MHSMP-71-47-C

HE Friction Sensitivity
Oblique Impact Sensitivity of Explosives
(The Skid Test)

J. H. Van Velkinburgh

DEVELOPMENT DIVISION

APRIL - JUNE 1971
SANL 804-002

For
Lawrence Livermore Laboratory
Livermore, California

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71-47C

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This is the study of the friction sensitivity of explosives and the mechanism of frictional initiation via an apparatus which subjects a small explosive sample to shear while under a sustained normal loading force. It is also the use and study of a sensitivity test for large bare explosive charges to oblique impact and the use of a sensitivity test to determine relative shock sensitivities of small diameter explosive samples.

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Section C

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ABSTRACT

Oblique impact tests were performed on both artifically aged and unaged LX-09-0.

Oblique impact, instrumented vertical drops, and friction tests were performed on RX-25-AA.

An extensive oblique impact and instrumented vertical drop test series was performed using three compositional variations of LX-10-0.

DISCUSSION

Three specially instrumented oblique impact tests were performed this period. Instrumentation included two accelerometers on the explosive billet to measure normal and rotational acceleration plus an accelerometer attached to the impact surface and one attached to the concrete block. The accelerometers on the skid surface and block were aligned so that their active axes were parallel to the motion of the explosive billet. These tests were made to observe if there was any movement of the sanded impact surface with respect to the concrete block. Accelerometer records indicated a ringing rather than forward movement and "snap back" of the sanded surface. An observed "snap back" would have helped to explain the abnormally high rotational velocities observed during some of the instrumented oblique impact tests. Thus the super-rotation has yet to be satisfactorily explained.

Four additional instrumented oblique impact tests were done using LX-09-0 (11.8-inch diameter, 28.6 pounds). Billets artificially aged at 158 F (70 C) for 11 months and unaged billets were tested. Tests were done at an impact angle of 45° and drop heights of 2.5 feet and 3.5 feet. Results of tests are listed in Table I and plots of acceleration histories given in Figs. 1 through 8.

Friction tests and a series of oblique impact and instrumented vertical drop tests were done on RX-25-AA. Friction test results indicated a high level of sensitivity. Three tests each at 500, 1000, 2000, 4000, and 5000 pounds normal force were done. All tests gave a reaction level III (light and smoke). Oblique impact tests results bore out the high sensitivity observations. One test each at 14°, 0.88 feet and 45°, 2.5 feet were performed. Both experienced reaction level III's. Unreacted material was broken into sub-pea-gravel size and scattered 50-75 meters from the impact point. Normal and rotational acceleration histories up to the time of reaction are given in Figs. 11 through 14. Acceleration histories for two vertical drops (3 inches and 24 inches) are given in Figs. 9 and 10. Tables II and III give results of the vertical and instrumented skid tests respectively.

Instrumented oblique impact and vertical drop tests were performed using three compositional variations of LX-10-0. Material designations and nominal compositions are:

RX-04-EB	95.5/4.5 HMX/Viton
RX-04-DW	95.0/5.0 HMX/Viton
RX-04-EA	94.5/5.5 HMX/Viton

Several oblique and vertical drops used a large steel plate (10.875-inch diameter, 1.850-inch thickness, 48.67 pounds) permanently attached to the equatorial surface of the billet. Tables IV and V give pertinent test parameters and results for the vertical drop and oblique impact tests respectively. Figs. 15 through 35 give plots of the acceleration histories for these tests.

COMMENTS; CONCLUSIONS

The friction test and oblique impact test results on RX-25-AA indicate high sensitivity to frictional initiation but only moderate "explosiveness." Additional oblique impact tests are planned to determine the initiation threshold.

Several more oblique impact tests are planned for the LX-10-0 variants. Several oblique impact tests are planned for PBX 9404 using the steel plate attached to the equatorial surface.

Table I. LX-09-0 Aging Study

Oblique Impact Test Results
(45° Impact Angle)

Billet Status (aged/unaged)	Billet Weight (lbs)	Drop Height (ft)	Final Rotational Velocity (Rads/sec) (Fastax)	Coefficient of Restitution (Fastax)
Unaged	28.27	2.5	20.20	0.30
Aged	28.26	2.5	17.50	0.30
Unaged	27.90	3.5	29.00	0.34
Aged	28.24	3.5	27.60	0.34

Table II. Vertical Drop Test Results

(RX-25-AA)

Billet Weight (lbs)	Drop Height (in)	Contact Spot Diameter (in)	Coefficient of Restitution Fastax	Accelerometer
24.62	3.0	0.75	0.56	0.52
24.62	24.0	1.18	0.51	0.48

Table III. Oblique Impact Test Results

(RX-25-AA)

Billet Weight (lbs)	Height (ft)	Impact Angle (°)	
24.60	.88	14	Reaction Level 3
24.60	2.5	45	Reaction Level 3

Table IV. Vertical Drop Tests Results
(LX-10-0 Variants)

Material	Drop Height (in)	Billet Weight (lbs)	Contact Spot Diameter (in)	Coefficient of Restitution Fastax	Accelerometer	
RX-04-EA	1.5	23.55	0.66	.40-.45	.33	
RX-04-EA	3.0	23.53	0.76	.39	.34	
RX-04-EA	38.0	23.55	1.38	.48	.45	
RX-04-EB	1.5	23.55	0.64	.42	.32	
RX-04-EB	3.0	23.53	0.76	.46	.37	
RX-04-EB	36.0	23.54	1.34	.46	.38	
RX-04-DW	1.5	23.68	0.67	.42	.40	
RX-04-DW	3.0	23.56	0.75	.42	.35	
RX-04-DW	12.0	23.68	1.06	.45	.36	
RX-04-DW	36.0	23.52	1.35	.46	.37	
RX-04-DW	.75	65.90	0.65	—	.30	Steel Plate Attached
RX-04-DW	1.5	66.94	0.81	—	.345	Steel Plate Attached
RX-04-DW	3.0	67.45	1.00	.34	.26	Steel Plate Attached
RX-04-DW	12.0	68.80	1.38	.34	.24	Steel Plate Attached
RX-04-DW	36.0	67.45	1.81	—	—	Steel Plate Attached Piece Broke on Impact

Table V. Oblique Impact Test Results

(LX-10-0 Variants)

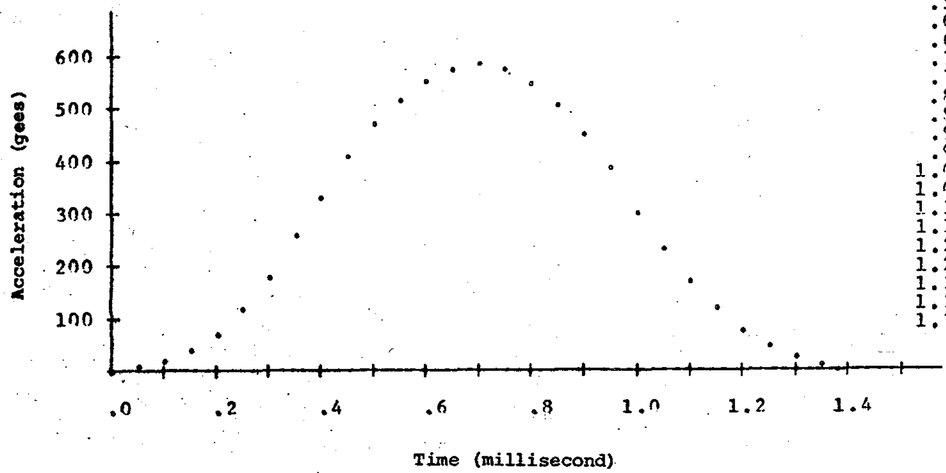
45° Impact Angle

Material	Drop Height (in)	Billet Wt. (lbs)	Final Rotational Velocity (Rads/sec) (FASTAX)	
RX-04-EA*	42	23.55	26.60	
RX-04-EA*	42	23.54	25.89	
RX-04-EB*	42	23.54	26.11	
RX-04-EB*	42	23.53	20.52	
RX-04-DW*	42	23.47	——	#6 Reaction
RX-04-DW*	120	66.66	Indeterminate	Piece broke Test on floor cover, steel plate on equator

14° Impact Angle

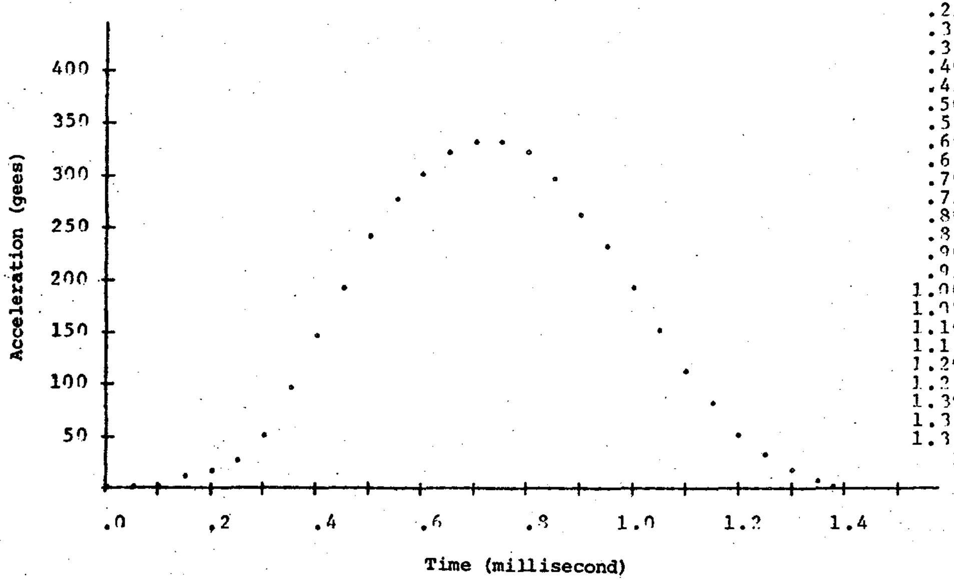
Material	Drop Height (in)	Billet Wt. (lbs)	Final Rotational Velocity (Rads/sec) (FASTAX)	
RX-04-EA*	10.5	23.51	Indeterminate	
RX-04-EA*	10.5	23.50	<6.0	
RX-04-EB*	10.5	23.53	<6.0	
RX-04-EB*	10.5	23.54	<6.0	
RX-04-DW*	10.5	23.55	<7.0	
RX-04-DW*	10.5	23.53	Indeterminate	
RX-04-DW*	5.25	68.80	<6.0	Steel Plate on Equator
RX-04-DW	7.5	70.08	——	#6 Reaction Steel Plate on Equator
RX-04-DW	60	65.83	Indeterminate	Test on floor cover, steel plate on equator

