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IMPROVING QUALITY AND PERFORMANCE OF LEADS LOADED WITH COMPOSITION A-5

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U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER

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A study was conducted to improve the quality and performance of leads loaded with Composition A-5. The effect of parameters, such as stearic acid content, HMX content, and RDX particle size, on Comp A-5 sensitivity was examined. Parameters affecting lead uniformity and output studied were A-5 particle size and density. Results show A-5 particle size had the greatest effect on lead performance and quality.

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INTRODUCTION

Over the last 10 years, there have been several fuze reliability problems which have involved leads loaded with Composition (Comp) A-5. In the cases noted, changing the particular lot of Comp A-5 used in the fuze resulted in an improvement in fuze reliability. It was considered that lead performance as a function of variations in the HMX content, stearic acid content, and RDX particle size in the Comp A-5 and/or variations in the density of the lead could account for the differences in the fuze reliability.

This report summarizes the results of a study to investigate the effect of the above mentioned variables on lead performance. The work was done as a product improvement program (PIP #GG87883) to improve quality of leads.

TEST RESULTS

Physical Characteristics of Composition A-5

Numerous batches of Comp A-5 manufactured at Holston Army Ammunition Plant (HAAP) were analyzed for the percentages of RDX, stearic acid, HMX in the RDX, moisture, cyclohexanone, and bulk density. Batches which represent the mean and combinations of the extremes in percent stearic acid and percent HMX in RDX were chosen for sensitivity testing. The analysis of the eight batches that were selected is shown in table 1. A batch of Comp A-5, designated LAB 1088-96, was produced in the laboratory using Class 5 RDX. Analysis of this batch is also included in table 1.

Proportional Gap Test (PGT) Sensitivity of Composition A-5 Versus Stearic Acid and HMX Content

Proportional gap sensitivity tests (ref 1) were conducted on the nine batches of Comp A-5 listed in table 1. The results are reported in table 2. Results of the tests showed no systematic relationship between the Comp A-5 sensitivity and the HMX content or the stearic acid content of the Comp A-5. A description of the proportional gap test is outlined in the appendix. For this series of tests, all acceptor pellets were pressed to a density of 1.65 g/cm^3. For each lot of Composition A-5, a 30-shot Bruceton test (ref 3), in which the thickness of the aluminum barrier was the variable, was performed with donors of two sizes, 0.050 and 0.100 inch. Five of the lots could not be initiated at the 0.050-inch donor diameter. These lots were tested at 0.200-inch donor diameters.

The lot-to-lot sensitivity variation of the Comp A5 is large. This variation is evidenced by the fact that five of the eight production lots tested could not be initiated at the 0.05-inch donor diameter and by the three P(Al)Dbg range in sensitivity at the 0.1 inch donor diameter. This fact makes it clear that the use of Comp A-5 should be avoided in small diameter leads.

Proportional Gap Test Sensitivity of Composition A-5 Versus Particle Size Distribution of RDX

The particle size distribution of RDX in the eight production batches of Comp A-5 listed in table 1 was measured. Results of this analysis are shown in table 3. The method of performing the analysis is shown in the appendix.

The PGT results of the production lots of Comp A-5 show no correlation between sensitivity and particle size distribution of the RDX. The sensitivity of the Comp A-5 made with Class 5 RDX was more sensitive than the production lots of Comp A-5 made with Class 3 RDX. From this knowledge, it is apparent that particle size can significantly influence sensitivity, but not within the range of Class 3 RDX particle size distribution.

Output of Composition A-5 Loaded Leads As A Function of Density, Particle Size, and HMX Content

Lead Configurations

Lot HOL80E000E-041, which contained 27.5% HMX, and lot HOL80G000E-044, which contained 2.9% HMX were sieved into four different fractions. They were 20/40, 40/80, 80/120, and 20/200. These fractions were loaded into lead cups having a 3 to 1 length to diameter ratio (fig. 1) at three different density ranges, 1.55 to 1.60 g/cm^3, 1.61 to 1.70 g/cm^3, and 1.71 to 1.76 g/cm^3. The leads were loaded at LSAAP on a 41 station rotary press which is typically used for high volume lead production. Lot numbers assigned to the samples are shown in table 4. The density of five leads from each lot were checked using the water displacement method per MIL-G-48226. The results are shown in table 5.

