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REPORT R-1978

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CONTRIBUTION OF THE 5.56 MM, BALL M193 CARTRIDGE METAL COMPONENTS TO GAS TUBE FOULING IN THE M16A1 RIFLE

BY

ANDREW J. GRANDY

November 1970

DEPARTMENT OF THE ARMY
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

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CONTRIBUTION OF THE 5.56 MM, BALL M193 CARTRIDGE METAL COMPONENTS TO GAS TUBE FOULING IN THE M16A1 RIFLE

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ANDREW J. GRANDY

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Ammunition Development & Engineering Laboratories
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

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ABSTRACT

A study was made of 5.56 mm Ball, M193 Cartridge metal parts and their contribution to gas tube fouling in the M16A1 rifle. Previous studies have identified calcium carbonate ($CaCO_3$) as the matrix which traps metallic debris resulting in gas tube fouling in the M16A1 rifle. It was the purpose of this study to identify the origin of the gilding metal residue found to be trapped in the $CaCO_3$ matrix. In the case of four lots of 5.56 mm Ball, M193 ammunition examined, it was found that two lots associated with excessive gas tube and general weapon fouling can be characterized as having bullets with poorly formed cannelures and excessive bullet extraction forces. These two lots were loaded with ball propellant containing .71% to .97% $CaCO_3$. Two cartridge lots with well made, dimensionally correct bullet cannelures displaying relatively low bullet extraction forces and loaded with ball propellant containing .53% $CaCO_3$ contributed little or nothing to gas tube or weapon fouling in the M16A1 rifle.

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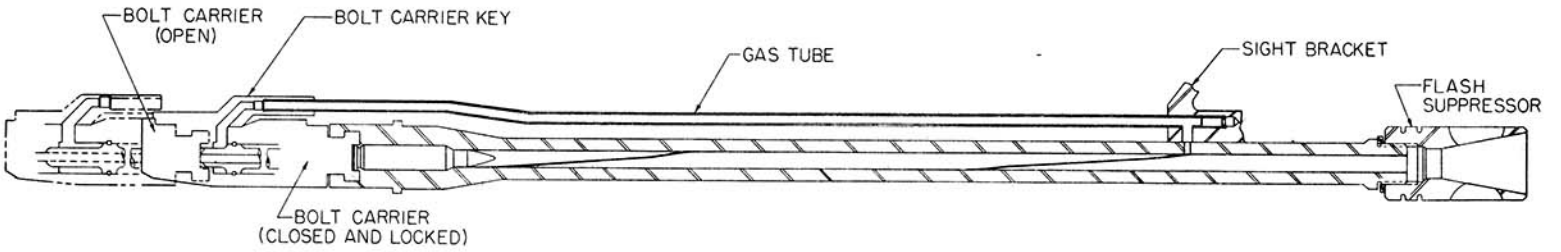
INTRODUCTION

The M16A1 rifle is a 5.56 mm, gas-operated, air-cooled, shoulder fired weapon. Gas operation is achieved by means of gas pressure developed by the fired round being guided from the barrel through a port into a gas tube and back into the bolt carrier of the rifle. This provides the force required to translate the bolt assembly. A schematic of the gas system is shown in Figure 1.

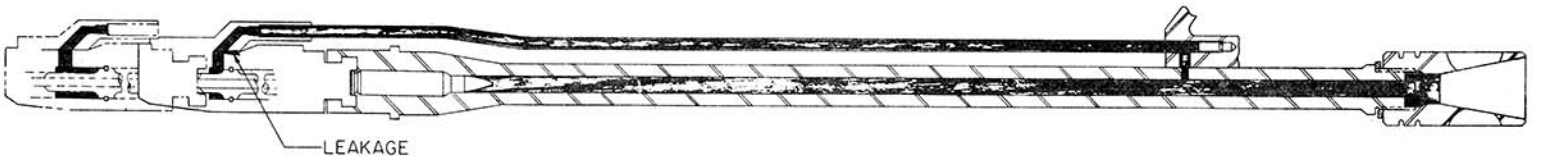
Experience gained during weapon and ammunition acceptance testing has shown that, on occasion, residue generated during firing causes fouling in the M16A1 rifle. Areas where fouling commonly occurs are shown in Figure 1. These are: the barrel, the flash suppressor, the sight bracket bleed hole, the bolt carrier key, the bolt cavity, and the gas tube. Investigations covered by this report deal mainly with the fouling or clogging of the gas tube, a critical rifle component which cannot be readily maintained in the field. Gradual buildup of fouling residue can cause clogging of the gas tube thereby effecting the rate of fire and inducing rifle malfunctions.

Previous work substantiates that the existence of a high calcium carbonate ($CaCO_3$) content (> .25%) in the propellant charge of a ball round loaded with ball propellant correlates with gas tube fouling in the M16A1 rifle. [1,2] Further, the fouling debris is largely a mechanically bonded mixture of a copper-zinc alloy, corresponding to 90% copper and 10% zinc with a particle size of 0.3 to 0.4 microns and $CaCO_3$. [1] It is too early to predict the actual flow conditions in the gas tube during the ballistic cycle. Continuing study may suggest that the barrel port pressure history [3] may play a dominant role in the amount and location of debris ingested by the gas tube. [4]

Up to this time no appreciable effort was expended to investigate the cartridge metal parts and their contribution to fouling. Two cartridge lots which caused consistent gas tube clogging and weapon fouling were closely studied and compared with two ammuntion lots which caused little or no fouling in order to obtain additional information on contribution of the metal parts to gas tube clogging and general weapon fouling in the M16A1 rifle. Availability of this ammunition has provided an opportunity to conduct discriminatory, dimensional, visual and ballistics studies of these cartridge lots while assessing their performance in standard M16A1 rifles.



GAS SYSTEM
M16A1 RIFLE-NEW



GAS SYSTEM
M16A1 RIFLE-FIRED
DARK SHADING INDICATES CRITICAL FOULING AREAS

Figure 1. Gas System, M16A1 Rifle, New and Fired

MACROGRAPHIC STUDY

Early in the Gas Tube Clogging Study Program it was recognized that fouling residue in the M16A1 rifle consisted mainly of a copper-zinc alloy (Cu-Zn) and calcium carbonate ($CaCO_3$). The calcium carbonate being pinpointed as the "matrix" which embeds gilding metal and primer product particles.[2] On this basis, a concerted effort was made to determine how the gilding metal particles are generated in some cartridge lots while it is virtually nonexistent in others.

The only possible sources of the reported amounts of copper-zinc found in heavily fouled M16A1 rifles, particularly in the gas tube,[1] is the gilding metal bullet jacket. Thus, this study centered on the ball bullet of the M193 cartridge and its assembled condition with the cartridge case.

Four M193 cartridge lots were chosen for this analysis. These included two lots which contributed to excessive fouling in the M16A1 rifle, lots FC-1921 and FC-1938, and two M193 cartridge lots which are associated with little or no fouling, lots TW-18309 and TW-18310. For this report they will be simply termed lots A, B, C and D as shown below.

TABLE I. Fouling and Nonfouling Ammunitions Lots*

Test Lot No.	Test Lot No.
A - FC-1921	C - TW-18309
B - FC-1938	D - TW-18310

*the significance of $CaCO_3$ content was not known at the time of these tests and thus the chosen lots vary in percentages of $CaCO_3$, see Appendix B.

Close, visual examination of twenty selected cartridges from each of the four test lots was made from 2X to 25X magnification. Cartridges were examined in the assembled and disassembled condition. Figure 2 at approximately 5X magnification shows an assembled cartridge from each lot, viewed at the case mouth end. Note the "upset" condition of test samples A and B at the case mouth,

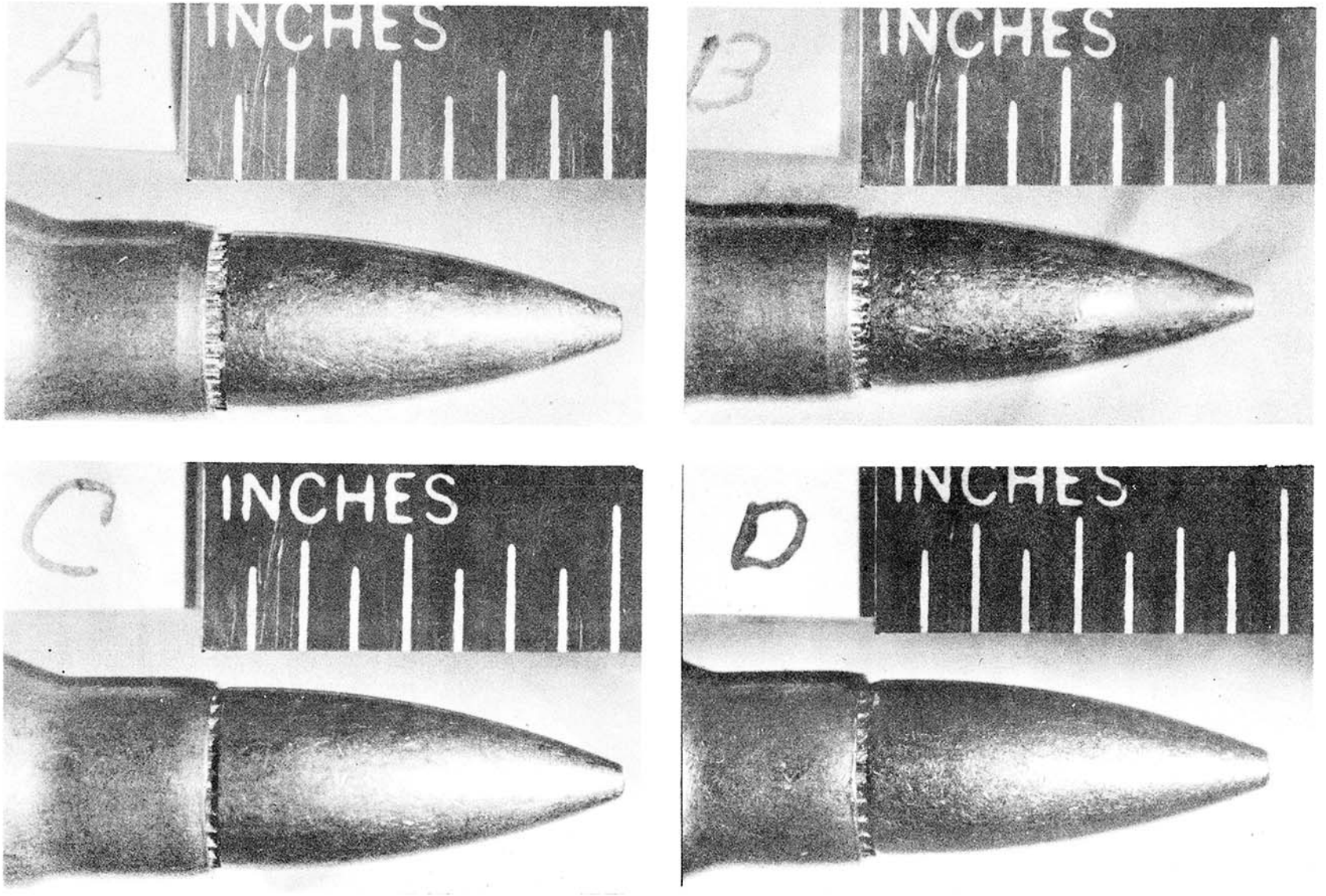


Figure 2. Assembled Cartridges viewed at Case Mouth (5X)

particularly the deformation (angled condition) of the case. Also, partly visible are the poorly formed cannelures of rounds A and B as opposed to the clean definition of the visible portion of the cannelures on rounds C and D.

Figure 3 at 6X shows the bullets of the four sample cartridges extracted from the cartridge cases. Clearly visible now are the poorly machined cannelures existent on samples A and B and the cleanly defined cannelures of samples C and D. Note the influence of excessive crimpng forces (sharp angle on case mouth) on samples A and B as compared to the smooth cylindrical condition of the case mouths of samples C and D.

Figure 4 shows ten samples each of extracted bullets from the four test lots at 2X magnification. It can be seen that it is extremely difficult to visually determine any imperfections at this low magnification. Figures 5, 6, 7 and 8 are individual views of the same bullets shown in Figure 4 at 4X magnification. At this slightly higher magnification a marked difference can be noted in the cannelures of the four test lots. Lots A and B display a characteristic, nonuniform type of condition of cannelure while lots C and D appear uniform in the cannelure area.