* Accelerometer record to be analyzed



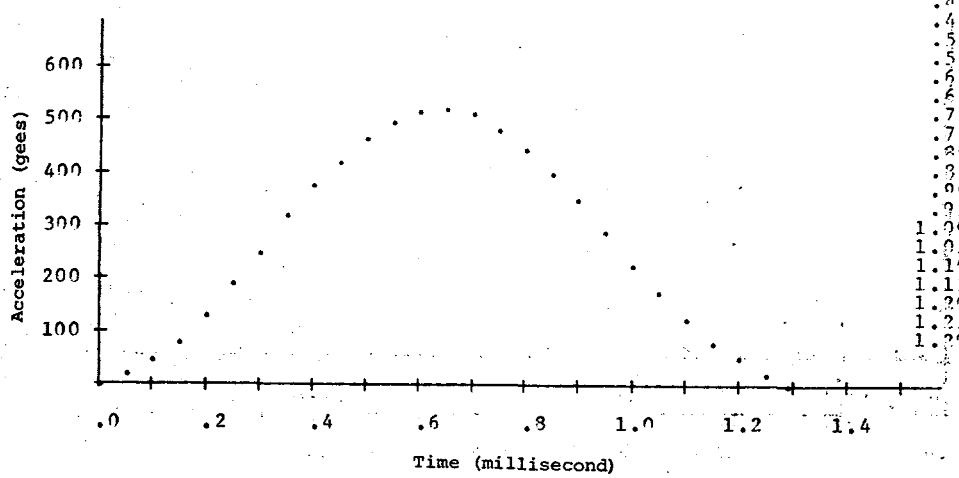
TIME	ACCELERATION
.00	.0
.05	10.0
.10	20.0
.15	40.0
.20	70.0
.25	120.0
.30	180.0
.35	260.0
.40	330.0
.45	410.0
.50	470.0
.55	515.0
.60	550.0
.65	575.0
.70	585.0
.75	575.0
.80	545.0
.85	505.0
.90	450.0
.95	385.0
1.00	300.0
1.05	230.0
1.10	170.0
1.15	120.0
1.20	75.0
1.25	45.0
1.30	25.0
1.35	10.0
1.38	.0

Fig. 1. LX-09-0 Aging Study; 2.5', 45°; Unaged Billet; Normal Acceleration



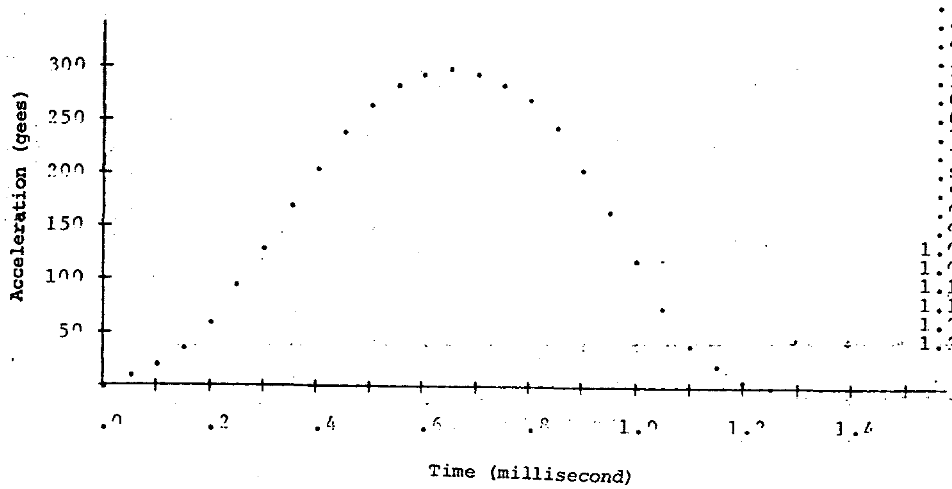
TIME	ACCELERATION
.00	.0
.05	.0
.10	.0
.15	10.0
.20	15.0
.25	25.0
.30	50.0
.35	95.0
.40	145.0
.45	190.0
.50	240.0
.55	275.0
.60	300.0
.65	320.0
.70	330.0
.75	330.0
.80	320.0
.85	295.0
.90	260.0
.95	230.0
1.00	190.0
1.05	150.0
1.10	110.0
1.15	80.0
1.20	50.0
1.25	30.0
1.30	15.0
1.35	5.0
1.38	.0

Fig. 2. LX-09-0 Aging Study; 2.5', 45°; Unaged Billet; Rotational Acceleration



TIME	ACCELERATION
.00	.0
.05	20.0
.10	45.0
.15	80.0
.20	130.0
.25	190.0
.30	250.0
.35	320.0
.40	375.0
.45	420.0
.50	465.0
.55	495.0
.60	515.0
.65	520.0
.70	510.0
.75	480.0
.80	445.0
.85	400.0
.90	350.0
.95	290.0
1.00	225.0
1.05	175.0
1.10	125.0
1.15	80.0
1.20	50.0
1.25	20.0
1.30	.0

Fig. 3. LX-09-0 Aging Study; 2.5', 45°; Aged Billet; Normal Acceleration



TIME	ACCELERATION
.00	.0
.05	10.0
.10	20.0
.15	35.0
.20	60.0
.25	95.0
.30	130.0
.35	170.0
.40	205.0
.45	240.0
.50	265.0
.55	285.0
.60	295.0
.65	300.0
.70	295.0
.75	285.0
.80	270.0
.85	245.0
.90	205.0
.95	165.0
1.00	120.0
1.05	75.0
1.10	40.0
1.15	20.0
1.20	5.0
1.25	.0

Fig. 4. LX-09-0 Aging Study; 2.5', 45°; Aged Billet; Rotational Acceleration

TIME	ACCELERATION
.00	.0
.05	25.0
.10	65.0
.15	140.0
.20	230.0
.25	325.0
.30	430.0
.35	530.0
.40	610.0
.45	670.0
.50	720.0
.55	755.0
.60	770.0
.65	760.0
.70	730.0
.75	680.0
.80	610.0
.85	525.0
.90	415.0
.95	320.0
1.00	235.0
1.05	160.0
1.10	100.0
1.15	55.0
1.20	20.0
1.25	.0

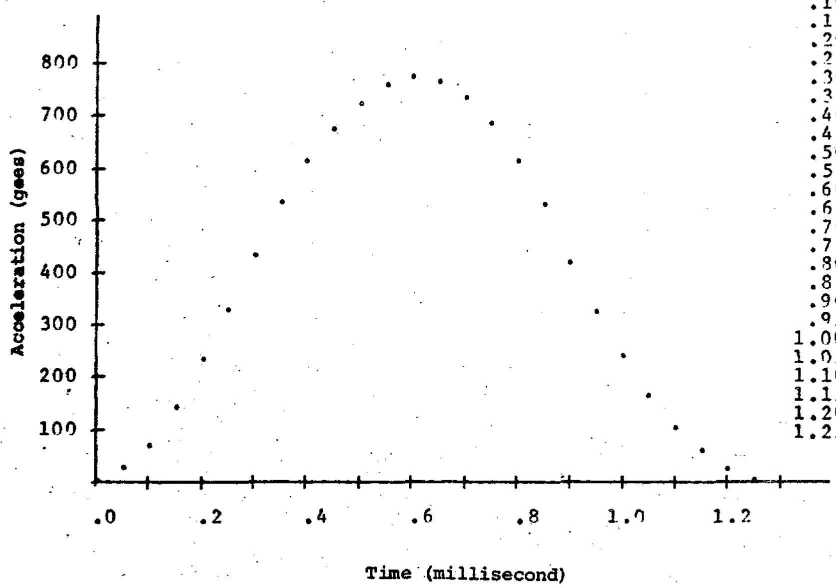


Fig. 5. LX-09-0 Aging Study; 3.5', 45°; Unaged Billet, Normal Acceleration

TIME	ACCELERATION
.00	.0
.05	.0
.10	20.0
.15	45.0
.20	90.0
.25	145.0
.30	205.0
.35	280.0
.40	340.0
.45	390.0
.50	430.0
.55	460.0
.60	480.0
.65	485.0
.70	480.0
.75	455.0
.80	415.0
.85	360.0
.90	285.0
.95	205.0
1.00	135.0
1.05	90.0
1.10	35.0
1.15	15.0
1.21	.0

