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Report No. 10

**SENSITIVITY OF CASED EXPLOSIVE
MATERIALS TO IMPACT BY
REGULAR FRAGMENTS (U)**

Contract No. DA-19-020-ORD-5617

PA Control No. PA-AG-62-1

Prepared by

Arthur D. Little, Inc.
Cambridge, Mass.

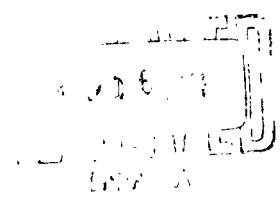
For

Commanding Officer
Picatinny Arsenal
Dover, New Jersey

31 December 1962

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A R T H U R D . L I T T L E , I N C .



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ABSTRACT

This is the tenth in a series of monthly reports on an experimental program dealing with the sensitivity of certain cased explosives and propellants to impact by regular fragments. The program is designed to aid in determining a more realistic quantity-distance relationship for the storage of Ordnance explosive material. It is the intent of this project, through an experimental program, to establish a limiting fragment mass vs impact velocity relationship for the detonation of certain explosives and/or propellants enclosed in casings of different thicknesses.

SENSITIVITY OF CASED EXPLOSIVE MATERIALS TO
IMPACT BY REGULAR FRAGMENTS (U)

Introduction

This is the tenth progress report on an experimental program covering the progress conducted under Contract DA-19-020-ORD-5617 for Picatinny Arsenal. This report covers the period from 30 November to 28 December 1962. The objective of the program is to determine the sensitivity of certain cased explosives and propellants to impact by regular fragments. A technique of explosive fragment acceleration is being used to cover the range of velocities of interest. No firings into receiver charges were conducted during the report period. Considerable effort was devoted to obtaining high speed photographs of fragments in flight. Evaluation of the results are not complete but preliminary work has indicated that fragment velocities were lower than had been previously recorded.

A change in technique has resulted in photographing fragment velocities from 6000 ft/sec to 1700 ft/sec (recorded both by high speed camera and aluminum make screens) for fragments weighing from 1.0 oz to 2.9 oz respectively. These fragments were explosively propelled using a metal surround, rather than plaster. The pictures show the fragment traveling ahead of the debris. Recovered fragments show minimum damage and no loss of weight. Evaluation of results will not be completed until additional test firings of lower weight fragments are made. These firings are scheduled for the third of January 1963.

Test Technique Evaluation

Fragment velocities achieved in previous firings were evaluated by repeating tests and using an independent velocity measuring device. In addition, an

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improved method of explosively launching the fragments was developed.

Velocities Achieved in Past Firings

A total of 8 firings were made with plaster cast fragments. Velocity was measured both by high speed camera and by aluminum make screens as used previously. The results are shown in Table I and can be summarized as follows.

- a. The actual fragment velocity was less than that indicated by the aluminum make screens.
- b. The plaster surround and/or metal spalled from the fragment was causing false velocity readings.
- c. The fragments in some instances were following the plaster debris.
- d. The triggering circuit using a twisted wire ion probe for starting the counters was satisfactory.

In terms of velocities of fragments fired at receiver charges it has been determined that maximum velocities achieved with different fragments are those in Table II. The number of firings at these maximum velocities are also presented. These firings provide data points in the region of the boundary velocity curves of Picatinny Arsenal's Report No. C70596 Report No. 2 and will serve to confirm the curves when additional, higher velocity firings are made.

Development of Improved Fragment Acceleration

The data obtained from the above firings established that higher velocities than achieved by the techniques used to date will be required. Improvements are also necessary to insure accurate velocity measurements with velocity screens.

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Metal was substituted for the plaster surround and firings made to determine combination of fragment and lucite buffer plate thickness (between fragment and explosive) that would provide the highest velocity without fragment damage (Figure 1). The results of these tests are given in Table IIIa. No velocity measurements were made.

The results of these tests were used to evaluate fragment velocities attainable (for a 4 in charge) with metal surround. Data was recorded by velocity screens and high speed camera. Results of these tests are given in Table IIIb.