The cannelure sections from the four sample bullets are grouped together at 25X magnification for comparative purposes in Figure 9. In the sample from cartridge lot A, the cannelure is only partially formed with portions double knurled or double set. The partially formed section is a strong indication that the bullet was not circular either during or prior to the knurling operation. The sample from lot B shows that it was completely double knurled or double set with a predominance of feathered edges on the outside diameter of the cannelure. Possible causes are dull tools, damaged tools or excessive chip accumulation in the tools. The cannelures on the samples from lots C and D are well defined and do not evidence any erratic, undesireable "cutting" influence during the knurling operation.

Five bullet samples from each of the test lots were sectioned in the transverse plane, through the cannelure and then mounted and polished. These sections are shown in Figures 10, 11, 12 and 13 at 4X magnification.

The transverse sections of bullet samples from lots A and B display an "out-of-round" condition of bullet jacket and lead filler, nonuniform wall thickness of the bullet jacket and poorly defined

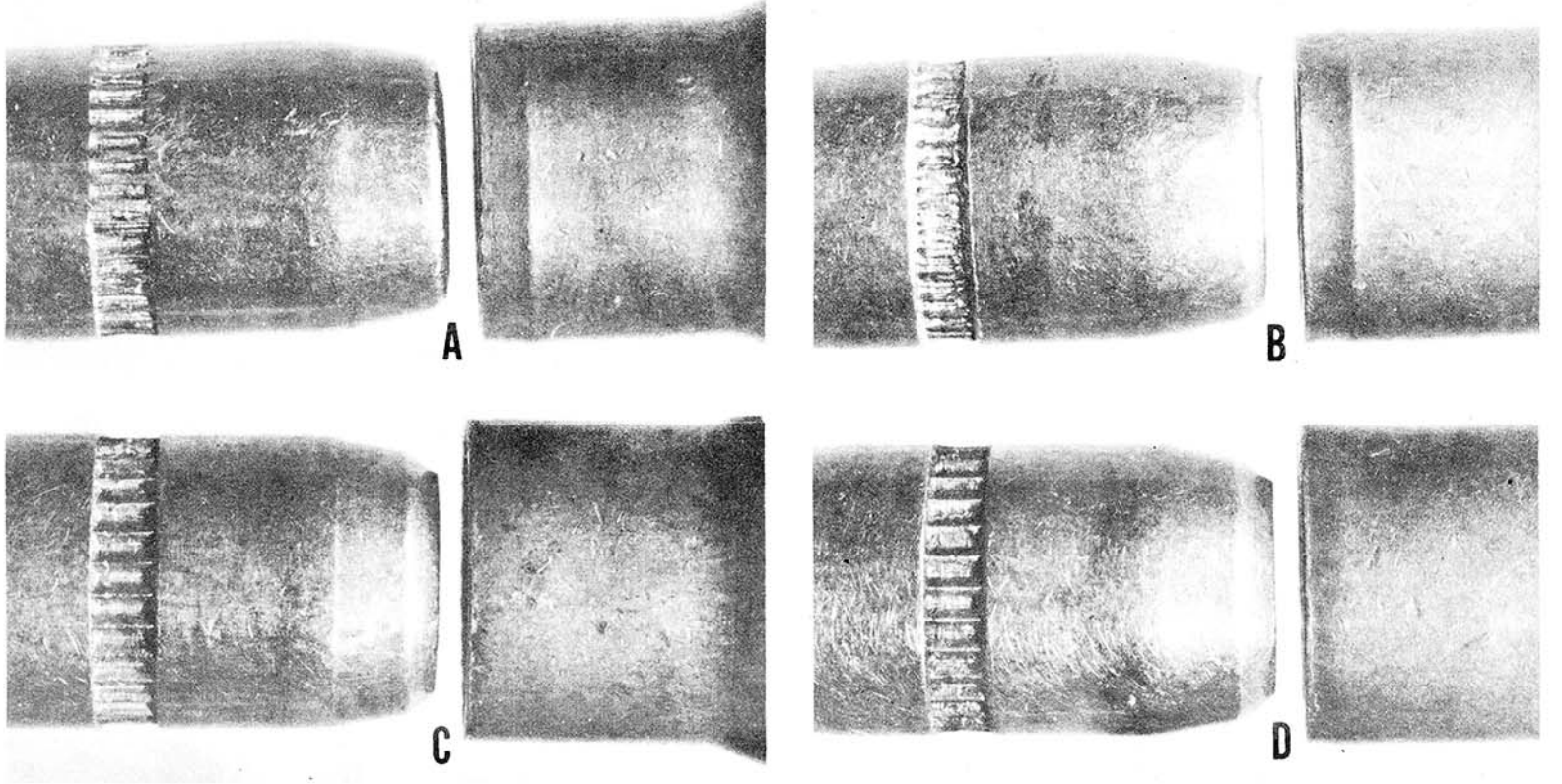


Figure 3. Disassembled Cartridges, Lots A, B, C and D (6X)

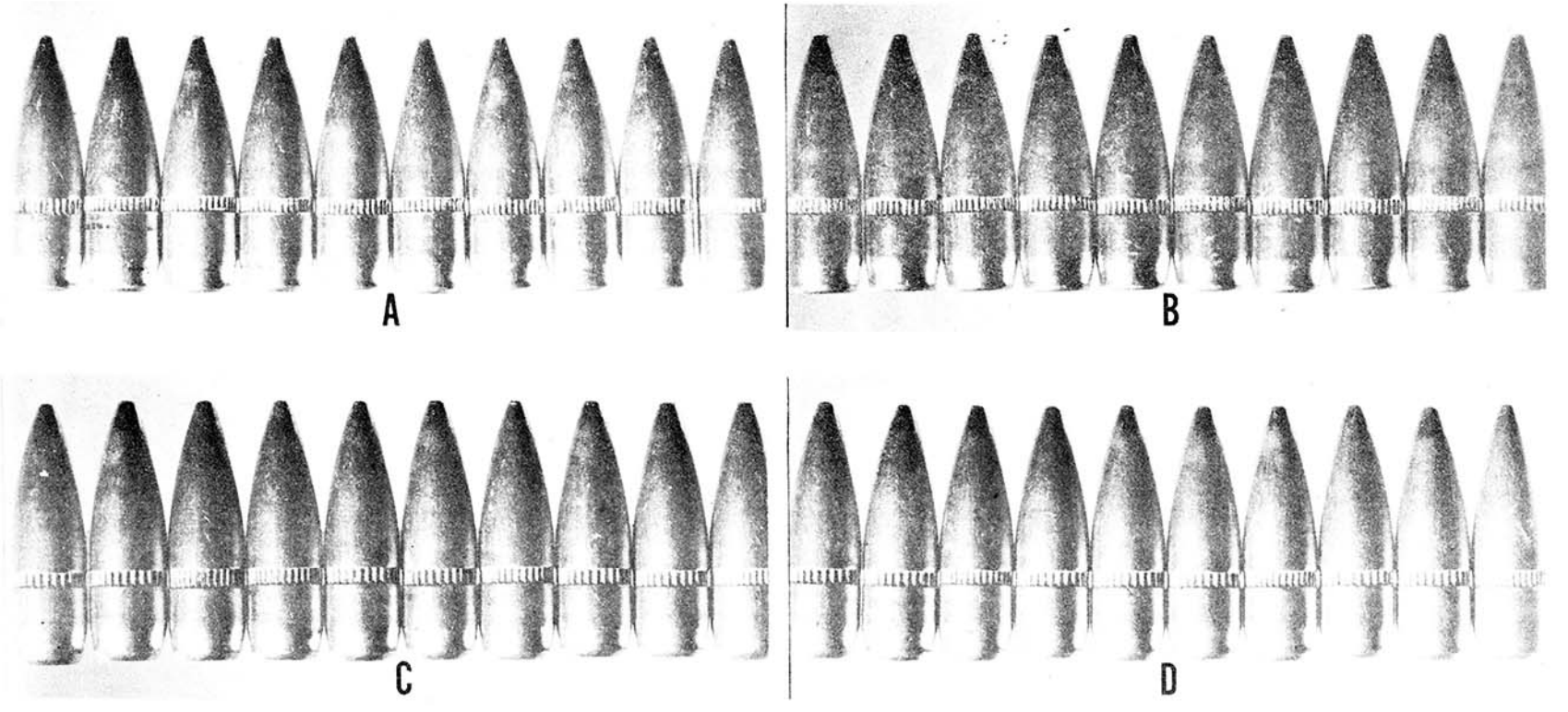


Figure 4. Extracted Bullets, Lots A, B, C and D (2X)

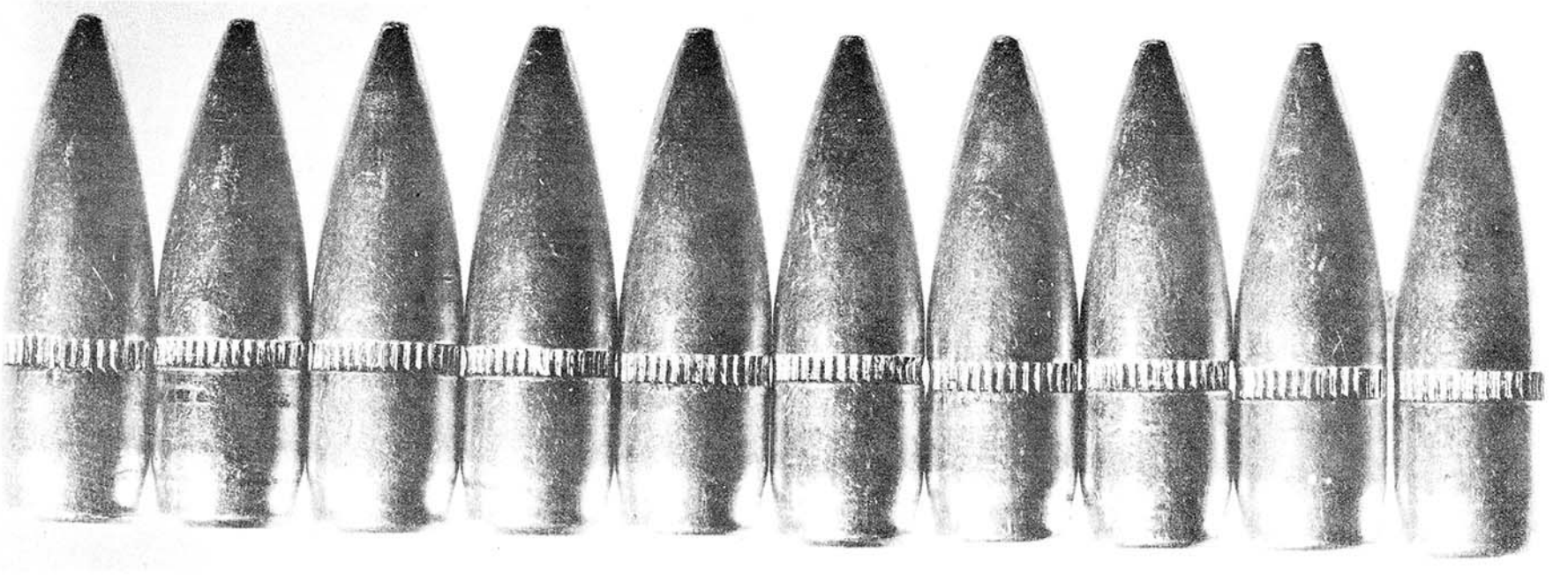


Figure 5. Extracted Bullets, Lot A (4X)