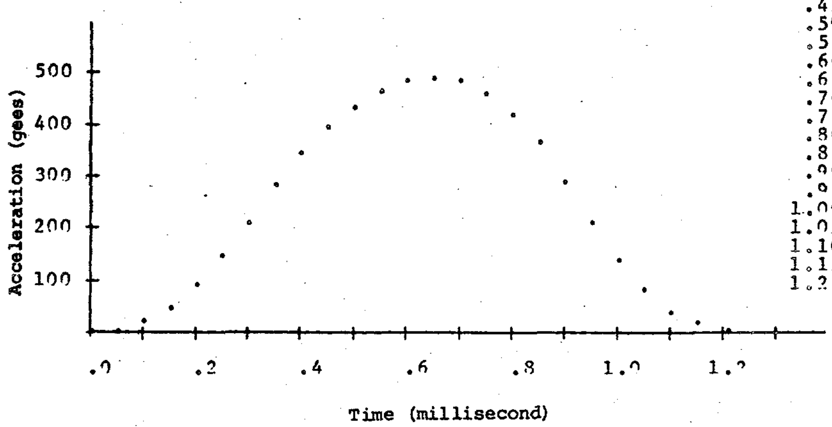
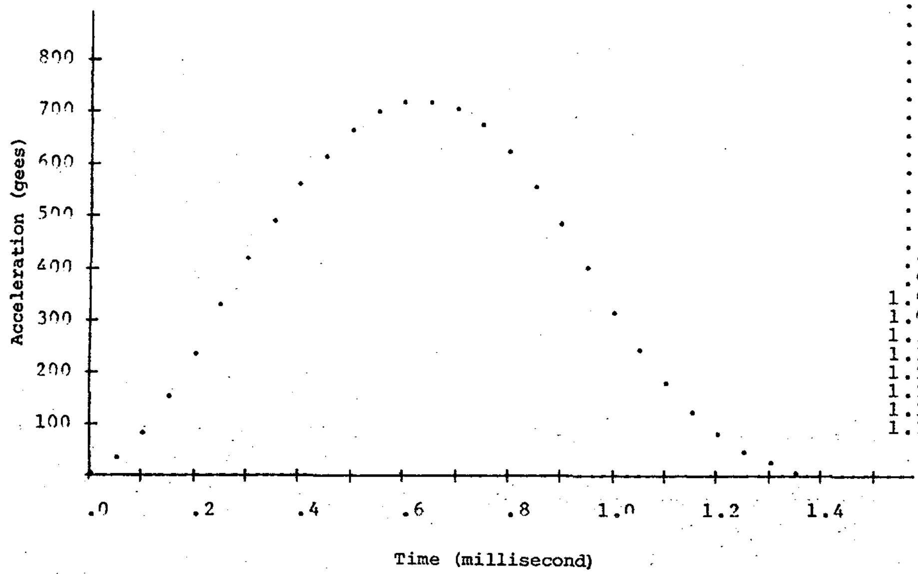
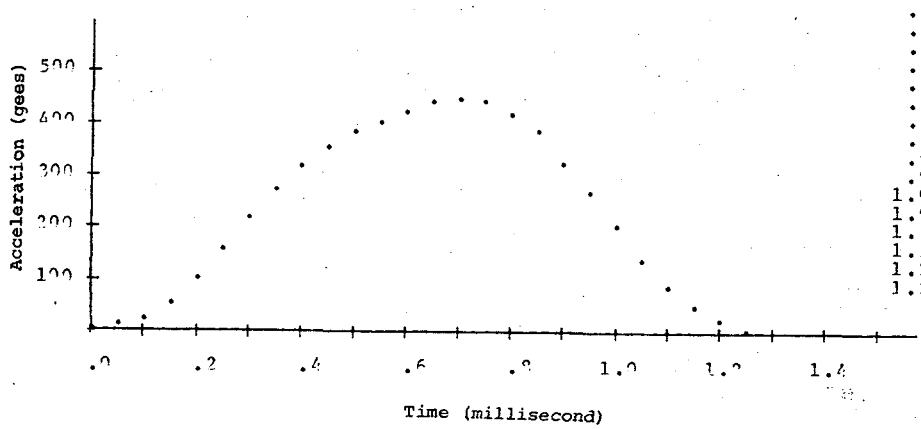


Fig. 6. LX-09-0 Aging Study; 3.5', 45°; Unaged Billet; Rotational Acceleration



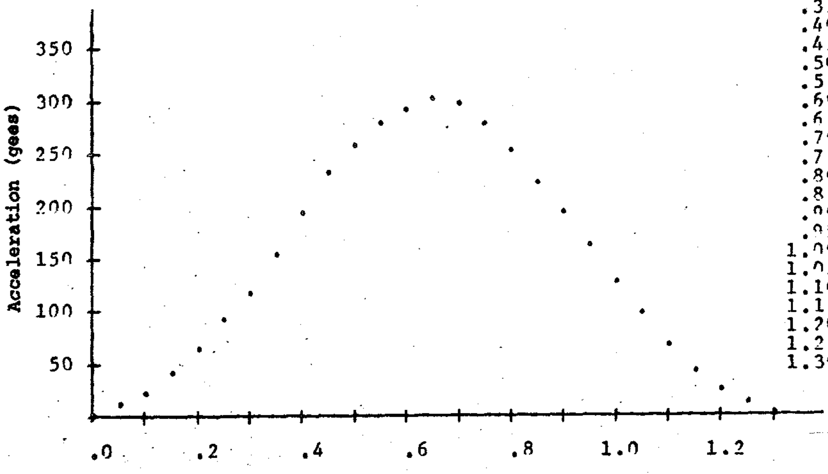
TIME	ACCELERATION
.00	.0
.05	30.0
.10	80.0
.15	150.0
.20	230.0
.25	325.0
.30	415.0
.35	485.0
.40	555.0
.45	610.0
.50	660.0
.55	695.0
.60	715.0
.65	715.0
.70	700.0
.75	670.0
.80	620.0
.85	550.0
.90	480.0
.95	395.0
1.00	310.0
1.05	240.0
1.10	175.0
1.15	120.0
1.20	75.0
1.25	40.0
1.30	20.0
1.35	.0

Fig. 7. LX-09-0 Aging Study; 3.5', 45°; Aged Billet; Normal Acceleration



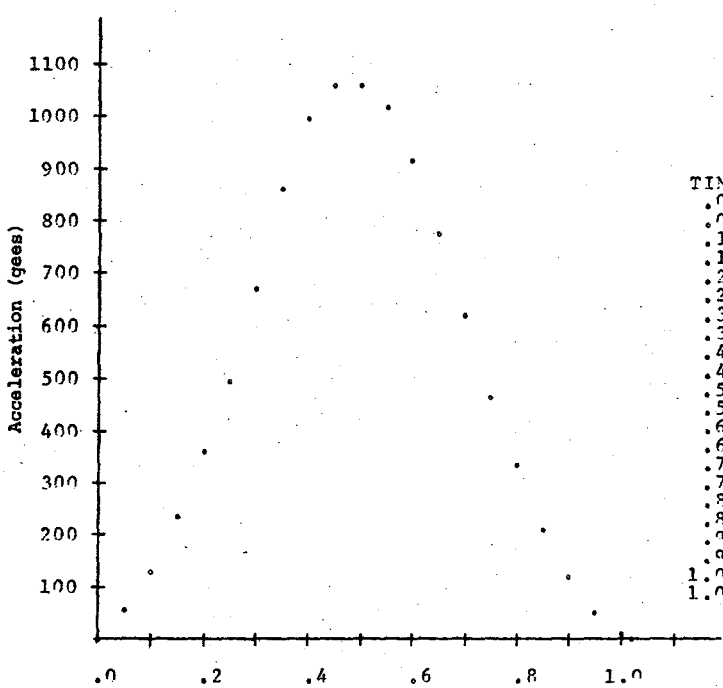
TIME	ACCELERATION
.00	.0
.05	10.0
.10	20.0
.15	50.0
.20	100.0
.25	155.0
.30	215.0
.35	270.0
.40	315.0
.45	350.0
.50	380.0
.55	400.0
.60	420.0
.65	440.0
.70	445.0
.75	440.0
.80	415.0
.85	380.0
.90	320.0
.95	265.0
1.00	200.0
1.05	135.0
1.10	85.0
1.15	45.0
1.20	20.0
1.25	.0

Fig. 8. LX-09-0 Aging Study; 3.5', 45°; Aged Billet; Rotational Acceleration



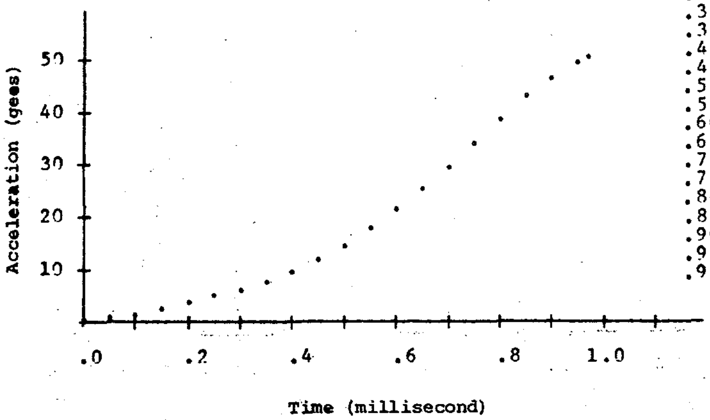
TIME	ACCELERATION
.00	.0
.05	10.0
.10	20.0
.15	40.0
.20	62.0
.25	90.0
.30	115.0
.35	153.0
.40	192.0
.45	230.0
.50	255.0
.55	277.0
.60	290.0
.65	300.0
.70	295.0
.75	275.0
.80	250.0
.85	220.0
.90	192.0
.95	160.0
1.00	125.0
1.05	95.0
1.10	65.0
1.15	40.0
1.20	22.0
1.25	10.0
1.30	.0

Fig. 9. RX-25-AA Vertical Drop; Drop Height = 3.0"; Spot Size = 0.75"



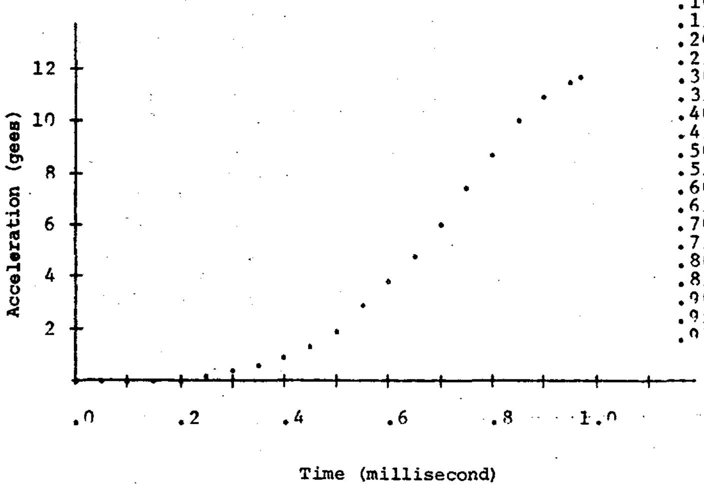
TIME	ACCELERATION
.00	.0
.05	55.0
.10	130.0
.15	235.0
.20	360.0
.25	495.0
.30	670.0
.35	860.0
.40	995.0
.45	1060.0
.50	1060.0
.55	1015.0
.60	915.0
.65	775.0
.70	620.0
.75	465.0
.80	335.0
.85	210.0
.90	120.0
.95	50.0
1.00	10.0
1.05	.0