Output of the Leads Using the Steel Dent Test

Steel dent tests of leads, loaded as shown in table 4, were conducted using the test set-up shown in figure 2. Results are shown in table 6. The M55 detonators (lot LS81F322-006) used in the test were produced on one loading machine to minimize the influence of the detonator in the test. The detonators were tested for sensitivity and energy output per MIL-D-14978. The results are shown in table 7.

Test results showed no significant difference in the average dent in the lots tested when the low orders (zero dent) were not included in the average. From this fact, it is concluded that the HMX content of the RDX in the Comp A-5 did not effect the output of the leads. The granulation and density of the Comp A-5 affected the lead sensitivity, but not output.

Initially, two types of witness block materials were used, aluminum (hardness -Rockwell B 70 to 80) and steel (hardness - Rockwell B 85 to 95). Ten each leads from lot LS81F124-008 were fired against aluminum and steel blocks. The average dent in the aluminum blocks was roughly 0.037 inches. The steel block averaged 0.012-inch dent. The dent in the aluminum block was too jagged to get an accurate measurement of the depth. Therefore, the aluminum block was omitted from further testing.

In the leads, there were variations in the depth below flush of the Comp A-5. The variation ranged from 0.004 to 0.017 inches. The possible effect of these variations on output was evaluated. Ten leads from each lot were measured for depth below flush and subjected to the dent test. The results are shown in table 8. There was no significant difference in the dent results as a function of the explosive depth below flush.

Output of Leads Using the Fragment Velocity Test

Fragment velocity tests (ref 2) were run on the leads shown in table 4 using the set-up shown in figure 3. See table 9 for the results of the tests. In the fragment velocity test a 0.0215-inch thick aluminum disc is added to the output end of the lead to form fragments. The time it takes for the fragments to travel across a 1.069-inch gap is measured, and the velocity of the fragments is an indication of the output of the leads.

There was no significant difference in the average fragment velocity as a function of HMX content or density. Leads loaded with Comp A-5 screened 40/80 and 20/200 showed a higher average fragment velocity than the leads loaded wih Comp A-5 screened 20/40 and 80/120.

DISCUSSION

Difficulties were encountered in obtaining the desired density ranges in loading leads with Comp A-5 screened 80/120 and 20/200. Approximately 20% of the leads loaded with these fractions were found to be outside the desired density range. These granulations had poor flow characteristics and are not suitable for use in a volumetric loading machine.

During the dent testing, a number of low orders (zero dent) occurred in lots LS81F124-001, -005, -010, and -014. These lots were loaded with Comp A-5 screened 20/40. From this data, it is concluded this granulation is difficult to initiate.

The fragment velocity test data shows there was a higher average fragment velocity with leads loaded with Comp A-5 screened 40/80 than leads loaded with Comp A-5 screened 20/40 and 80/120. It is indicated that use of a 40/80 screen fraction to load leads results in improved performance.

The average fragment velocity of leads, loaded with Comp A-5 screened 20/200 matched the average fragment velocity of leads loaded with the 40/80 sieve fraction. However, the 20/200 sieve fraction could not be uniformly and accurately loaded on the rotary press as indicated by the large number of rejects (20%) that were found.

CONCLUSIONS

1. There are large lot-to-lot variations in Comp A-5 sensitivity.

2. Comp A-5 should not be used in small diameter leads (0.100 in. or less).

3. A range of three to twenty-seven percent HMX in RDX does not affect the sensitivity of Comp A-5 in the proportional gap test.