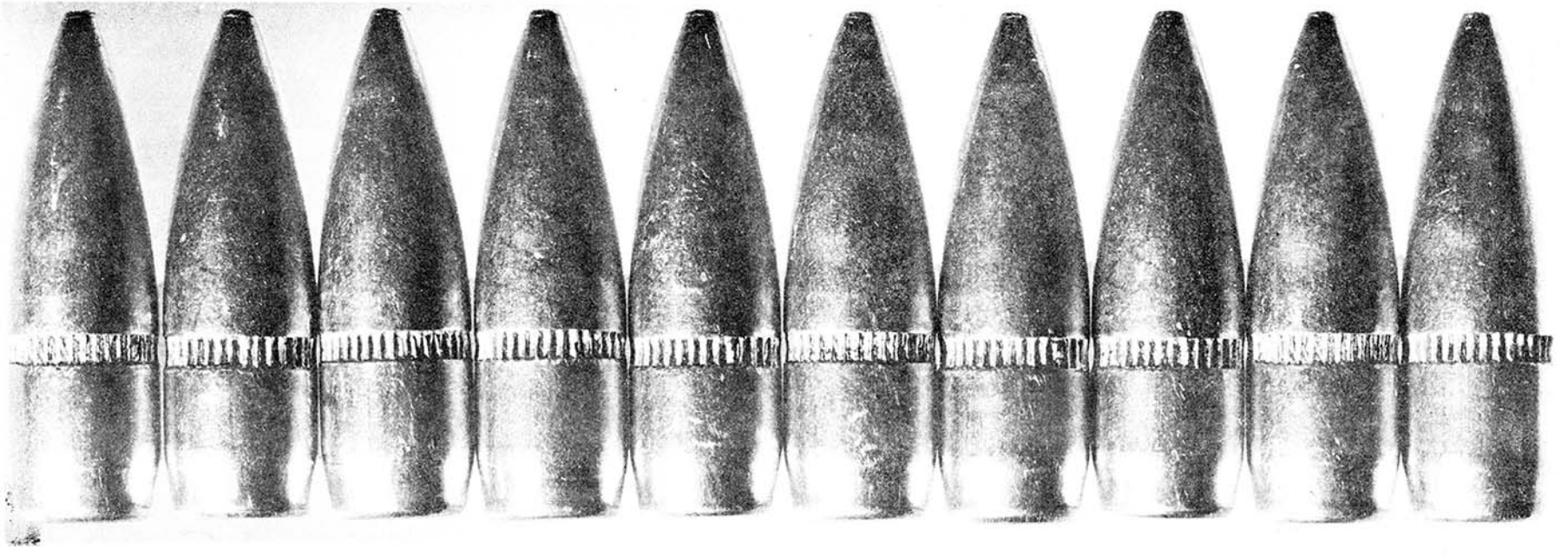


Figure 6. Extracted Bullets, Lot B (4X)

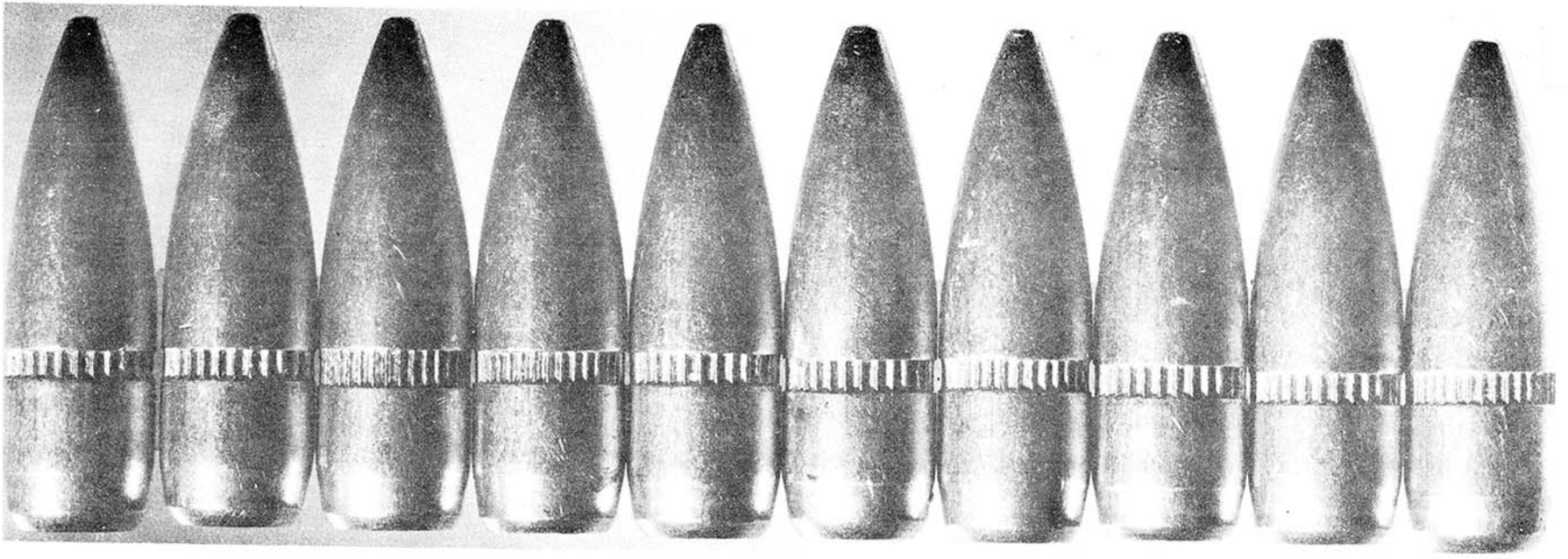


Figure 7. Extracted Bullets, Lot C (4X)

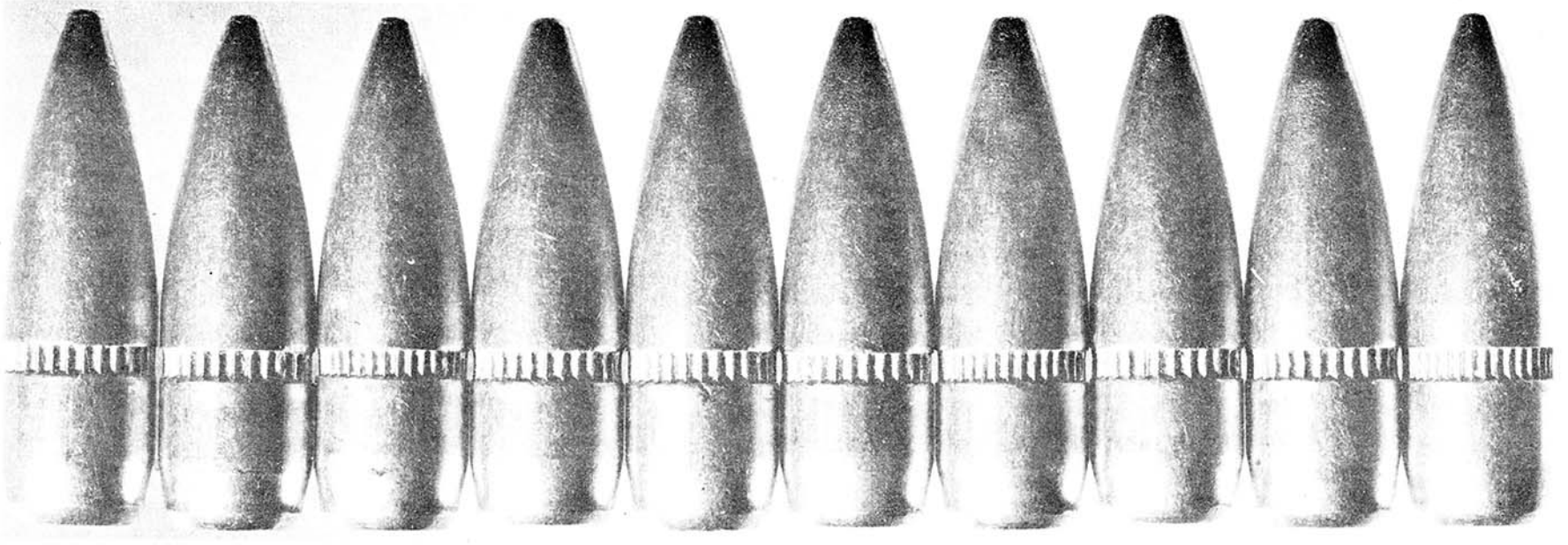


Figure 8. Extracted Bullets, Lot D (4X)

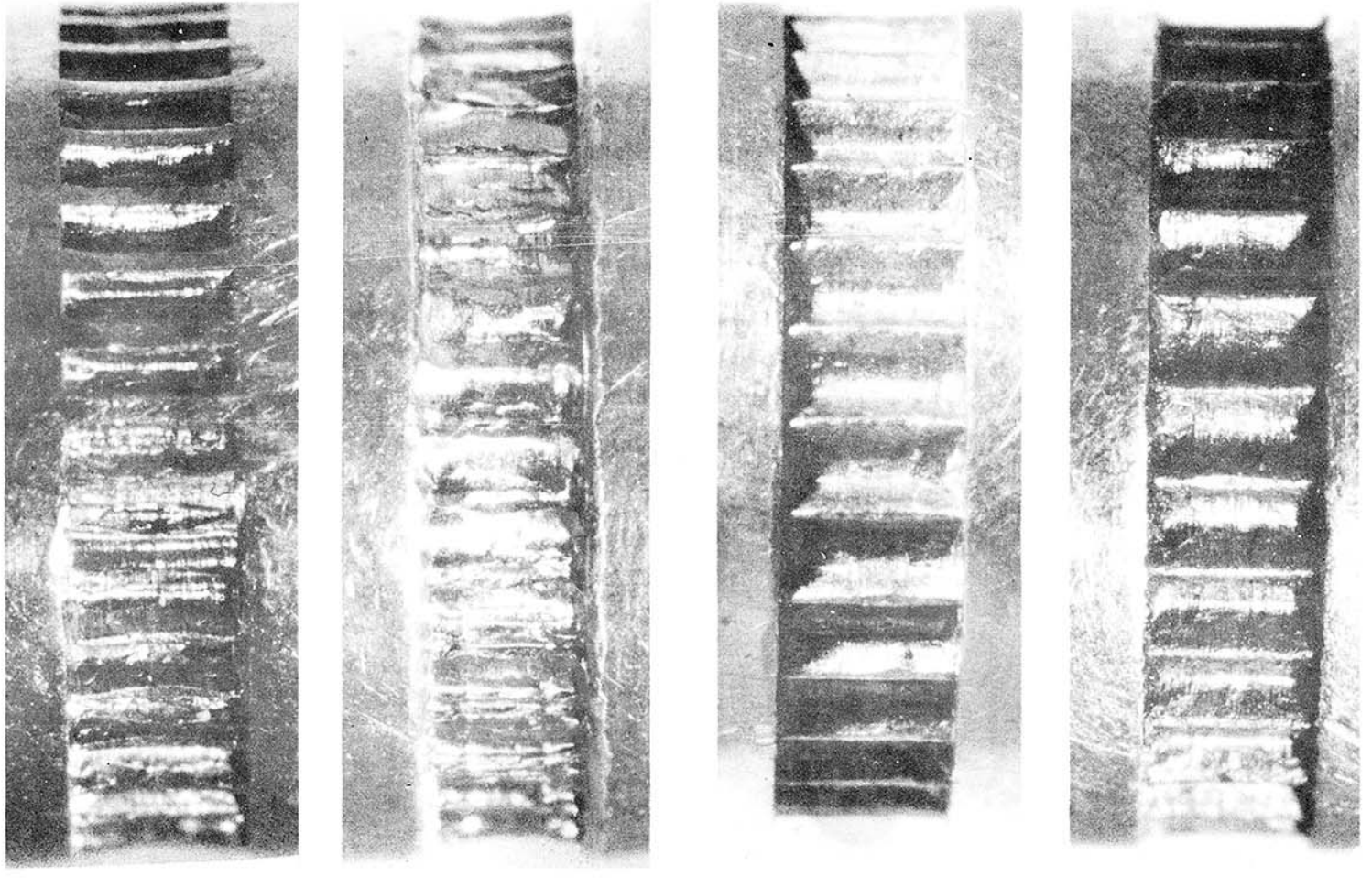


Figure 9. Extracted Bullets, Lots A, B, C and D (25X)

Figure 10. Transverse Sections, Bullets, Lot A (4X)

