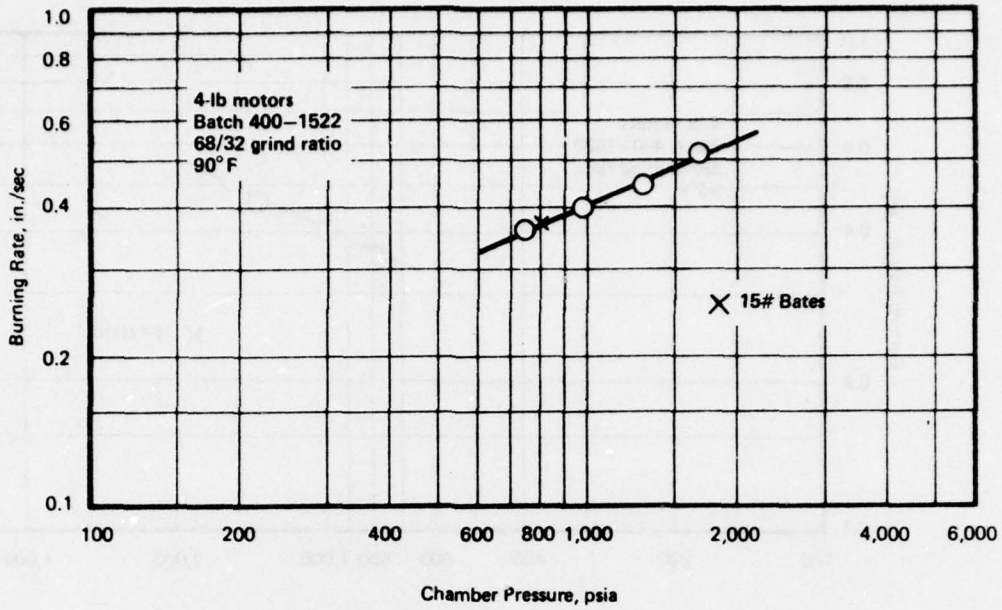

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1517
68/32 grind ratio
90° F
× 15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

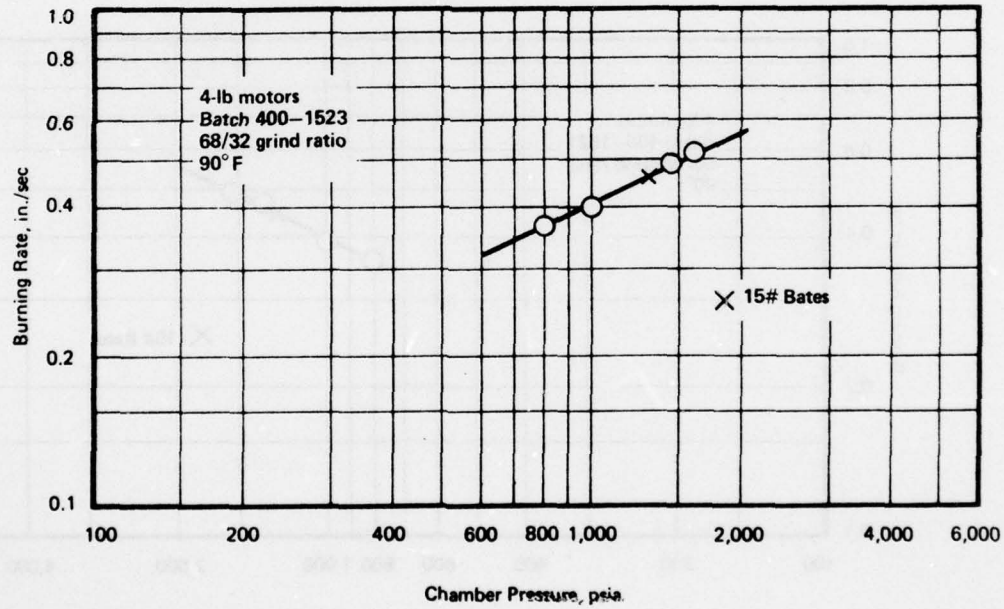

Burning Rate, in./sec
0.4
0.2
0.1
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

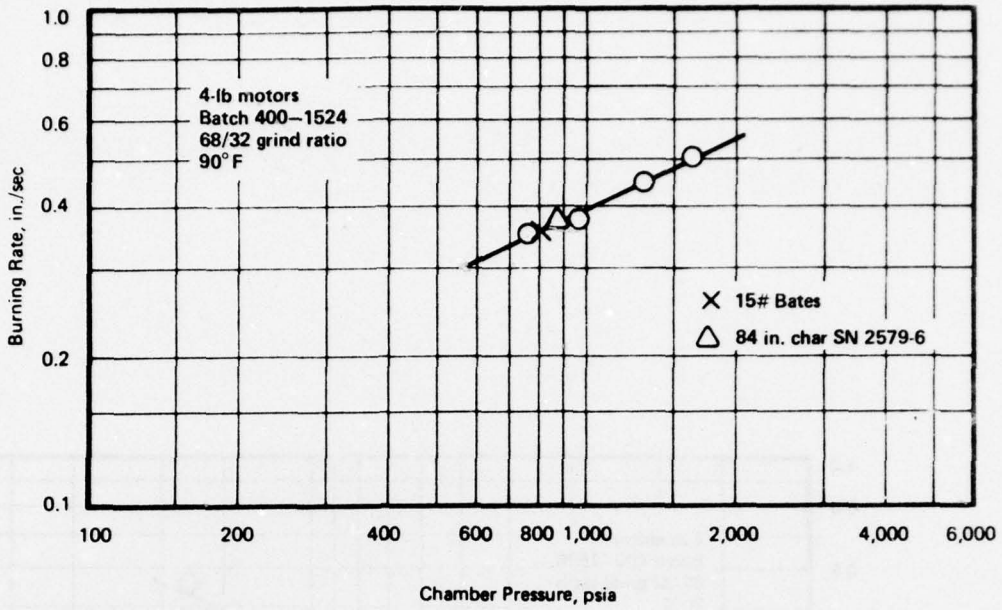

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1519
68/32 grind ratio
90°F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

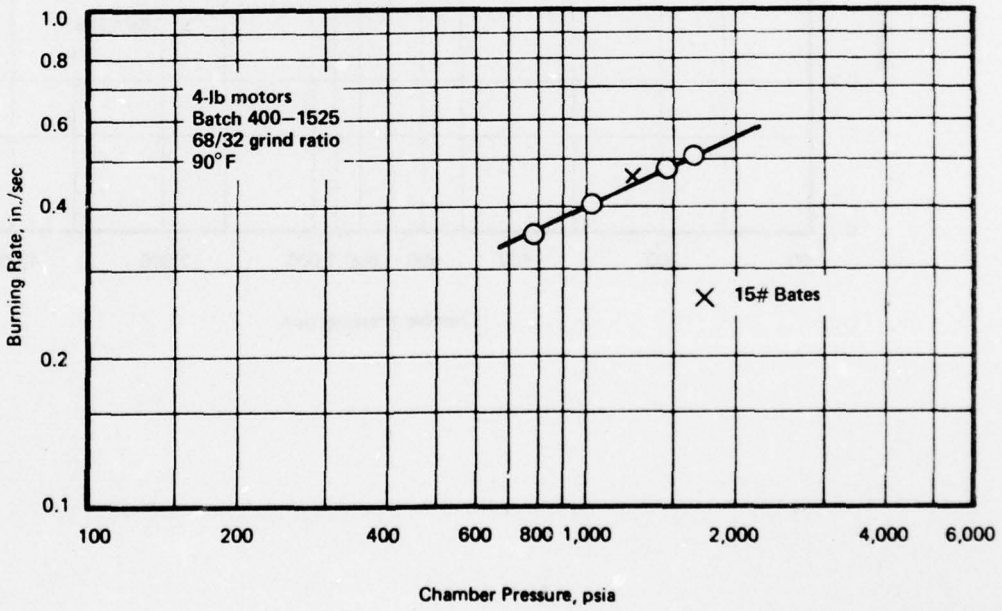

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400—1520
68/32 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

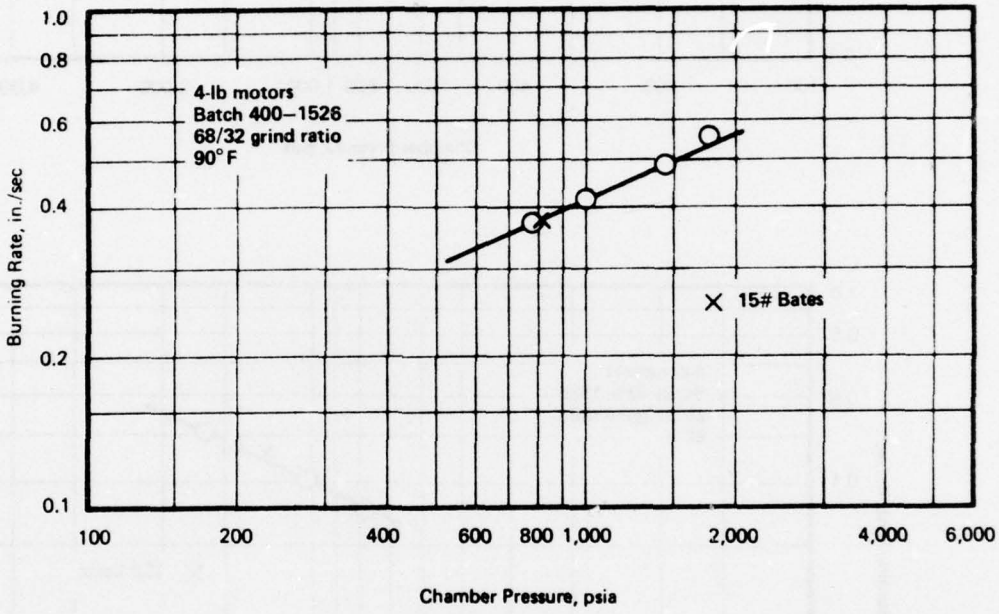

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400—1521
68/32 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

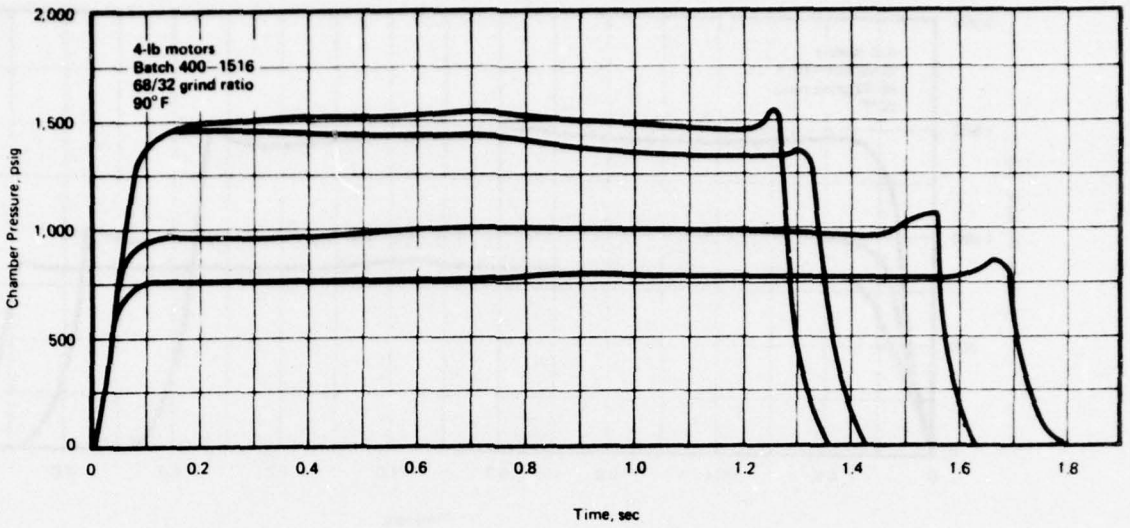

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1522
68/32 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

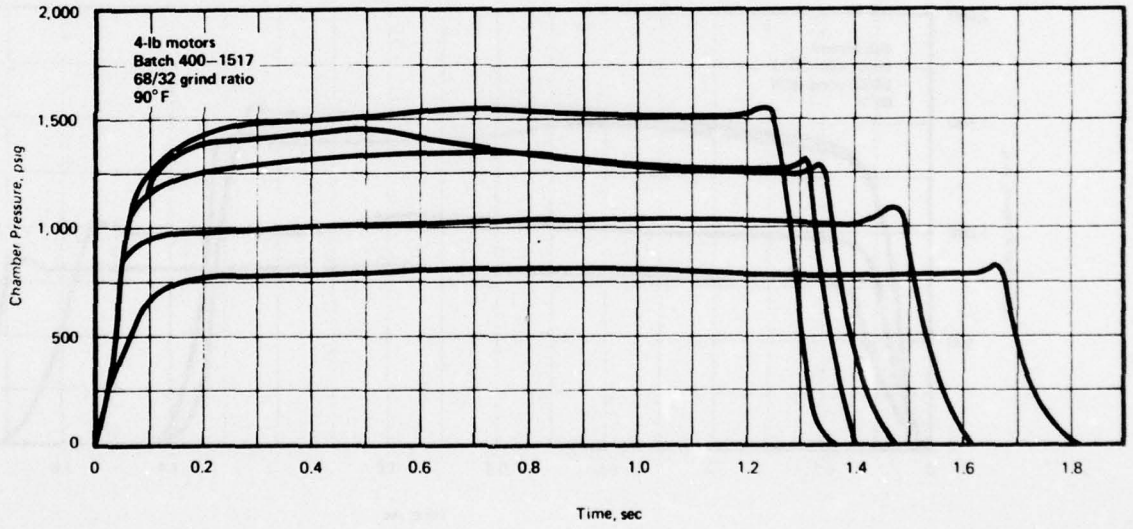

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1523
68/32 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

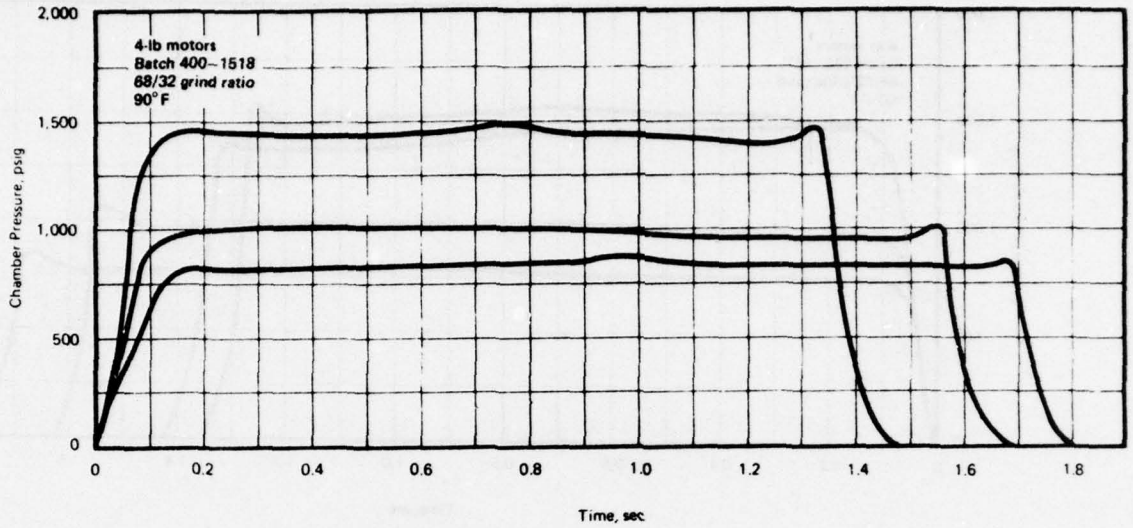

4-lb motors
Batch 400–1524
68/32 grind ratio
90° F
15# Bates
84 in. char SN 2579-6
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

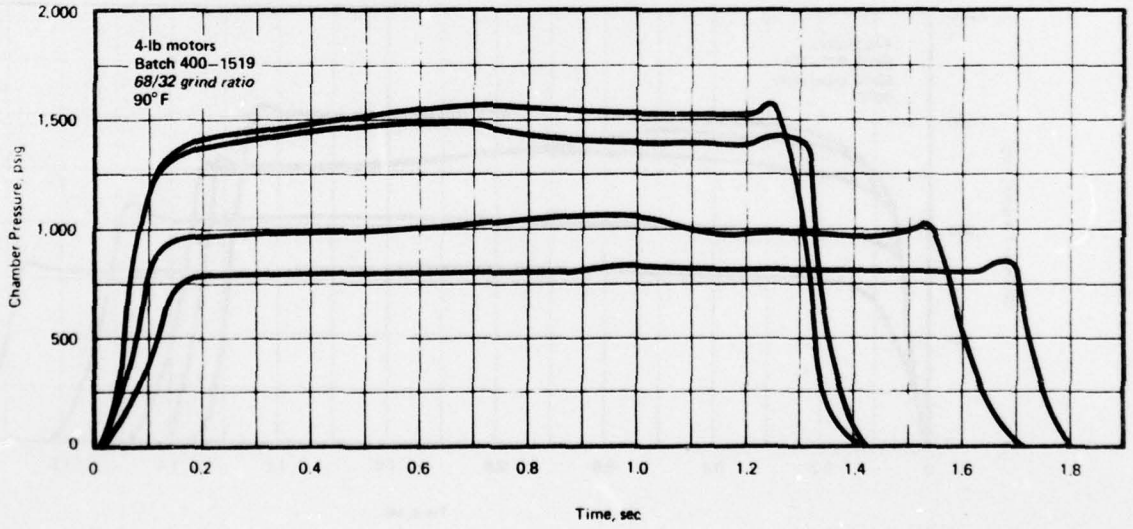

4-lb motors
Batch 400–1525
68/32 grind ratio
90° F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

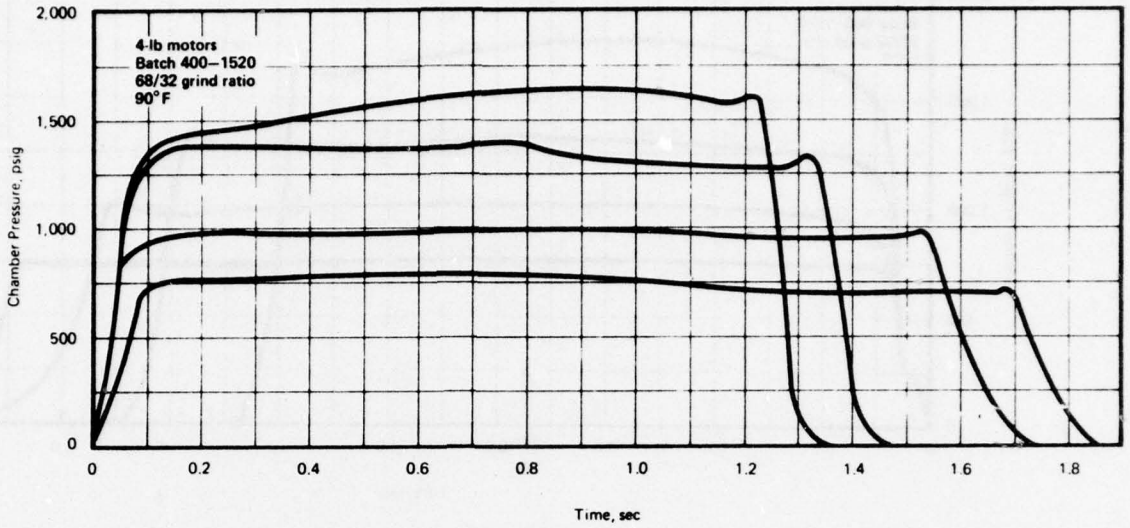

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1526
68/32 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

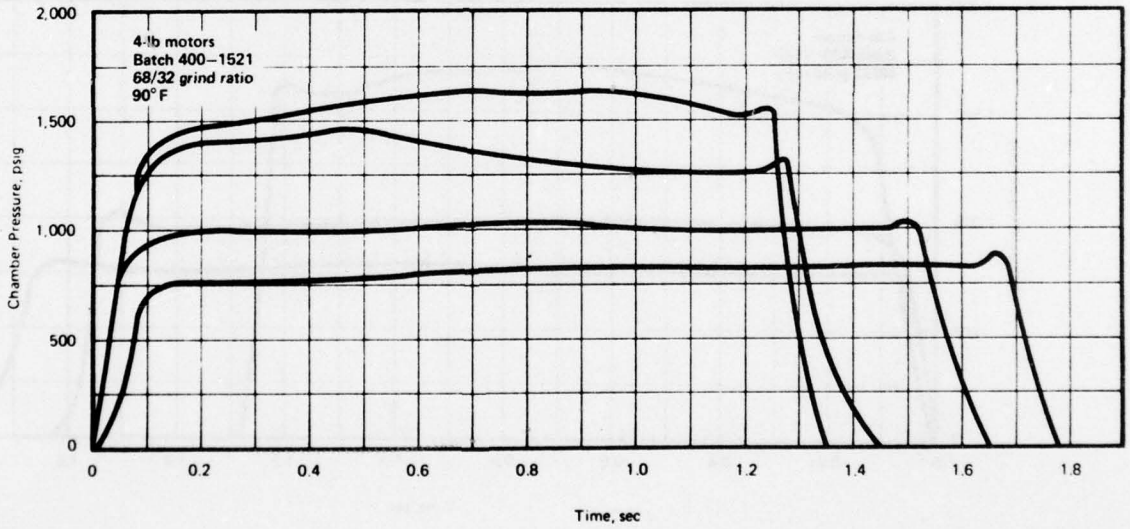

4-lb motors
Batch 400–1516
68/32 grind ratio
90° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

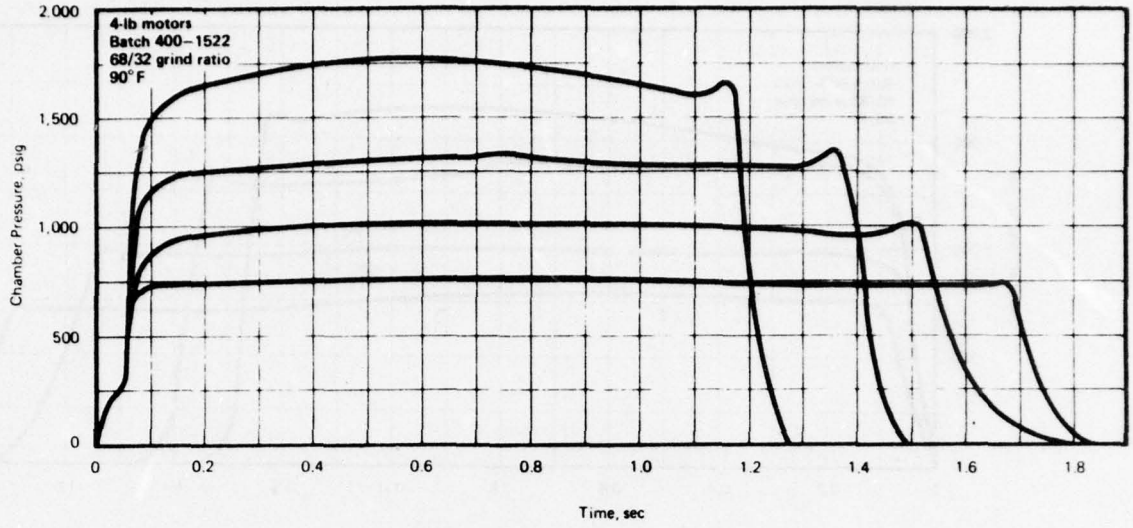

4-lb motors
Batch 400–1517
68/32 grind ratio
90° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

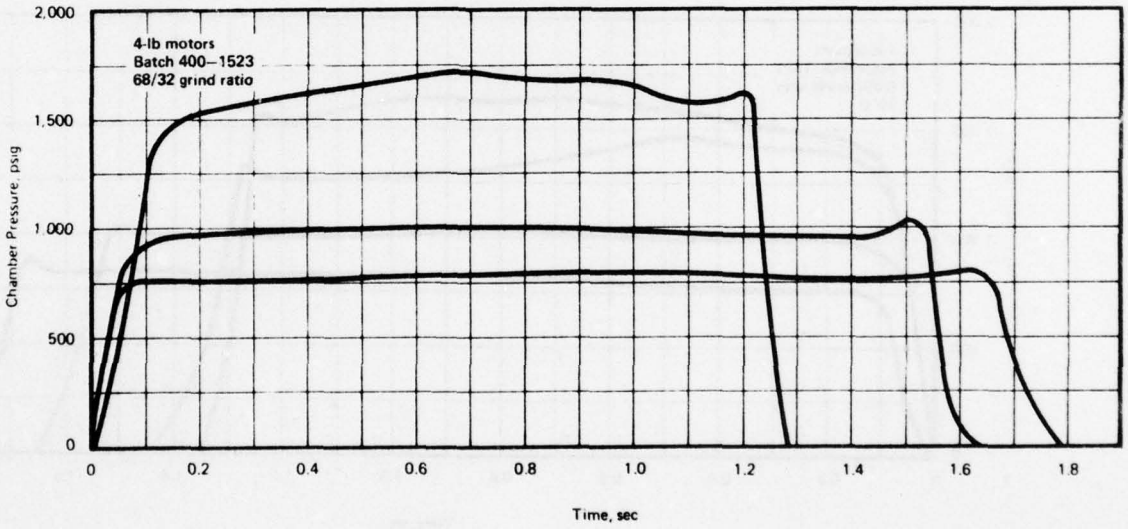

4-lb motors
Batch 400–1518
68/32 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

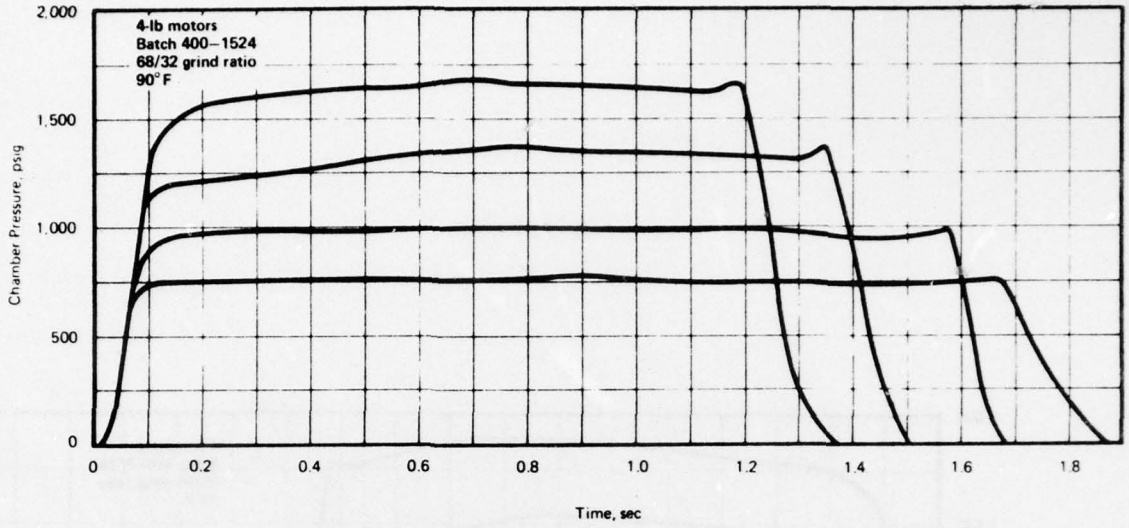

4-lb motors
Batch 400–1519
68/32 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

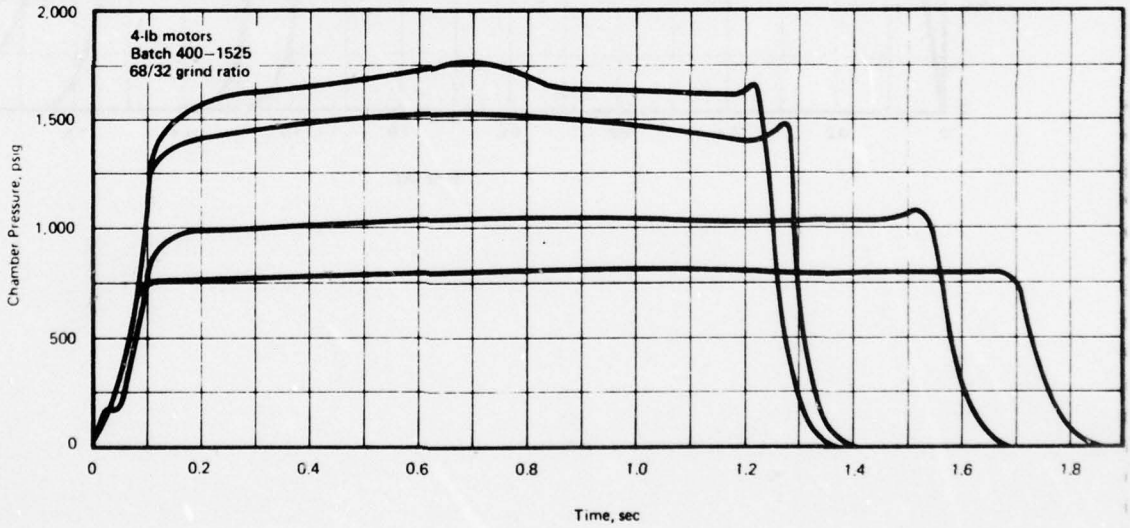

4-lb motors
Batch 400–1520
68/32 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1521
68/32 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1522
68/32 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1523
68/32 grind ratio
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

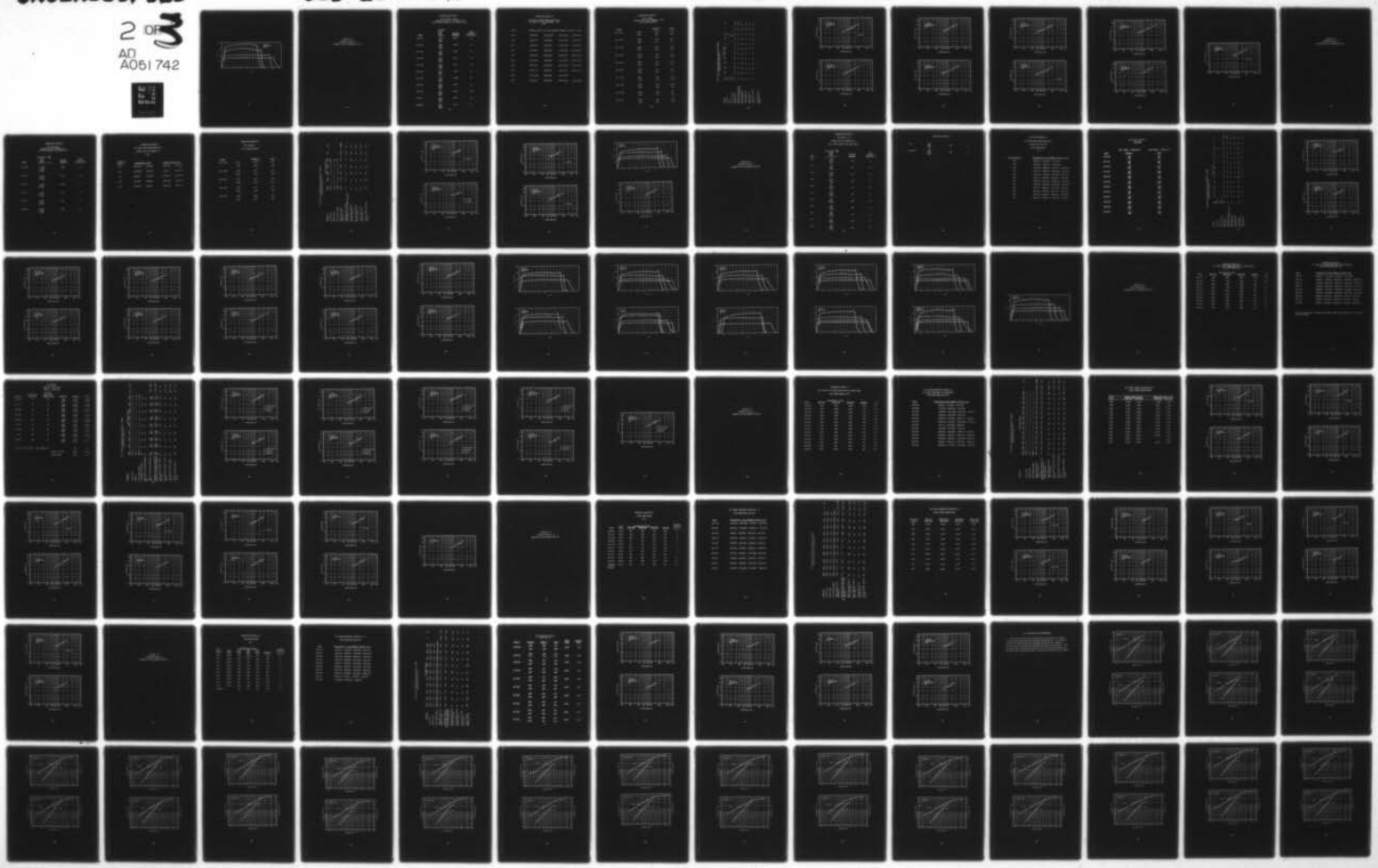

4-lb motors
Batch 400–1524
68/32 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1525
68/32 grind ratio
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

AD-A051 742 UNITED TECHNOLOGIES CORP SUNNYVALE CALIF CHEMICAL SY--ETC F/G 21/9.2
84-INCH PROPELLANT CARTRIDGES AND GRAINS. VOLUME II. PROPELLANT--ETC(U)
NOV 77 T V O'HARA, J B HENRY, W A STEPHEN F04611-76-C-0010

UNCLASSIFIED CSD-2579-FR AFRPL-TR-77-92 NL

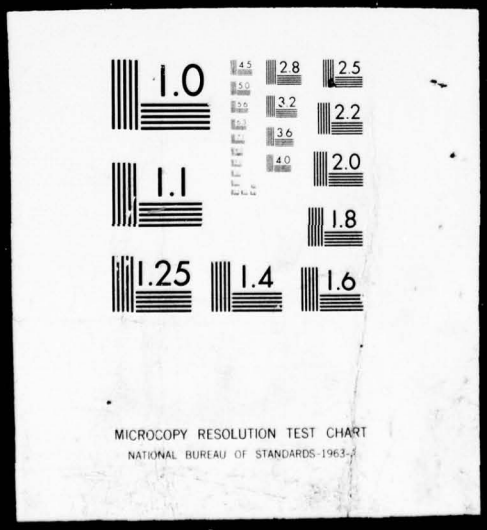
2 OF 3
AD
A051 742

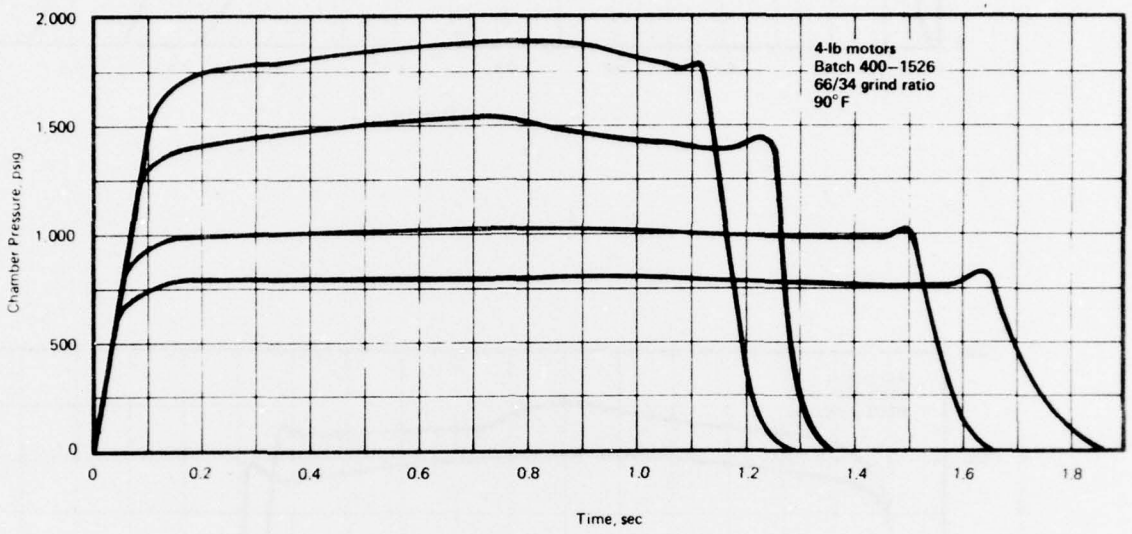


SIFIED

2 OF 3

AD
A051742




4-lb motors
Batch 400–1526
66/34 grind ratio
90°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

SECTION 2.9

PRODUCTION RUN NO. 5

(BATCHES 400-1527 THROUGH 400-1537)

PRODUCTION CASTING #5

UTP 18803A, 90°F
BATCHES 400-1527 THROUGH 1537
FOUR-POUND MOTORS 67/33 GRIND RATIO

Batch	All Data r1000 r1400 41700	Pressure Exponent	One Standard Deviation, %
400-1527	.4130 .4911 .5427	0.515	2.0
400-1528	.4180 .4878 .5332	0.459	0.7
400-1529	.4219 .5005 .5523	0.508	1.9
400-1530	.4222 .5016 .5441	0.512	0.6
400-1532	.4168 .4858 .5306	0.455	0.9
400-1533	.4192 .4847 .5271	0.431	0.6
400-1534	.4241 .4951 .5414	0.4599	0.9
400-1535	.4236 .4956 .5427	0.467	1.4
400-1536	.4213 .4955 .5442	0.482	0.04
400-1537	.4224 .5003 .5517	0.503	1.8
Composite	.4204 .4930 .5410	0.475	1.5

PRODUCTION CASTING #5

UTP 18803A FOUR-POUND MOTOR DATA
BATCHES 400-1527 THROUGH -1537
89°F

Batch	Burning Rates in./sec/Average Chamber Pressure, psia			
1527	.3976/901	.4268/1128	.4616/1229	.5392/1653
1528	.3680/761	.3936/865	.4612/1265	.5242/1619
1529	.3660/747	.4058/954	.5124/1447	.5378/1663
1530	.3709/767	.3936/886	.4875/1322	.5344/1581
1532	.3590/705	.3881/880	.4983/1477	.5280/1673
1533	.3610/698	.3908/866	.4722/1313	.5053/1538
1534	.3819/792	.4195/992	.5097/1452	.5445/1749
1535	.3707/777	.3989/855	.4804/1279	.5415/1723
1536	.4212/1000	.488/1355	.5582/1793	
1537	.3791/816	.4078/908	.5042/1487	.5778/1808

PRODUCTION CASTING #5

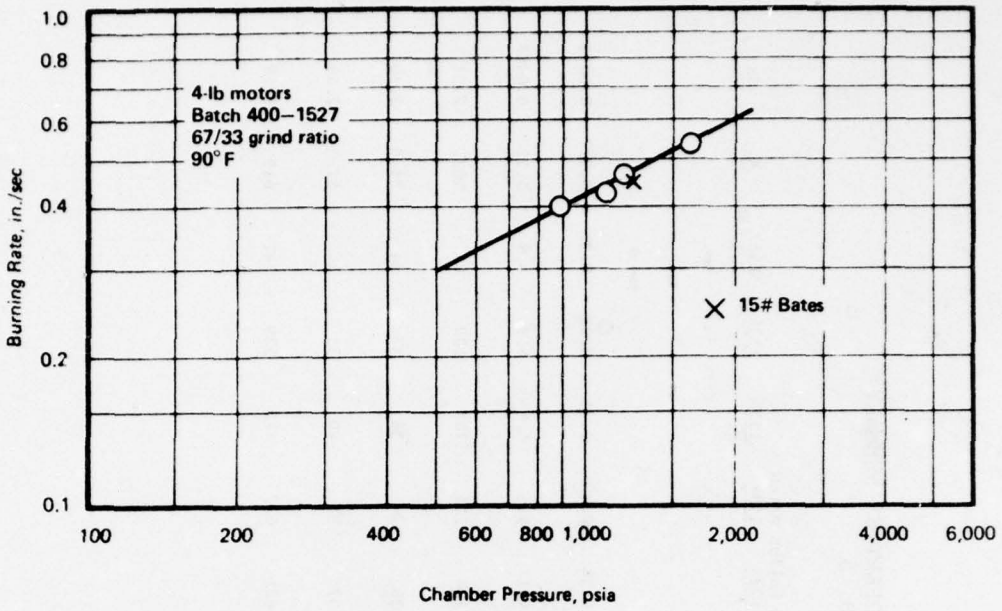
UTP 18803A
BATCHES 400-1527 THROUGH -1537
67/33 GRIND RATIO

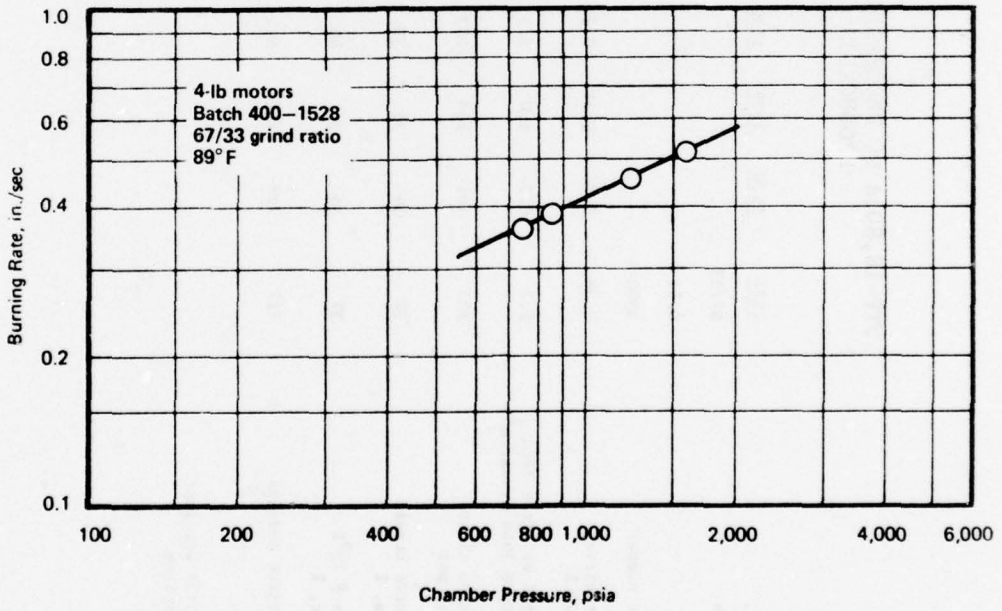
Batch		Premix C	Final
400-1527	1000	.485	.452
	1400	.616	.589
400-1528	1000	.483	.451
	1400	.627	.577
400-1529	1000	.490	.461
	1400	.626	.583
400-1530	1000	.479	.455
	1400	.618	.574
400-1532	1000	.474	.449
	1400	.608	.573
400-1533	1000	.478	.447
	1400	.609	.572
400-1534	1000	.481	.454
	1400	.613	.570
400-1535	1000	.474	.448
	1400	.608	.568
400-1536	1000	.485	.456
	1400	.617	.581
400-1537	1000	.482	.462
	1400	.616	.579

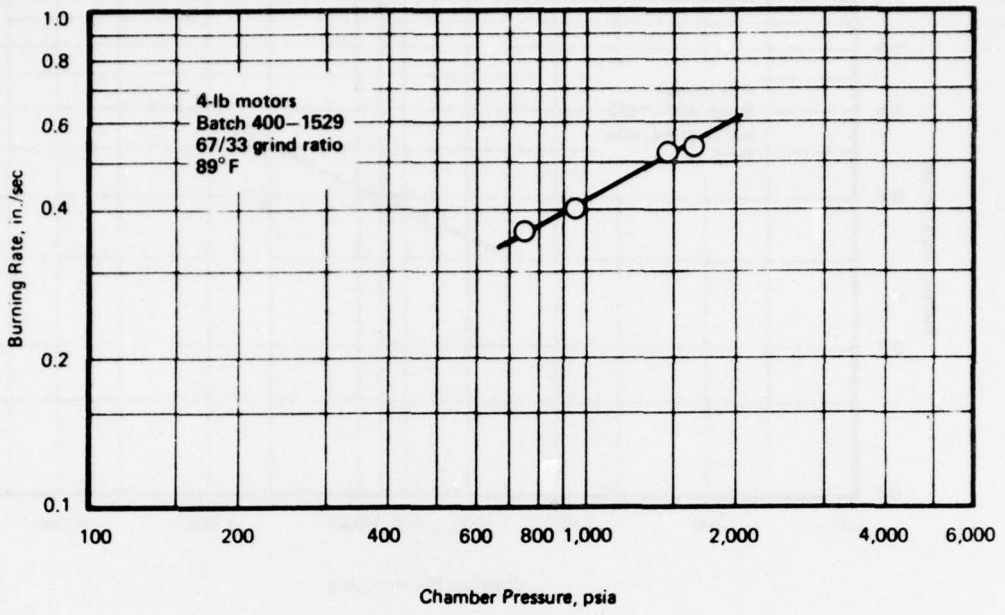
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 5

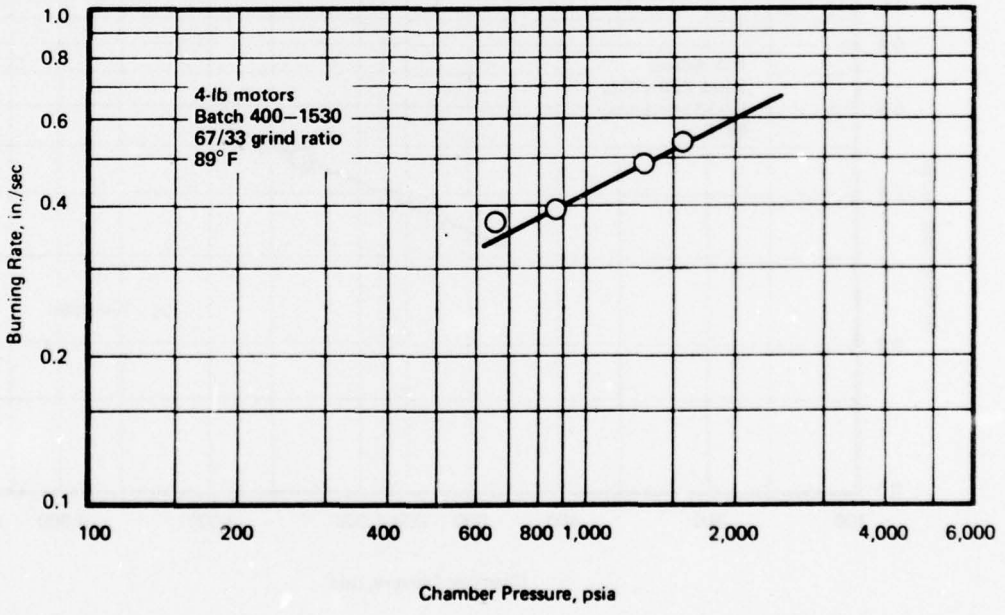
Parameter	400 Gallon Batch 1527	1528	1529	1530	1532	1533	1534	1535	1536	1537	$\bar{X}$	Sx
Grind ratio	67/33	→	→	→	→	→	→	→	→	→		
NCO/OH	0.81	→	→	→	→	→	→	→	→	→		
Fuel premix number	3500-5	→	→	→	→	→	→	→	→	→		
IDPI @ 1 hr after addition, wt %	0.38	0.38	0.38	0.36	0.38	0.38	0.40	0.36	0.38	0.37	0.377	0.0012
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	5.3	6.0	6.0	5.3	4.2	4.1	4.6	5.4	6.9	4.9	5.27	0.0087
Max. corrected stress @ 75°F, σ^c_m, psi	103	102	104	103	105	104	106	101	100	99	103	2.21
Max. correctes strain @ 75°F, ε^c_m, %	37	34	35	38	39	36	34	38	33	34	35.8	2.10
True strain @ 75°F rupture, Er, %	37	35	36	40	41	37	35	40	35	34	37.0	2.49
Initial tangent modulus Eo, psi	717	728	592	614	553	621	617	478	529	741	619	87.9

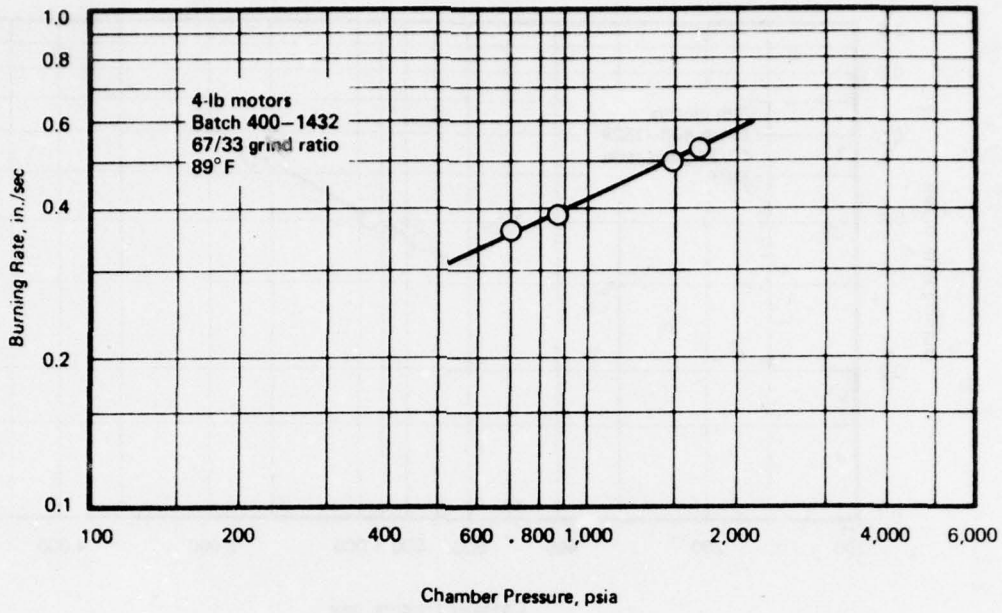
Batch 400-1531 was lost when fire system came on

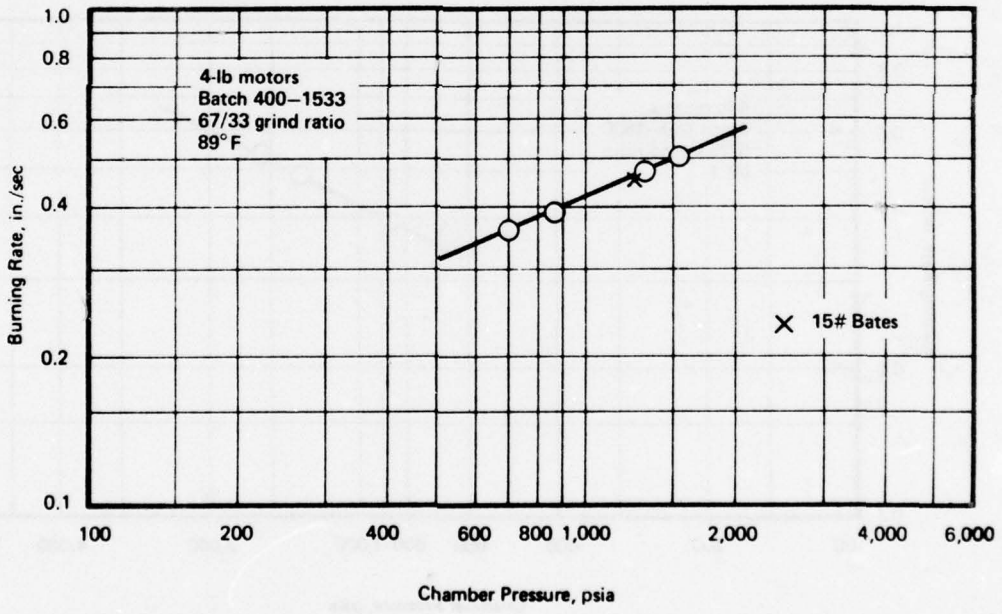

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1527
67/33 grind ratio
90° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

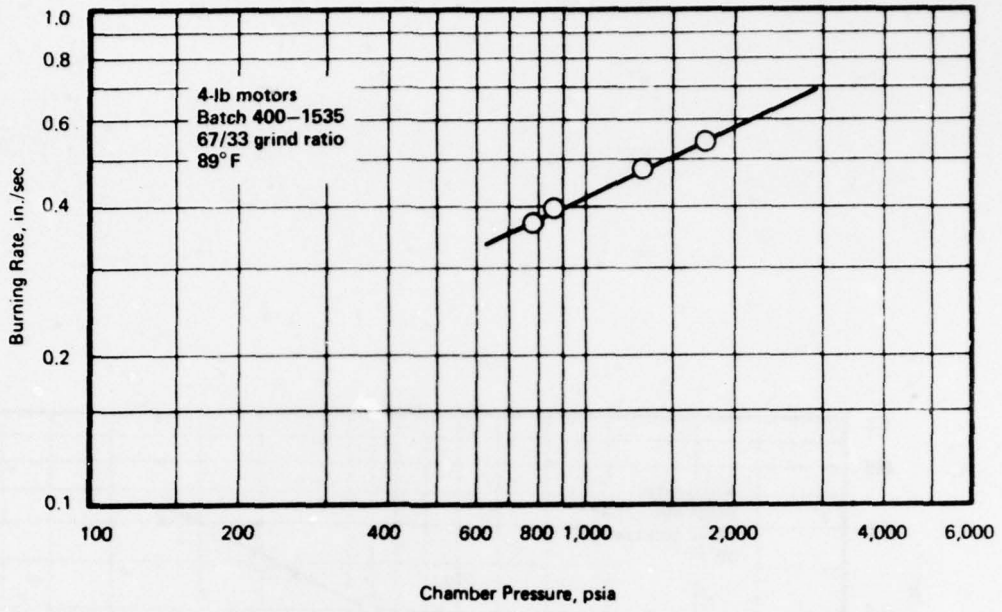

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1528
67/33 grind ratio
89° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

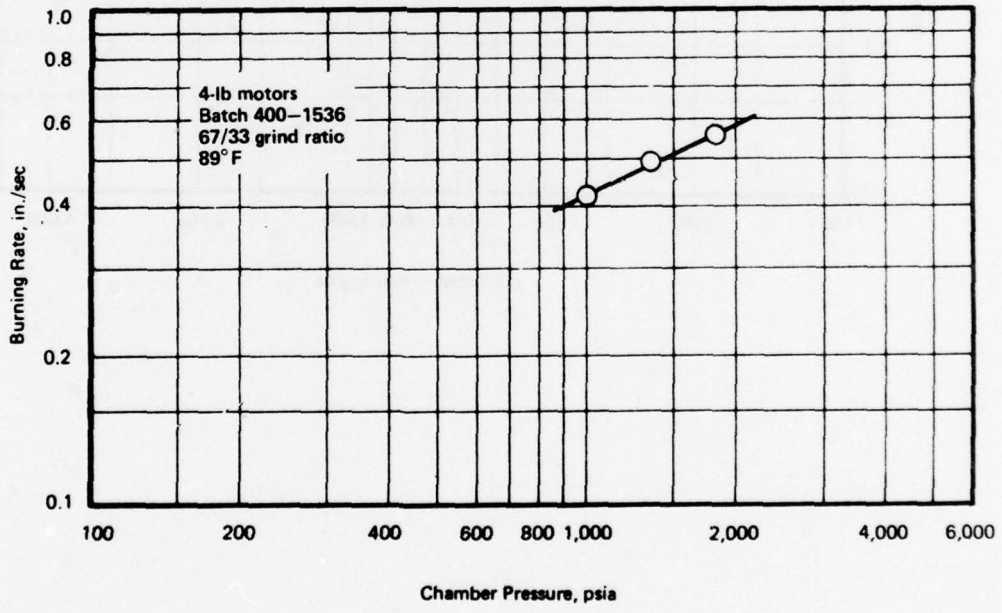

4-lb motors
Batch 400–1529
67/33 grind ratio
89° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

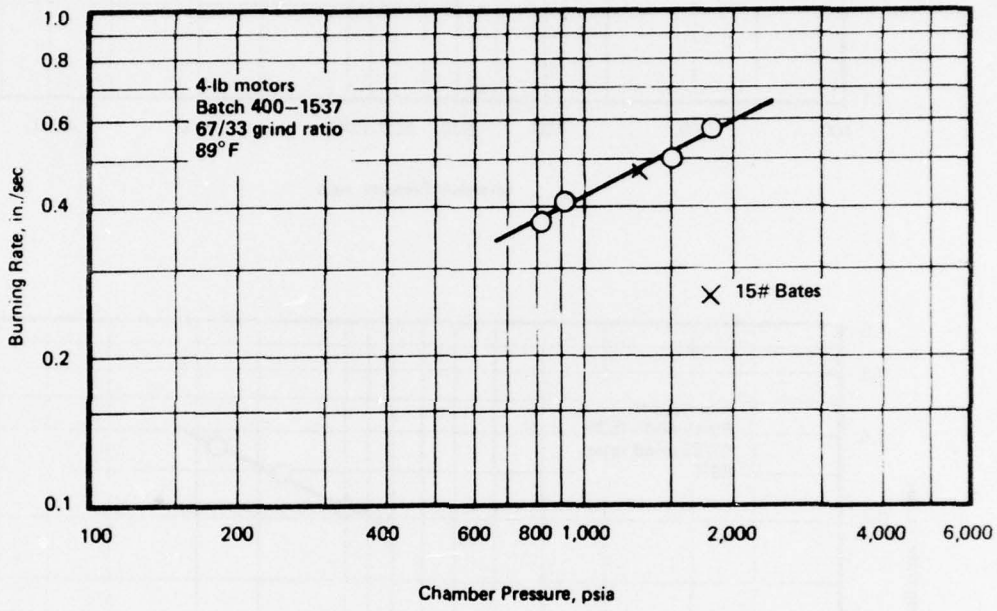

4-lb motors
Batch 400–1530
67/33 grind ratio
89° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1432
67/33 grind ratio
89° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1533
67/33 grind ratio
89° F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1535
67/33 grind ratio
89° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1536
67/33 grind ratio
89° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1537
67/33 grind ratio
89°F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.10

PRODUCTION RUN NO. 6

(BATCHES 400-1539 THROUGH 400-1543)

PRODUCTION CASTING #6

UTP 18803A 80 F
BATCHES 400-1539 THROUGH 1543
FOUR POUND MOTORS 67/33 GRIND RATIO

Batch	Burning Rate, $\frac{in}{sec}$ r_{1000} r_{1400} r_{1700}	Pressure Exponent	One Standard Deviation, %
400-1539	0.3937 0.4608 0.5047	0.468	0.4
400-1540	0.4114 0.4632 0.4935	0.353	0.8
400-1541	0.4170 0.4816 0.5234	0.428	1.1
400-1542	0.4054 0.4756 0.5216	0.475	0.3
400-1543	0.4072 0.4824 0.5319	0.503	1.8
Composite	0.4063 0.4728 0.5160	0.450	2.3

PRODUCTION CASTING #6

UTP 18803A FOUR POUND MOTOR DATA

BATCHES 400-1539 THROUGH 1543

80°F

400 Gallon Batch	Burning Rate, in/sec		Chamber Pressure, psia	
1539	.4092/1126	.3769/898	.4366/1241	.4554/1343
1540	.4195/1085	.4005/912	.45/1306	.4629/1366
1541	.3728/761	.418/1018	.4505/1232	.4832/1370
1542	.3551/761	.3954/941	.4654/1342	.4838/1451
1543	.3643/780	.396/982	.4606/1306	.500/1456

PRODUCTION CASTING #6

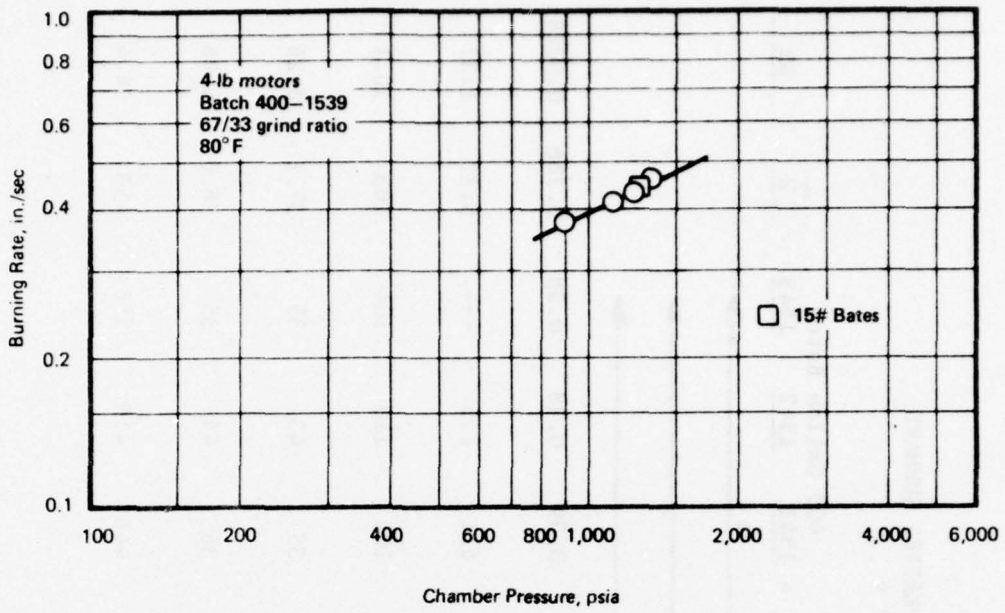
UTP 18803A

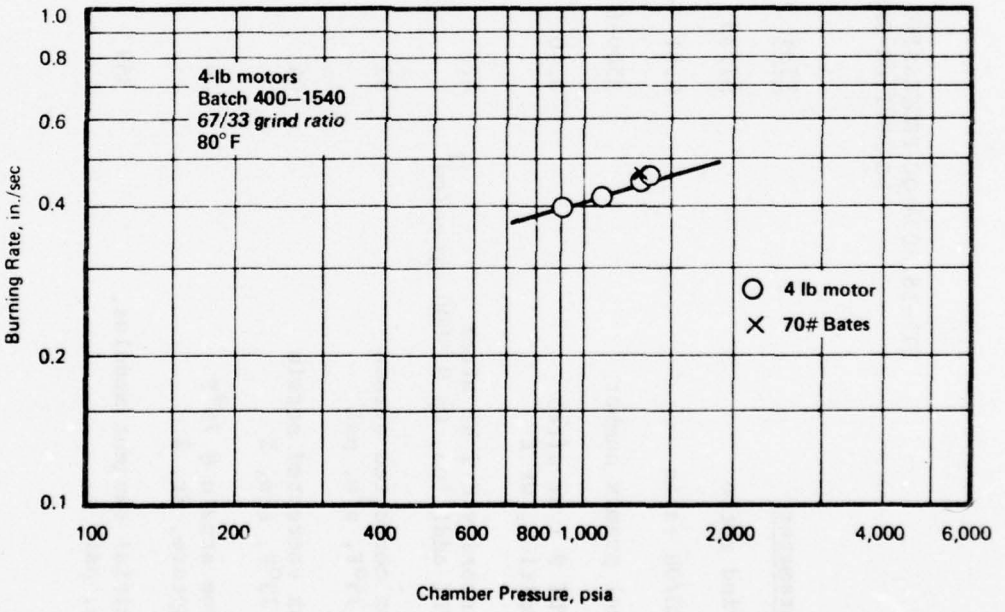
67/33 GRIND RATIO

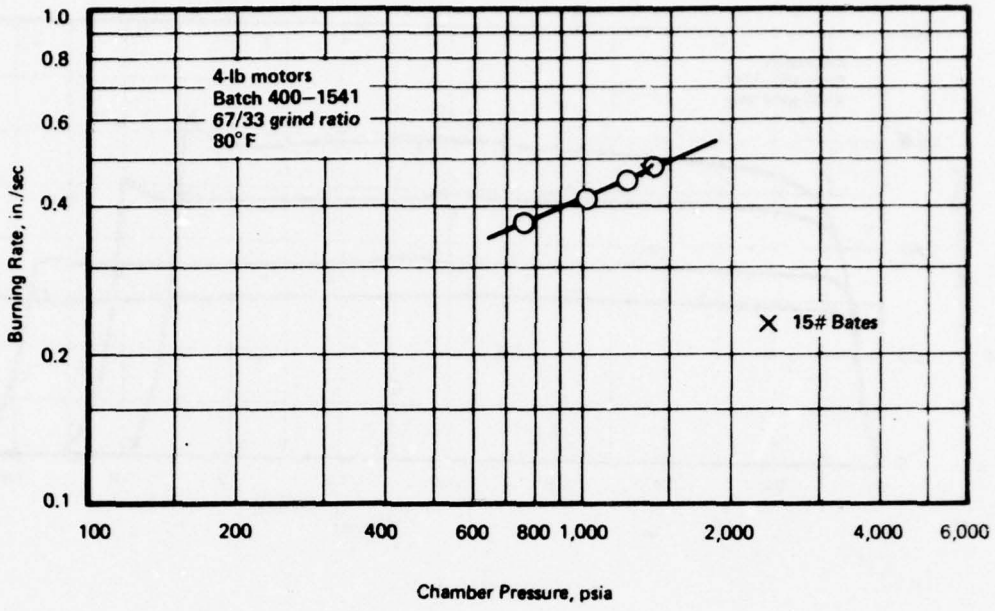
Batch		Premix C	Prop
400-1539	1000	.478	.448
	1400	.619	.569
400-1540	1000	.481	.451
	1400	.612	.574
400-1541	1000	.481	.452
	1400	.615	.572
400-1542	1000	.477	.452
	1400	.610	.574
400-1543	1000	.485	.457
	1400	.622	.576

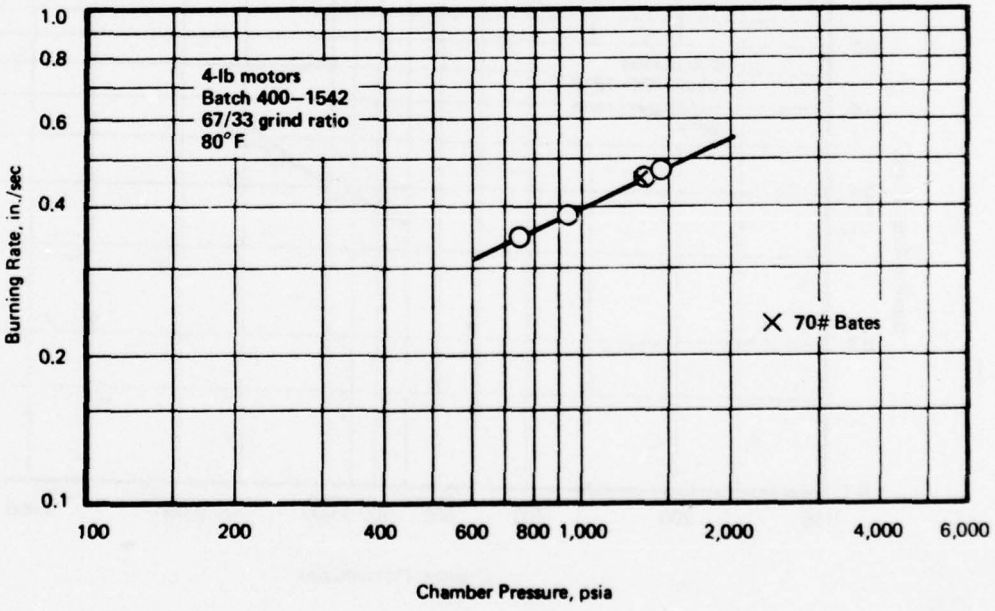
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 6

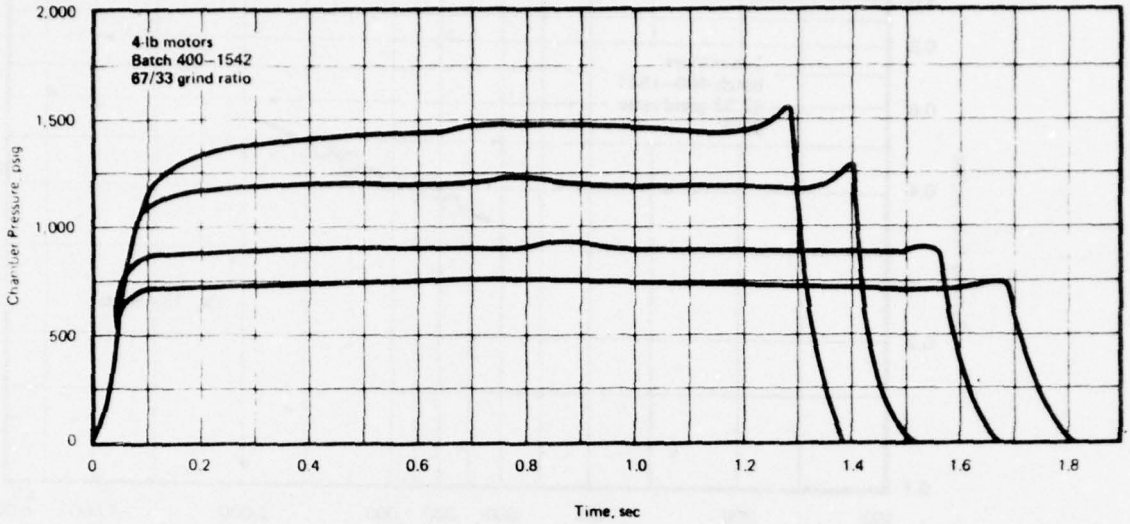
Parameter	400 Gallon Batch 1539	1540	1541	1542	1543	$\bar{X}$	Sx
Grind ratio	67/33 →						
NCO/OH ratio	0.81 →						
Fuel premix number	3500-6 →						
IPDI @ 1 hr after addition, wt %	0.40	0.38	0.39	0.38	0.38	0.386	0.0089
Viscosity @ 1 hr after IPDI addition, Kp @ 5000 dynes/cm^2	4.7	4.6	6.1	7.5	---	5.73	1.37
Max corrected stress @ 75°F, $\sigma^c m$, psi	91	97	105	118	104	103	10.1
Max corrected strain @ 75°F, $\varepsilon^c m$, %	44	29	35	43	35	37.2	6.26
True strain @ 75°F rupture, Er, %	46	29	36	44	35	38.0	6.96
Initial tangent modulus, Eo, psi	359	489	446	416	556	453	74.4

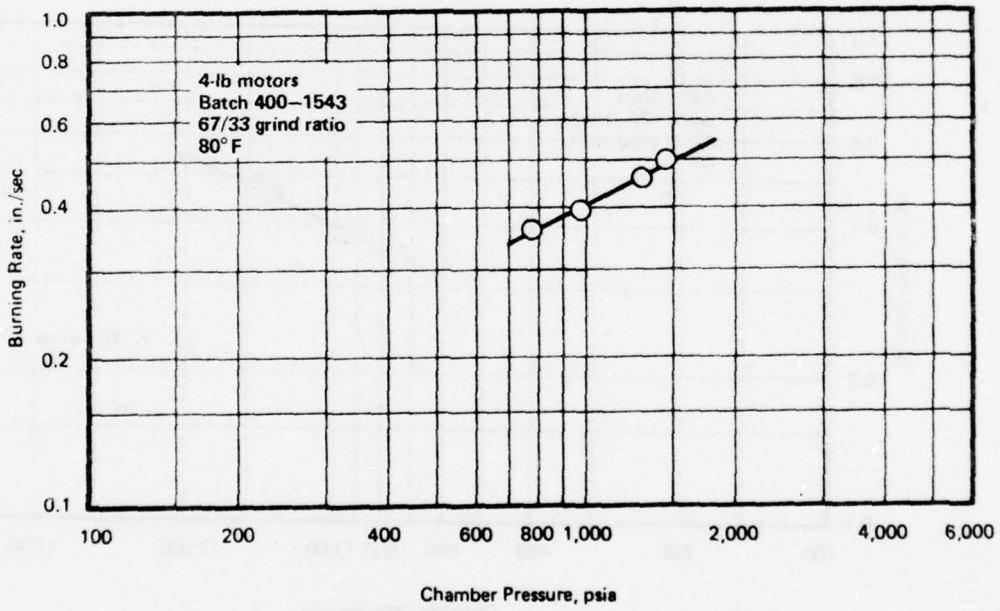

4-lb motors
Batch 400–1539
67/33 grind ratio
80°F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1540
67/33 grind ratio
80°F
4 lb motor
70# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1541
67/33 grind ratio
80° F
× 15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1542
67/33 grind ratio
80° F
× 70# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1542
67/33 grind ratio
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1543
67/33 grind ratio
80° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.11

PRODUCTION RUN NO. 7

(BATCHES 400-1546 THROUGH 400-1557)

PRODUCTION CASTING #7

UTP 18803 A 72 F

BATCHES 400-1546 THROUGH 1557

FOUR POUND MOTORS 68/32 GRIND RATIO

Batch	Burning Rate, $\frac{in}{sec}$ r_{1000} r_{1400} r_{1700}	Pressure Exponent	One Standard Deviation, %
1546	.4088 .4622 .4961	.365	1.6
1547	.4145 .4841 .5294	.461	1.0
1548	.4065 .4770 .5232	.476	0.9
1549	.4056 .4717 .5146	.449	0.9
1550	.4069 .4773 .5233	.474	0.9
1551	.4096 .4790 .5240	.464	1.5
1552	.4054 .4746 .5197	.468	1.4
1553	.4037 .4745 .5209	.480	1.5
1554	.4080 .4800 .5271	.483	1.1
1555	.4112 .4802 .5252	.461	2.2
1556	.3999 .4726 .5204	.496	1.8