It was found that

- a. Metal surround does not trigger screens.
- b. Velocity screens adequately record velocity of fragment.
- c. Heavy fragments (1" x 1" x 1/4" thick weighing approximately 1.1 oz) can be fired at nearly 6000 ft/sec.

The third series of firings (scheduled for 3 January 1963) will consist of a group of fragment of lower weight and smaller size fired over a distance of approximately 6 feet with their time of flight recorded by ionization probe and an aluminum make screen. It is expected that this series of firings will establish the maximum velocity which fragments of a given size and weight can be launched undamaged by a donor charge 4" long and 2.5" in diameter.

Future Work

Present plans call for completion of the evaluation firings early in January and a complete case status review with representatives of Picatinny Arsenal later in the month.

Man Hours Expended

Total inclusive man hours to date on this program are 2170 or 76% of the total estimated under the original proposal. Of this, 364 man hours or 13% were expended during the current report period.

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Report Distribution

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TABLE I

TEST TECHNIQUE AND EVALUATION FIRINGS

Run #	Date	Frag. Dim. in.	Weight oz.	Charge Length in.	Screen Distance in.	Time micro-sec.	Velocity ft/sec	Remarks
T-1	12/7/62	1/2x1/2x1/2	0.5	3	64-1/2 146-1/2 Dynafox Camera	210 7039	----- ----- -----	Horizontal firing - three plates for baffle - fragment hit edge of hole in two plates - Penetrated 5 sheets Celotex - no record on Dynafax film.
T-2	12/7/62	1/2x1/2x1/2	0.5	3	64 87 Dynafox	1896 ---	2820 ----- 1940	Good shot - frag. penetrated 19 sheets Celotex - recovered looked o.k. can see frag. on film. Gas cloud on film traveling approx. 650'/sec.
T-3	12/7/62	3/8x3/8x5/16	0.2	3	65-1/4 140-1/2 Dynafox	889 --- ---	6100 ----- -----	Second screen did not stop - penetrated 20 sheets of Celotex - no frag. on film record.
T-4	12/7/62	1/2x1/2x1/2	0.5	3	63-1/2 140 Dynafox	833 --- ---	6340 ----- 1950	Good shot through 24 sheets of Celotex on out - frag. not recovered. Frag. captured on film. Gas cloud traveling approx. 650'/sec.

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TABLE I (Cont)

Run #	Date	Frag. Dim. in.	Weight oz.	Charge Length in.	Screen Distance in.	Time micro-sec.	Velocity ft/sec	Remarks
T-5	12/8/62	1/2x1/2x1/2	0.5	2	56	1339 1339 1337 Scope Scope	3500	This firing had 5 different triggering devices located at different points on the charge and placed on differently. Stop screen was common to all - system checked.
T-6	12/8/62	1/2x1/2x1/2	0.5	2	63-3/4 87-3/4 142-3/4 Scope Scope- approx 164	2130 4951 ---- no stop 714	2500 1480 ---- ---- 1910	One common start triggering device - 5 stop screens located at different intervals - system did not check - last reading probably correct.
T-7	12/8/62	3/8x3/8x5/16	0.2	4	63 89 112 137-1/2 159-1/2	896 1364 ----	5900 5500	
T-8	12/8/62	1/2x1/2x1/2	0.2	4	64 90 113-1/4 138 161	1037 2735 2120 382	5600, 4800, 4250 (three pipe on scope) 3100 one pip 5150 2750 4460 3010	One common start - 5 screens placed at distances shown. Velocities not consistent - last reading from scope probably correct.

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TABLE II

VELOCITY DATA SUMMARIZED

PLASTER CAST FRAGMENTS

Fragment		Weight (oz)	Maximum Fragment Velocity		Boundary Velocity	
Size (in)	Ft/Sec		Pentolite ft/sec	Cyclotol ft/sec		
7/8 x 7/8 x 3/4	1640 (10)	2.65	1300	1570		
1/2 x 1/2 x 1/2	1950 (11)	0.5	2300	2700		
3/8 x 3/8 x 5/16	3400 (5)	0.2	3250	4000		

Number in parenthesis represents number of firings at that velocity.