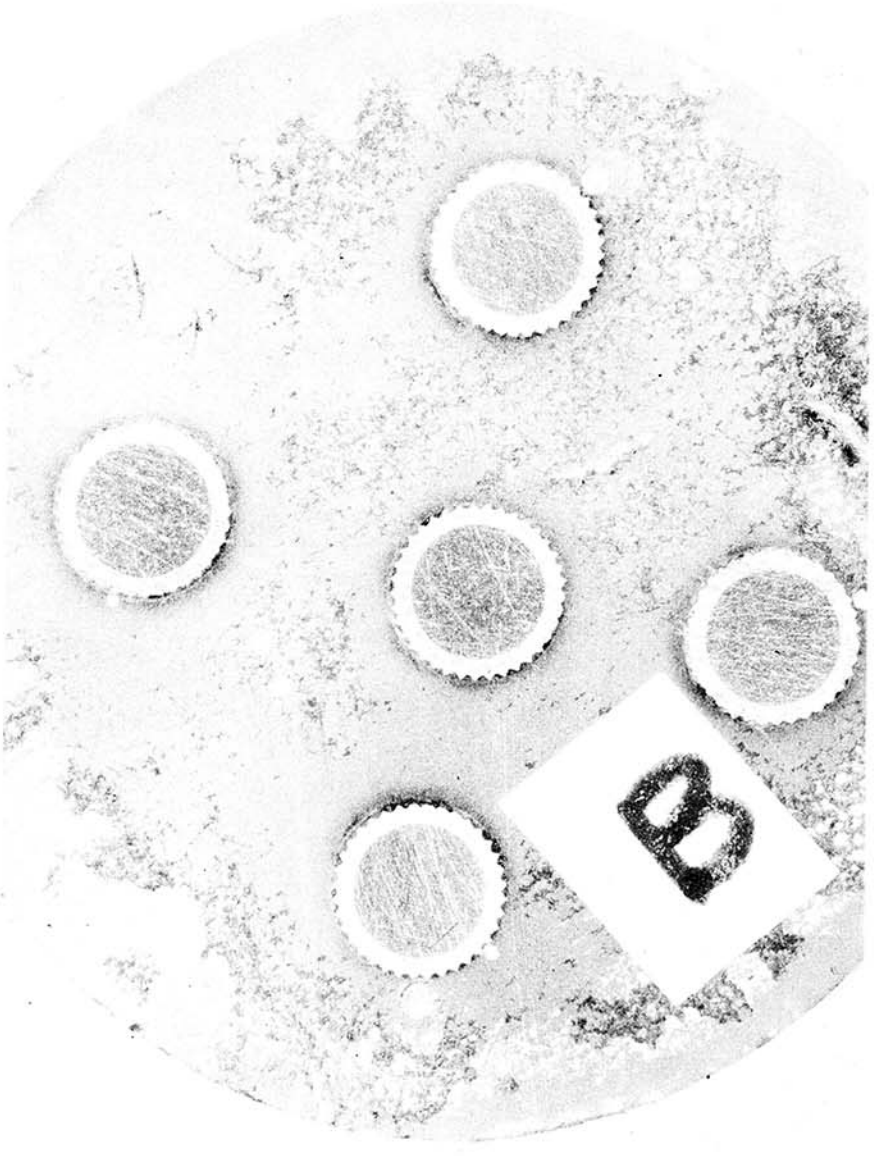


Figure 11. Transverse Sections, Bullets, Lot B (4X)

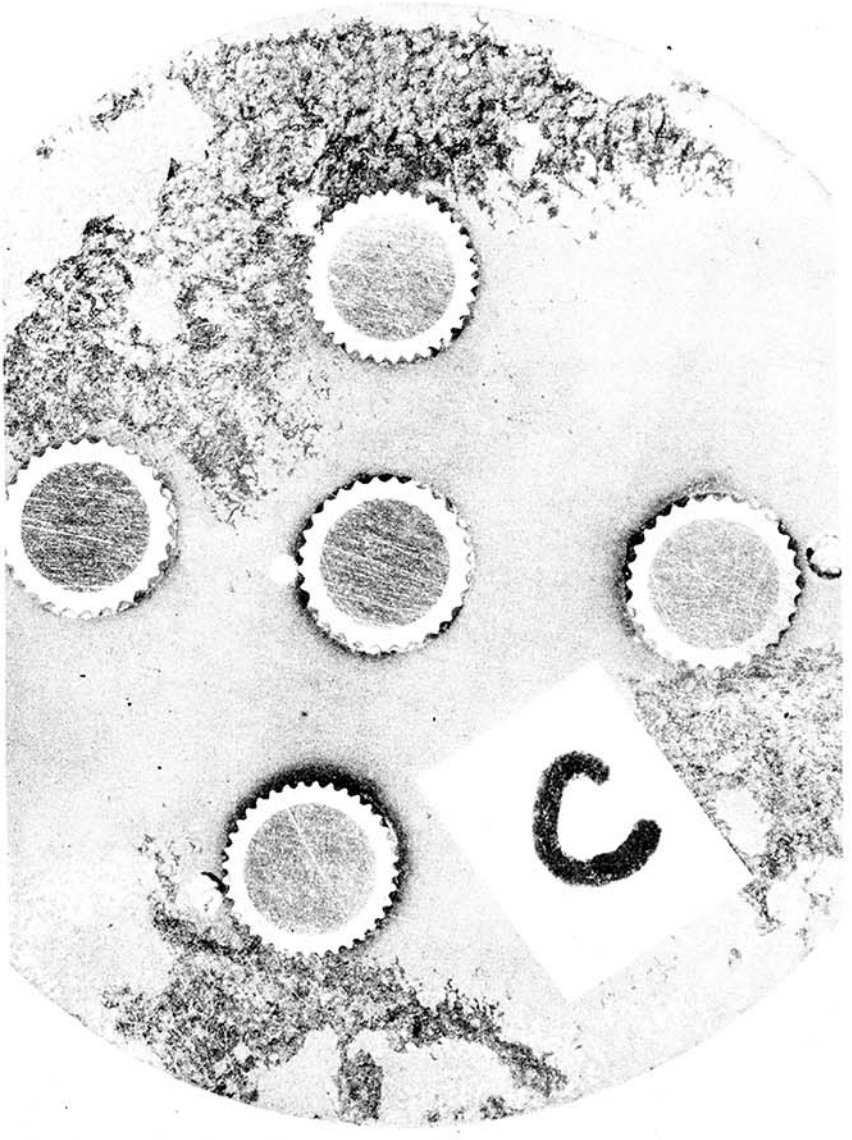


Figure 12. Transverse Sections, Bullets, Lot C (4X)

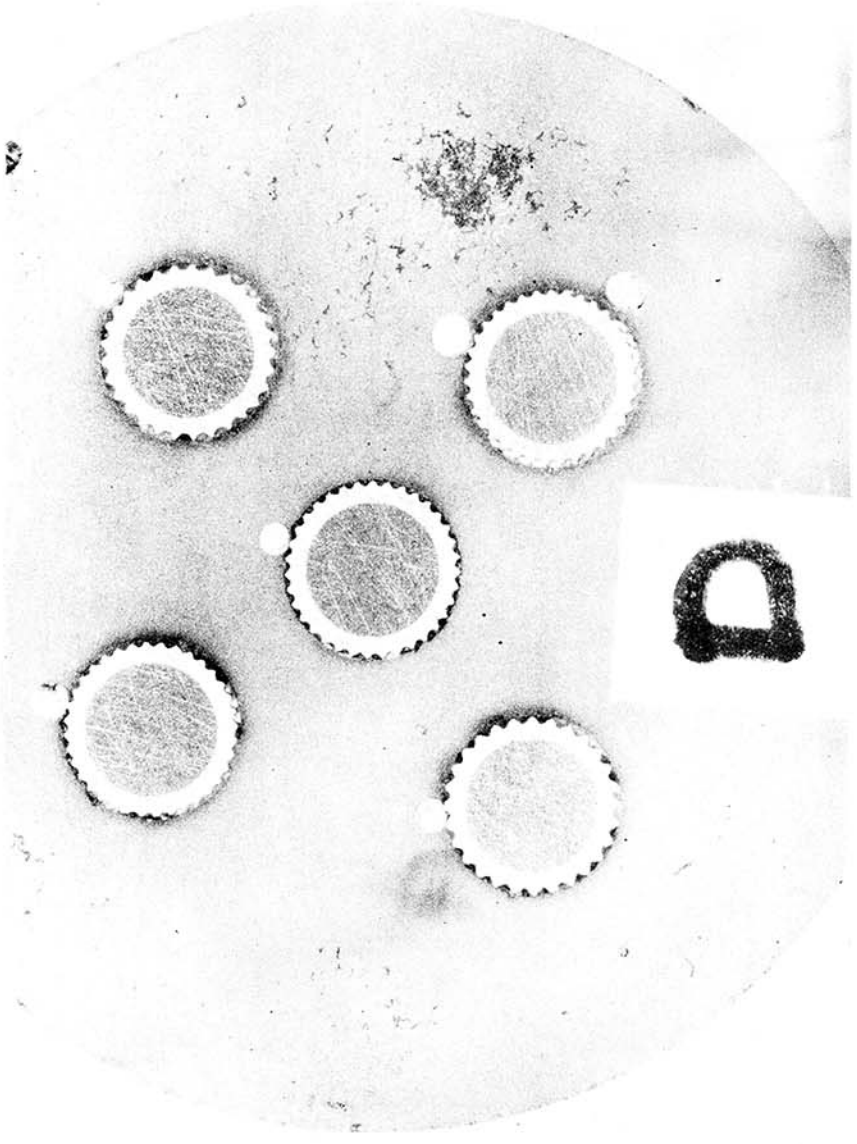


Figure 13. Transverse Sections, Bullets, Lot D (4X)

cannelure geometry. Samples from lots C and D display a uniform jacket wall thickness and a circular condition of the bullet jacket and lead filler assembly.

BULLET EXTRACTION STUDY

Two types of extraction tests were conducted. The first included normal bullet extraction from twenty cartridges taken from lots A, B, C and D. This was followed by supplementary extraction tests using an additional forty cartridges from each of the test lots. Twenty each of these cartridges were subjected to normal bullet extraction tests, and the remaining twenty from each lot were tested using the restricting collar shown in Figure 14. The restricting collar, a normal 5.56 mm barrel-chamber section, provided the "chambered" environment for the rounds during the manual extracting process. The restricting collar was positioned over the bullet neck portion of the cartridge allowing just enough bullet protrusion for manipulation in the test equipment.

In the first instance, the normal extraction process included a straightforward pull of the bullet with the case being held at the base. Use of the restricting collar allowed confinement of the case mouth within the dimensional limitations afforded by a standard 5.56 mm barrel-chamber as shown in Figure 14. Note that the 0.255 + 0.002 inch diameter of the restricing collar was positioned directly on the first shoulder of the cartridge case. This provided the same radial restriction for each of the cartridges tested. Use of the two test methods allowed a comparison of extraction forces for supported and unsupported cartridge case mouths during bullet extraction.

In the case where the cartridge case mouth was unsupported, it could expand during extraction to clear the lower edge of the cannelure with minimum interference. Use of the restricting collar limited the amount of expansion of the case mouth thereby increasing the interference and resulting extraction force. As will be shown later, poorly made cannelures result in over-crimping of the case mouth. This over-crimped condition leads to higher bullet extraction forces.

Extraction Tests, Lots A, B, C and D

A Tinius-Olsen Universal Tester with a range of 0 to 600 pounds was used to extract all bullets at a speed of 4.0 inches per minute. Values obtained for the four test lots are shown in Table C-1, Appendix C. Composite histogram plots of lots A, B, C and D are shown in Figure 15. The composite average bullet extraction force for lots A and B was 163 pounds and the composite average bullet extraction force for lots C and D was 96 pounds. Thus, a marked difference existed in the bullet extraction characteristics. Lots A and B are closely paired with no individual value below 110 pounds with a maximum individual value of 208 pounds. Lots C and D are closely paired with an individual value as low as 66 pounds and a maximum individual value of 120 pounds. A graphical presentation of the extraction values for each of the lots is shown in Figure 16. Extreme variation values shown in Figure 16 show the larger limits in lots A and B. Specification limit for 5.56 mm ball ammunition lot acceptance is 35 pounds minimum bullet extraction force.

Individual, minimum, maximum and average bullet extraction forces for the supplementary ammunition lots are shown in Table C-2, Appendix C. For clarity, they will be referred to as lots A_1, B_1, C_1 and D_1. The average values obtained with the restricting collar are higher than without for lots A_1 and B_1. The average values obtained with the restricting collar are either the same or lower than without for lots C_1 and D_1. Again lots A_1 and B_1 are closely paired at the higher extraction force level and lots C_1 and D_1 are also closely paired at the lower extraction force level.