PRODUCTION CASTING #7

1557	.3984		
	.4665	.469	1.5
	.5110		
Composite	.4061		
	.4756	.469	1.7
	.5209		

PRODUCTION CASTING #7

UTP 18803A FOUR POUND MOTOR DATA

BATCHES 400-14546-1557

68/32 GRIND RATIO

72 F

400 Gallon Batch	Burning Rate, in sec/Chamber Pressure, psia
1546	.3984/916, .4336/1235, .4733/1447
1547	.4049/942, .4578/1271, .5037/1502
1548	.3527/739, .3868/896, .4329/1177, .4864/1434
1549	.3567/737, .3849/911, .4387/1200, .4833/1459
1550	.3545/740, .3913/924, .4353/1181, .4921/1467
1551	.356/746, .3953/899, .4362/1192, .4979/1494
1552	.3545/749, .3927/921, .4368/1222, .4947/1492
1553	.3602/766, .3806/900, .4256/1156, .5120/1590
1554	.362/767, .3836/907, .4524/1220, .5148/1622
1555	.3644/787, .410/938, .4397/1217, .5255/1675
1556	.3525/753, .387/959, .4388/1252, .5163/1619
1557	.3645/747, .3464/731, .4137/1124, .493/1542

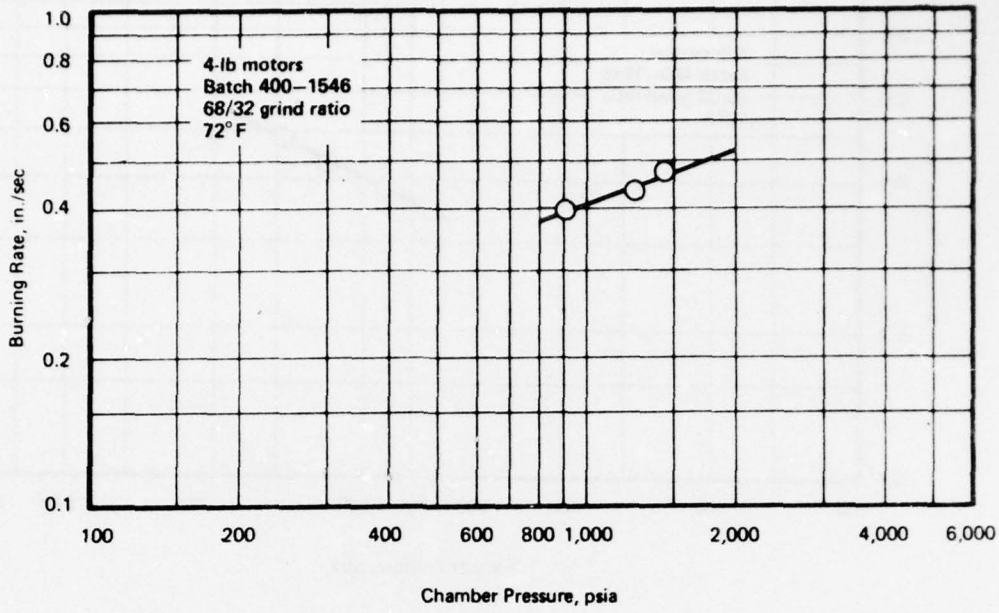
PRODUCTION CASTING #7

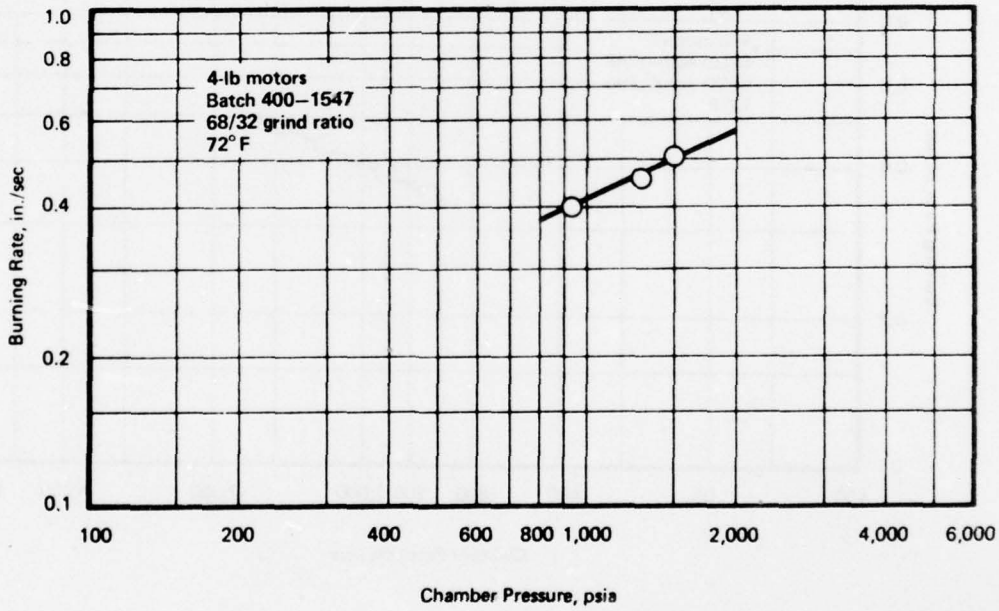
LSBR DATA

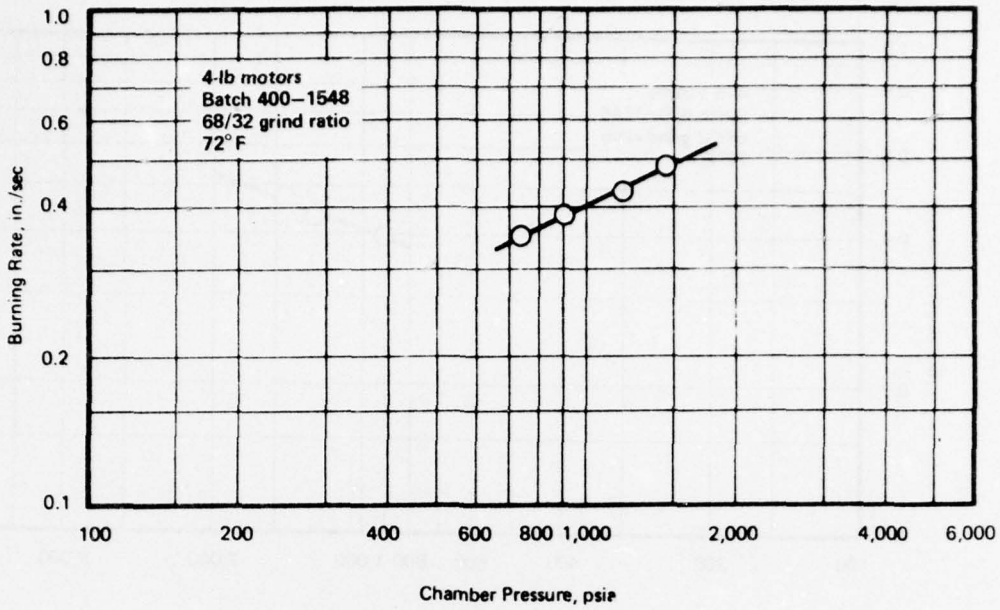
	Spec Limits: 0.605–0.646	Spec Limits: 0.570–0.617
Batch	**Premix C**	**Final**
400-1546	.484	.461
	.619	.576
400-1547	.492	.465
	.624	.584
400-1548	.487	.457
	.623	.577
400-1549	.482	.458
	.620	.579
400-1550	.484	.454
	.609	.573
400-1551	.479	.454
	.607	.574
400-1552	.480	.453
	.607	.570
400-1553	.481	.456
	.615	.576
400-1554	.478	.458
	.611	.578
400-1555	.490	.465
	.623	.585
400-1556	.480	.453
	.612	.574
400-1557	.474	.450
	.604	.571

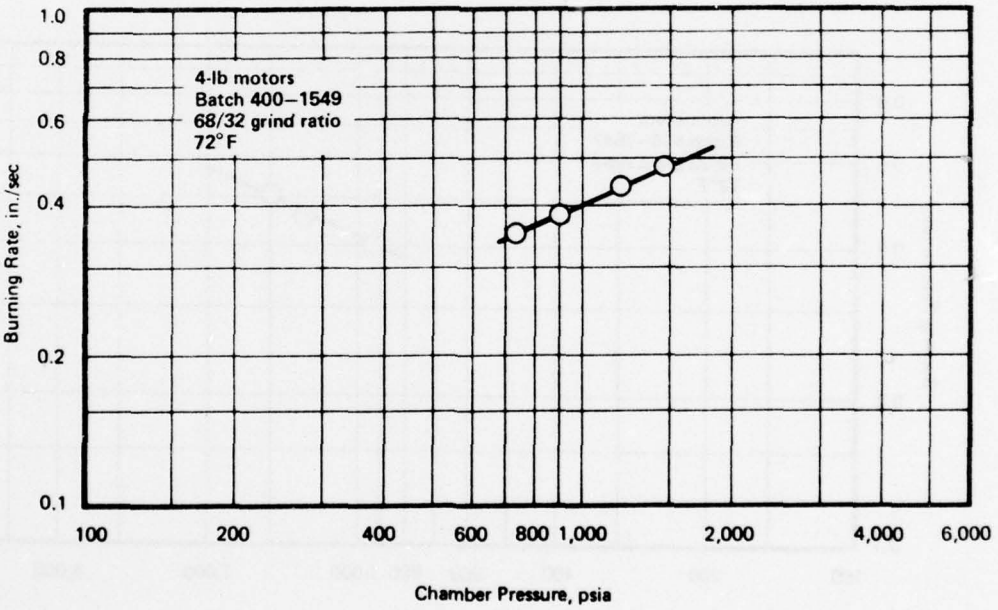
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 7

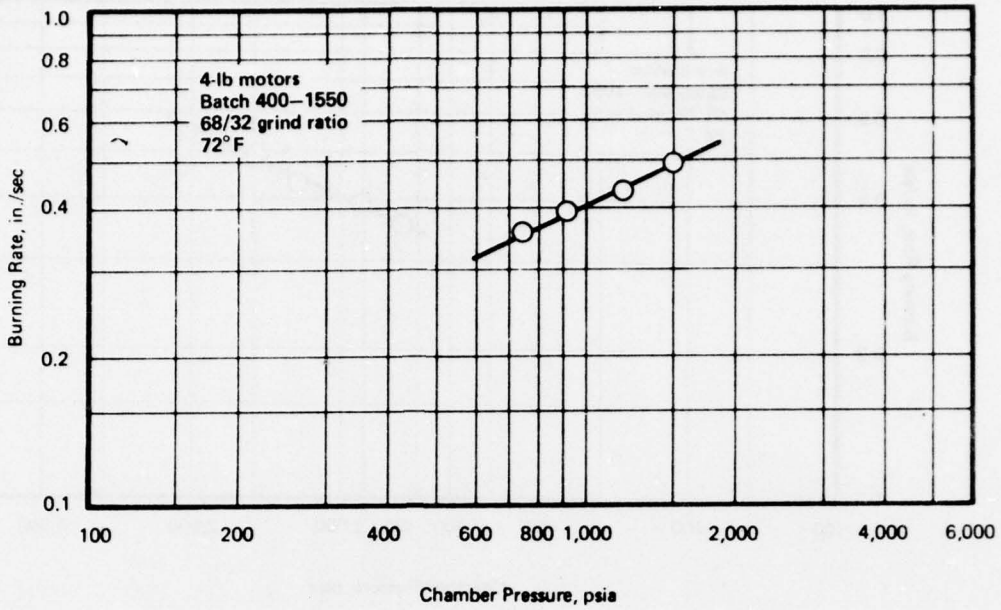
Parameter	400 Gallon Batch 1546	1547	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557	$\bar{X}$	Sx
Grind ratio	68/32	←	←	←	←	←	←	←	←	←	←	←		
NCO/OH ratio	0.82	←	←	←	←	←	←	←	←	←	←	←		
Fuel Premix number	3500-6	←	←	←	←	←	←	←	←	←	←	←		
IPDI @ 1 after addition, wt %	0.40	0.40	0.38	0.38	0.37	0.38	0.38	0.38	0.38	0.38	0.40	0.38	0.384	0.0099
Viscosity @ 1 hr after IDPI addition, Kp @ 5000 dynes/cm^2	6.16	4.14	4.54	4.97	5.34	5.05	7.12	5.72	5.83	6.10	5.43	5.12	5.46	0.008
Max corrected stress @ 75^{o}F, $\sigma^{c}m$, psi	134	134	136	131	124	107	104	102	105	122	121	102	119	13.7
Max corrected strain @ 75^{o}F, $\varepsilon^{c}m$, %	37	32	35	33	35	24	24	22	18	28	34	39	30.1	6.69
Initial tangent modulus, E_o, psi	592	706	645	821	726	1056	812	891	1081	875	834	638	806	156
True strain @ 75^{o}F fupture, E_r, %	37	34	36	34	36	25	26	23	20	29	34	40	31.2	6.35

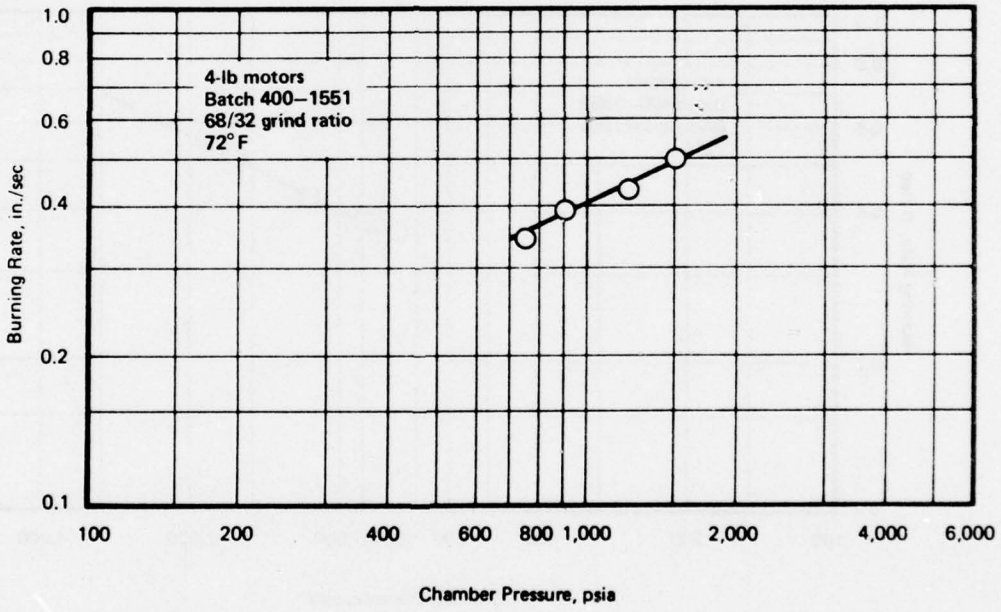

4-lb motors
Batch 400–1546
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

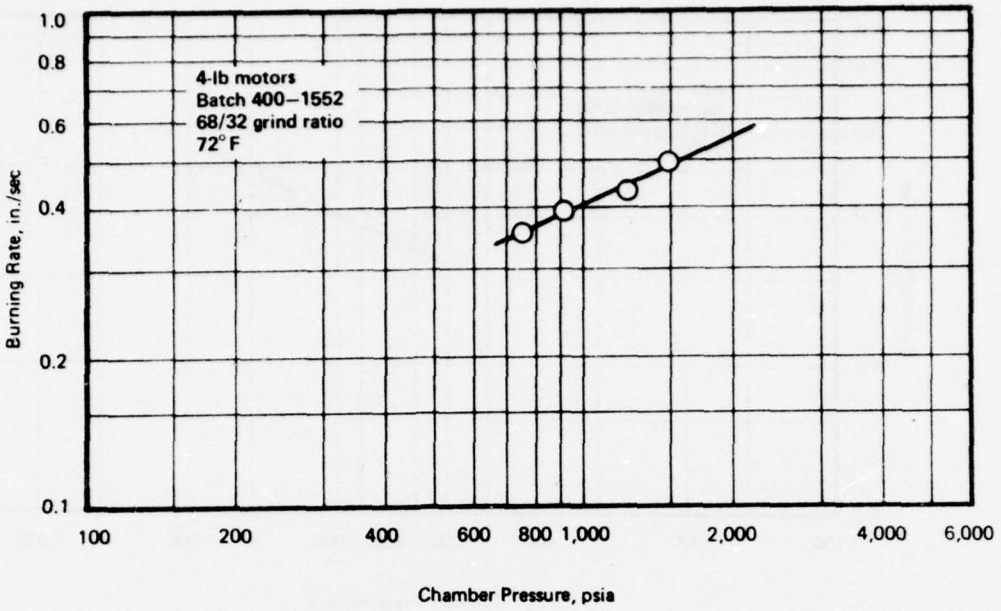

4-lb motors
Batch 400–1547
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

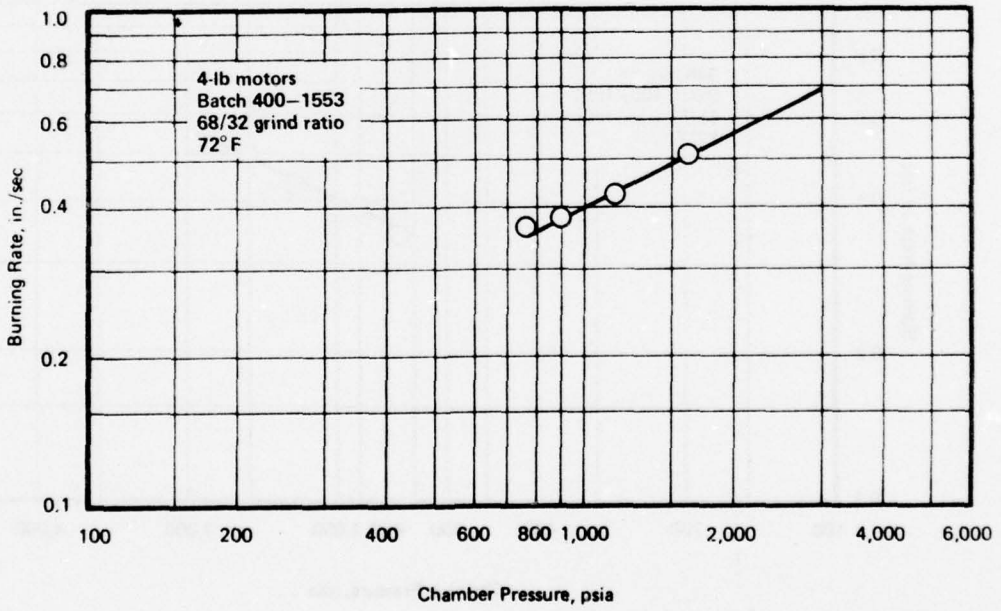

4-lb motors
Batch 400–1548
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

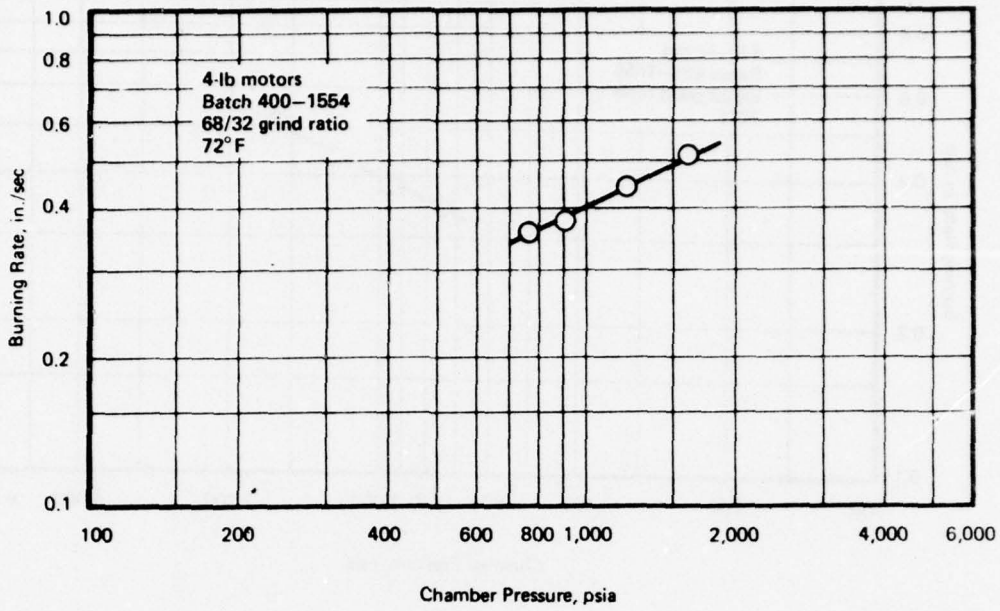

4-lb motors
Batch 400–1549
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

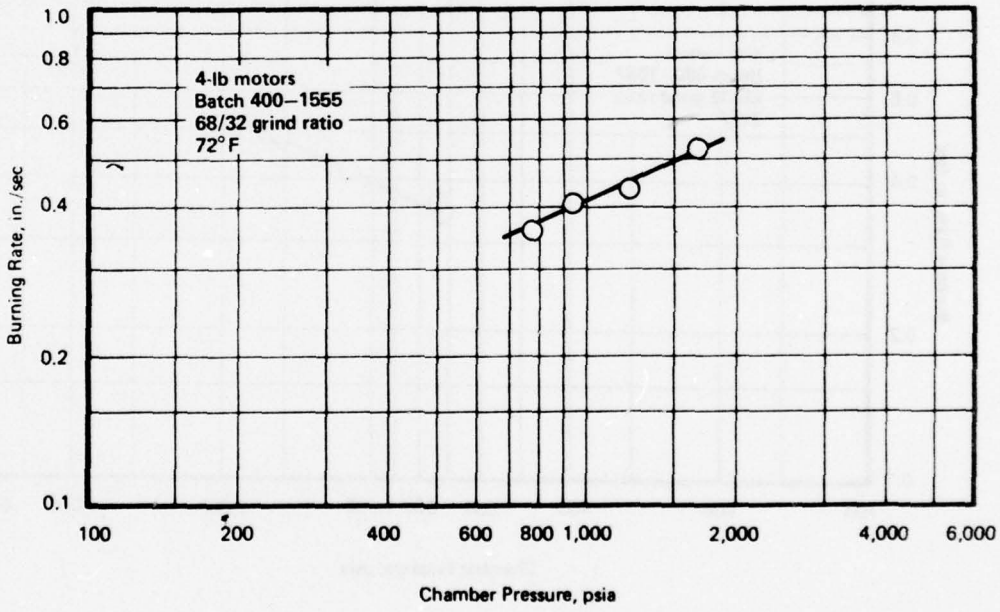

4-lb motors
Batch 400—1550
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

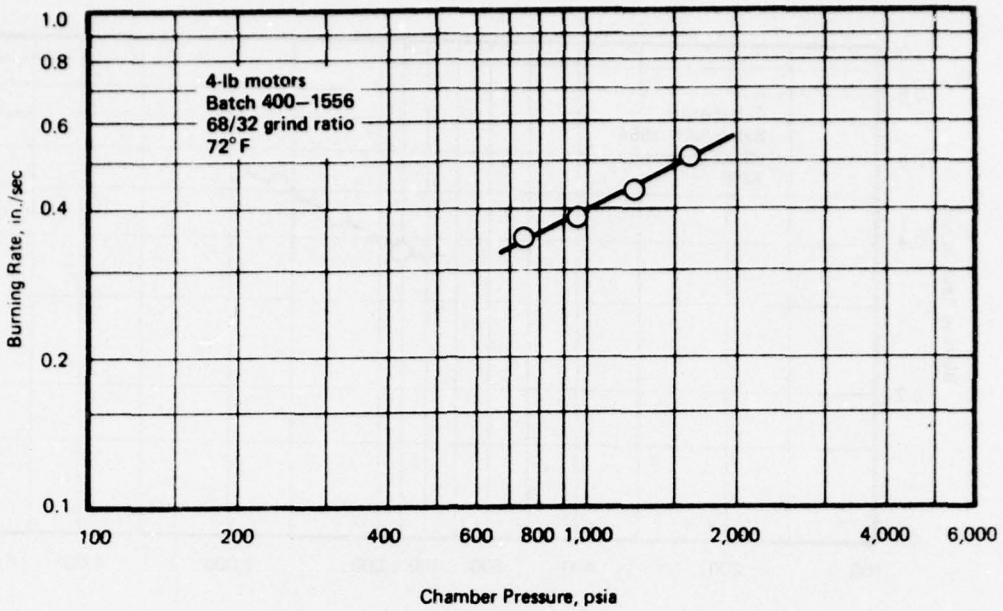

4-lb motors
Batch 400—1551
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

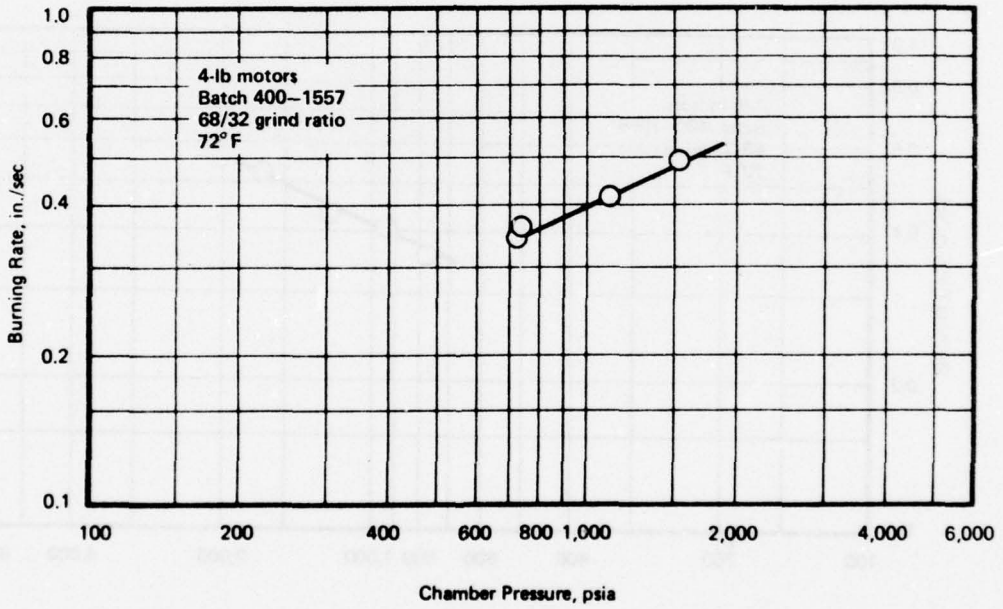

4-lb motors
Batch 400–1552
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

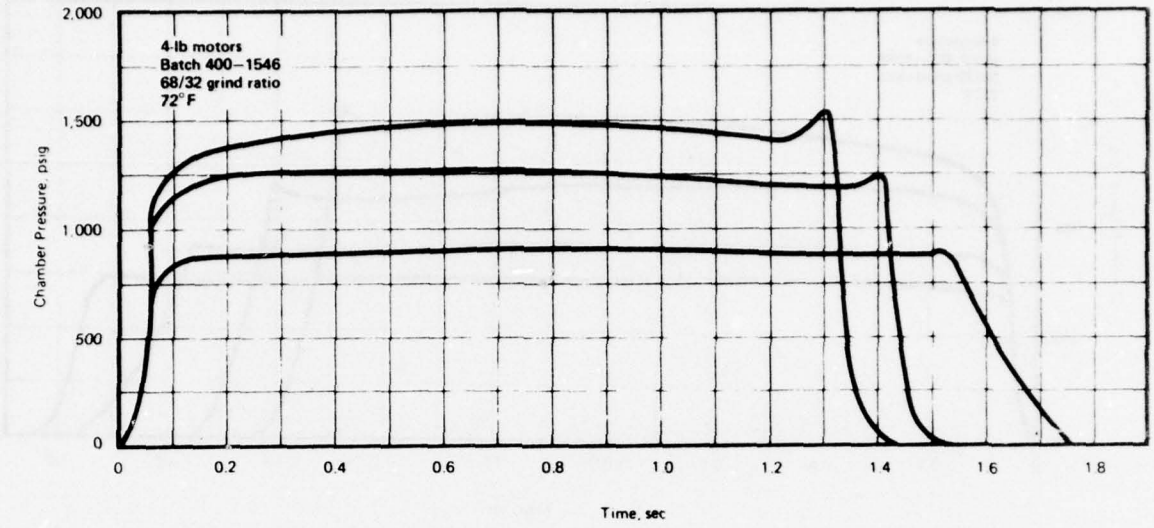

4-lb motors
Batch 400–1553
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

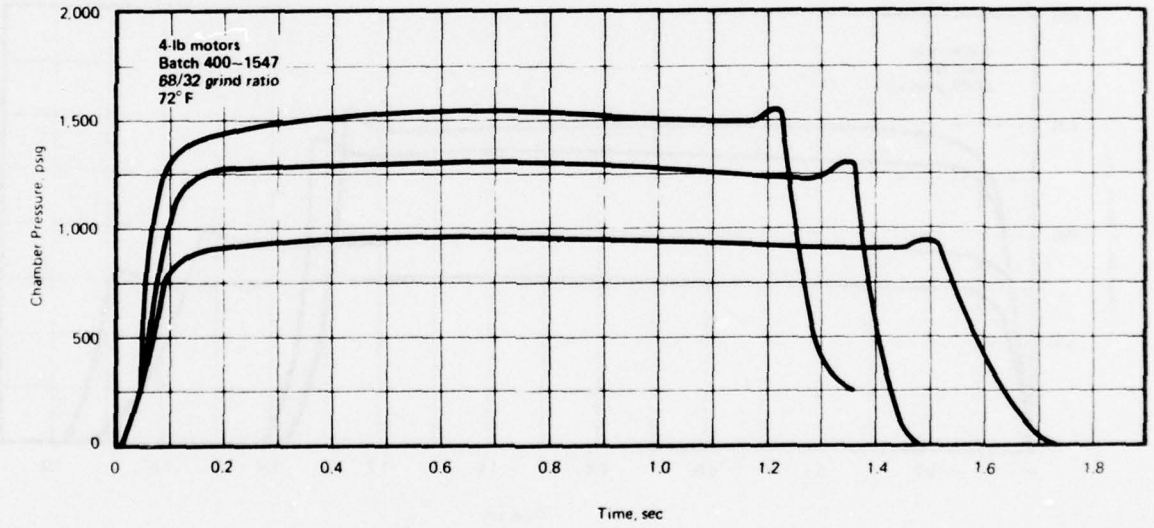

4-lb motors
Batch 400–1554
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

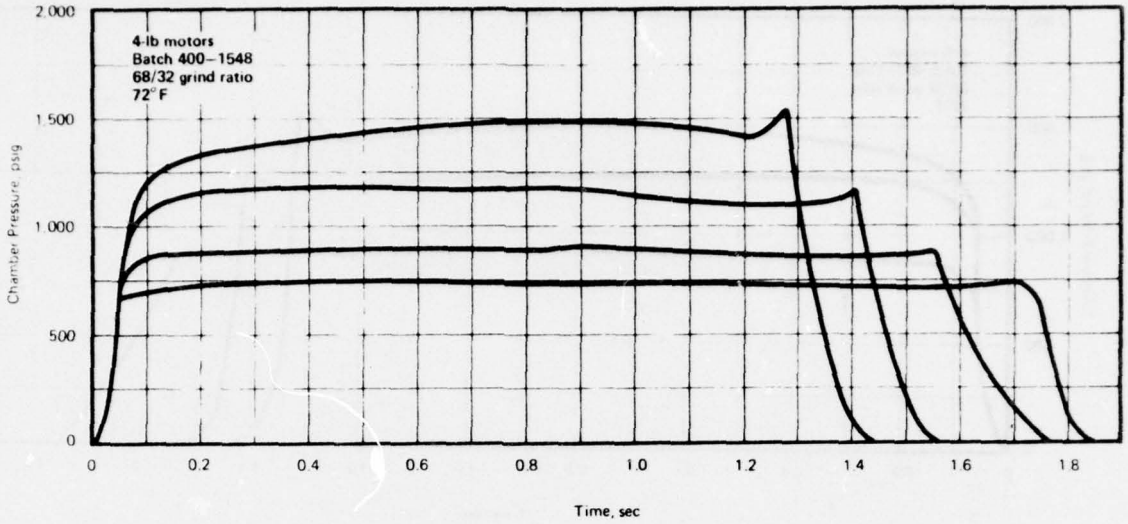

4-lb motors
Batch 400–1555
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

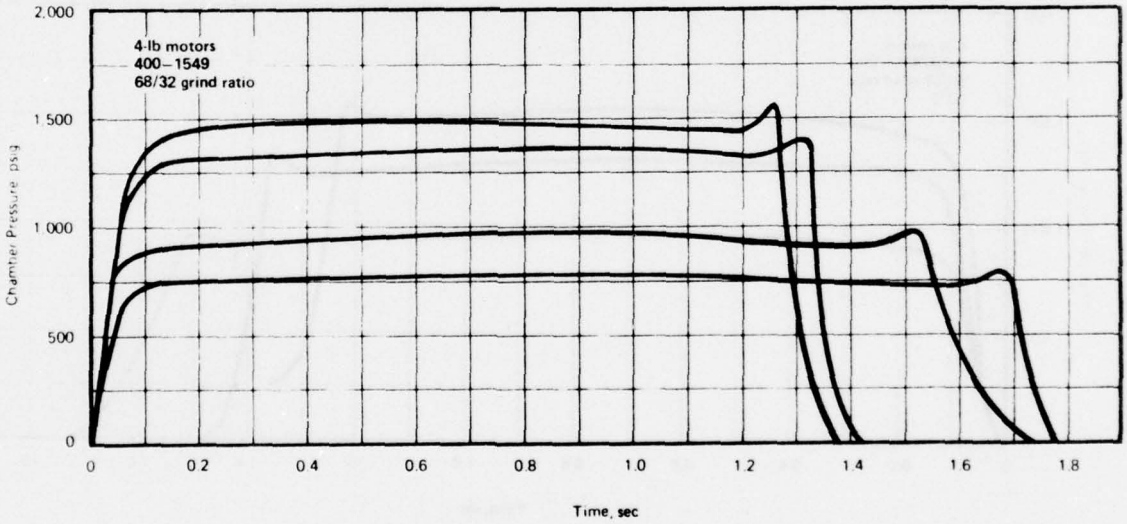

4-lb motors
Batch 400–1556
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

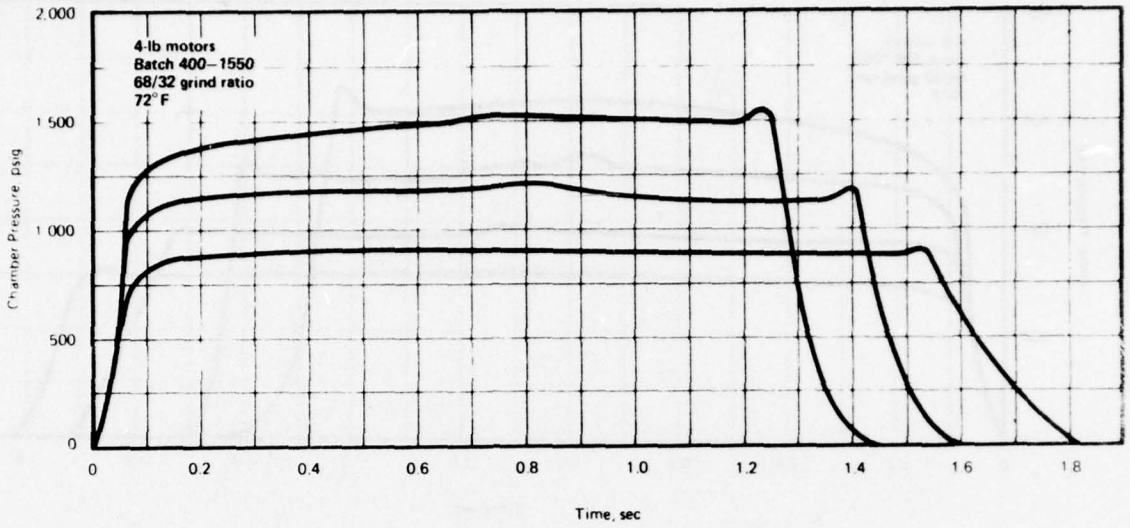

4-lb motors
Batch 400–1557
68/32 grind ratio
72° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

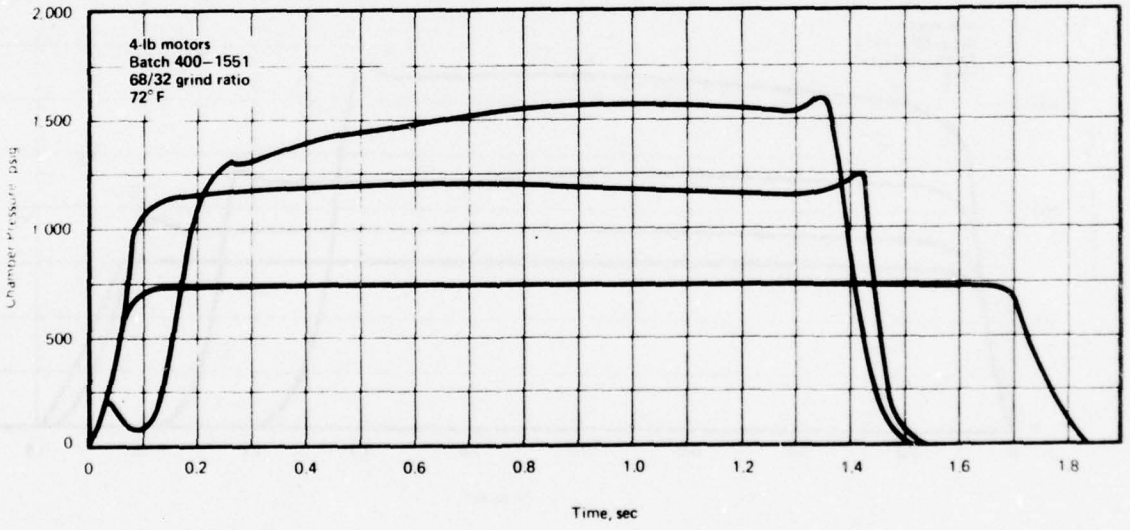

4-lb motors
Batch 400–1546
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

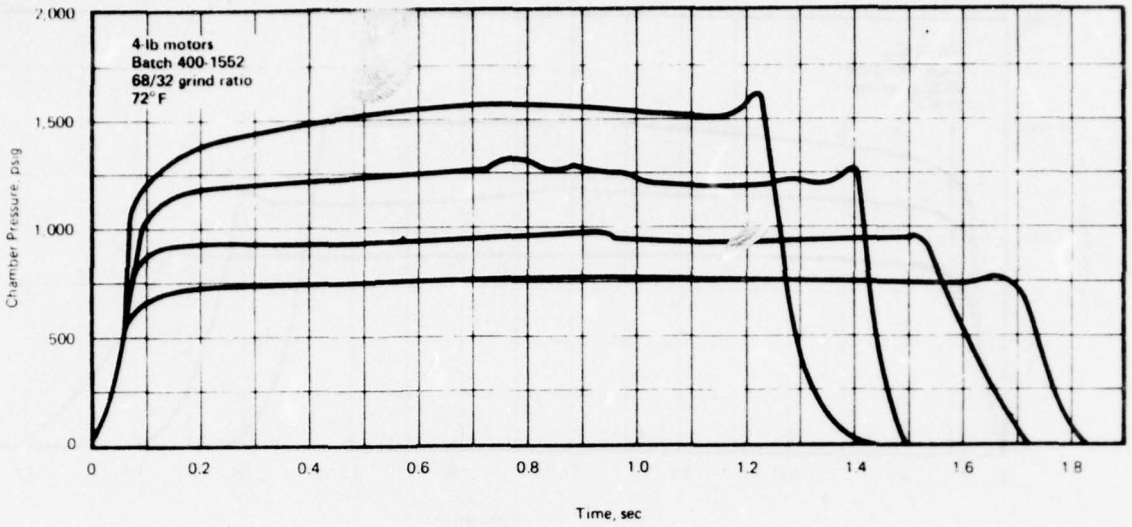

4-lb motors
Batch 400–1547
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

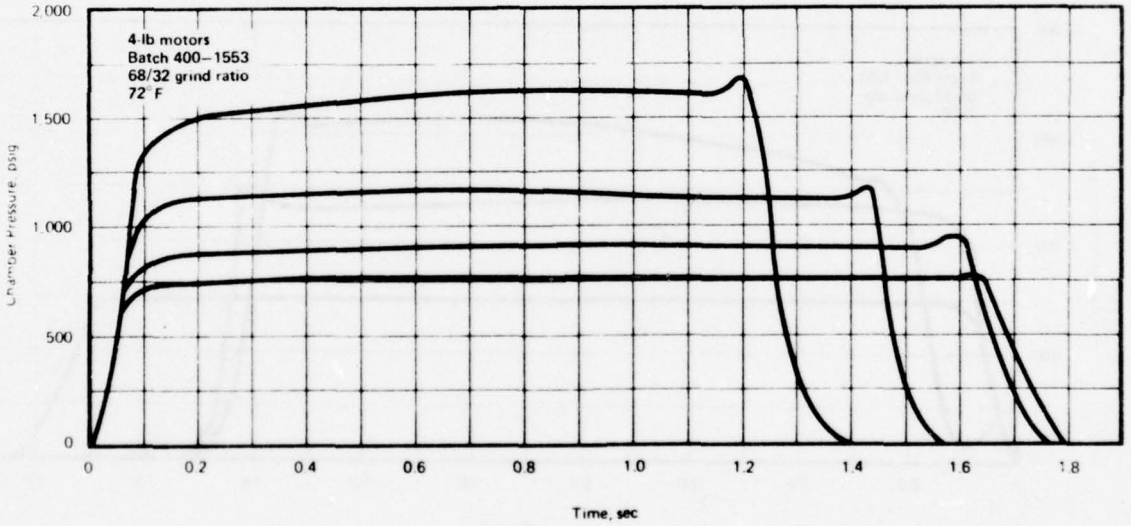

4-lb motors
Batch 400–1548
68/32 grind ratio
72°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

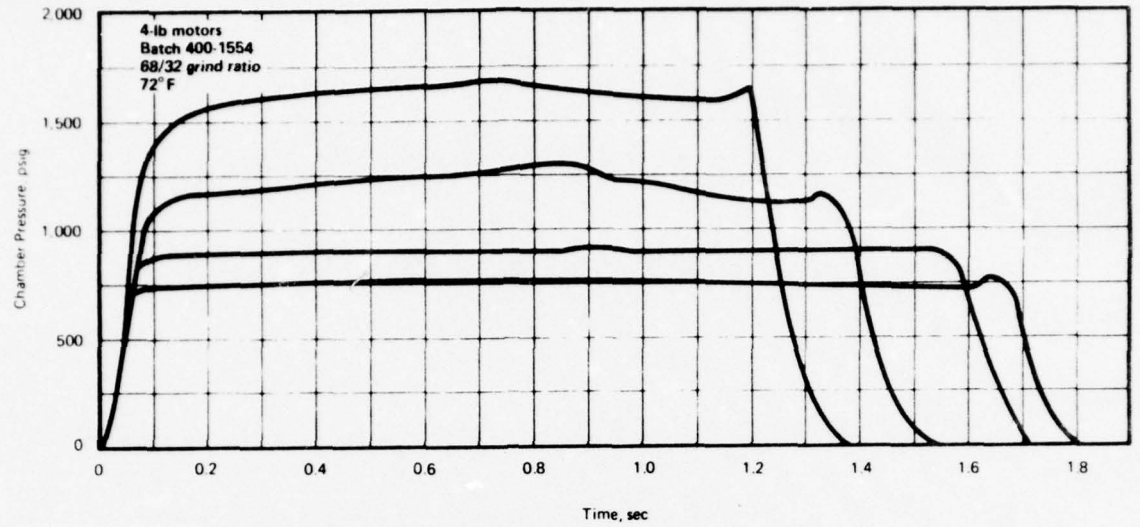

4-lb motors
400–1549
68/32 grind ratio
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

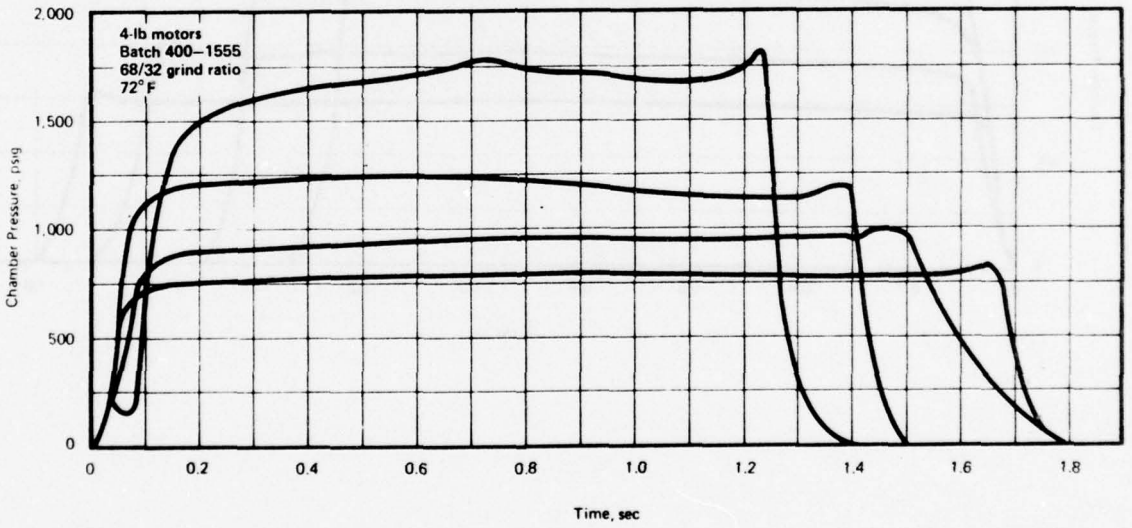

4-lb motors
Batch 400–1550
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

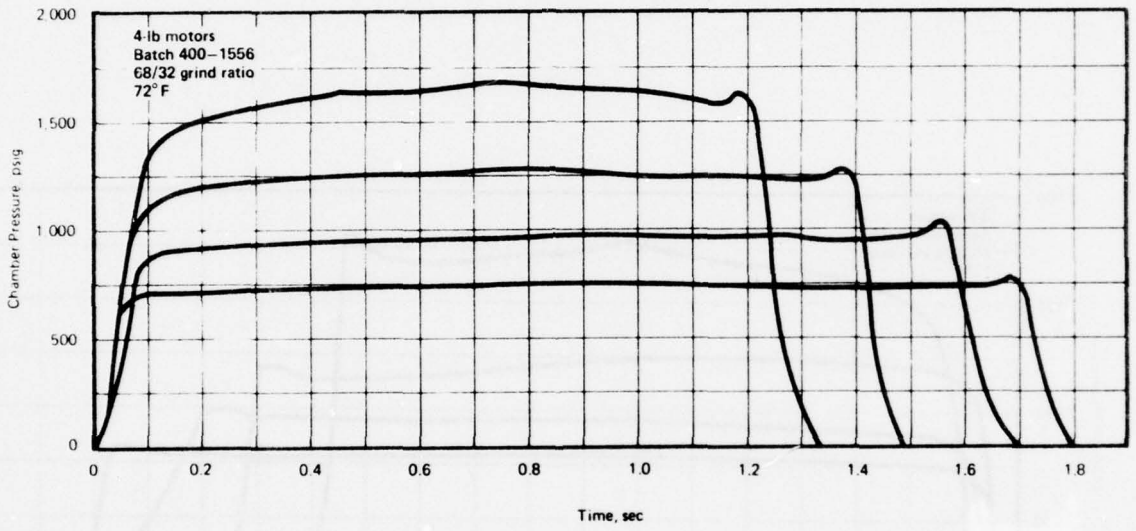

4-lb motors
Batch 400–1551
68/32 grind ratio
72° F
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400-1552
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1553
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400-1554
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400—1555
68/32 grind ratio
72° F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec


4-lb motors
Batch 400–1556
68/32 grind ratio
72°F
Chamber Pressure, psig
2,000
1,500
1,000
500
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Time, sec

SECTION 2.12

PRODUCTION RUN NO. 8

(BATCHES 400-1574 THROUGH 400-1582)

PRODUCTION CASTING #8
UTP 18803A 67/33 GRIND RATIO AND 0.81 NCO/OH RATIO
FOUR POUND MOTORS 80 F

Batch	Burning Rate, in/sec 1000 psia	1400 psia	1700 psia	Exponent	σ, %
400-1574	.3933	.4606	.5045	.469	0.9
400-1575	.3925	.4702	.5218	.537	0.8
400-1576	.3946	.4706	.5210	.523	1.5
400-1577	.3982	.4710	.5189	.499	0.7
400-1578	.3971	.4705	.5189	.504	1.0
400-1579	.3991	.4813	.5362	.557	1.1
400-1580	.3964	.4740	.5255	.532	1.9
400-1581	.3944	.4730	.5252	.539	0.5
00-1582	.3996	.4720	.5197	.495	0.7
Composite	.3956	.4720	.5226	.525	1.45

PRODUCTION CASTING #8
UTP 18803A 67/33 GRIND RATIO AND .81 NCO/OH RATIO
FOUR POUND MOTOR DATA, 80°F

Batch	Burning Rate, in/sec/Chamber pressure, psia
400-1574	.3798/927, .4523/1336, .4718/1447, .4523/1385*
400-1575	.3789/941, .504/1585, .5065/1647, .4736/1405, .4994/1547*
400-1576	.3798/925, .5238/1652, .4869/1511, .4894/1501, .4879/1557*
400-1577	.3874/948, .5046/1648, .5218/1700, .4839/1468, .4955/1536*
400-1578	.3888/962, .5016/1534, .5053/1640, .505/1628, .4817/1473*
400-1579	.3934/970, .5223/1605, .5566/1819, .5067/1506, .4799/1441*
400-1580	.396/982, .4949/1465, .5306/1708, .461/1340, .455/1372*
400-1581	.386/965, .459/1320, .5367/1777, .457/1326, .459/1305*
400-1582	.395/971, .4629/1357, .5258/1727, .454/1320, .4624/1324*

All four motors used a fiberglass cartridge except those identified by * which were steel cartridges.

UTP 18803A

PRODUCTION CASTING #8

TABLE I - LSBR DATA

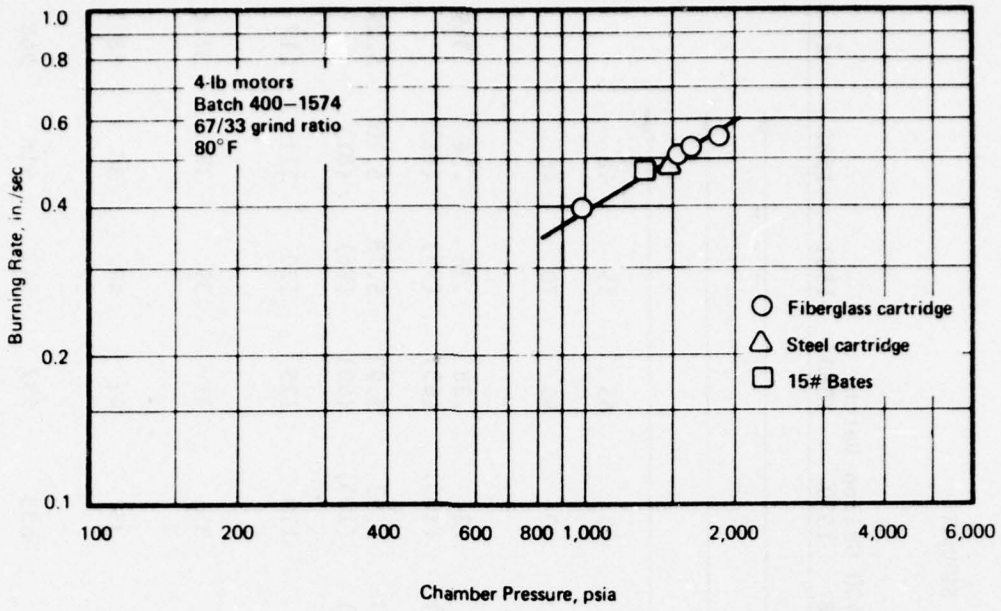
Batch No.	AP Addition Time, min	Mix Time After IPDI Addition, min	Pressure	Premix C	Final
400-1574	43	40	1000	0.490	0.475
			1400	0.623	0.598
400-1575	55	70	1000	0.505	0.448
			1400	0.643	0.582
400-1576	40	40	1000	0.482	0.451
			1400	0.616	0.577
400-1577	75	70	1000	0.480	0.477*
			1400	0.612	0.565*
400-1578	35	40	1000	0.480	0.452
			1400	0.610	0.569*
400-1579	55	70	1000	0.491	0.452
			1400	0.619	0.577
400-1580	65	40	1000	0.490	0.450
			1400	0.618	0.576
)0-1581	55	70	1000	0.486	0.452
			1400	0.615	0.566*
400-1582	48	40	1000	0.478	0.451
			1400	0.611	0.570

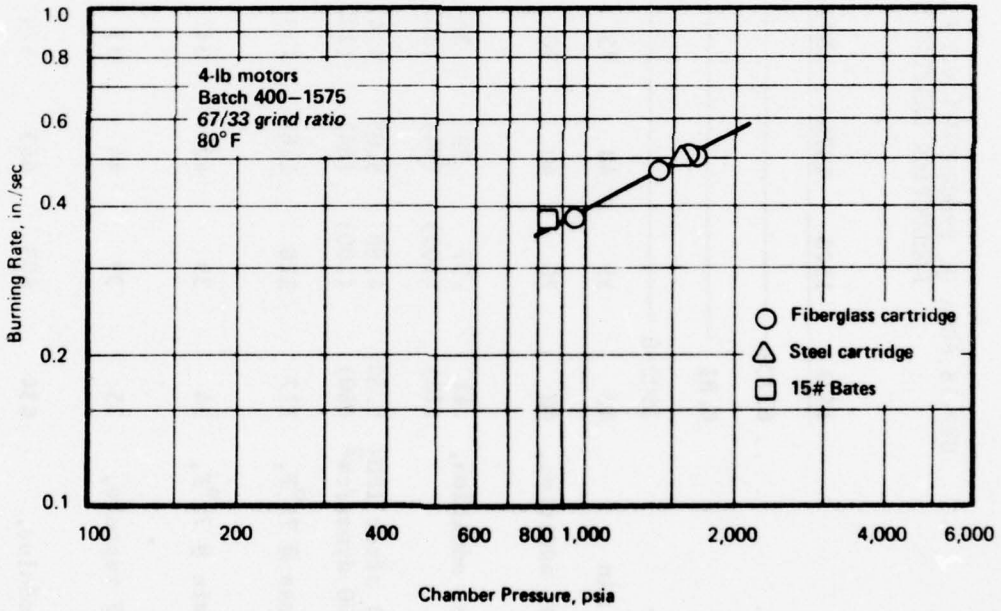
* Burn rate out of spec. Spec limits are:

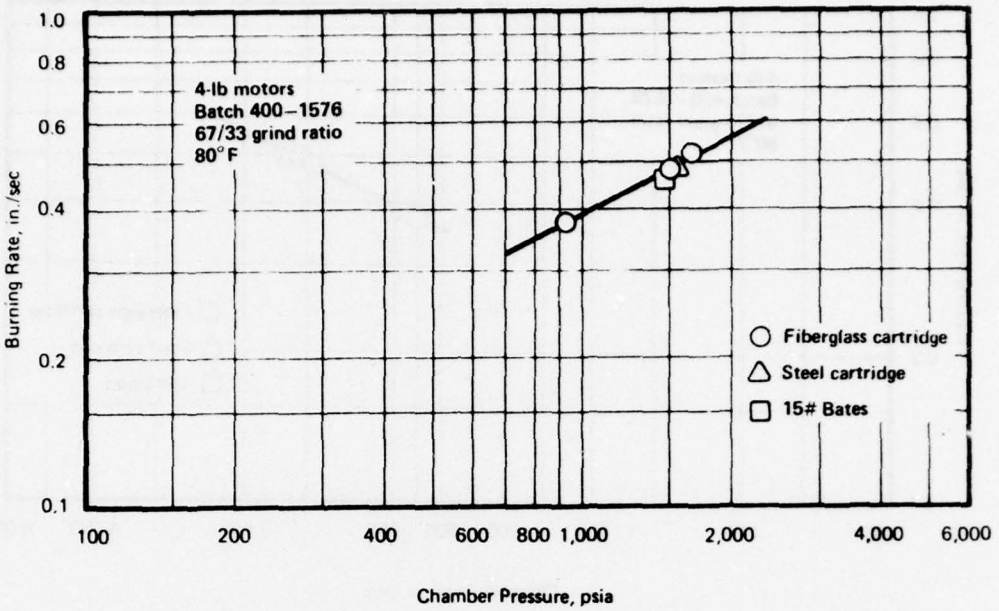
	Min	Max
Premix C @ 1400	0.605	0.646
Final @ 1400	0.570	0.617

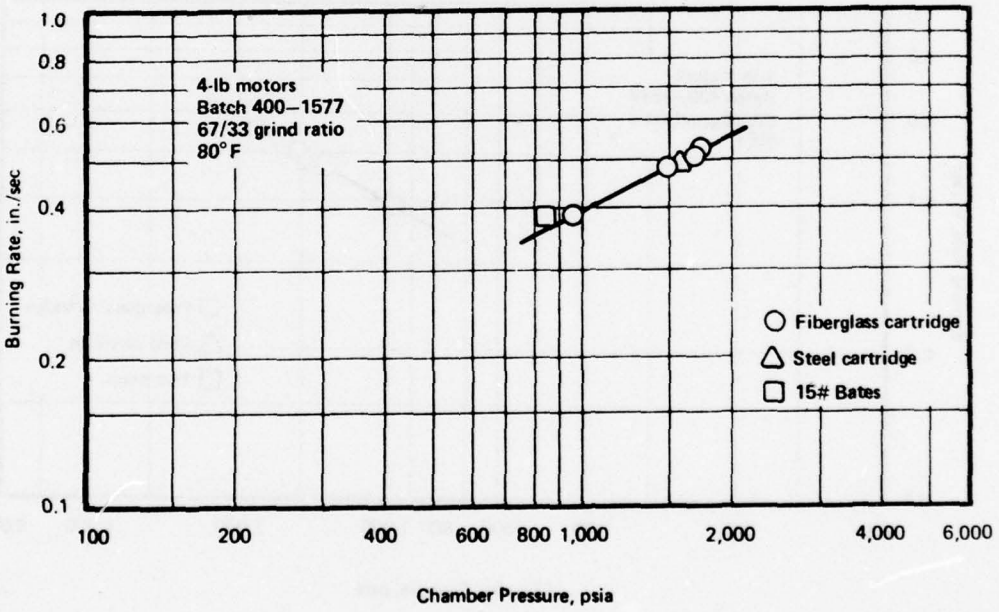
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 8

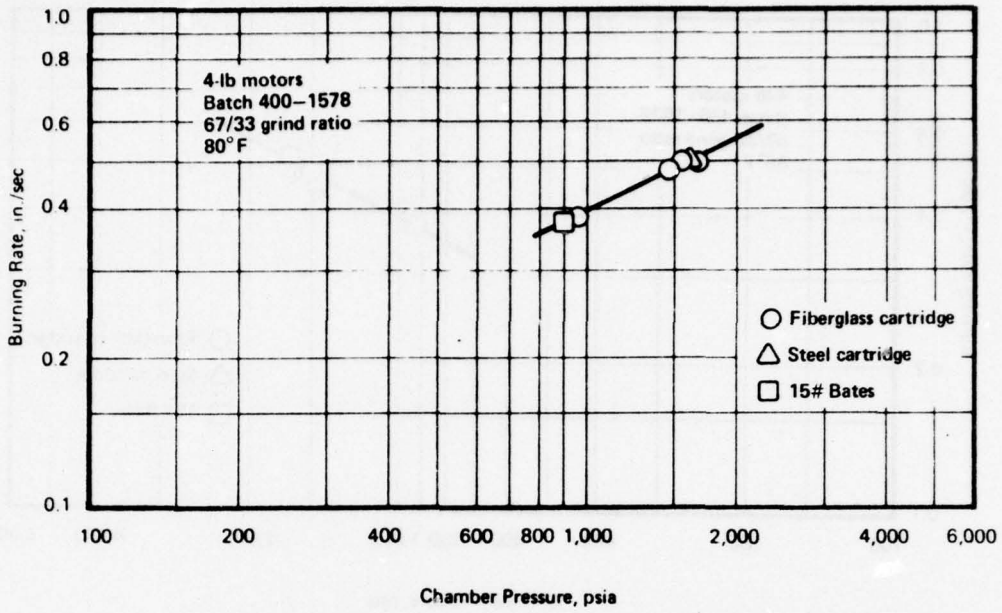
Parameter	400 Gallon Batch 1574	1575	1576	1577	1578	1579	1580	1581	1582	$\bar{X}$	Sx
Grind ratio	67/33 →										
NCO/OH	0.81 →										
Fuel premix number	3500-8 →										
AP addition time, min	43	55	40	75	35	55	65	55	48		
Mix time after IPDI addition, sec	40	70	40	70	40	70	40	70	40		
IPDI @ (-min) after addition, wt %	.41 (70)	.37 (105)	.39 (84)	.35 (101)	.36 (81)	.34 (105)	.38 (65)	.36 (96)	.36 (81)	.369	.0022
Viscosity @ (-min) after IPDI addition, Kp @ 5000 dynes/cm^2	5.34 (60)	4.86 (100)	5.05 (84)	4.47 (102)	5.57 (81)	4.93 (105)	5.93 (60)	5.78 (96)	5.70 (81)	5.29	.0049
Max corrected stress @ 75^{o}F, $\sigma^c m$, psi	117	120	116	113	113	119	125	120	111	117	4.4
Max corrected strain @ 75^{o}F, $\varepsilon^c m$, %	34	39	42	34	36	35	41	39	38	37.6	2.96
True strain @ 75^{o}F rupture, E_r, %	35	39	44	35	36	35	42	40	38	38.2	3.31
Initial tangent modulus, E_o, psi	634	603	463	579	431	635	537	542	618	560	73.8

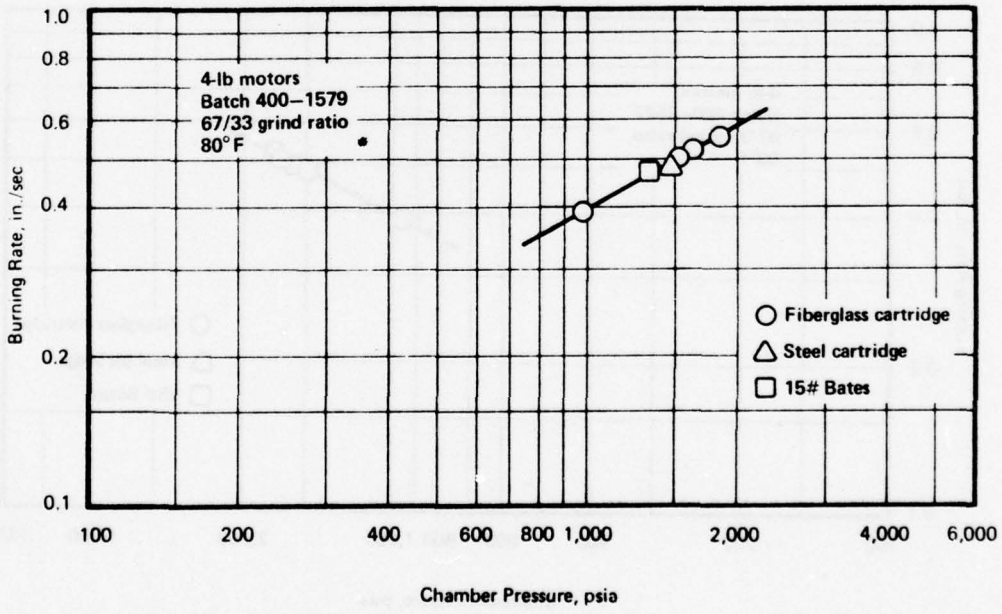

4-lb motors
Batch 400–1574
67/33 grind ratio
80° F
Fiberglass cartridge
Steel cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

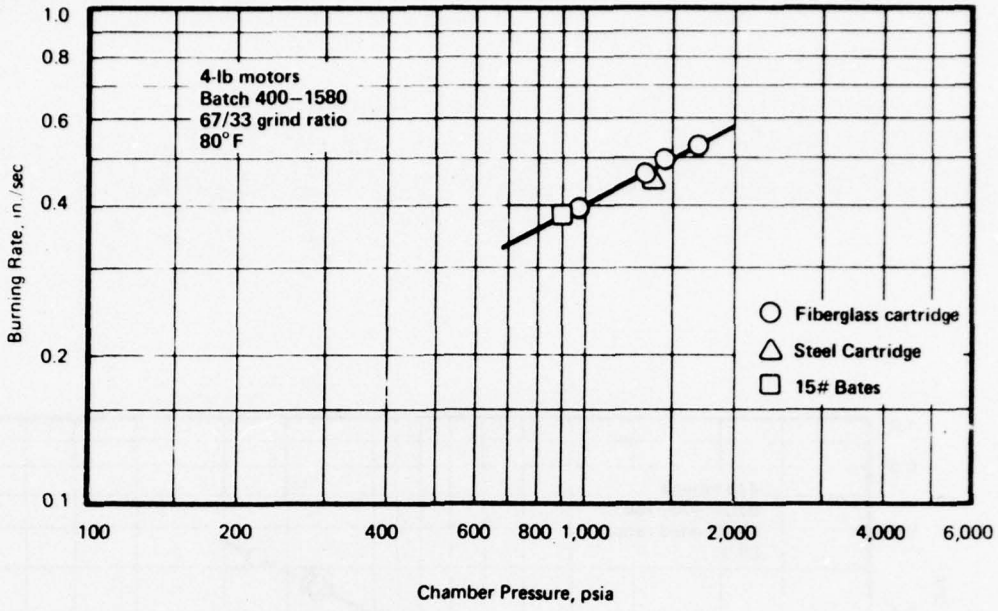

4-lb motors
Batch 400–1575
67/33 grind ratio
80° F
Fiberglass cartridge
Steel cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

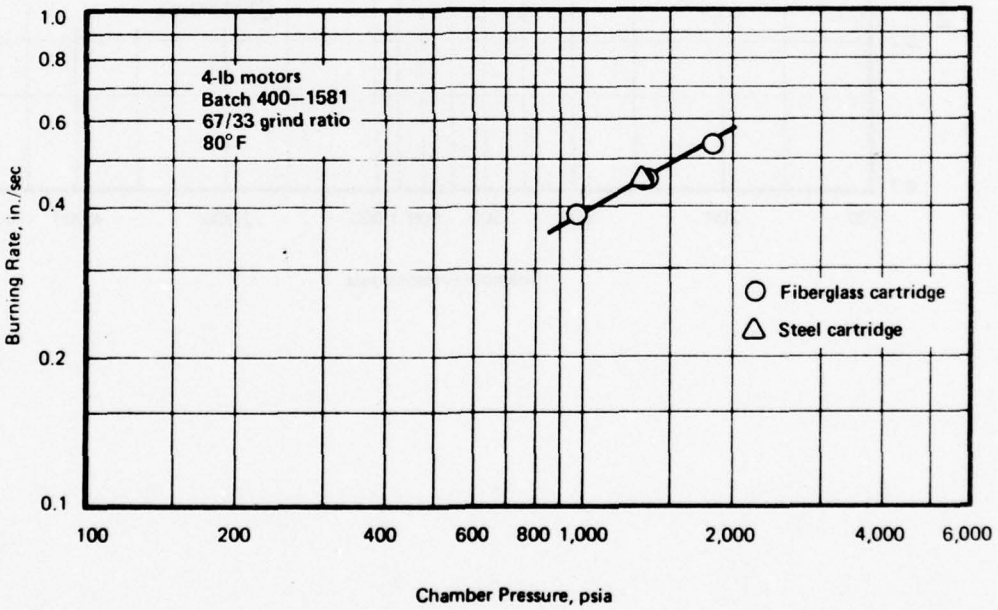

4-lb motors
Batch 400–1576
67/33 grind ratio
80° F
Fiberglass cartridge
Steel cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

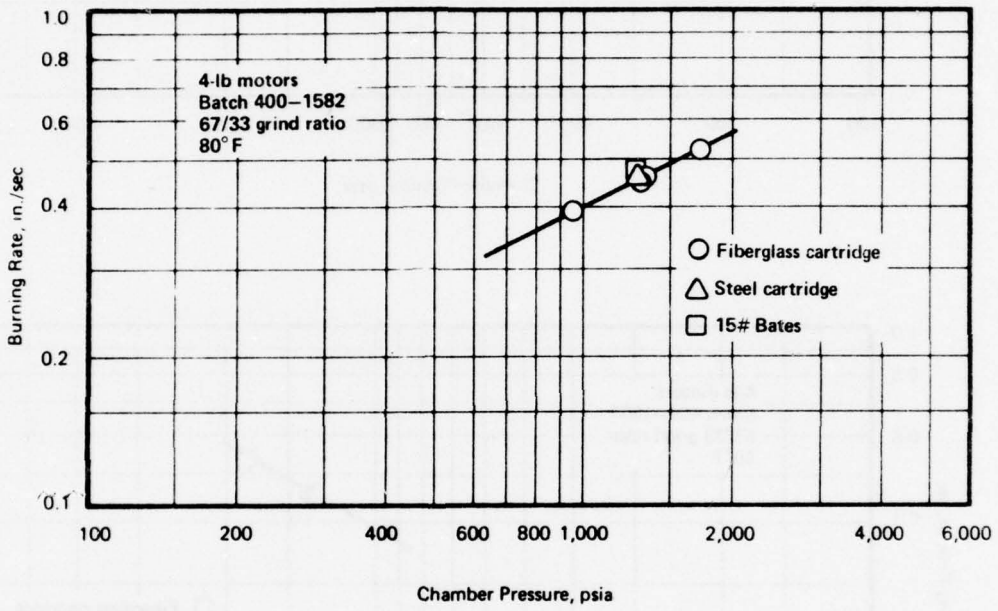

4-lb motors
Batch 400–1577
67/33 grind ratio
80° F
Fiberglass cartridge
Steel cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1578
67/33 grind ratio
80°F
Fiberglass cartridge
Steel cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1579
67/33 grind ratio
80°F
Fiberglass cartridge
Steel cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1580
67/33 grind ratio
80° F
Fiberglass cartridge
Steel Cartridge
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1581
67/33 grind ratio
80° F
Fiberglass cartridge
Steel cartridge
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1582
67/33 grind ratio
80° F
Fiberglass cartridge
Steel cartridge
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.13

PRODUCTION RUN NO. 9

(BATCHES 400-1588 THROUGH 400-1600)

PRODUCTION CASTING #9

UTP 18,803A 67/33 GRIND RATIO AND 0.81 NCO/OH RATIO

FOUR POUND MOTORS, 70°F

Batch	Burning Rate, in/sec 1000 psia	1400 psia	1700 psia	Exponent	, %
400-1588	.3948	.4815	.5400	.590	0.27
400-1589	.4046	.4825	.5340	.523	0.50
400-1590	.4035	.4882	.5434	.552	1.53
400-1591	.4078	.4903	.5453	.548	1.54
400-1592	.4046	.4877	.5432	.555	0.62
400-1593	.3993	.4894	.5503	.604	1.27
400-1594	.4036	.4834	.5364	.536	0.00
400-1595	.4084	.4892	.5428	.536	0.00
400-1596	.4073	.4895	.5443	.546	1.15
400-1597	.4123	.4924	.5455	.527	0.57
400-1598	.4125	.4960	.5517	.548	0.86
400-1599	.4132	.4967	.5523	.547	0.02
400-1600	.4134	.498	.5550	.555	0.62
Composite	.4063	.4898	.5456	.556	1.43

UTP 18,803A PRODUCTION CASTING #9
67/33 GRIND RATIO AND .81 NCO/OH RATIO
FOUR POUND MOTOR DATA 70°F

Batch	Burning Rate/in/sec/Chamber Pressure, psia
400-1588	.385/957, .525/1629, .5914/1976
400-1589	.3976/969, .5398/1718, .5527/1832
400-1590	.3700/798, .4107/1030, .5435/1650, .5654/1871
400-1591	.4048/990, .5821/1859, .5904/2017
400-1592	.3686/794, .4027/994, .5535/1737, .590/1992
400-1593	.3649/793, .4126/1064, .5567/1692, .6252/2133
400-1594	.361/776, .4181/1068, .5649/1873
400-1595	.3775/810, .4207/1057, .5459/1718
400-1596	.3848/837, .4258/1087, .5599/1751, 5641/1857
400-1597	.3885/835, .430/1084, .5557/1741, .5634/1826
400-1598	.3746/810, .4298/1074, .5392/1659, .5867/1877
400-1599	.380/820, .4159/1012, .5382/1622, .5859/1893
400-1600	.3832/831, .4173/1014, .5493/1689, .6049/1966

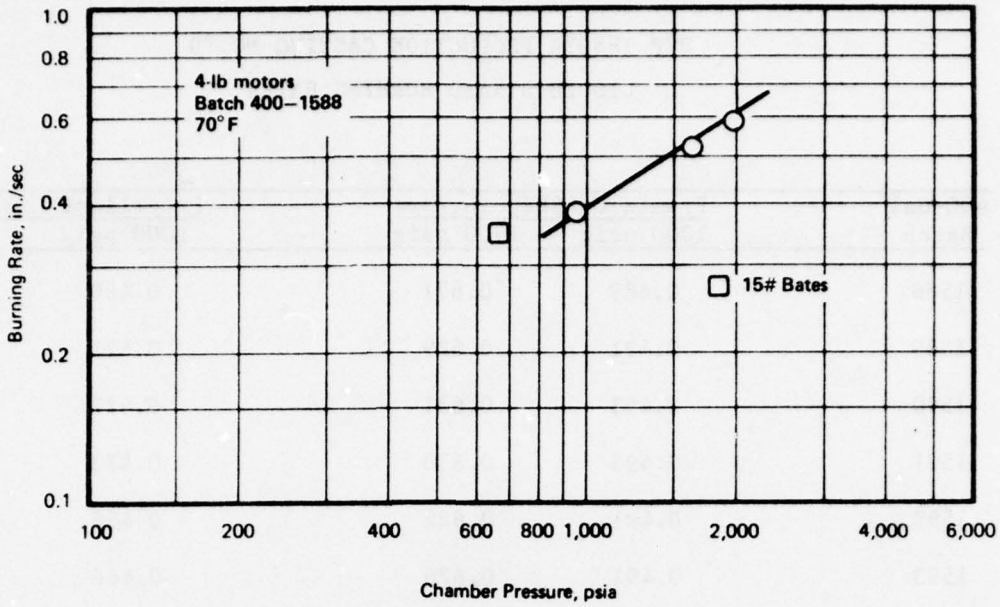
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 9