Fig. 10. RX-25-AA Vertical Drop; Drop Height = 24.0"; Spot Size = 1.18"



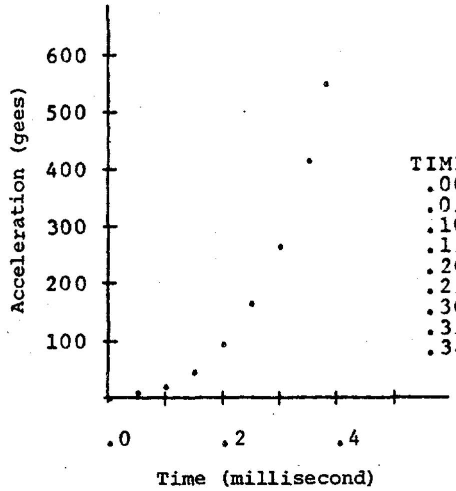
TIME	ACCELERATION
.00	.0
.05	.5
.10	1.0
.15	2.0
.20	3.2
.25	4.5
.30	5.7
.35	7.2
.40	9.1
.45	11.4
.50	14.0
.55	17.5
.60	21.2
.65	25.0
.70	29.0
.75	33.5
.80	38.0
.85	42.7
.90	46.0
.95	49.0
.97	50.0

Fig. 11. RX-25-AA Oblique Impact Test; 0.88', 14°; Normal Acceleration; Reaction at 0.97 millisecond



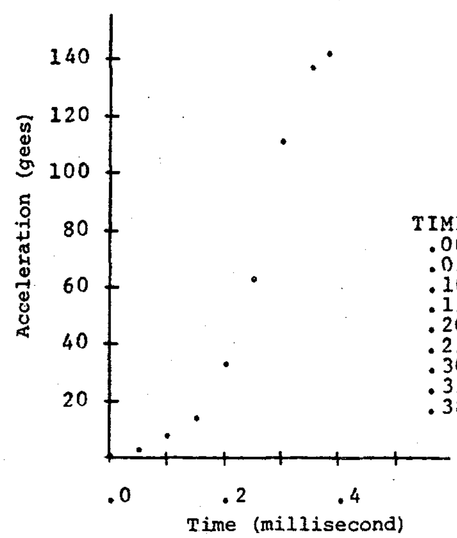
TIME	ACCELERATION
.00	.0
.05	.0
.10	.0
.15	.0
.20	.0
.25	.2
.30	.4
.35	.6
.40	.9
.45	1.3
.50	1.9
.55	2.9
.60	3.8
.65	4.8
.70	6.0
.75	7.4
.80	8.7
.85	10.0
.90	10.9
.95	11.5
.97	11.7

Fig. 12. RX-25-AA Oblique Impact Test; 0.88' 14°; Rotational Acceleration; Reaction at 0.97 millisecond



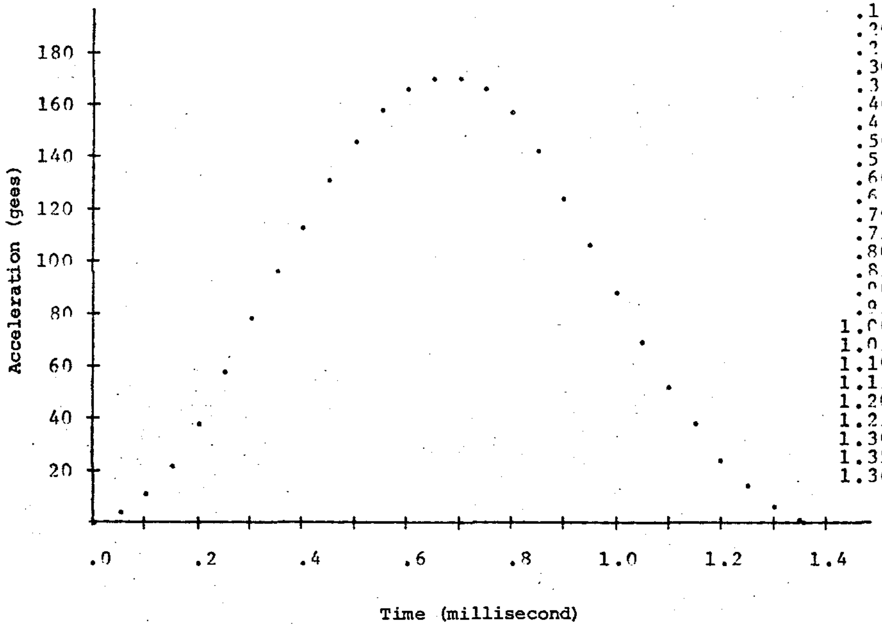
TIME	ACCELERATION
.00	.0
.05	10.0
.10	20.0
.15	45.0
.20	95.0
.25	165.0
.30	265.0
.35	415.0
.38	548.0

Fig. 13. RX-25-AA 2.5', 45°; Reaction Level 3 at ∿ 0.38 millisecond, Normal Acceleration



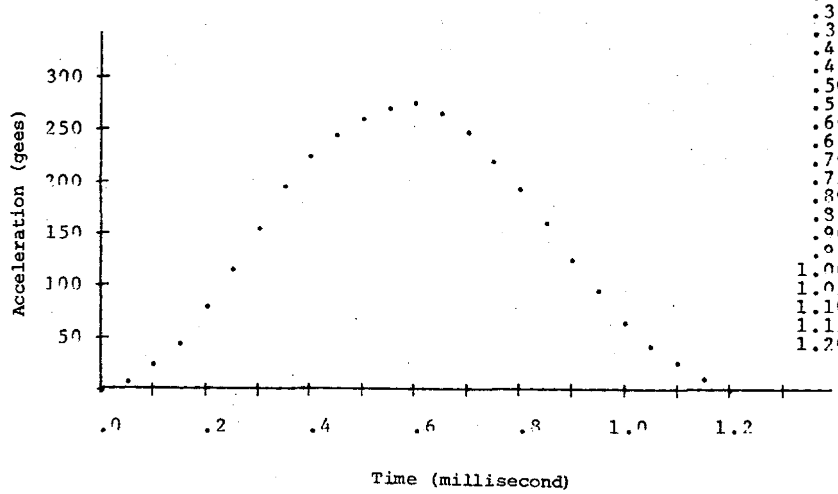
TIME	ACCELERATION
.00	.0
.05	2.0
.10	7.0
.15	13.0
.20	32.0
.25	62.0
.30	110.0
.35	136.0
.38	141.0

Fig. 14. RX-25-AA 2.5', 45°; Reaction Level 3 at ∿ 0.38 millisecond, Rotational Acceleration



TIME	ACCELERATION
.00	.0
.05	4.0
.10	11.0
.15	22.0
.20	38.0
.25	58.0
.30	78.0
.35	96.0
.40	113.0
.45	131.0
.50	146.0
.55	158.0
.60	166.0
.65	170.0
.70	170.0
.75	166.0
.80	157.0
.85	142.0
.90	124.0
.95	106.0
1.00	88.0
1.05	69.0
1.10	52.0
1.15	38.0
1.20	24.0
1.25	14.0
1.30	6.0
1.35	1.0
1.36	.0

Fig. 15. RX-04-EA Vertical Drop; Drop Height = 1.5"; Spot Size = 0.66"



TIME	ACCELERATION
.00	.0
.05	8.0
.10	24.0
.15	45.0
.20	80.0
.25	116.0
.30	155.0
.35	195.0
.40	225.0
.45	245.0
.50	260.0
.55	270.0
.60	275.0
.65	265.0
.70	248.0
.75	220.0
.80	193.0
.85	160.0
.90	125.0
.95	95.0
1.00	65.0
1.05	42.0
1.10	25.0
1.15	10.0
1.20	.0

Fig. 16. RX-04-EA Vertical Drop; Drop Height = 3.0"; Spot Size = 0.76"

TIME	ACCELERATION
.00	.0
.05	15.0
.10	50.0
.15	150.0
.20	325.0
.25	515.0
.30	700.0
.35	890.0
.40	1060.0
.45	1240.0
.50	1360.0
.55	1370.0
.60	1280.0
.65	1140.0
.70	955.0
.75	720.0
.80	500.0
.85	320.0
.90	175.0
.95	95.0
1.00	30.0
1.05	5.0
1.07	.0

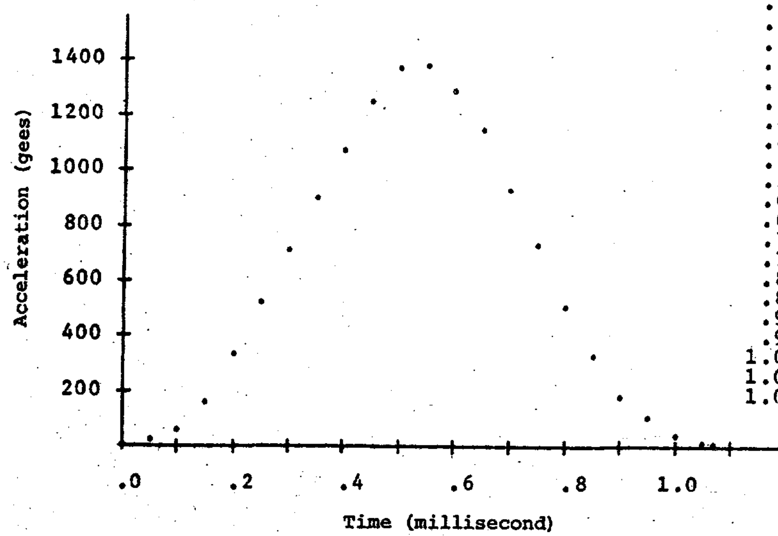


Fig. 17. RX-04-EA 38" Vertical Drop

TIME	ACCELERATION
.00	.0
.05	3.0
.10	10.0
.15	20.0
.20	39.0
.25	57.0
.30	78.0
.35	98.0
.40	122.0
.45	142.0
.50	160.0
.55	171.0
.60	178.0
.65	181.0
.70	178.0
.75	167.0
.80	153.0
.85	136.0
.90	118.0
.95	96.0
1.00	75.0
1.05	56.0
1.10	39.0
1.15	24.0
1.20	14.0
1.25	7.0
1.30	1.0
1.32	.0