Three instances of case mouth shear (noted as "Small Sliver of Brass on Case Mouth" in Table C-2) were encountered in test of lot A_1 with and without the restricting collar. The two shears obtained with the restricting collar were intact; i.e., brass rings with an outside diameter of 0.223 to 0.225 inch and an inside diameter of approximately 0.217 to 0.219 inch. The single incident of shear without use of the restricting collar resulted in circularly shaped pieces with an average wall thickness of 0.007 inch. Six instances of case mouth shear were recorded in test of lot B_1, with and without the restricting collar. The three shears obtained with the restricting collar were essentially identical to the intact brass rings obtained during test of lot A_1 under the same conditions. No case mouth shears were obtained in tests of lots C_1 and D_1.

Use of the restricting collar resulted in slightly higher individual extraction forces in tests of lots A_1, B_1, C_1 and D_1. Composite average for lots A and B tested earlier is slightly higher than the corresponding average for lots A_1 and B_1 with restricting collar. Composite average for lots C and D tested earlier is almost similar to values obtained for lots C_1 and D_1, with or without the restricting collar. Composite histogram plot of extraction values obtained with the restricting collar is shown in Figure 17. Composite plot without the restricting collar is shown in Figure 18. The foregoing comparisons have clearly shown that the bullet extraction forces encountered with the nonfouling ammunition, lots C, D, C_1 and D_1 are significantly lower than those of the fouling ammunition, lots A, B, A_1 and B_1.

The reported incidences of case mouth shears which occurred only in tests of lots A_1 and B_1 correlate with the observed crimping conditions noted in schematic, Figure 19. Dimensionally, all test cartridges were within the assembled case mouth specification diameter of 0.251 inch maximum. The restricting collar diameter 0.254 + 0.002 inch which cooperated with the case mouth crimp of each cartridge allowed the slight deformation required in the case mouth to clear the bullets in lots C, D, C_1 and D_1. However, the exaggerated, overstressed case mouth condition existing in cartridge lots A, B, A_1 and B_1, can result in interference at the rear of the cannelure during extraction. If this interference is sufficient, the rear shoulder of the cannelure will shear a portion of the case mouth. The intact brass (shear) rings obtained during tests of lots A_1 and B_1 indicate that the restricting collar supported the case mouth and allowed a uniform, constant stress to be applied circumferentailly on the interior of the case mouth. The circularly shaped pieces (shear) resulted from the same stress conditions except the case mouth exterior was unsupported resulting in a nonuniform application of the extraction load.

In general, it was noted that when the cannelure was properly formed and displayed a clean-cut appearance such as the samples from lots C and D shown in Figure 9, there appeared to be little or no crimping effect on the diametral condition of the knurl (cannelure). However, in the case of lots A and B, the relatively fragile and irregularly formed cannelure can be easily deformed during crimping. This results in relatively higher bullet extraction forces than is normally obtained when the cannelure is properly made. It is postulated that the condition can cause larger amounts of copper-zinc to be mechanically liberated from the cannelure area on the bullet jacket thereby increasing the amount of metallic debris in the gas stream.

For lots A and B, the macrographic study revealed the condition shown in Figure 19 of the deformed case mouth embedded in the bullet cannelure. Microscopic dimensional techniques revealed the approximate depth of penetration made by the inner diameter of the case mouth into the cannelure to be 0.005 to 0.009 inch on radius. Case mouth deformation (angle) and corresponding angular upset of the cannelure are shown in Figure 19. For lots C and D, the macroscopic evidence, Figure 19, along with dimensional checks revealed that the limits of interference between the inner case mouth and rear edge of the cannelure can be between 0.0034 to 0.0062 inch.

CARTRIDGE METAL PARTS INSPECTION

Cartridge Assembly and Cartridge Case

Exterior envelope dimensions of the twenty assembled sample cartridges from each lot were within the limits specified in the cartridge assembly drawing, Figure A-1, Appendix A. Measurable exterior dimensions of the cartridge cases from each lot were also within drawing limitations as shown in Figure A-2, Appendix A.

Bullet

Twenty bullets each from the test lots were dimensionally examined using a Gaertner toolmaker's microscope.* This comparator type instrument was used in preference to manual measuring devices such as gauges, micrometers, etc., to avoid physical damage to the bullets especially in the cannelure area. All of the test bullets were

*Microscope with protractor head, vernier readings to 1 minute through 360°. Longitudinal micrometer range, 4 inches and transverse micrometer range, 2 inches. Drums graduated 0 to 0.05 inch to read in increments of 0.0001 inch.