4. The sensitivity of Comp A-5 is not affected by a stearic acid content of 1.0 to 1.5%, the range permitted by the Comp A-5 specification.

5. Comp A-5, having an HMX content in the RDX ranging from 3% to 27%, did not affect the output of leads as measured by the steel dent and fragment velocity tests.

6. The density range that was studied (1.55 to 1.75 g/cm^3) does not affect the output of leads in the steel dent and fragment velocity tests.

7. Particle size of Comp A-5 affects the output of the leads. Leads loaded with Comp A-5 screened 40/80 showed a higher fragment velocity than leads loaded with Comp A-5 screened 20/40 or 80/120.

8. Particle size of Comp A-5 affected the consistency of leads loaded on a rotary press. The 80/120 and 20/200 fractions could not be loaded accurately and consistently.

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Table 1. Properties of Composition A-5 produced by Holston Army Ammunition Plant

Batch/ Lot	RDX (%)	Stearic Acid (%)	HMX in RDX (%)	Moisture (%)	Cyclohexanone (%)	Bulk Density (g/cm^3)
4R89-190-2A4/ HOL80G000E-044	98.6	1.45	27.5	0.04	0.15	0.98
4R79-190-1A7/ HOL80G000E-043	99.1	0.95	18.9	0.03	0.13	1.09
4R79-189-1A5/ HOL80G000E-041	98.6	1.42	2.9	0.01	0.50	1.01
4R79-189-2A5 HOL80G000E-042	99.0	1.02	4.4	0.02	0.60	1.01
4R79-24/ HOL79C630-059	98.5	1.54	12.0	0.017	0.18	0.99
4R79-7/ HOL79C630-057	99.0	1.05	10.8	0.010	0.44	1.04
4R79-13/ HOL79C630-058	98.7	1.26	11.7	0.009	0.33	1.02
4979-23/ HOL79C630-062	98.8	1.2	14.9	0.02	0.28	1.02
LAB 1088-96*	98.8	1.22	10.3	0.010	0.00	0.74

*Comp A-5 produced in laboratory at HAAP using Class 5 RDX.

Table 2. Composition A-5 sensitivity versus stearic acid and HMX content[a]

Comp A-5 Lot	Sensitivity P(Al)DBg	Deviation P(Al)DBg	HMX in RDX (%)	Stearic Acid (%)
0.050-Inch Donor Diameter				
HOL79C630-059	17.7042	0.5969	12.0	1.54
HOL80G000E-043	17.4900	1.3846	18.9	0.95
HOL80G000E-044	16.1329	1.0663	27.5	1.45
LAB1088-96	12.5735	0.5778	10.3	1.22
0.100-Inch Donor Diameter				
HOL79C630-62	14.2583	0.2833	14.9	1.20
HOL79C630-59	13.5786	0.2206	12.0	1.54
HOL79C630-57	13.4000	0.2411	10.8	1.05
HOL80G000E-41	12.8393	0.1735	2.9	1.42
HOL79C630-58	12.7929	0.2309	11.7	1.26
HOL80G000E-42	11.9083	0.1287	4.4	1.02
HOL80G000E-44	11.6500	0.1696	27.5	1.45
HOL80G00E-43	11.2417	0.1956	18.9	0.95
LAB1088-96	10.8250	0.1733	10.3	1.22
0.200-Inch Donor Diameter[b]				
HOL79C630-62	11.0350	0.1012	14.9	1.20
HOL79C630-58	10.6504	0.2929	11.7	1.26
HOL79C630-57	10.4850	0.2267	10.8	1.05
HOL80G000E-41	10.2465	0.1098	2.9	1.42
HOL80G000E-42	10.1243	0.3074	4.4	1.02

[a]Proportional gap test data arranged by increasing sensitivity within each donor diameter.

[b]The lots listed below could not be initiated with 0.050-inch donors at zero gap.