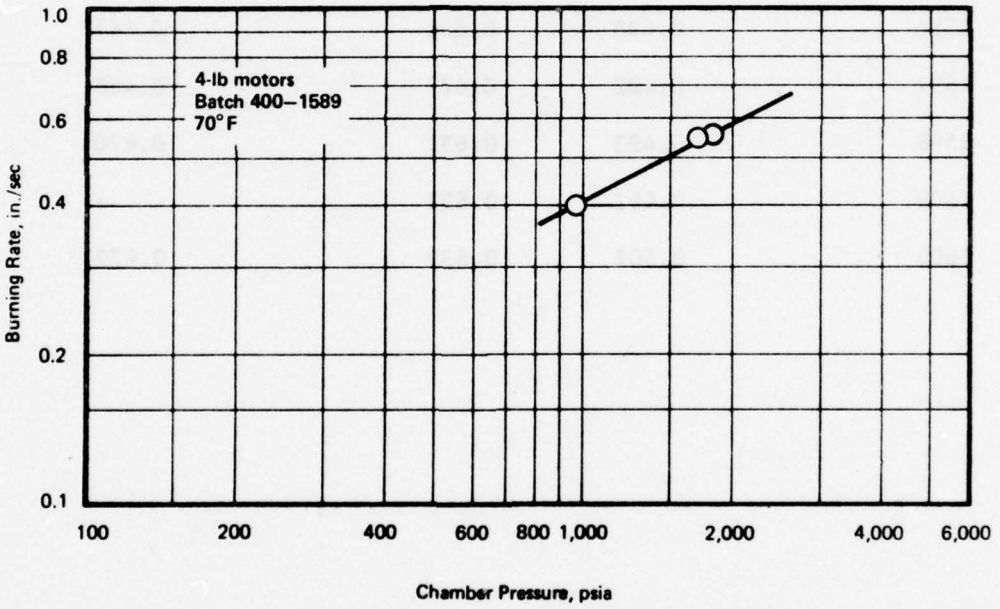
Parameter	400 Gallon Batch														
	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599	1600	$\bar{X}$	Sx
Grind ratio	67/33 →														
NCO/OH ratio	0.81 →														
Fuel Premix number	3500-8 →														
IPDI @ 60 min after addition, wt, %	0.40	0.40	0.38	0.38	0.38	0.38	0.40	0.38	0.38	0.40	0.38	0.39	0.40	0.388	0.0099
Viscosity @ 60 min after IPDI addition, Kp @ 5000 dynes/cm^2	2.71	2.53	3.18	3.91	3.85	5.19	3.74	4.10	3.24	3.76	3.65	3.74	6.49	3.85	1.03
Max corrected stress @ 75°F, $\sigma^c m$, psi	97	102	101	99	97	92	101	97	98	90	113	116	109	100.9	7.6
Max corrected strain @ 75°F $\varepsilon^c m$, %	31	30	34	36	31	34	36	37	32	29	34	32	26	32.46	3.13
True strain @ 75°F rupture, E_r, %	32	30	36	38	32	34	38	37	33	29	34	36	27	33.54	3.48
Initial tangent modulus, E_o, psi	813	952	588	600	694	588	867	661	632	761	952	896	1005	770	153

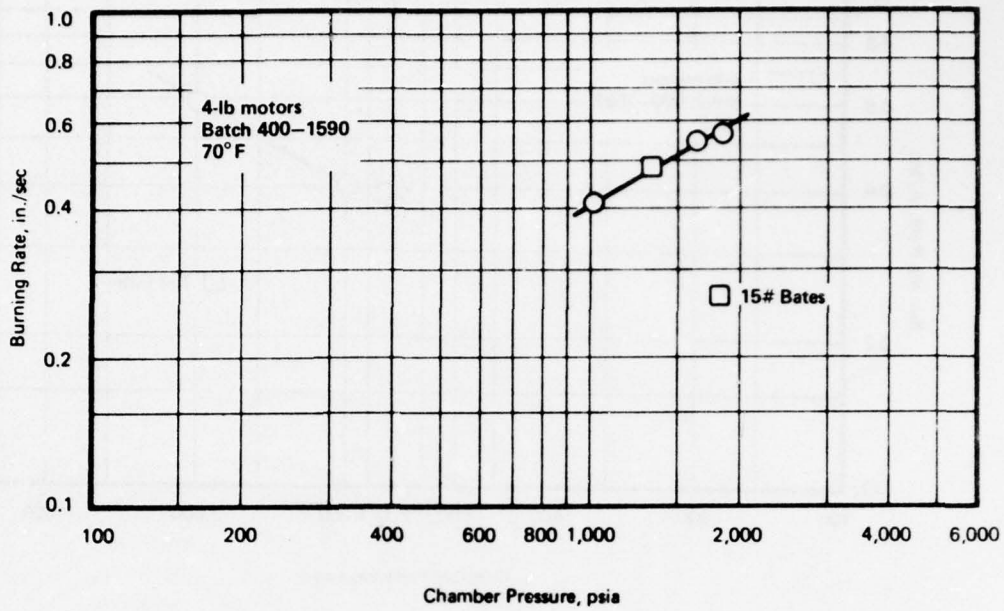
UTP 18803A PRODUCTION CASTING NO. 9

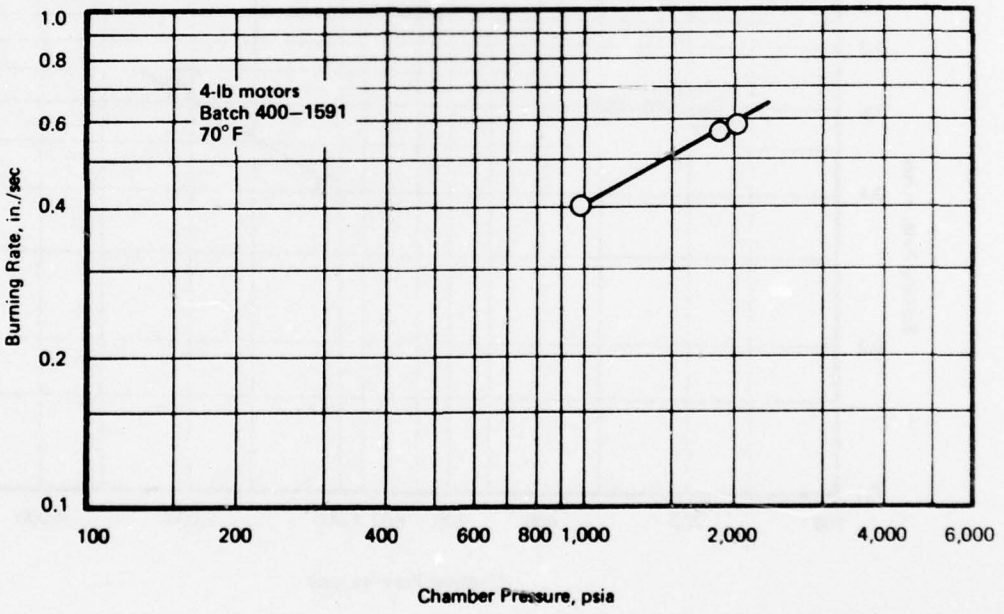
LIQUID STRAND BURNING RATES

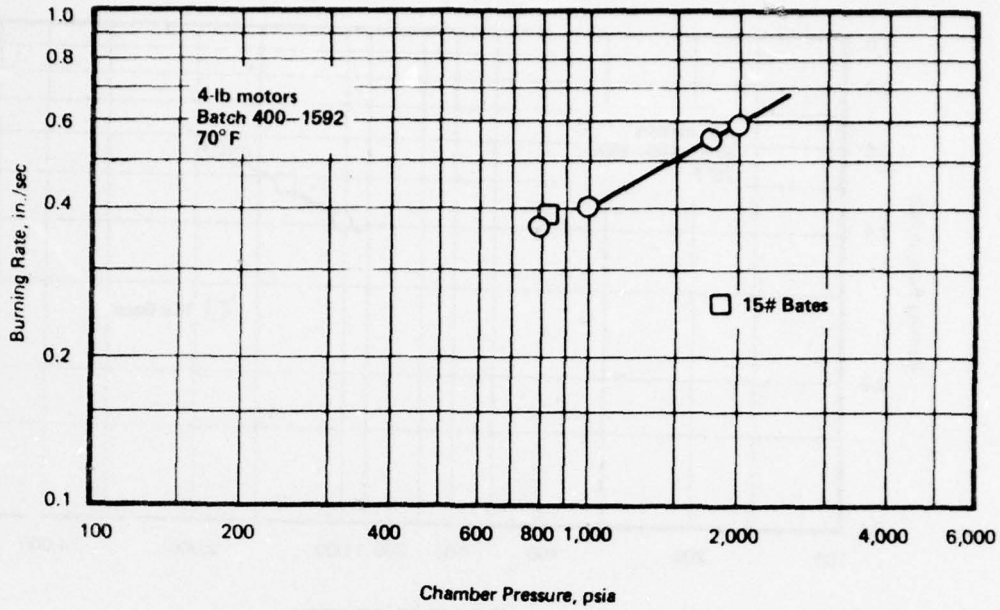
400-Gal Batch	Premix C LSBR, in./sec		Propellant LSBR, in./sec	
	1000 psig	1400 psig	1000 psig	1400 psig
1588	0.489	0.631	0.460	0.583
1589	0.491	0.629	0.471	0.600
1590	0.493	0.631	0.472	0.598
1591	0.493	0.630	0.473	0.598
1592	0.491	0.622	0.466	0.593
1593	0.491	0.626	0.466	0.589
1594	0.490	0.624	0.456	0.589
1595	0.478	0.613	0.469	0.594
1596	0.498	0.631	0.467	0.594
1597	0.492	0.627	0.468	0.598
1598	0.493	0.631	0.470	0.596
1599	0.492	0.632	-	0.599
1600	0.502	0.639	0.472	0.596

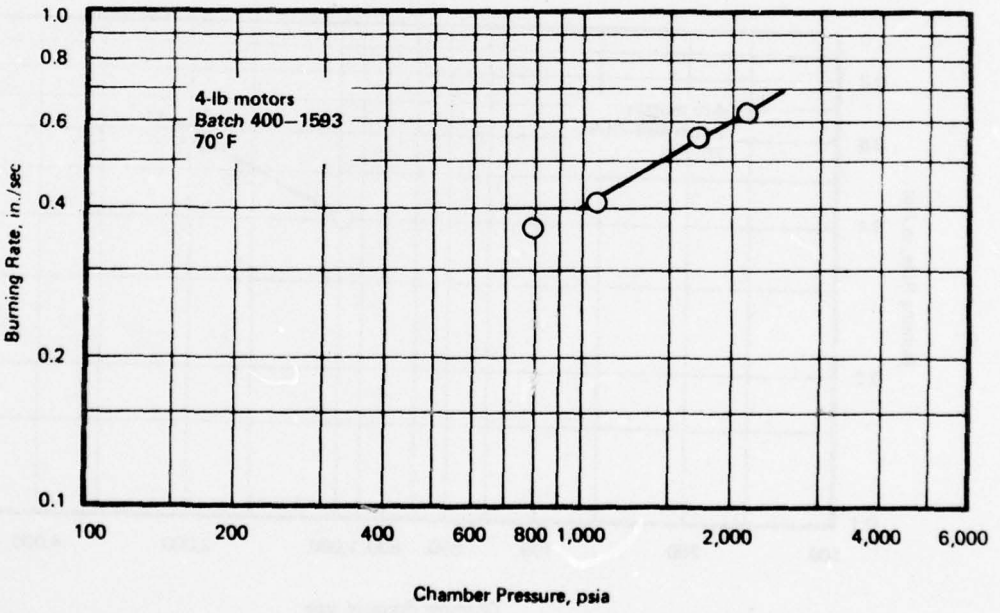

4-lb motors
Batch 400–1588
70° F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

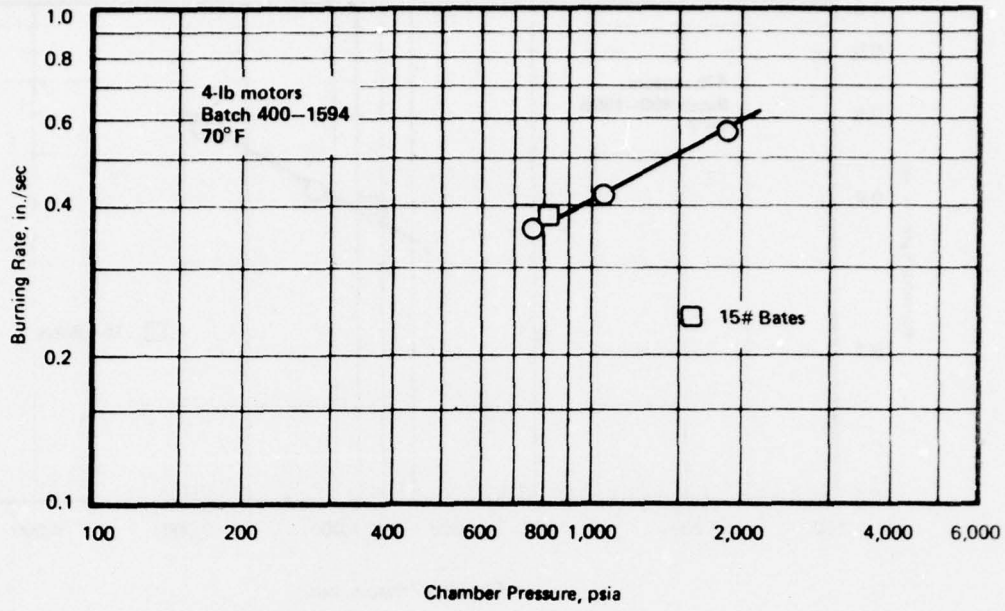

4-lb motors
Batch 400–1589
70° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

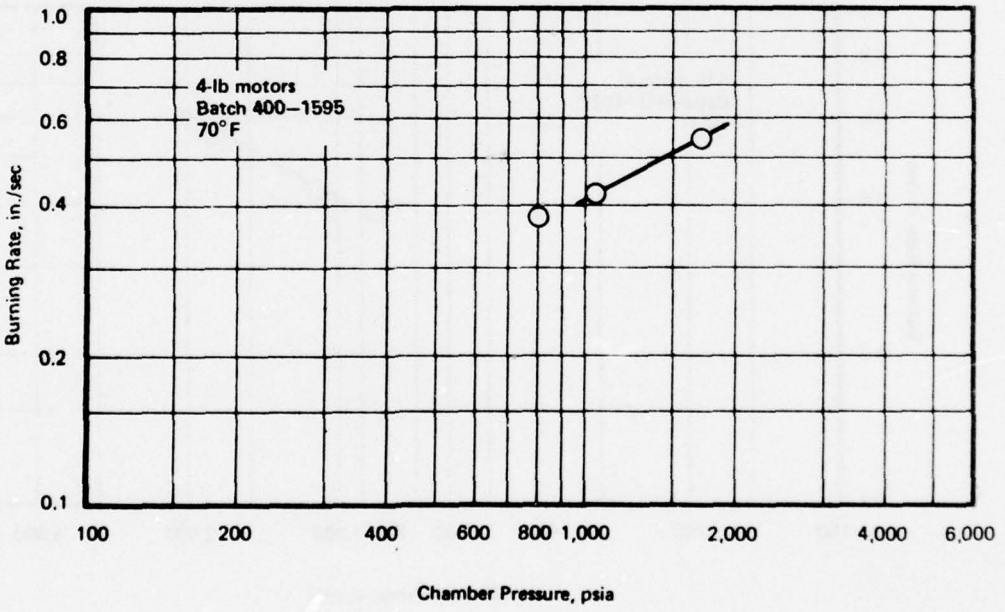

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1590
70° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

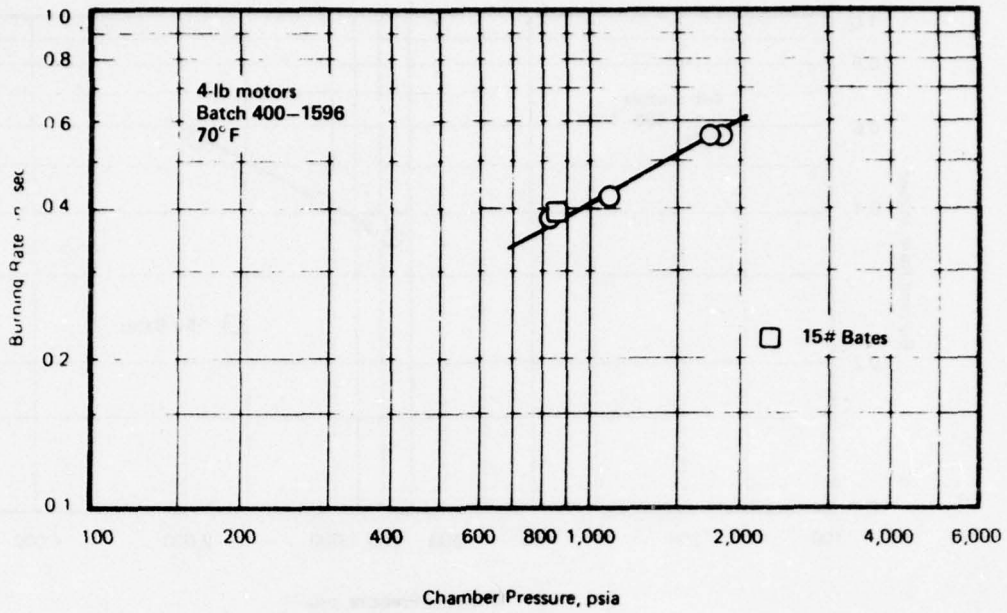

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1591
70° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

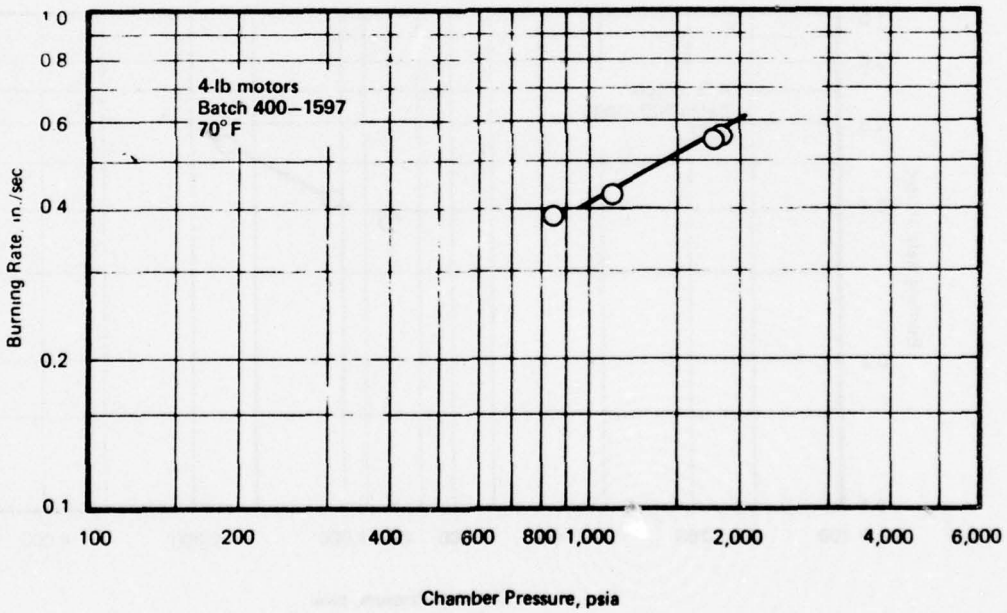

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1592
70° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

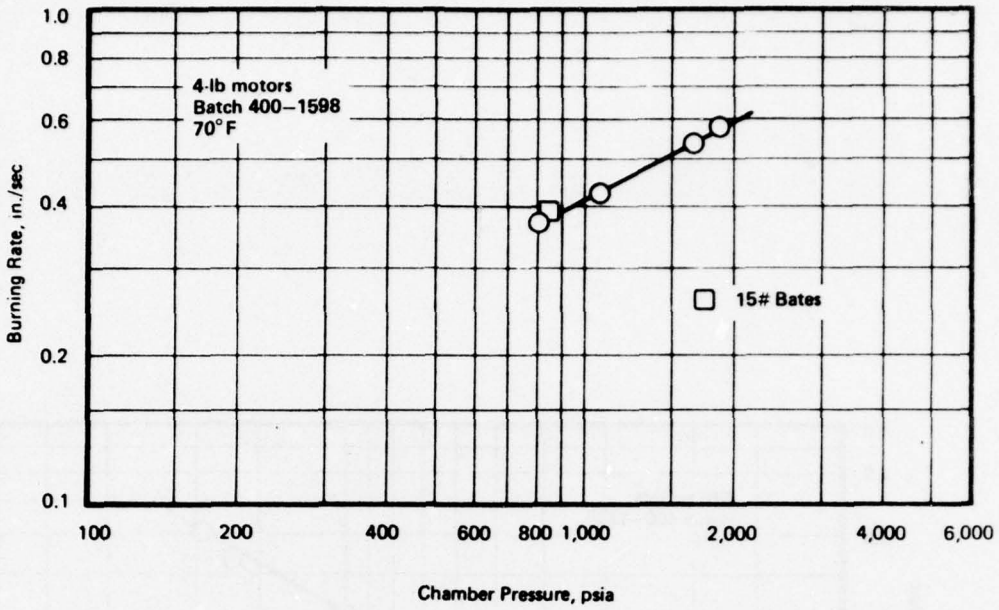

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1593
70° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

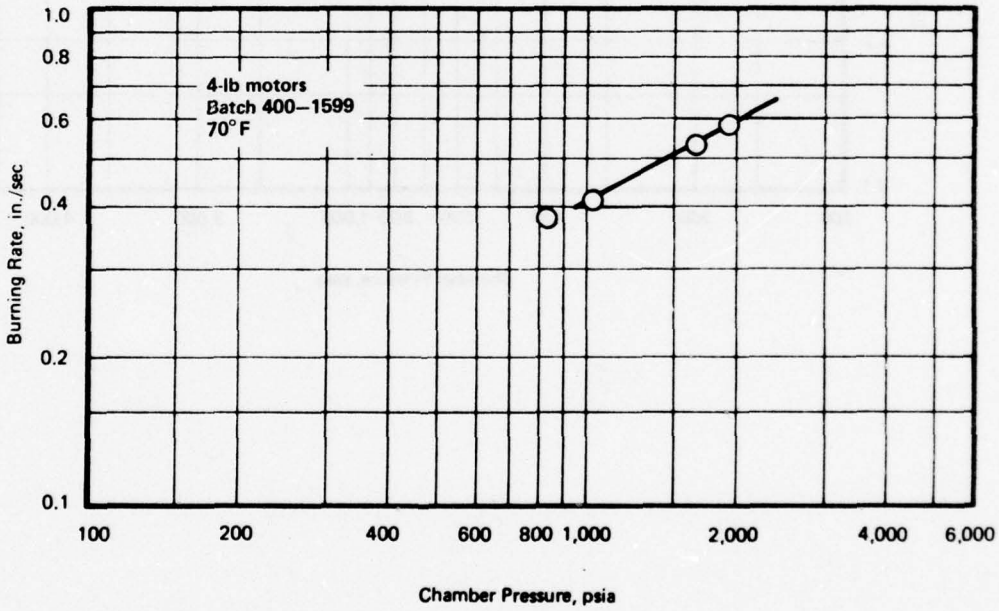

4-lb motors
Batch 400–1594
70° F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

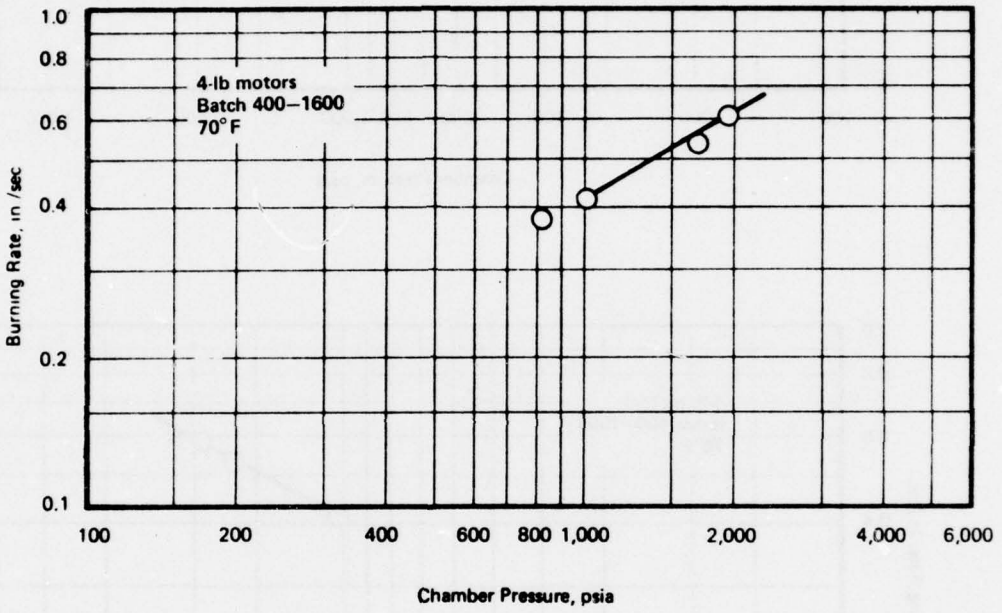

4-lb motors
Batch 400–1595
70° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1 0
0 8
0 6
0 4
0 2
0 1
4-lb motors
Batch 400–1596
70° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1 0
0 8
0 6
0 4
0.2
0 1
Burning Rate, in./sec
4-lb motors
Batch 400–1597
70° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1598
70°F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motors
Batch 400–1599
70°F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
4-lb motors
Batch 400–1600
70°F
Burning Rate, in./sec
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.14

PRODUCTION RUN NO. 10

(BATCHES 400-1606 THROUGH 400-1615)

PRODUCTION CASTING #10

FOUR POUND MOTORS

62°F

Batch	Grind Ratio	Burning Rate, in/sec			Exponent	Standard Deviation Sx, %
		1000 psia	1400 psia	1700 psia		
400-1606	65/35	.403	.481	.533	.528	.2
400-1607	68/32	.399	.459	.497	.412	.8
400-1608	66/34	.395	.472	.523	.530	.8
400-1609	66/34	.394	.467	.515	.504	.8
400-1610	66/34	.411	.481	.527	.466	.6
400-1611	66/34	.404	.475	.522	.483	1.1
400-1612	66/34	.401	.480	.532	.532	.2
400-1613	66/34	.402	.475	.523	.495	.7
400-1614	66/34	.406	.489	.545	.554	0.1
400-1615	66/34	.402	.469	.513	.459	0.0
Composite of 66/34 Batches	66/34	.400	.477	.528	.522	1.4

UTP 18803A PRODUCTION CASTING NO. 10

FOUR POUND MOTOR DATA 62°F

Batch	Burning Rate, in/sec/Chamber Pressure, psia
400-1606	.3786/849, .4220/1088, .4459/1217, .5085/1551
400-1607	.3693/812, .3993/1012, .4306/1176, .4573/1404
400-1608	.382/887, .3938/986, .4262/1176, .4817/1444
400-1609	.3679/840, .3826/949, .4376/1207, .4670/1415
400-1610	.3706/810, .3887/878, .4606/1263, .487/1452
400-1611	.3637/789, .3955/944, .4266/1151, .4839/1435
400-1612	.3952/921, .3858/931, .4767/1380, .5156/1608
400-1613	.3739/859, .3963/843, .4586/1323, .4905/1472
400-1614	.3782/821, .3881/920, .4567/1238, .4995/1450
400-1615	.3722/804, .4113/1053, .4414/1227, .4680/1395

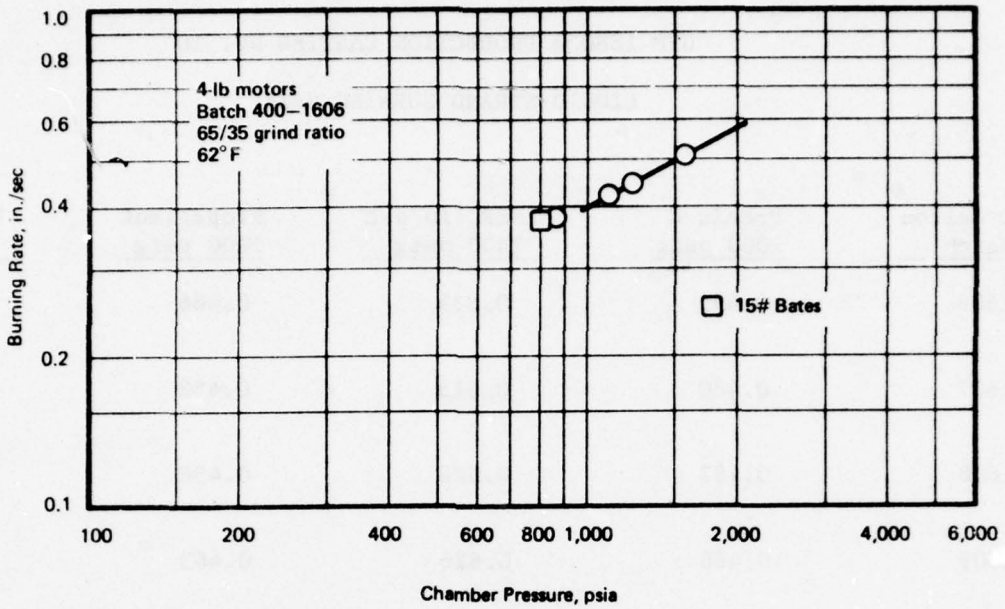
UTP-18,803A QC PROCESS AND PROPERTIES SUMMARY
PRODUCTION CASTING, 400-GALLON BATCH

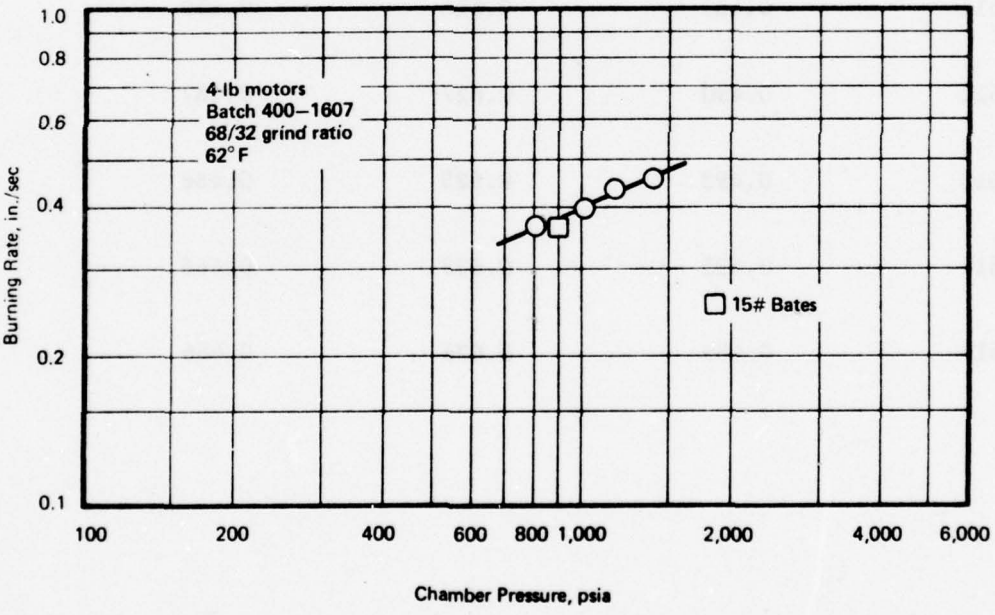
Parameter	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	$\bar{X}$	Sx
Grind ratio	65/35	68/32	66/34	66/34	66/34	66/34	66/34	66/34	66/34	66/34		
NCO/OH ratio	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81		
Fuel premix number	3500.9	3500.9	3500.9	3500.9	3500.9	3500.9	3500.9	3500.9	3500.9	3500.9		
IPDI @ 60 min after addition, %	0.38	0.37	0.38	0.36	0.36	0.38	0.36	0.36	0.36	0.36	0.367	0.0095
Viscosity @ 60 min after IPDI addition, Kp @ 5000 ues/cm^2	5.48	5.14	5.16	5.77	5.20	5.74	6.08	6.89	6.28	6.81	5.845	0.66
Max corrected stress @ 75°F, $\sigma^c m$, psia	114	118	112	100	107	99	102	112	114	113	109.1	6.66
Max corrected strain @ 75°F, $\varepsilon^c m$, %	42	38	37	36	40	33	38	38	34	39	37.5	2.68
True strain @ 75°F rupture, E_r, %	44	39	38	38	41	34	39	38	36	40	38.7	2.71
Initial tangent modulus, E_o, psi	746	966	884	706	805	838	828	866	1015	985	863.9	101.4

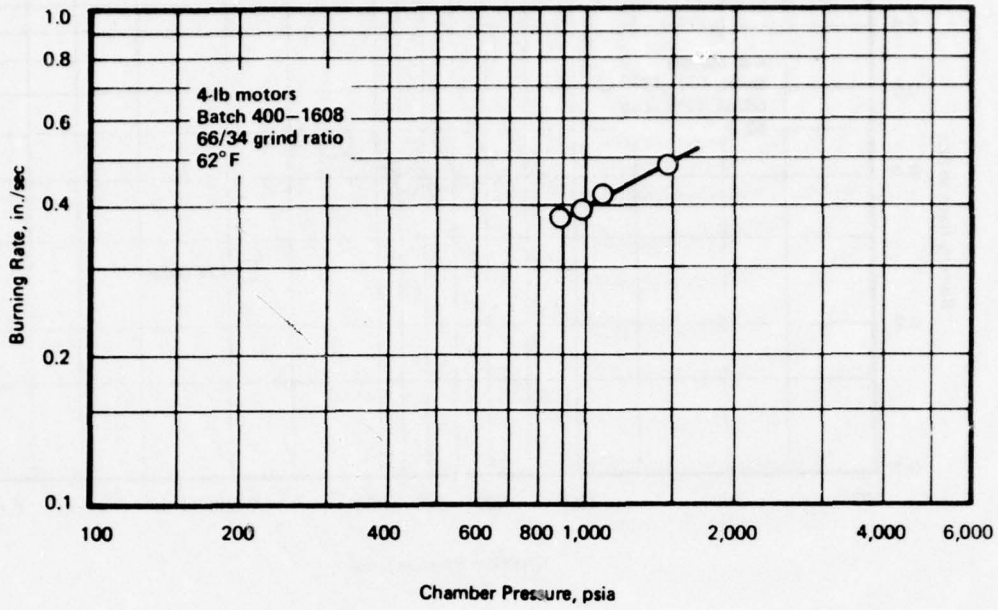
UTP 18803A PRODUCTION CASTING NO. 10

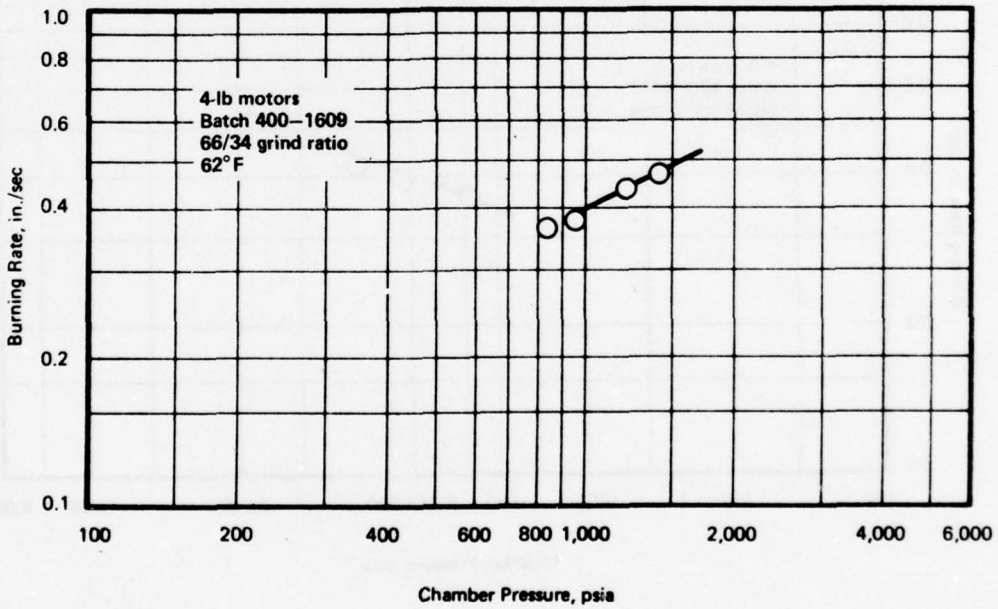
LIQUID STRAND BURNING RATE

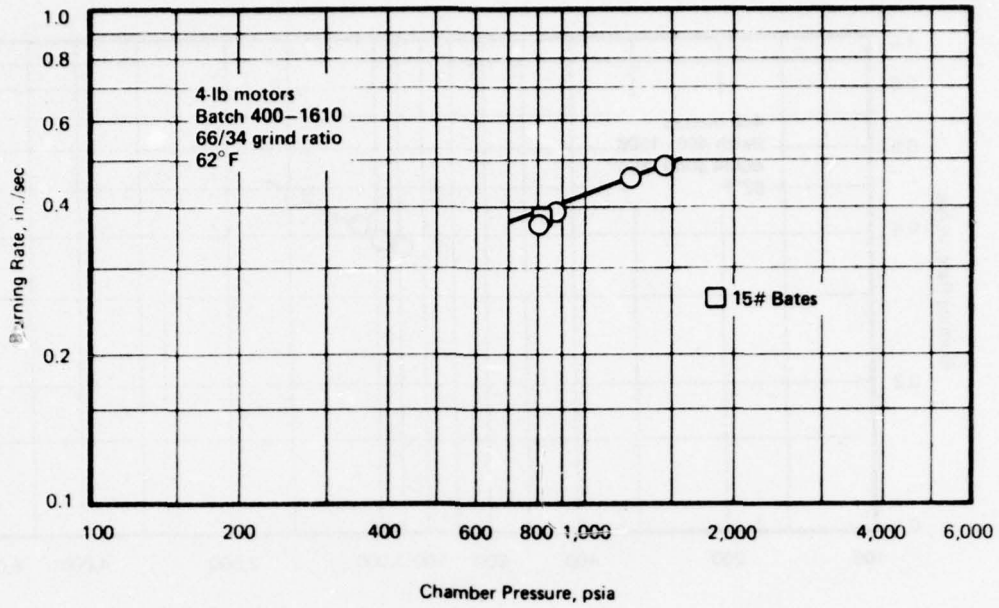
400 Gallon Batch	Premix C 1000 psig	LSBR, in/sec 1400 psig	Propellant 1000 psig	LSBR, in/sec 1400 psig
1606	0.495	0.635	0.466	0.600
1607	0.480	0.613	0.458	0.581
1608	0.487	0.628	0.458	0.589
1609	0.486	0.626	0.463	0.590
1610	0.487	0.625	0.460	0.582
1611	0.487	0.616	0.459	0.582
1612	0.490	0.627	0.467	0.591
1613	0.493	0.625	0.466	0.596
1614	0.495	0.633	0.466	0.593
1615	0.489	0.626	0.466	0.592

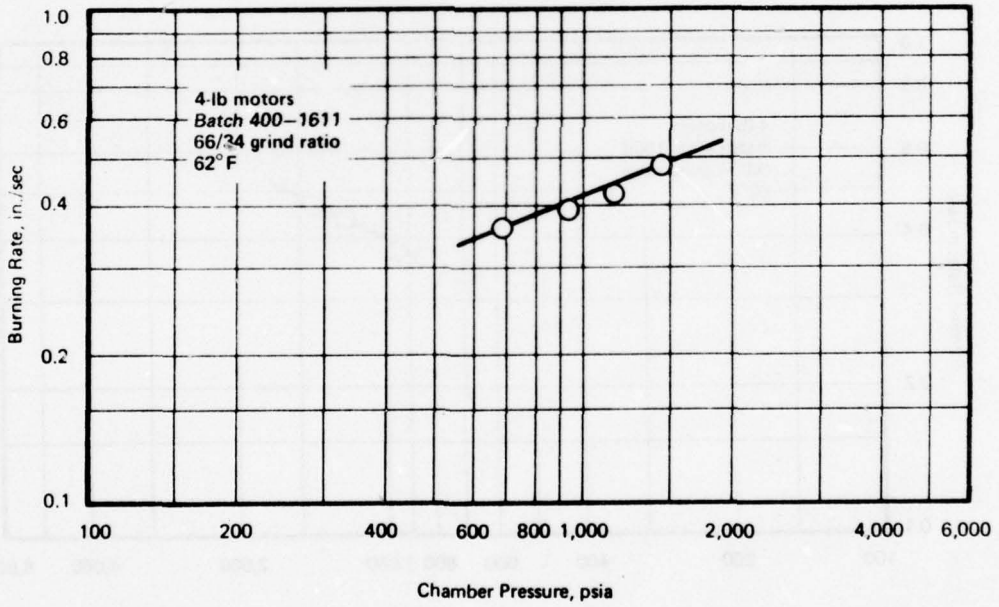

4-lb motors
Batch 400–1606
65/35 grind ratio
62° F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

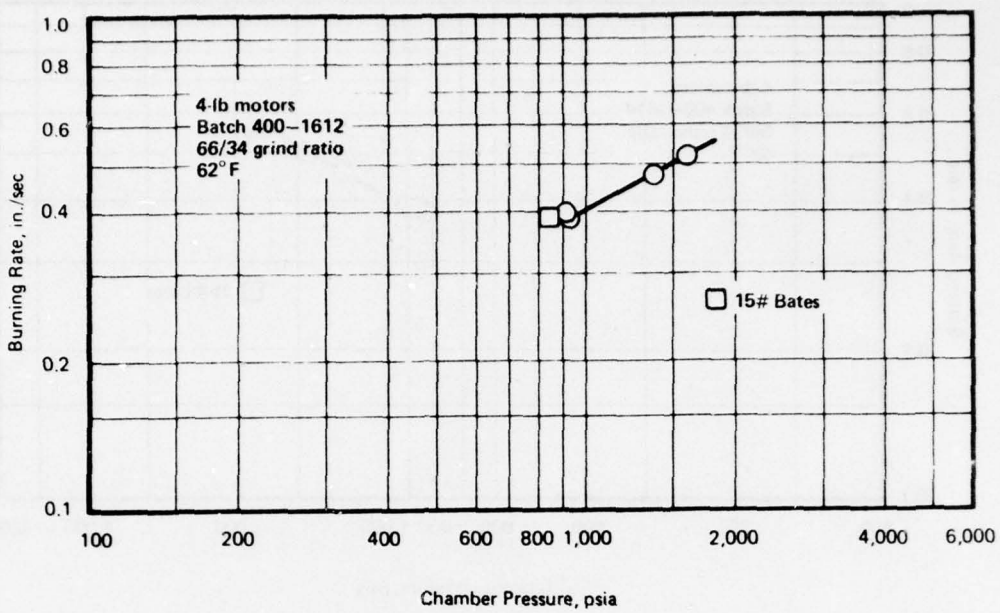

4-lb motors
Batch 400–1607
68/32 grind ratio
62° F
15# Bates
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

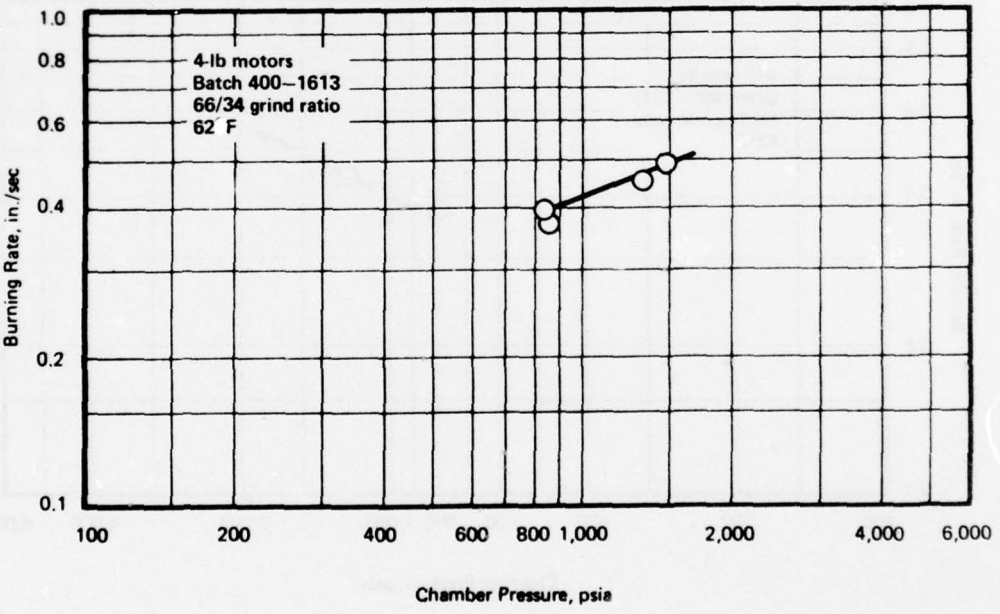

4-lb motors
Batch 400–1608
66/34 grind ratio
62° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

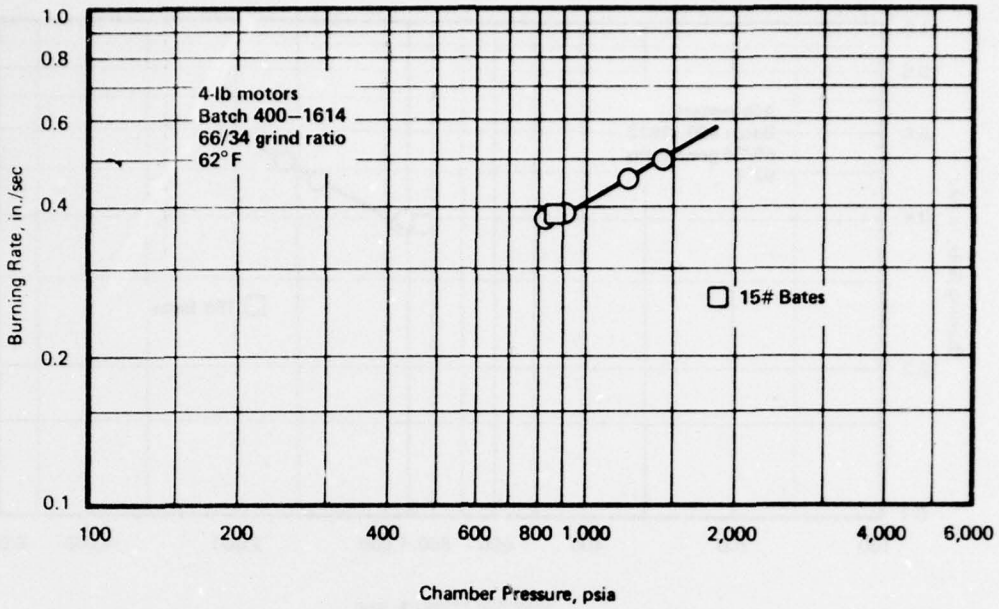

4-lb motors
Batch 400–1609
66/34 grind ratio
62° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

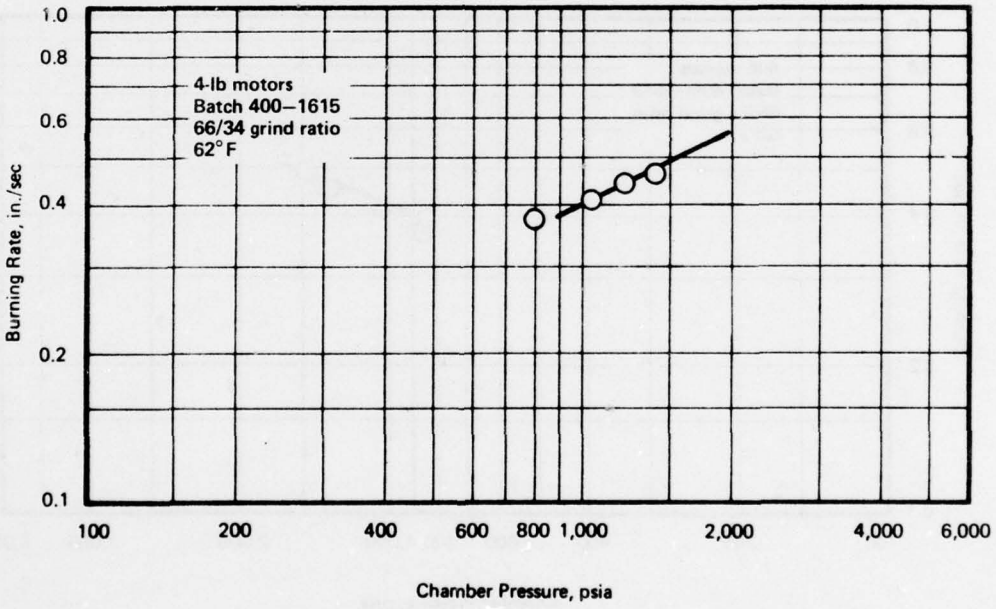

1.0
0.8
0.6
0.4
0.2
0.1
4-lb motors
Batch 400–1610
66/34 grind ratio
62°F
15# Bates
Burning Rate, in./sec
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
4-lb motors
Batch 400–1611
66/34 grind ratio
62°F
Burning Rate, in./sec
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1612
66/34 grind ratio
62° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1613
66/34 grind ratio
62° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1614
66/34 grind ratio
62° F
15# Bates
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1615
66/34 grind ratio
62° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

SECTION 2.15

PRODUCTION RUN NO. 11

(BATCHES 400-1620 THROUGH 400-1629)

PRODUCTION CASTING #11

FOUR POUND MOTORS

68 F

400 Gallon Batch	Grind Ratio	Burning Rate, in/sec 1000 psia	1400 psia	1700 psia	Exponent	Standard Deviation, Sx, %
1620	65/35	.407	.480	.527	.487	0.4
1621	66/34	.397	.477	.531	.548	1.1
1622	66/34	.403	.472	.517	.469	.5
1623	66/34	.392	.469	.520	.531	.5
1624	66/34	.396	.463	.507	.467	.5
1625	66/34	.398	.481	.537	.564	.6
1626	66/34	.396	.466	.512	.482	--
1627	66/34	.397	.474	.525	.526	1.2
1628	66/34	.404	.478	.527	.499	.6
1629	66/34	.407	.486	.538	.523	0.4
Composite		.400	.474	.524	.510	1.53

UTP 18803A PRODUCTION CASTING NO. 11

FOUR POUND MOTOR DATA 68 F

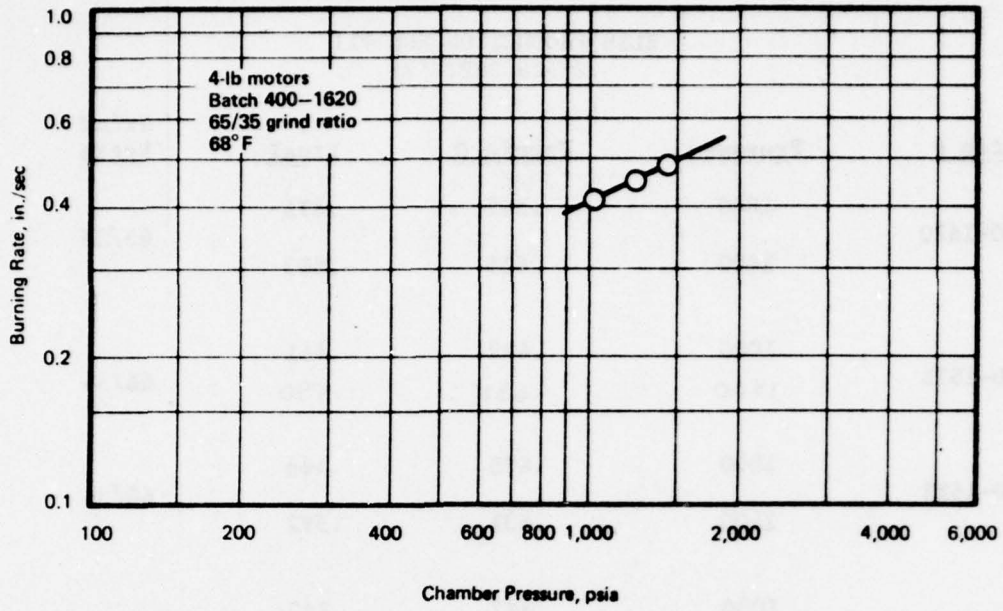
Batch	Burning Rate, in/sec/Chamber Pressure, psia
400-1621	.3507/753, .3792/913, .4357/1212, .4837/1414
400-1622	.3592/765, .3878/925, .4552/1283, .4835/1486
400-1623	.3462/755, .3805/955, .4393/1212, .4887/1530
400-1624	.3503/746, .3888/958, .4273/1194, .4635/1393
400-1625	.3591/777, .3900/961, .4491/1253, .4880/1424
400-1626	.3656/783, .3844/937, .4261/1200, .4444/1266
400-1627	.3566/773, .3900/959, .4352/1222, .4836/1431
400-1628	.3681/787, .3953/962, .4502/1225, .4809/1429
400-1629	.395/951, .413/1027, .416/1029, .503/1499
400-1620	.4133/1031, .4523/1244, .488/1450

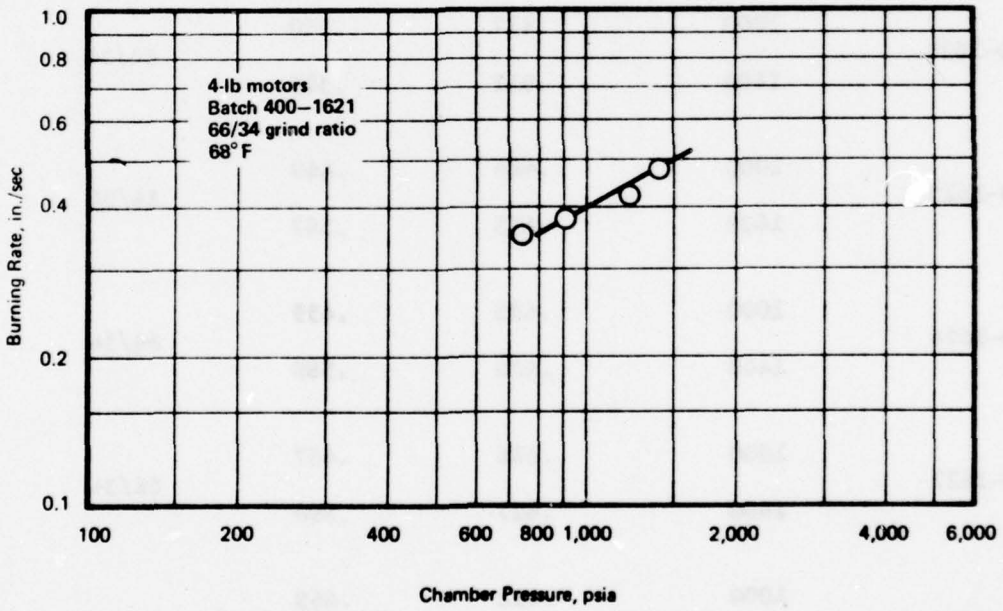
UTP-18,803A QC PROCESSING AND PROPERTIES SUMMARY
PRODUCTION CASTING NO. 11

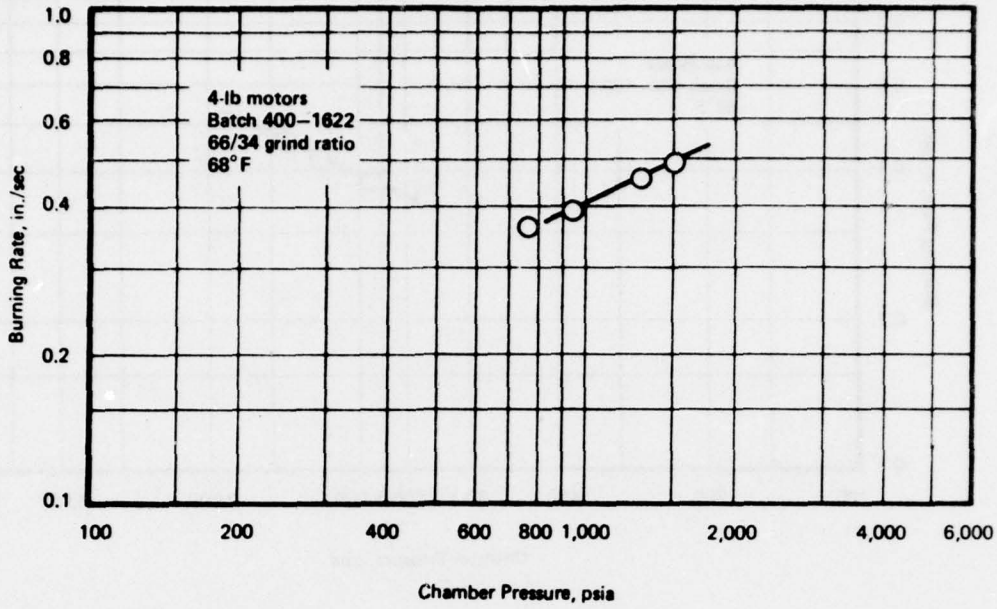
Parameter	400 Gallon Batch 1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	$\bar{X}$	S_x
Grind ratio	65/35	66/34	66/34	66/34	66/34	66/34	66/34	66/34	66/34	66/34		
NCO/OH ratio	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81		
Fuel premix number	3500-10	3500-10	3500-10	3500-10	3500-10	3500-10	3500-10	3500-10	3500-10	3500-10		
IPDI @ 60 min after addition, wt %	0.36	0.34	0.37	0.36	0.34	0.34	0.36	0.36	0.37	0.36	0.356	.0117
Viscosity @ 60 min after IPDI addition, Kp @ 5000 dynes/cm^2	6.04	6.35	6.36	5.85	7.26	5.86	5.77	5.75	6.71	5.91	6.186	0.49
Max corrected stress @ 75^{o}F, σ^c_m, psi	127	127	126	110	113	106	124	123	128	133	122	8.9
Max corrected strain @ 75^{o}F, ε^c_m, %	38	34	34	32	36	31	36	36	37	34	35	2.2
True strain @ 75^{o}F rupture, E_r, %	38	35	35	34	39	31	[illegible]	37	37	36	36	2.3
Initial tangent modulus, Eo, psi	1062	1100	1104	806	810	952	1010	916	816	988	956	117

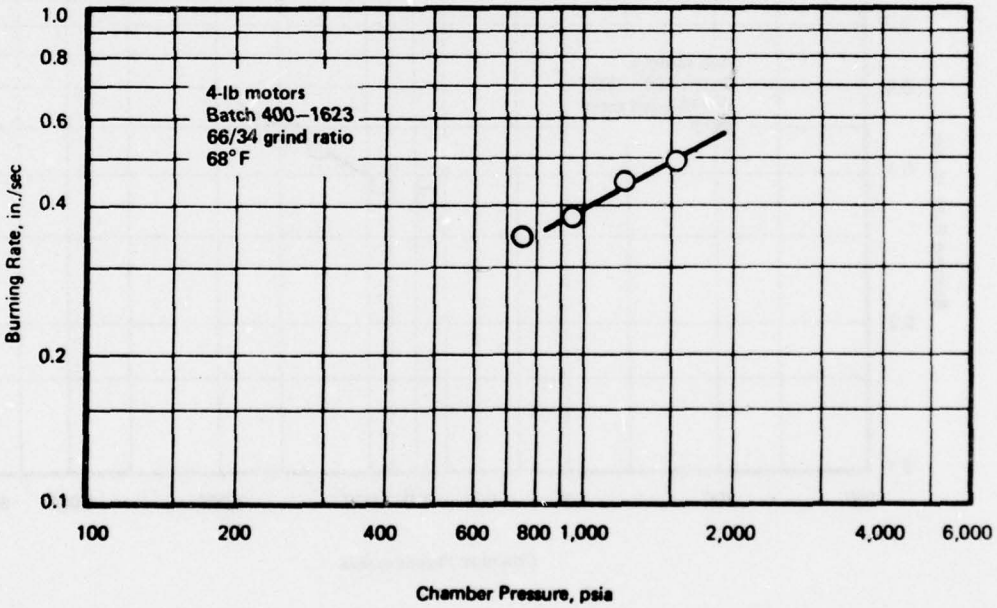
ELSH PRODUCTION RUN #11
28-29 SEPT '77

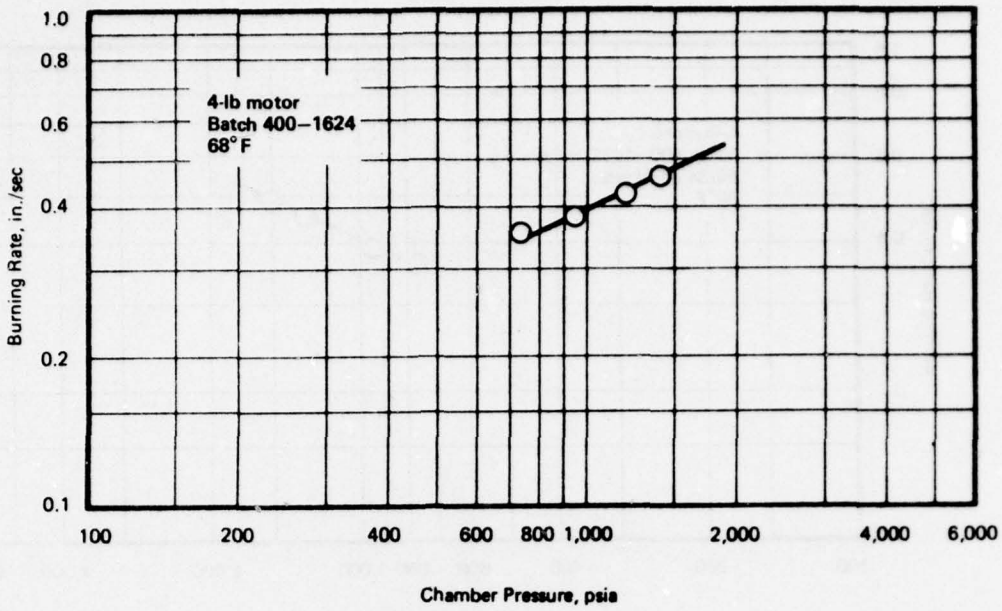
Batch #	Pressure	Premix C	Final	Grind Ratio	Curative Ratio
400-1620	1000	.502	.471	65/35	0.81
	1400	.635	.603		
400-1621	1000	.492	.461	66/34	0.81
	1400	.635	.590		
400-1622	1000	.495	.466	66/34	0.81
	1400	.631	.592		
400-1623	1000	.487	.462	66/34	0.81
	1400	.628	.588		
400-1624	1000	.477	.460	66/34	0.81
	1400	.612	.585		
400-1625	1000	.484	.460	66/34	0.81
	1400	.623	.587		
400-1626	1000	.483	.459	66/34	0.81
	1400	.620	.589		
400-1627	1000	.486	.467	66/34	0.81
	1400	.627	.590		
400-1628	1000	.492	.469	66/34	0.81
	1400	.633	.596		
400-1629	1000	.490	.462	66/34	0.81
	1400	.625	.594		

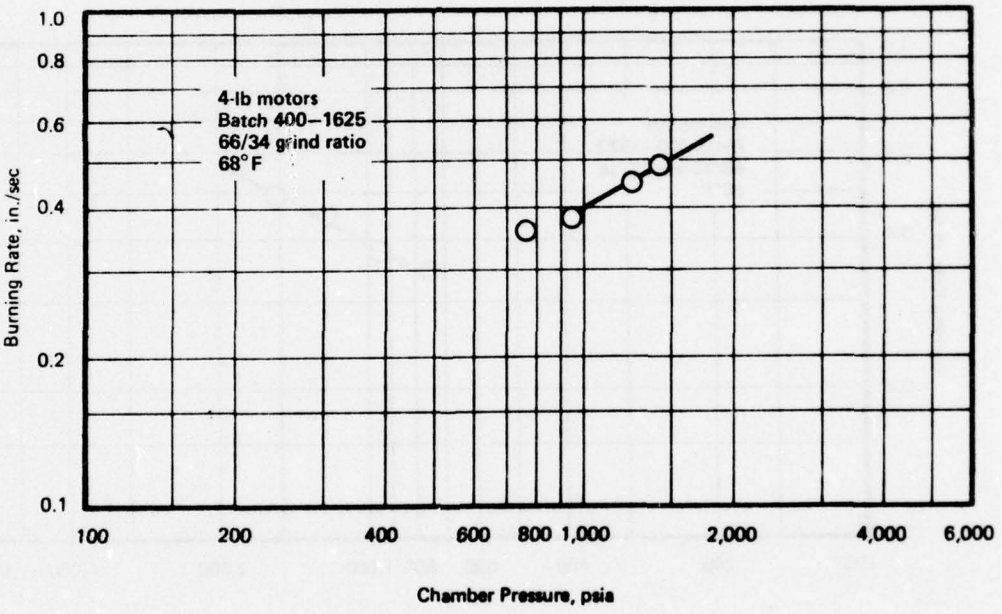

4-lb motors
Batch 400–1620
65/35 grind ratio
68° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

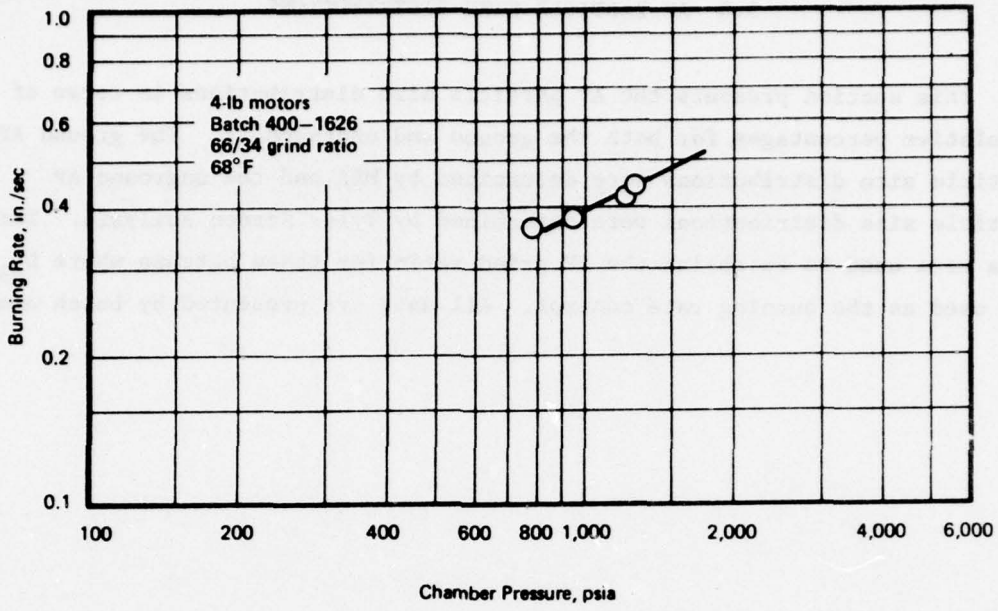

4-lb motors
Batch 400–1621
66/34 grind ratio
68° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

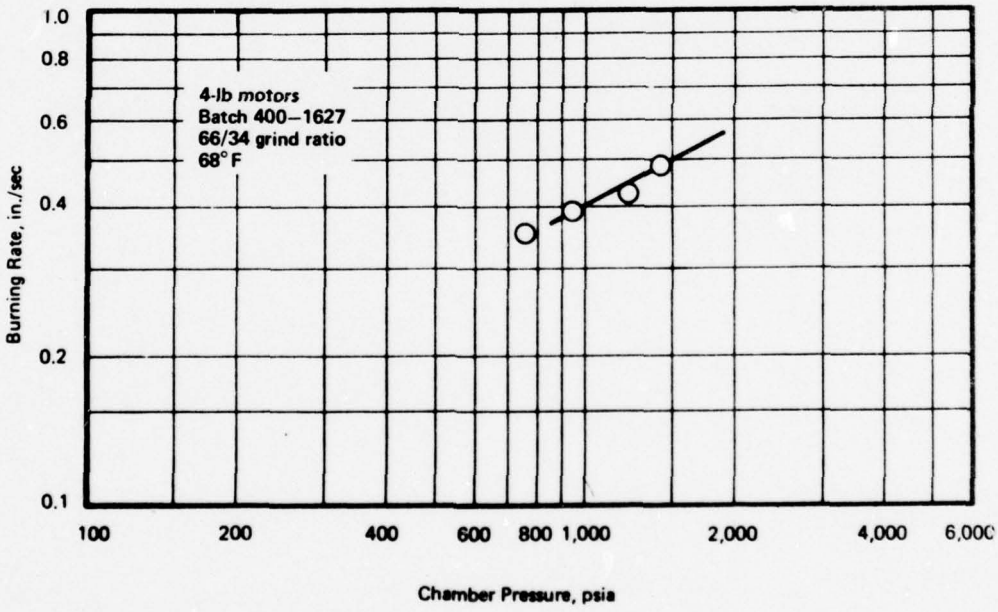

1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1622
66/34 grind ratio
68° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


1.0
0.8
0.6
0.4
0.2
0.1
Burning Rate, in./sec
4-lb motors
Batch 400–1623
66/34 grind ratio
68° F
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia


4-lb motor
Batch 400–1624
68° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

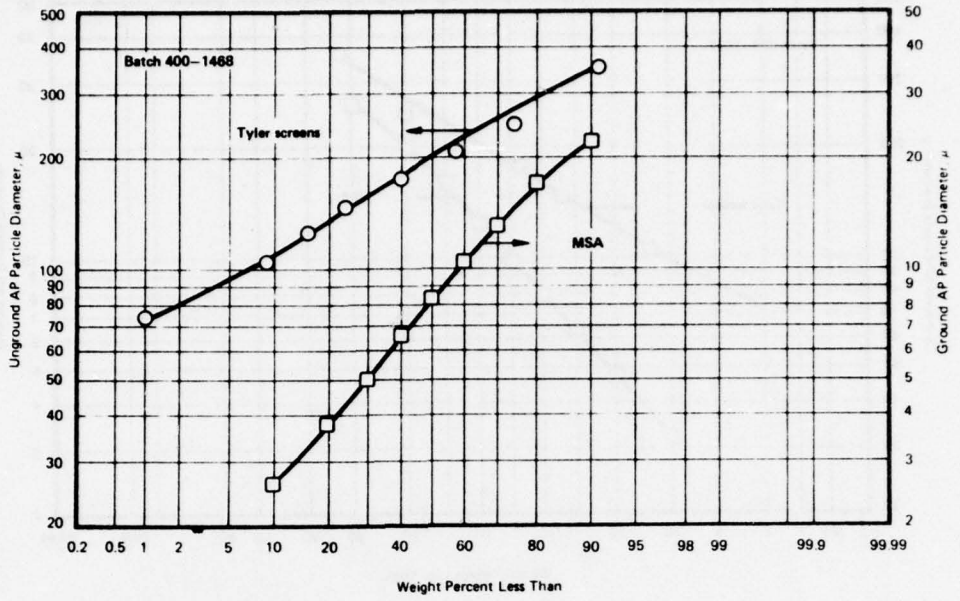

4-lb motors
Batch 400–1625
66/34 grind ratio
68° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

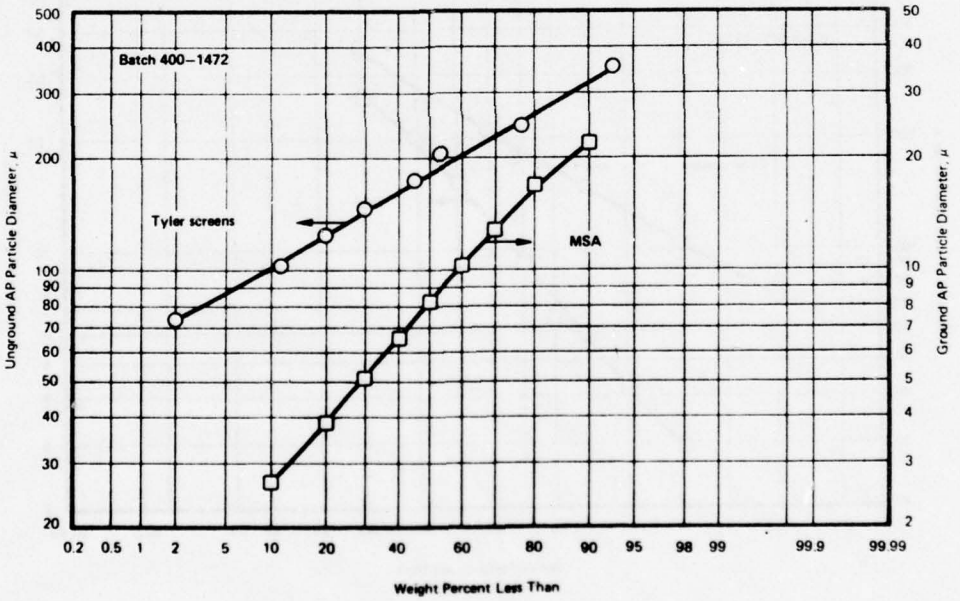

4-lb motors
Batch 400–1626
66/34 grind ratio
68° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

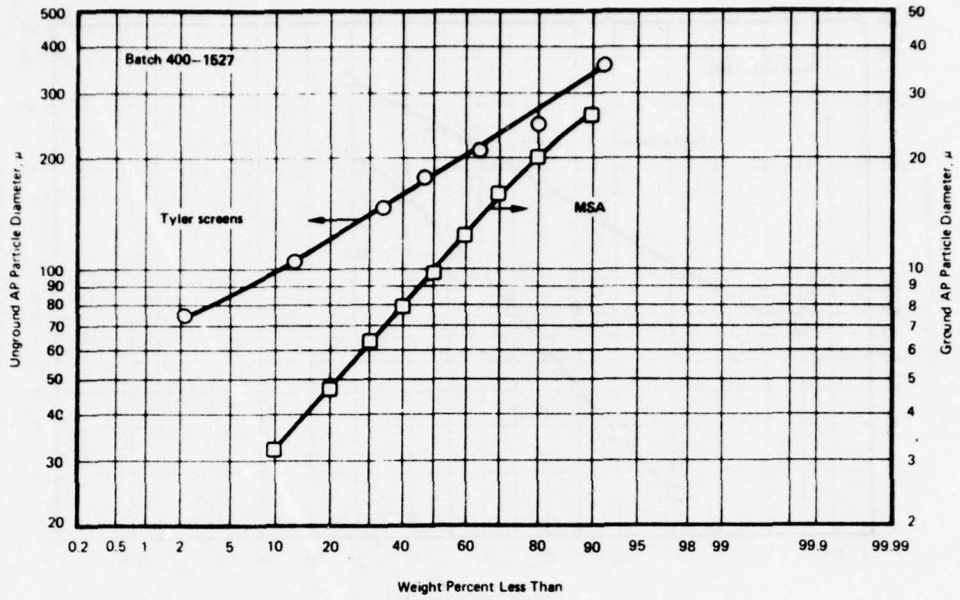

4-lb motors
Batch 400–1627
66/34 grind ratio
68° F
Burning Rate, in./sec
1.0
0.8
0.6
0.4
0.2
0.1
100
200
400
600
800
1,000
2,000
4,000
6,000
Chamber Pressure, psia

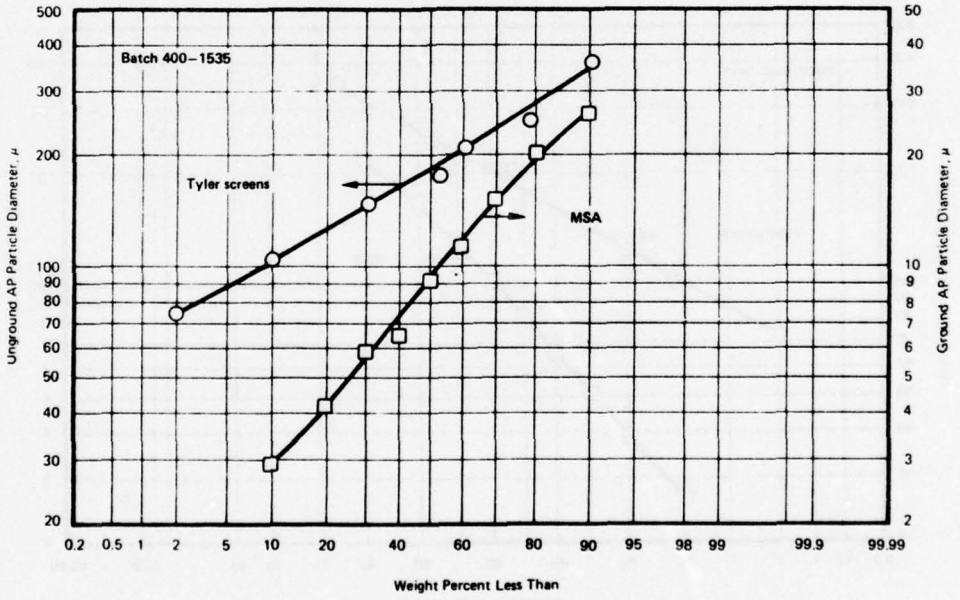
3.0 AP PARTICLE SIZE DISTRIBUTIONS

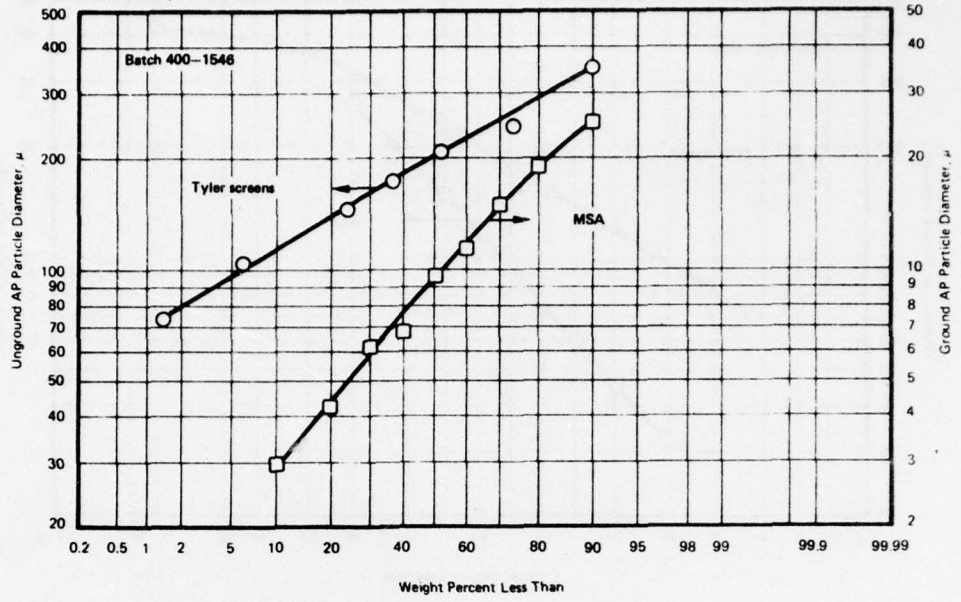
This section presents the AP particle size distributions in terms of cumulative percentages for both the ground and unground AP. The ground AP particle size distributions were determined by MSA and the unground AP particle size distributions were determined by Tyler Screen Analysis. These data were used to establish the AP grind ratio for those batches where D_{43} was used as the burning rate control. All data are presented by batch number.