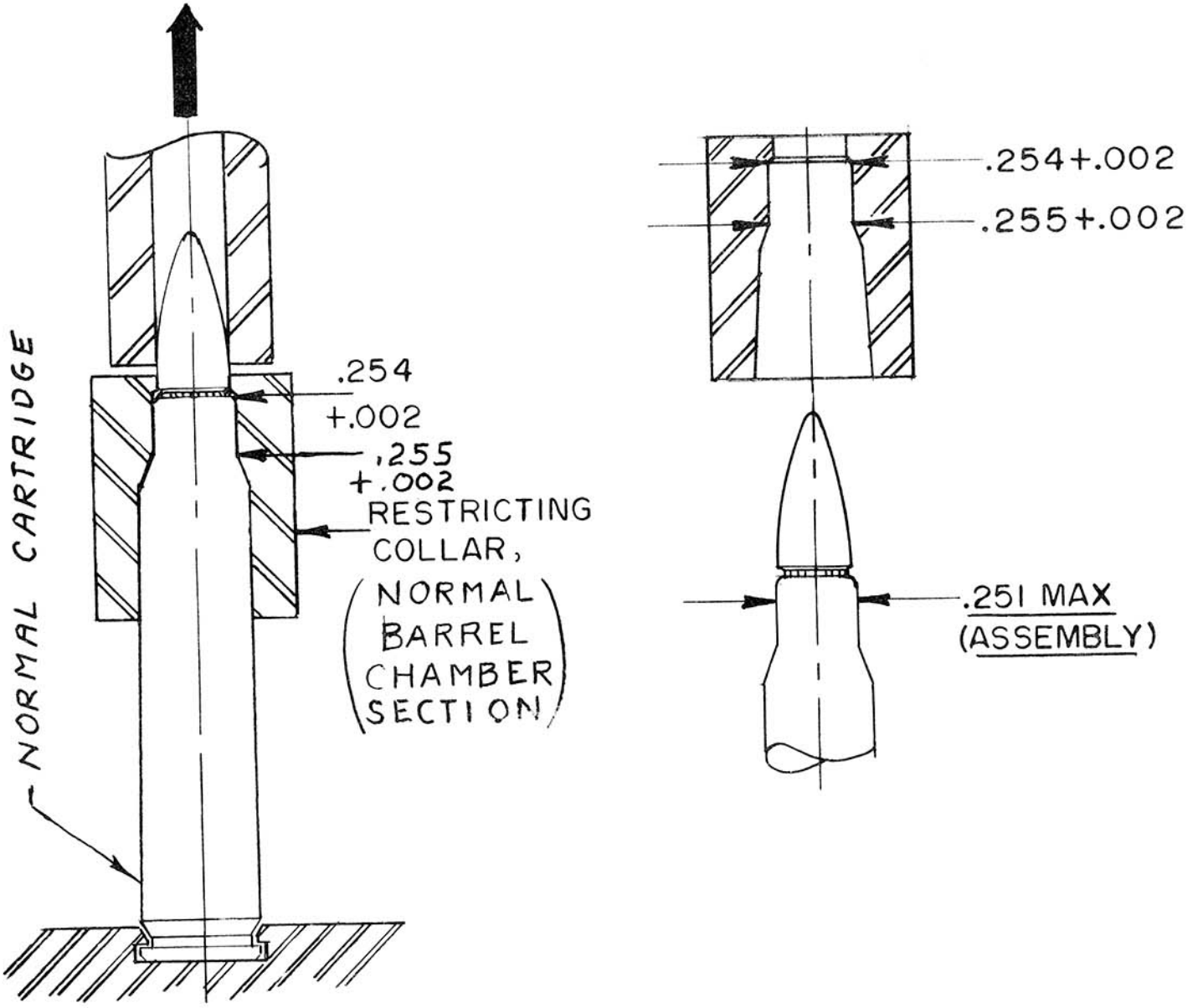


Figure 14. Schematic, Bullet Extraction Test with Restricting Collar

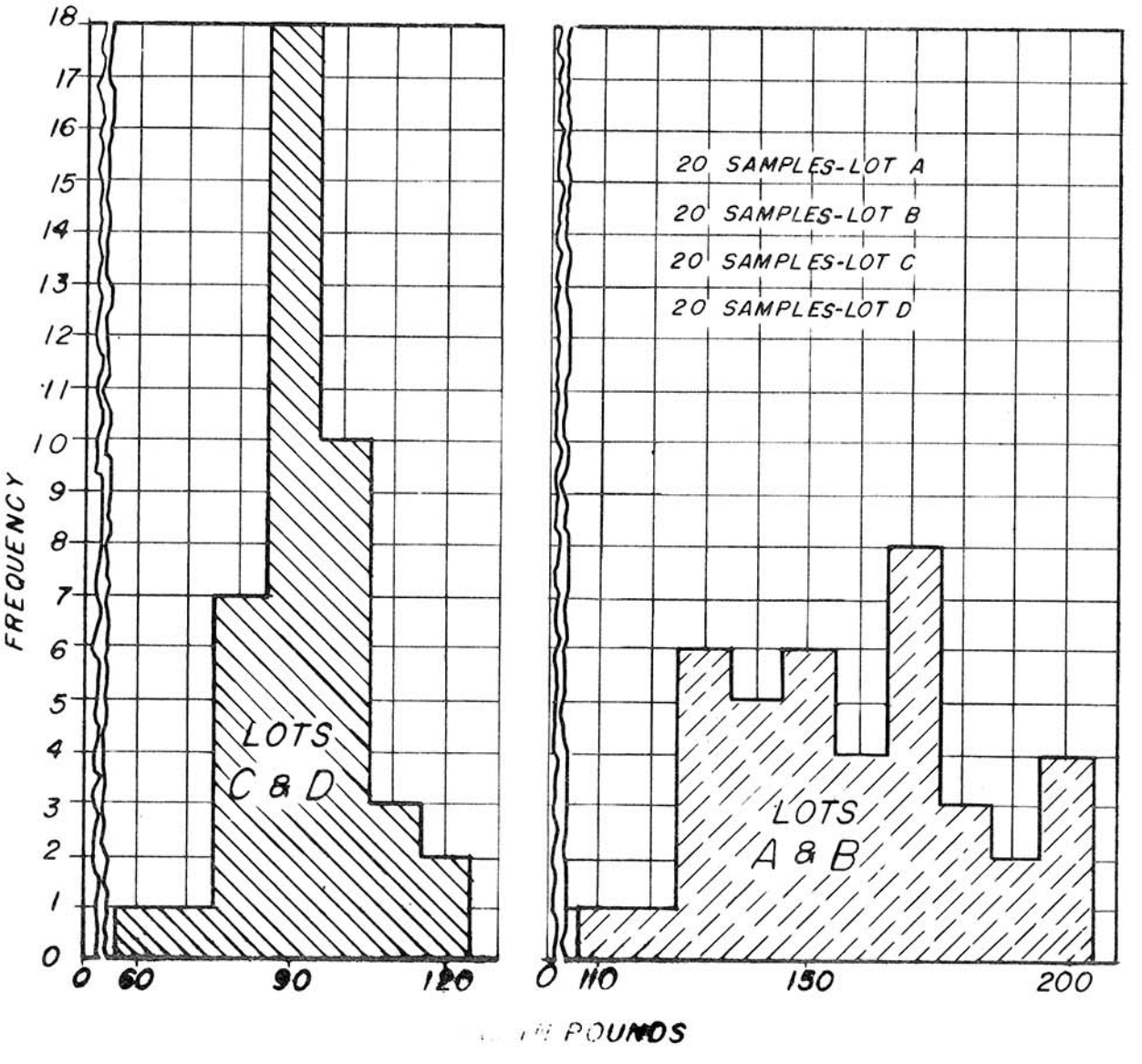


Figure 15. Composite Histogram Plot, Bullet Extraction, Lots A, B, C and D

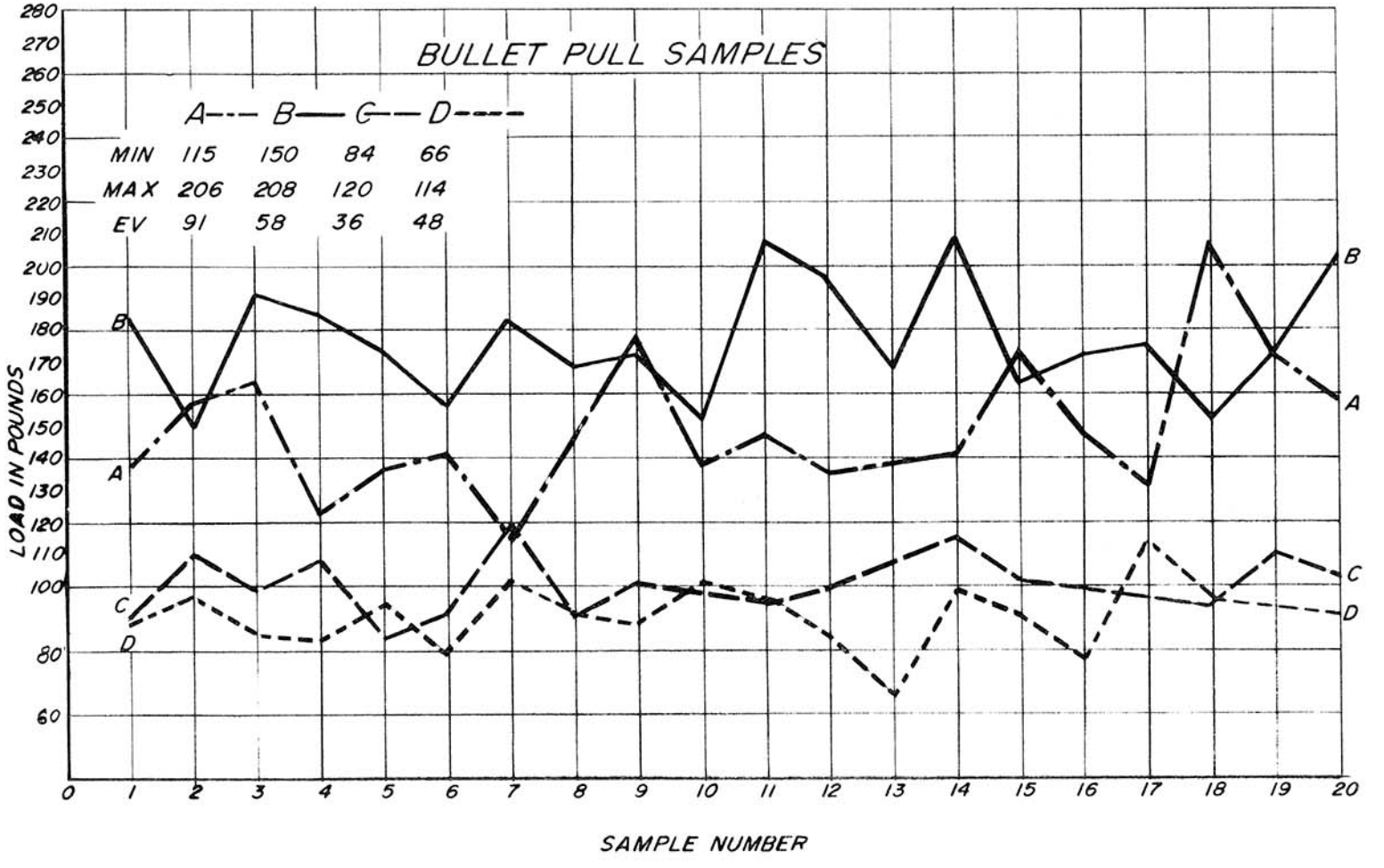


Figure 16. Bullet Extraction Values, Lots A, B, C and D

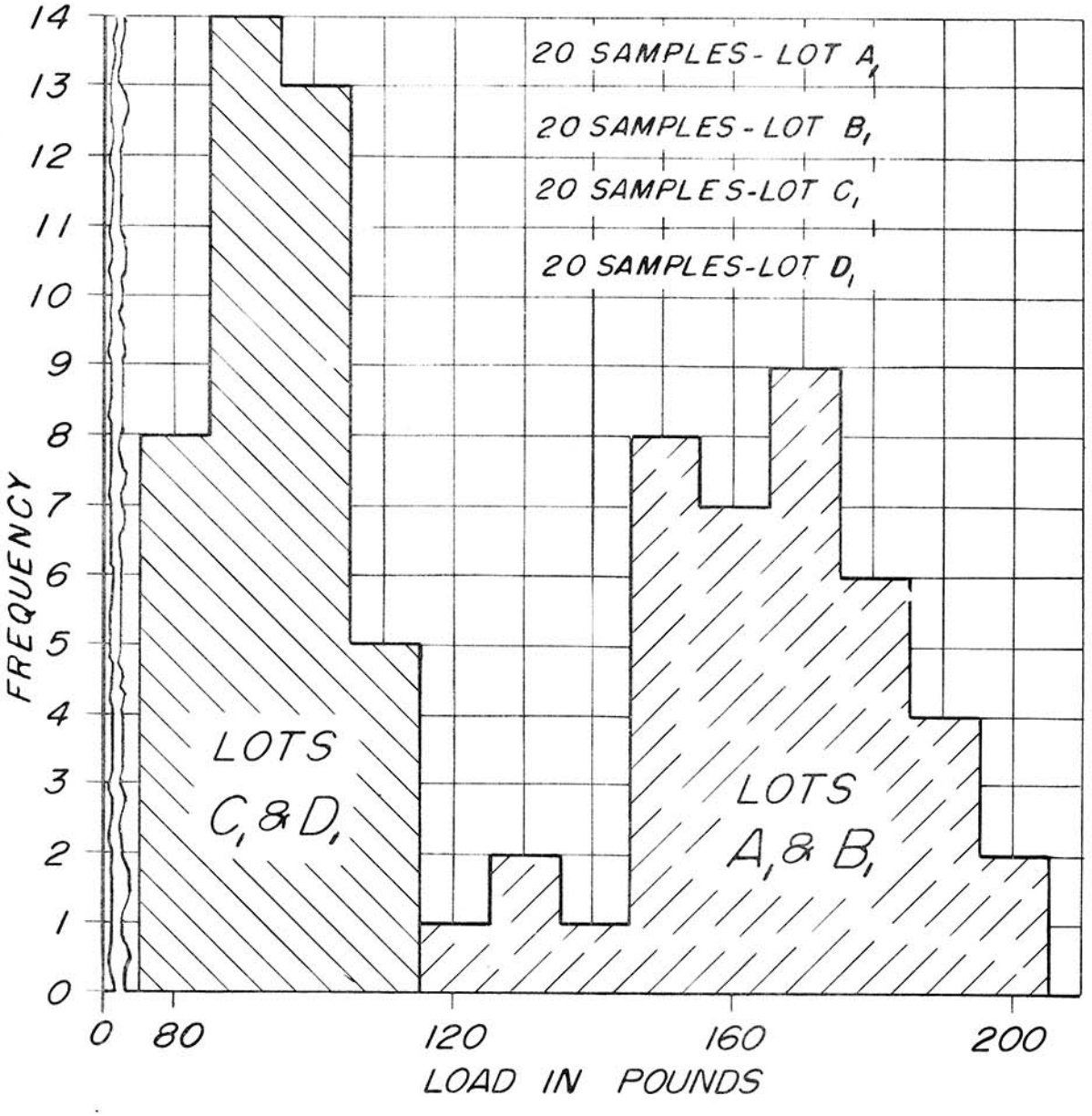


Figure 17. Composite Histogram Plot, Bullet Extraction Test with Restricting Collar, Lots A_1, B_1, C_1 and D_1

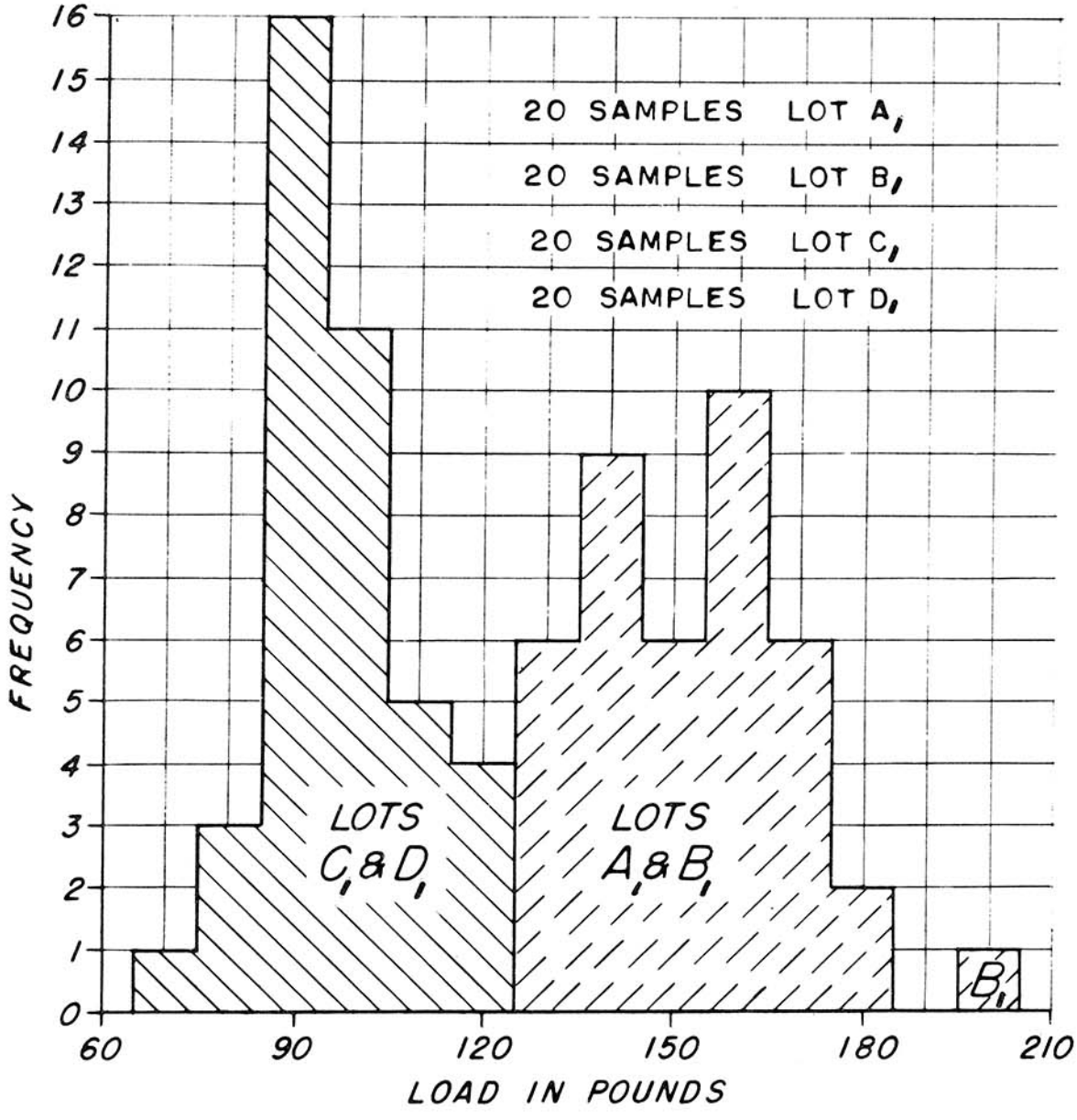


Figure 18. Composite Histogram Plot, Bullet Extraction Test without Restricting Collar, Lots A_1, B_1, C_1 and D_1