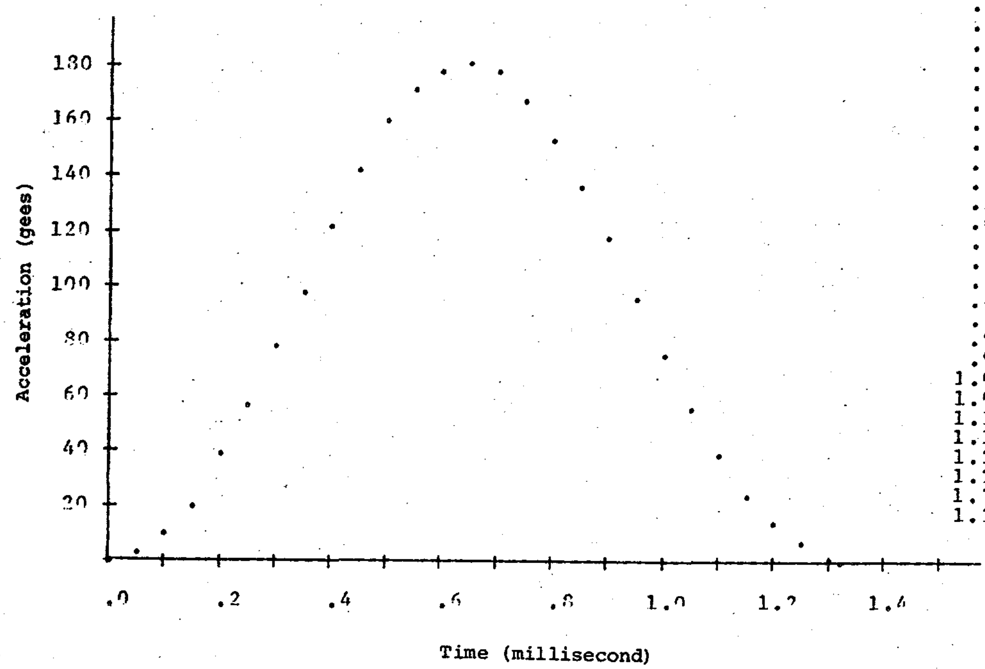
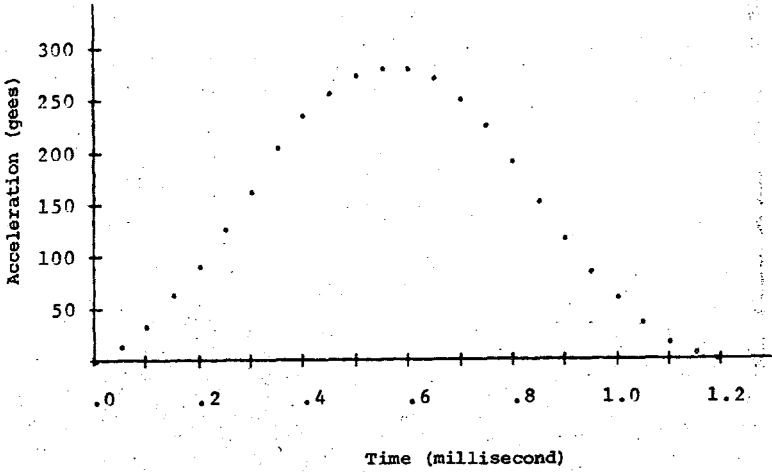
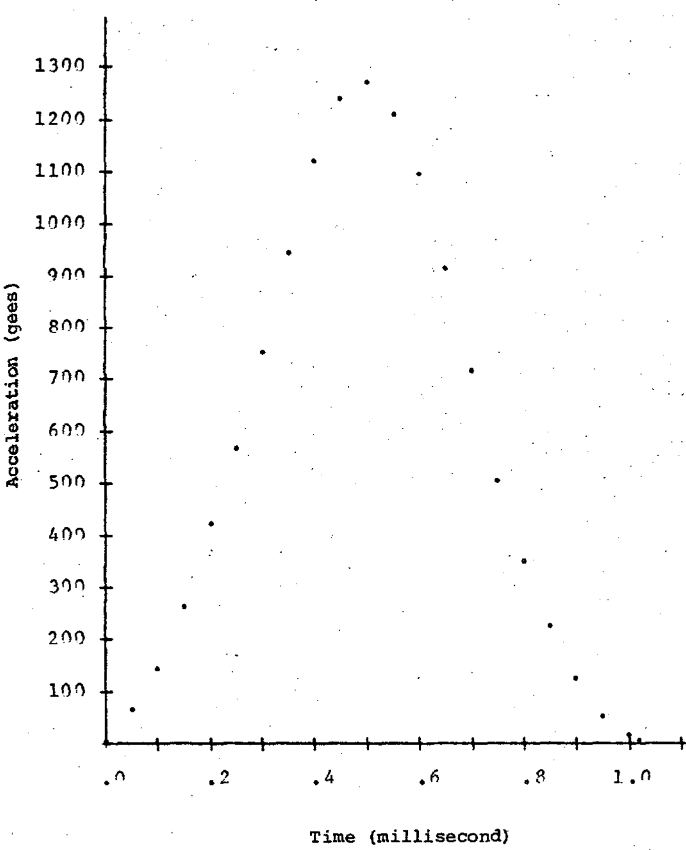


Fig. 18. RX-04-EB Vertical Drop; Drop Height = 1.5"; Spot Size = 0.64"



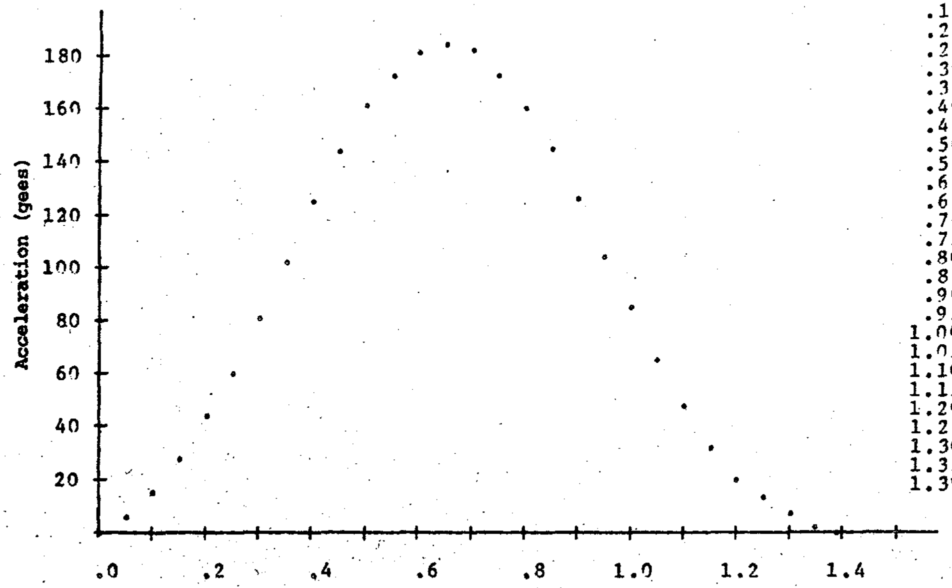
TIME	ACCELERATION
.00	.0
.05	14.0
.10	33.0
.15	64.0
.20	92.0
.25	127.0
.30	163.0
.35	204.0
.40	235.0
.45	257.0
.50	273.0
.55	280.0
.60	280.0
.65	270.0
.70	250.0
.75	225.0
.80	190.0
.85	152.0
.90	117.0
.95	85.0
1.00	60.0
1.05	35.0
1.10	17.0
1.15	6.0
1.19	.0

Fig. 19. RX-04-EB Vertical Drop; Drop Height = 3.0"; Spot Size = 0.76"



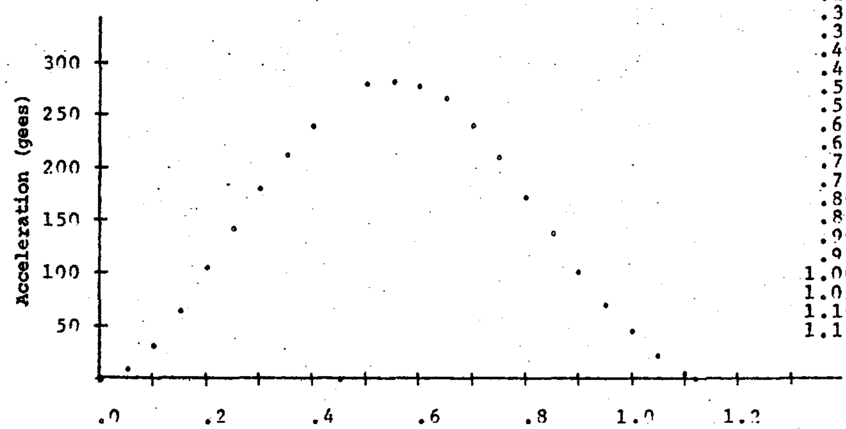
TIME	ACCELERATION
.00	.0
.05	60.0
.10	140.0
.15	260.0
.20	420.0
.25	565.0
.30	750.0
.35	940.0
.40	1115.0
.45	1235.0
.50	1265.0
.55	1205.0
.60	1090.0
.65	910.0
.70	710.0
.75	500.0
.80	345.0
.85	220.0
.90	120.0
.95	45.0
1.00	10.0
1.02	.0