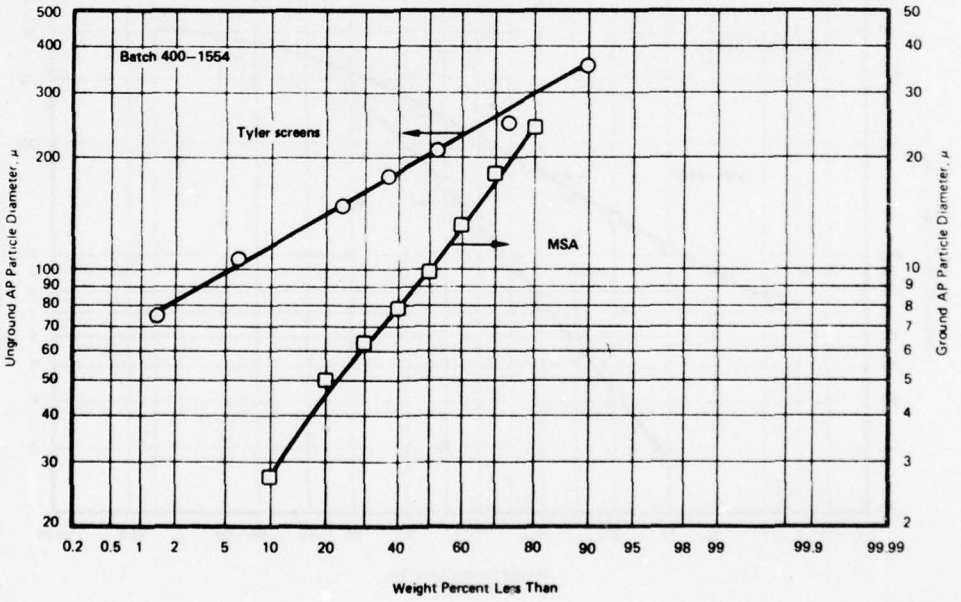

Batch 400–1468
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2 0.5 1 2 5 10 20 40 60 80 90 95 98 99 99.9 99.99

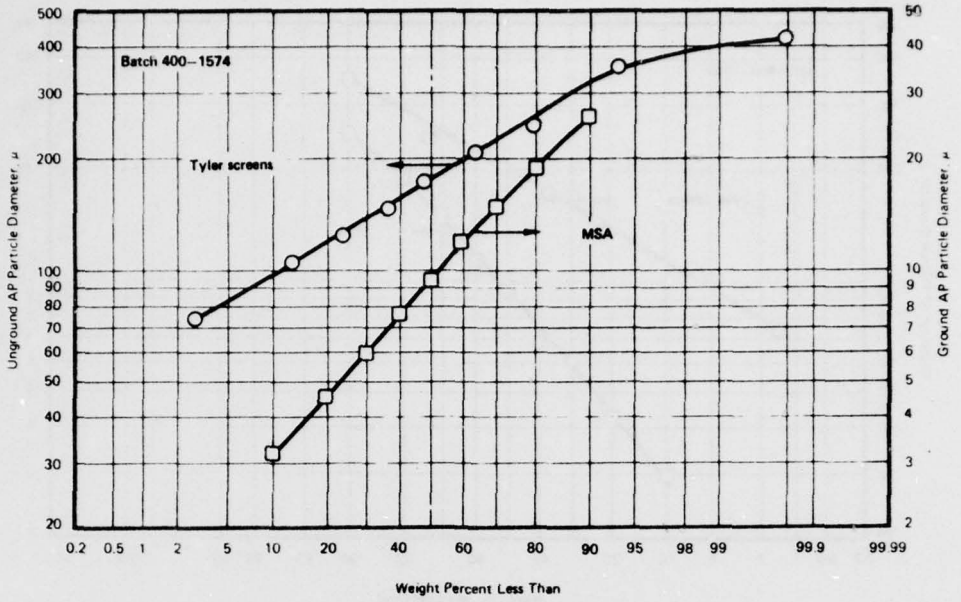

Batch 400–1472
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2 0.5 1 2 5 10 20 40 60 80 90 95 98 99 99.9 99.99

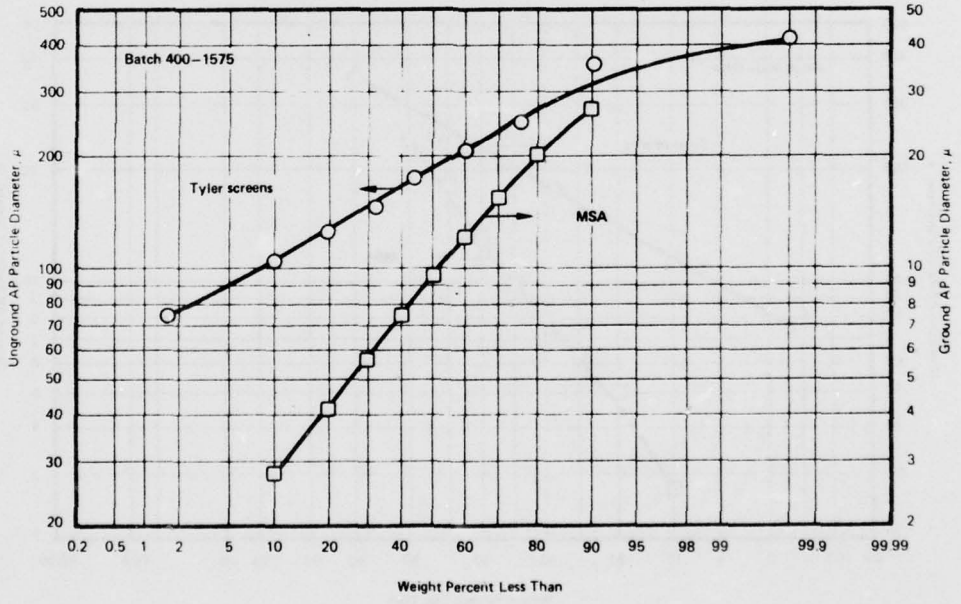

Batch 400–1527
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2
0.5
1
2
5
10
20
40
60
80
90
95
98
99
99.9
99.99

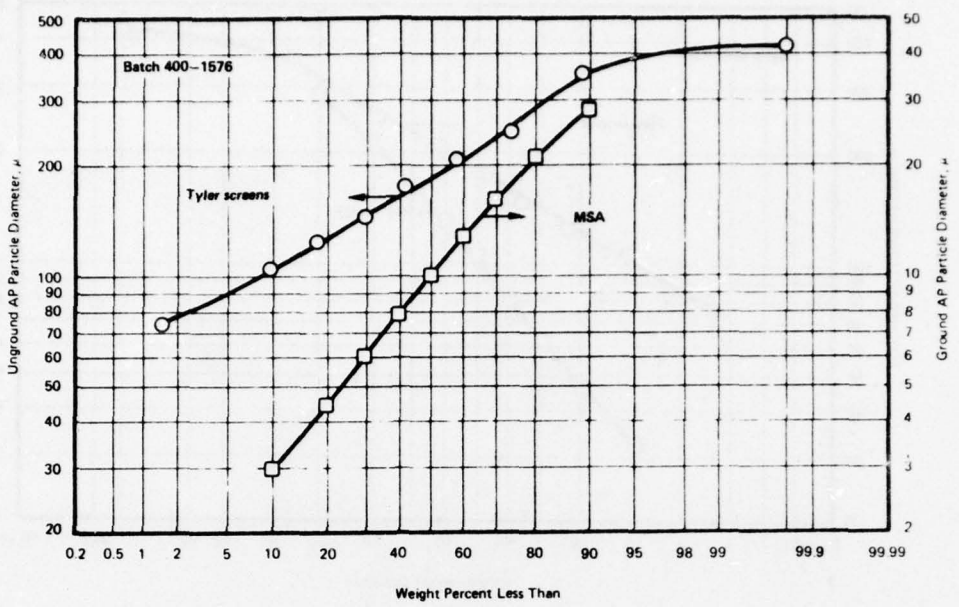

Batch 400–1535
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2
0.5
1
2
5
10
20
40
60
80
90
95
98
99
99.9
99.99

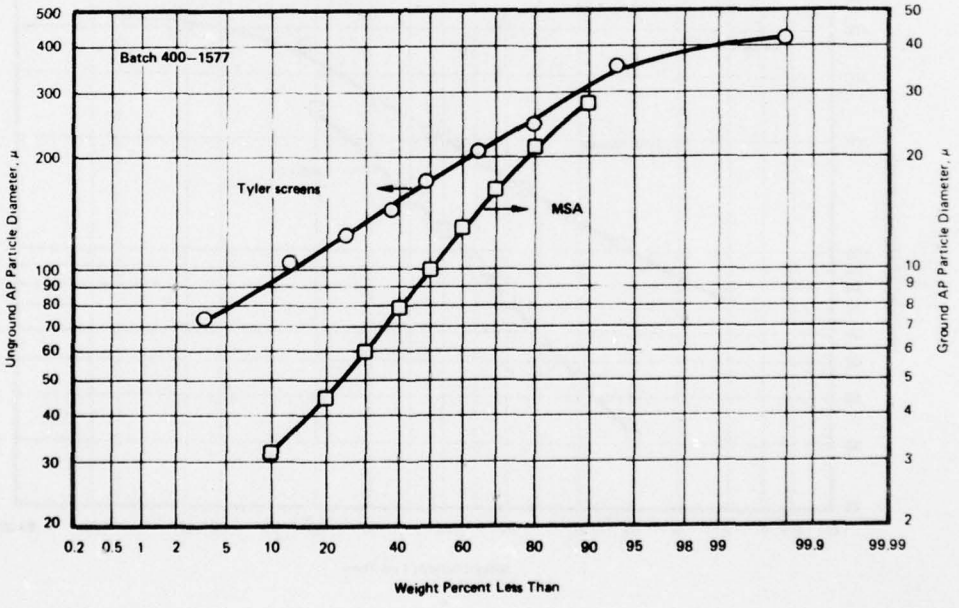

Batch 400–1546
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2
0.5
1
2
5
10
20
40
60
80
90
95
98
99
99.9
99.99


Batch 400–1554
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2
0.5
1
2
5
10
20
40
60
80
90
95
98
99
99.9
99.99


Batch 400–1574
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2 0.5 1 2 5 10 20 40 60 80 90 95 98 99 99.9 99.99


Batch 400–1575
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2 0.5 1 2 5 10 20 40 60 80 90 95 98 99 99.9 99.99


Batch 400–1576
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
500
400
300
200
100
90
80
70
60
50
40
30
20
50
40
30
20
10
9
8
7
6
5
4
3
2
0.2 0.5 1 2 5 10 20 40 60 80 90 95 98 99 99.9 99.99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Ground AP Particle Diameter, μ
Weight Percent Less Than
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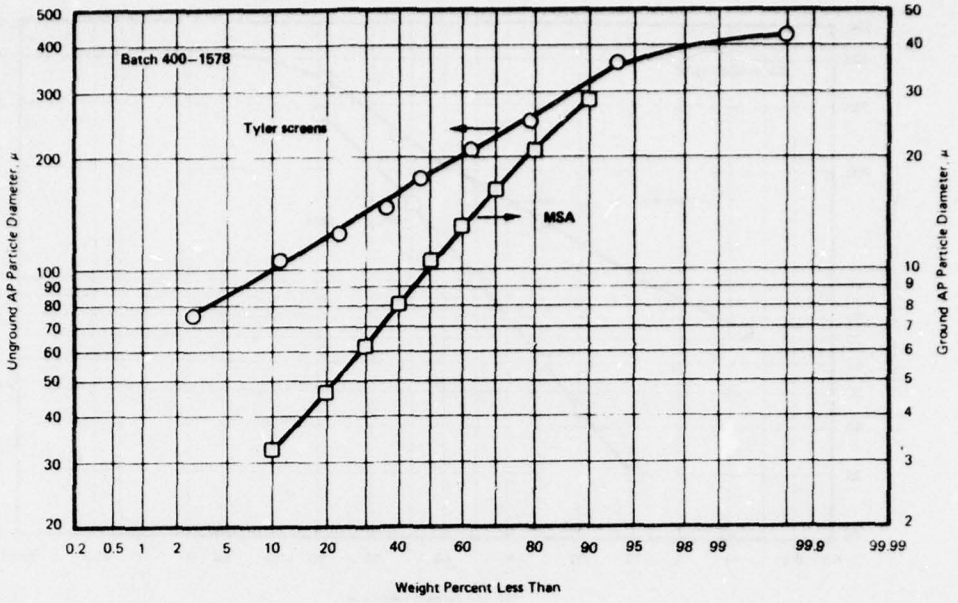
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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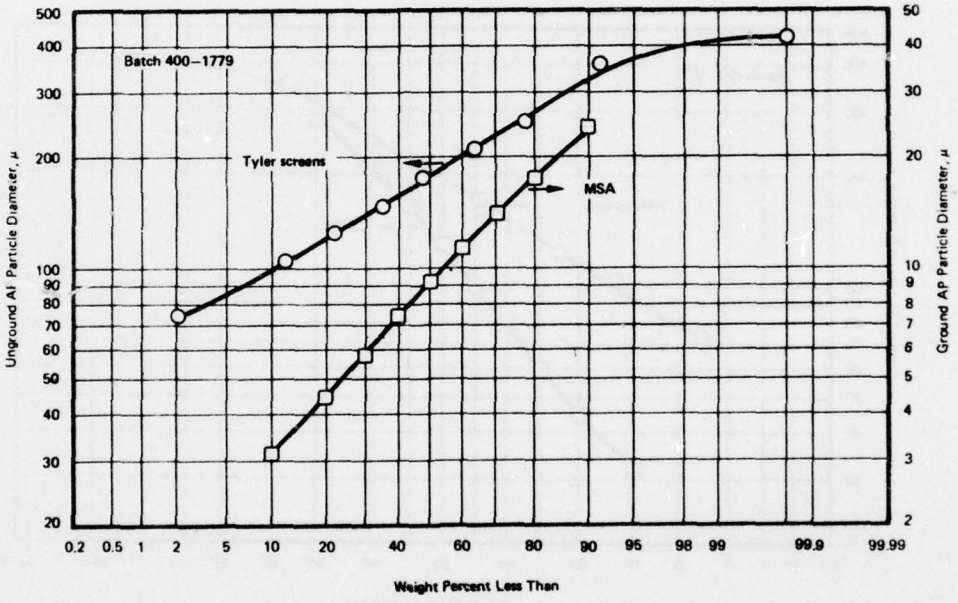
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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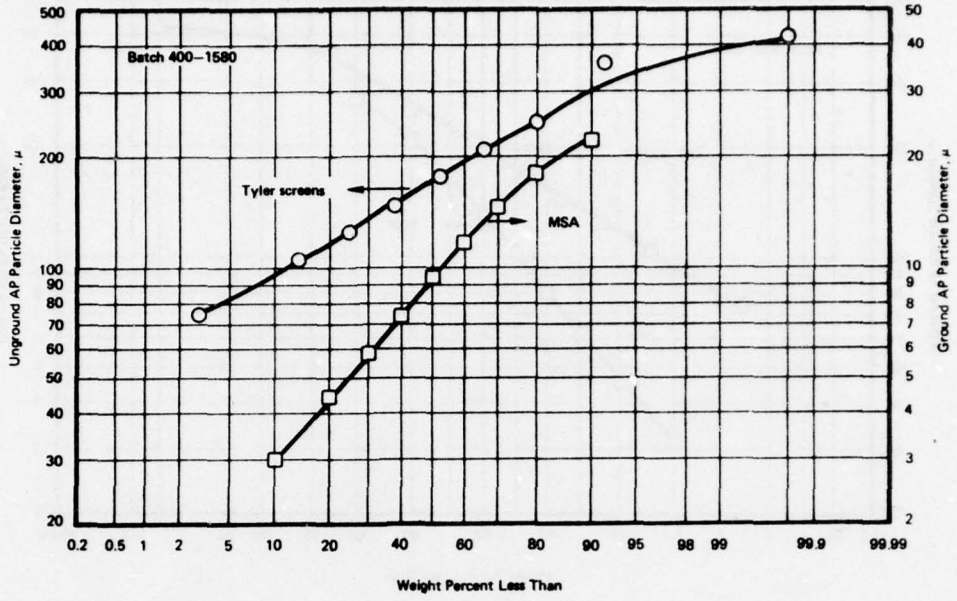
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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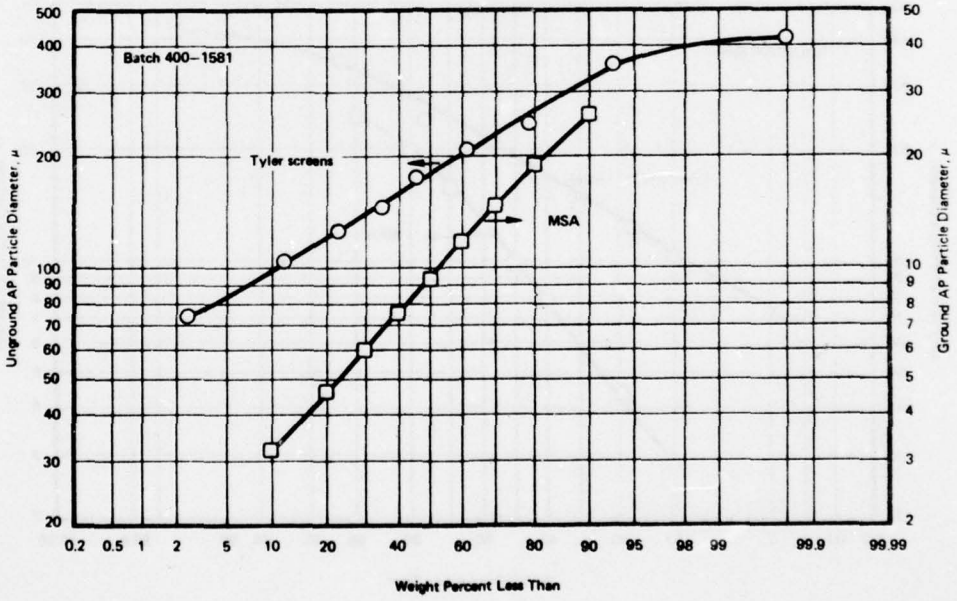
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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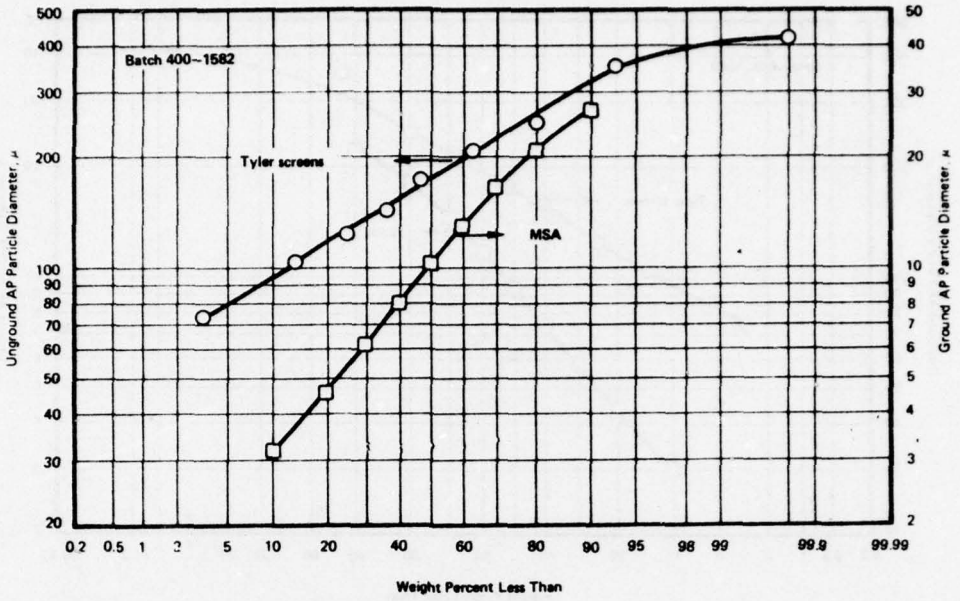
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Ground AP Particle Diameter μ
Weight Percent Less Than
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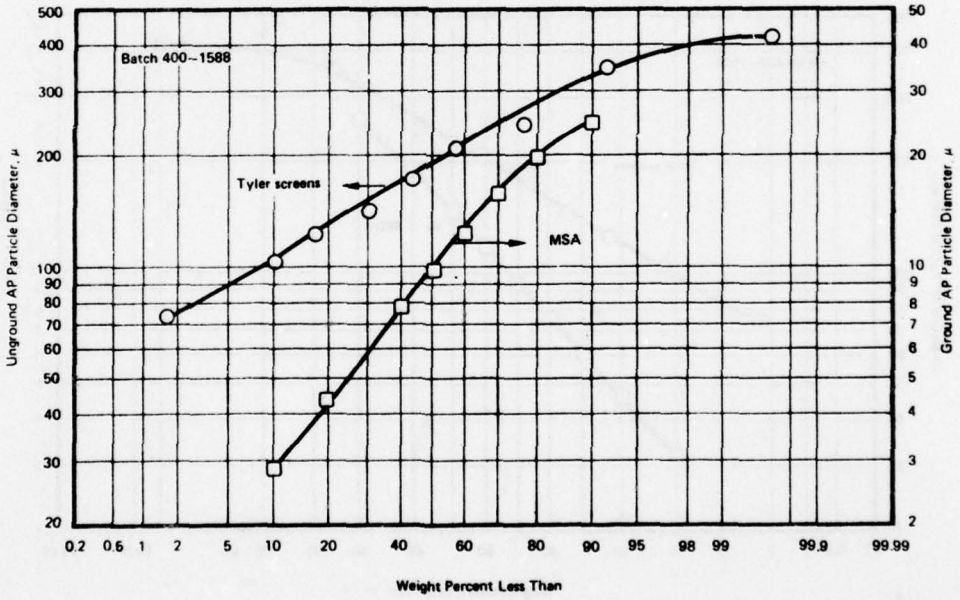
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Unground AP Particle Diameter, μ
Ground AP Particle Diameter μ
Weight Percent Less Than
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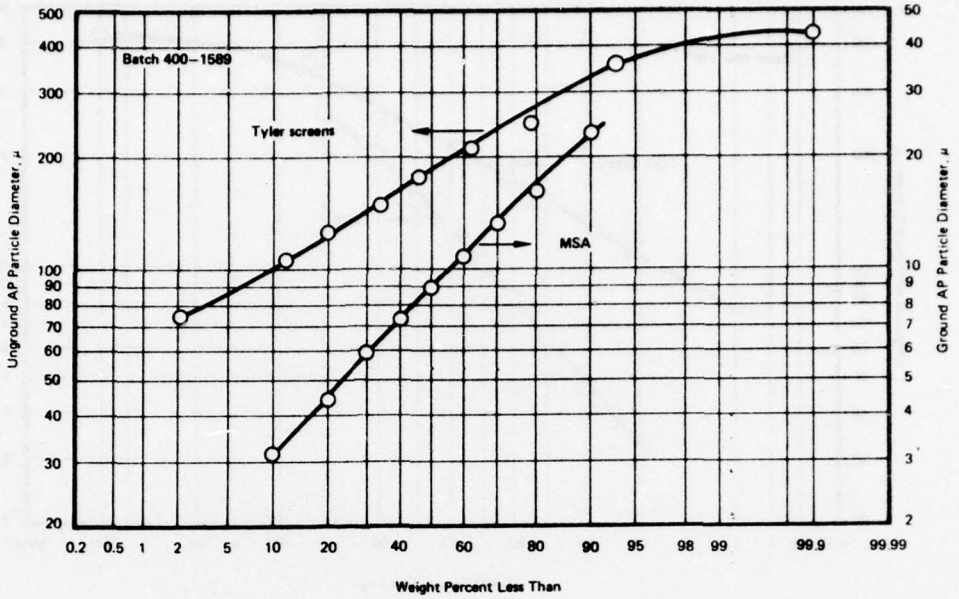
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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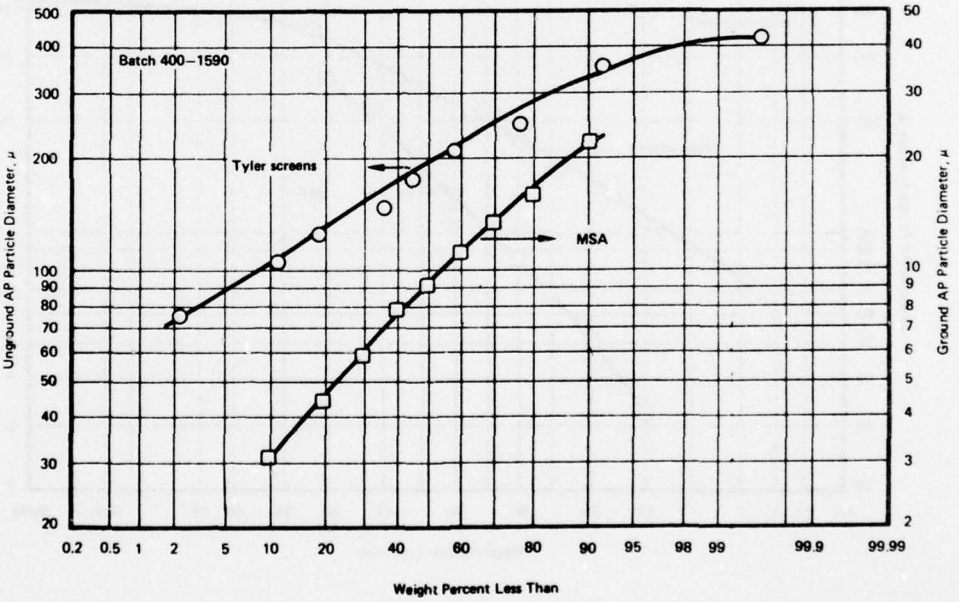
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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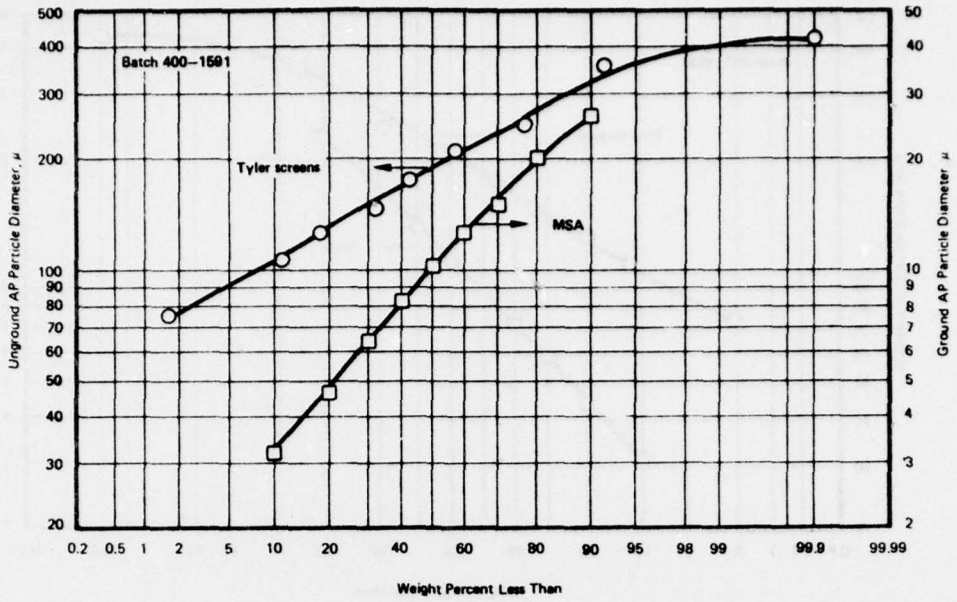
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Ground AP Particle Diameter μ
Weight Percent Less Than
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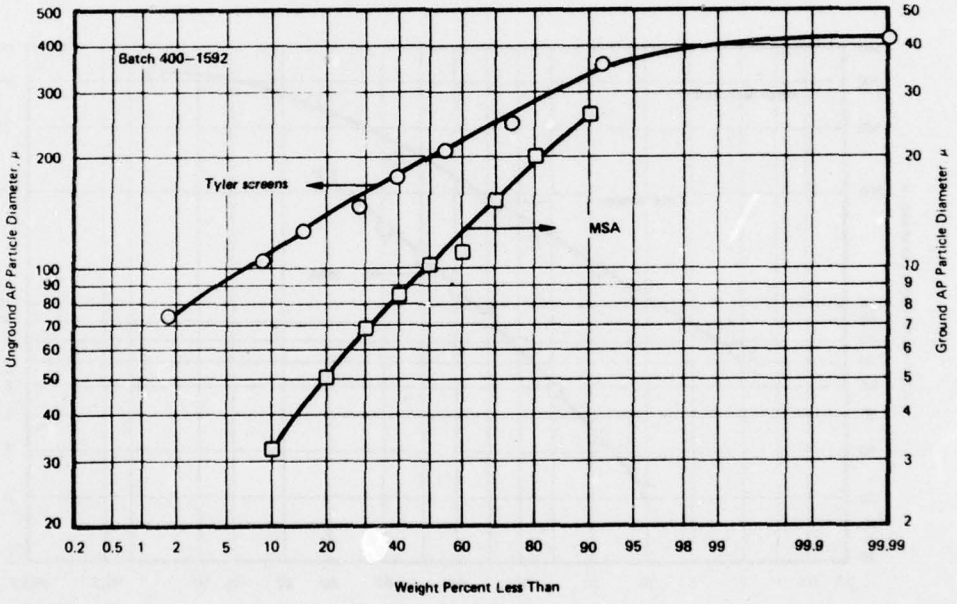
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Weight Percent Less Than
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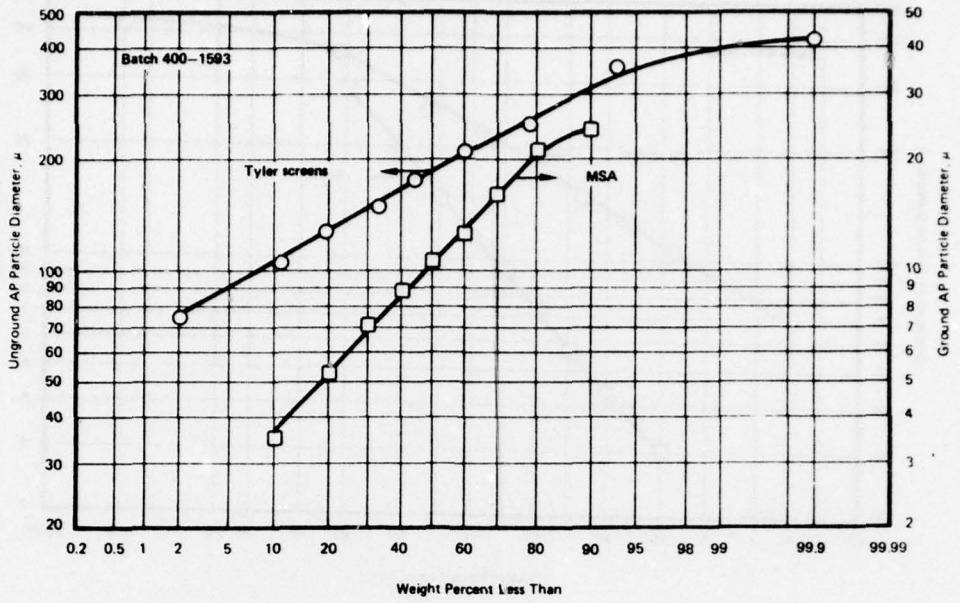
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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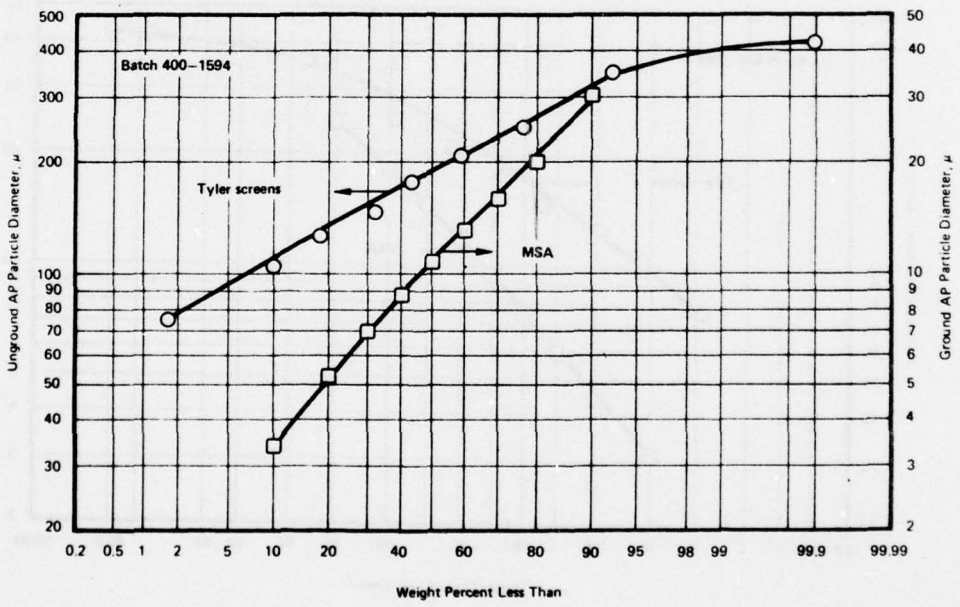
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Weight Percent Less Than
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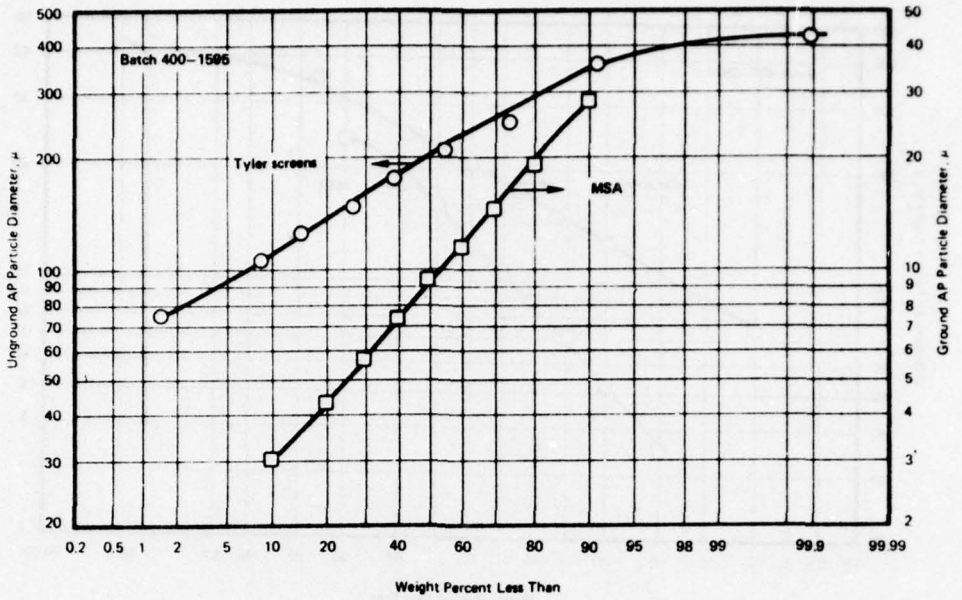
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Weight Percent Less Than
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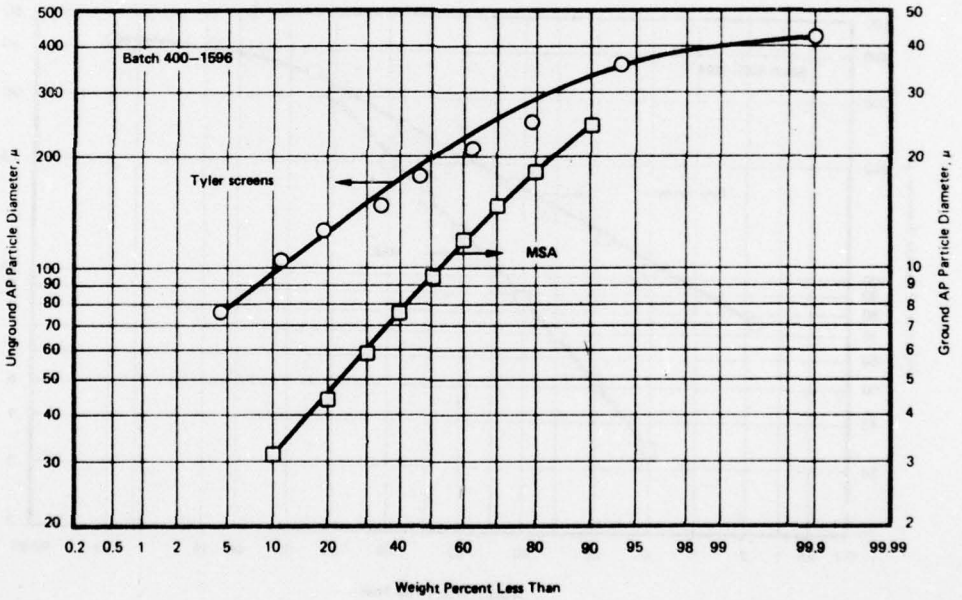
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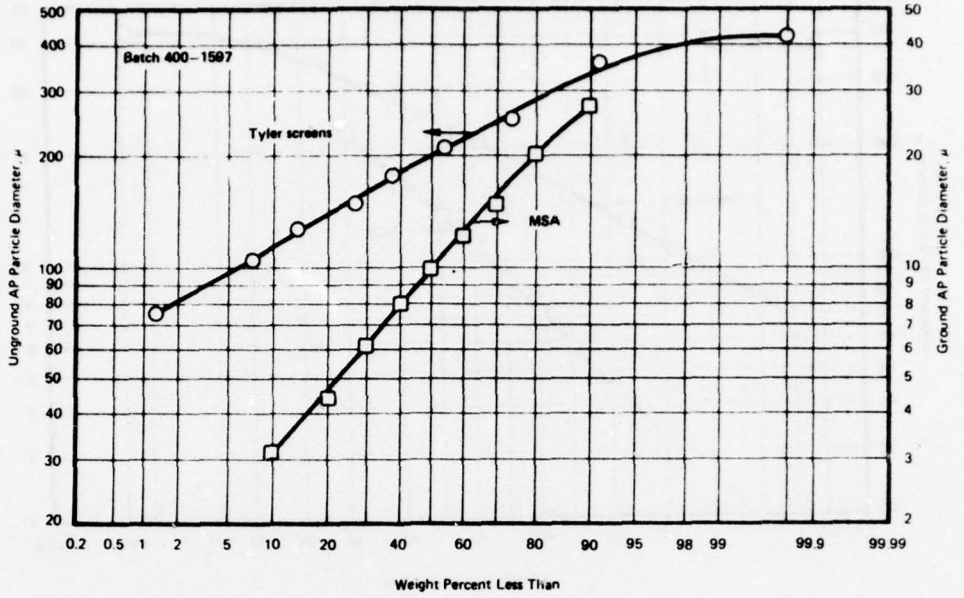
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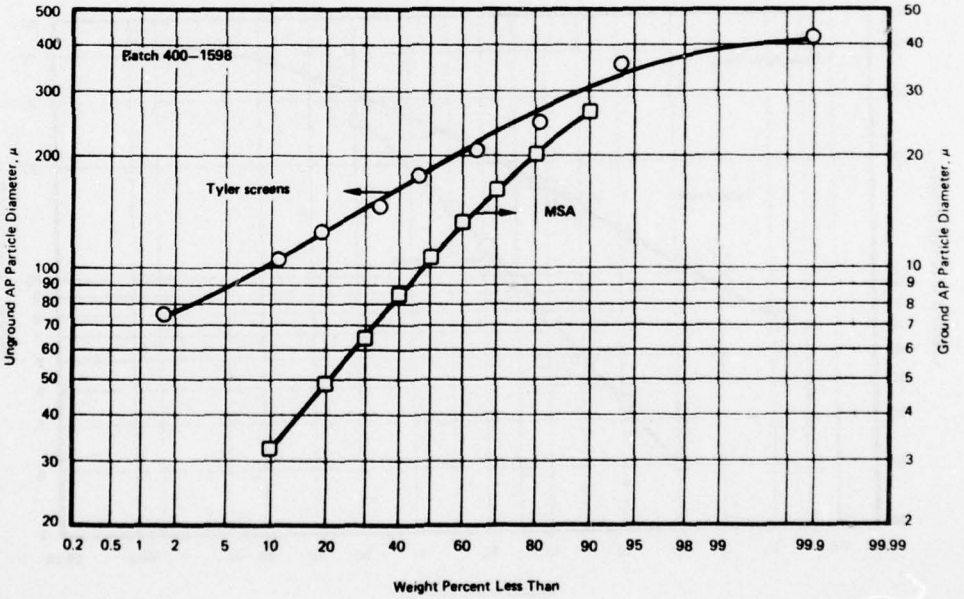
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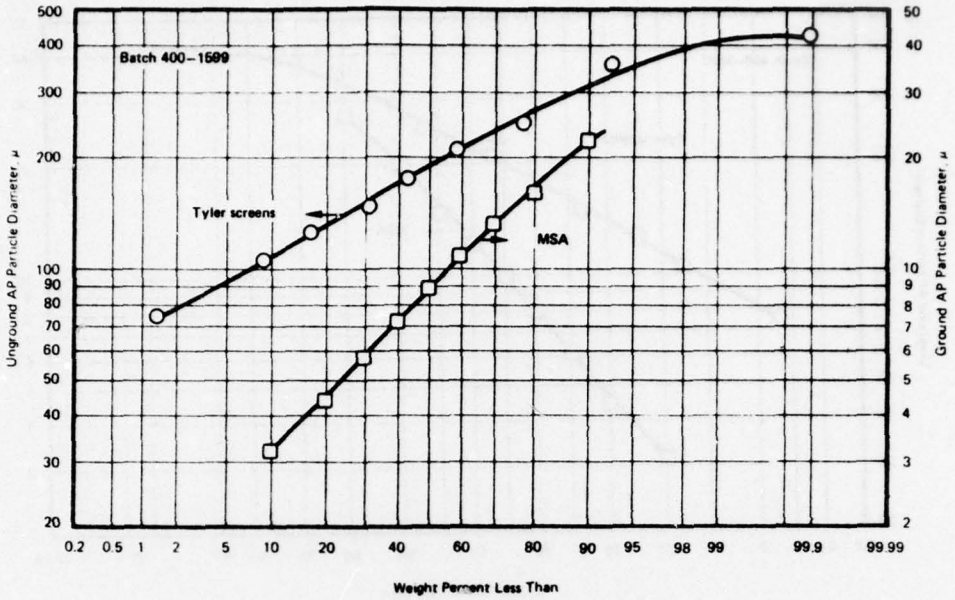
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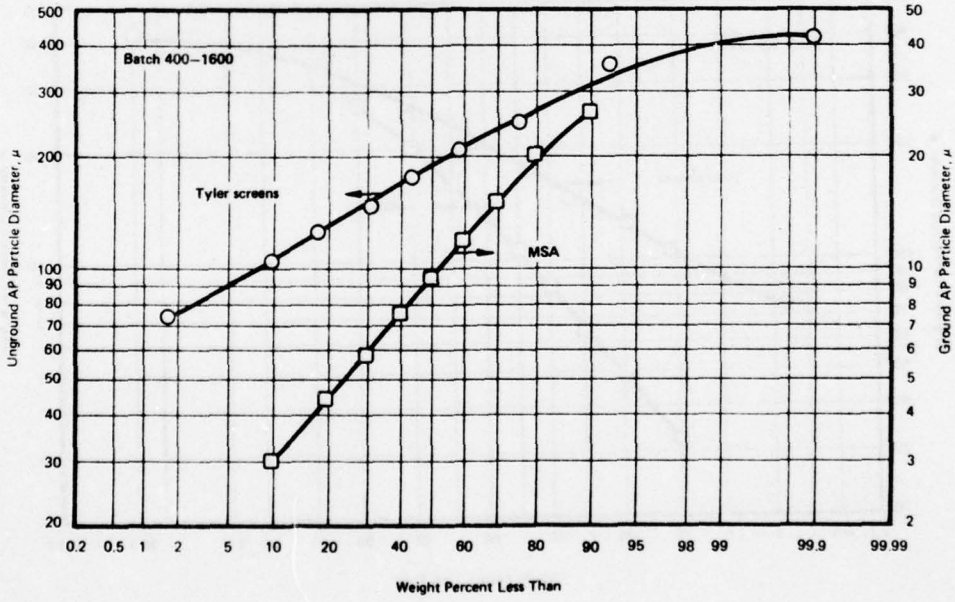
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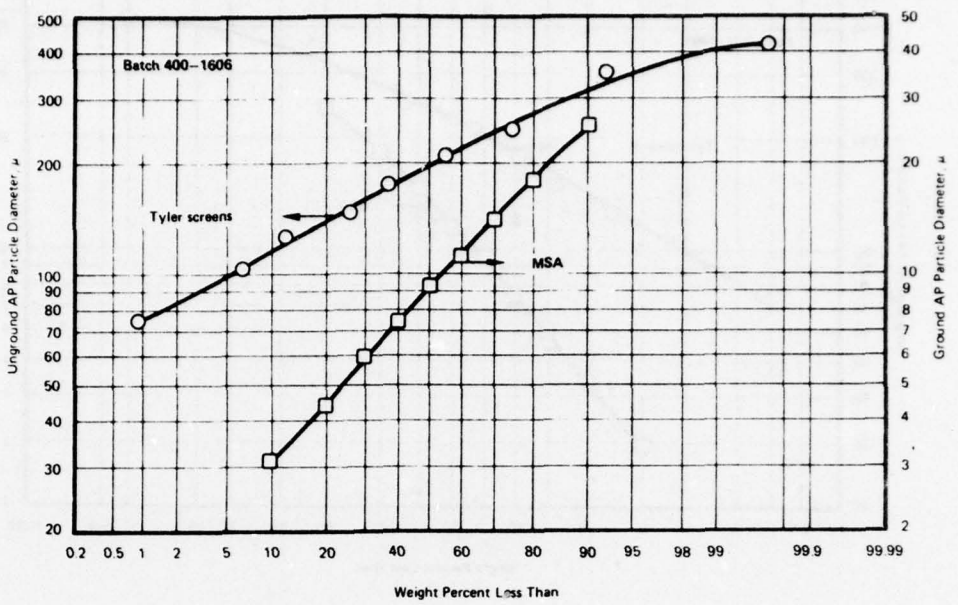
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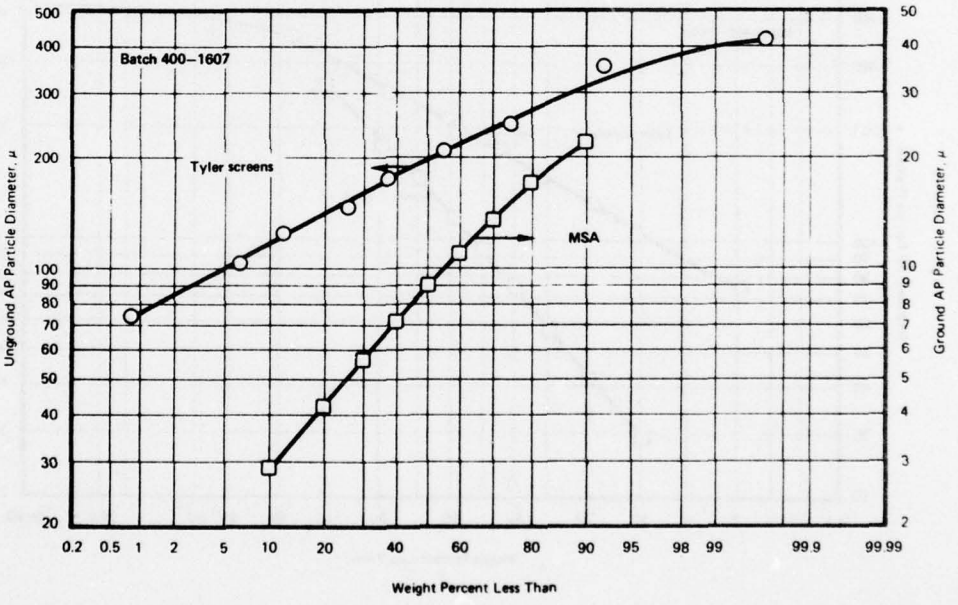
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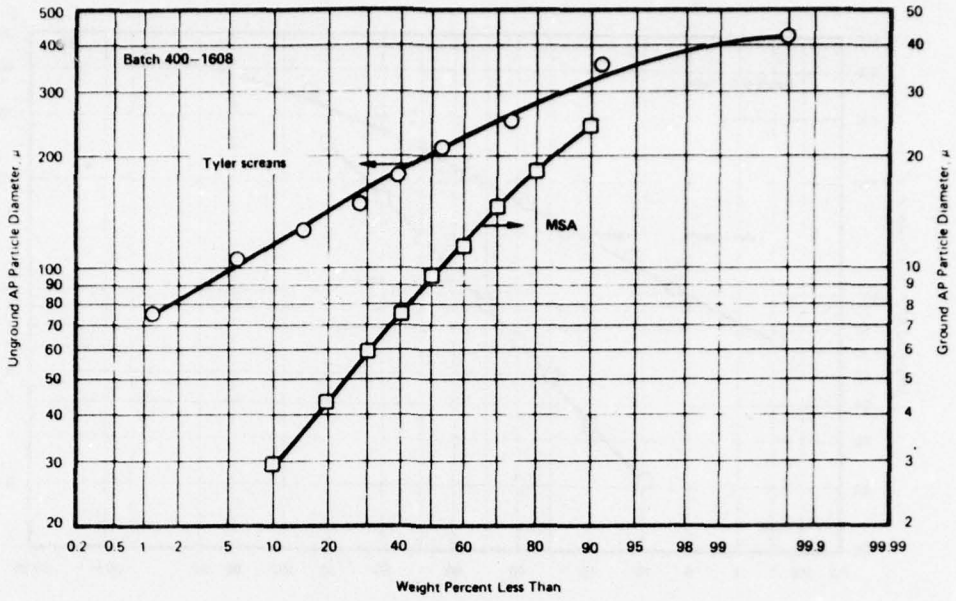
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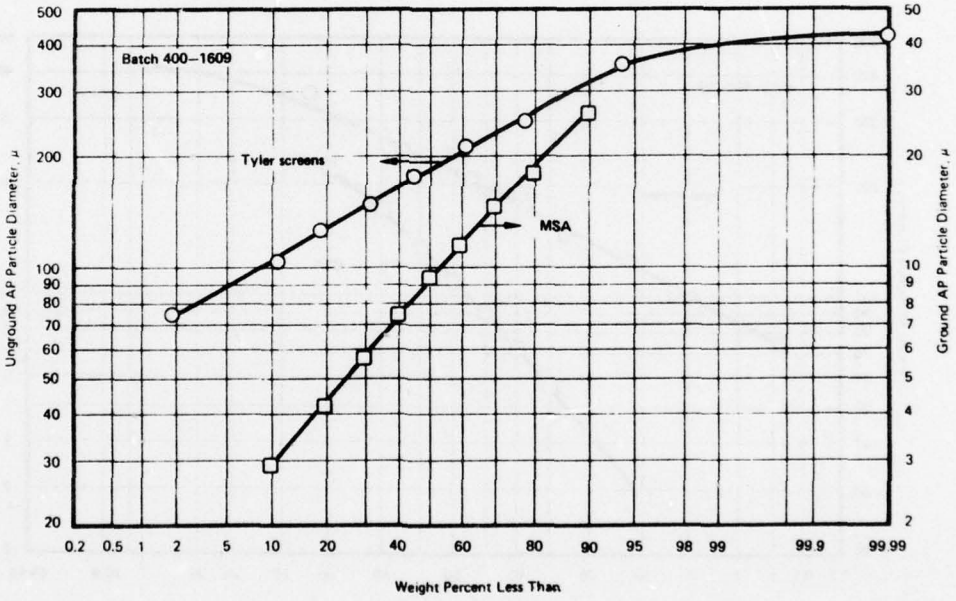
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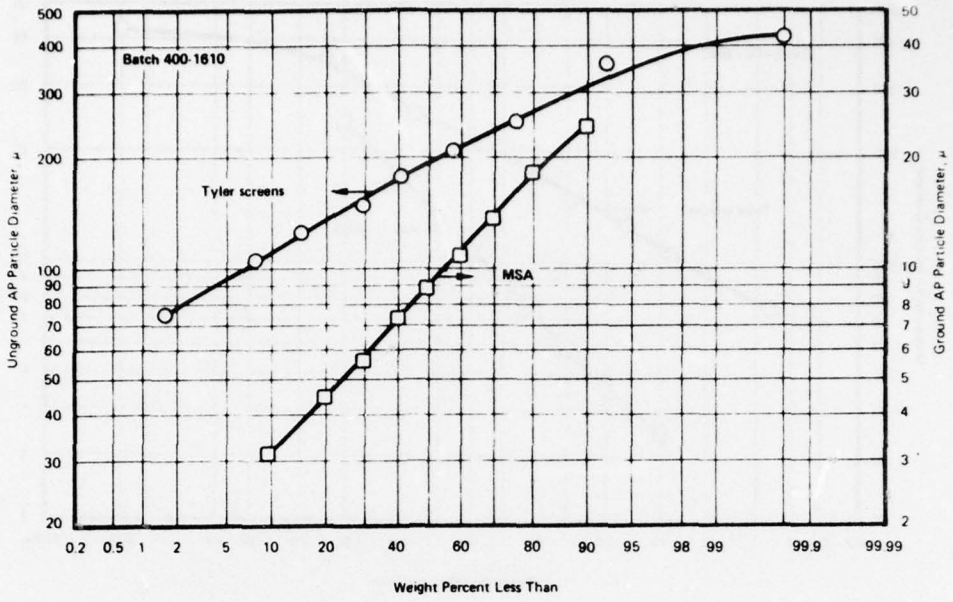
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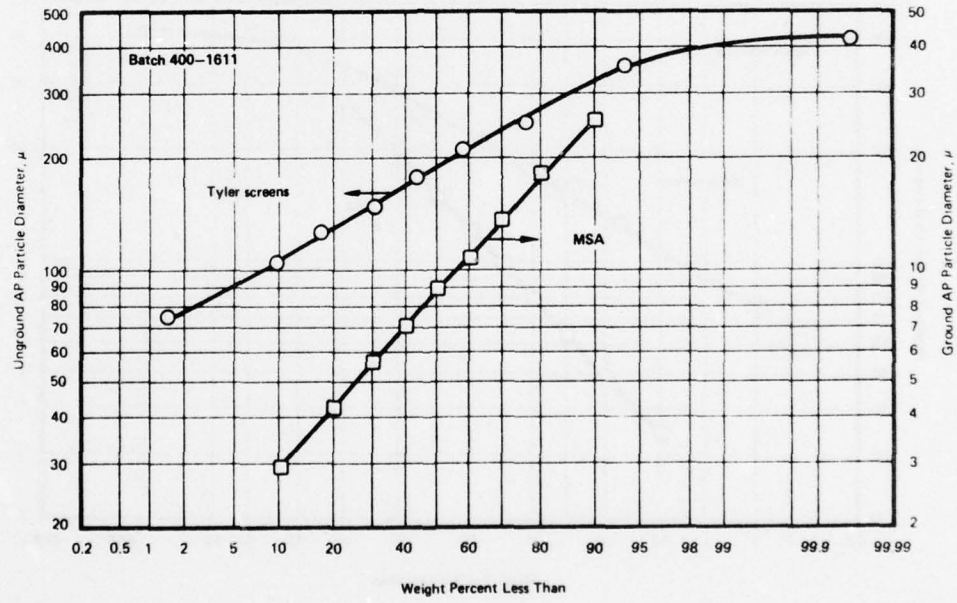
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AD-A051 742 UNITED TECHNOLOGIES CORP SUNNYVALE CALIF CHEMICAL SY--ETC F/G 21/9.2
84-INCH PROPELLANT CARTRIDGES AND GRAINS. VOLUME II. PROPELLANT--ETC(U)
NOV 77 T V O'HARA, J B HENRY, W A STEPHEN F04611-76-C-0010

UNCLASSIFIED CSD-2579-FR AFRPL-TR-77-92 NL

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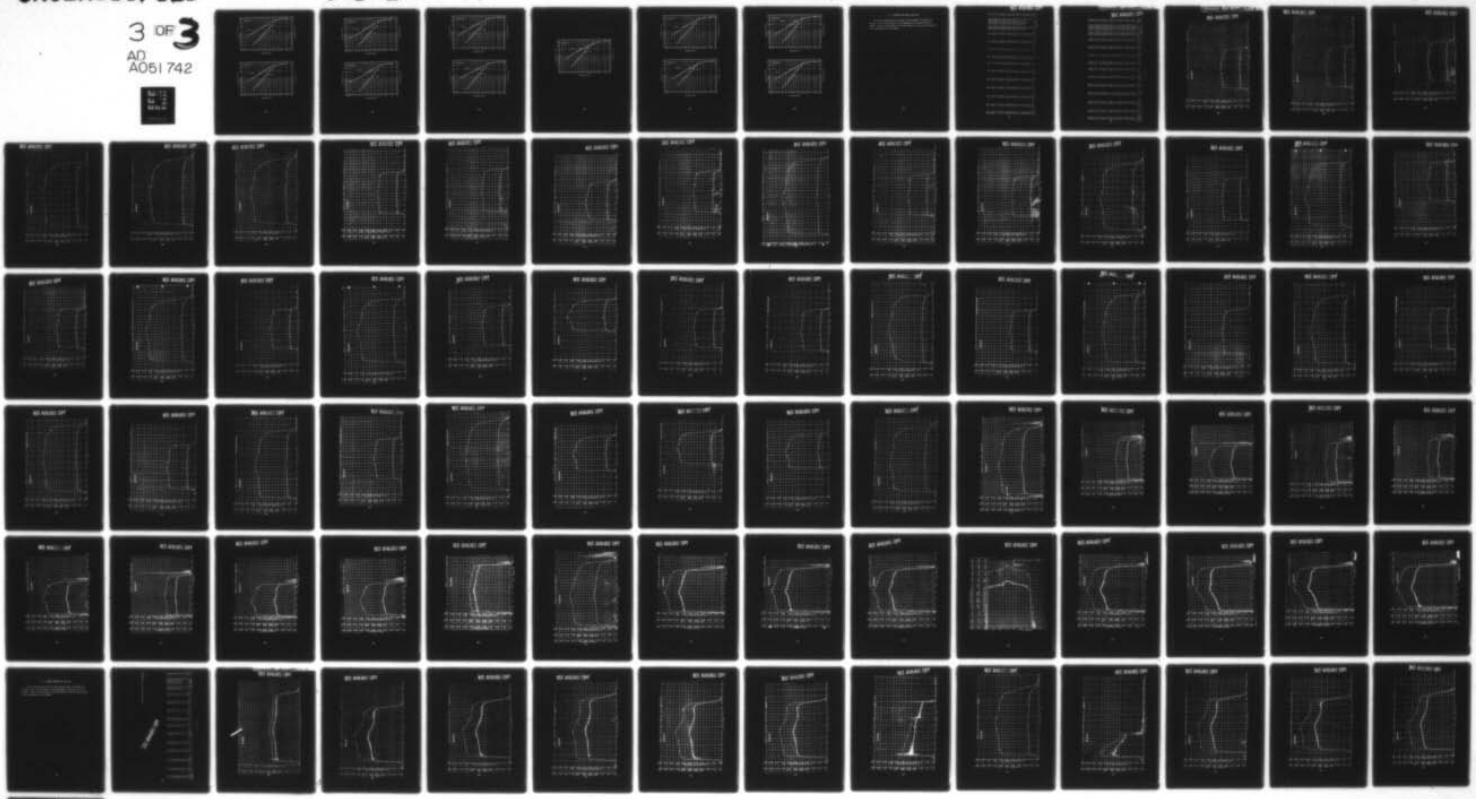

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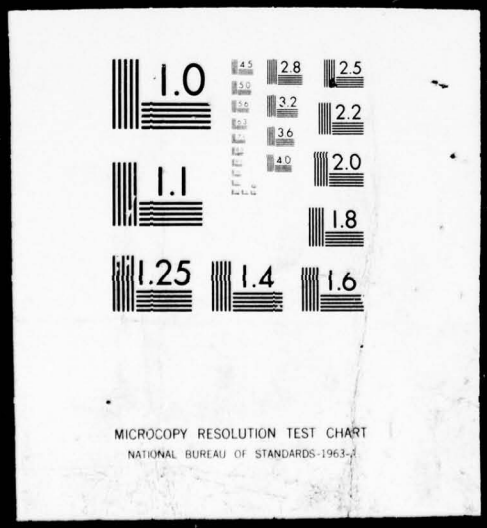

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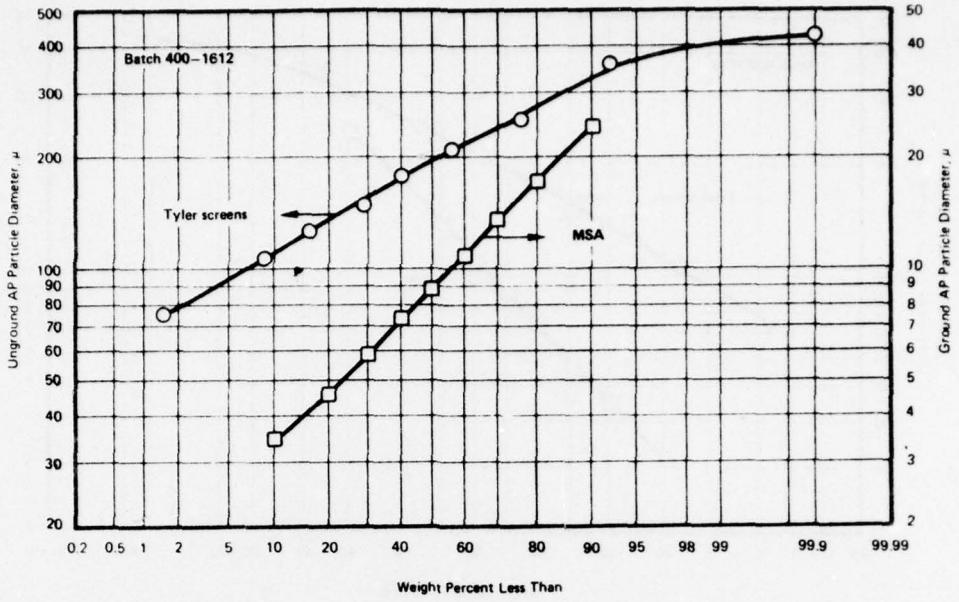
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Tyler screens
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Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
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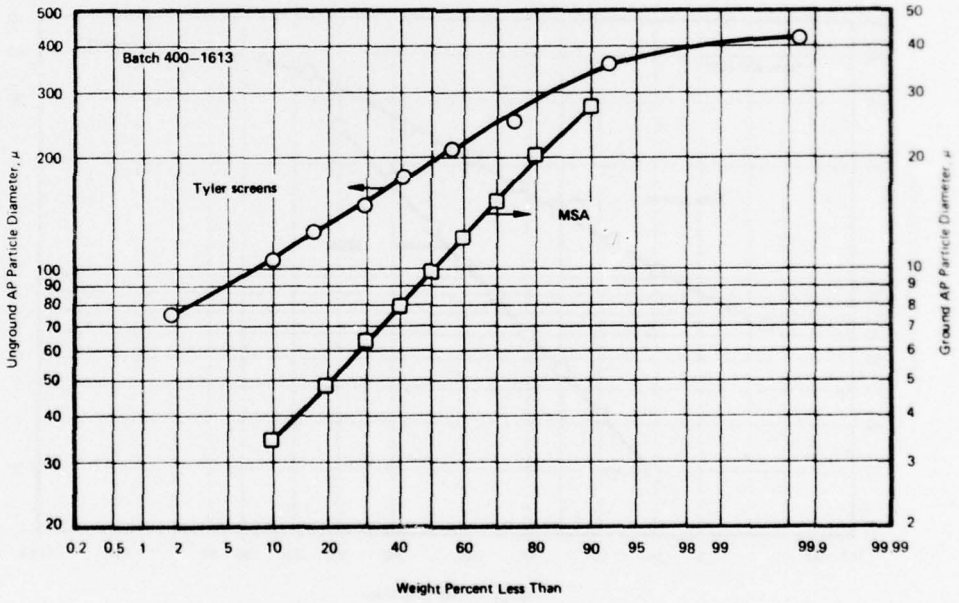
99.99