Table 3. Sieve analysis of the RDX used to produce the Composition A-5

PIP batch designation (lot)	Sieves (%)											
	#35		#60		#80		#120		#170		#230	
	P[a]	R[b]	P[a]	R[b]	P[a]	R[b]	P[a]	R[b]	P[a]	R[b]	P[a]	R[b]
HOL79C630-062	57	43	22	35	17	5	16	1	16	0	16	0
HOL79C630-059	73	27	28	45	25	3	24	1	24	0	24	0
HOL79C630-057	92	8	18	74	10	8	4	6	2	2	2	1
HOL80G000E-041	48	52	30	18	29	1	28	1	27	1	27	0
HOL79C630-058	76	24	30	46	19	11	13	6	11	2	10	1
HOL80G000E-042	36	64	17	19	15	2	14	1	13	1	13	0
HOL80G000E-044	80	20	21	59	12	9	8	4	6	2	5	1
HOL80G000E-043	73	27	28	45	6	12	16	0	10	6	10	0
LAB1088-96[c]	---------------------NO SAMPLE AVAILABLE-----------------											

[a]Percent passed.

[b]Percent retained.

[c]A 2-pound laboratory sample of this lot was made with Class 5 RDX (97% minimum through a No. 325 U.S. Standard Sieve).

Table 4. Lot numbers of leads

Material:	Comp A-5 lot #HOL81G000E-041				Comp A-5 lot #HOL81G000E-044			
	Granulation (U.S. Std Sieve #)				Granulation (U.S. Std Sieve #)			
	20/40	40/80	80/120	20/200	20/40	40/80	80/120	20/200
Density (g/cm^3)	Lot #LS81F124-				Lot #LS81F124-			
1.55 to 1.61	001	002	003	004	010	011	012	013
1.62 to 1.70	005	006	007	008	014	015	016	017
1.71 to 1.76	*	*	009	*	*	018	019	*

* These lead configurations could not be loaded using the rotary press because the powder cavity was not large enough to contain the explosive needed to reach the desired density.

Table 5. Density of leads

Lot	Density (g/cm^3)					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
LS-81F124-001	1.56	1.56	1.60	1.61	1.57	1.58
LS-81F124-002	1.55	1.59	1.59	1.59	1.63	1.59
LS-81F124-003	1.59	1.61	1.61	1.56	1.57	1.59
LS-81F124-004	1.62	1.62	1.61	1.61	1.62	1.62
LS-81F124-005	1.62	1.63	1.66	1.69	1.70	1.66
LS-81F124-006	1.62	1.62	1.70	1.68	1.66	1.66
LS-81F124-007	1.66	1.64	1.62	1.63	1.65	1.64
LS-81F124-008	1.67	1.65	1.66	1.64	1.66	1.66
LS-81F124-009	1.70	1.73	1.73	1.74	1.71	1.72
LS-81F124-010	1.56	1.58	1.60	1.58	1.58	1.58
LS-81F124-011	1.58	1.59	1.58	1.56	1.56	1.57
LS-81F124-012	1.61	1.59	1.57	1.61	1.56	1.59
LS-81F124-013	1.56	1.57	1.58	1.57	1.57	1.57
LS-81F124-014	1.64	1.66	1.61	1.64	1.65	1.64
LS-81F124-015	1.63	1.68	1.67	1.64	1.64	1.65
LS-81F124-016	1.69	1.69	1.64	1.65	1.69	1.67
LS-81F124-017	1.67	1.67	1.69	1.71	1.72	1.69
LS-81F124-018	1.73	1.76	1.73	1.74	1.72	1.74
LS-81F124-019	1.74	1.72	1.75	1.77	1.77	1.75