Fig. 20. RX-04-EB Vertical Drop; Drop Height = 36"; Spot Size = 1.34"



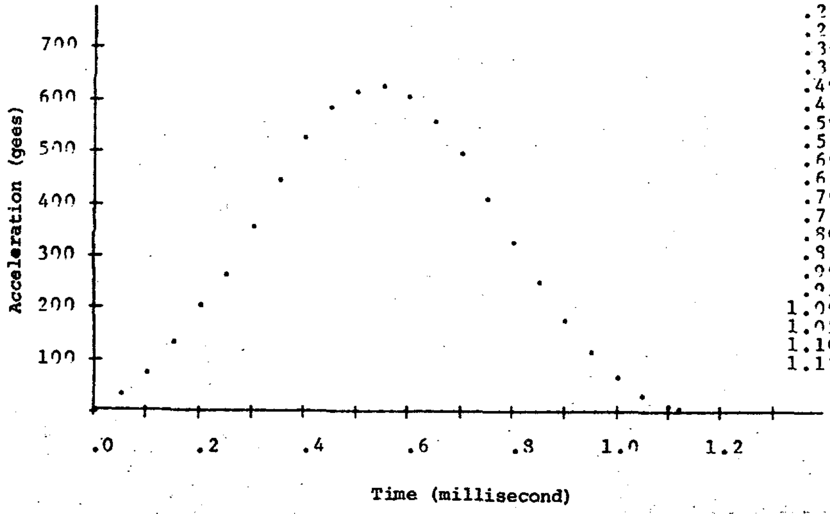
TIME	ACCELERATION
.00	.0
.05	6.0
.10	15.0
.15	28.0
.20	44.0
.25	60.0
.30	81.0
.35	102.0
.40	125.0
.45	144.0
.50	161.0
.55	172.0
.60	181.0
.65	184.0
.70	182.0
.75	172.0
.80	160.0
.85	145.0
.90	126.0
.95	104.0
1.00	85.0
1.05	65.0
1.10	48.0
1.15	32.0
1.20	20.0
1.25	13.0
1.30	7.0
1.35	2.0
1.39	.0

Fig. 21. RX-04-DW Vertical Drop; Drop Height = 1.5"; Spot Size = 0.67"



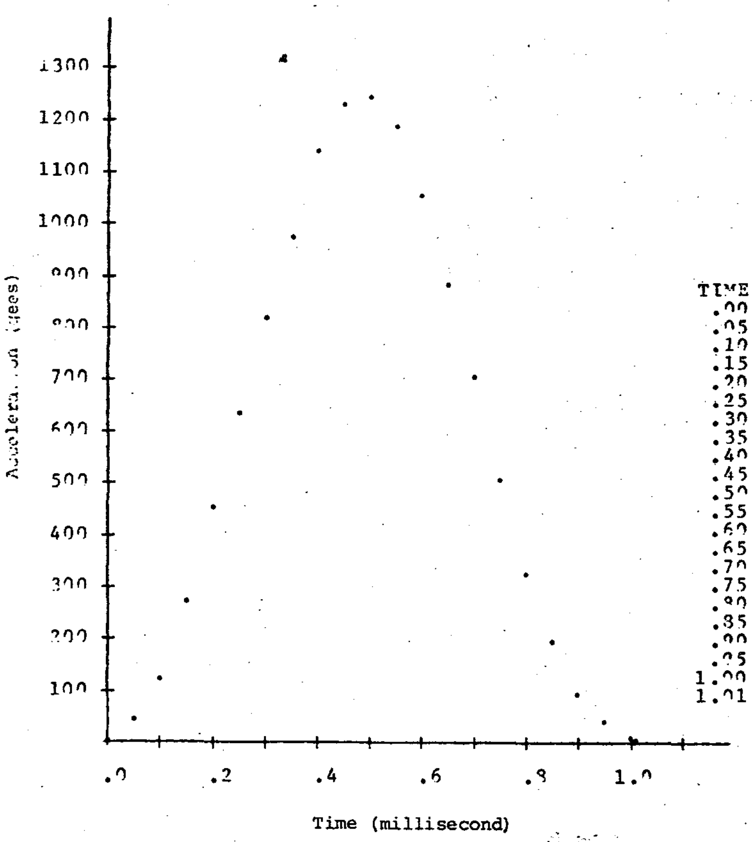
TIME	ACCELERATION
.00	.0
.05	10.0
.10	32.0
.15	65.0
.20	105.0
.25	142.0
.30	180.0
.35	212.0
.40	240.0
.45	265.0
.50	280.0
.55	282.0
.60	277.0
.65	265.0
.70	240.0
.75	210.0
.80	172.0
.85	137.0
.90	100.0
.95	70.0
1.00	45.0
1.05	22.0
1.10	5.0
1.12	.0

Fig. 22. RX-04-DW Vertical Drop; Drop Height = 3.0"; Spot Size = 0.75"



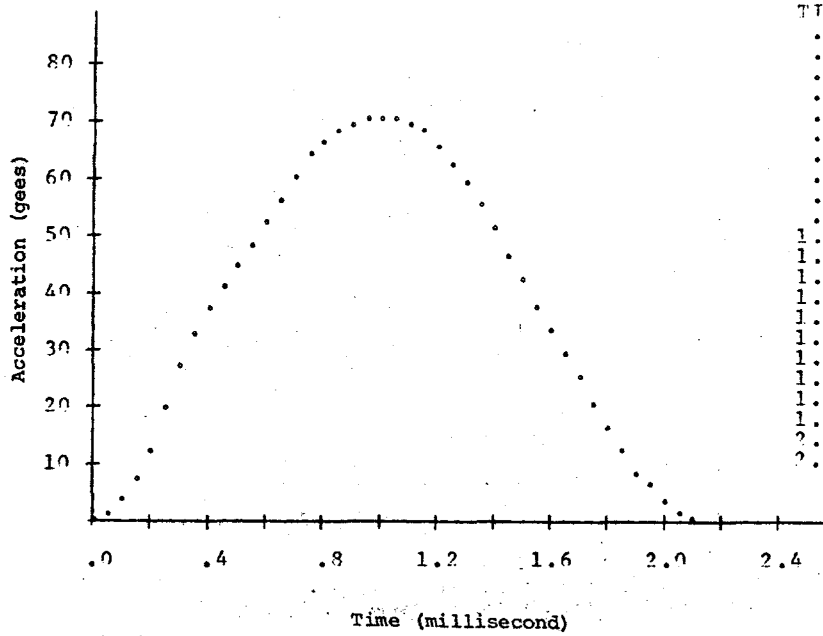
TIME	ACCELERATION
.00	.0
.05	30.0
.10	70.0
.15	130.0
.20	200.0
.25	260.0
.30	350.0
.35	440.0
.40	520.0
.45	580.0
.50	610.0
.55	620.0
.60	600.0
.65	550.0
.70	490.0
.75	405.0
.80	320.0
.85	245.0
.90	170.0
.95	110.0
1.00	60.0
1.05	25.0
1.10	5.0
1.12	.0

Fig. 23. RX-04-DW Vertical Drop; Drop Height = 12.0"; Spot Size = 1.06"



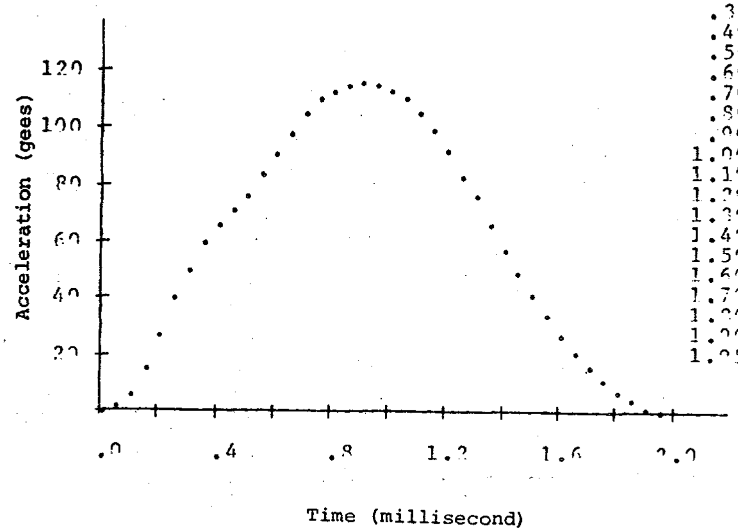
TIME	ACCELERATION
.00	.0
.05	40.0
.10	120.0
.15	270.0
.20	450.0
.25	630.0
.30	815.0
.35	970.0
.40	1135.0
.45	1225.0
.50	1240.0
.55	1180.0
.60	1050.0
.65	880.0
.70	700.0
.75	500.0
.80	320.0
.85	190.0
.90	90.0
.95	35.0
1.00	5.0
1.01	.0

Fig. 24. RX-04-DW Vertical Drop; Drop Height = 36.0"; Spot Size = 1.35"



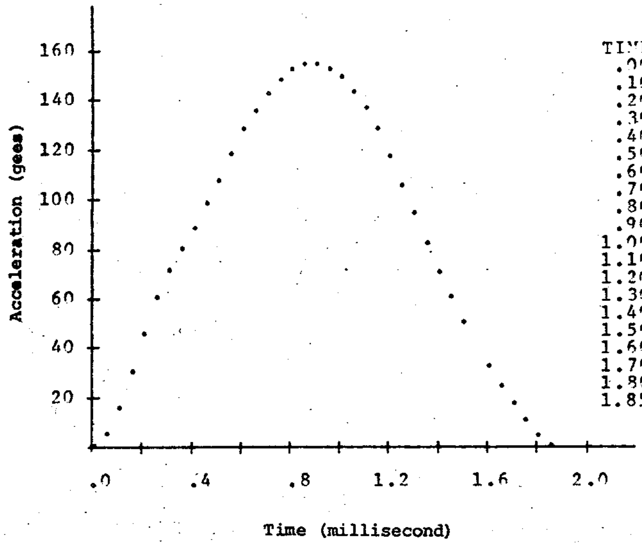
TIME	ACCELERATION
.00	.0
.10	3.5
.20	12.0
.30	27.0
.40	37.0
.50	44.5
.60	52.0
.70	60.0
.80	66.0
.90	69.0
1.00	70.0
1.10	69.0
1.20	65.0
1.30	59.0
1.40	51.0
1.50	42.0
1.60	33.0
1.70	25.0
1.80	16.0
1.90	8.0
2.00	3.0
2.10	.0