Batch 400–1613
Tyler screens
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Weight Percent Less Than
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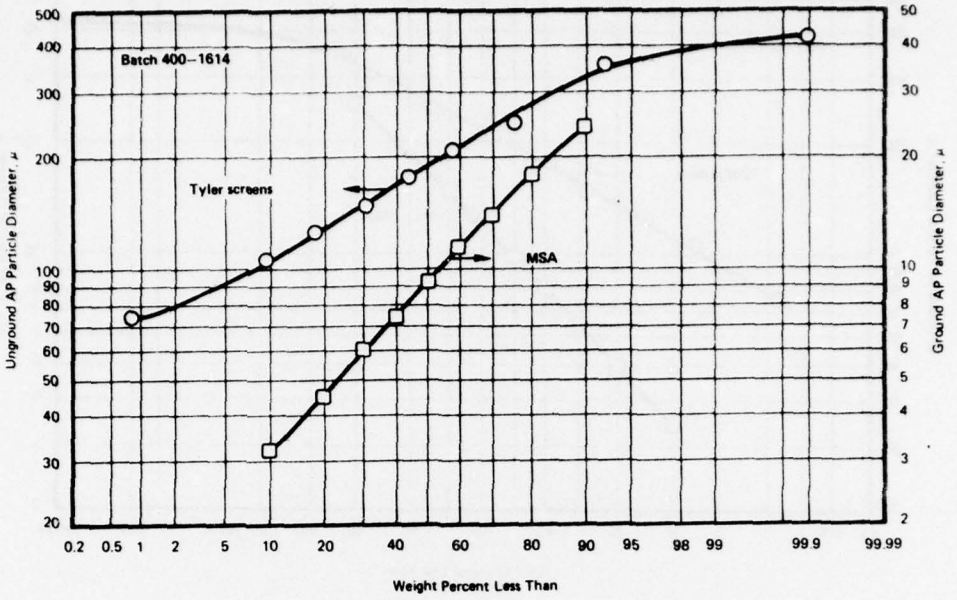
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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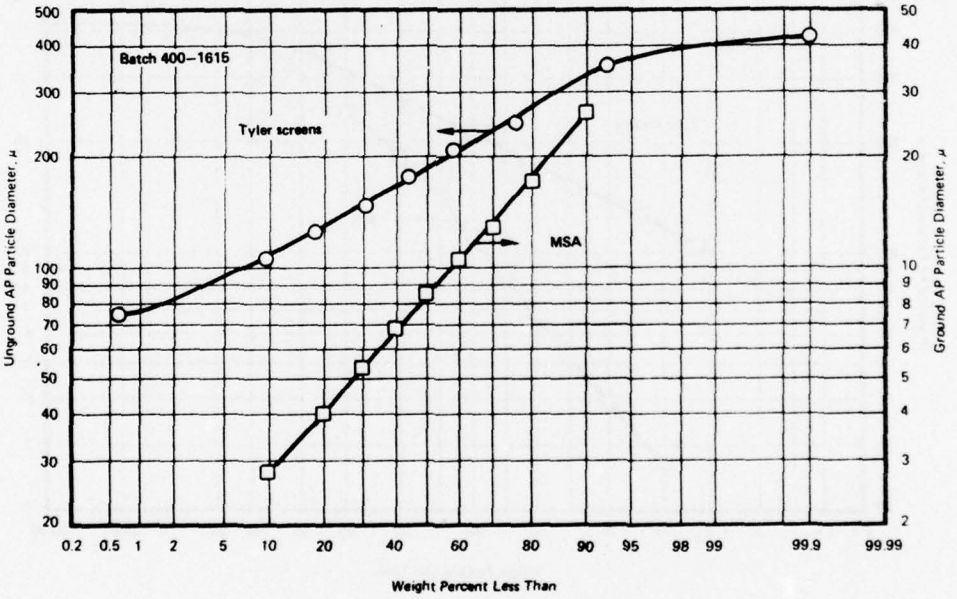
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Tyler screens
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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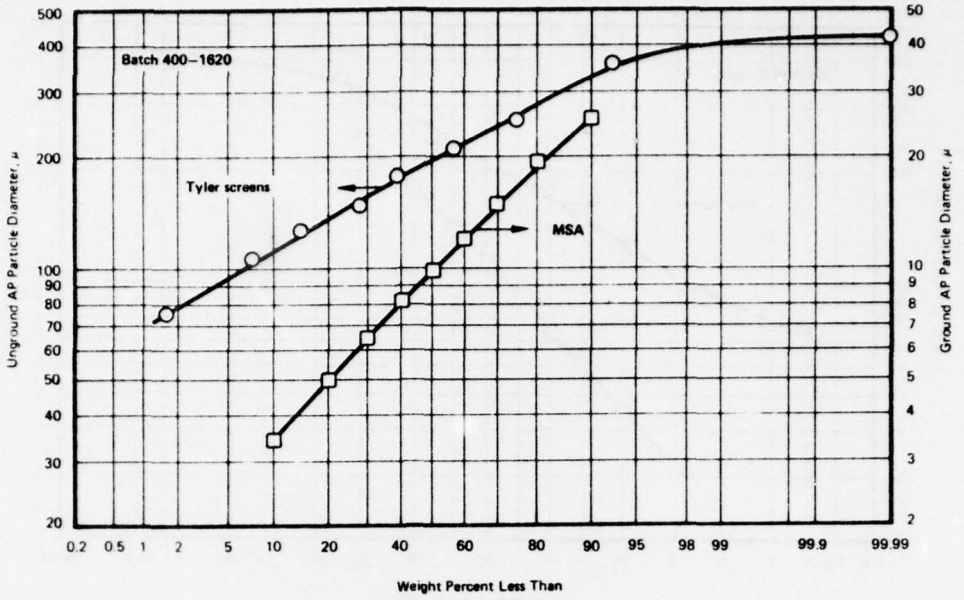
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Tyler screens
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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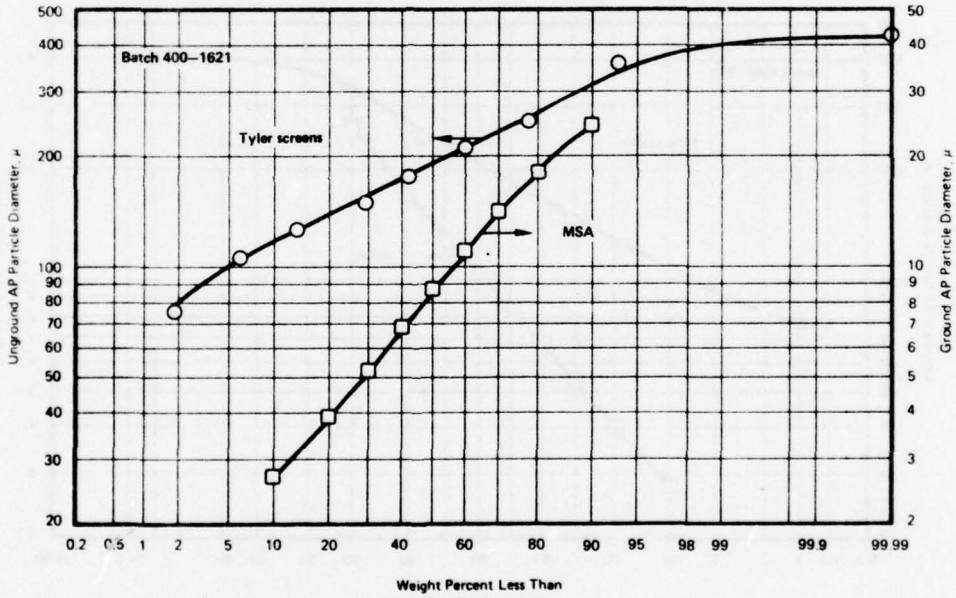
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Tyler screens
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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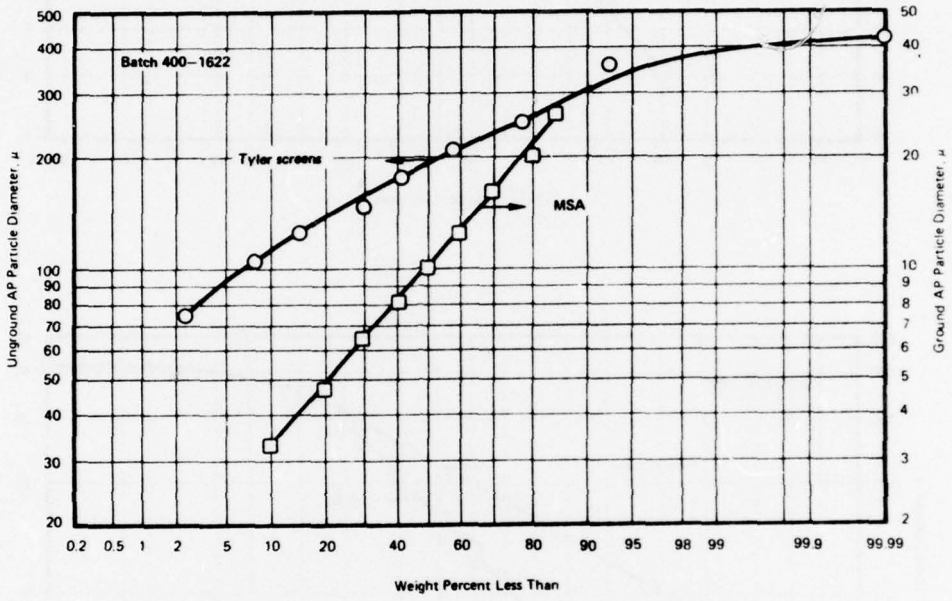
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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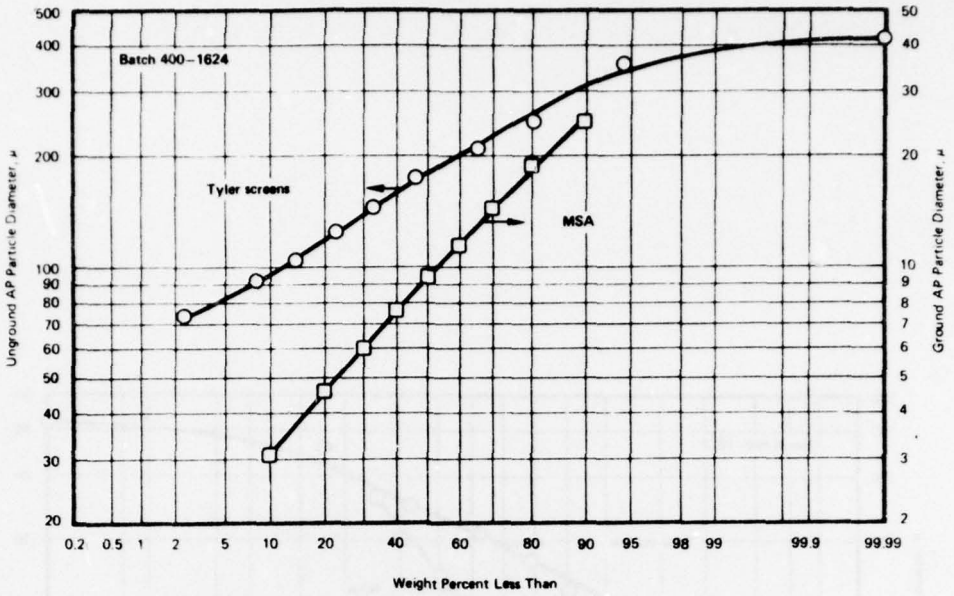
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Tyler screens
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Ground AP Particle Diameter, μ
Weight Percent Less Than
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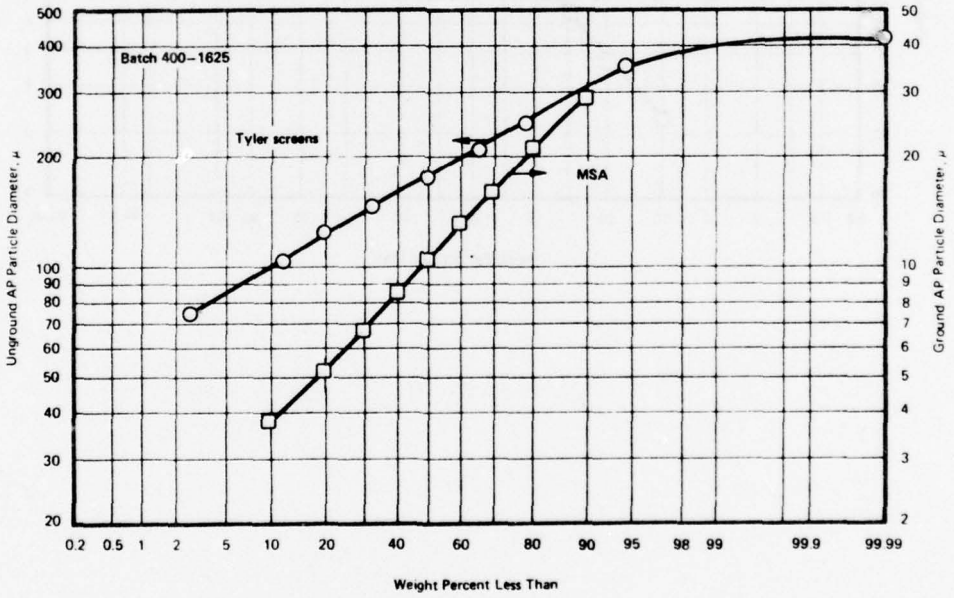
Batch 400–1625
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter, μ
Weight Percent Less Than
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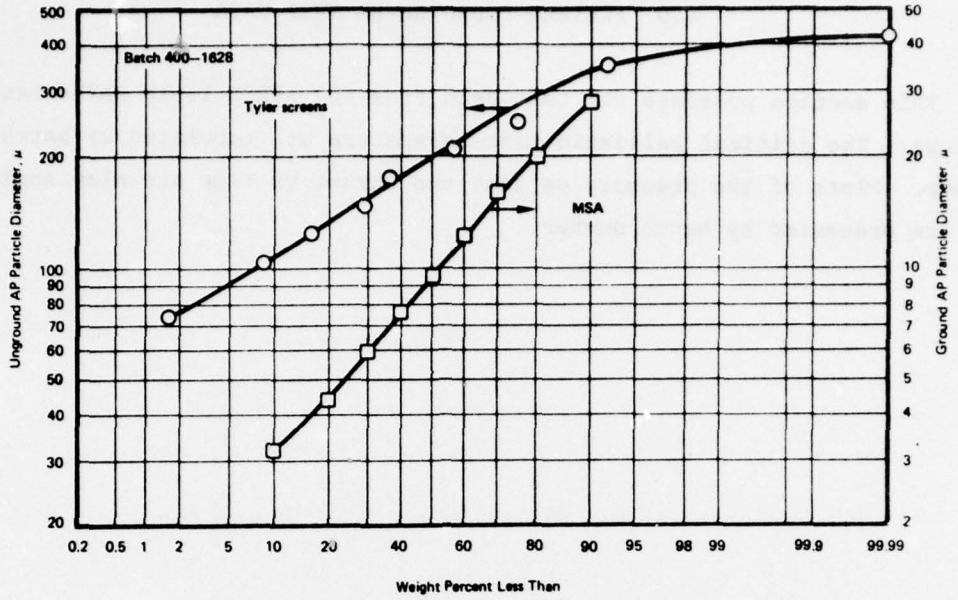
Batch 400–1628
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter μ
Weight Percent Less Than
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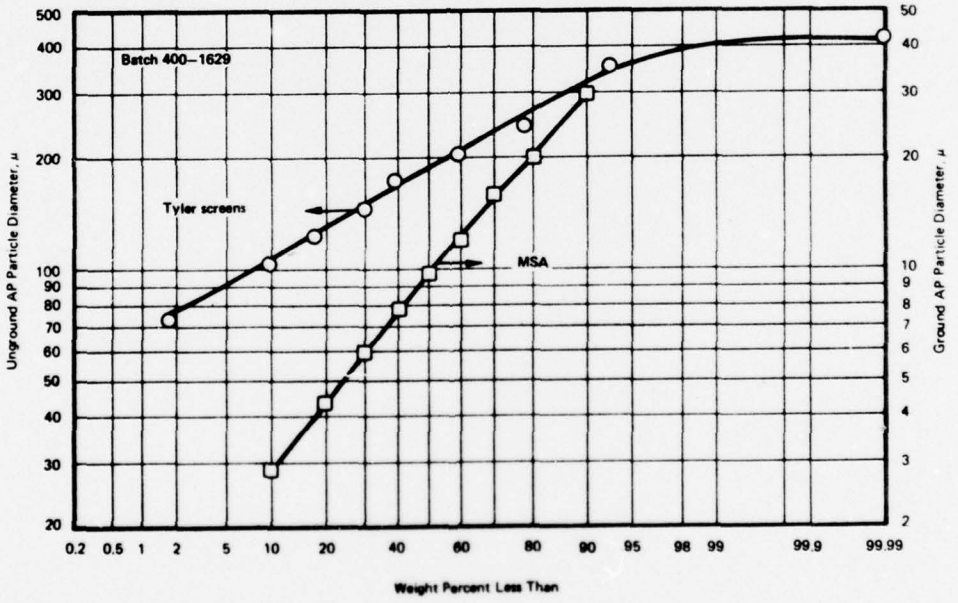
Batch 400–1629
Tyler screens
MSA
Unground AP Particle Diameter, μ
Ground AP Particle Diameter μ
Weight Percent Less Than
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4.0 FIFTEEN-POUND BATES TEST DATA

This section presents the test data from the AFRPL 15-lb BATES test firings. The critical ballistic test parameters are tabulated by batch number. Plots of the pressure vs time and thrust vs time are also included and are presented by batch number.

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15-LB BATES DATA, 70°F

400-gal Batch No.	Propellant Cast in 84-in. Cartridge P/N	S/N	Propellant Weight, lb	Initial Throat Diameter, in.	Throat Erosion Rate, mils/sec	Expansion Ratio	Action Time, sec	Action Time Average Chamber Pressure, psia	Burning Rate, in./sec	Measured c*, ft/sec	Delivered Specific Impulse, sec	Isp, 15-deg HA MC, sec	Efficiency Isp, 15-deg HA MC, %
1450	N/A	N/A	14.13	1.096	2.0	9.649	2.747	833	0.386	4,991	239.3	241.6	0.915
1450	N/A	N/A	14.04	1.095	1.8	9.638	2.769	830	0.381	5,025	239.0	241.6	0.915
1450	N/A	N/A	14.13	1.093	2.2	9.684	2.749	831	0.385	4,966	237.5	240.0	0.909
1450	N/A	N/A	13.595	0.958	6.0	9.549	2.162	1,328	0.491	5,071	247.9	241.4	0.9135
1450	N/A	N/A	13.97	0.963	6.2	9.435	2.269	1,287	0.469	5,062	247.8	241.7	0.915
1450	N/A	N/A	14.01	0.961	7.2	9.429	2.218	1,333	0.480	5,105	247.7	241.1	0.9127
1454	C11479-02-01	2579-02	14.1	1.091	1.73	9.76	2.896	800	0.361	5,015	237.9	241.1	0.9136
1455	C11479-02-01	2579-02	14.03	0.965	6.0	9.355	2.494	1,164	0.419	5,052	244.8	240.5	0.9111
1456	C11479-02-01	2579-02	14.22	1.092	1.94	9.753	2.832	831	0.365	5,071	237.8	240.1	0.9097
1457	C11479-02-01	2579-02	13.82	0.959	5.8	9.50	2.332	1,253	0.479	5,040	246.2	240.7	0.9112
1458	C11479-02-01 C11479-01-01	2579-02 2579-01	13.91	1.089	1.74	9.805	3.424	895	0.407	5,046	240.0	240.5	0.9110
1459	C11479-01-01	2579-01	14.1	0.963	6.5	9.431	2.307	1,268	0.453	5,056	246.8	241.0	0.912
1460	C11479-01-01	2579-01	14.07	1.10	1.6	9.616	2.83	817	0.373	5,087	237.4	240.1	0.909
1461	C11479-01-01	2579-01	14.12	0.967	6.8	9.324	2.353	1,243	0.444	5,076	246.2	240.9	0.9115
1462	C11479-01-01	2579-01	13.86	1.106	1.77	9.543	2.823	799	0.374	5,089	237.4	240.5	0.911
1463	C12185-01-01	2579-01	14.09	0.967	5.7	9.399	2.354	1,230	0.446	5,015	244.3	239.2	0.9054
1464	C12185-01-01	2579-01	14.05	1.096	1.8	9.674	2.755	833	0.381	5,035	238.0	240.3	0.910
1465	C12185-01-01	2579-01	13.93	0.970	5.5	9.342	2.286	1,251	0.458	5,024	245.7	240.3	0.910
1495	C11479-01-01	2579-07	14.09	1.045	1.88	9.675	2.667	863	0.399	5,015	238.4	240.0	0.9085
1496	C11479-01-01	2579-07	14.09	0.961	6.17	9.446	2.108	1,395	0.505	5,116	247.7	240.5	0.9104
1497	C11479-01-01	2579-07	14.07	1.095	1.69	9.709	2.672	854	0.399	5,064	238.2	239.8	0.908
1498	C11479-01-01	2579-07	14.09	0.958	2.1	9.448	2.093	1,442	0.509	5,189	247.2	239.6	0.907
1499	C11479-01-01 C11479-03-01	2579-07 2579-08	13.97	1.092	3.73	9.634	2.684	839	0.396	4,971	238.0	240.2	0.910
1502	C11479-03-01	2579-08	14.17	0.965	6.5	9.384	2.167	1,354	0.492	5,025	246.6	240.0	0.908
1500	C11479-03-01	2579-08	14.18	0.963	7.3	9.425	2.124	1,364	0.502	5,042	247.6	240.8	0.9114
1503	C11479-03-01	2579-08	14.04	1.092	2.8	9.766	2.677	1,250	0.398	4,956	238.4	240.5	0.911
1505	C11479-01-01	2579-09	14.2	1.099	1.4	9.65	2.881	794	0.366	4,968	236.5	240.1	0.909
1506	C11479-01-01	2579-09	14.28	0.962	7.6	9.469	2.164	1,362	0.485	5,007	246.6	239.7	0.907
1507	C11479-01-01	2579-09	14.2	1.096	2.42	9.625	2.688	849	0.392	4,959	238.4	240.7	0.91
1509	C11479-01-01 C11479-03-01	2579-09 2579-10	14.22	1.098	2.4	9.61	2.684	868	0.386	5,074	239.3	240.7	0.9117
1510	C11479-03-01	2579-10	14.18	0.967	6.8	9.38	2.14	1,388	0.492	5,102	247.7	240.6	0.9105
1511	C11479-03-01	2579-10	13.90	1.098	2.6	9.618	2.71	831	0.422	5,039	237.4	239.8	0.9078
1512	C11479-03-01	2579-10	14.16	0.963	7.7	9.4	2.141	1,396	0.490	5,106	247.9	240.7	0.9113
1513	C11479-03-01 C12185-02-01	2579-10 2579-06	14.2	1.09	2.03	9.76	2.712	866	0.387	5,041	239.0	240.5	0.9101
1514	C12185-02-01	2579-06	14.24	0.96	7.0	9.496	2.126	1,393	0.492	5,022	247.9	240.6	0.9109
1514	C12185-02-01	2579-06	14.18	1.095	2.4	8.40	2.691	857	0.406	5,000	238.9	240.9	0.9122

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15-LB BATES DATA, 70°F

400-gal Batch No.	Propellant Cast in 84-in. Cartridge P/N	S/N	Propellant Weight, lb	Initial Throat Diameter, in.	Throat Erosion Rate, mils/sec	Expansion Ratio	Action Time, sec	Action Time Average Chamber Pressure, psia	Burning Rate, in./sec	Measured c*, ft/sec	Delivered Specific Impulse, sec	Isp, 15-deg HA MC, sec	Efficiency Isp, 15-deg HA MC, %
1515	C12185-02-01 C12185-03-01	2579-06 2579-07	13.96	1.098	2.09	9.636	2.628	854	0.398	4,960	238.5	240.3	0.9098
1516	C11479-02-01	2579-12	14.2	1.095	1.62	9.69	2.783	826	0.375	4,963	238.9	241.6	0.9147
1517	C11479-02-01	2579-12	14.18	0.962	6.79	9.44	2.286	1,283	0.460	5,005	247.2	241.2	0.9134
1518	C11479-02-01	2579-12	14.23	1.099	1.62	9.59	2.775	819	0.378	4,944	238.6	241.4	0.914
1519	C11479-02-01	2579-12	14.12	0.965	5.59	9.435	2.323	1,234	0.455	4,993	247.2	241.6	0.914
1520	C11479-02-01 C11479-03-01	2579-12 2579-11	14.14	1.114	1.58	9.352	2.843	783	0.371	4,997	237.6	241.5	0.9143
1521	C11479-03-01	2579-11	14.22	0.961	6.2	9.489	2.333	1,282	0.455	5,065	247.2	241.2	0.9132
1522	C11479-03-01	2579-11	14.15	1.093	1.94	9.72	2.841	807	0.372	4,953	237.9	241.2	0.913
1523	C11479-03-01	2579-11	14.14	0.96	6.2	9.538	2.256	1,323	0.471	5,075	248.0	241.4	0.914
1524	C11479-03-01 C12185-02-01	2579-11 2579-08	14.2	1.097	1.4	9.635	2.845	810	0.371	4,991	237.9	241.0	0.912
1525	C12185-02-01	2579-08	13.81	0.97	5.44	9.345	2.297	1,231	0.460	5,015	246.5	241.3	0.913
1526	C12185-03-01	2579-09	14.23	1.107	1.6	9.451	2.77	826	0.381	5,050	238.8	241.4	0.9135
1527	C11479-01-01	2579-13	14.1	0.963	6.1	9.48	2.309	1,259	0.452	5,004	246.8	240.8	0.9118
1533	C11479-01-01	2579-14	14.15	0.962	6.28	9.445	2.309	1,259	0.454	4,981	245.9	240.0	0.908
1537	C12185-03-01	2579-11	13.84	0.962	3.0	9.473	2.209	1,298	0.472	5,028	247.0	240.5	0.910
1539	C12185-02-01	2579-12	14.14	0.962	6.36	9.470	2.358	1,262	0.442	5,084	246.8	240.9	0.9118
1541	C12185-01-01	2579-10	14.15	0.961	6.5	9.477	2.231	1,342	0.472	5,119	247.6	240.7	0.9112
1574	C11479-01-01	2579-17	14.05	0.963	6.4	9.458	2.255	1,321	0.470	5,137	248.3	241.8	0.915
1575	C11479-01-01	2579-17	14.02	1.096	2.0	9.674	2.755	838	0.385		239.6	241.6	0.915
1576	C11479-01-01	2579-17	14.0	0.963	6.4	9.408	2.268	1,473	0.468	5,039	248.4	242.0	0.916
1577	C11479-01-01	2579-17	14.04	1.097	1.8	9.628	2.756	840	0.387	5,079	239.9	242.3	0.916
1578	C11479-01-01 C11479-03-02	2579-17 2579-18	14.08	1.098	1.8	9.648	2.773	908	0.381	5,001	239.4	241.7	0.915
1579	C11479-03-02	2579-18	14.08	0.966	2.227	9.389	2.227	1,319	0.477	5,079	249.1	242.4	0.9176
1580	C11479-03-02	2579-18	14.15	1.102	2.0	9.566	2.761	911	0.386	5,015	239.4	241.6	0.915
1581	C11479-03-02	2579-18	14.02	0.966	2.16	9.363	2.239	1,311	0.475	5,088	250.3	243.7	0.923
1582	C11479-03-02	2579-18	14.14	0.97	7.2	9.23	2.209	1,313	0.481	5,067	247.6	241.2	0.913
1588	C11479-01-01	2579-19	13.92	1.208	0.7	8.012	3.041	684	0.348	5,069	232.8	242.2	0.917
1590	C11479-01-01	2579-19	14.03	0.964	8.7	9.233	2.184	1,343	0.485	5,139	248.9	242.2	0.917
1592	C11479-01-01 C11479-02-01	2579-19 2579-20	14.06	1.101	2.7	9.41	2.731	831	0.388	5,032	239.6	241.8	0.915
1594	C11479-02-01	2579-20	13.99	1.109	1.1	9.453	2.764	812	0.382	5,035	238.8	241.5	0.914
1596	C11479-02-01	2579-20	14.11	1.093	2.4	9.635	2.687	867	0.394	5,062	240.2	241.4	0.914
1598	C12185-01-01	2579-14	14.04	1.101	2.0	9.542	2.686	846	0.394	5,035	239.2	241.0	0.912
1606	C11479-01-01	2579-21	14.2	1.110	19.4	9.366	2.835	802	0.372	5,062	239.0	241.9	0.916
1607	C11479-01-01	2579-21	14.26	1.102	2.3	9.491	2.88	898	0.363	5,021	237.1	240.2	0.9095
1610	C11479-01-01	2579-21	14.09	1.099	2.0	9.534	2.753	831	0.381	5,031	238.9	241.0	0.912
1612	C11479-01-01	2579-22	14.11	1.097	2.0	9.59	2.70	855	0.389	5,054	240.8	242.1	0.916
1614	C11479-01-01	2579-22	14.08	1.09	2.0	9.717	2.699	860	0.388	5,025	241.0	242.2	0.917

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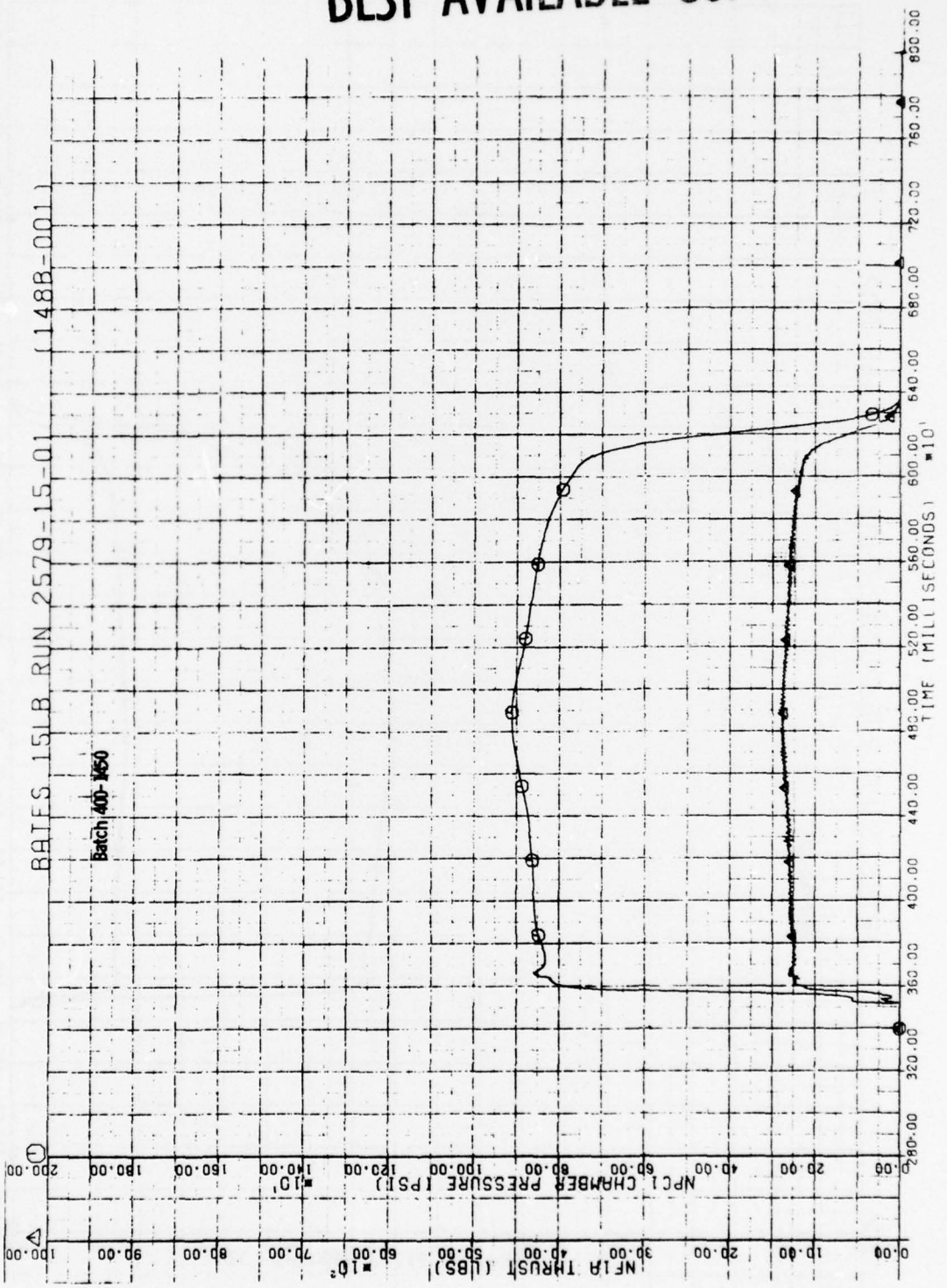

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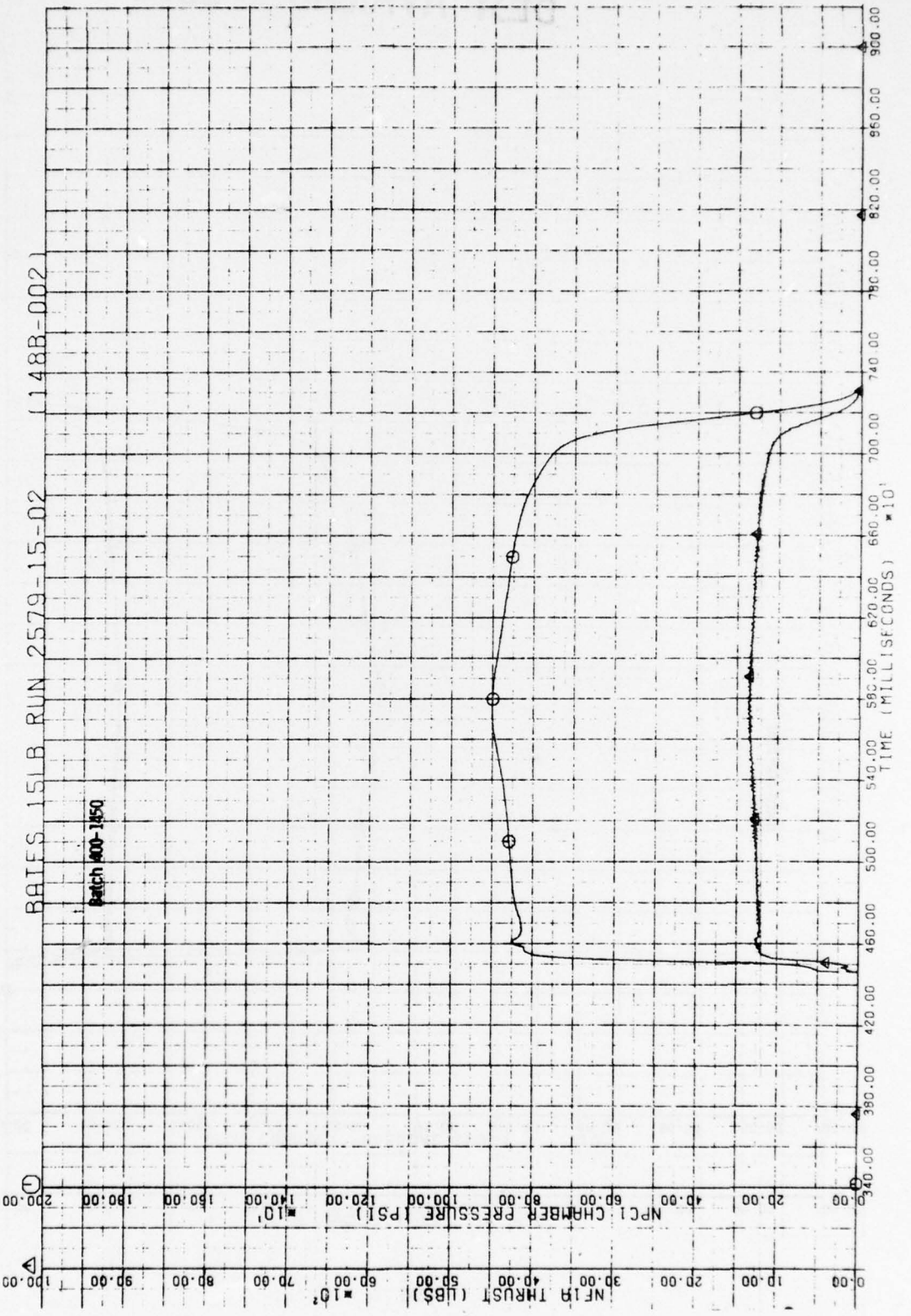

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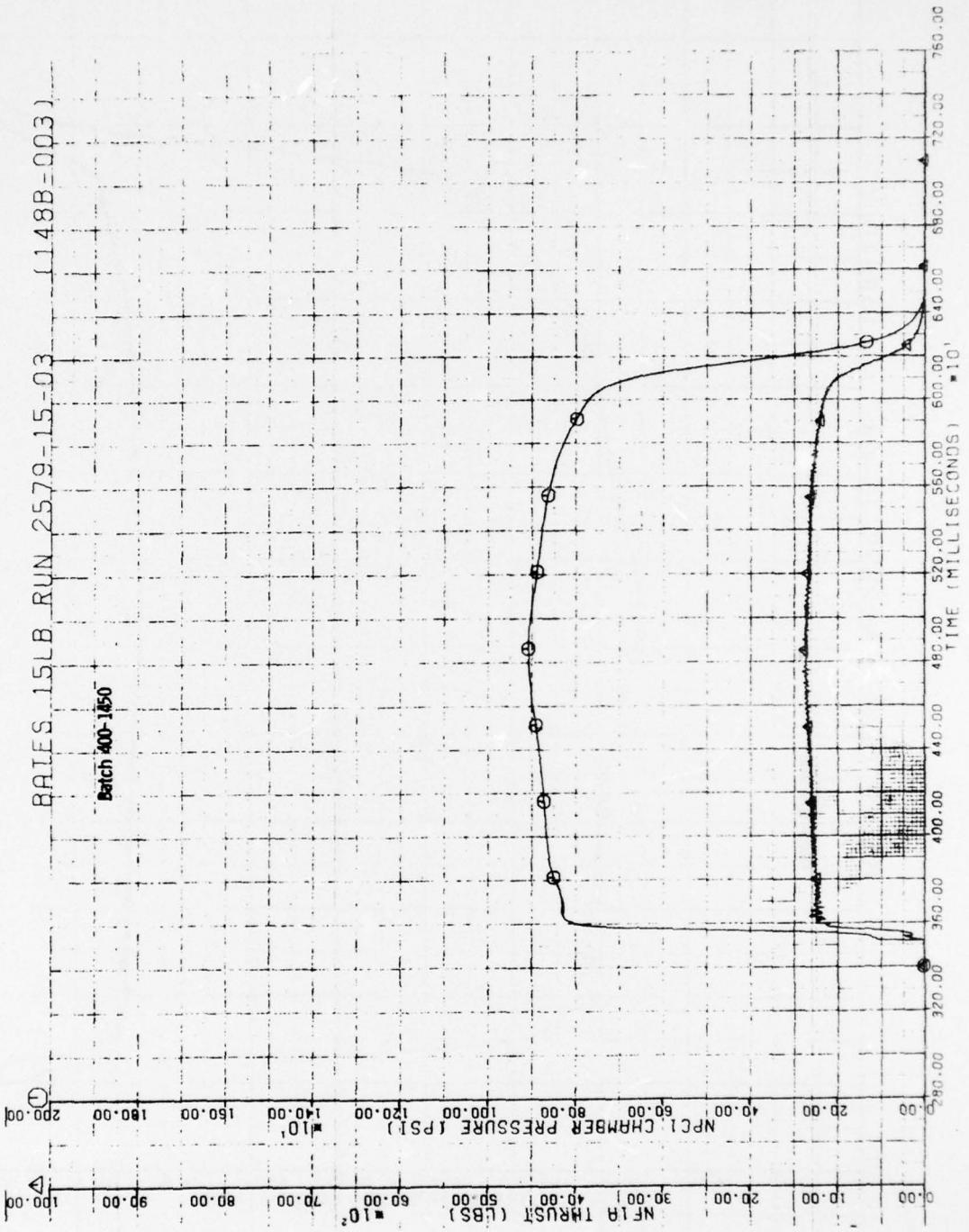

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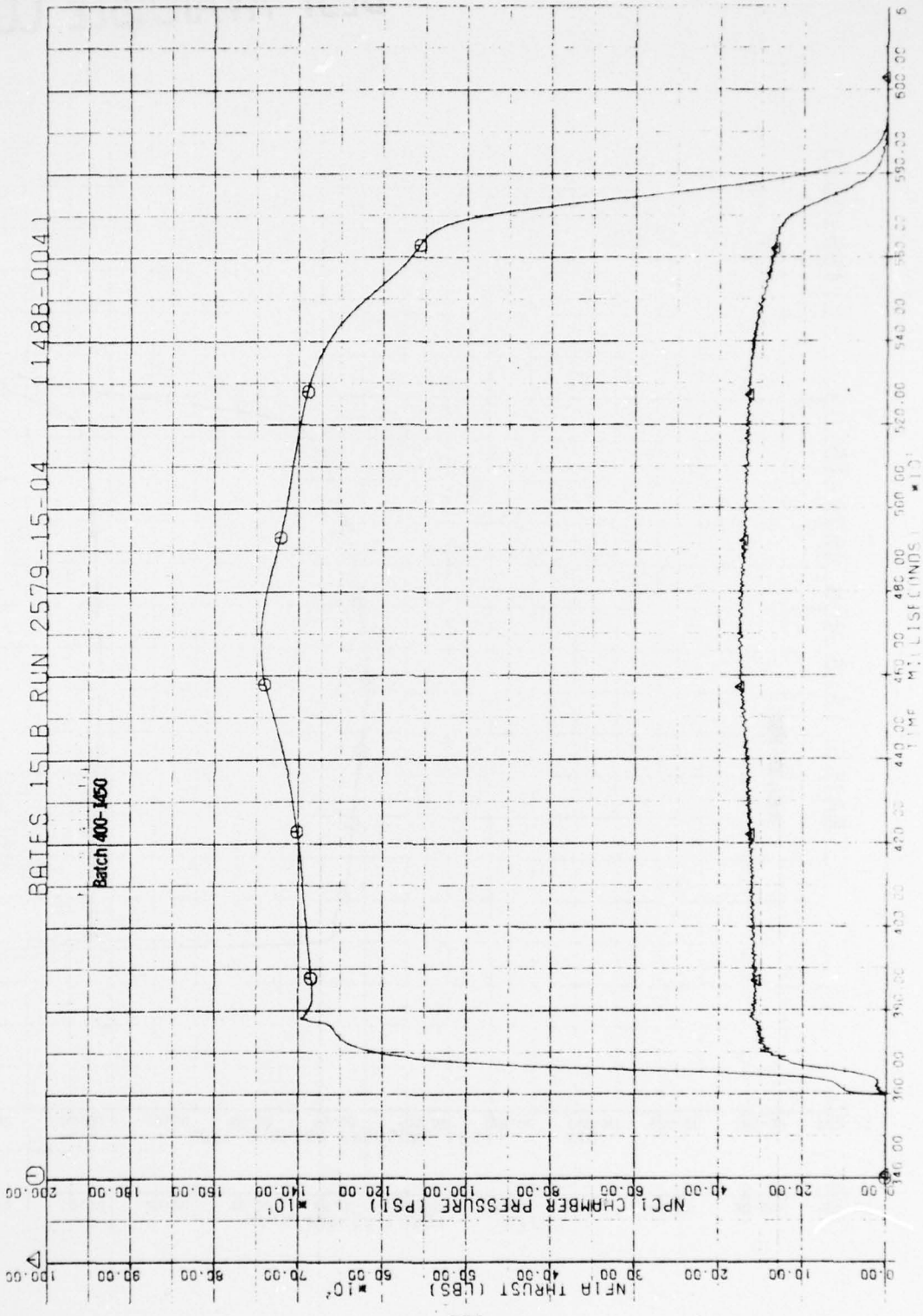

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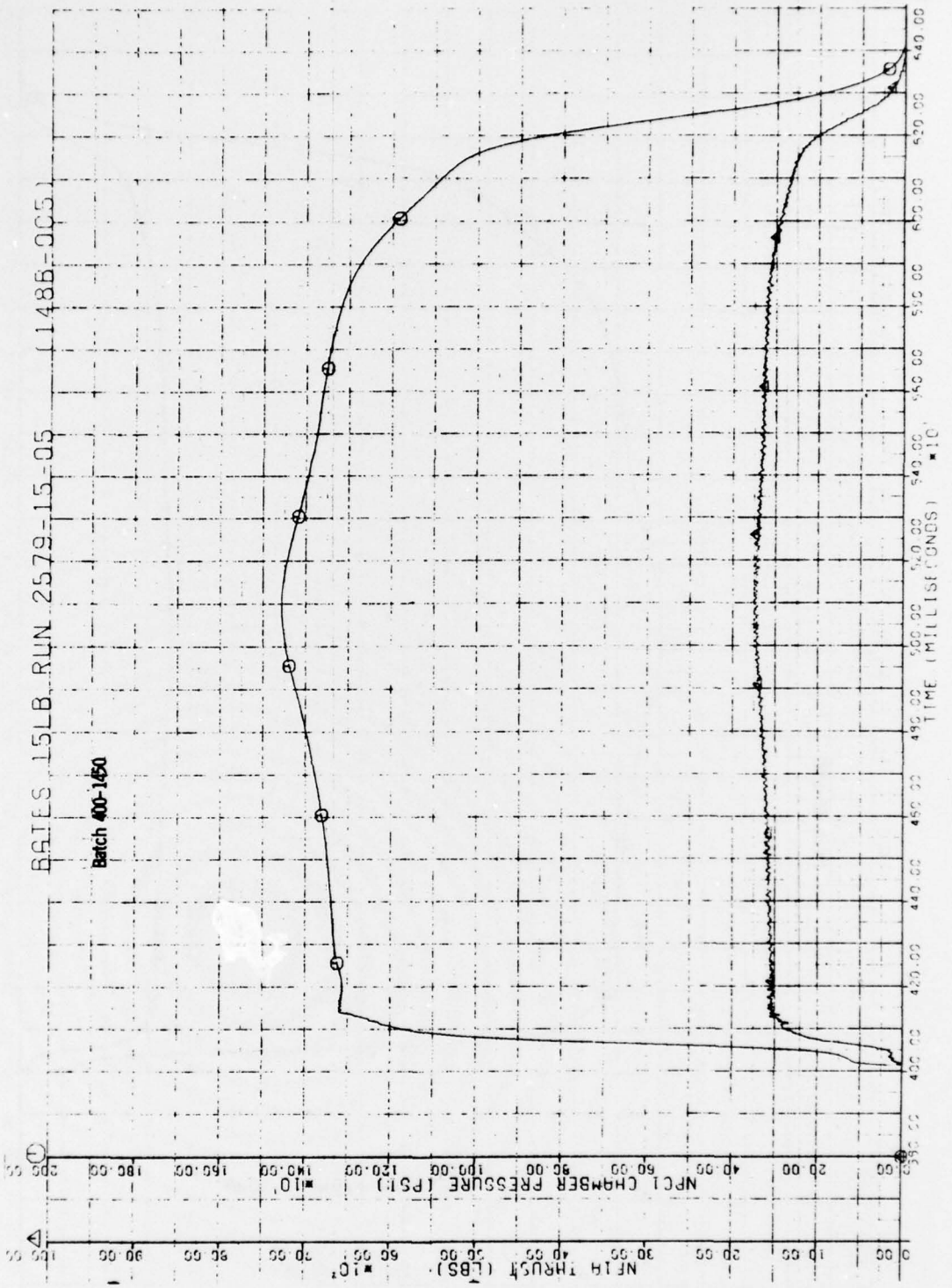

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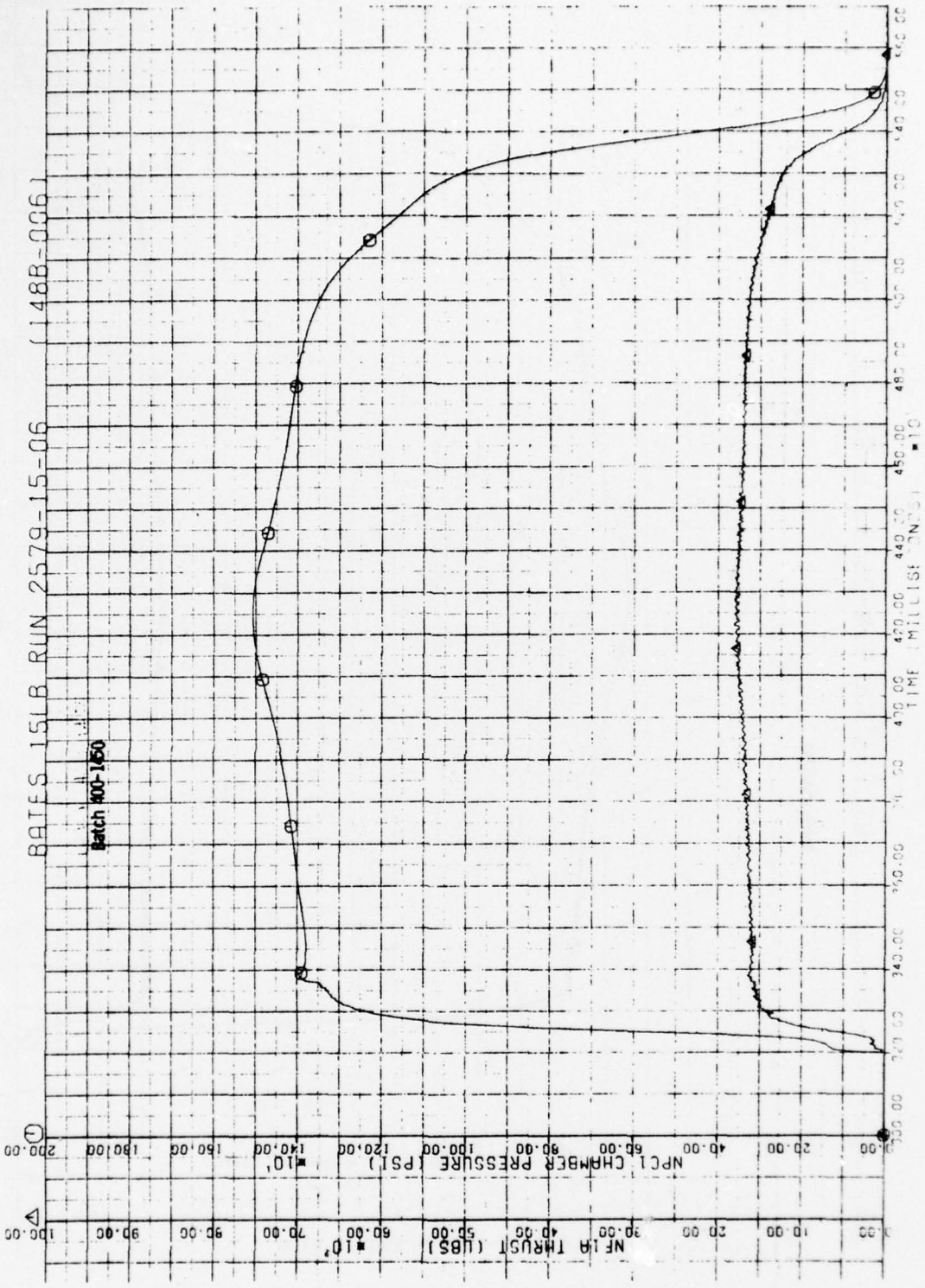

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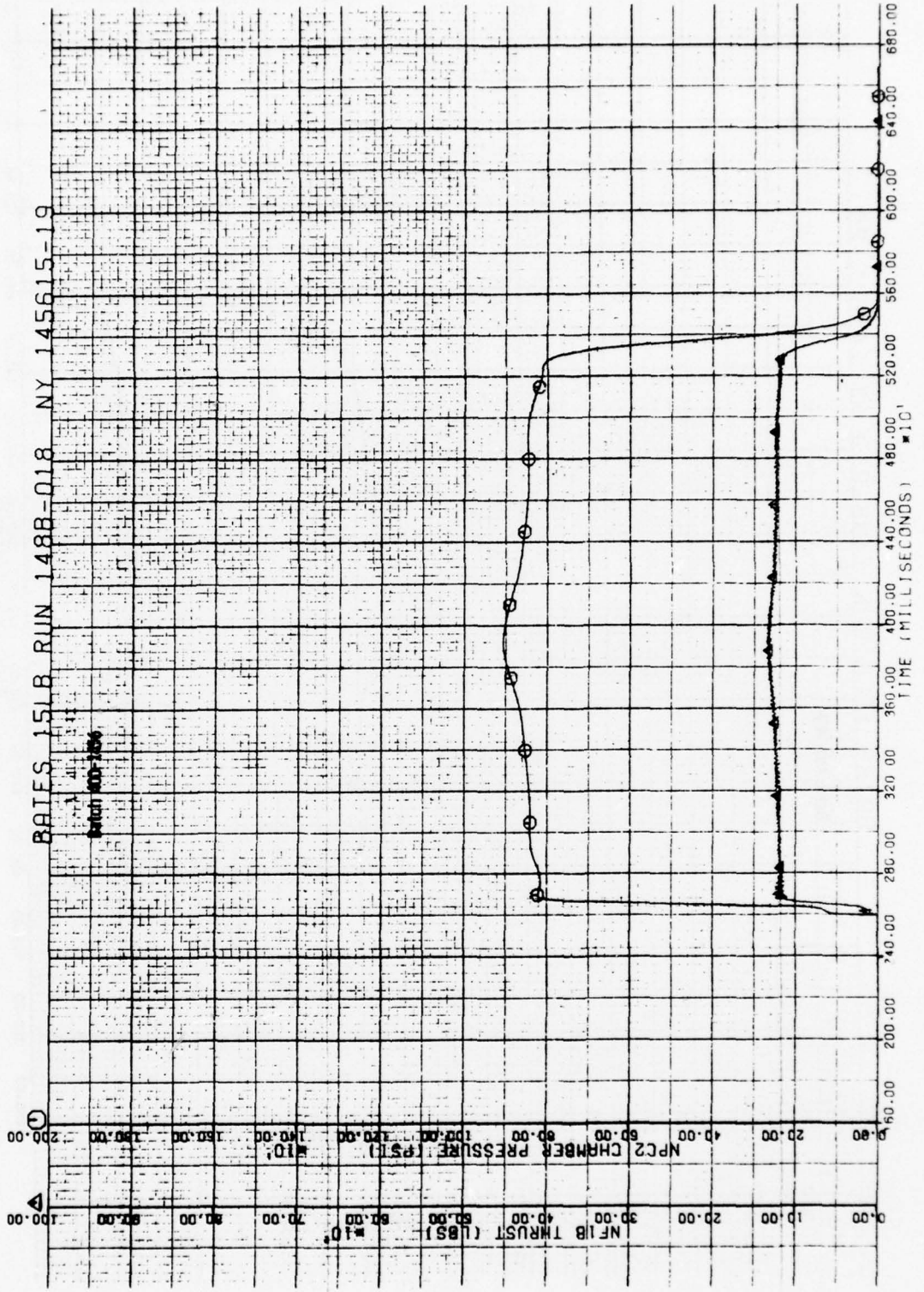

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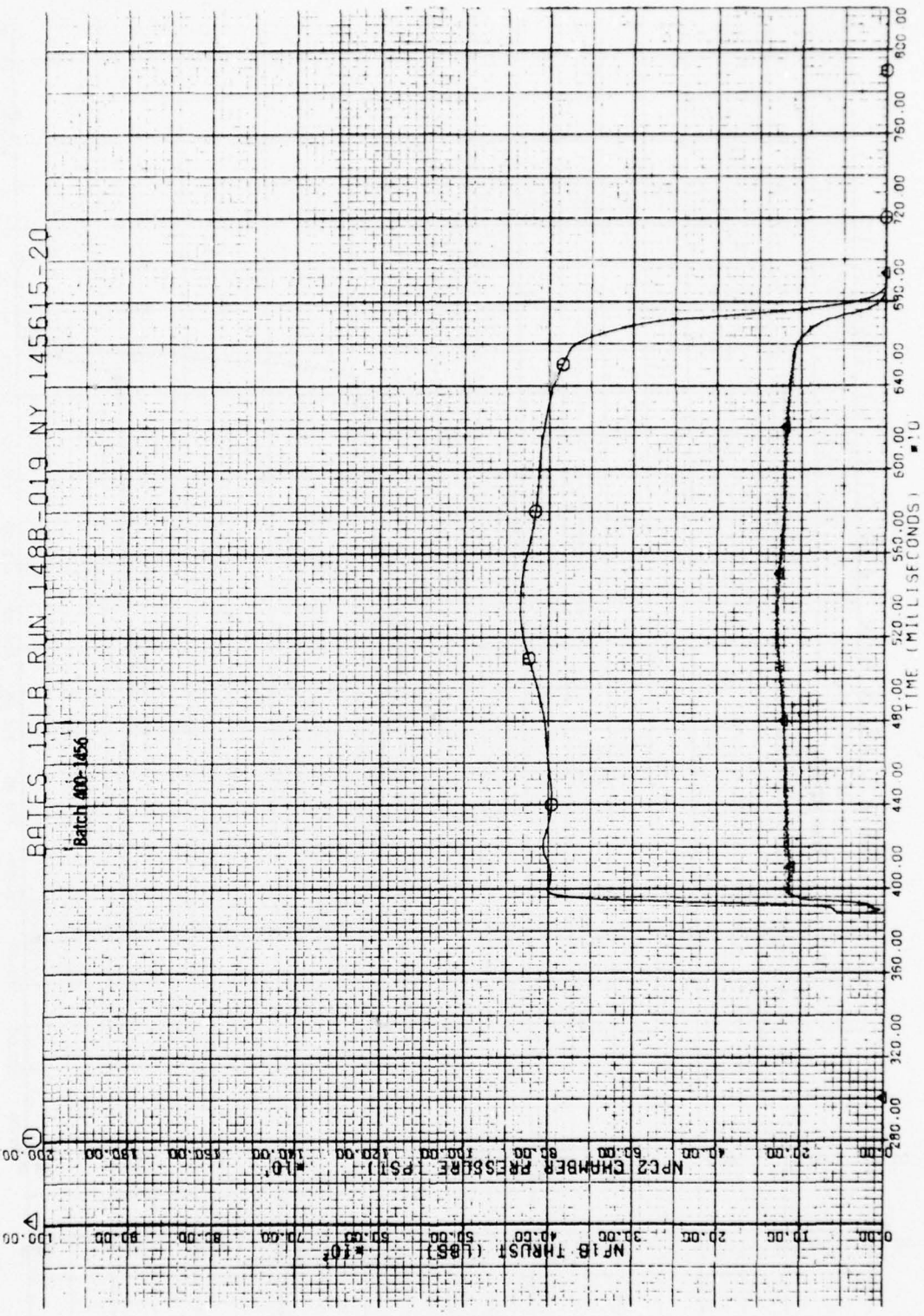

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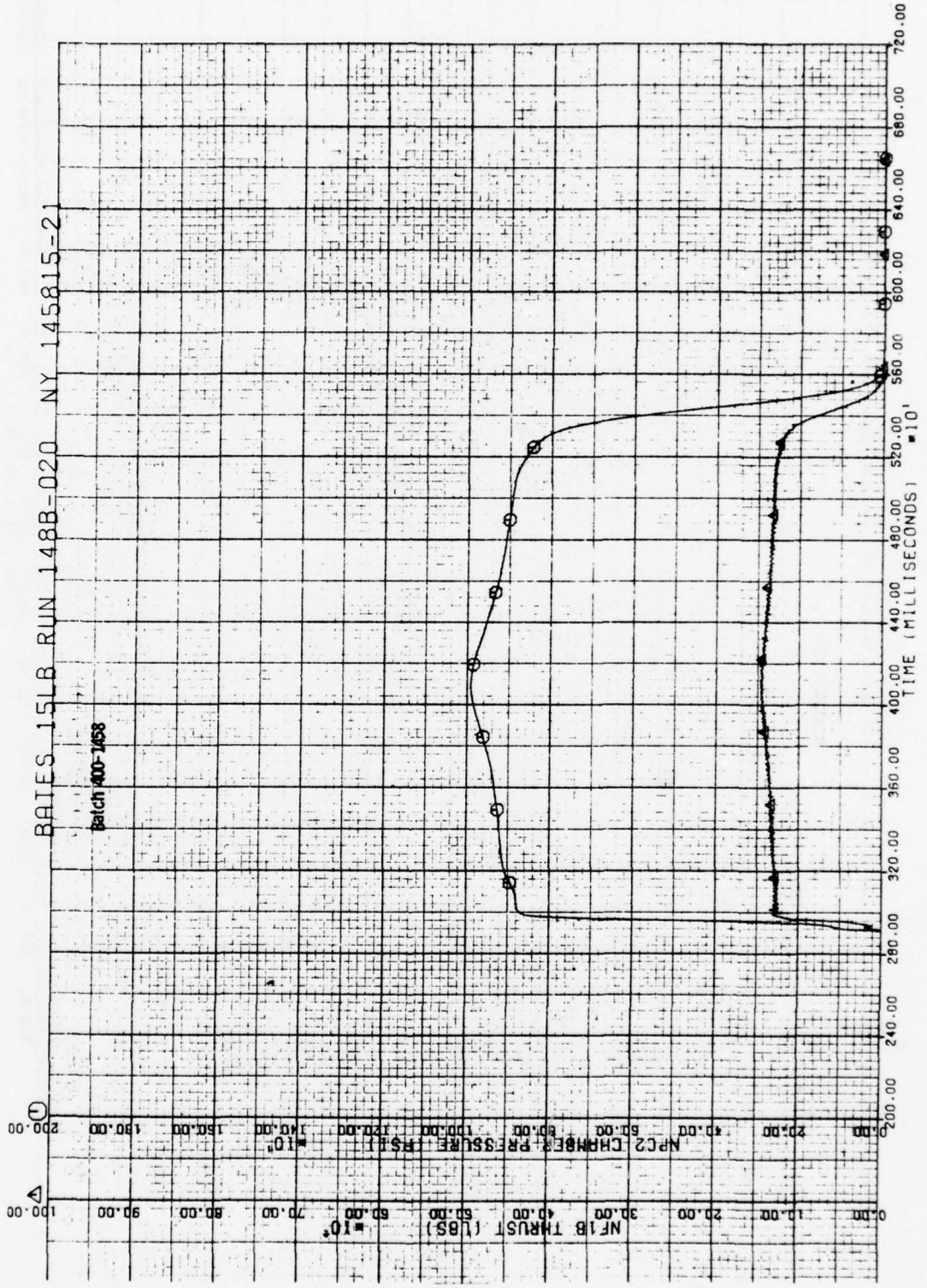

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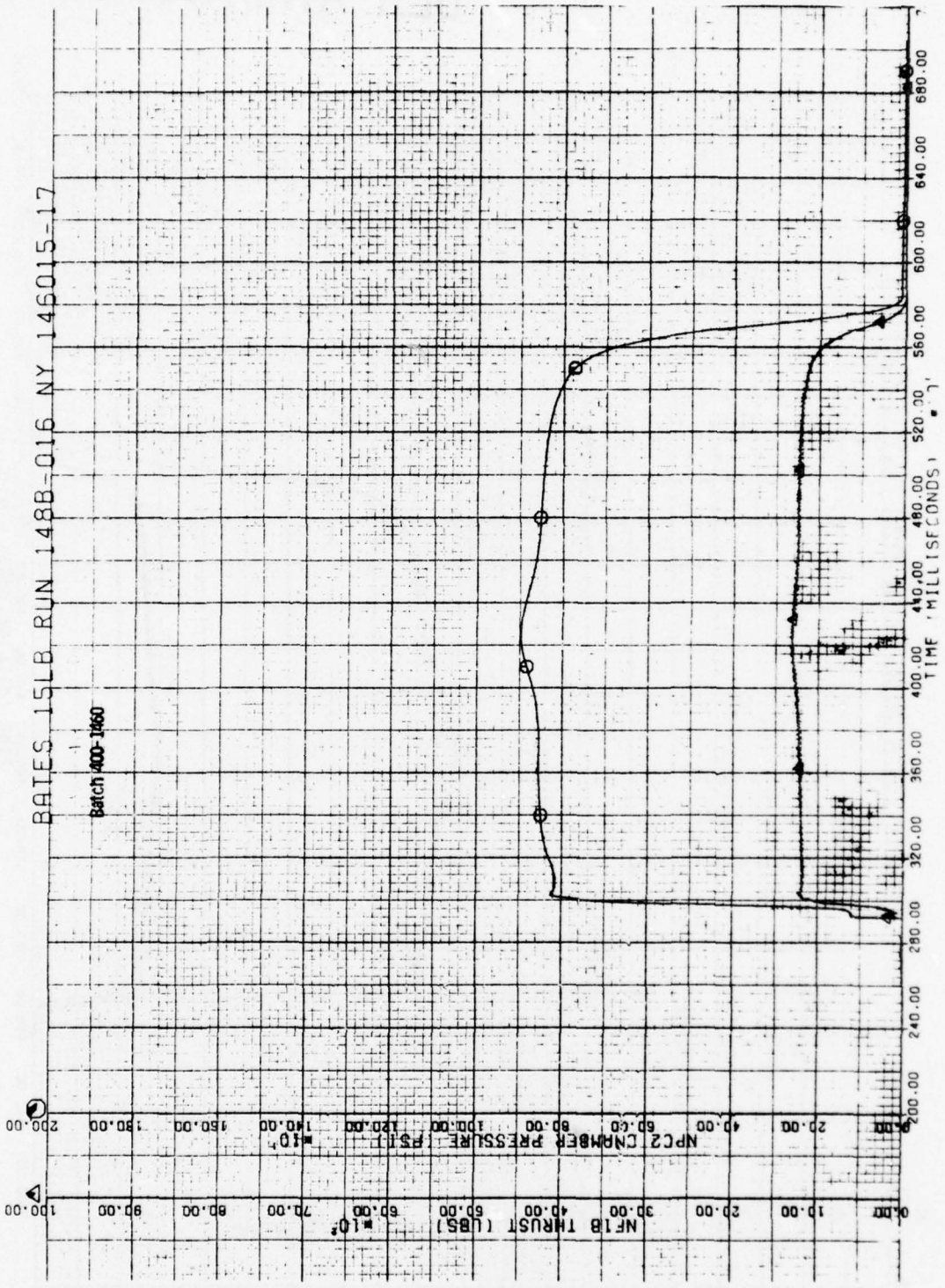

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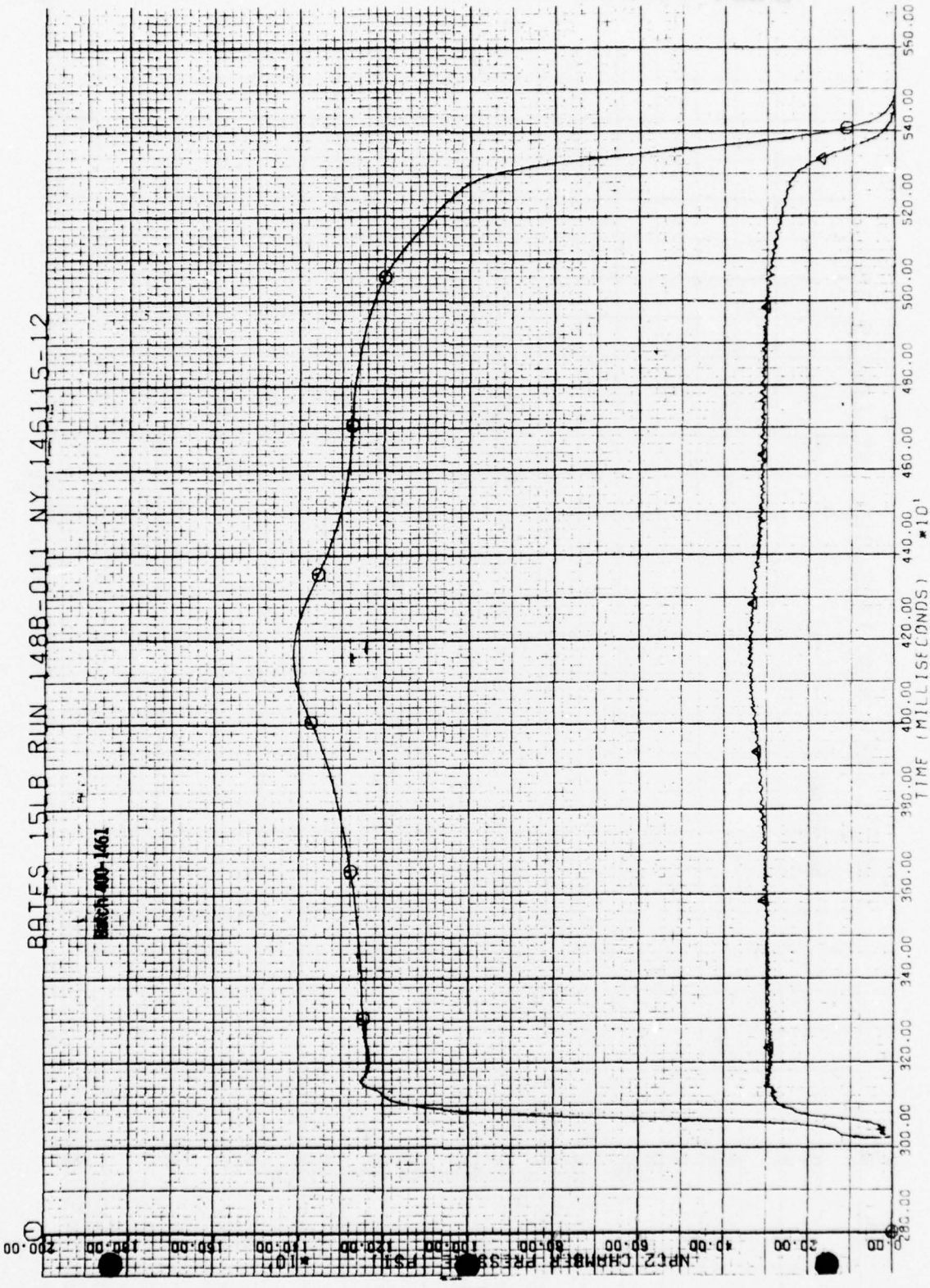

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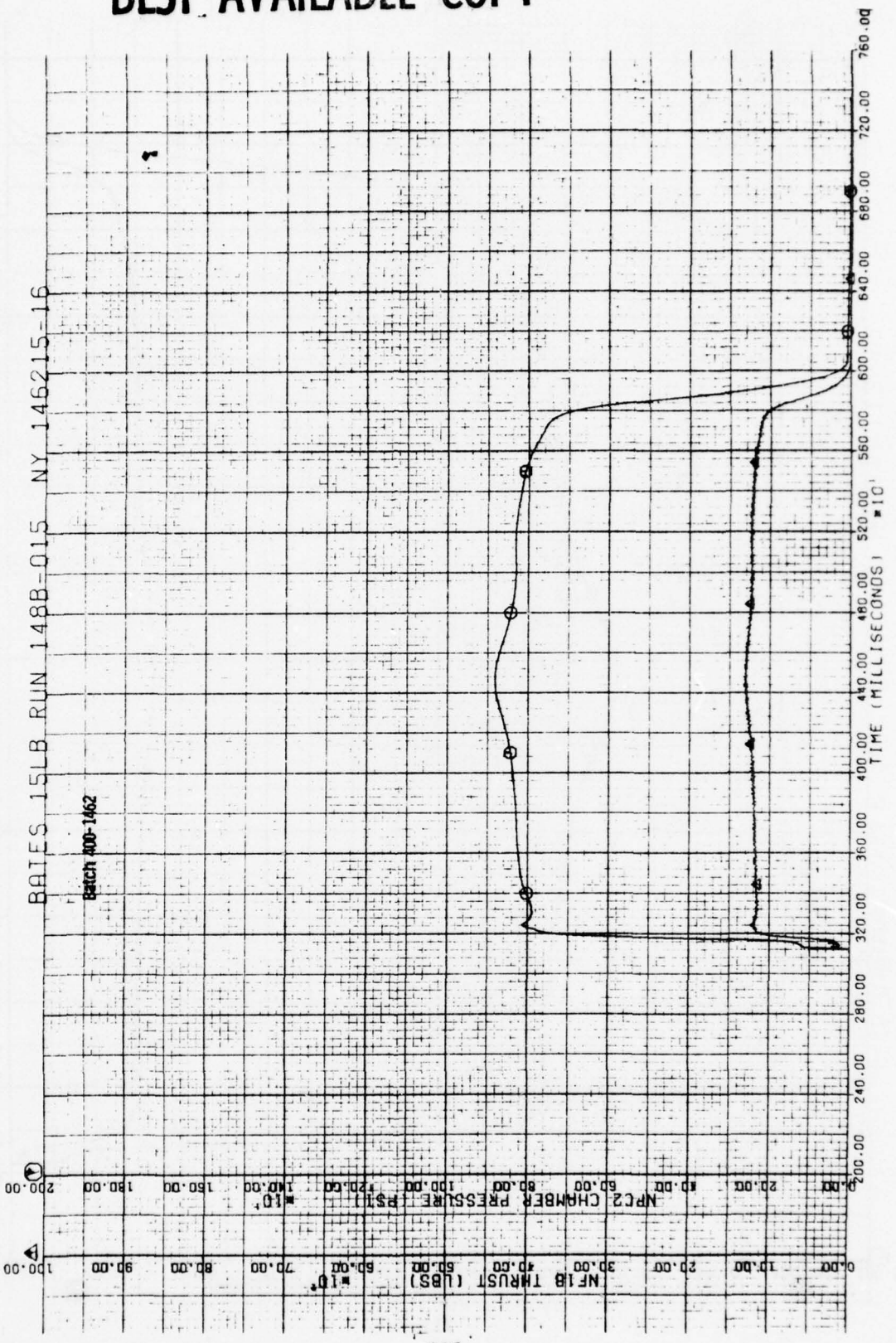

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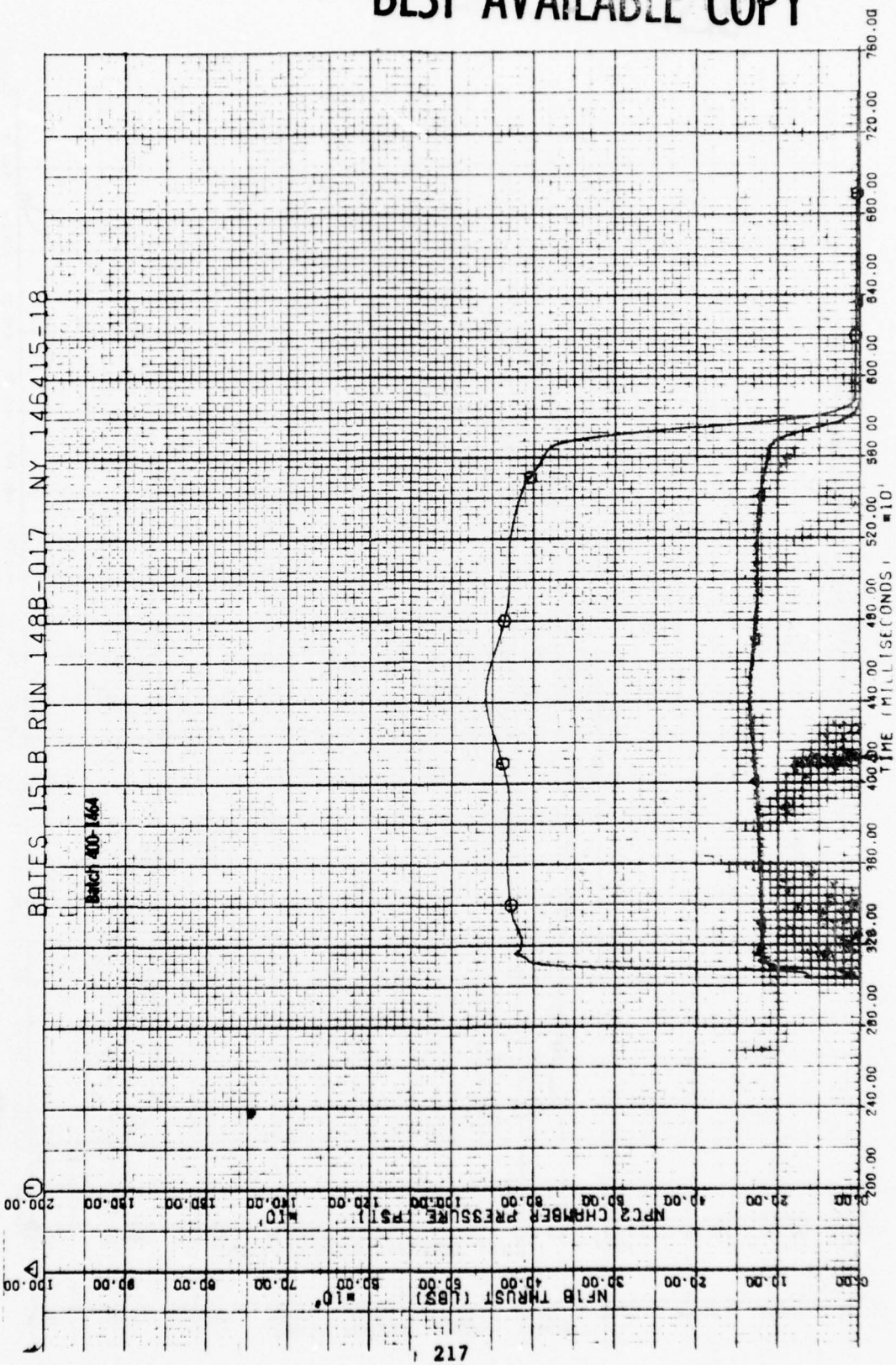