Table 6. Dent test results

Lot	Average dent[a,b] (in.)	Standard deviation	Failures[b] (zero dent)
LS-81F124-001	0.008	0.002	43
LS-81F124-002	0.010	0.001	0
LS-81F124-003	0.011	0.001	0
LS-81F124-004	0.011	0.002	0
LS-81F124-005	0.010	0.001	14
LS-81F124-006	0.011	0.002	0
LS-81F124-007	0.011	0.002	0
LS-81F124-008	0.010	0.002	0
LS-81F124-009	0.012	0.002	1
LS-81F124-010	0.010	0.003	14
LS-81F124-011	0.011	0.002	0
LS-81F124-012	0.010	0.002	0
LS-81F124-013	0.011	0.001	0
LS-81F124-014	0.011	0.002	14
LS-81F124-015	0.011	0.001	0
LS-81F124-016	0.010	0.002	0
LS-81F124-017	0.011	0.001	0
LS-81F124-018	0.011	0.001	0
LS-81F124-019	0.010	0.002	6

[a]Fifty leads were tested.

[b]Failures (zero dent) were not included in the average.

Table 7. M55 detonator sensitivity and energy output test results

Lot No. LS81F332-006

Depth of dent (in.)	Number
0.016	12
0.017	45
0.018	80
0.019	43
0.020	8
0.021	12

Average - 0.0181 Total Tested - 200

Standard Deviation - 0.0012