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TABLE IIIa

TEST TECHNIQUE AND EVALUATION FIRINGS

All charges 4" long x 3.5 in diameter

<u>Firing No.</u>	<u>Date</u>	<u>Fragment Size (in.)</u>	<u>Lucite Buffer Thickness (in.)</u>	<u>Remarks</u>
T-9	12/18/62	1 x 1 x 5/8	0.500	Fragment Broken
T-10	12/18/62	1 x 1 x 3/8	0.250	No damage
T-11	12/18/62	1 x 1 x 1/4	0.125	No damage
T-12	12/18/62	1 x 1 x 5/8	0.750	Fragment broken
T-13	12/18/62	1 x 1 x 3/8	0.60	No damage
T-14	12/18/62	1 x 1 x 1/4	0.60	No damage
T-15	12/18/62	1 x 1 x 5/8	0.30	Different exp. material used. No damage
T-16	12/18/62	1 x 1 x 1/4	0.30	No damage
T-17	12/18/62	1 x 1 x 5/8	1.00	Some damage
T-18	12/18/62	1 x 1 x 5/8	2.00	No damage

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TAB. IIIb

TEST TECHNIQUE AND EVALUATION FIRINGS

All fragments are 1 x 1 square - metal surround - lucite buffer.
 All charges are 4" long x 3.5 in diameter.

Firing No.	Date	Frag. Dim.	Fragment Wt.	Velocity by Screens	Lucite Buffer Thickness	Velocity from High-Speed Camera
T-19	12/19/62	1 x 1 x 1/4	1.1	5910	.060	5910
T-20	12/19/62	1 x 1 x 1/4	1.1	-----	.060	5910
T-21	12/19/62	1 x 1 x 1/4	1.1	-----	.060	5800
T-22	12/19/62	1 x 1 x 3/8	1.74	4640	.030	4775
T-23	12/19/62	1 x 1 x 3/8	1.74	4700	.030	4910
T-24	12/19/62	1 x 1 x 3/8	1.74	4660	.030	4630
T-25	12/19/62	7/8 x 7/8 x 3/4	2.6	3220	Plaster surround	Camera showed only by plaster - no frag.
T-26	12/20/62	1 x 1 x 5/8	2.9	1745	.030	1710
T-27	12/20/62	1 x 1 x 1/4	1.1	5640	.125	5650
T-28	12/20/62	1 x 1 x 1/4	1.1	4300	.750	4260
T-29	12/20/62	1 x 1 x 1/4	1.1	3640	1.187	3820

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TABLE IIIb (Cont)

TEST TECHNIQUE AND EVALUATION FIRINGS

All fragments are 1 x 1 square - metal surround - lucite buffer.

All charges are 4" long x 3.5 in diameter.

Firing No.	Date	Frag. Dim.	Fragment Wt.	Velocity by Screens	Lucite Buffer Thickness	Velocity from High-Speed Camera
T-30	12/20/62	1 x 1 x 3/8	1.74	3680	6.500	3780
T-31	12/20/62	1 x 1 x 3/8	1.74	----	1.00	3110
T-32	12/21/62	7/8 x 7/8 x 3/4	2.6	1710	Five thin Al screens to remove (slow up) plaster.	1640
T-33	12/21/62	3/8 x 3/8 x 5/16	0.2	3330	same as above	3440
T-34	12/21/62	1 x 1 x 1/4	1.1	2440	2.00	2470
T-35	12/21/62	1 x 1 x 3/8	1.74	1875	2.00	-----
T-36	12/21/62	1 x 1 x 5/8	2.9	1870 (shock velocity)	2.00	1310
T-37	12/21/62	1 x 1 x 3/8	1.74	2410	1.500	2420
T-38	12/21/62	3/8 x 3/8 x 5/16	0.2	3360	Five thin Al screens to slow down plaster	3380