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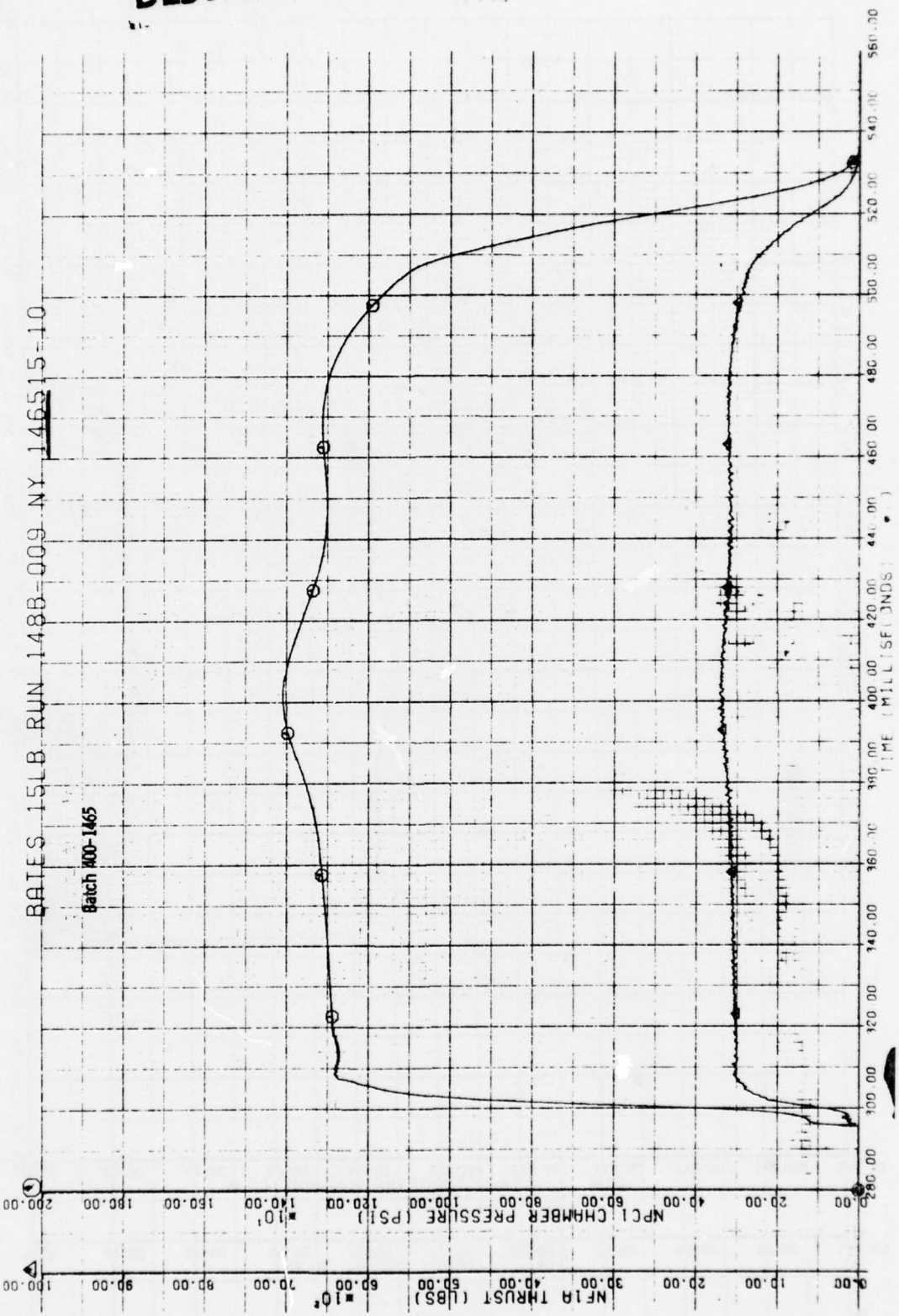

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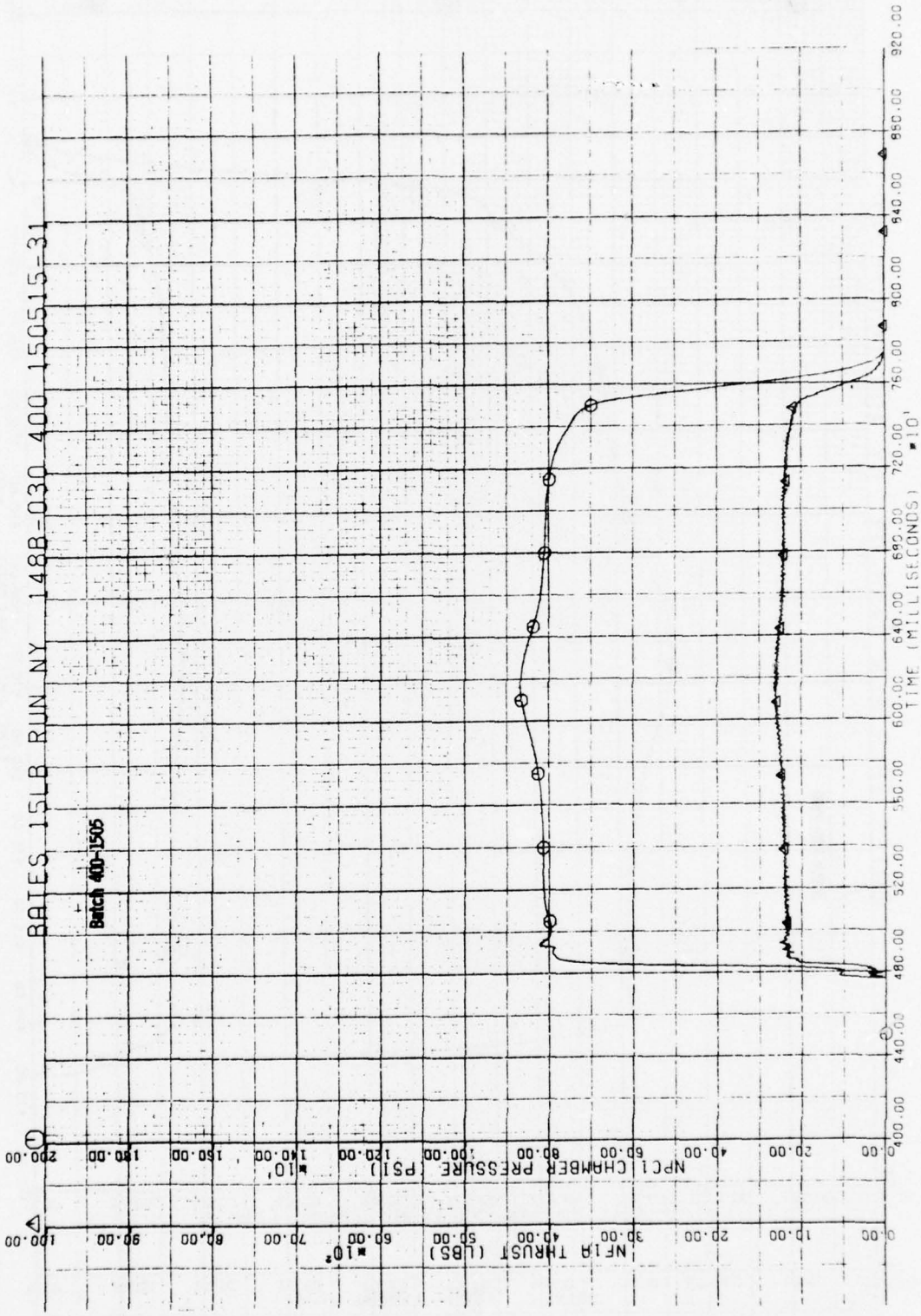

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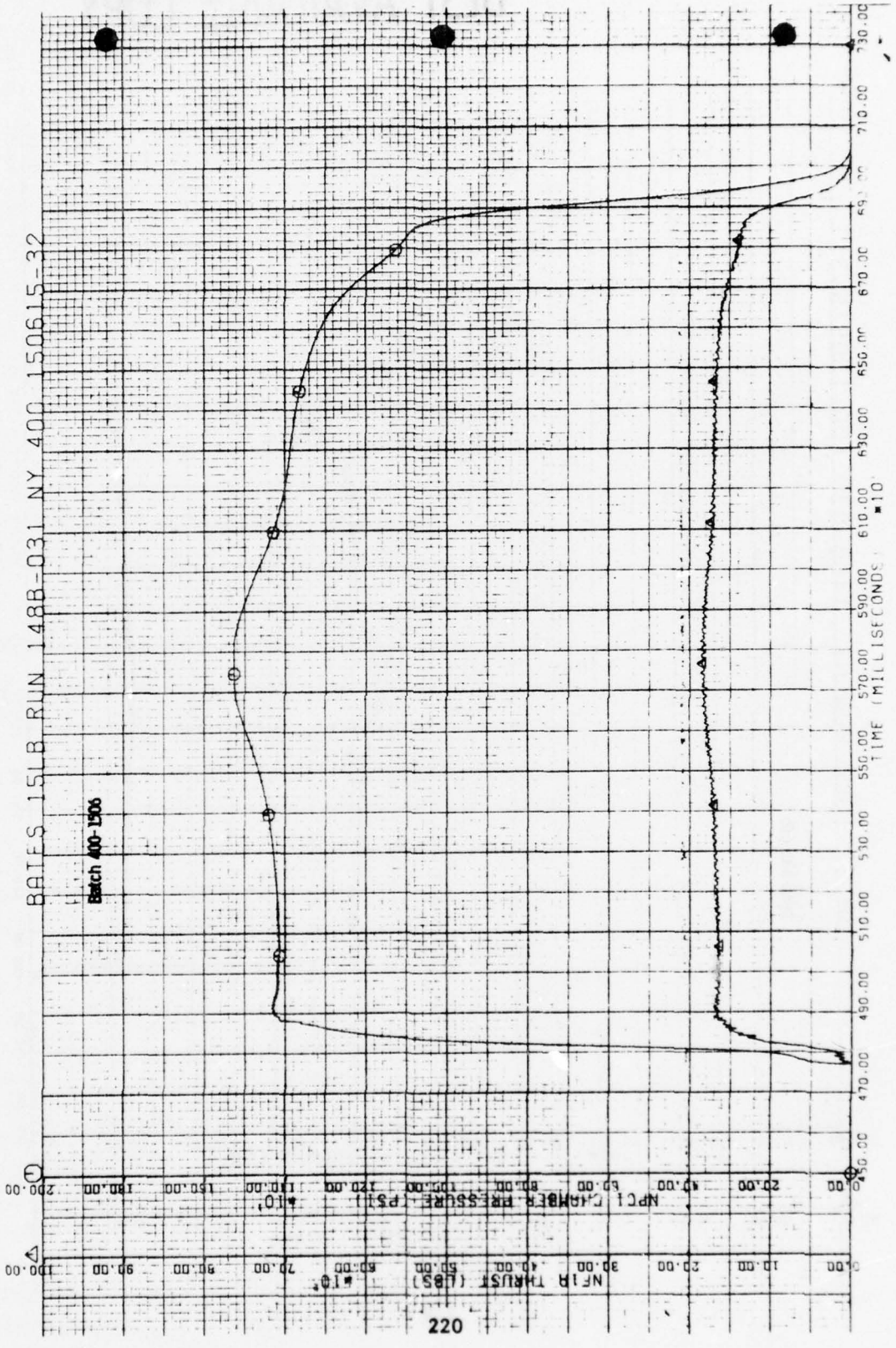

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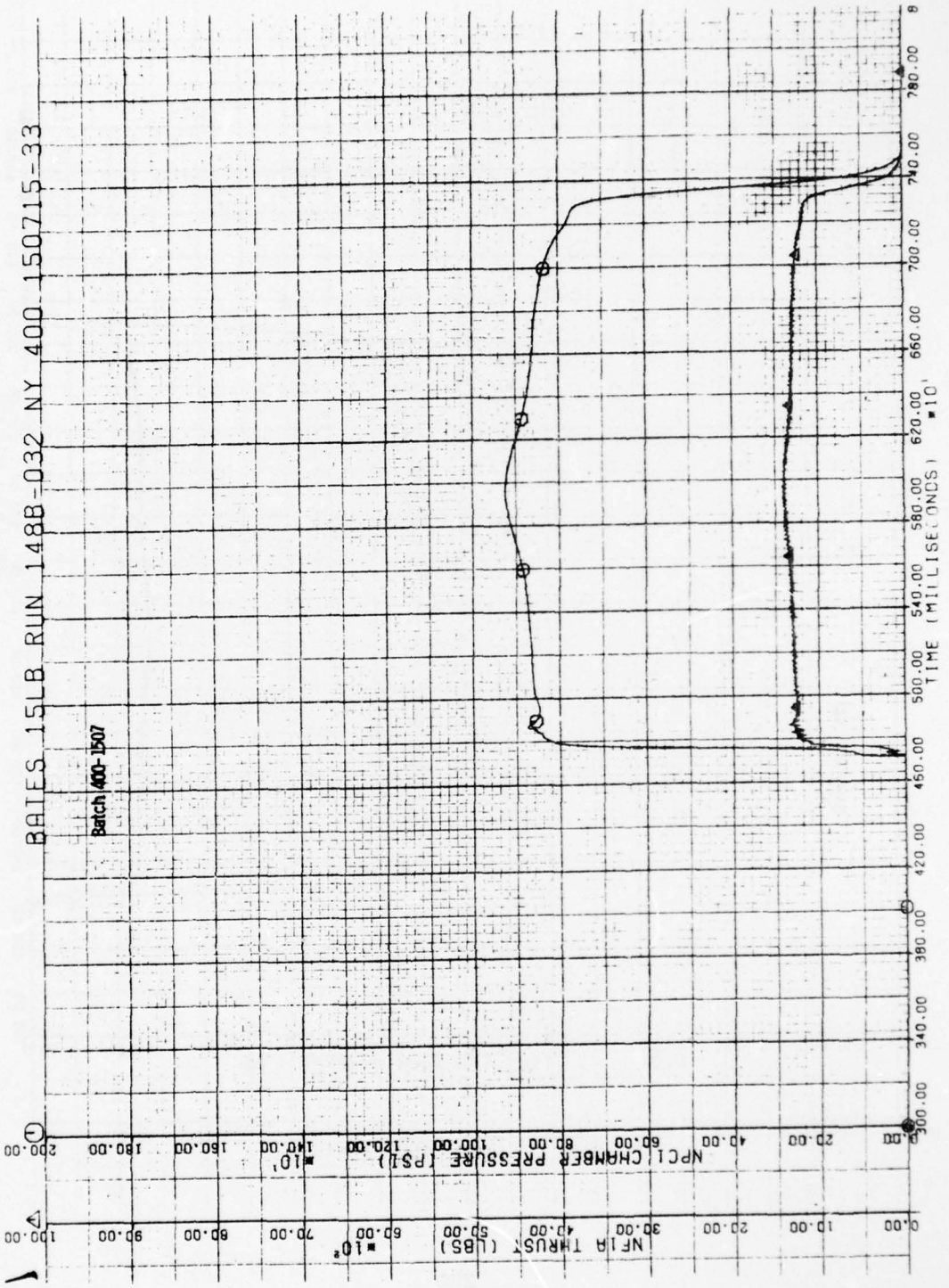

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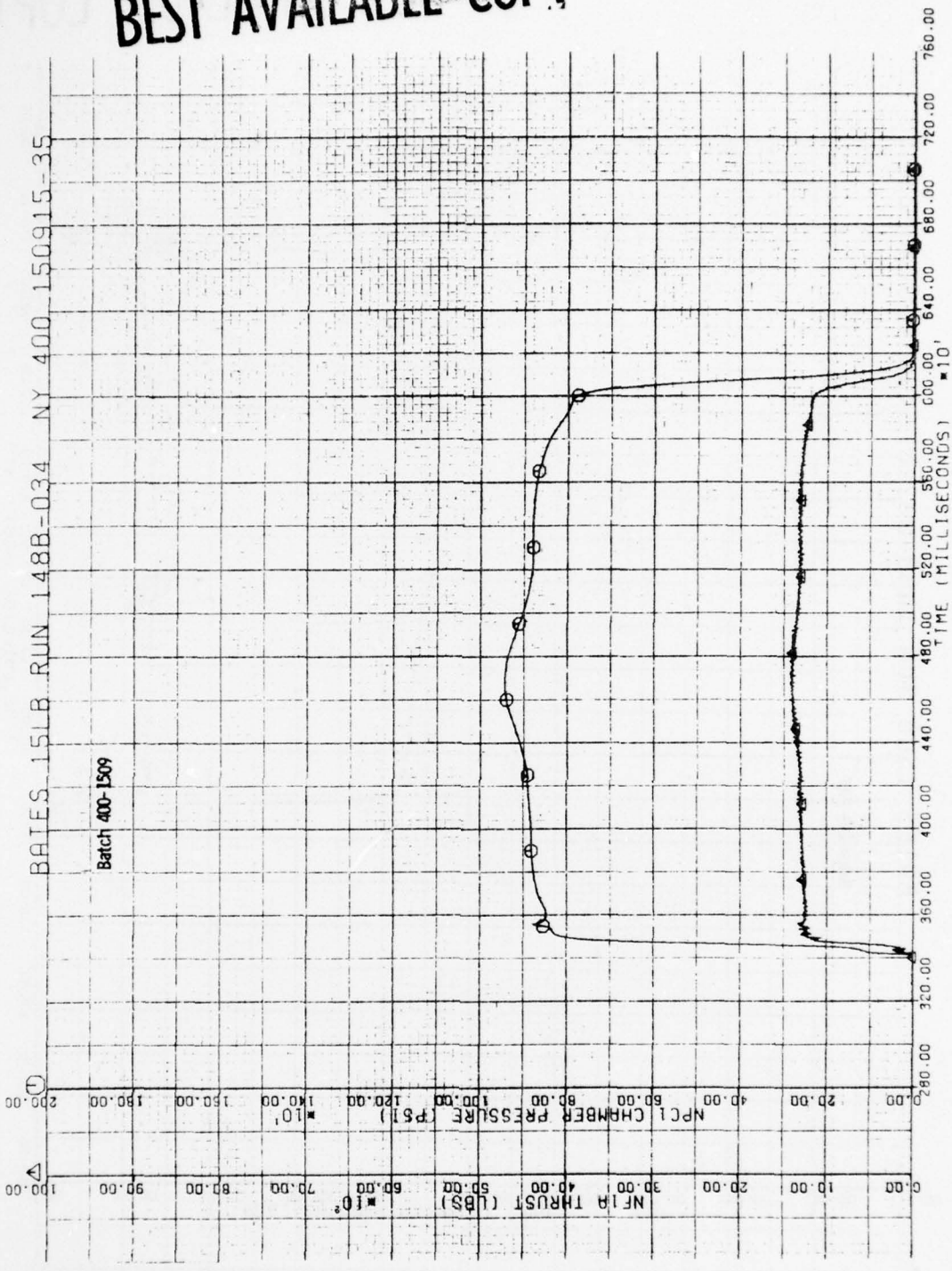

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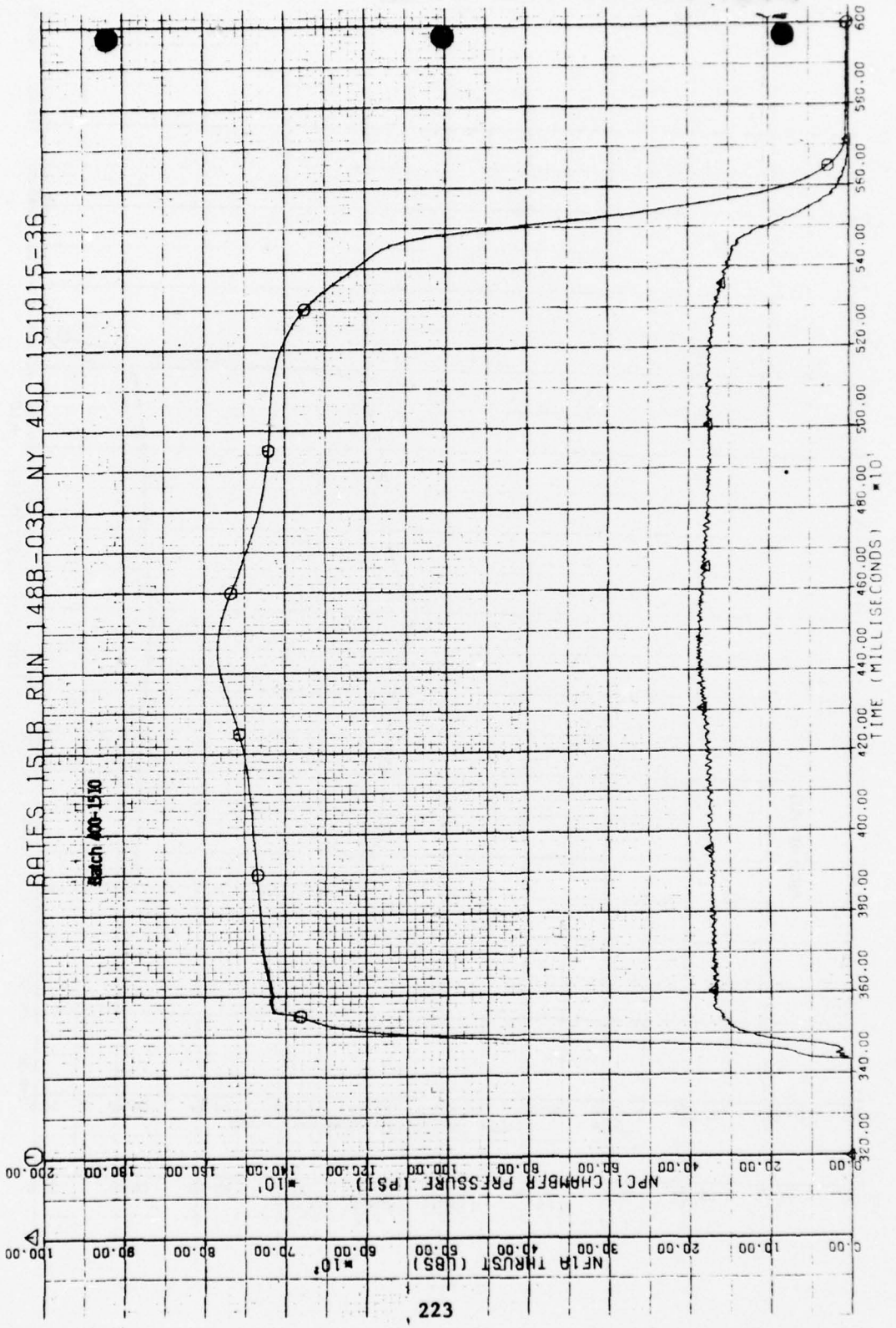

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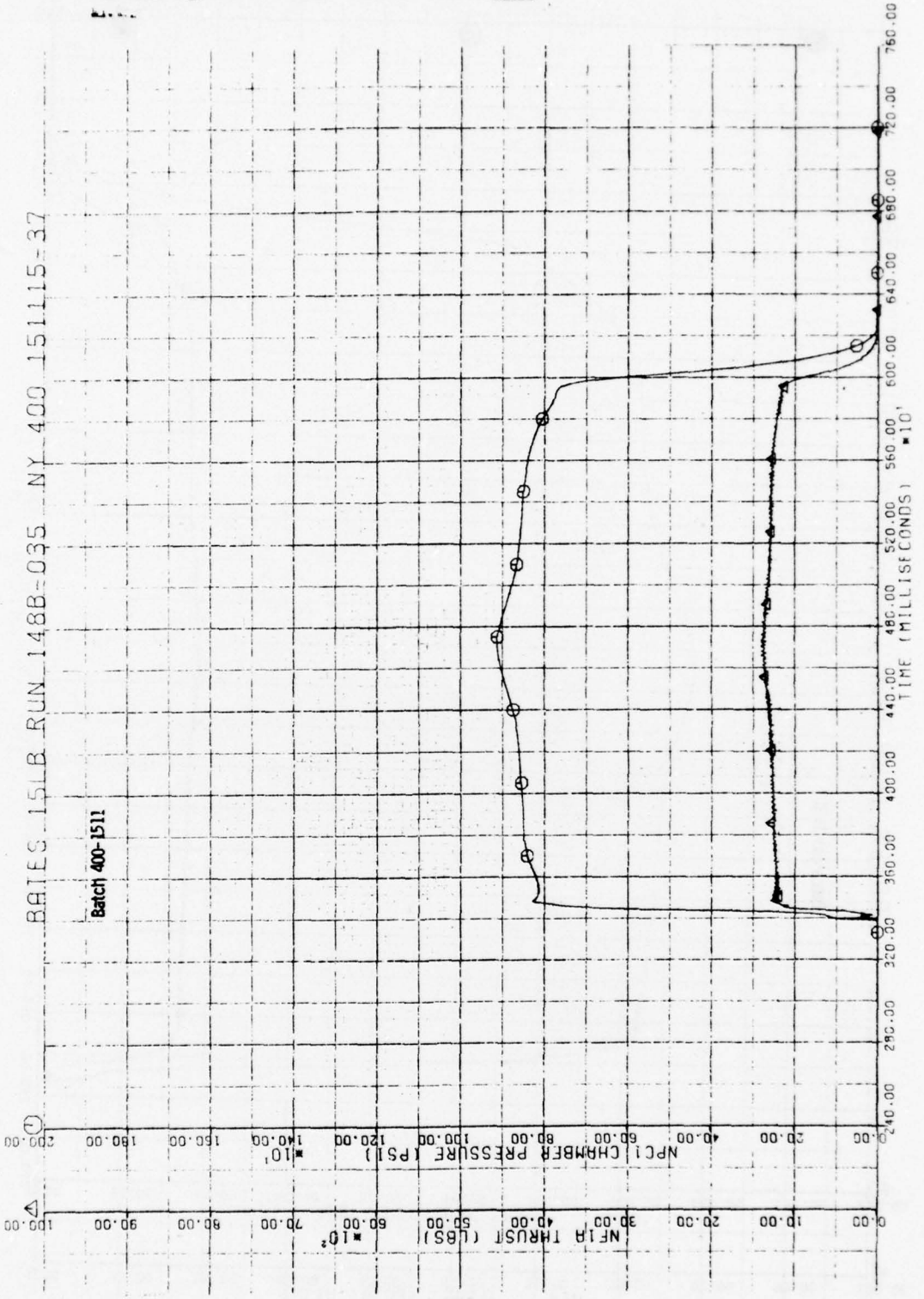

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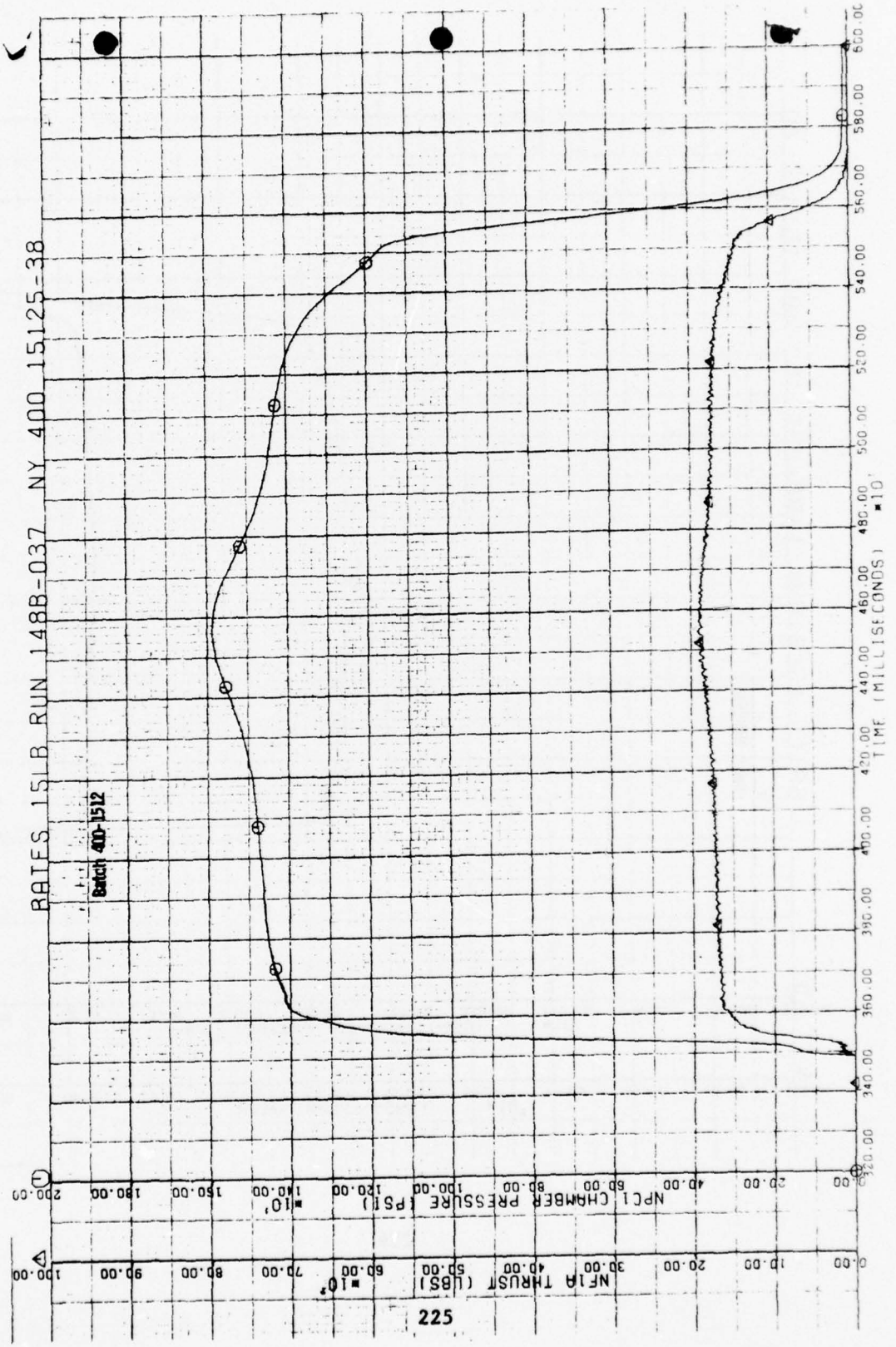

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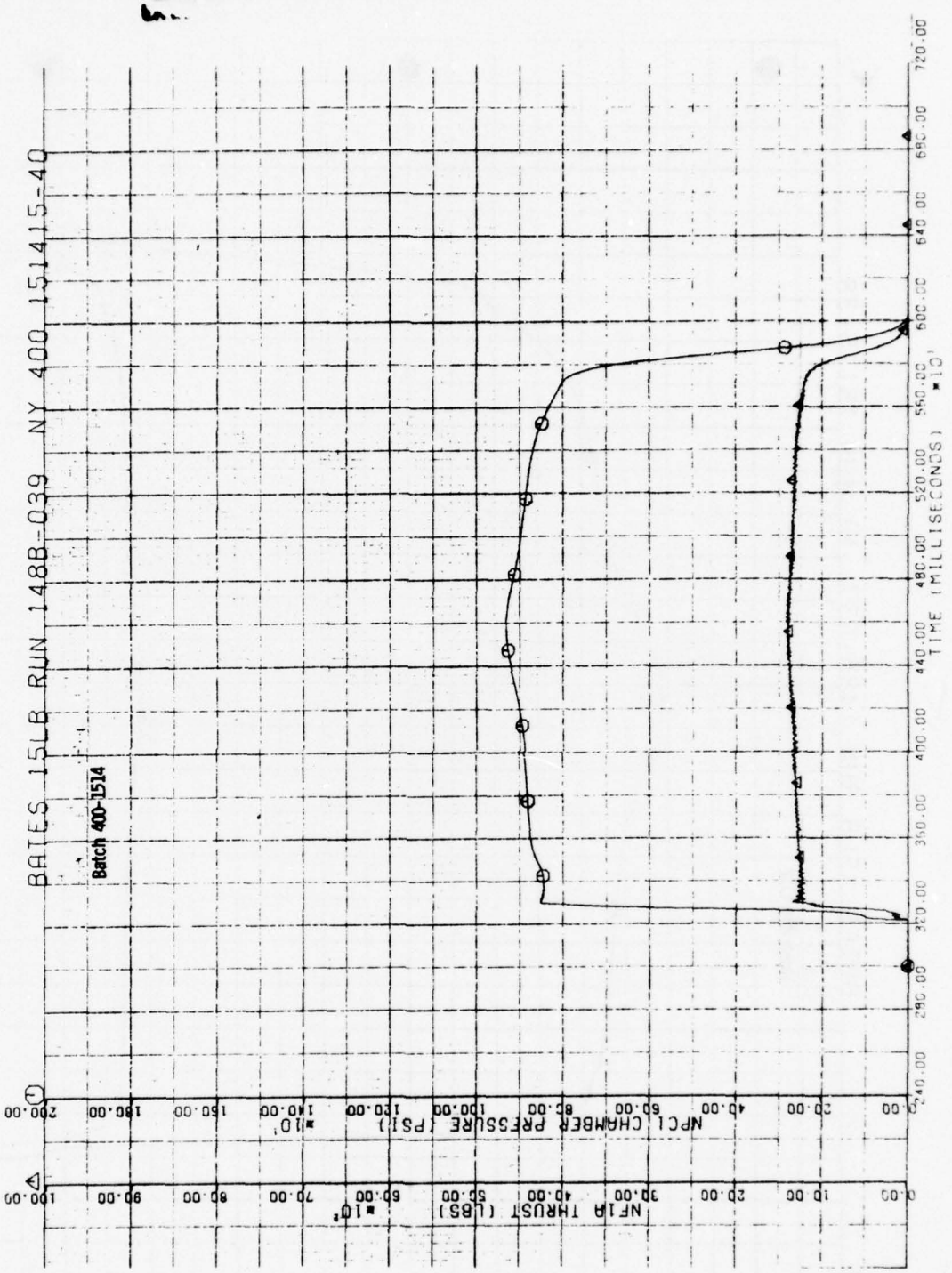

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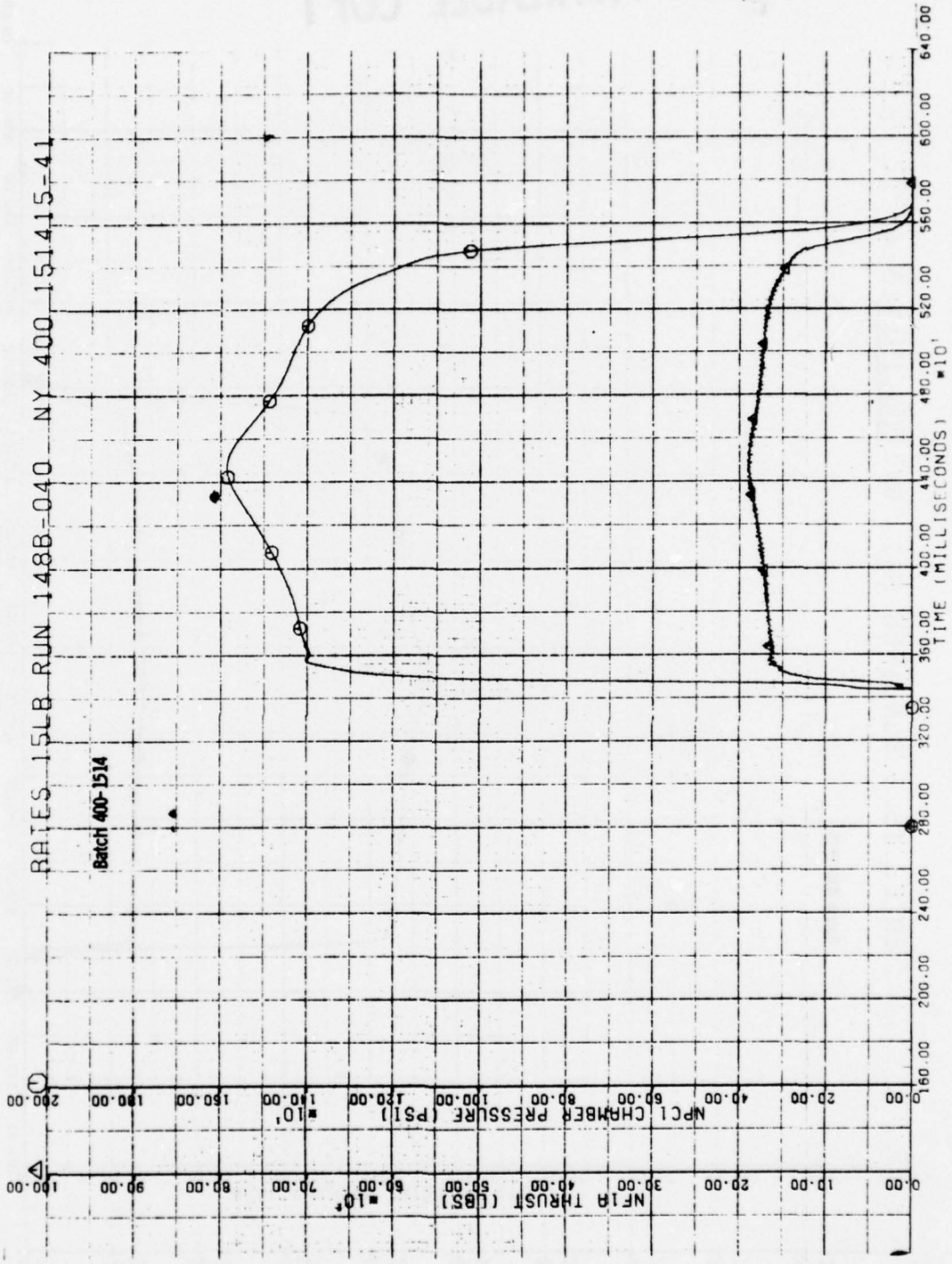

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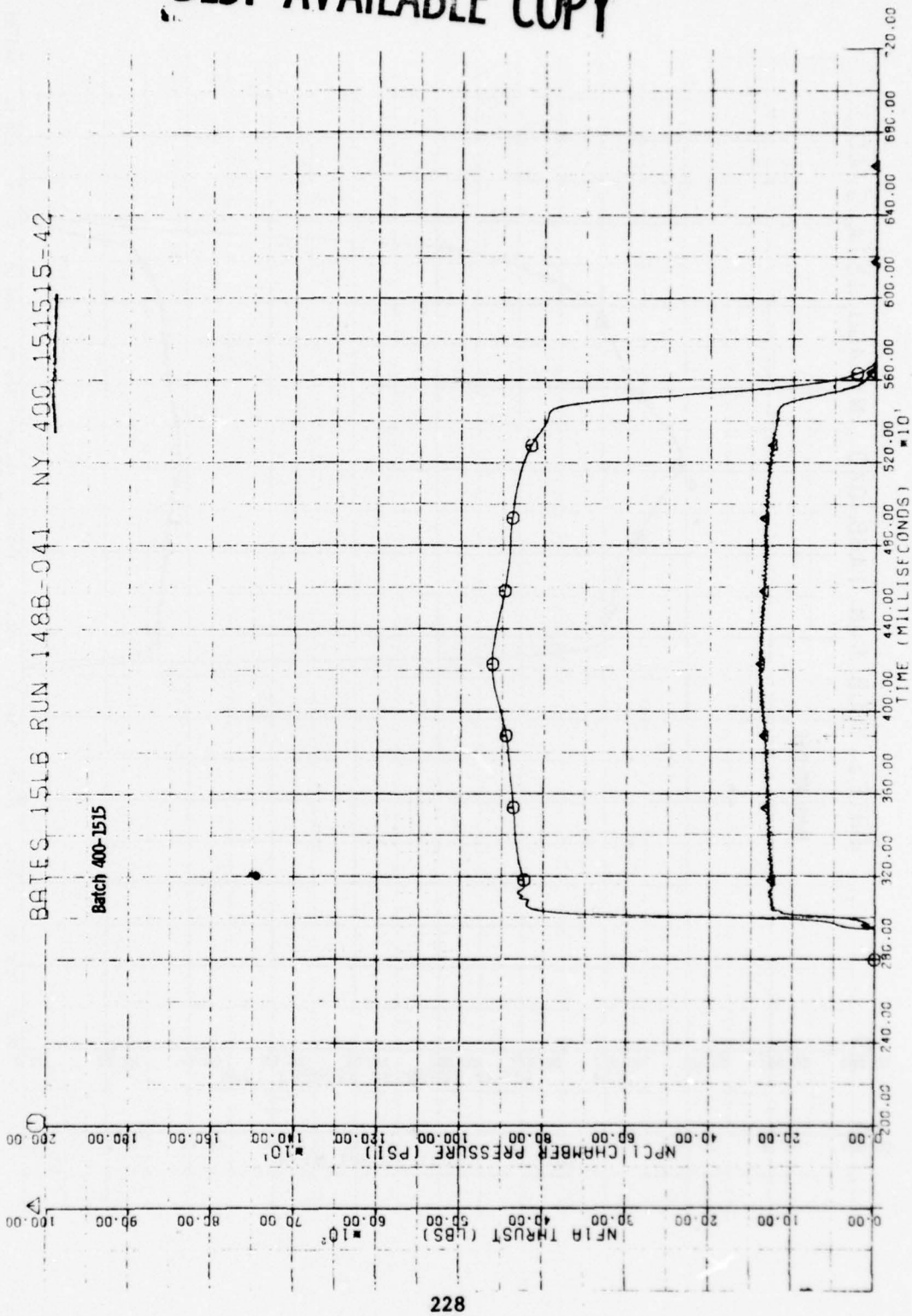

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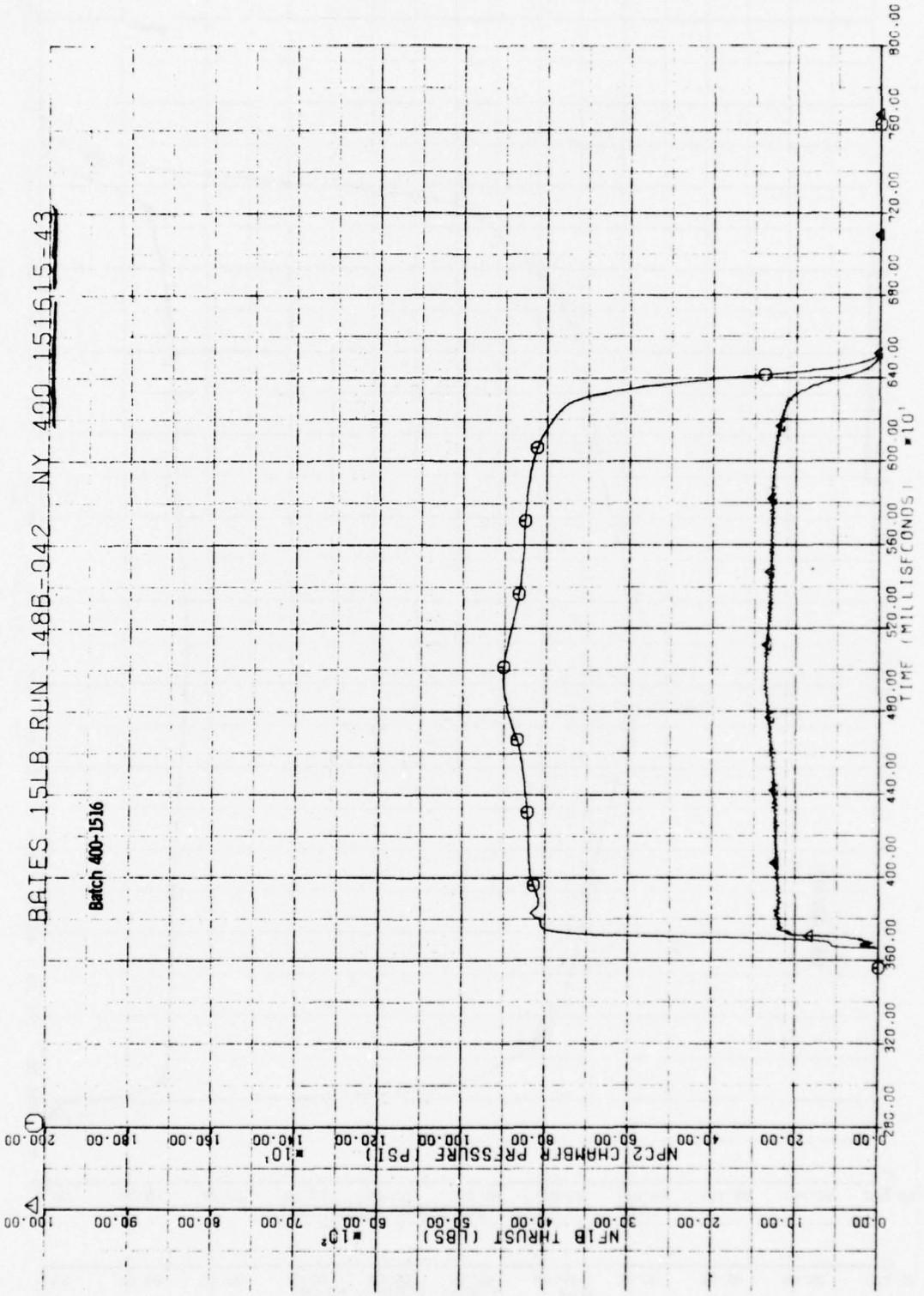

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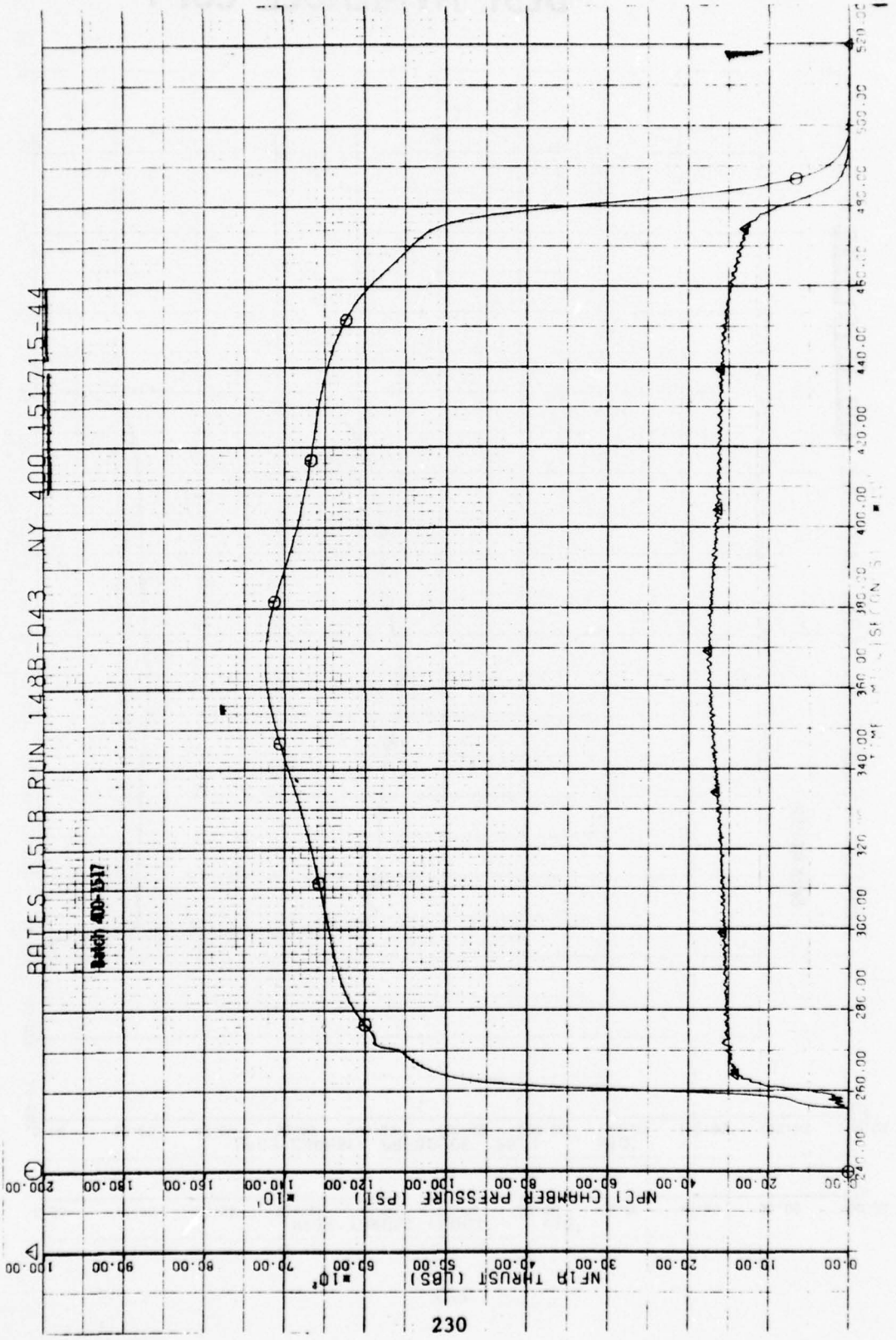

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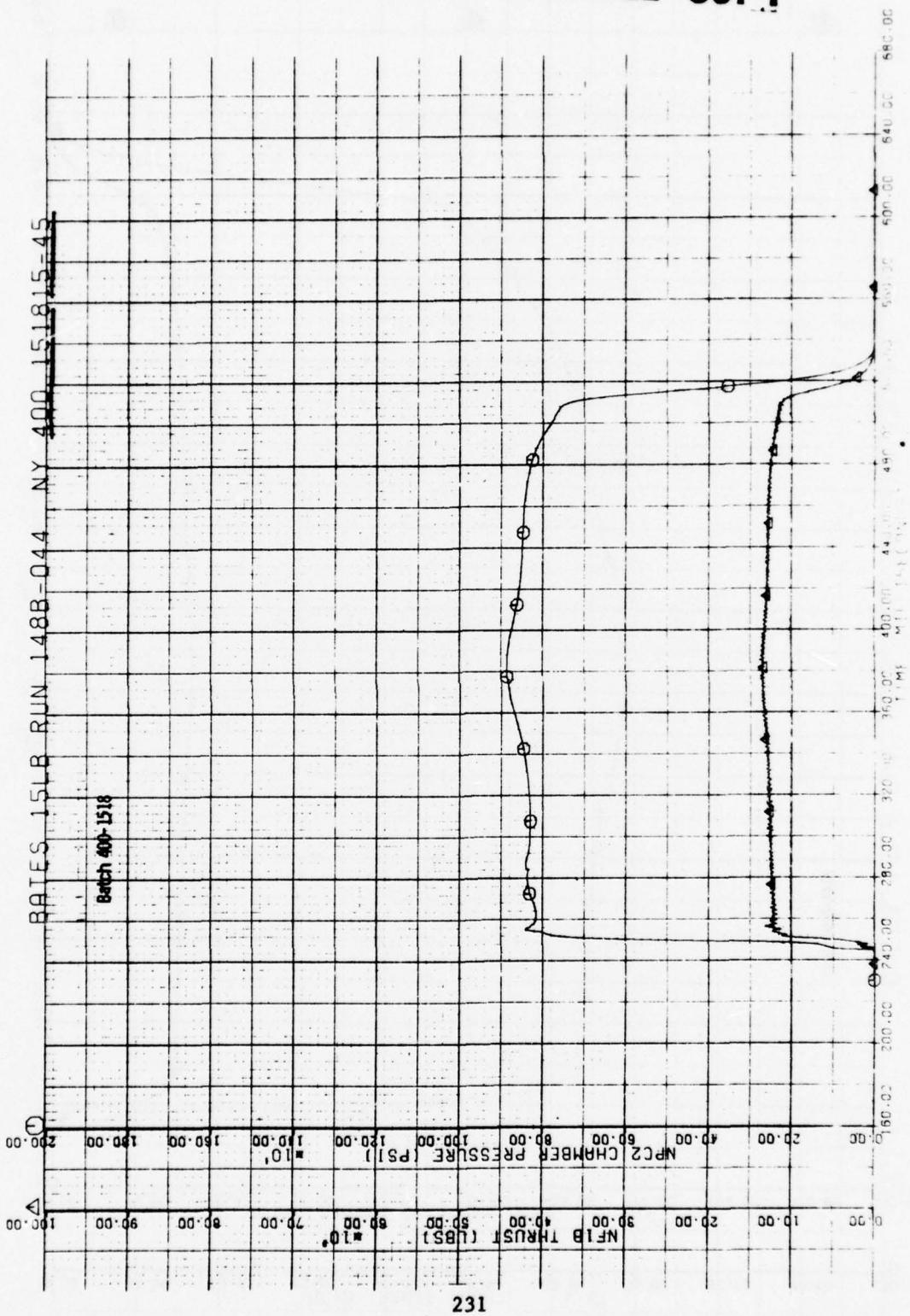

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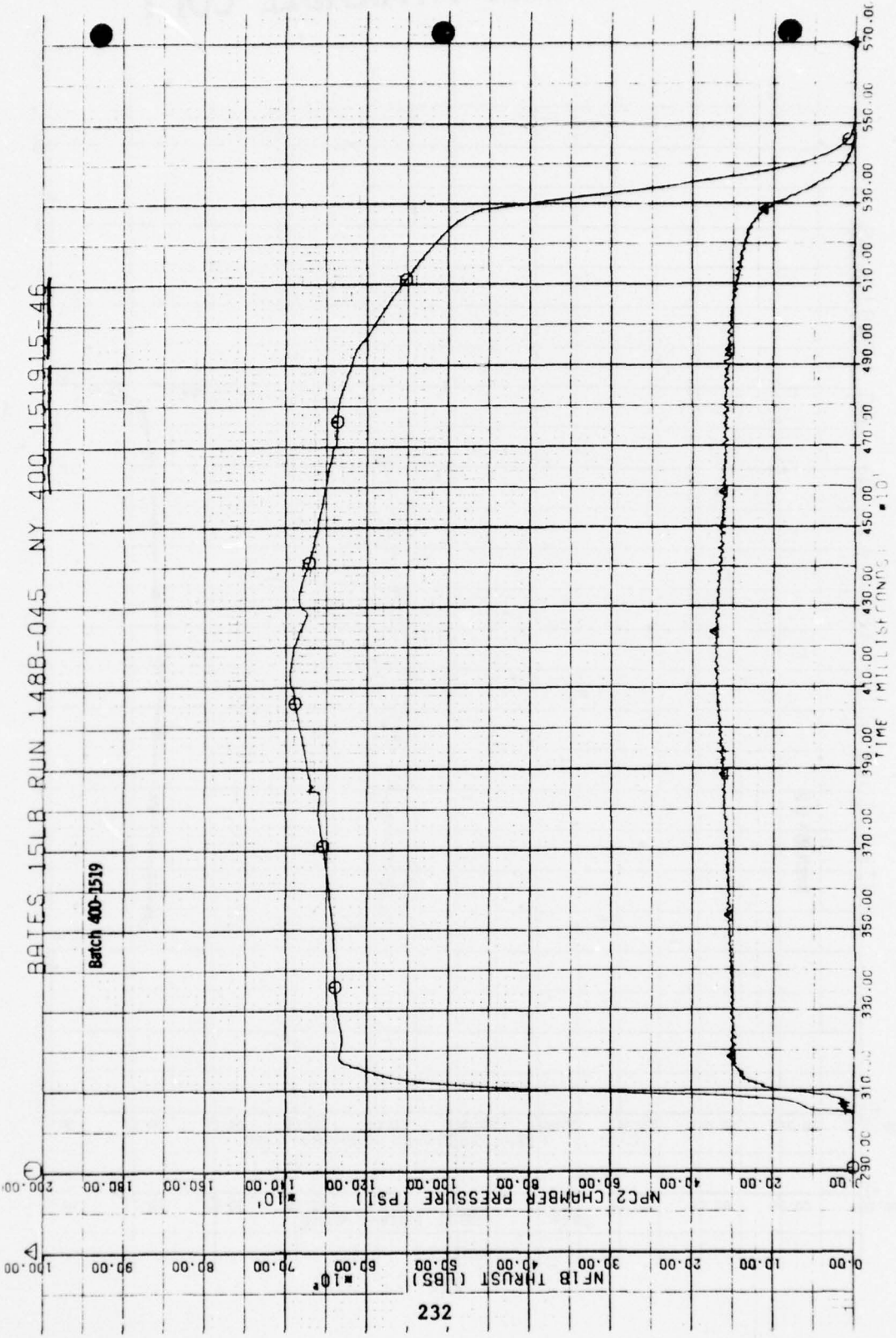

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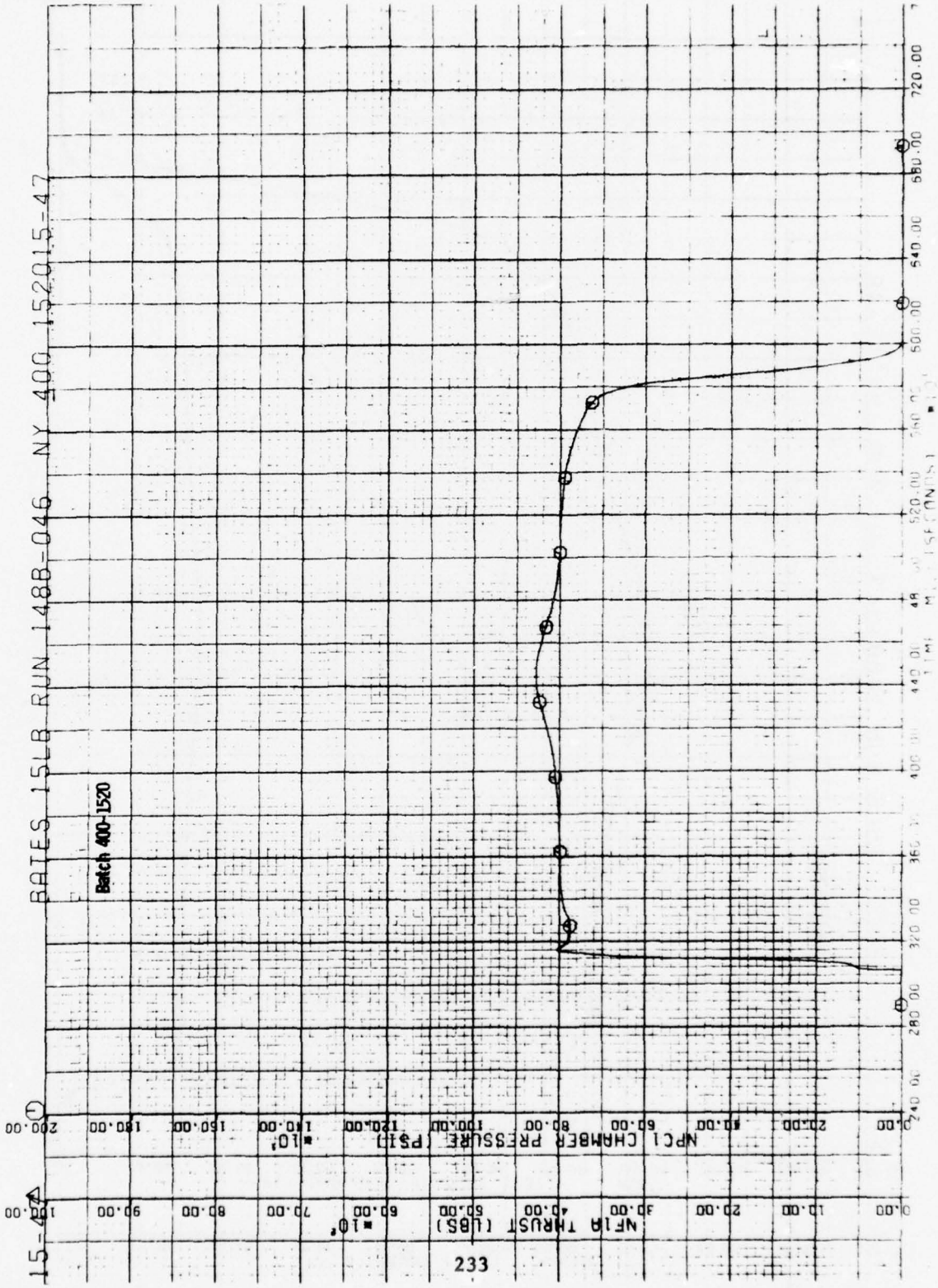

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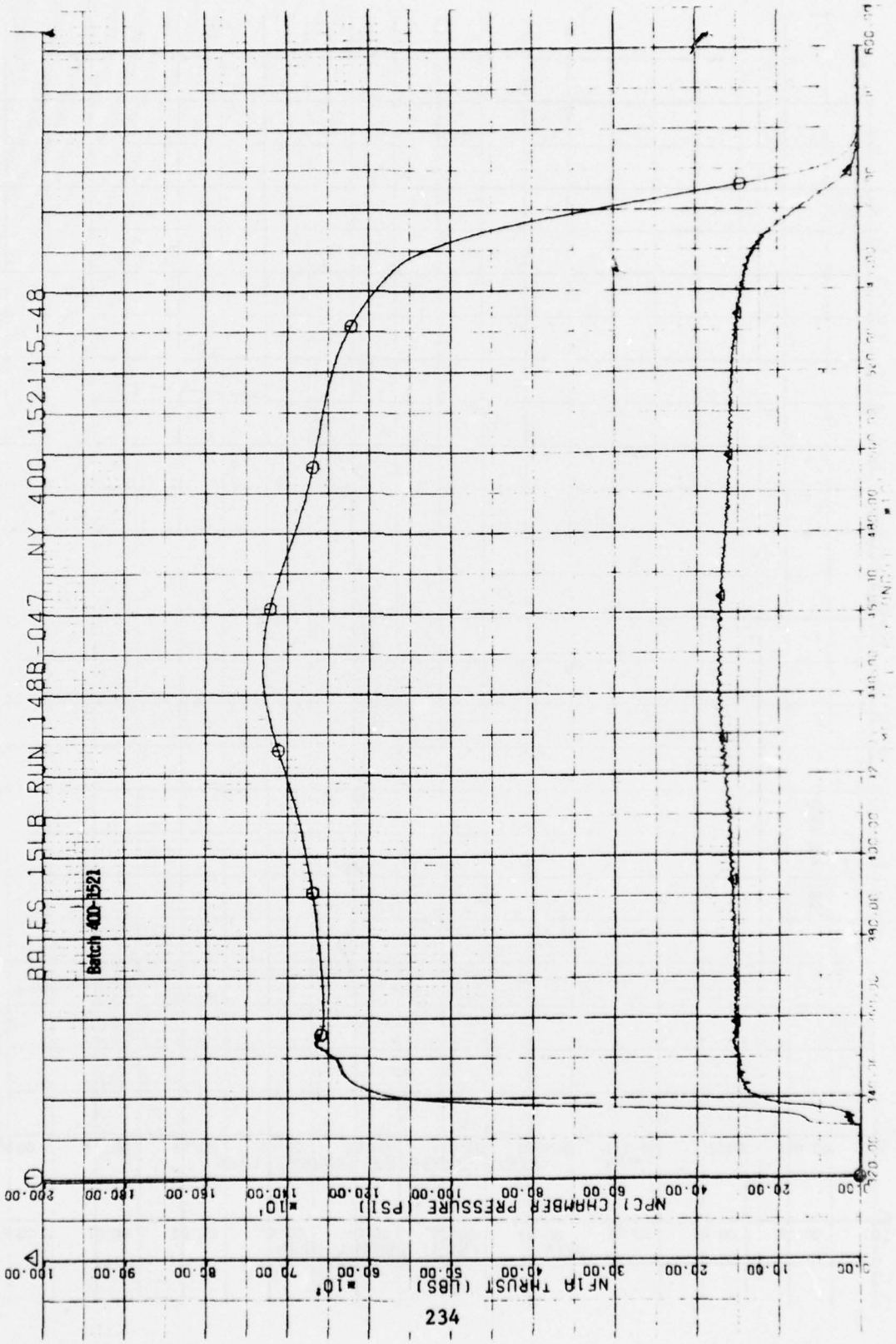

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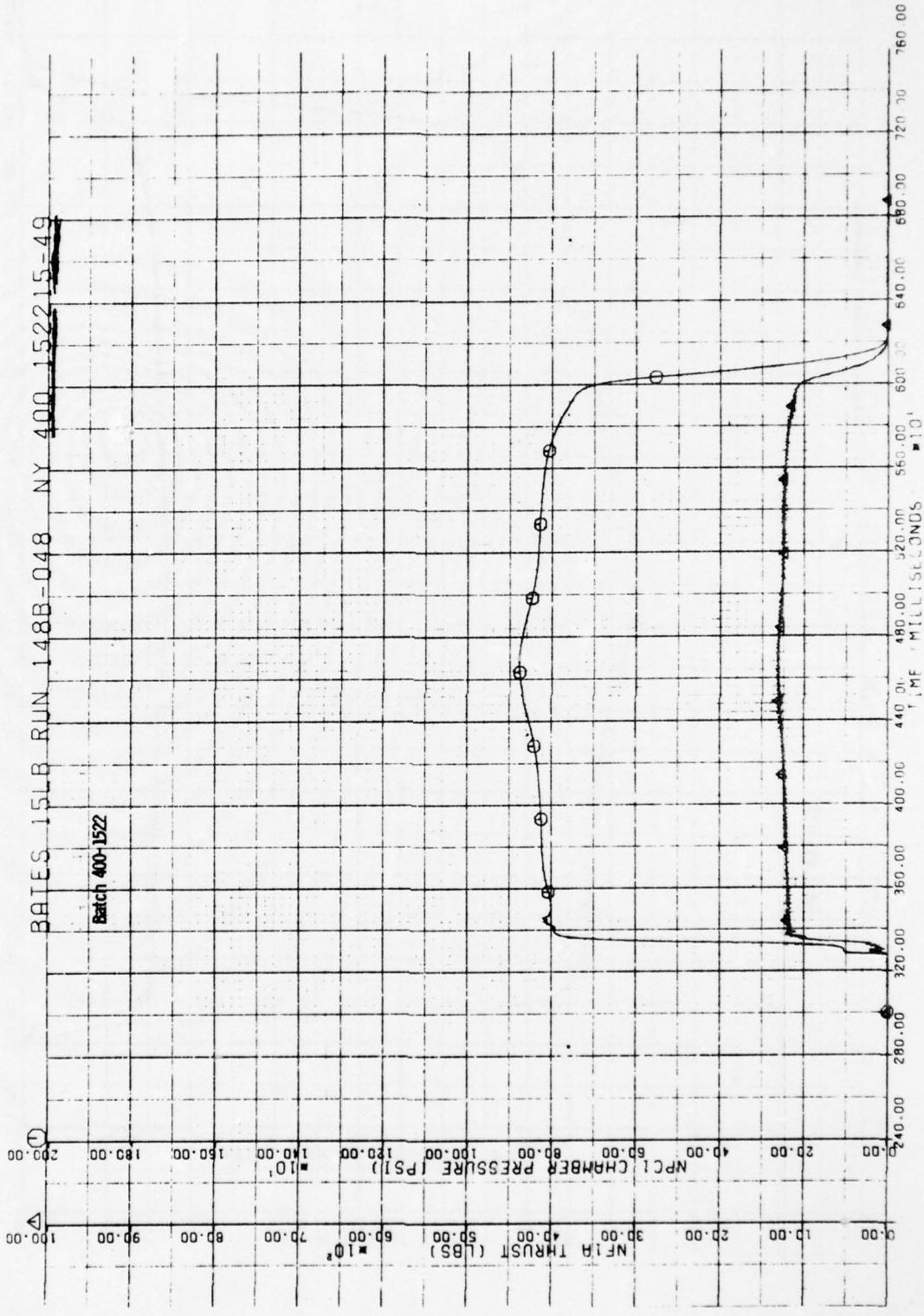

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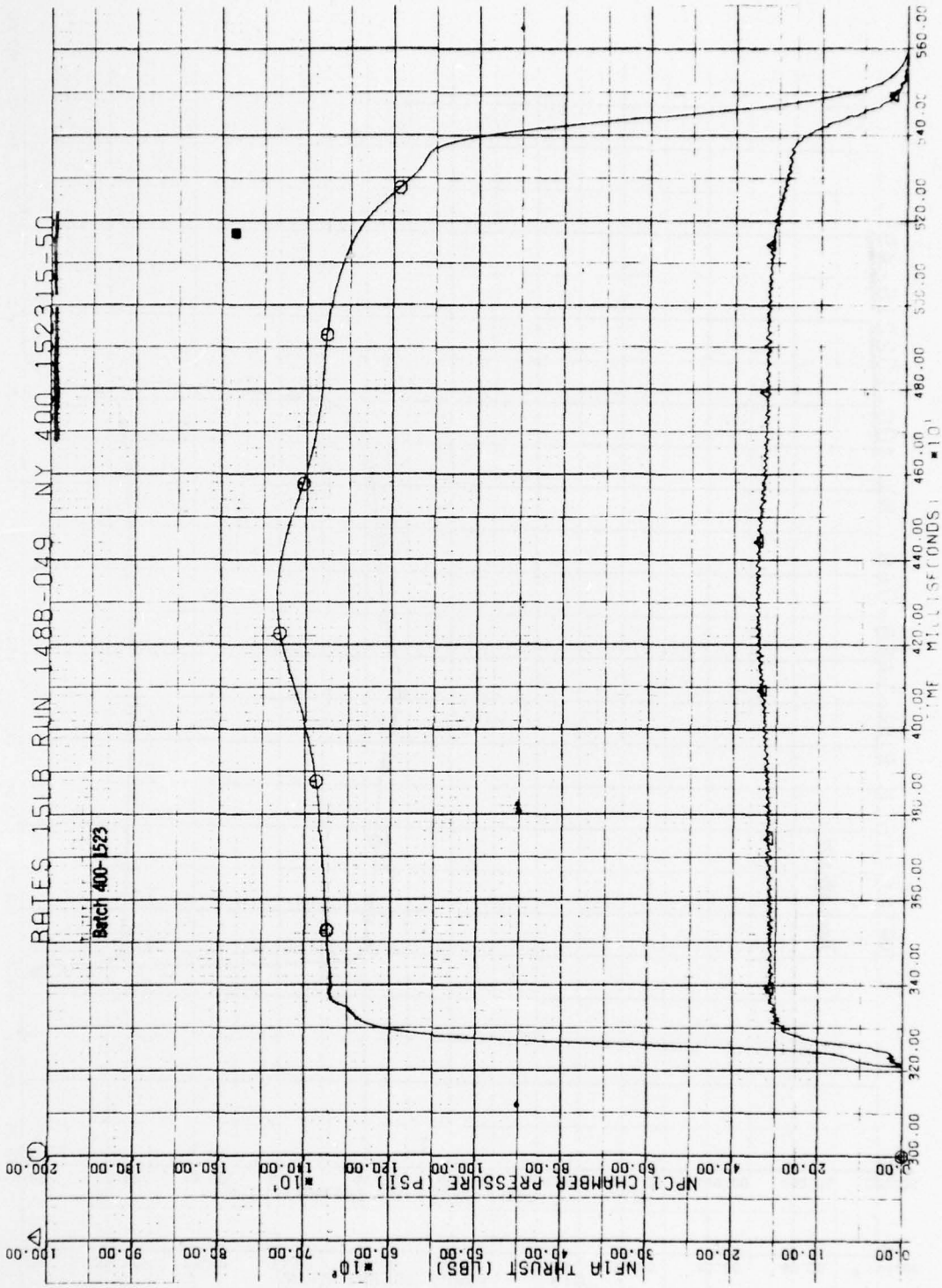