Table 8. Explosive depth below flush in lead versus average dent

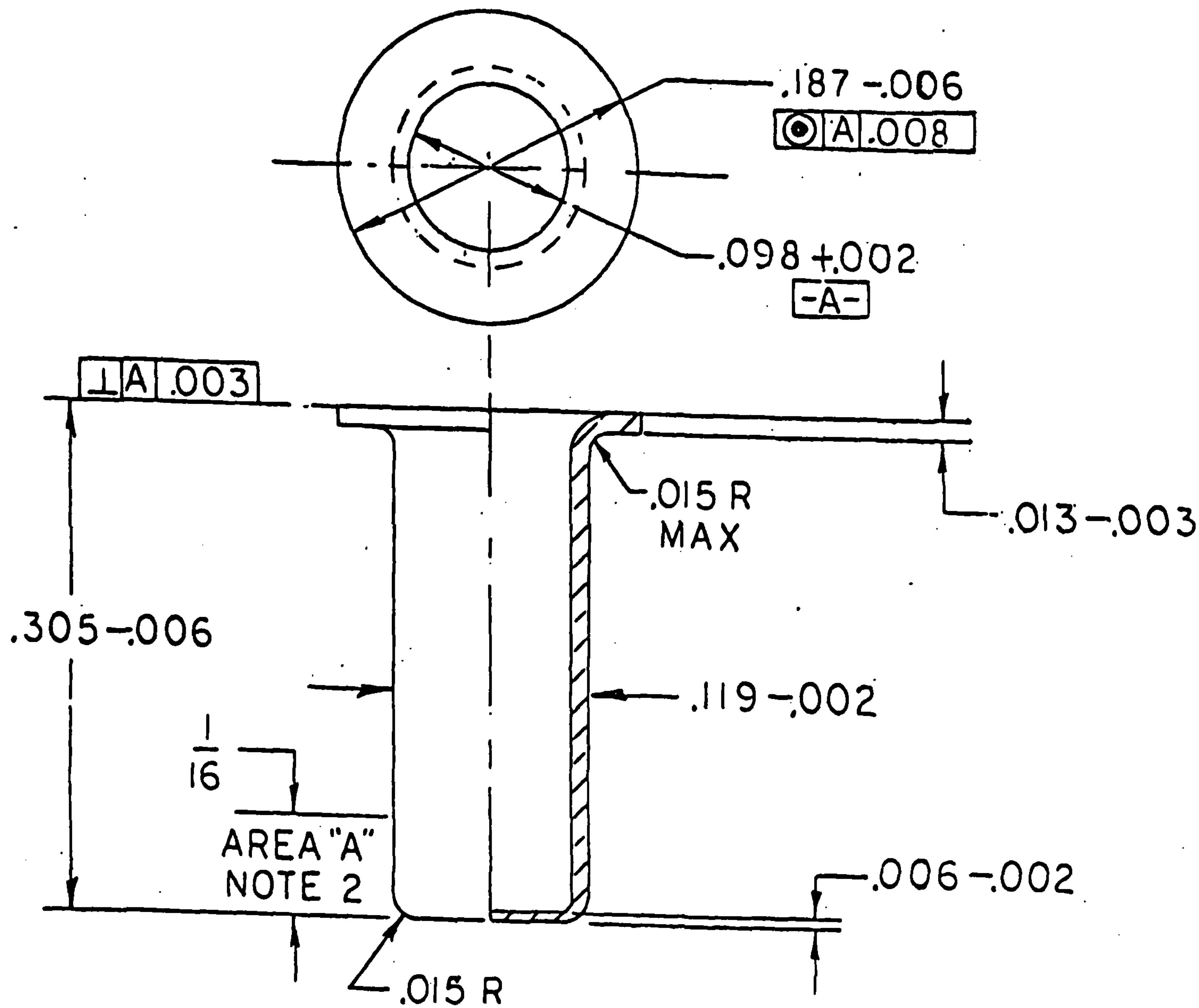
Lot	Average depth* below flush (in.)	Standard deviation	Average dent (in.)	Standard deviation
LS-81F124-001	0.006	0.001	-8 failures (o dent)--	
LS-81F124-002	0.017	0.002	0.011	0.001
LS-81F124-003	0.008	0.001	0.011	0.001
LS-81F124-004	0.008	0.002	0.011	0.002
LS-81F124-005	0.011	0.001	0.011	0.001
LS-81F124-006	0.008	0.001	0.011	0.001
LS-81F124-007	0.011	0.002	0.012	0.001
LS-81F124-008	0.011	0.001	0.012	0.001
LS-81F124-009	0.009	0.001	0.011	0.001
LS-81F124-010	0.006	0.003	0.012	0.002
LS-81F124-011	0.005	0.002	0.012	0.001
LS-81F124-012	0.009	0.001	0.010	0.002
LS-81F124-013	0.007	0.002	0.012	0.001
LS-81F124-014	0.012	0.001	0.011	0.001
LS-81F124-015	0.009	0.001	0.011	0.001
LS-81F124-016	0.009	0.001	0.011	0.001
LS-81F124-017	0.004	0.002	0.012	0.001
LS-81F124-018	0.010	0.001	0.012	0.001
LS-81F124-019	0.015	0.001	0.012	0.001