Fig. 25. RX-04-DW Vertical Drop; Drop Height = 0.75"; Spot Size = 0.65"; Steel Plate on Equator



TIME	ACCELERATION
.00	.0
.10	6.0
.20	27.0
.30	50.0
.40	66.0
.50	76.0
.60	91.0
.70	105.0
.80	113.0
.90	116.0
1.00	113.0
1.10	105.0
1.20	[illegible]
1.30	76.0
1.40	57.0
1.50	41.0
1.60	27.0
1.70	16.0
1.80	7.0
1.90	1.0
1.95	.0

Fig. 26. RX-04-DW Vertical Drop; Drop Height = 1.5"; Spot Size = 0.81"; Steel Plate on Equator



TIME	ACCELERATION
.00	.0
.10	15.0
.20	45.0
.30	71.0
.40	88.0
.50	107.0
.60	128.0
.70	142.0
.80	152.0
.90	154.0
1.00	149.0
1.10	136.0
1.20	117.0
1.30	94.0
1.40	70.0
1.50	50.0
1.60	32.0
1.70	17.0
1.80	4.0
1.85	.0

Fig. 27. RX-04-DW Vertical Drop; Drop Height = 3.0"; Spot Size = 1.00"; Steel Plate on Equator

TIME	ACCELERATION
.00	.0
.05	7.0
.10	26.0
.15	57.0
.20	92.0
.25	126.0
.30	163.0
.35	185.0
.40	205.0
.45	230.0
.50	255.0
.55	280.0
.60	300.0
.65	315.0
.70	330.0
.75	335.0
.80	340.0
.85	337.0
.90	332.0
.95	323.0
1.00	305.0
1.05	285.0
1.10	262.0
1.15	230.0
1.20	200.0
1.25	160.0
1.30	140.0
1.35	110.0
1.40	87.0
1.45	65.0
1.50	50.0
1.55	35.0
1.60	20.0
1.65	6.0
1.69	.0

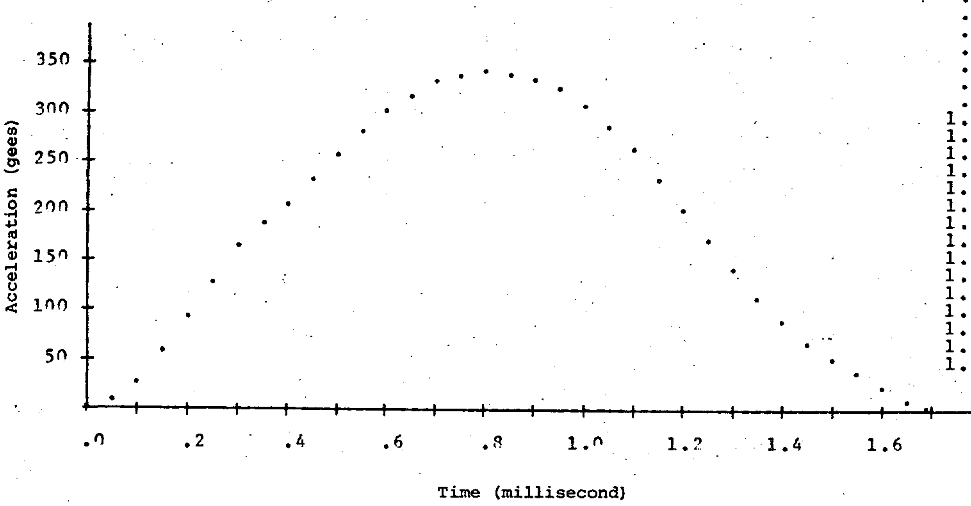
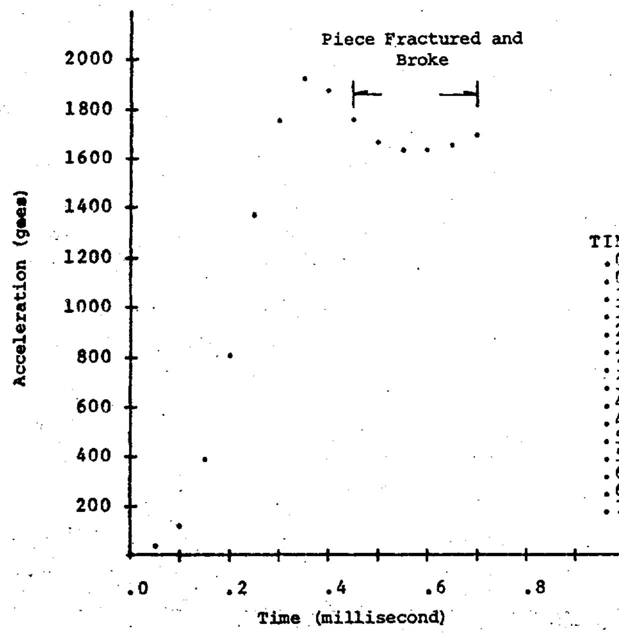
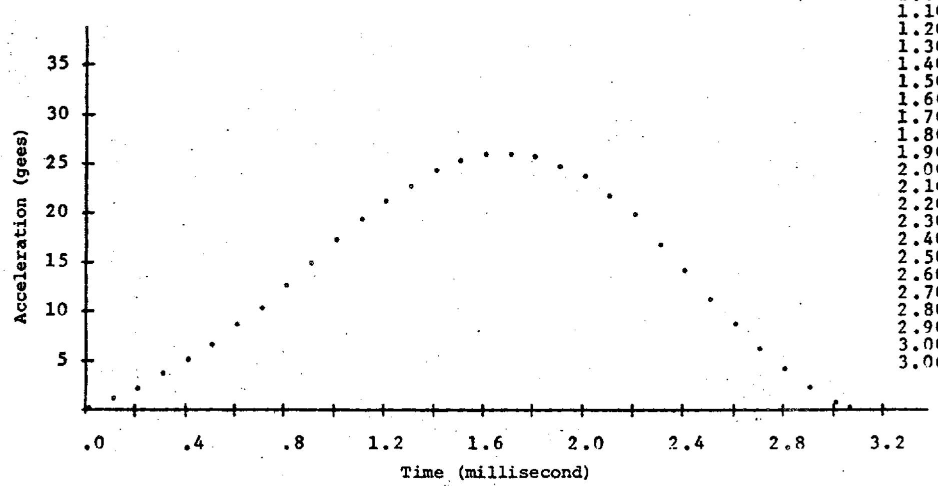


Fig. 28. RX-04-DW Vertical Drop; Drop Height = 12.0"; Spot Size = 1.38"; Steel Plate on Equator



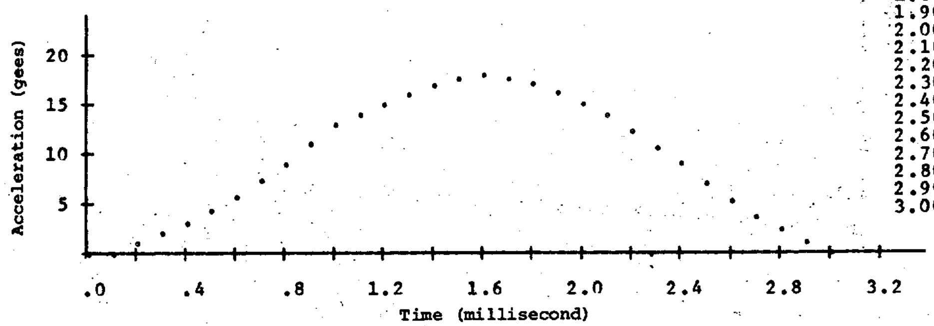
TIME	ACCELERATION
.00	.0
.05	30.0
.10	110.0
.15	380.0
.20	800.0
.25	1360.0
.30	1740.0
.35	1910.0
.40	1860.0
.45	1740.0
.50	1650.0
.55	1620.0
.60	1620.0
.65	1640.0
.70	1680.0

Fig. 29. RX-04-DW 50-lb Plate on Equator 36" Vertical Drop



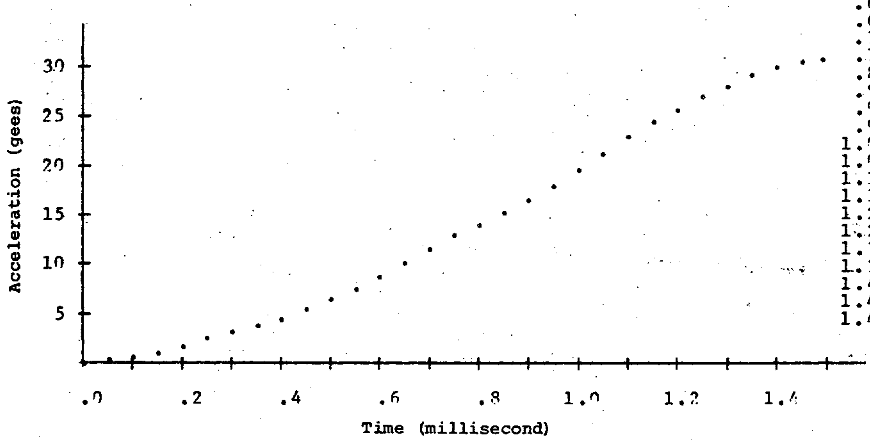
TIME	ACCELERATION
.00	.0
.10	1.0
.20	2.0
.30	3.5
.40	5.0
.50	6.5
.60	8.5
.70	10.2
.80	12.5
.90	14.7
1.00	17.0
1.10	19.0
1.20	21.0
1.30	22.5
1.40	24.1
1.50	25.1
1.60	25.8
1.70	25.8
1.80	25.5
1.90	24.5
2.00	23.5
2.10	21.5
2.20	19.5
2.30	16.5
2.40	14.0
2.50	11.0
2.60	8.5
2.70	6.0
2.80	4.0
2.90	2.0
3.00	.5
3.06	.0