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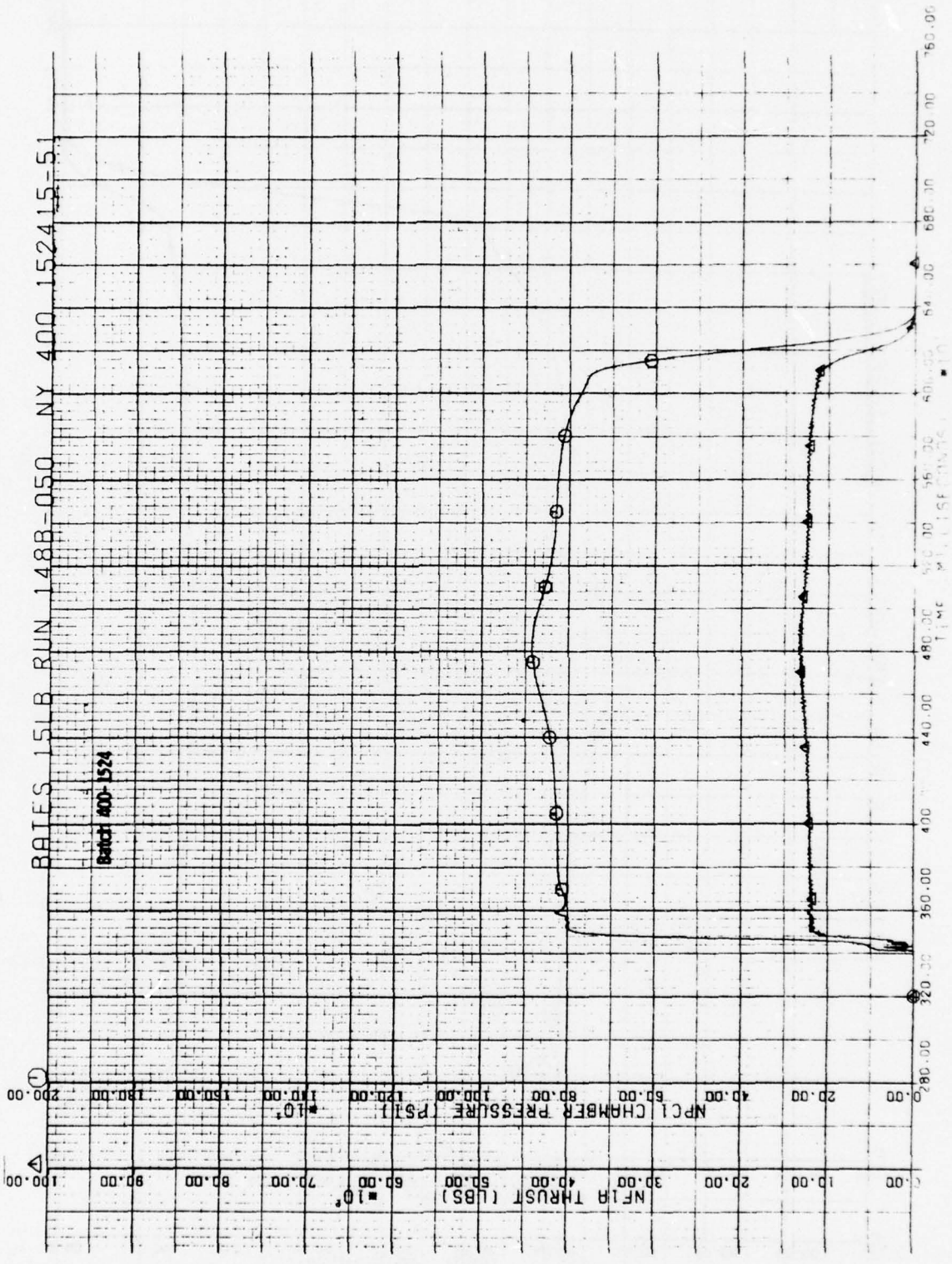

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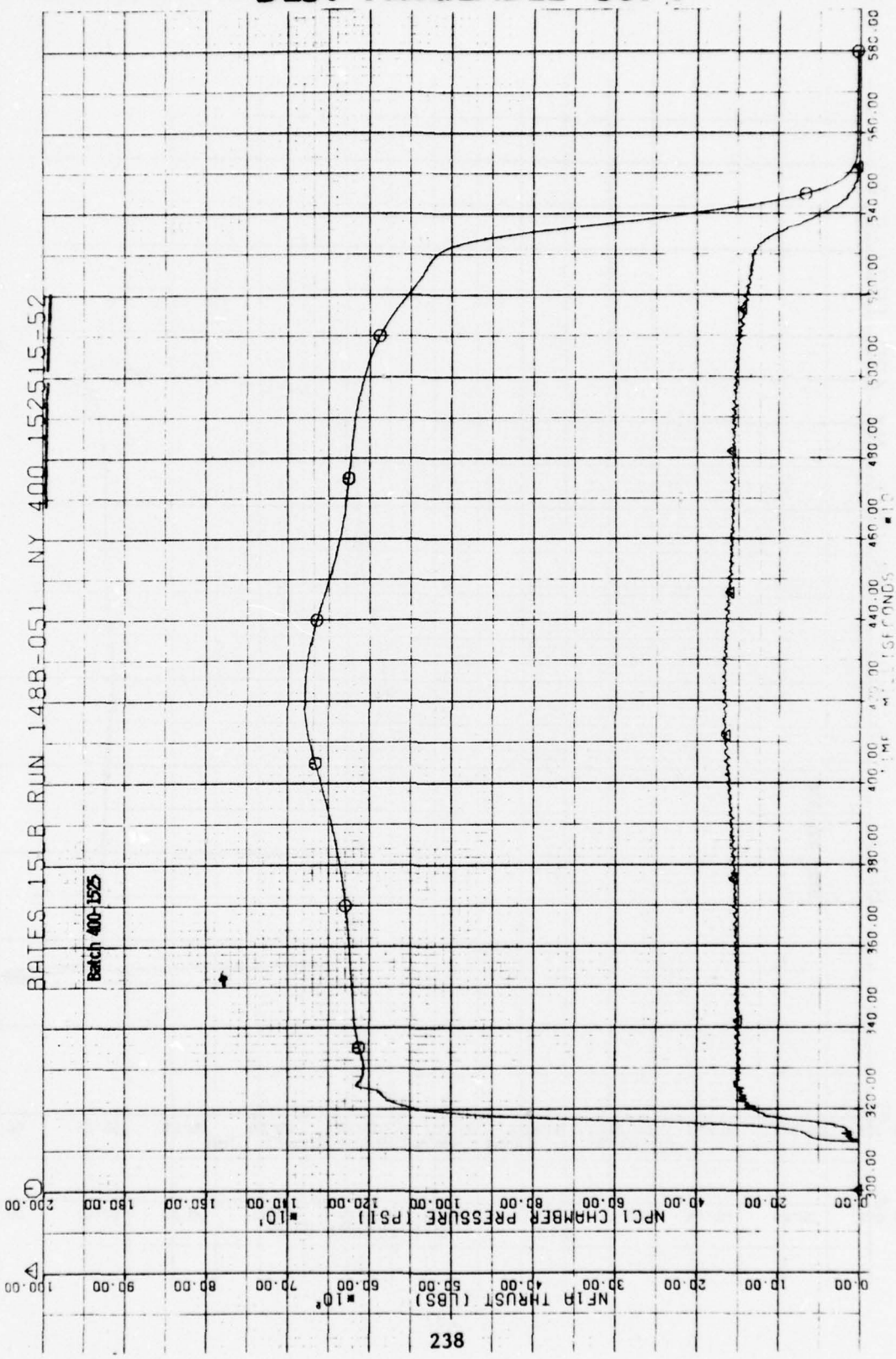

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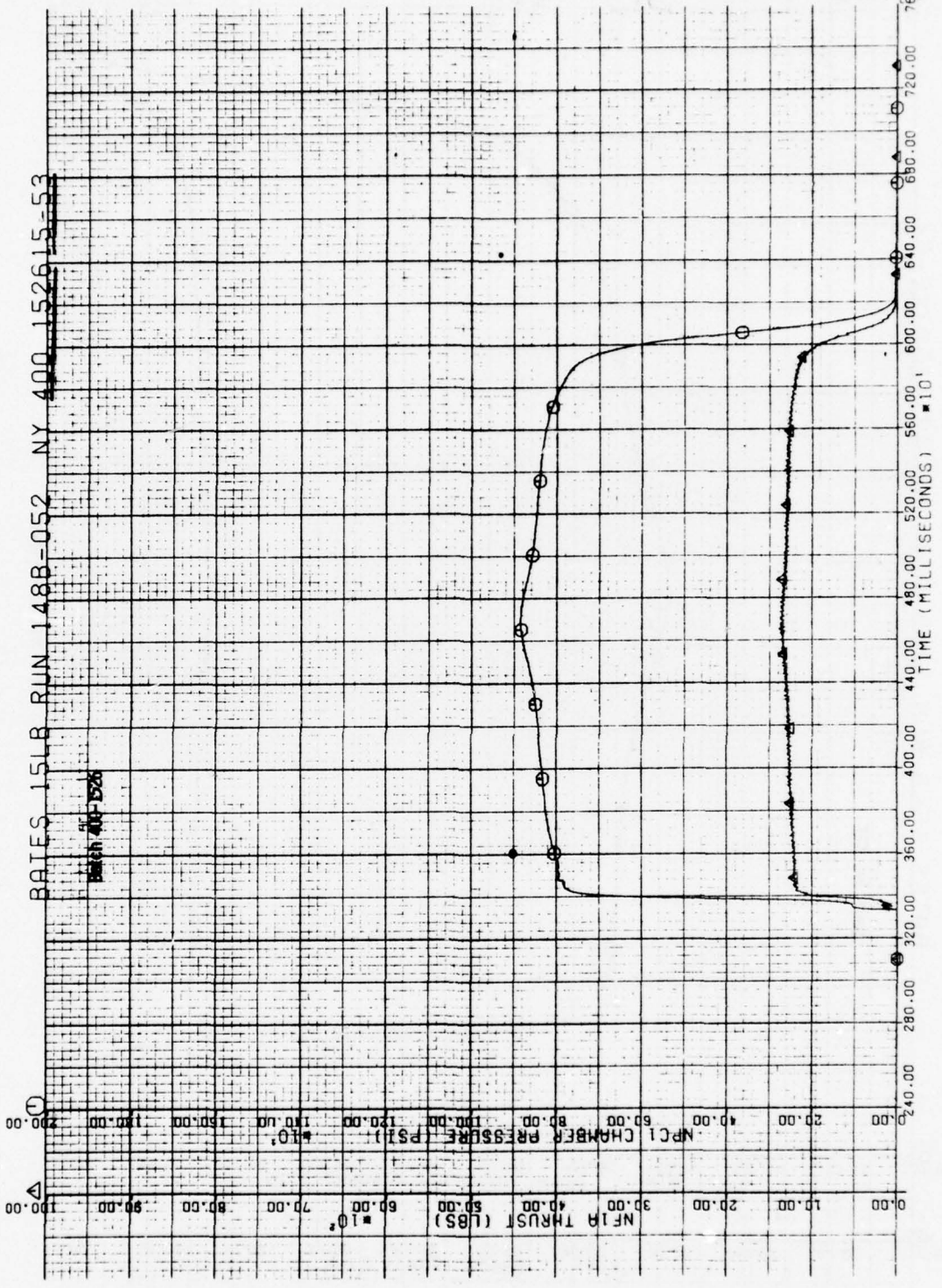

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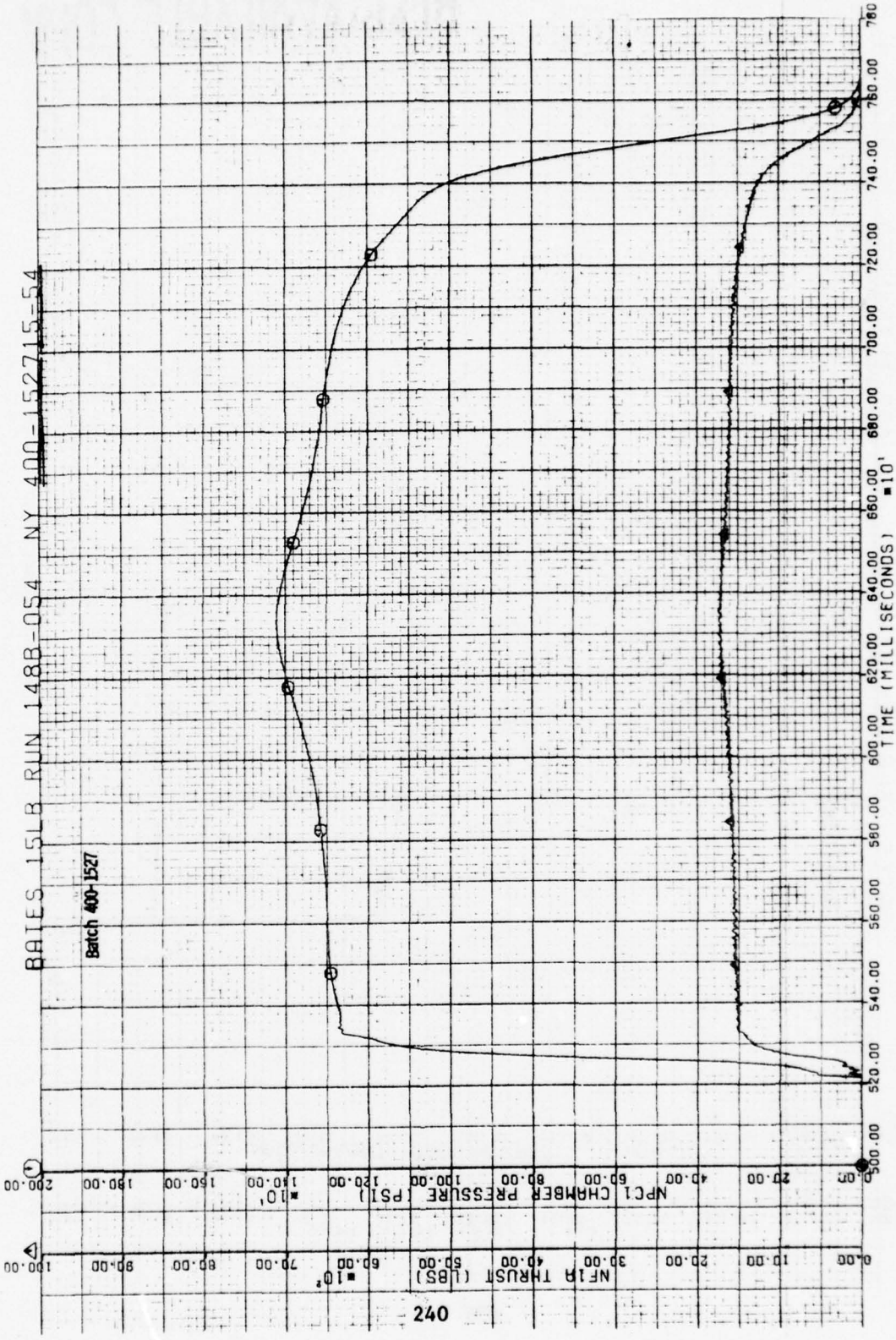

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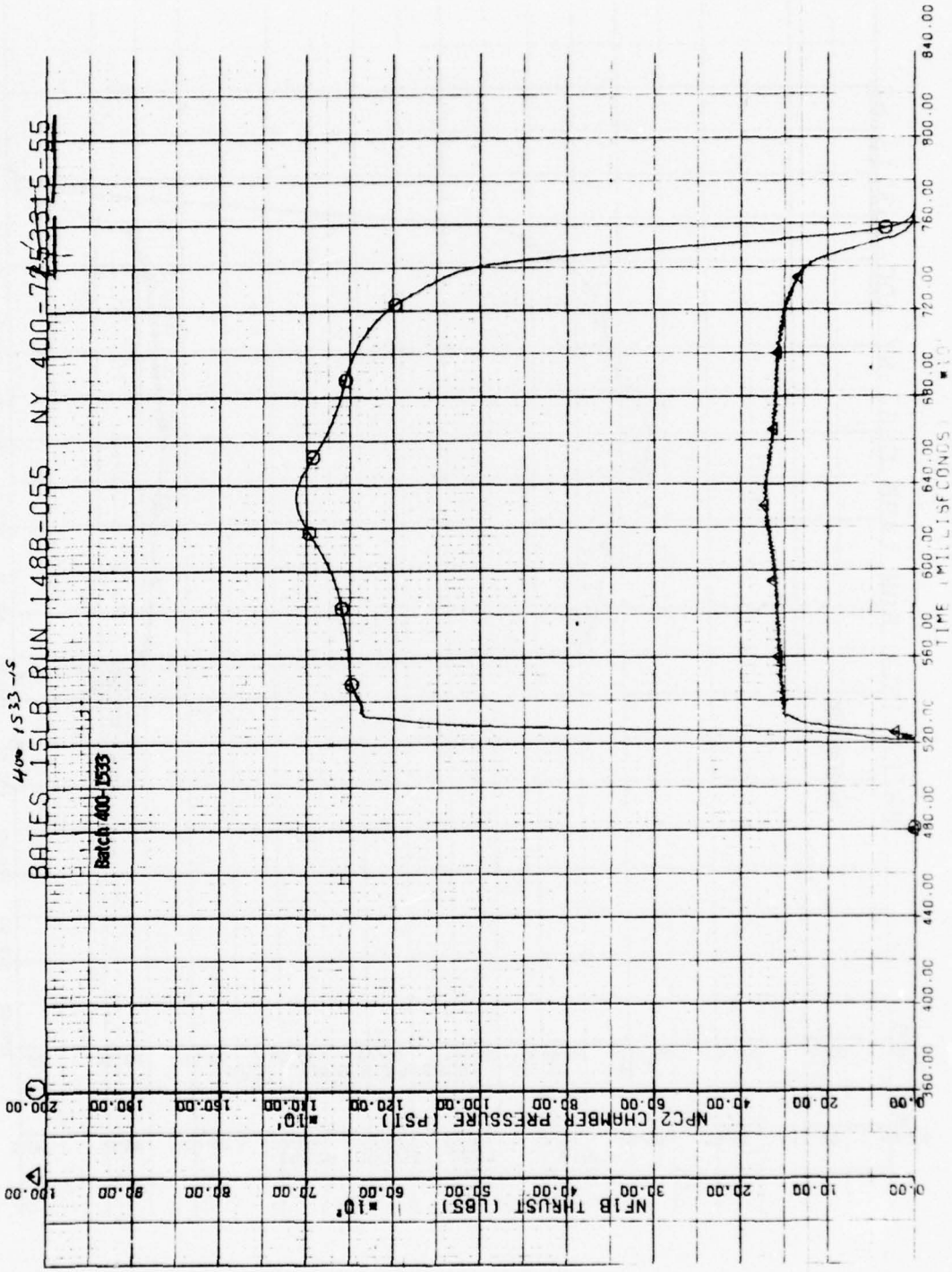

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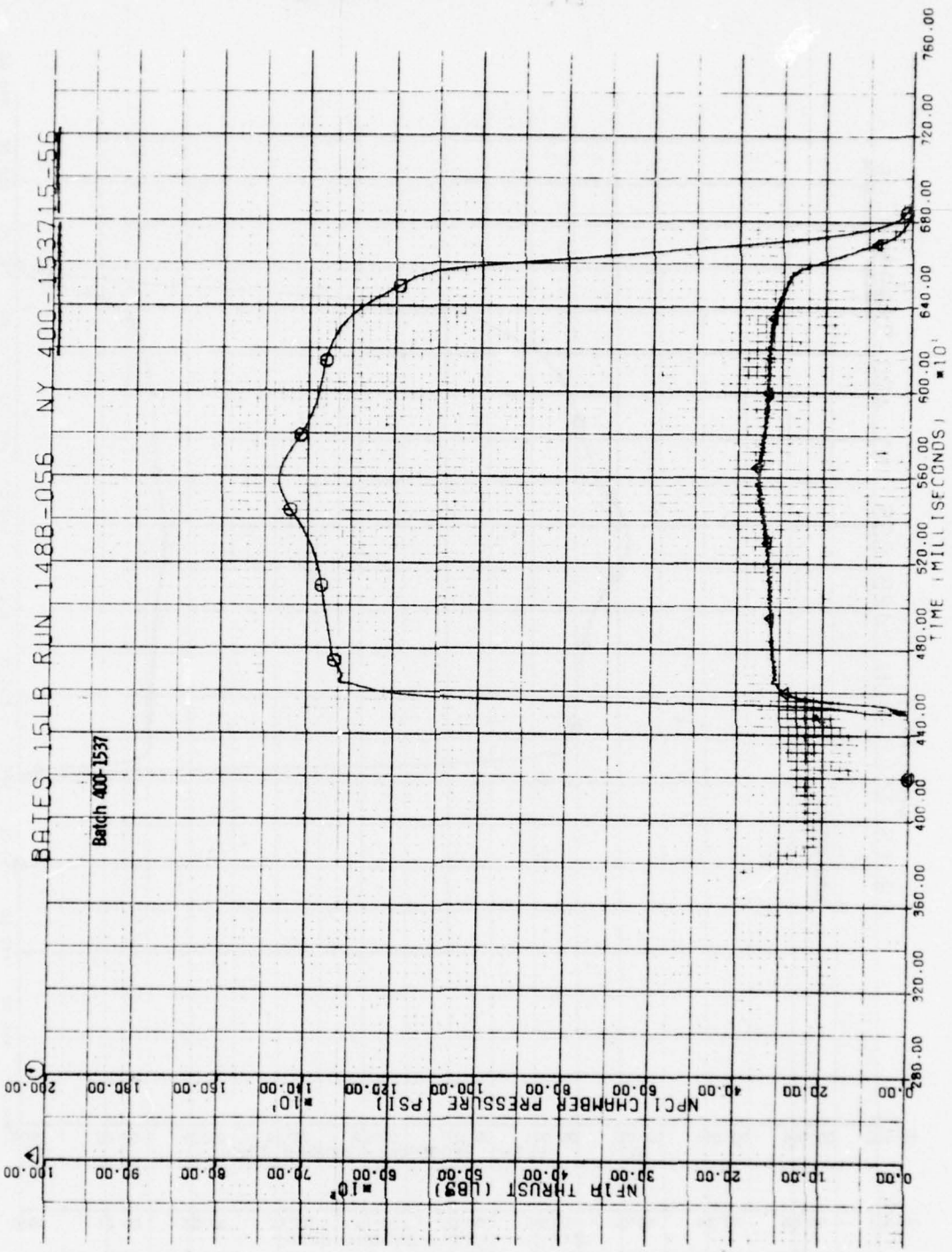

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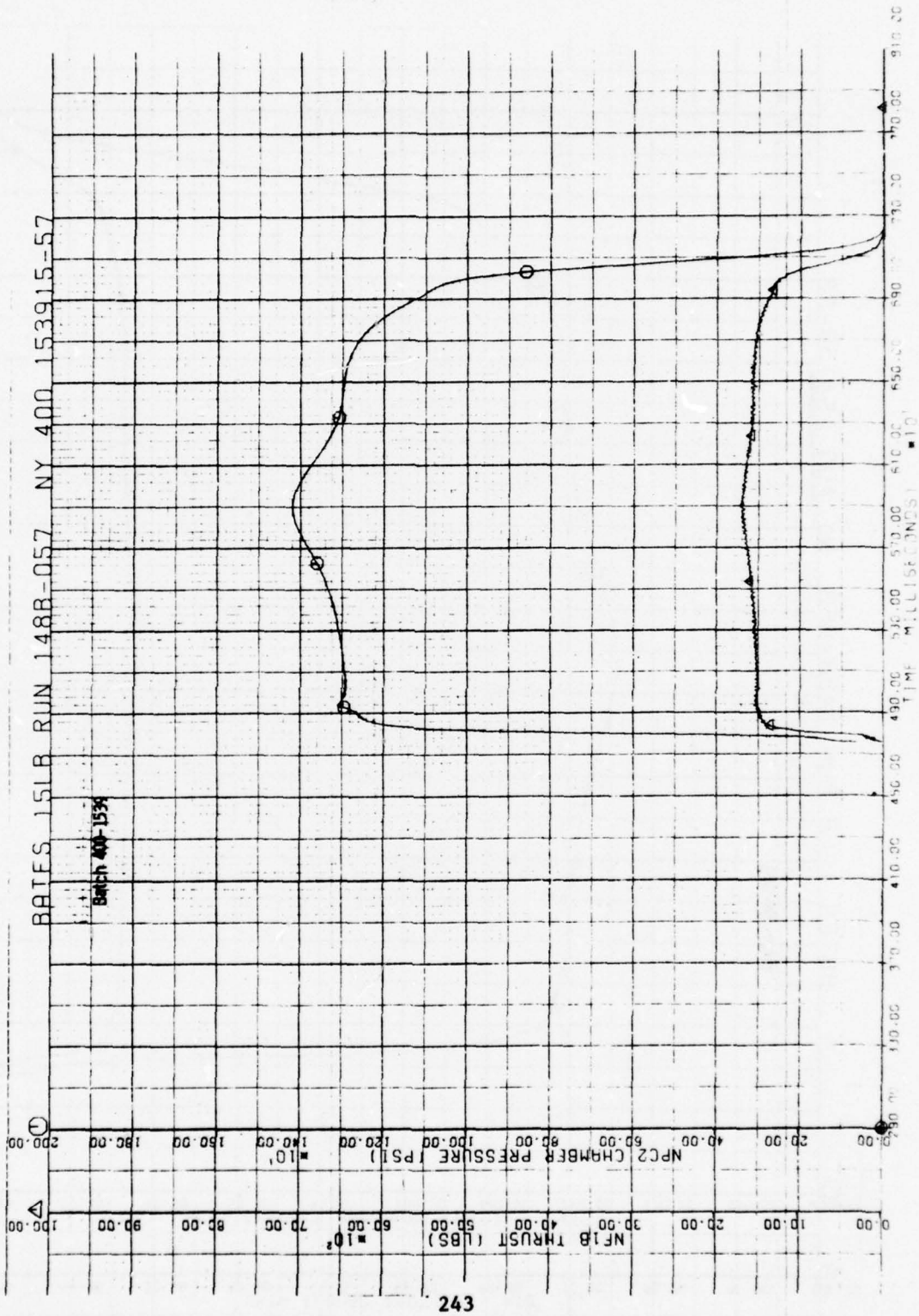

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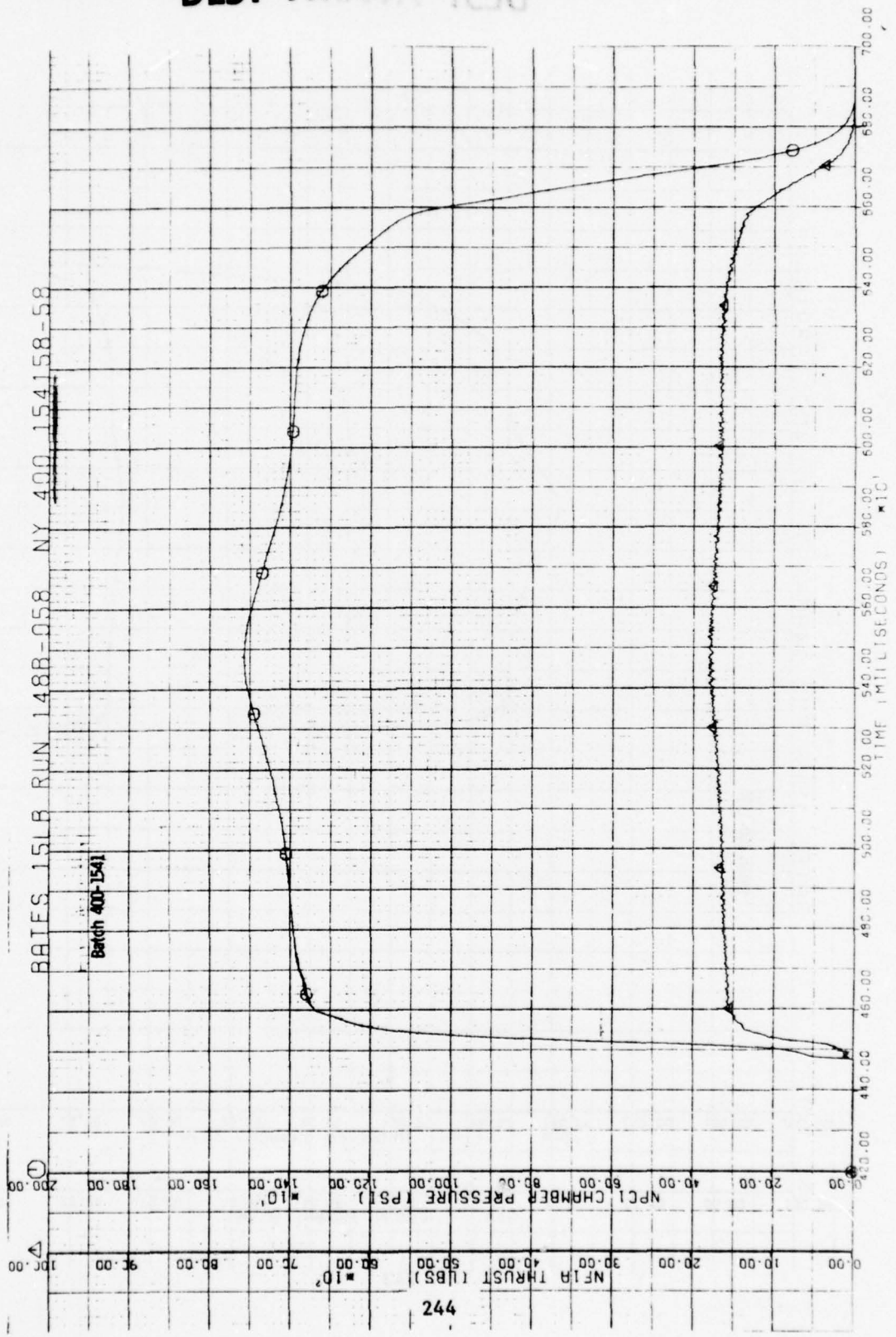

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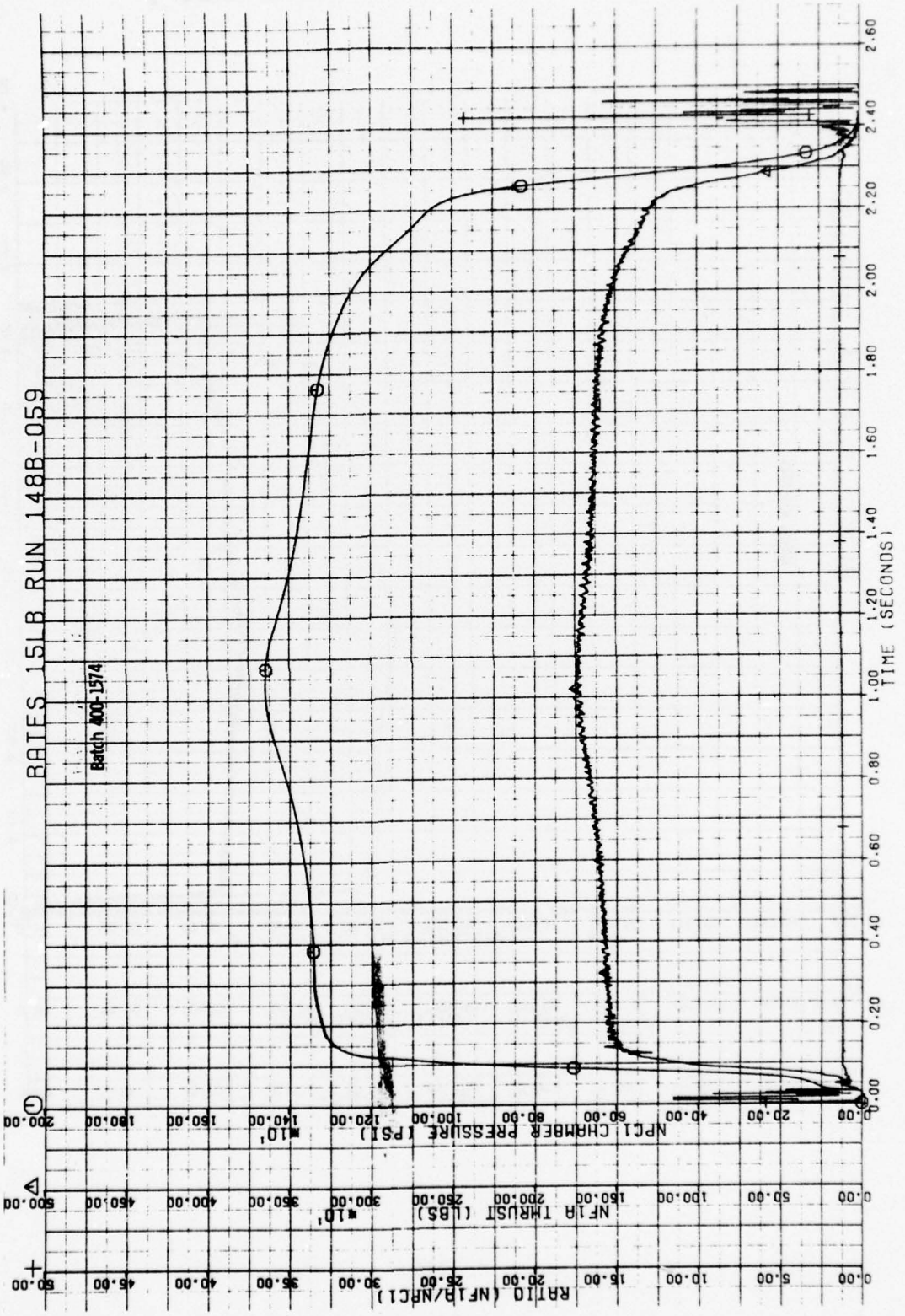

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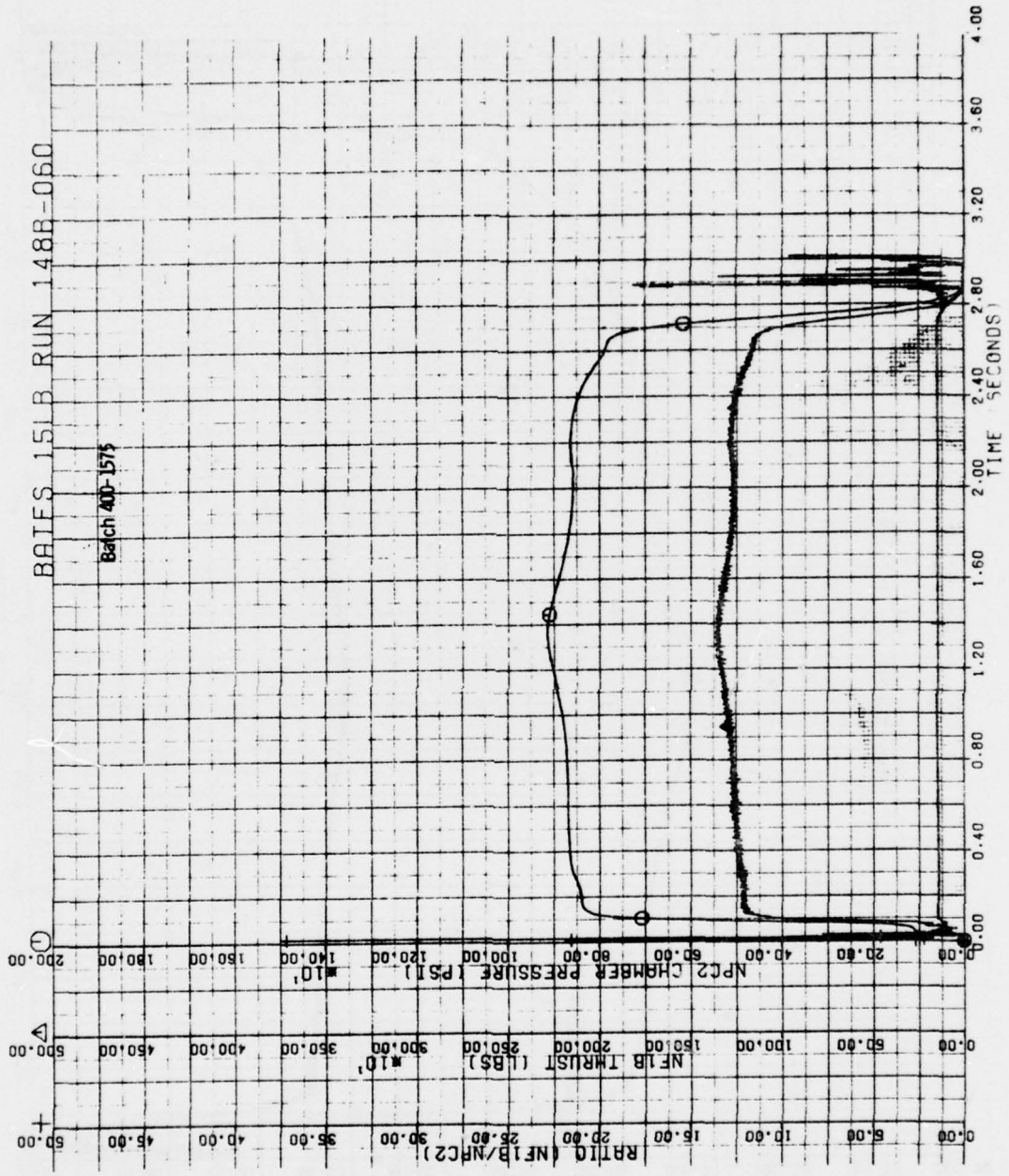

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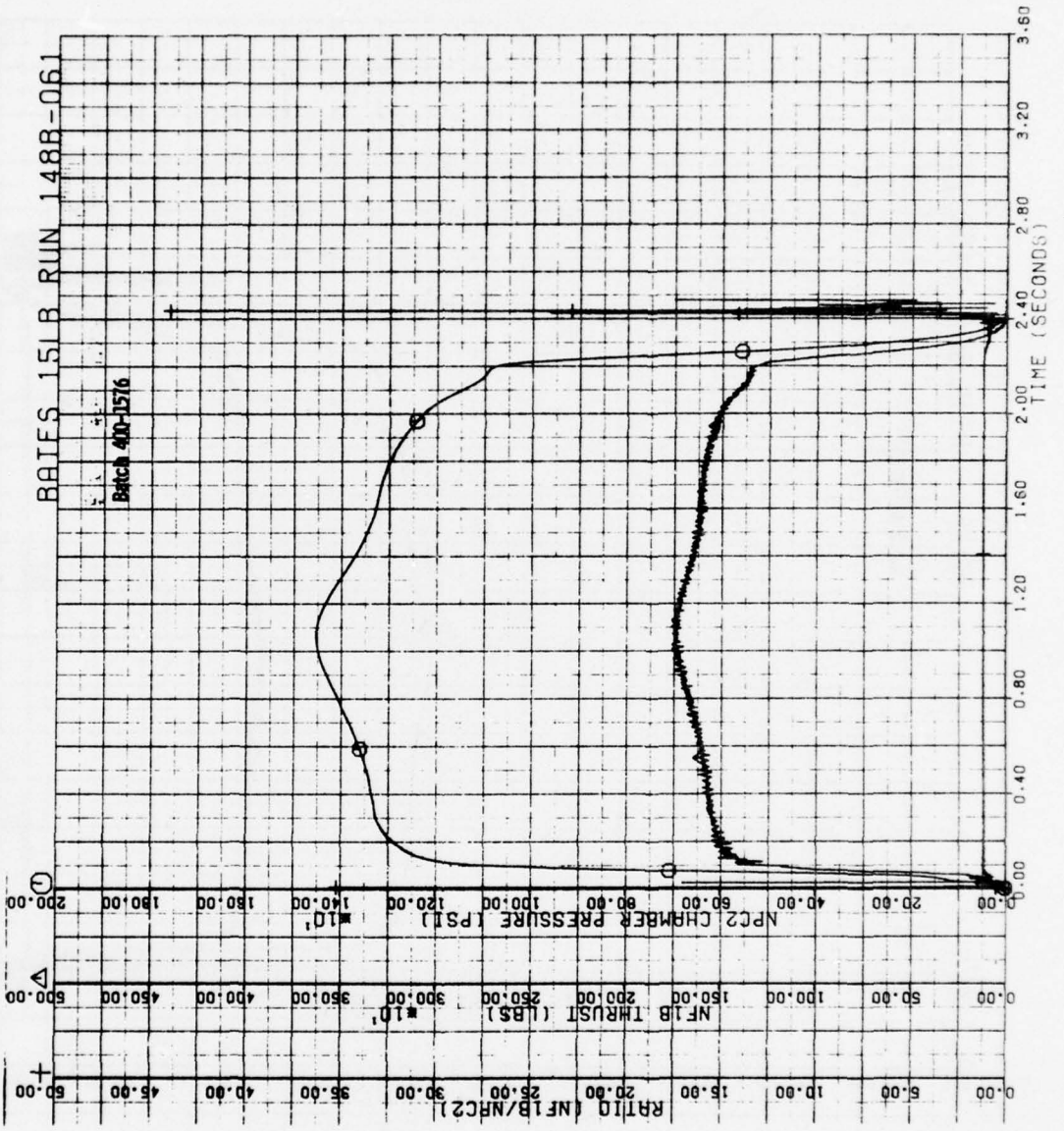

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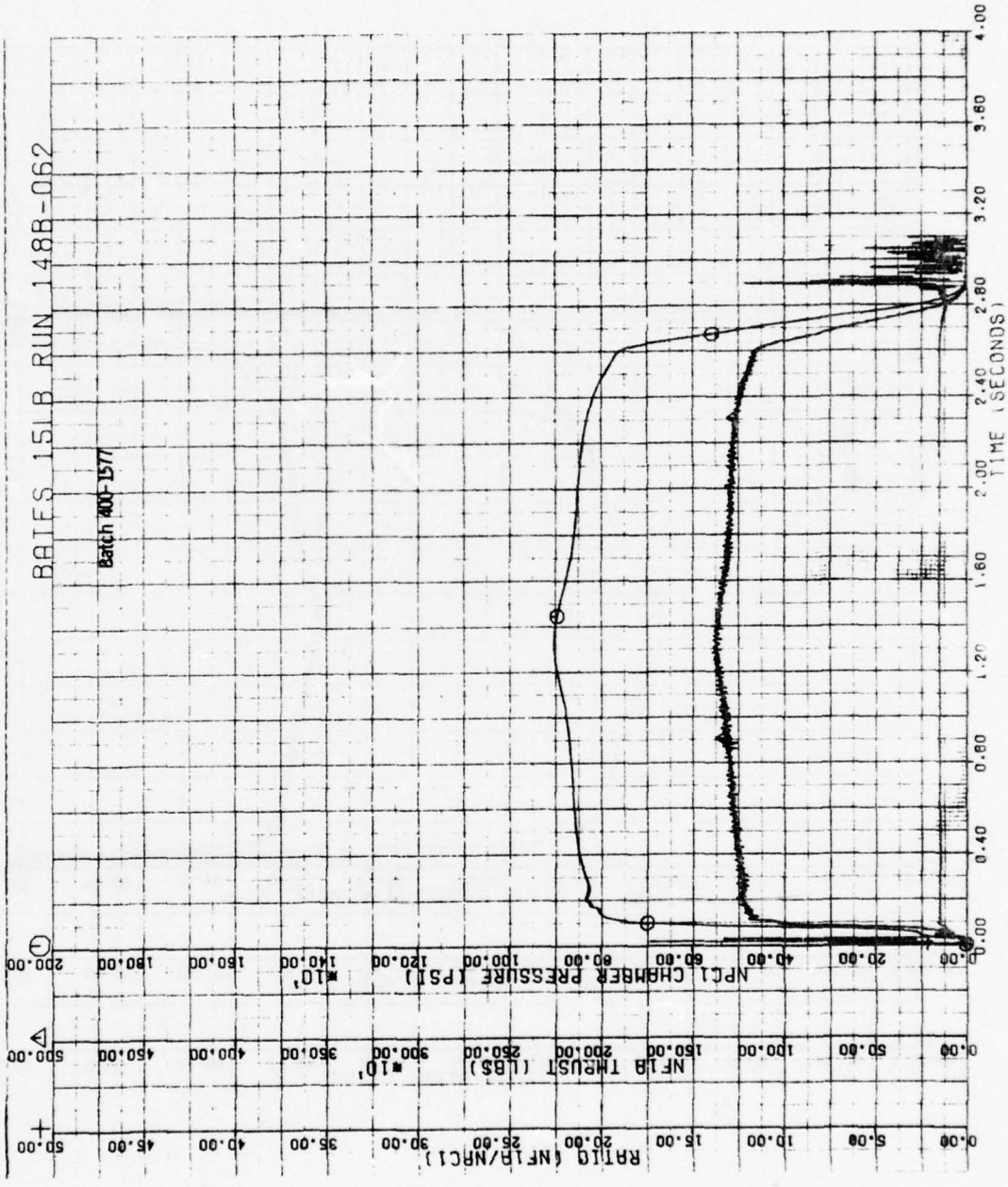

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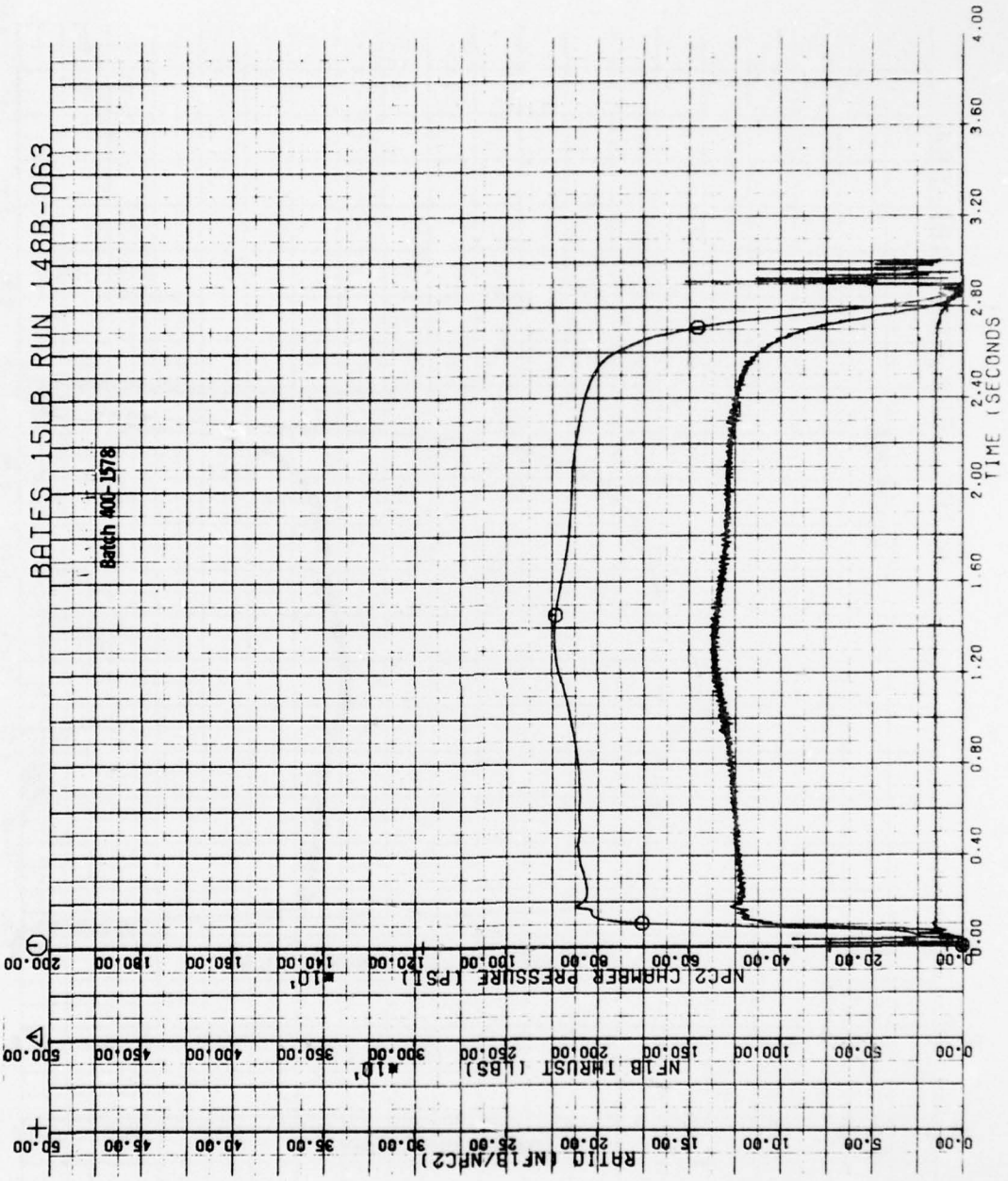

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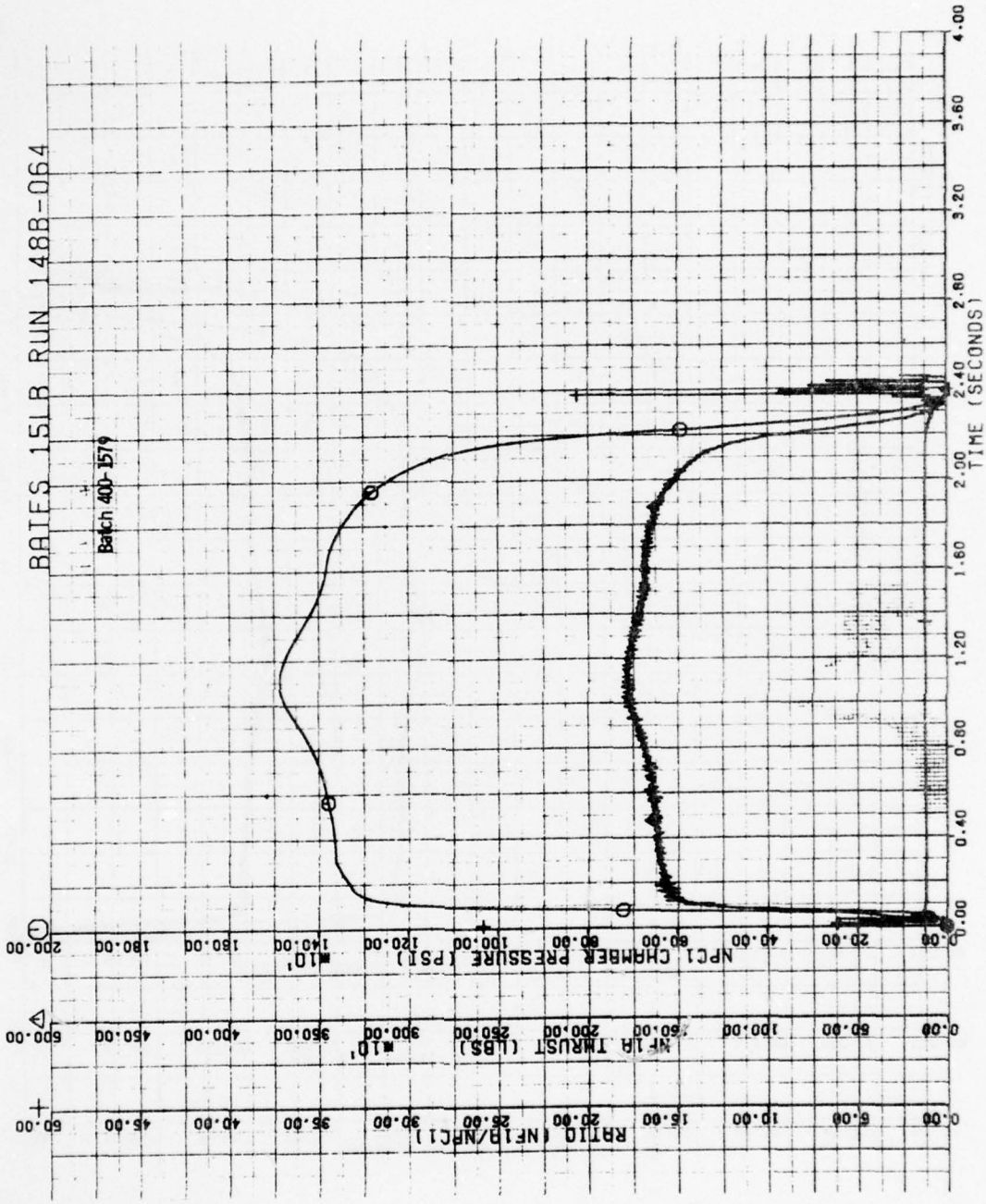

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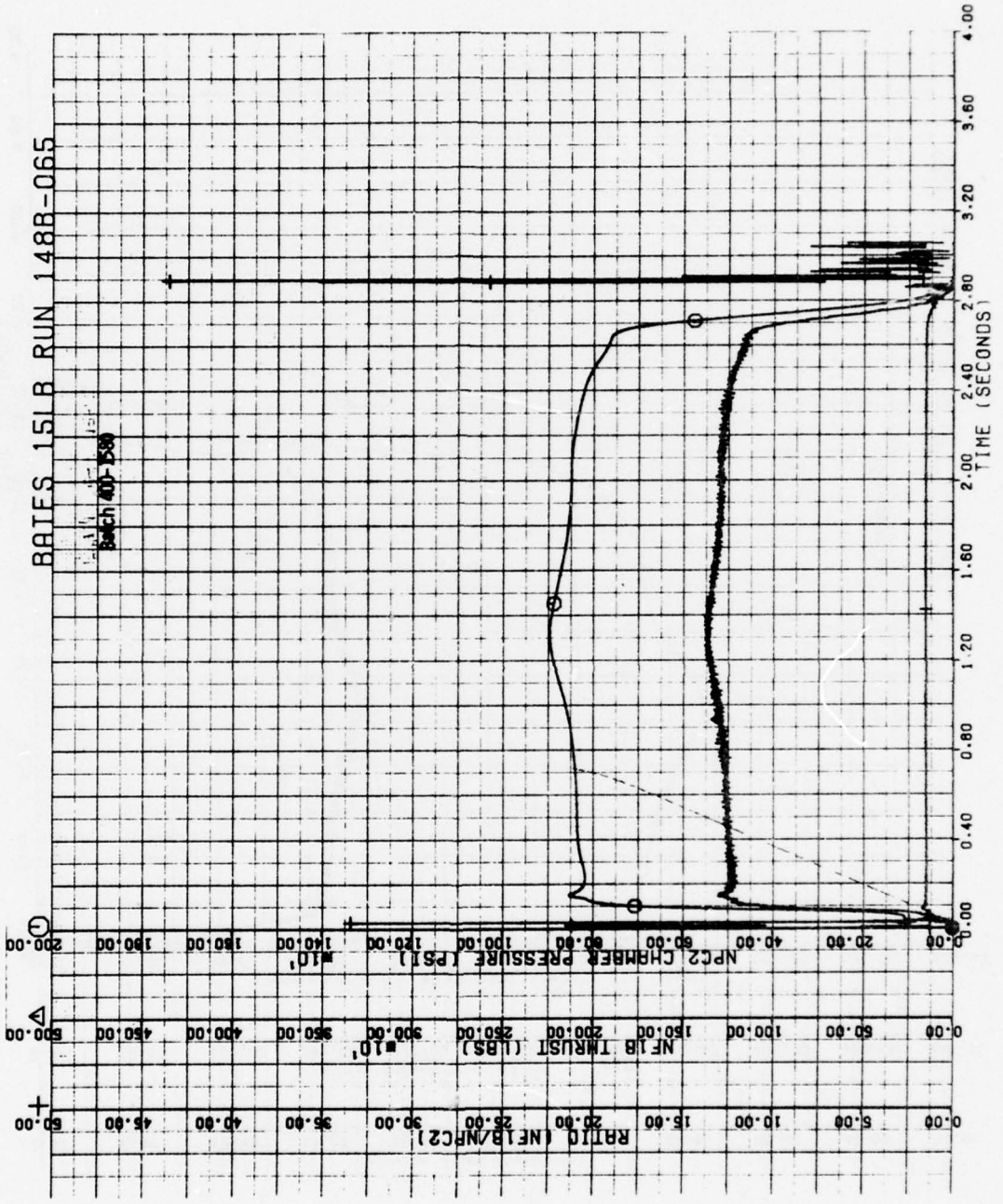

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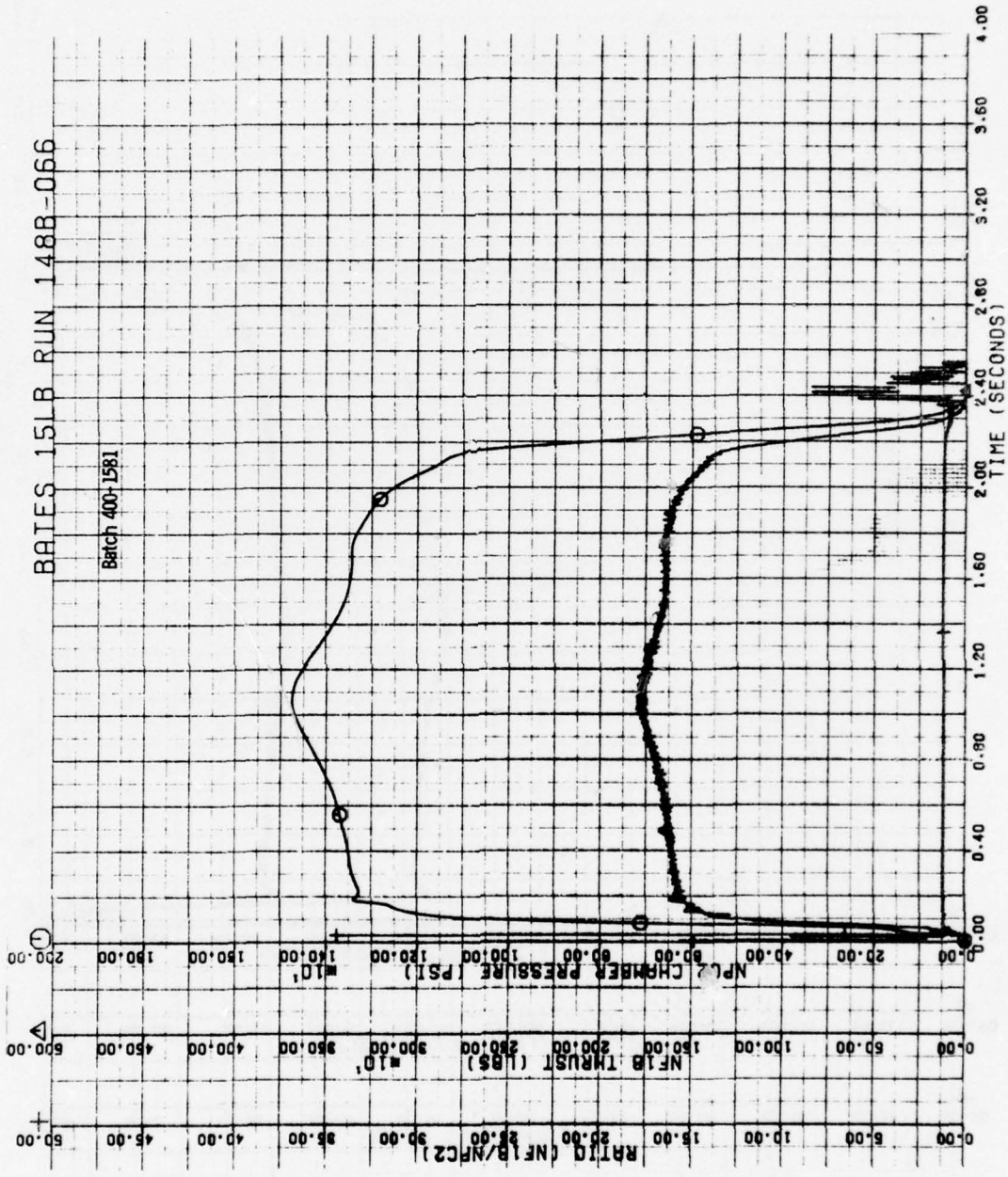

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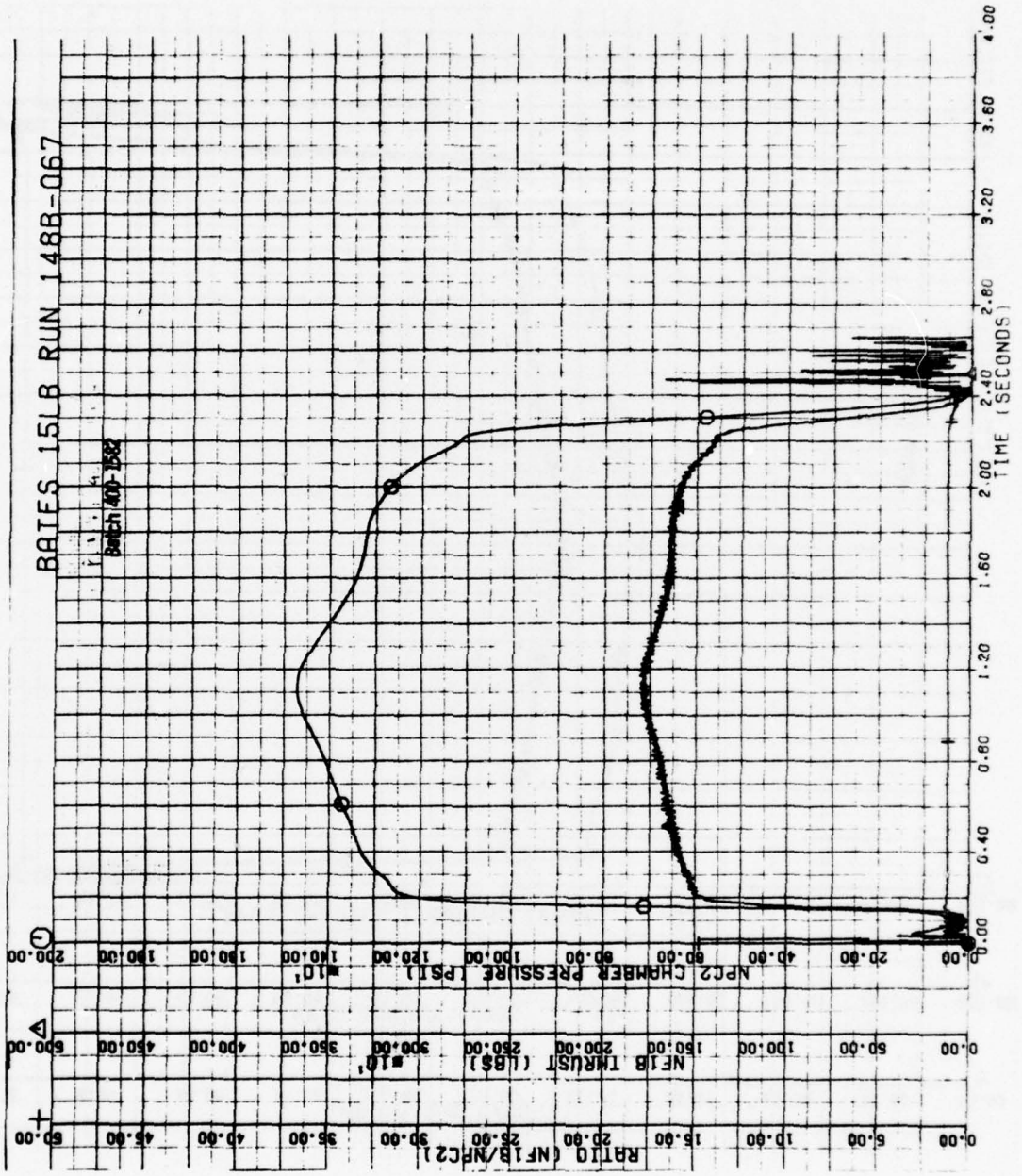

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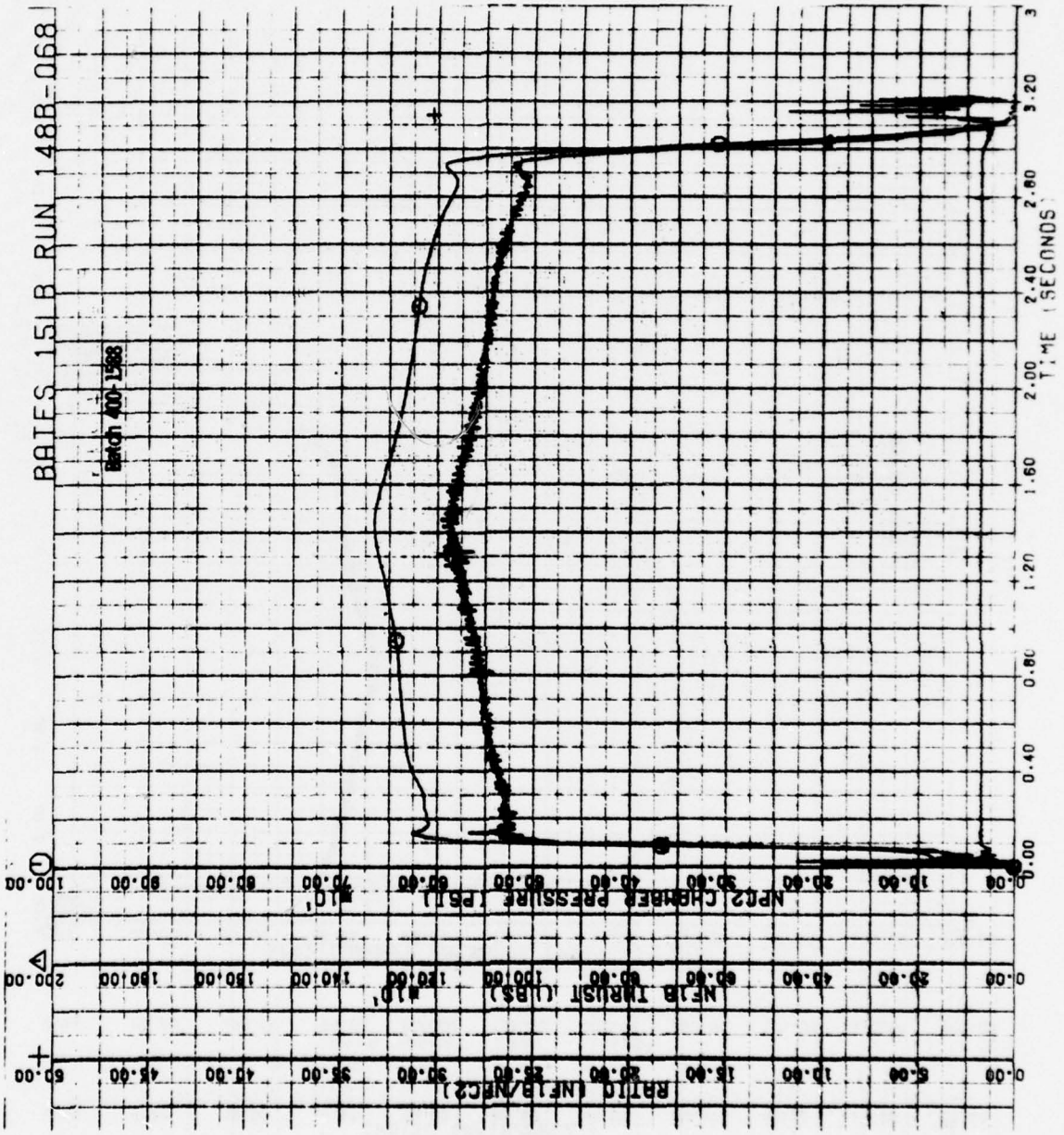

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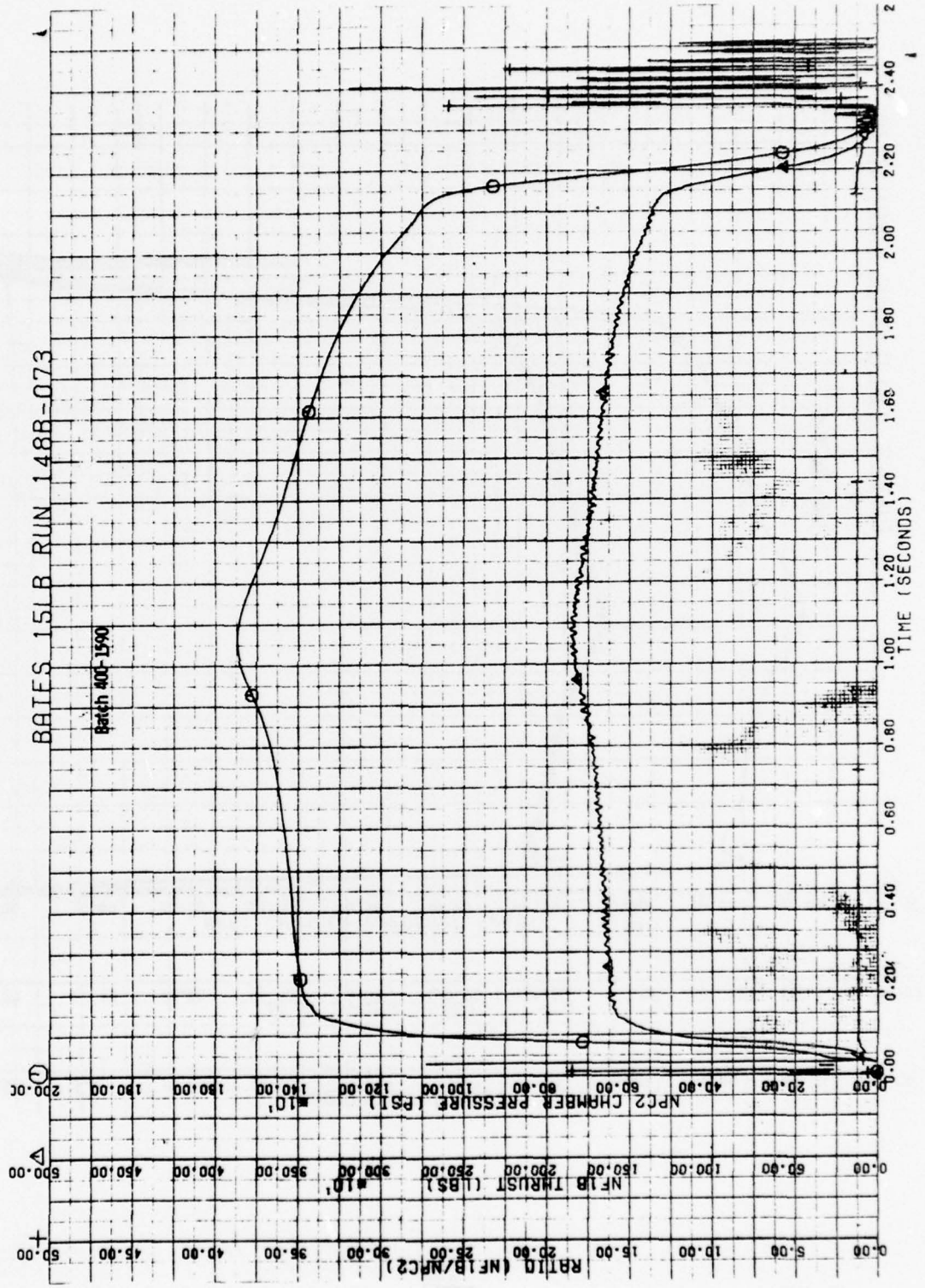

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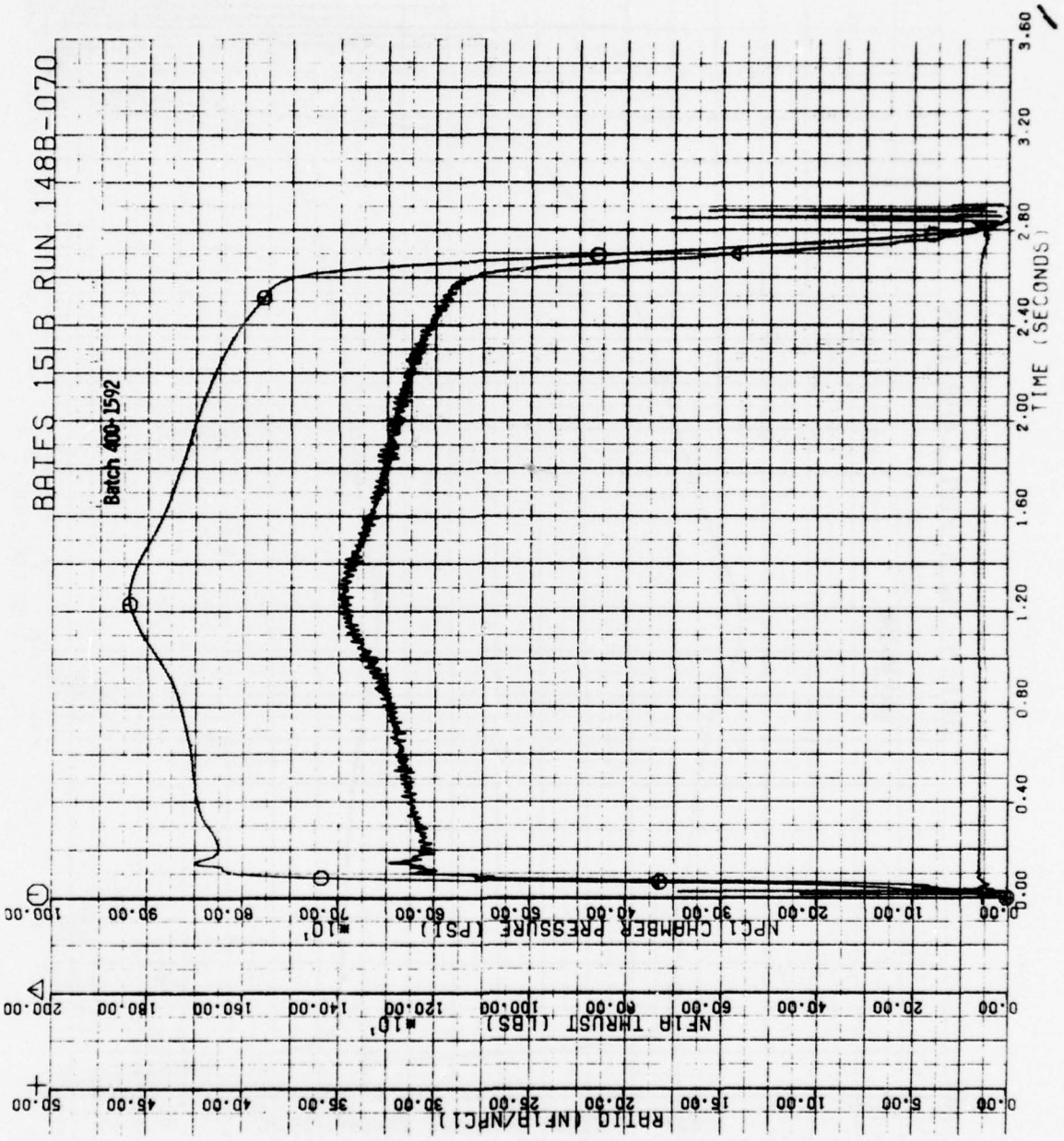