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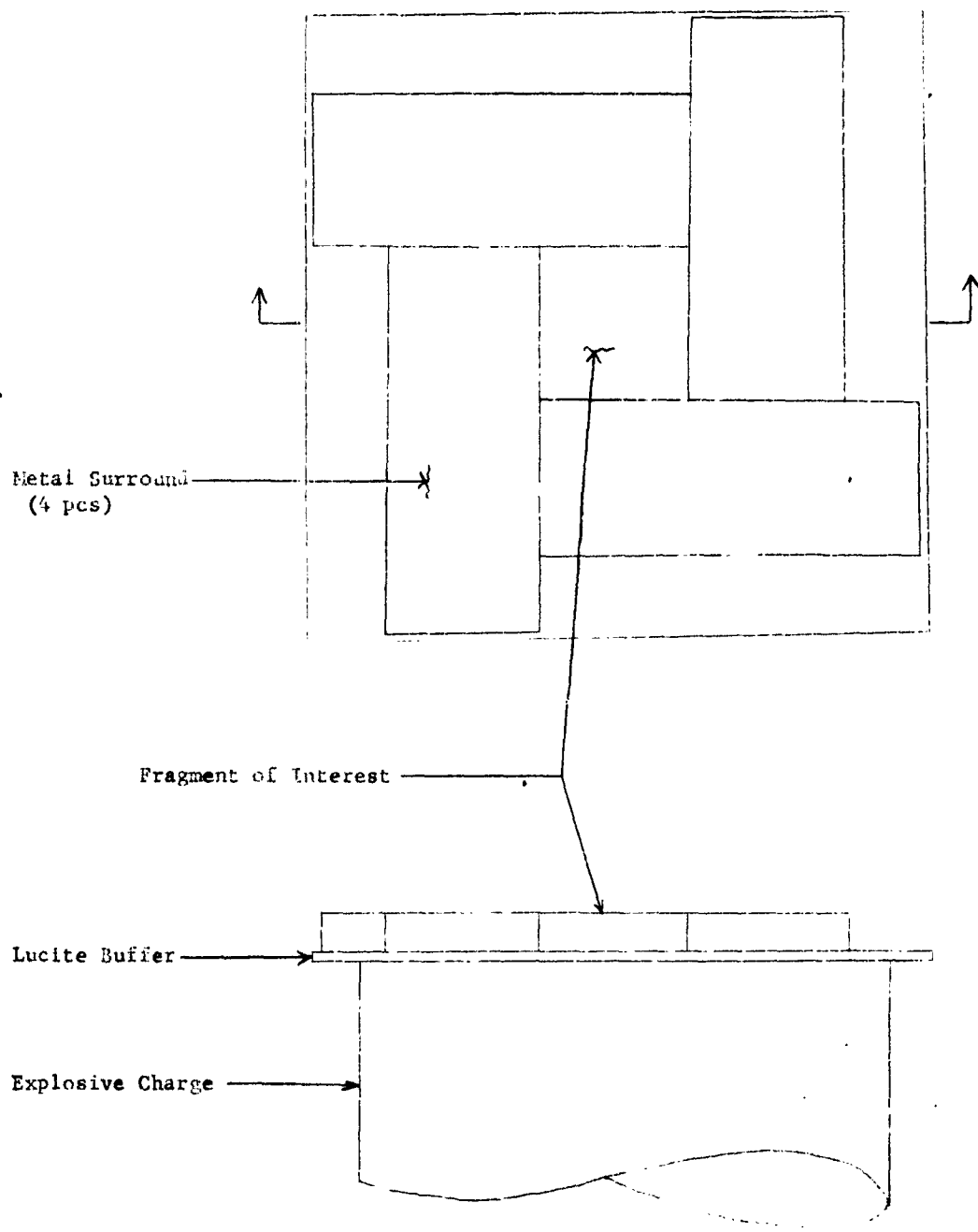


Figure 1

FRAGMENT ARRANGEMENT WITH METAL SURROUND

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