Fig. 30. RX-04-DW 50-lb Plate on Equator 0.44', 45°, Normal Acceleration



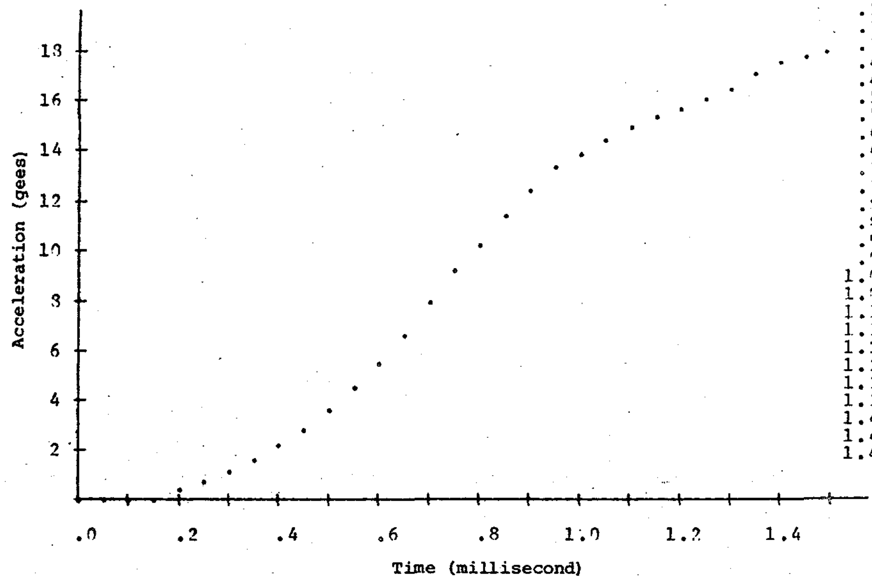
TIME	ACCELERATION
.00	.0
.10	.0
.20	1.0
.30	2.0
.40	3.0
.50	4.3
.60	5.7
.70	7.4
.80	9.0
.90	11.0
1.00	13.0
1.10	14.0
1.20	15.0
1.30	16.0
1.40	16.9
1.50	17.5
1.60	17.9
1.70	17.5
1.80	17.0
1.90	16.1
2.00	15.0
2.10	13.8
2.20	12.2
2.30	10.5
2.40	9.0
2.50	7.0
2.60	5.2
2.70	3.6
2.80	2.3
2.90	1.0
3.00	.0

Fig. 31. RX-04-DW 50-lb Plate on Equator 0.44', 14°, Rotational Acceleration



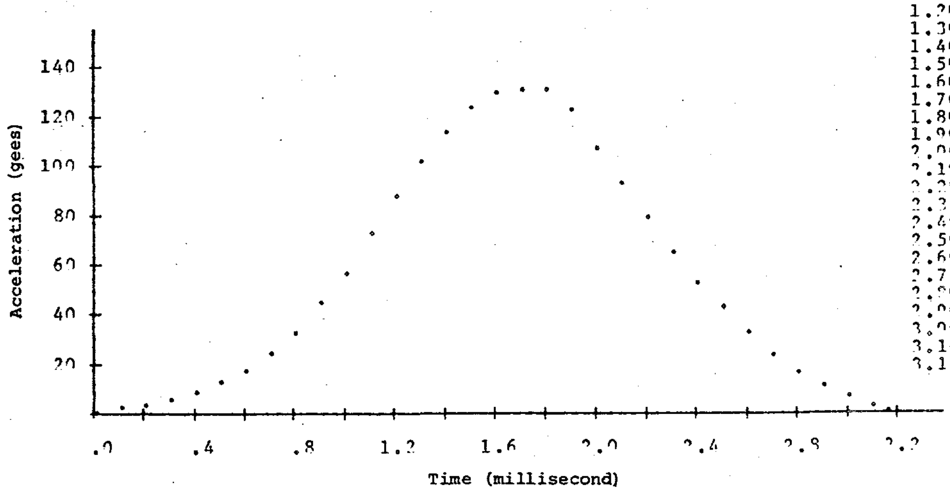
TIME	ACCELERATION	
.00	.0	
.05	.4	
.10	.6	
.15	1.0	
.20	1.6	
.25	2.5	
.30	3.2	
.35	3.8	
.40	4.5	
.45	5.5	
.50	6.5	
.55	7.5	
.60	8.7	
.65	10.1	
.70	11.6	
.75	12.9	
.80	14.0	
.95	15.3	
.90	16.5	
.95	17.9	
1.00	19.5	
1.05	21.2	
1.10	23.0	
1.15	24.5	
1.20	25.7	
1.25	27.0	
1.30	28.1	
1.35	29.2	
1.40	30.0	
1.45	30.5	
1.49	30.7	Detonation

Fig. 32. RX-04-DW 50-lb Plate on Equator 0.62', 14°, Normal Acceleration



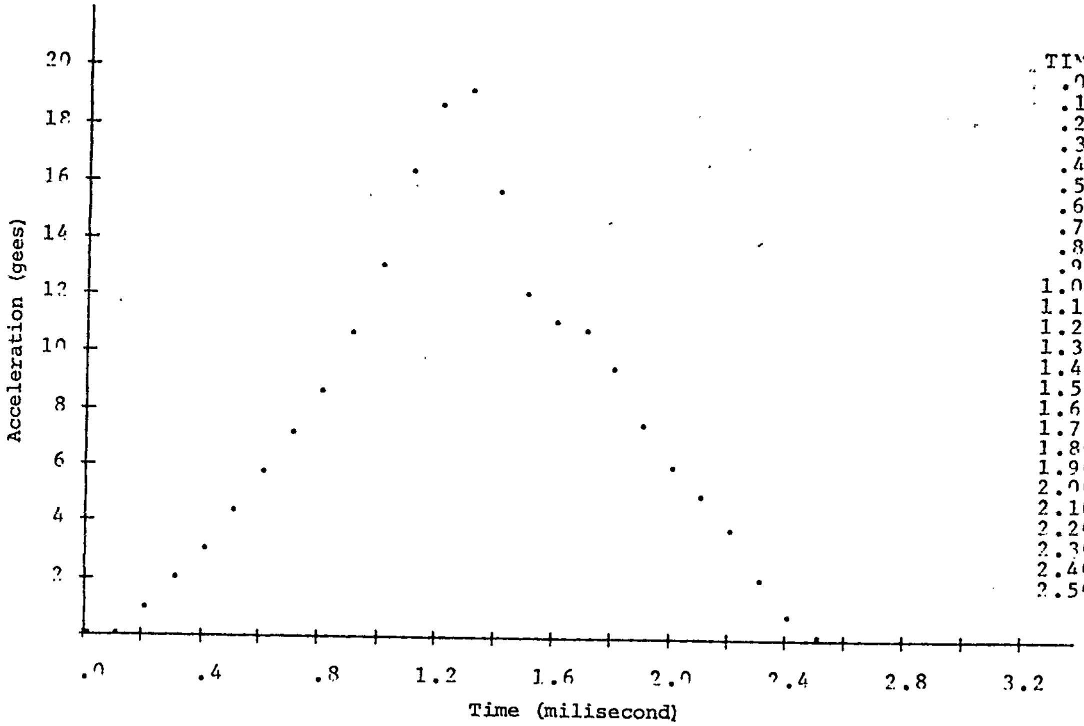
TIME	ACCELERATION
.00	.0
.05	.0
.10	.0
.15	.0
.20	.4
.25	.7
.30	1.1
.35	1.6
.40	2.2
.45	2.8
.50	3.6
.55	4.5
.60	5.5
.65	6.6
.70	7.9
.75	9.2
.80	10.2
.85	11.4
.90	12.4
.95	13.3
1.00	13.8
1.05	14.4
1.10	14.9
1.15	15.3
1.20	15.6
1.25	16.0
1.30	16.4
1.35	17.0
1.40	17.5
1.45	17.7
1.49	17.9 **Detonation**

Fig. 33. RX-04-DW 50-lb Plate on Equator 0.62', 14°, Rotational Acceleration



TIME	ACCELERATION
.00	.0
.10	2.0
.20	3.0
.30	5.0
.40	8.0
.50	12.0
.60	17.0
.70	24.0
.80	32.0
.90	44.0
1.00	56.0
1.10	72.0
1.20	87.0
1.30	101.0
1.40	113.0
1.50	123.0
1.60	129.0
1.70	130.0
1.80	130.0
1.90	122.0
2.00	106.0
2.10	92.0
2.20	78.0
2.30	64.0
2.40	52.0
2.50	42.0
2.60	32.0
2.70	23.0
2.80	16.0
2.90	10.0
3.00	6.0
3.10	[illegible]
3.16	.0

Fig. 34. RX-04-DW 50-lb Plate on Equator 5', 14°, Normal Acceleration



TIME	ACCELERATION
.00	.0
.10	.0
.20	.9
.30	2.0
.40	3.0
.50	4.3
.60	5.7
.70	7.1
.80	8.6
.90	10.6
1.00	13.0
1.10	16.3
1.20	18.6
1.30	19.1
1.40	15.6
1.50	12.0
1.60	11.0
1.70	10.7
1.80	9.4
1.90	7.4
2.00	5.9
2.10	4.9
2.20	3.7
2.30	2.0
2.40	.7
2.50	.0

Fig. 35. RX-04-DW 50-lb Plate on equator 5', 14°, Rotational Acceleration

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