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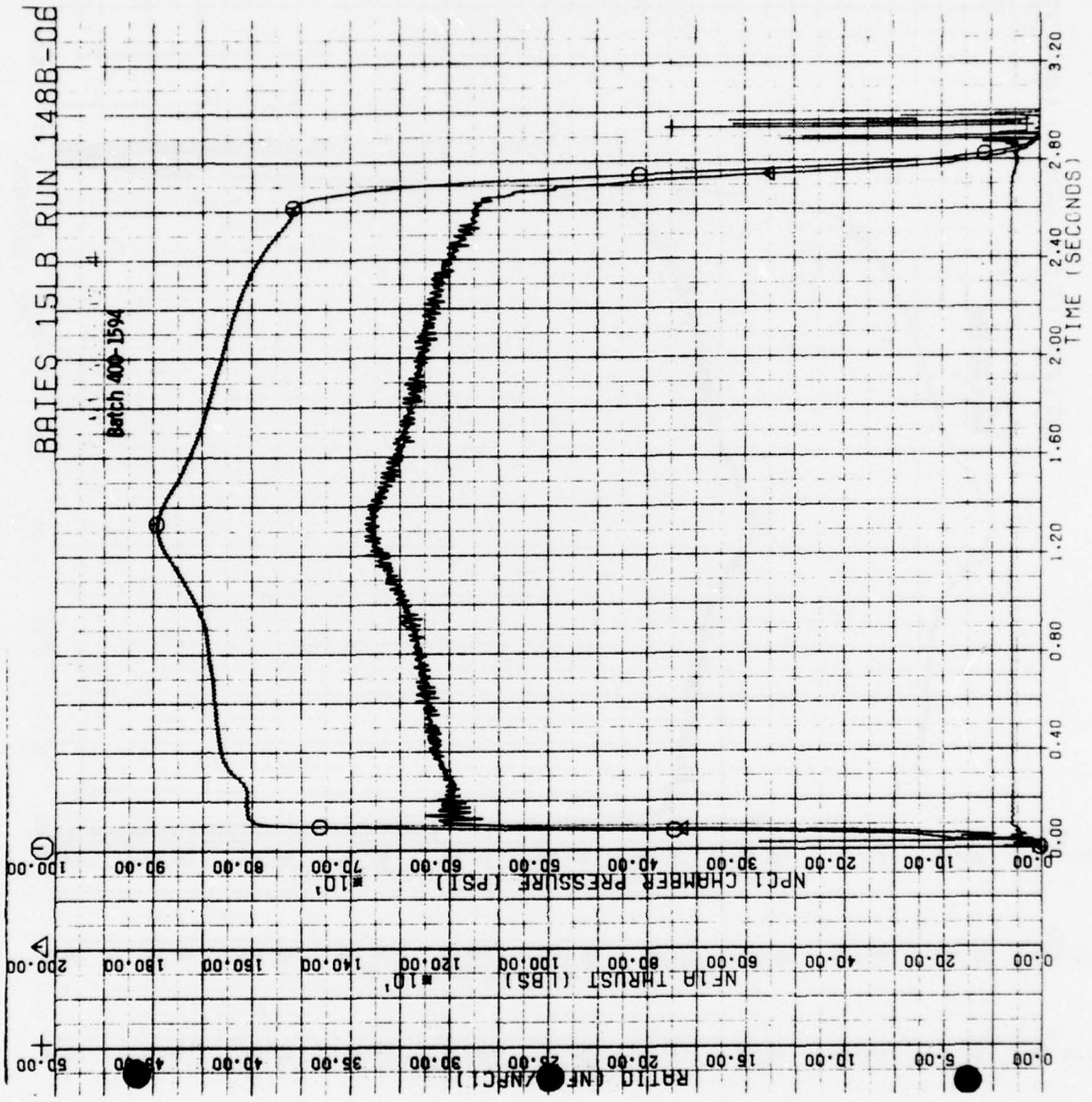

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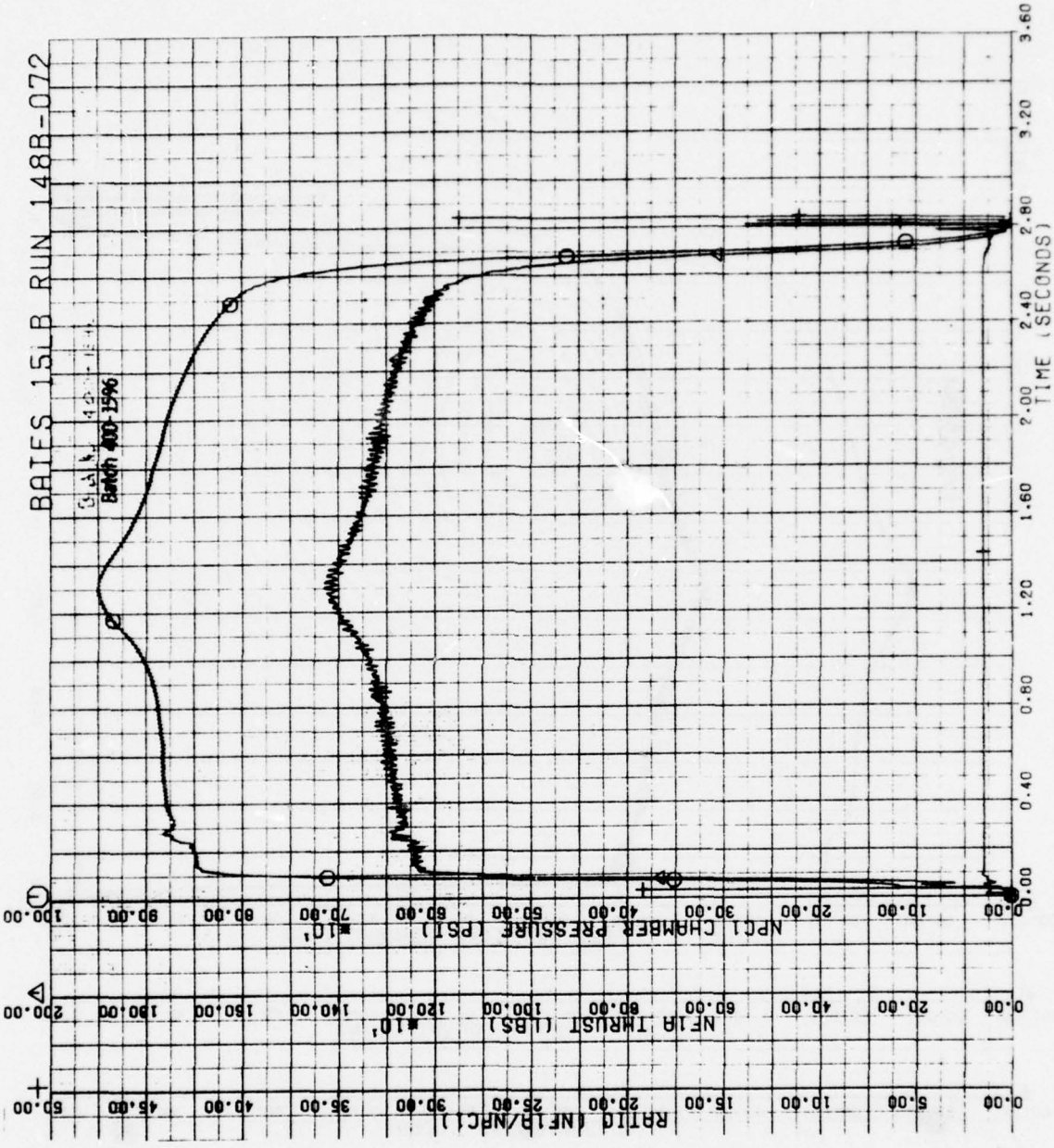

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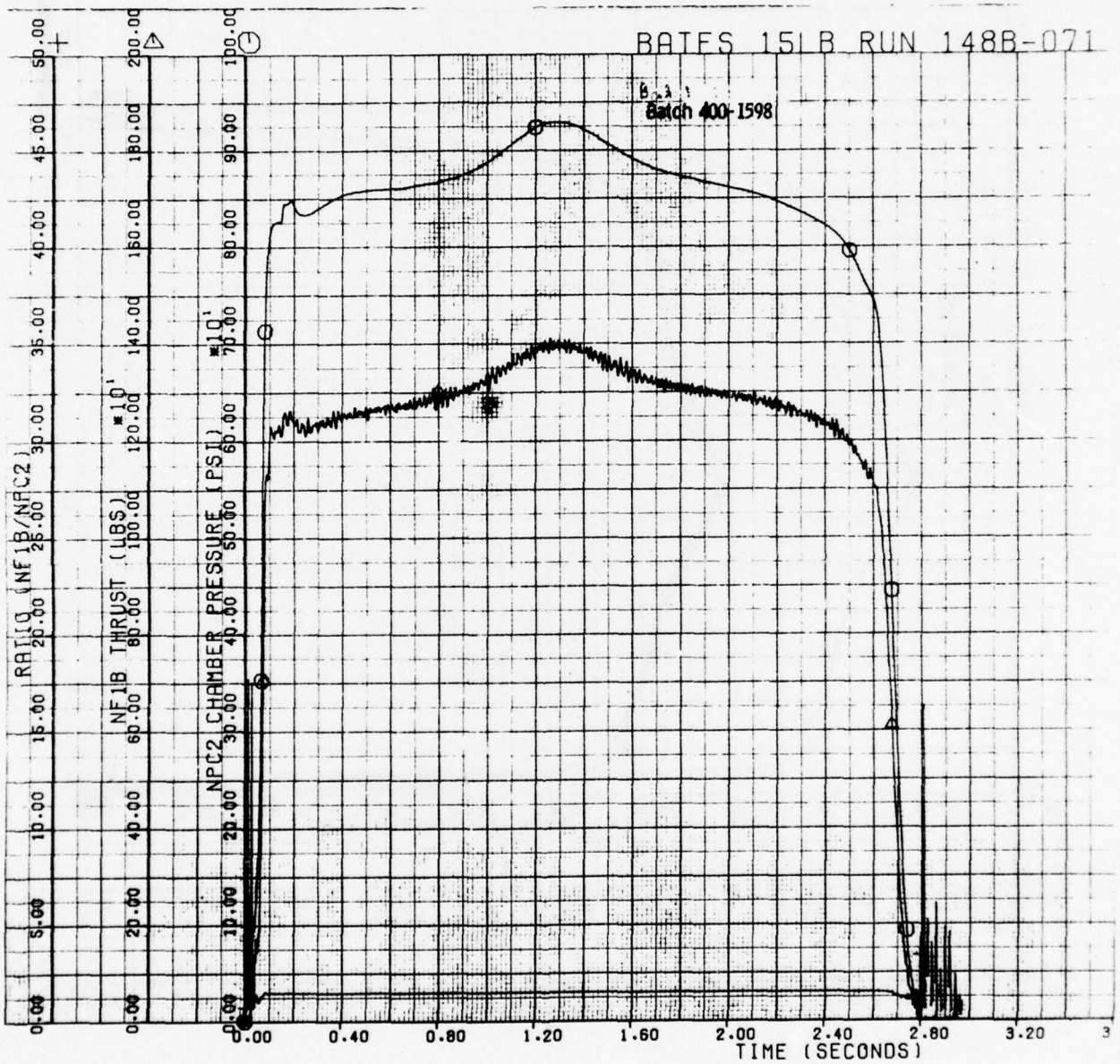

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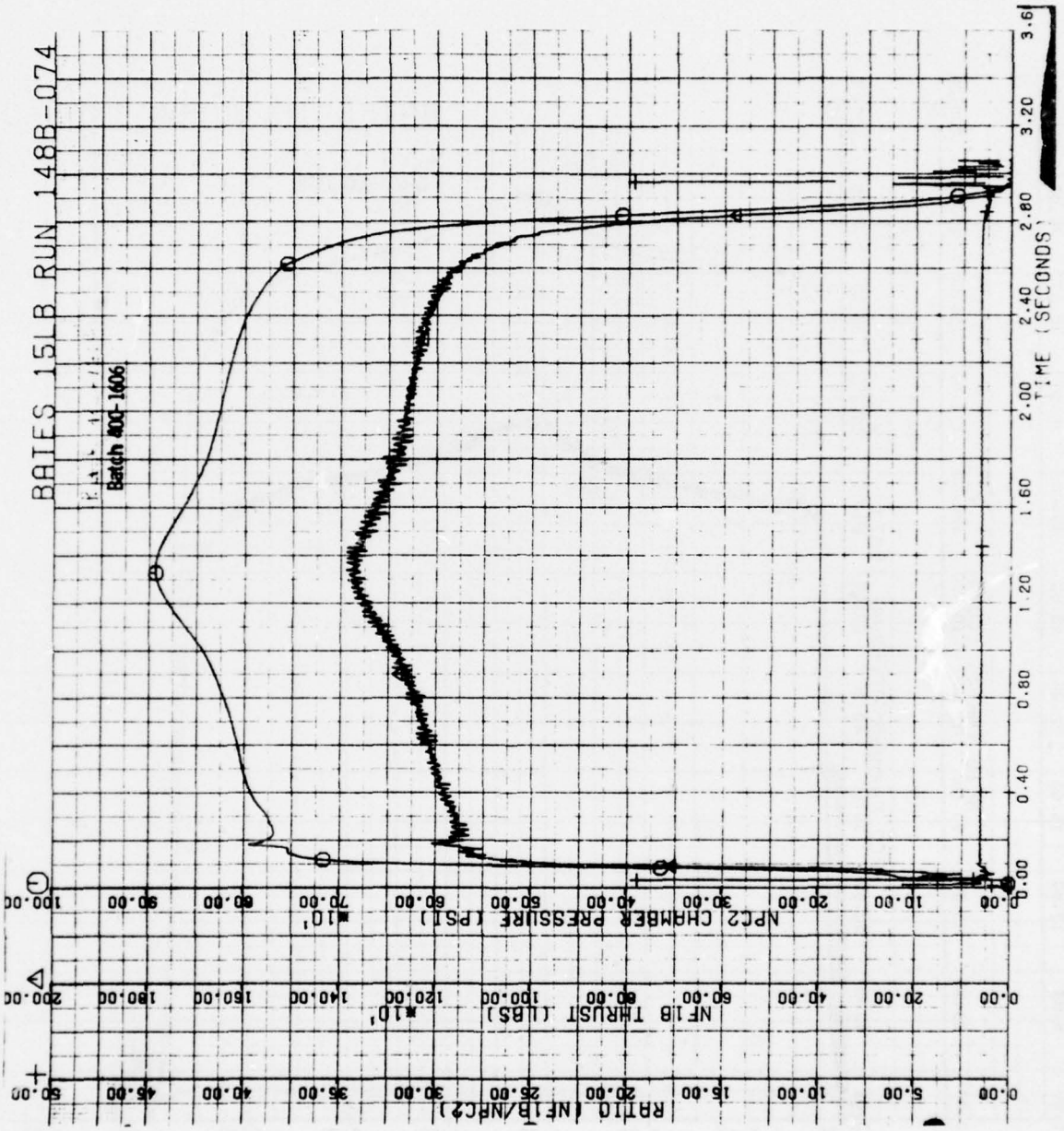

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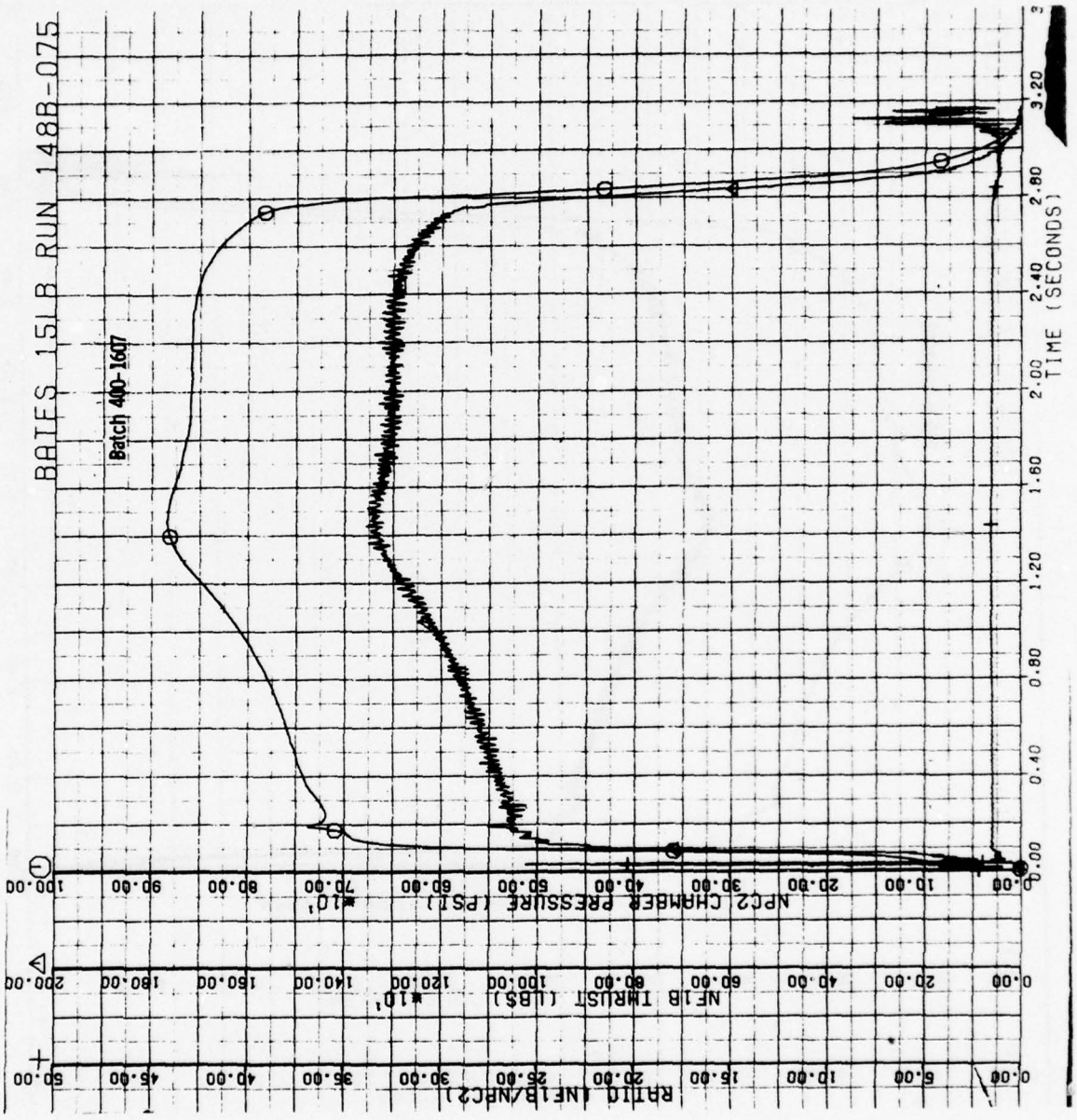

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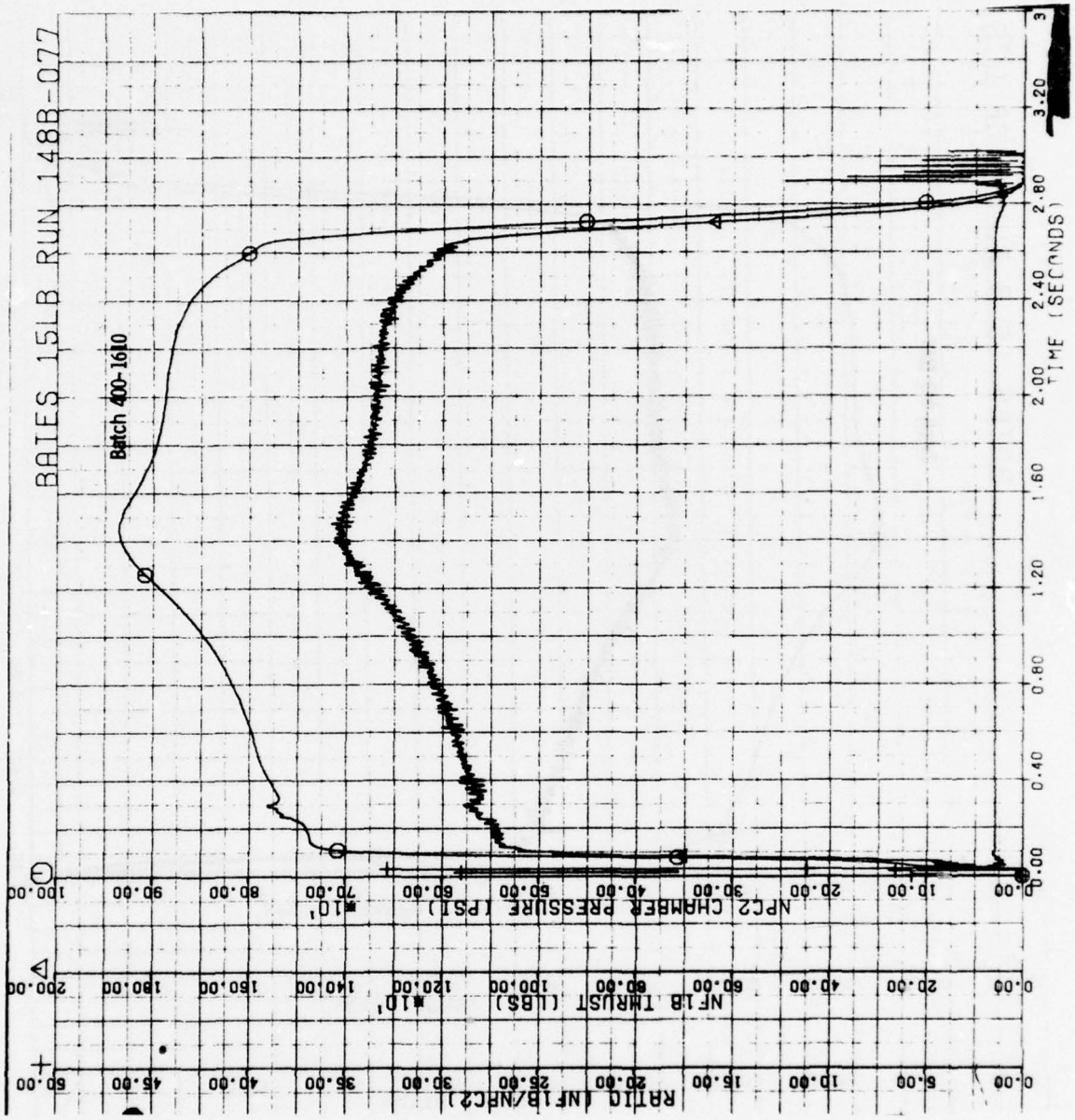

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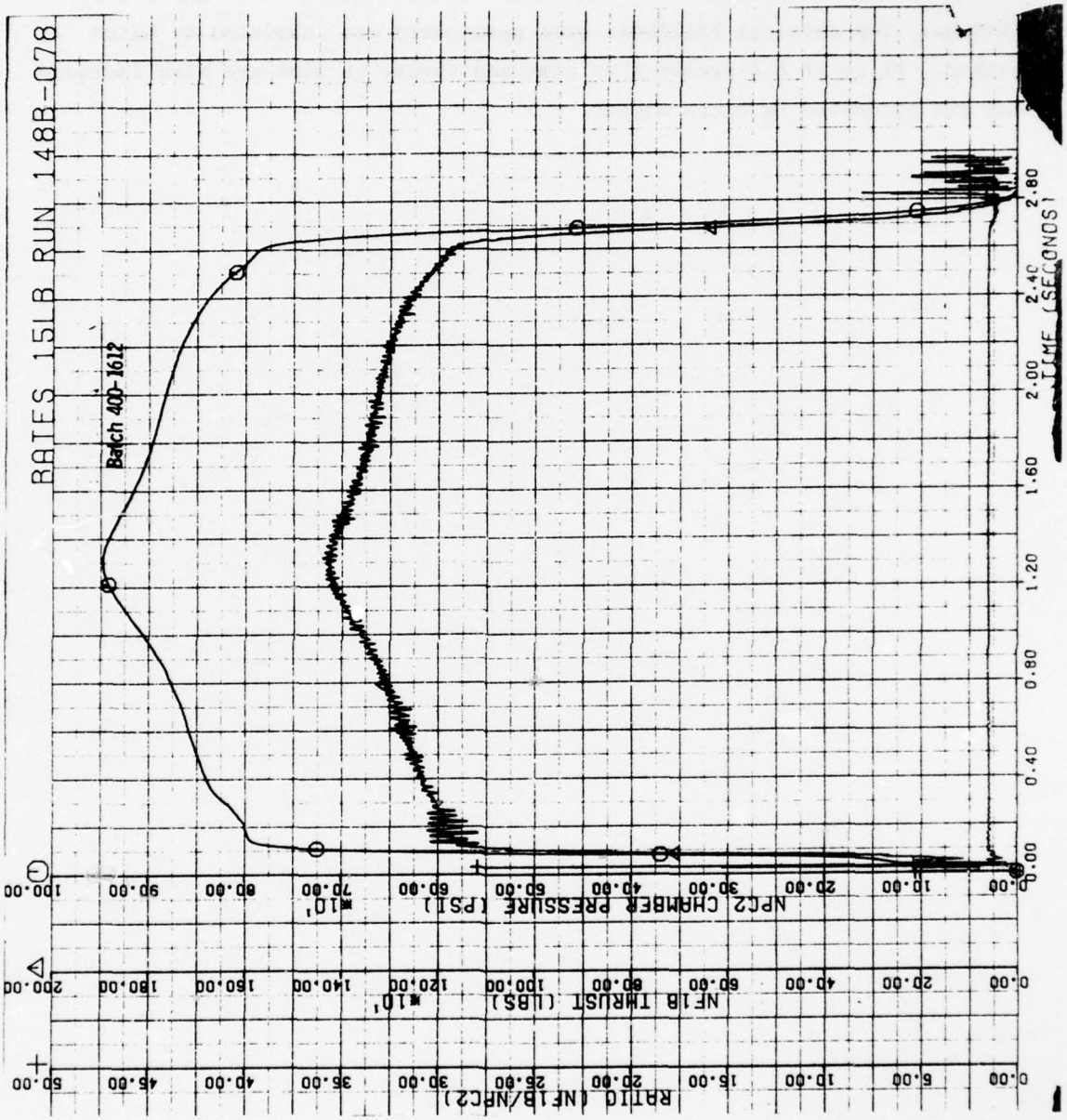

5.0 SEVENTY-POUND BATES TEST DATA

This section presents the test data from the AFRPL 70-lb BATES test firings. The critical ballistic test parameters are tabulated by batch number. Plots of the pressure vs time and thrust vs time are also included and are presented by batch number.

70-LB BATES DATA, 70°F

400-gal Batch No.	Propellant Cast in 84-in. Cartridge P/N	Propellant Cast in 84-in. Cartridge S/N	Propellant Weight, lb	Initial Throat Diameter, in.	Throat Erosion Rate, mils/sec	Expansion Ratio	Action Time, sec	Action Time Average Chamber Pressure, psia	Burning Rate, in./sec	Measured c*, ft/sec	Delivered Specific Impulse, sec	Isp, 15-deg HA MC, sec	Efficiency Isp, 15-deg HA MC, %
1450	N/A	N/A	74.19	1.87	3.6	9.443	4.665	881	0.393	5,016	242.2	243.2	0.921
1450	N/A	N/A	73.97	1.653	10	9.385	3.76	1,376	0.490	5,092	249.7	242.7	0.918
1450	N/A	N/A	75.7	1.65	10	9.436	3.915	1,357	0.482	5,093	250.0	243.1	0.920
1455	C11479-02-01	2579-02	75.46	1.65	8.7	9.461	4.335	1,232	0.435	5,124	248.1	242.6	0.9182
1457	C11479-02-01	2579-02	73.0	1.65	9.9	9.466	3.954	1,313	0.471	5,150	248.8	242.4	0.9174
1459	C11479-01-01	2579-01	73.24	1.65	8.8	9.487	3.810	1,371	0.477	5,144	250.7	243.6	0.9217
1496	C11479-01-01	2579-07	73.83	1.65	11.3	9.442	3.570	1,434	0.505	5,199	251.4	243.7	0.9225
1498	C11479-01-01	2579-07	73.73	1.655	11.2	9.381	3.616	1,444	0.496	5,144	252.3	244.5	0.9257
1500	C11479-03-01	2579-08	75.27	1.651	11.4	9.423	3.55	1,501	0.523	5,148	252.4	244.0	0.9238
1506	C11479-01-01	2579-09	75.9	1.663	11.9	9.226	3.784	1,388	0.498	5,020	250.3	243.3	0.921
1508	C11479-01-01	2579-09	75.76	1.65	12.7	9.372	3.577	1,464	0.508	5,106	251.5	243.5	0.922
1540	C12185-02-01	2579-12	73.94	1.654	14.4	11.65	3.933	1,296	0.459	5,125	*	*	*
1542	C12185-01-01	2579-10	74.22	1.653	12.76	11.726	3.880	1,328	0.461	5,109	250.8	242.5	0.9189

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* Thrust not reported due to 2% difference between channels.

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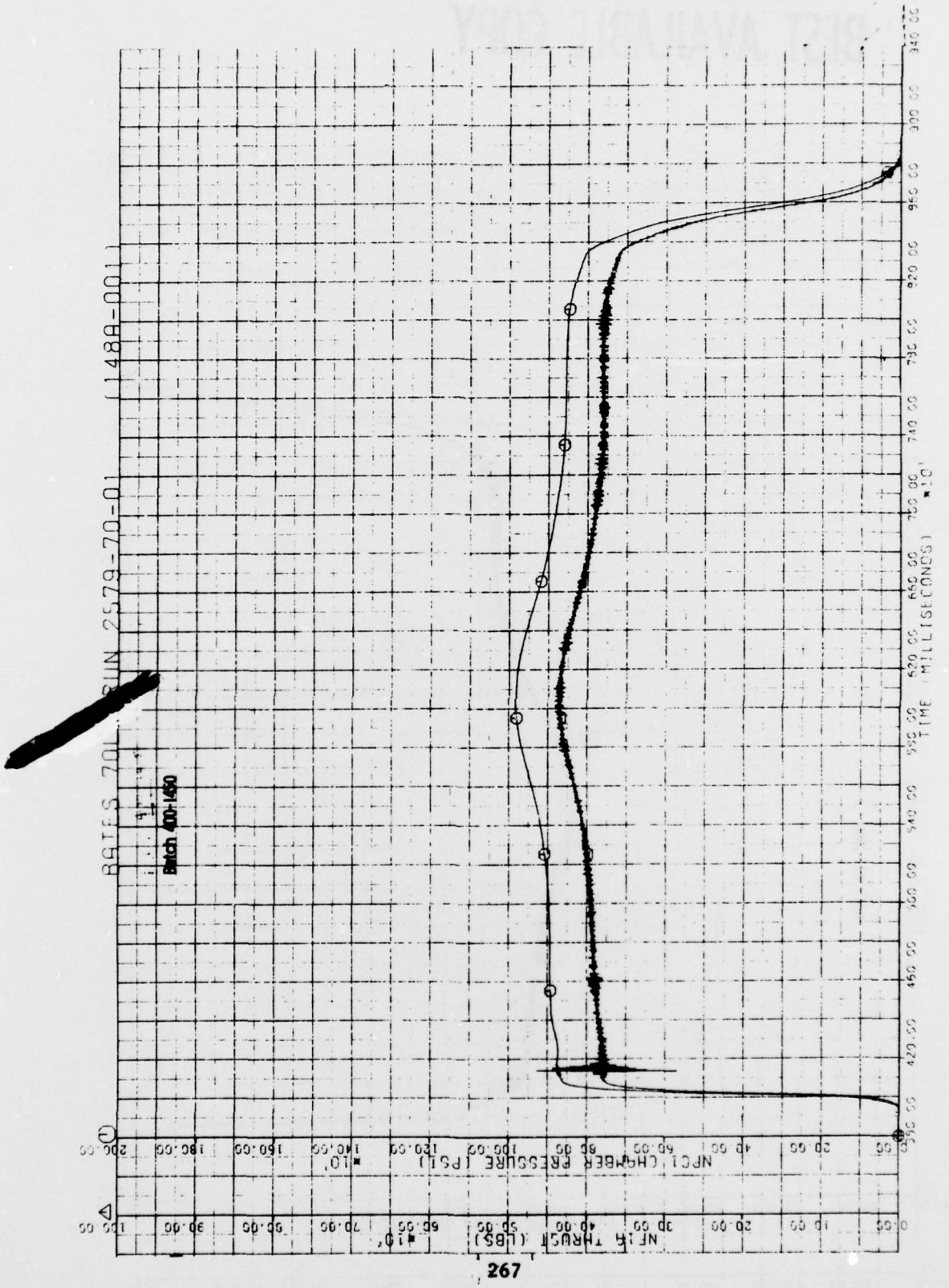

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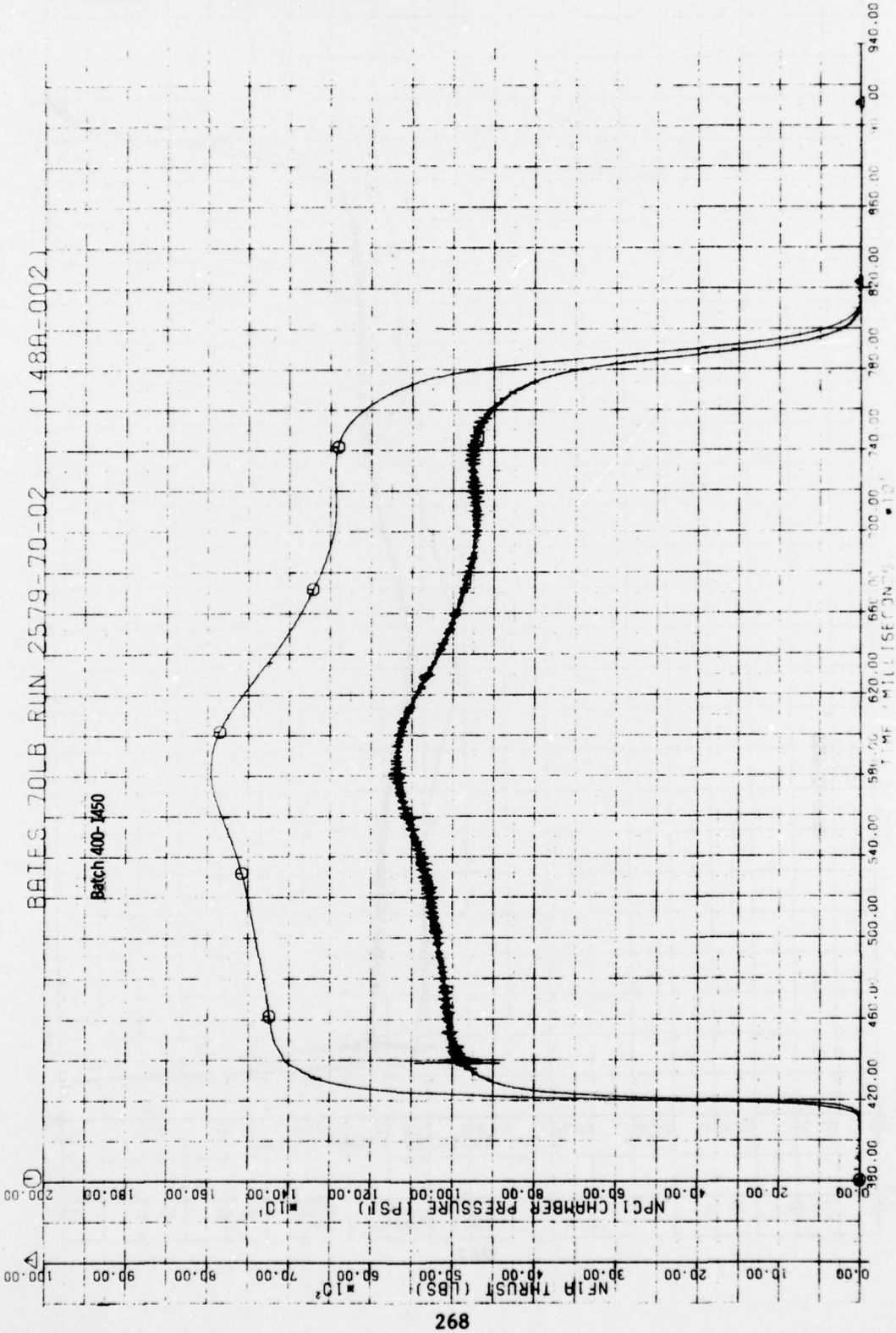

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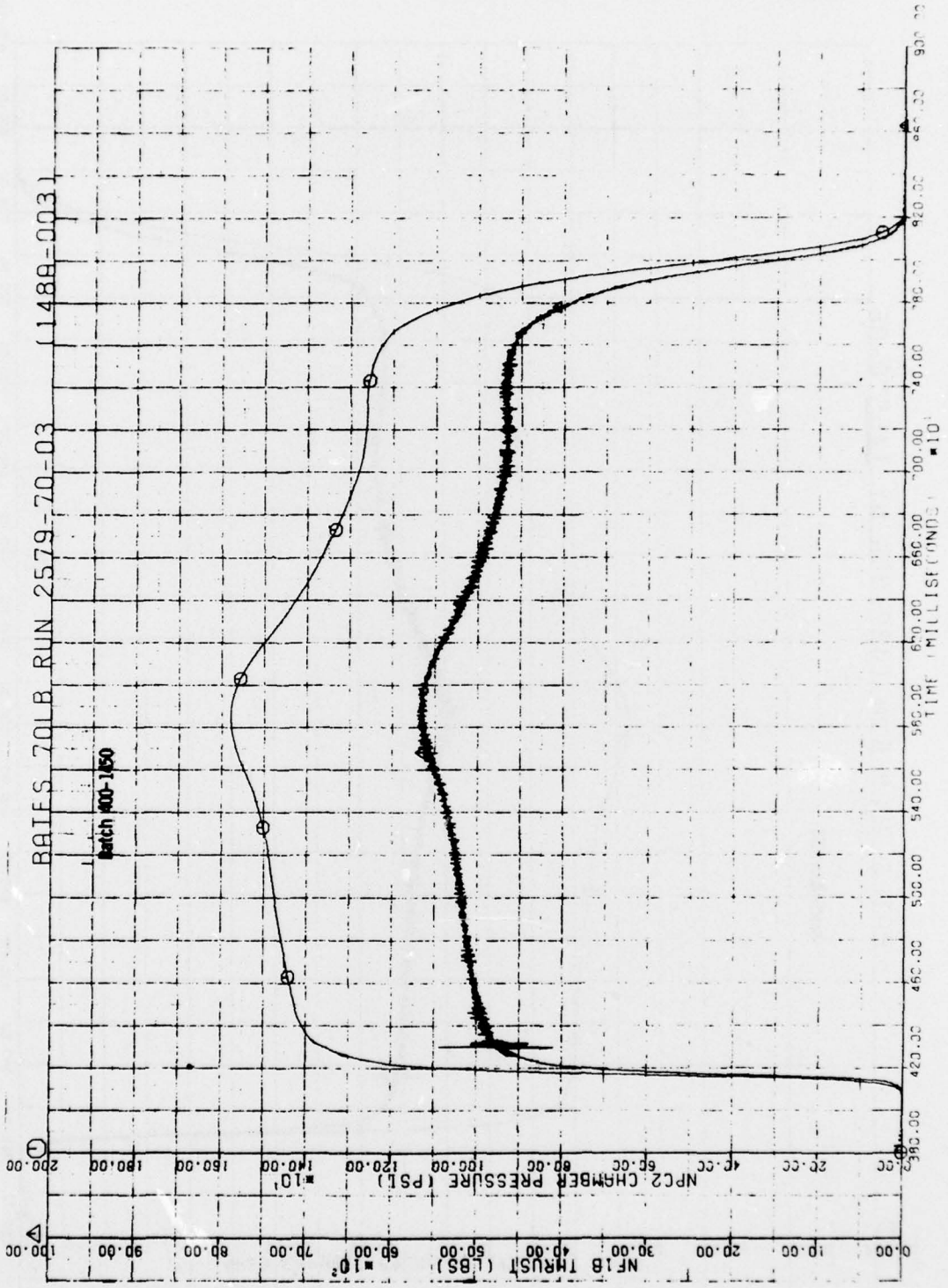

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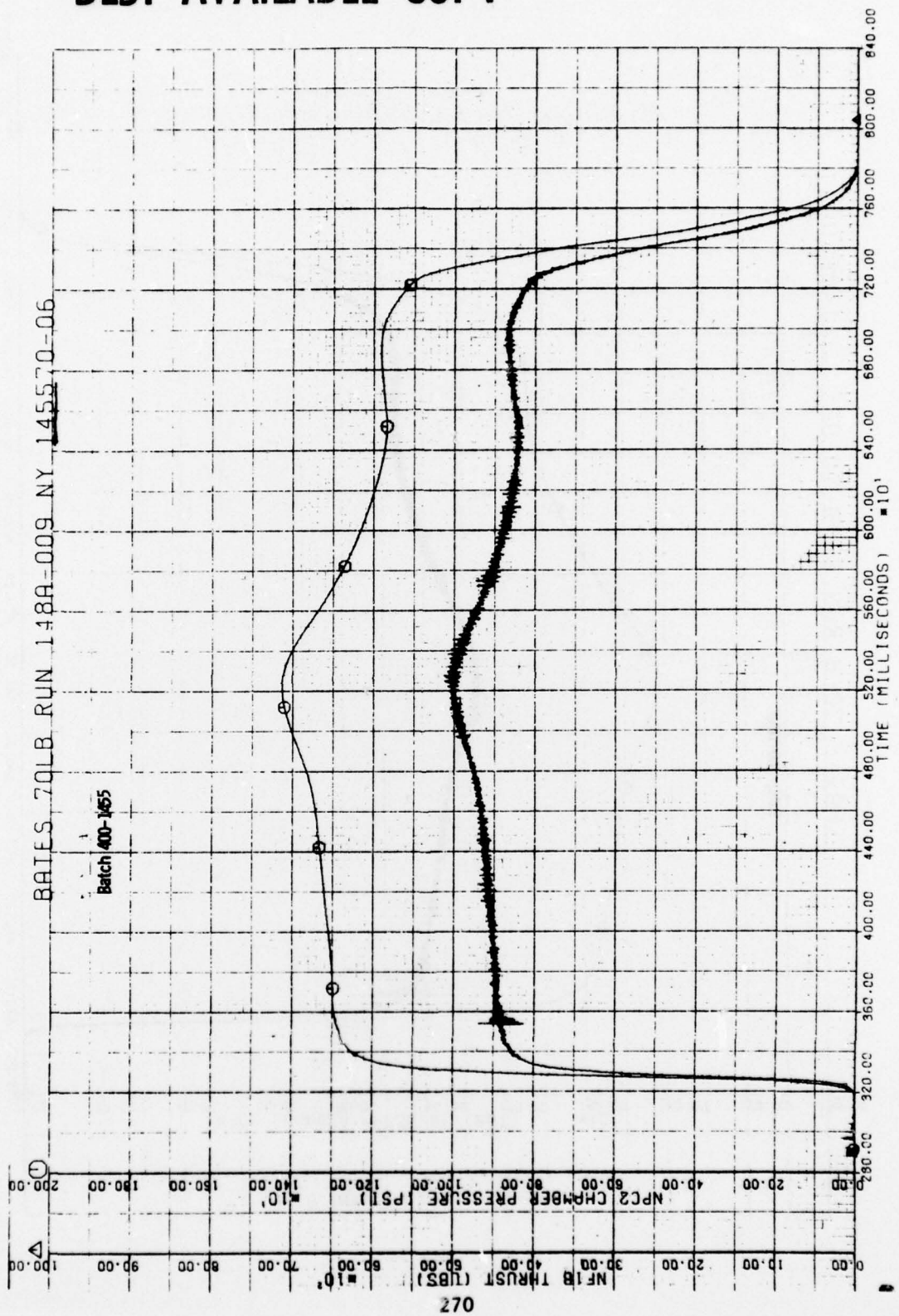

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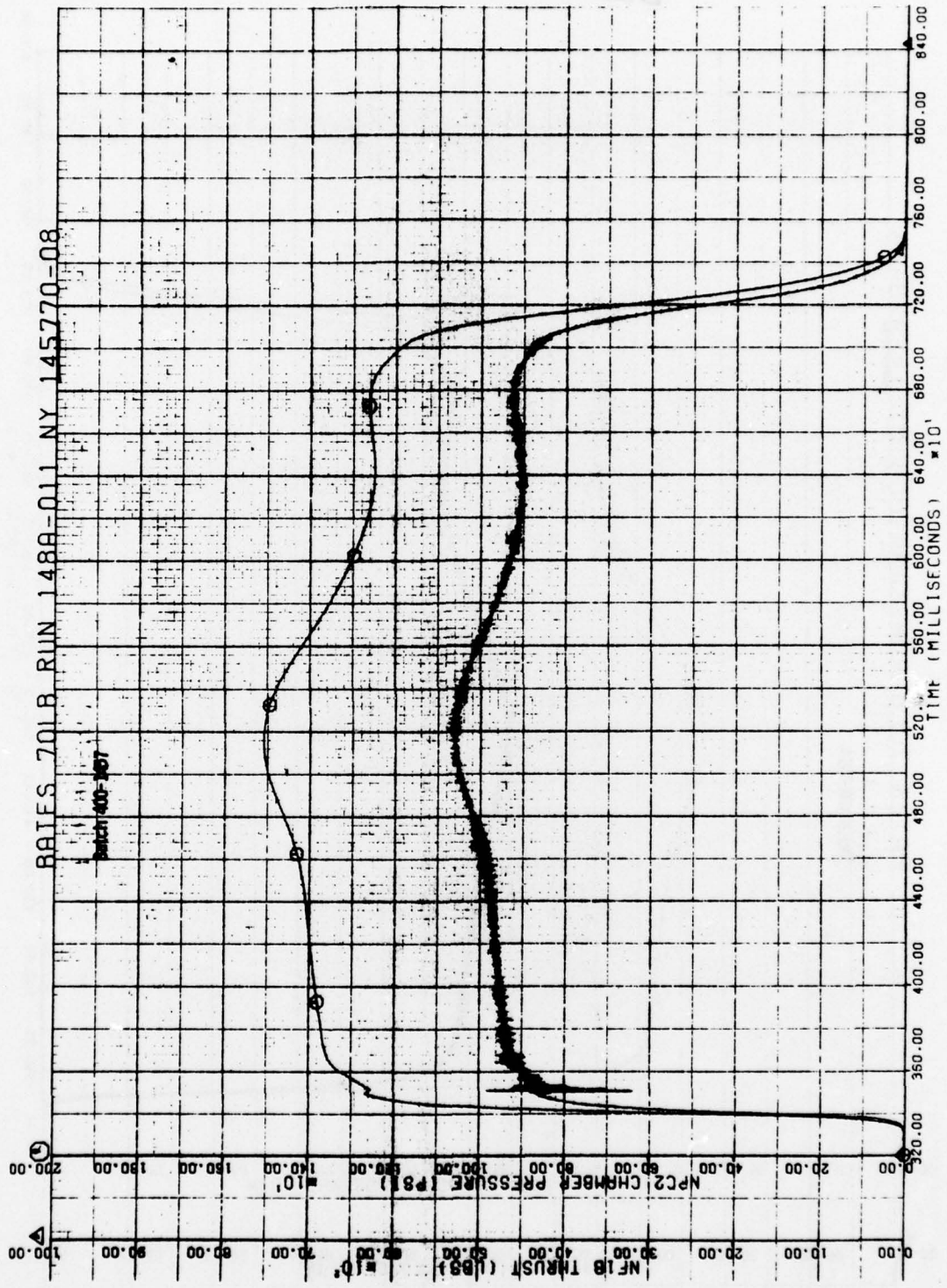

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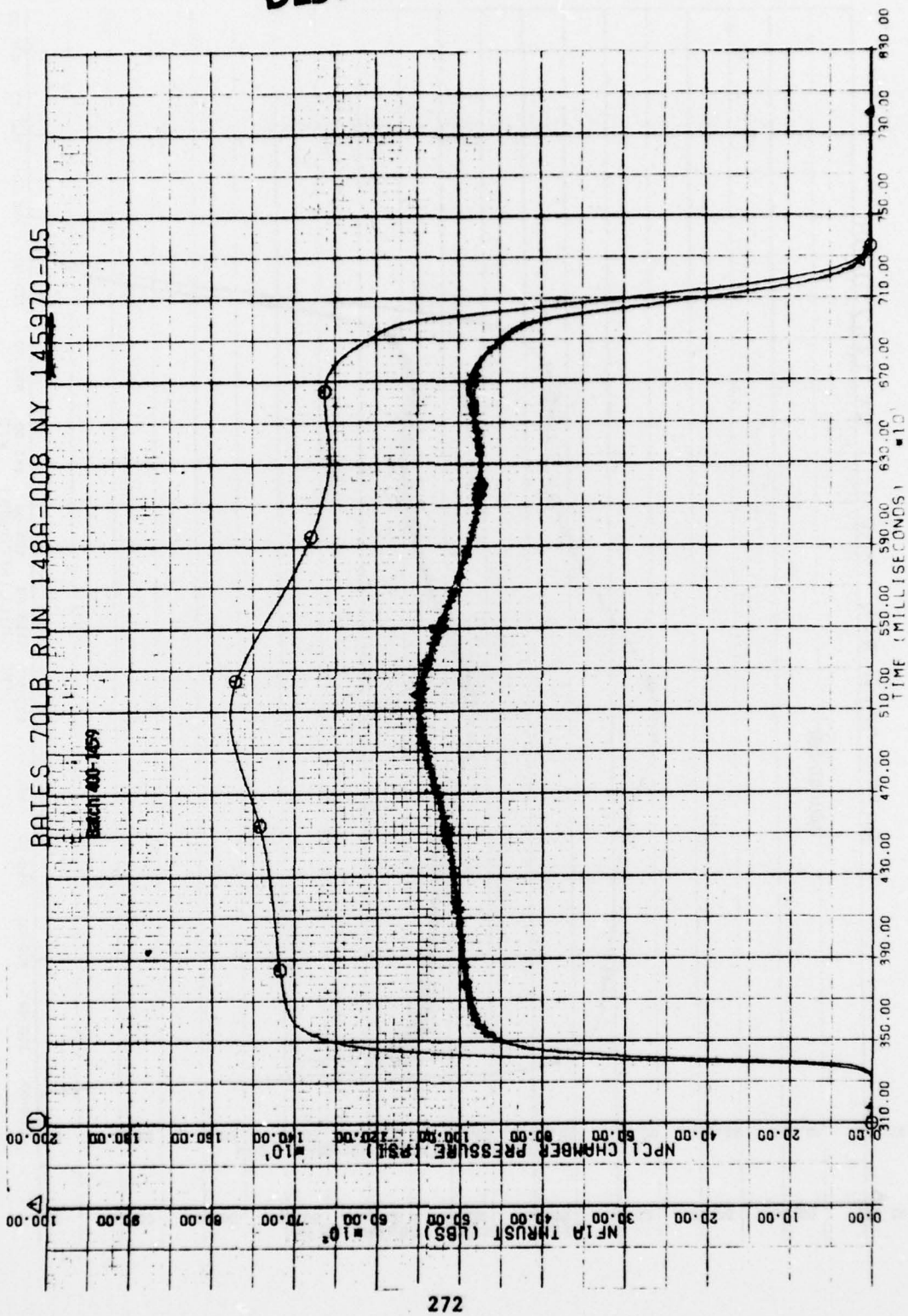

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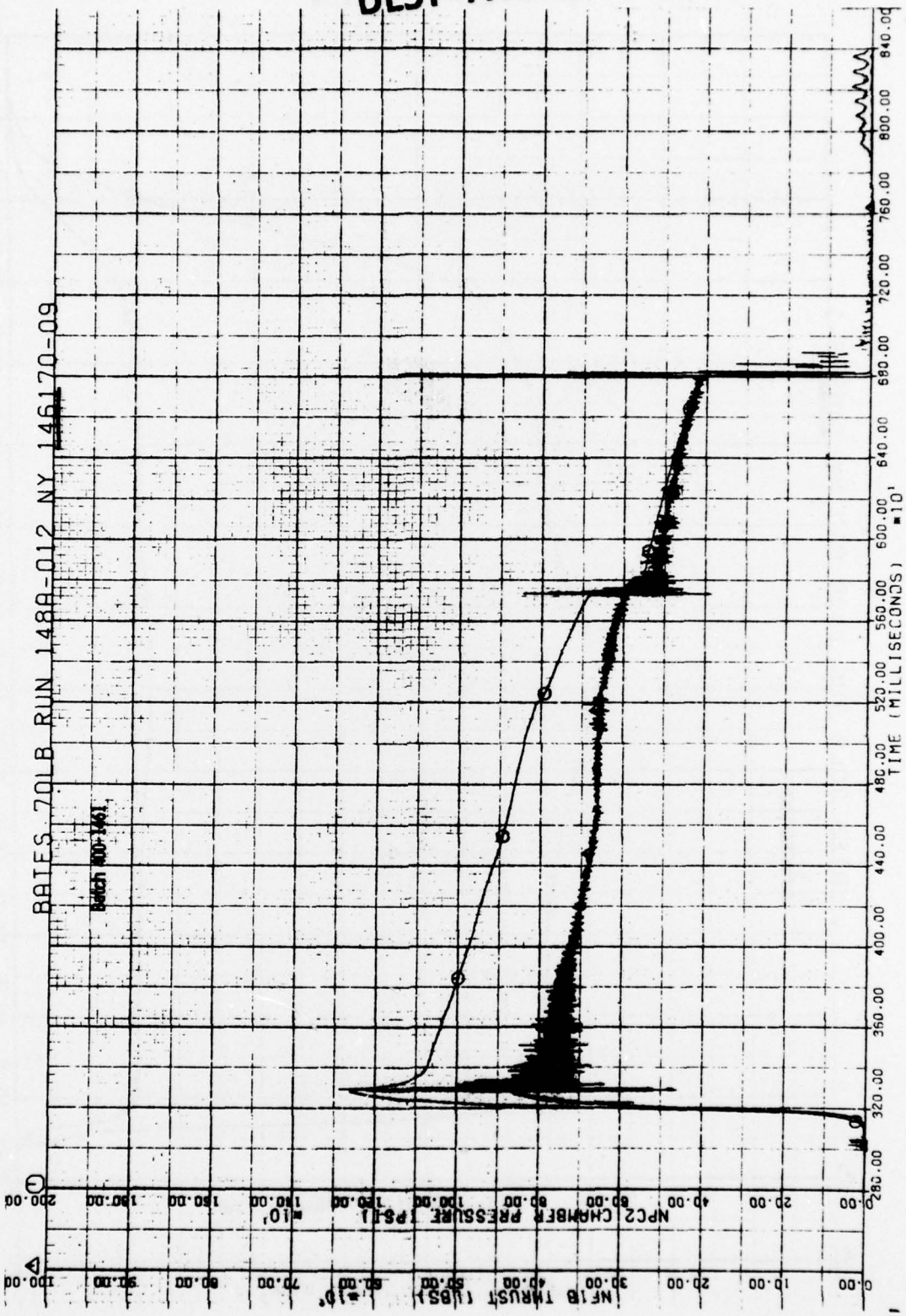

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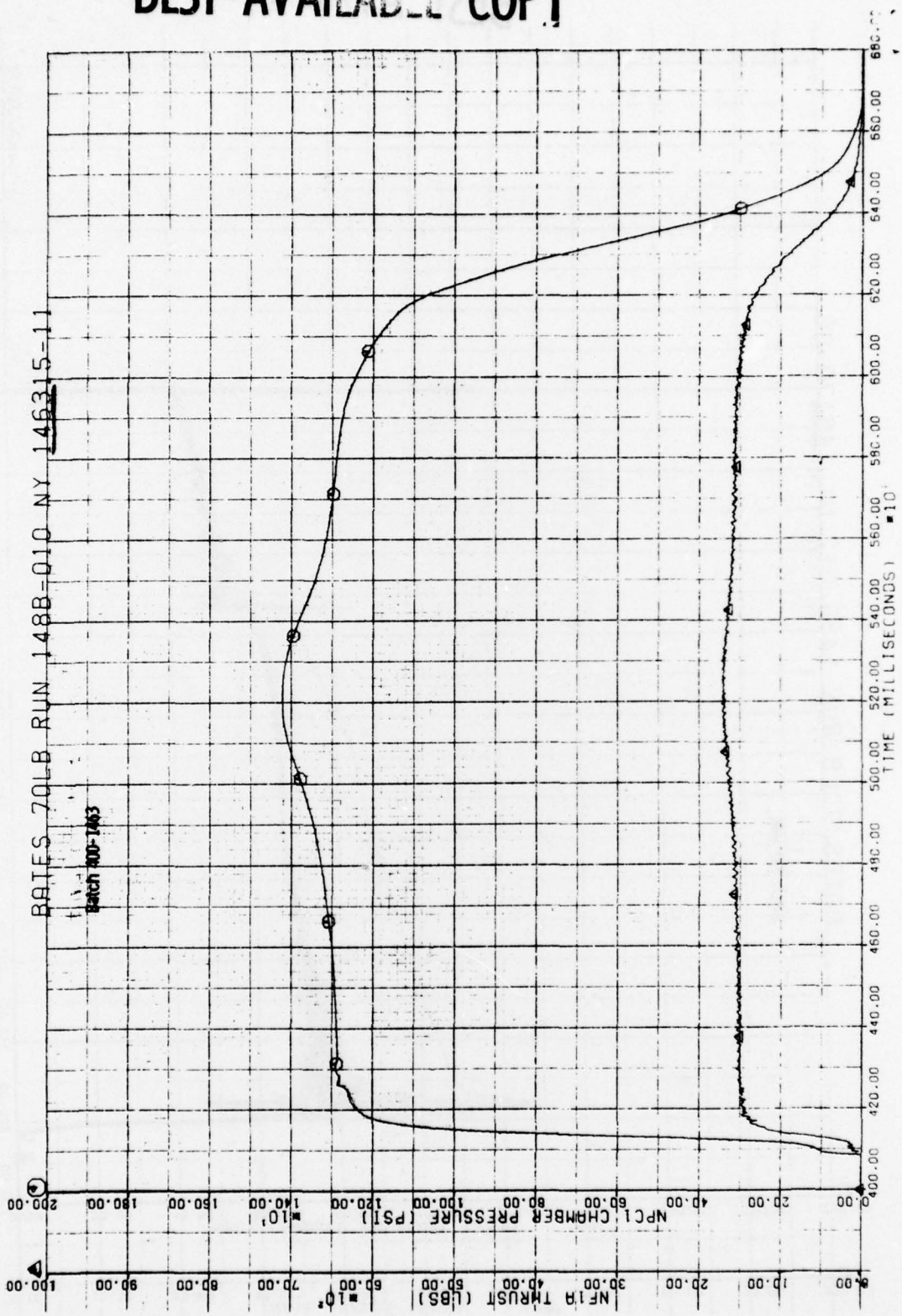

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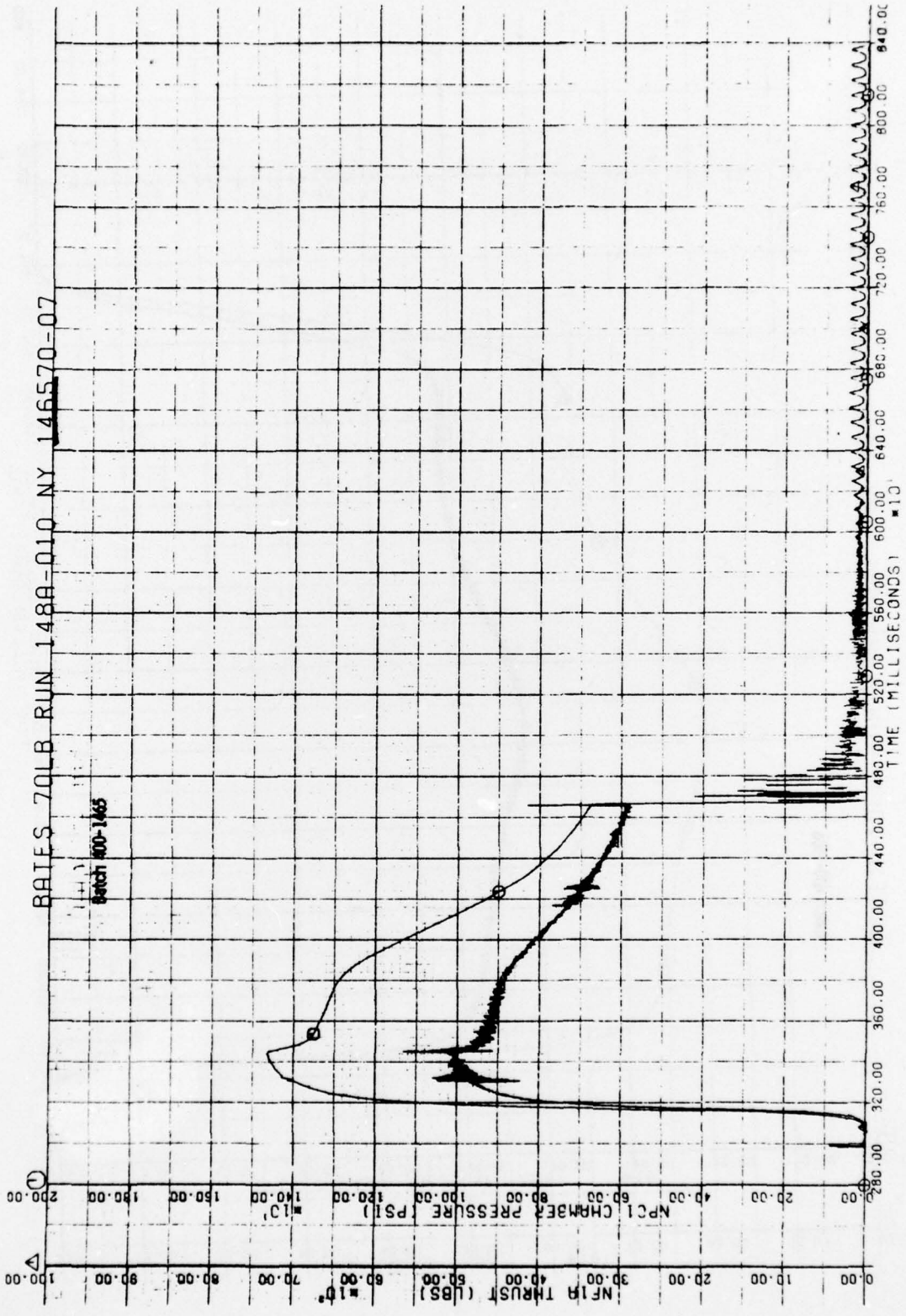

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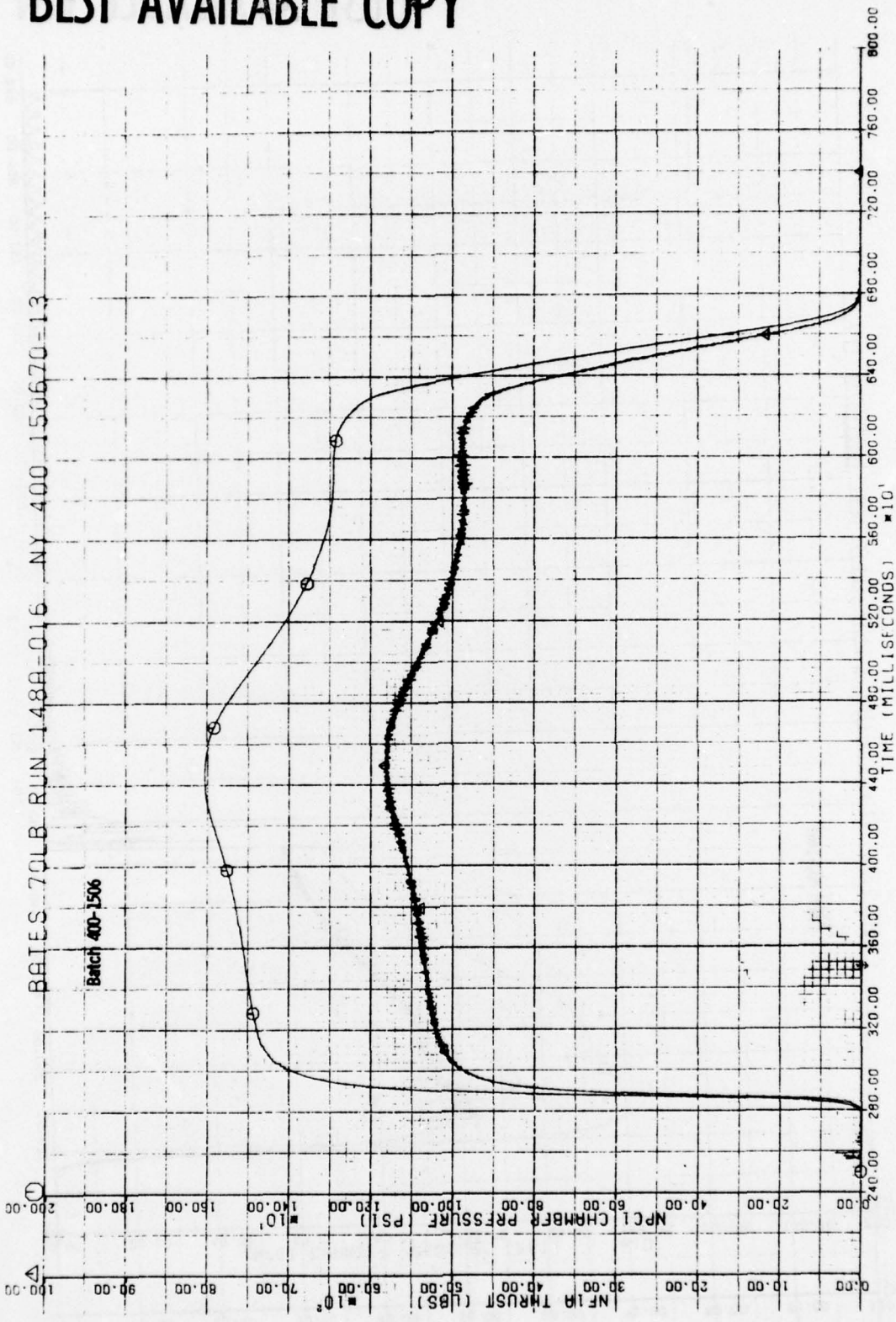

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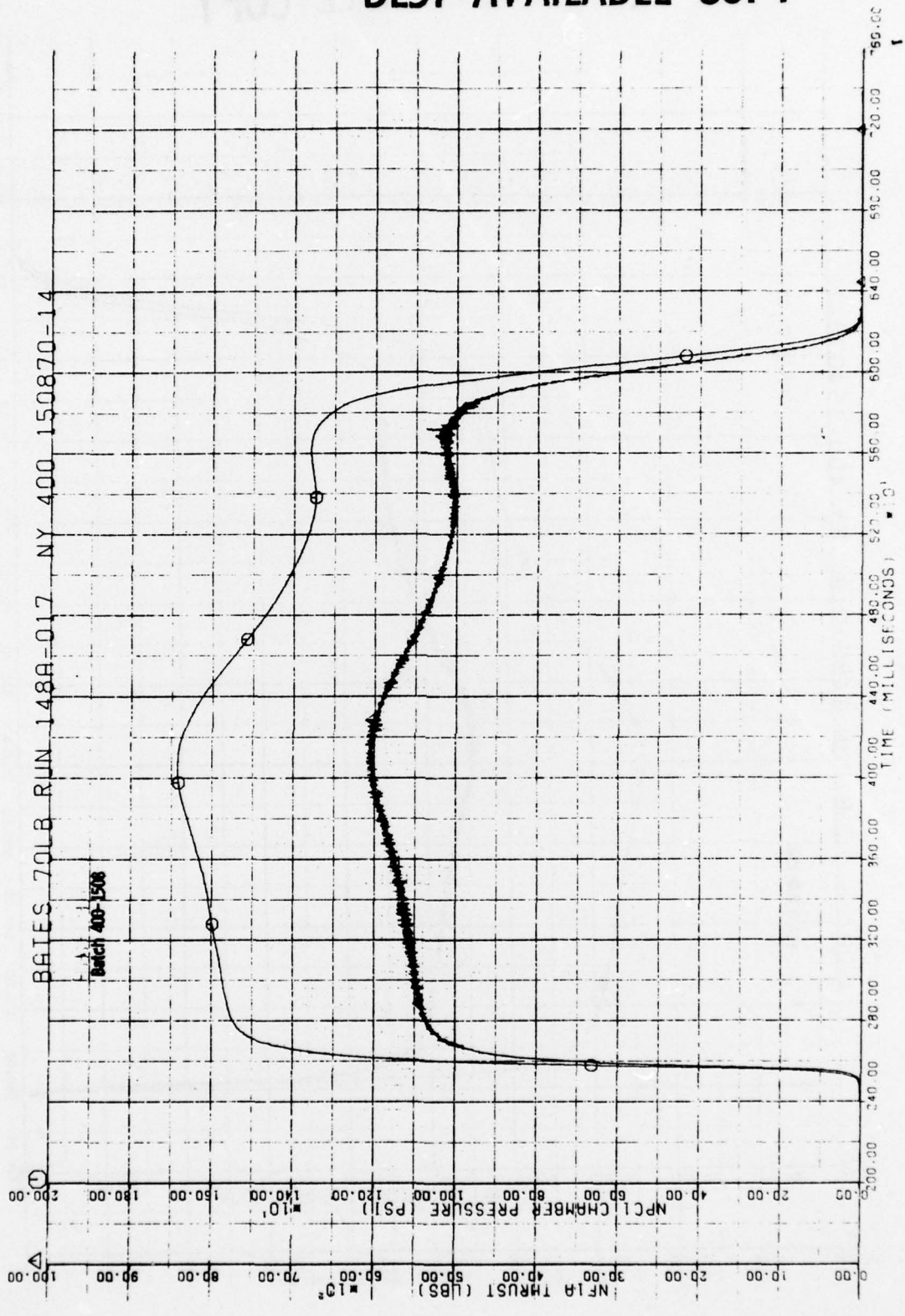

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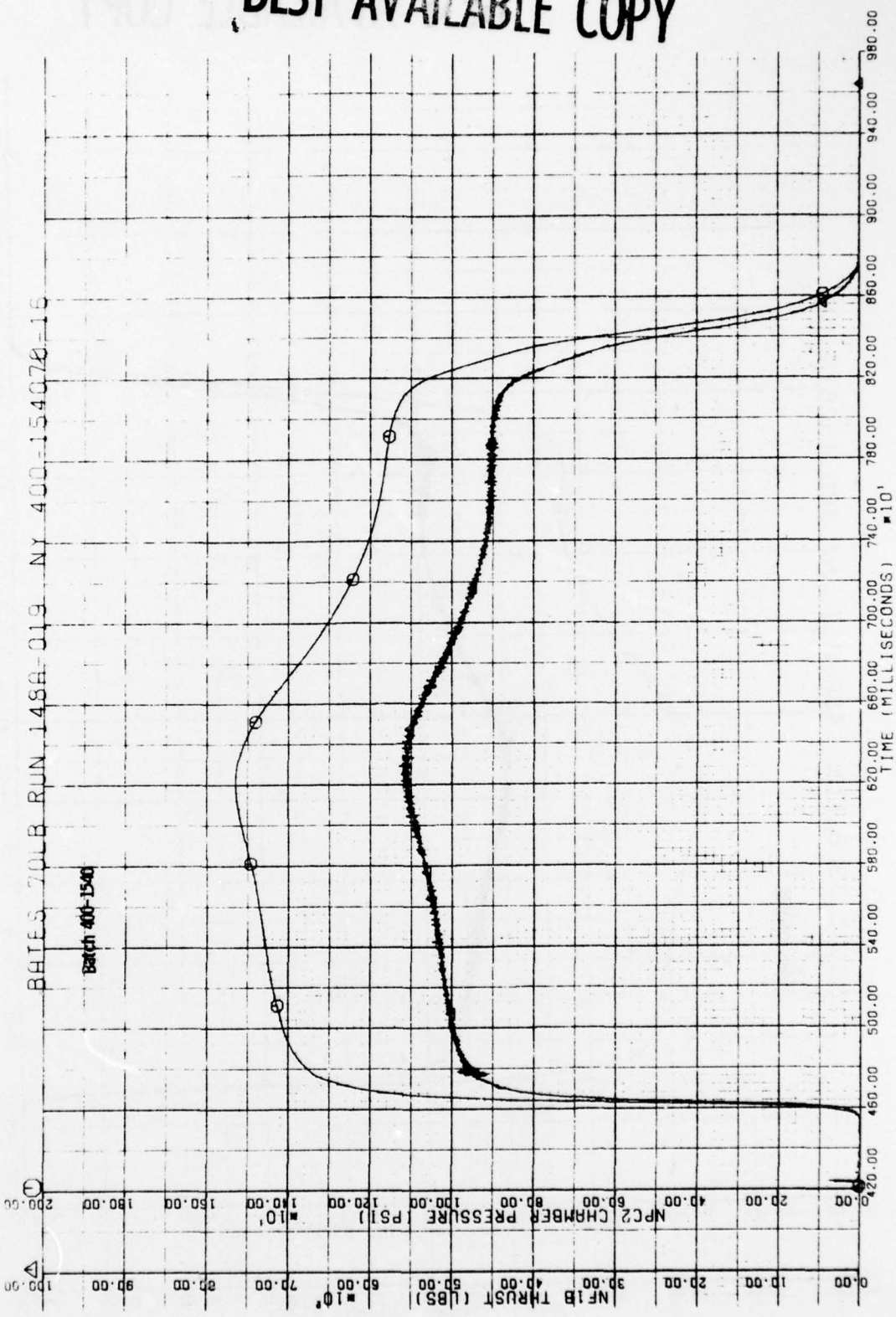

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