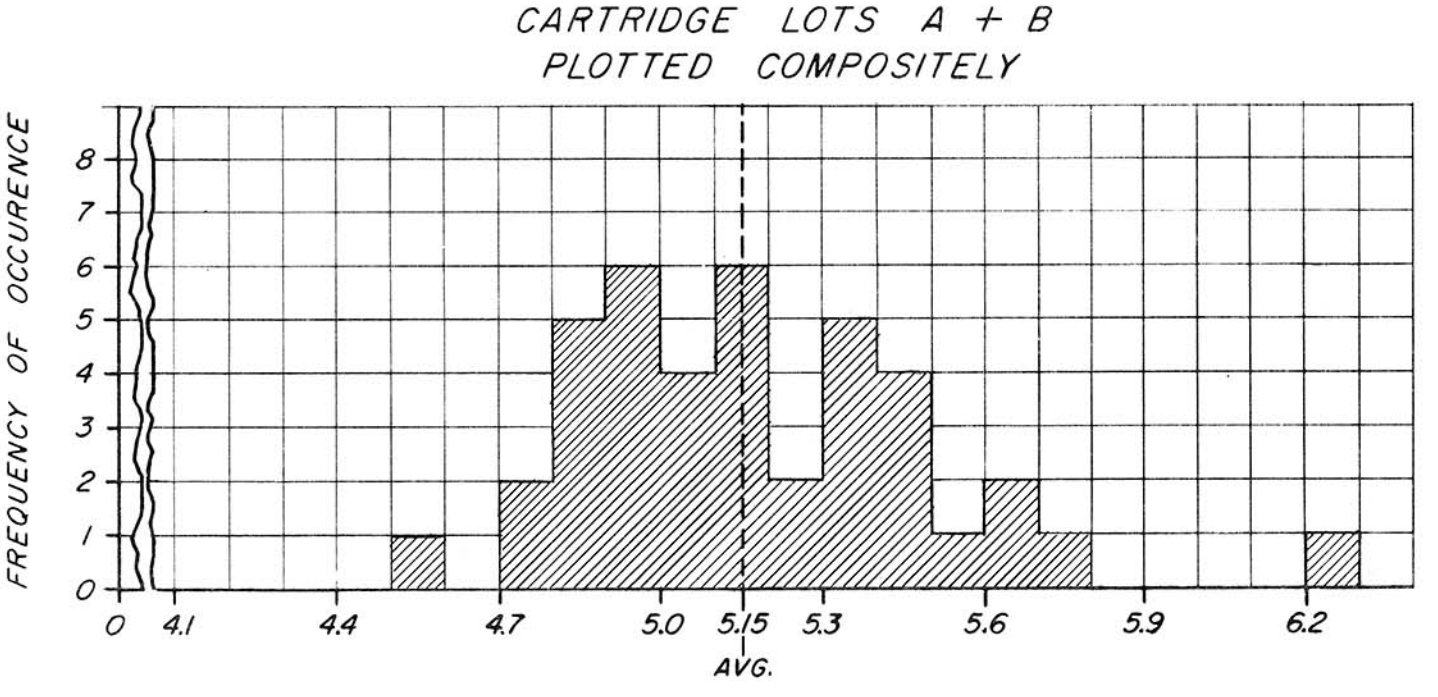


Figure 20. Composite Histogram Plot, Diameter of Cannelure/Width of Cannelure Lots A and B

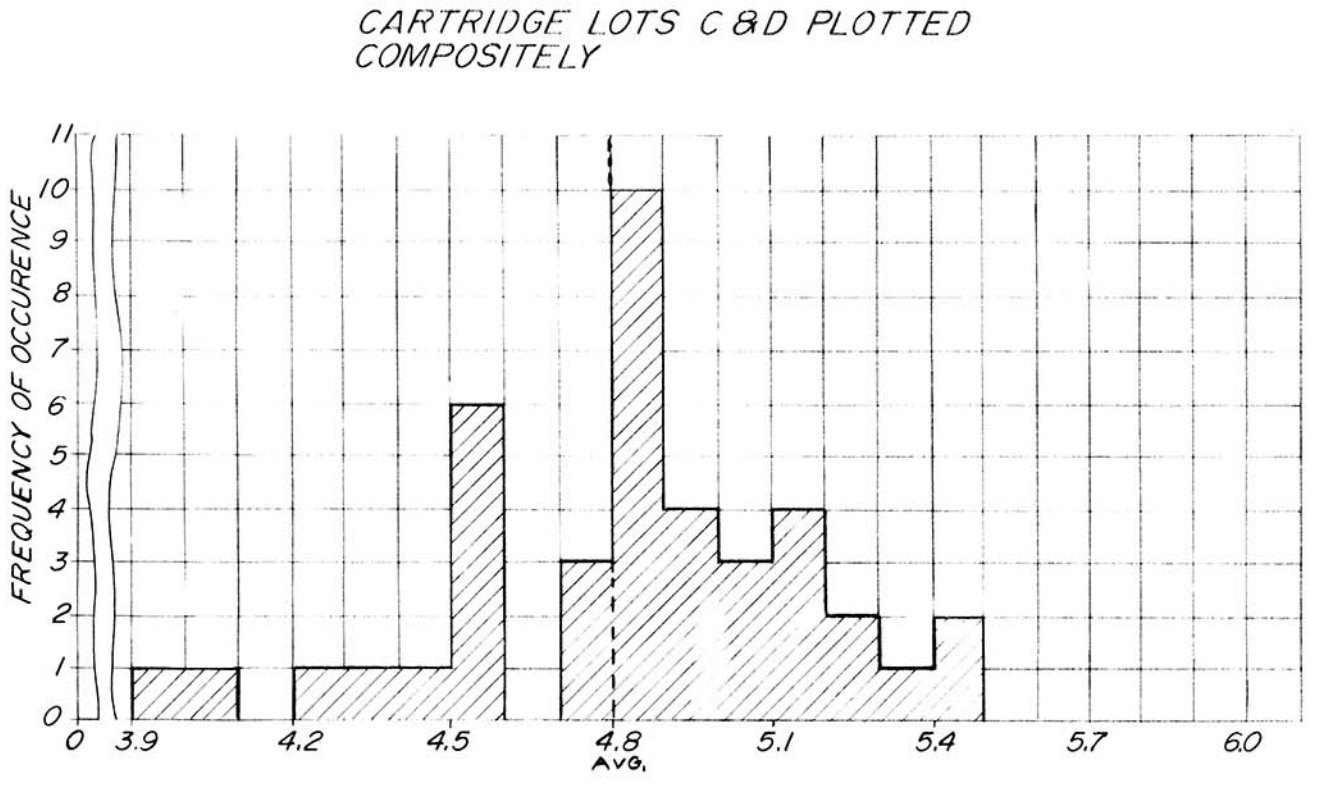


Figure 21. Composite Histogram Plot, Diameter of Cannelure/ Width of Cannelure, Lots C and D

TABLE II. Inspection Record, Bullet Dimensions, Lot A

Sample No.	Bullet Diameter (in.)	Cannelure Diameter (in.)	Cannelure Width (in.)	Cannelure Condition (Knurl)*	P_b Diameter
1	0.225	0.219	0.045	OK	0.138
2	0.224	0.214	0.040	D/S-F	0.131
3	0.225	0.217	0.043	D/S-F	0.144
4	0.223 0.224	0.216	0.043	Partly D/S-F	0.135
5	0.224	0.215	0.042	D/S-F	0.126
6	0.224	0.219	0.041	Partly D/S-G	0.130
7	0.224	0.216	0.040	D/S-P	0.124
8	0.224	0.217	0.043	D/S-G	0.138
9	0.222	0.221	0.039	OK	0.118
10	0.224	0.221	0.039	OK	0.117
11	0.224	0.215	0.045	OK	0.140
12	0.223	0.218	0.035	OK	0.136
13	0.223	0.214	0.040	Partly D/S-F	0.120
14	0.222	0.212	0.039	OK	0.124
15	0.224	0.215	0.039	OK	0.129
16	0.223	0.217	0.045 0.043	OK	0.136
17	0.222	0.217	0.038	**	0.115
18	0.224	0.216	0.046	OK	0.134
19	0.225	0.214	0.044	OK	0.136
20	0.222	0.219	0.044	OK	0.131

*D/S - Double Set (Knurl)
D/S-G-Double Set (Knurl) Good
D/S-F-Double Set (Knurl) Fair
D/S-P-Double Set (Knurl) Poor

**Slightly Misaligned

TABLE III. Inspection Record, Bullet Dimensions, Lot B

Sample No.	Bullet Diameter (in.)	Cannelure Diameter (in.)	Cannelure Width (in.)	Cannelure Condition (Knurl)*	P_b Diameter
1	0.223	0.216	0.044	OK	0.127
2	0.224	0.219	0.044	OK	0.127
3	0.223	0.215	0.047	OK	0.120
4	0.223	0.215	0.044	OK	0.119
5	0.223 0.224	0.216	0.045	D/S-G	0.126
6	0.223	0.216	0.042	D/S-G	0.139
7	0.223	0.214	0.040	OK	0.114
8	0.223	0.216	0.042	OK	0.122
9	0.223 0.225	0.217	0.042	D/S-F	0.120
10	0.224	0.217	0.042	D/S-F	0.130
11	0.224	0.213	0.041	D/S-G	0.131
12	0/224	0.218	0.041	OK	0.131
13	0.224	0.217	0.044	OK	0.128
14	0.224	0.216	0.041	D/S-G	0.134
15	0.225	0.217	0.044	PK	0.131
16	0.224	0.217	0.040	D/S-G	0.124
17	0.224	0.218	0.045	OK	0.125
18	0.224	0.218	0.045	OK	0.130
19	0.224	0.217	0.042	OK	0.129
20	0.223 0.224	0.215	0.043	OK	0.127

*D/S - Double Set (Knurl)
D/S-G - Double Set (Knurl) Good
D/S-F - Double Set (Knurl) Fair

TABLE IV. Inspection Record, Bullet Dimensions, Lot C

Sample No.	Bullet Diameter (in.)	Cannelure Diameter (in.)	Cannelure Width (in.)	Cannelure Condition (Knurl)	P_b Diameter
1	0.223 0.225	0.214	0.054	OK	0.137
2	0.223	0.215	0.048	OK	0.129
3	0.224	0.215	0.042	OK	0.139
4	0.224	0.215	0.047	OK	0.130
5	0.222 0.225	0.216	0.041	OK	0.134
6	0.225	0.215	0.047	OK	0.135
7	0.224	0.216	0.043	OK	0.140
8	0.225	0.217	0.048	OK	0.132
9	0.224	0.218	0.048	OK	0.138
10	0.224	0.219	0.040	OK	0.156
11	0.224	0.214	0.045	OK	0.149
12	0.223	0.217	0.045	OK	0.132
13	0.224				
13	0.223	0.216	0.045	OK	0.138
14	0.224	0.214	0.047	OK	0.142
15	0.223 0.225	0.217	0.045	OK	0.136
16	0.224	0.216	0.045	OK	0.132
17	0.223	0.217	0.051	OK	0.135
18	0.224	0.214	0.049	OK	0.130
19	0.224	0.219	0.048	OK	0.135
20	0.225	0.214	0.044	OK	0.140

TABLE V. Inspection Record, Bullet Dimensions, Lot D

Sample No.	Bullet Diameter (in.)	Cannelure Diameter (in.)	Cannelure Width (in.)	Cannelure Condition (Knurl)	P_b Diameter
1	0.223	0.218	0.043	OK	0.153
2	0.224	0.218	0.045	OK	0.141
3	0.224	0.216	0.044	OK	0.132
4	0.224	0.218	0.045	OK	0.144
5	0.224	0.218	0.044	OK	0.136
6	0.224	0.212	0.043	OK	0.154
7	0.223	0.214	0.043	OK	0.142
8	0.223	0.214	0.045	OK	0.149
9	0.224	0.217	0.042	OK	0.130
10	0.224	0.217	0.053	OK	0.139
11	0.224	0.218	0.046	OK	0.133
12	0.224	0.216	0.041	OK	0.146
13	0.223	0.217	0.045	OK	0.139
14	0.223	0.216	0.042	OK	0.174*
15	0.225	0.217	0.042	OK	0.149
16	0.223	0.219	0.041	OK	0.150
17	0.224	0.217	0.045	OK	0.149
18	0.223	0.218	0.043	OK	0.137
19	0.223	0.219	0.044	OK	0.163*
20	0.223	0.218	0.040	OK	0.193*

*Excess lead

From this comparison it can be seen that lots A and B (fouling ammunition) possessed the larger base areas of exposed gilding metal. For lots C and D, it was the reverse. This marked variation of exposed lead and gilding metal areas may be significant when considering the combined action of high pressure, high temperature gases on the base of the bullet, especially at the start of the ballistic cycle. Also, as will be shown under "Ballistic Studies," the chamber and port pressure time (p/t) relationship obtained for lots A and B are similar and they are markedly different than the similar PT relationship of lots C and D.