*Ten leads were tested from each lot.

Table 9. Fragment velocity test data

Lot	Time* (10^{-6} s)	Standard deviation	Velocity (ft/s)	Standard deviation
LS-81F124-001	27.560	36.989	5909	2545
LS-81F124-002	10.000	1.028	8996	1041
LS-81F124-003	11.027	0.477	8084	338
LS-81F124-004	10.338	1.529	8713	1045
LS-81F124-005	9.771	0.982	9197	1009
LS-81F124-006	10.257	0.963	8740	748
LS-81F124-007	11.157	1.192	8055	877
LS-81F124-008	10.021	0.434	8896	380
LS-81F124-009	10.876	0.746	8217	549
LS-81F124-010	11.581	2.045	7847	1046
LS-81F124-011	10.362	0.599	8614	466
LS-81F124-012	11.711	0.618	7618	397
LS-81F124-013	11.134	0.718	8021	478
LS-81F124-014	10.889	1.030	8237	800
LS-81F124-015	10.572	0.635	8446	510
LS-81F124-016	12.093	0.567	7375	336
LS-81F124-017	10.380	0.733	8612	605
LS-81F124-018	11.410	1.290	7897	955
LS-81F124-019	10.323	0.880	8690	884

*Ten leads were tested from each lot.



MATERIAL: ALUMINUM ALLOY 1100-0 ASTM B209

Figure 1. Lead cup

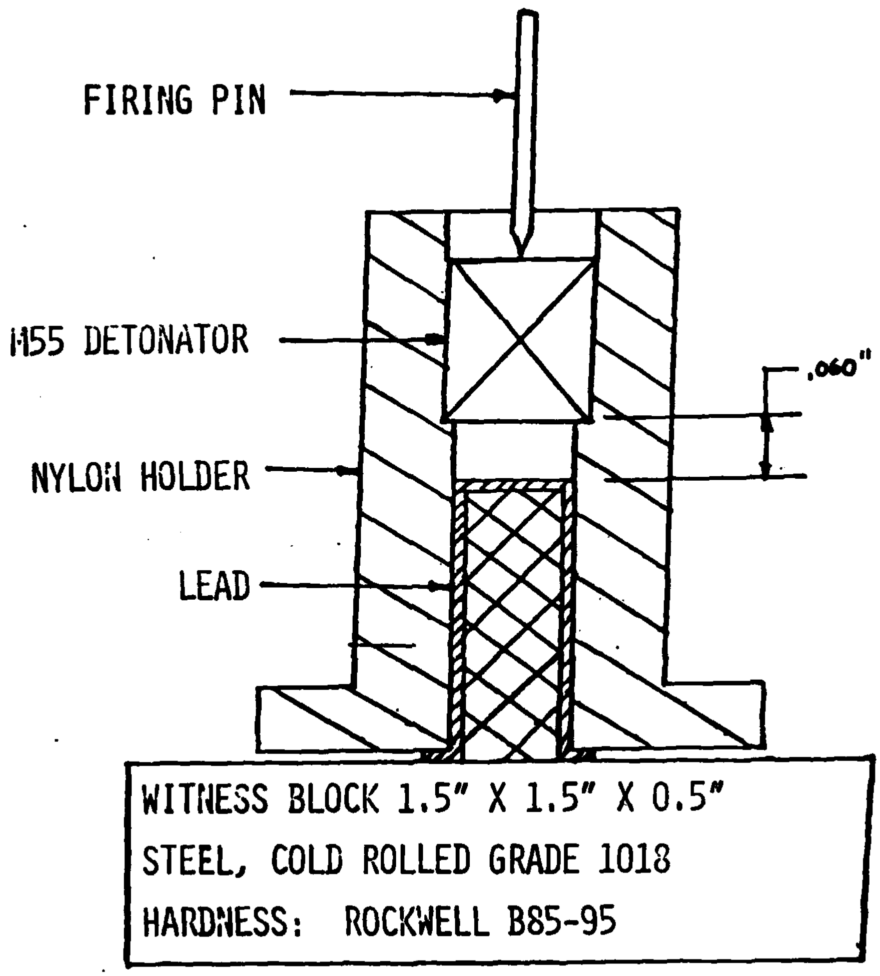


Figure 2. Dent test set-up

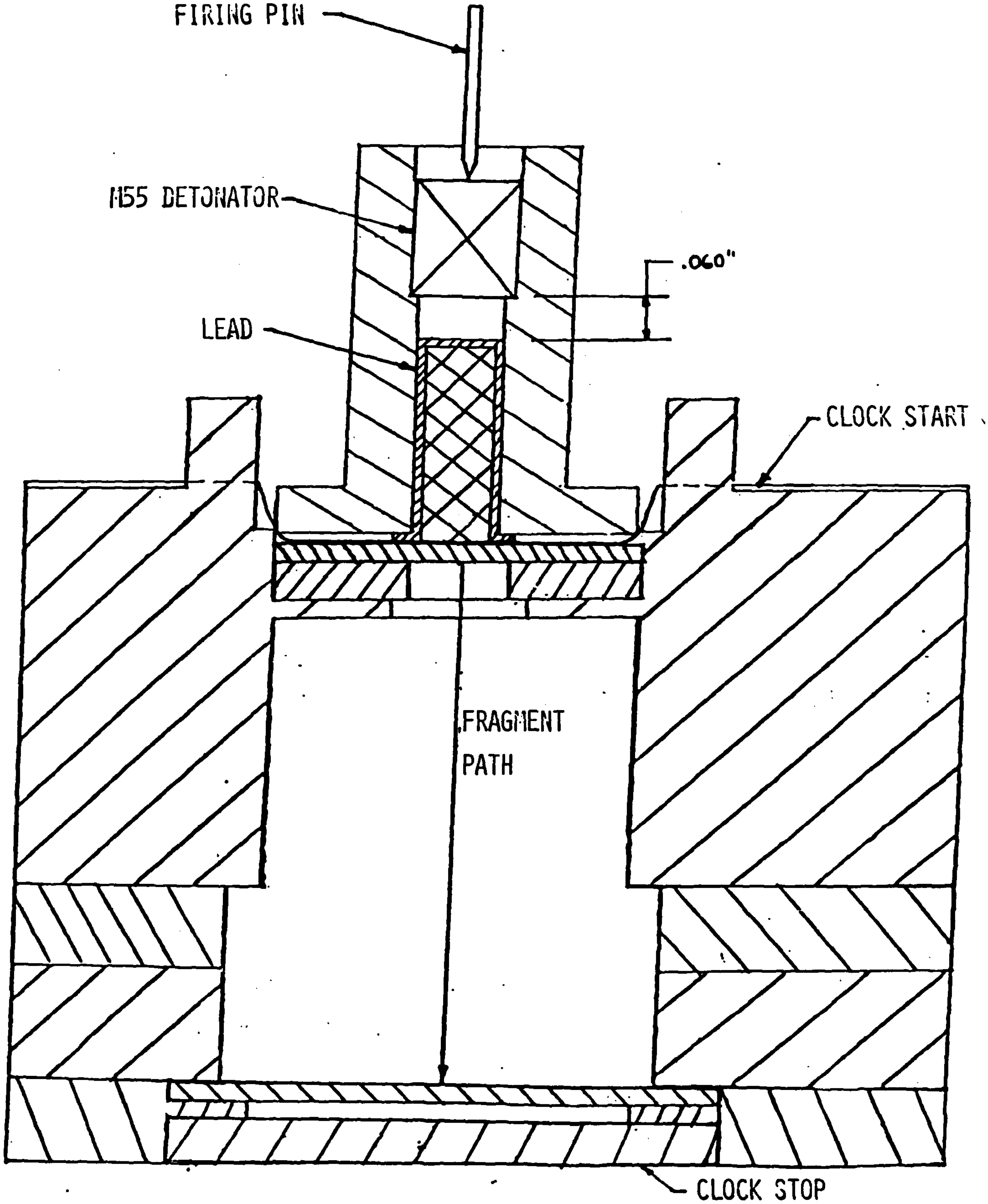


Figure 3. Fragment velocity test set-up

APPENDIX

TEST METHODS

DESCRIPTION OF PROPORTIONAL GAP TEST

The proportional gap test is a method of determining the relative stimulus needed to initiate an explosive. The explosive under test (called the acceptor) is initiated by another explosive called the donor. Both the acceptor and donor are precision loaded to reduce variations. The acceptor diameter is twice that of the donor. The "gap" between them is actually an aluminum barrier. The Bruceton Method is used to determine the 50% firing point. The stimulus is calculated in proportional decibangs [P(Al)DBg].

PROCEDURE USED FOR PARTICLE SIZE ANALYSIS OF RDX IN COMPOSITION A-5

A 10-gram sample of Composition A-5 was placed in a medium porosity crucible. The sample was washed with three separate 50-ml portions of chloroform which were previously saturated with RDX. Each portion was in contact with the Composition A-5 for approximately five minutes before applying suction, and was stirred occasionally to break up any lumps. The side of the crucible was washed down with RDX-saturated chloroform. This process insured complete removal of the stearic acid. The RDX was then aspirated in the crucible until the odor of chloroform was no longer detectable. When the sample was dry, a sieve analysis was run.

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