While this particular condition was noted during this study, no significance can be placed at this time on its influence on fouling in the M16A1 rifle.

CHEMICAL AND METALLURGICAL ANALYSES

Bullet Jacket Hardness

Figure 22 is a graphical illustration showing the average bullet jacket hardness from five samples each of lots A, B, C and D. Within the range of hardness observed, there is no apparent relationship between bullet jacket hardness and recorded fouling history for the test Lots A and B, associated with heavy fouling, fall between the extremes of hardness noted for the nonfouling lots C and D. This is true for hardness data obtained along longitudinally sectioned jackets as well as hardness data obtained on unsectioned bullet jacket noses and bases.

Bullet Jacket Chemical Analyses

Table VI is a summary of chemical analyses performed on five samples each of the bullet jacket materials from lots A, B, C and D. With the exception of tin content (0.002) in lots C and D and the absence of manganese in lot B, there is no specific pattern of differences between the alloying elements in the bullet jacket samples from lots A, B, C and D.

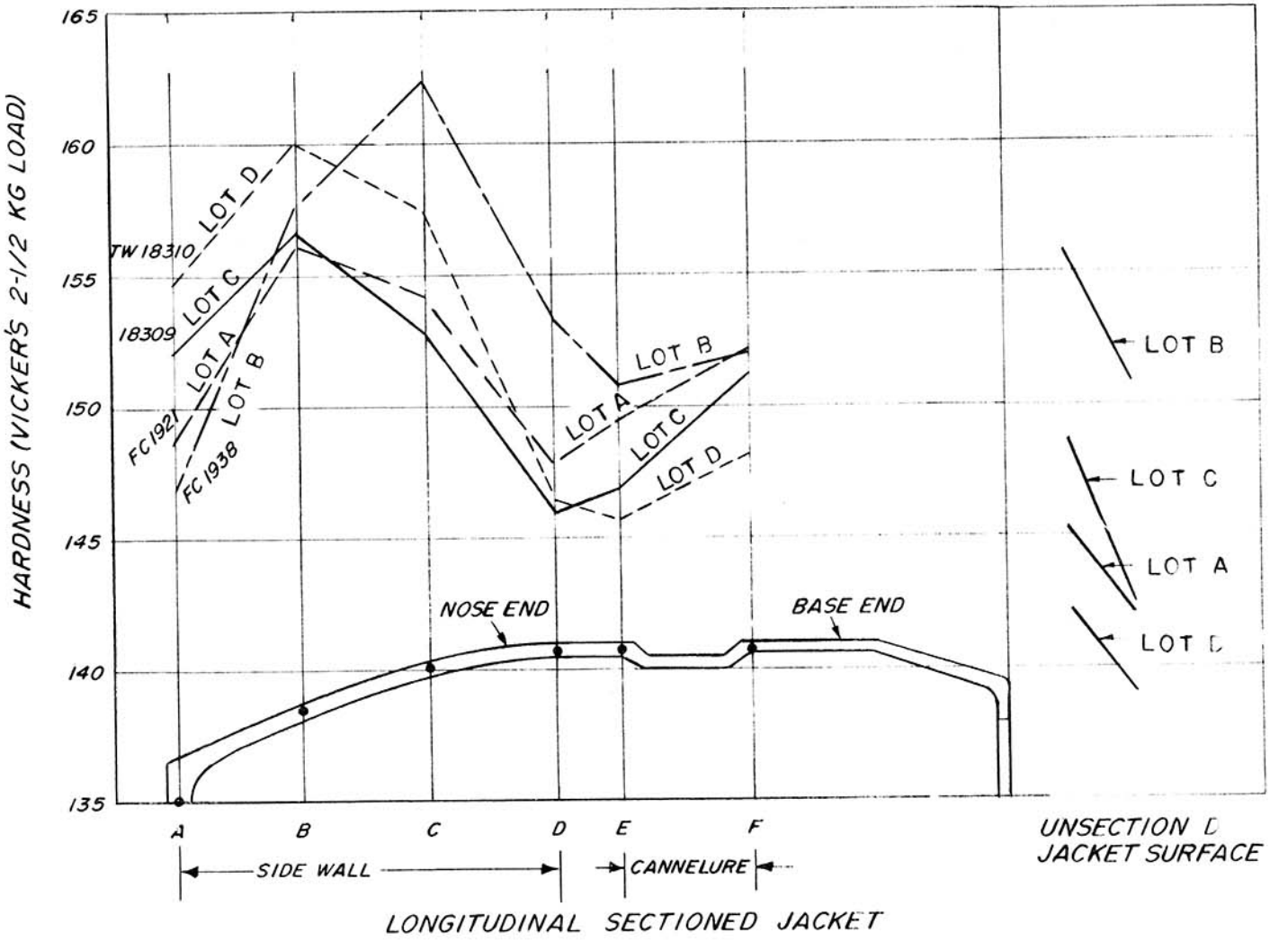


Figure 22. Bullet Jacket Hardness Readings, Lots A, B, C and D

TABLE VI. Summary of Chemical Analyses, Bullet Jackets, Lots A, B, C and D

ELEMENT	% ELEMENT			
	LOT-A	LOT-B	LOT-C	LOT-D
COPPER	90.11	89.73	89.81	89.98
LEAD	< .01	< .01	< .01	< .01
IRON	< .01	< .005	.01	.02
ZINC	9.9	10.3	10.1	10.0
TIN	—	—	< .002	< .002
ANTIMONY	—	—	—	—
NICKEL	< .002	< .005	< .006	< .004
BISMUTH	—	—	—	—
ALUMINUM	—	—	—	—
MANGANESE	< .002	—	< .002	< .002
SILVER	< .002	< .01	< .002	< .002
SILICON	< .001	< .005	< .001	< .001

Hardness Tests, Lead Bullet Cores

Table VII summarizes the hardness test performed on five samples each of lead bullet cores from lots A, B, C and D. Again, there is no apparent relationship between the bullet core hardness values and the fouling history of the test lots. The average hardness readings are comparable between lots A and C and for lots B and D, while the composite hardness average for lots A and B (7.7) is only 1.3 points below the composite average hardness (8.4) for lots C and D.

TABLE VII. Summary of Hardness Tests, Lead Bullet Cores, Lots A, B, C and D

SAMPLE NUMBER	HARDNESS BRINELL HARDNESS VALUES - (5 Kg LOAD) 12 SEC. LOADING TIME, OBTAINED ON LONGITUDINAL SECTION WITH 2mm BALL INDENTOR			
	LOT-A	LOT-B	LOT-C	LOT-D
1	6.7 6.7	6.8 7.1	9.2 9.3	7.6 7.6
2	6.7 6.7	10.2 10.2	8.9 8.8	11.2 11.2
3	6.6 6.6	7.5 7.7	7.4 7.2	8.4 8.0
4	7.4 7.2	10.0 9.9	7.1 7.1	7.3 7.3
5	7.4 7.4	7.8 7.6	6.5 6.3	10.6 10.6
AVERAGE	6.9	8.5	7.8	9.0
COMPOSITE AVERAGE	7.7		8.4	

Chemical Analyses, Lead Bullet Cores

Table VIII summarizes results of the chemical analyses performed on five samples each of the lead bullet core material from lots A, B, C and D. All of the lots are closely bracketed with respect to quantity of alloying elements and all lots were within specification limits for antimony and lead content.

TABLE VIII. Summary of Chemical Analyses, Lead Bullet Cores, Lots A, B, C and D

ELEMENT	% ELEMENT			
	LOT-A	LOT-B	LOT-C	LOT-D
TIN	∠.02	.03	.05-.15	.2-.5
*ANTIMONY	1.51	1.45	1.21	1.63
BISMUTH	.03	.03	.03	.05-.15
COPPER	.01	.02	.02	.01
IRON	.005	.005	.005	.005
ZINC	—	—	—	—
NICKEL	—	—	—	—
CALCIUM	—	—	—	—
SILVER	.005	.005	.005	.005
LEAD	98.4	98.4	98.6	97.9
** LEAD ANTIMONY	99.9	99.9	99.8	99.5
ARSENIC	.05	.06	.05	.07

* — SPECIFICATION — 1.0-2.5
** — SPECIFICATION — 99.2 MIN.

BALLISTIC TESTS, LOTS A, B, C AND D

Cartridge lots A (FC-1921) and B (FC-1938) have undergone extensive tests both at the Frankford Arsenal (gas tube clogging studies) and Aberdeen Proving Gounds (6,000 round endurance tests). Results of these tests have been thoroughly analyzed and recorded. [1,2] Since a quantity of ammunition lots A and B were available they were used again in this study to verify the previously reported, excessive fouling characteristics and to establish the relationship of the cartridge metal parts to the fouling phenomena.

Cartridge lots C (TW-18309) and D (TW-18310) were selected as candidates for nonfouling ammunition primarily on the basis of the cartridge metal parts characteristics and previous trouble-free performance in related fouling tests.

Fouling tests of cartridge lots A and B yielded data in direct agreement with earlier tests. [1,2] Fouling tests of cartridge lots C and D verified nonfouling characteristics of these lots for this study.

Fouling Test

Four standard 5.56 mm M16A1 rifles were used for these tests. The rifle actions were fitted with new, unused barrel assemblies with chrome plated chambers, new gas tubes and front sight brackets and new flash suppressors. One rifle was used with each of the four cartridge test lots. These were all fired in a fixed mount.

TABLE IX. Rifle Identification

Ammunition Lot Number	Rifle Number
A	SN 856760
B	SN 843489
C	SN 859742
D	SN 1188930

A total of 40,000 rounds was available for these tests; 10,000 rounds each of lots A, B, C and D.

Propellant Description Sheets and Cartridge Lot Acceptance Reports for the test ammunition are included in Appendix B.

Test Procedure

Firing sequence was in accordance with the endurance schedule noted in SAPD-253F. [5]

Each test was fired in 100-round cycles. A cycle consisted of five, 20-round magazines loaded and fired as follows:

20 rounds automatic	- 2 to 3 round bursts
20 rounds automatic	- single burst of 20 shots during which cyclic rate was recorded

20 rounds semiautomatic	- 1 shot per second
20 rounds automatic	- 2 to 3 round bursts
20 rounds semiautomatic	- 1 shot per second

The rifles were forced air cooled to ambient temperature after each cycle. Rifles were cleaned and lubricated before the test and at 1,000 round intervals. The lubricant used was Lubricating Oil, Semi-fluid, MIL-L-46000(A). Gas tube flowmeter* measurements and weights were recorded every 1,000 rounds and cyclic rate measured every 100 rounds.

Visual observation was maintained of fouling buildup every 500 rounds in the barrel bore, bolt carrier and flash suppressor.

Gas tube, front sight bracket and flash suppressor x-rays as well as chemical studies of residue for each of the four test lots were obtained. However, they are not presented in this report since they agreed with the previous findings. [1,2]

The malfunction legends are as follows:

FF	Failure to feed
BOB	Bolt overrode base of round in feeding from magazine
SR	Short recoil
FX	Failure to extract
FF-SR	Failure to feed, short recoil
FJ	Failure to eject
FFR	Failure to fire

Test Results

Lot A, Rifle SN 856760

The weapon functioned normally up to 4,000 rounds during which time there was a steady increase in flowmeter readings and a coincident, steady decrease in cyclic rate. After 5,880 rounds, 8FF, 4 FX and 7 BOB type malfunctions occurred. Highest cyclic rate recorded

*Half-bridge type air flow measuring device used to measure the rate of air flow through gas tube.

was 958 shots per minute (spm) and the lowest cyclic rate was 592 spm. Excessive fouling residue was noted in the bolt carrier, flash suppressor and the barrel bore. Plotted data are shown in Figure 23. The test was discontinued after 5,900 rounds since the rifle would not function in the semiautomatic or automatic firing modes.

The presence of a clogged gas tube was evidenced by the increase in flowmeter reading from 1.29 psi to 3.00 psi (1.71) and the increase in gas tube weight from 26.2798 to 27.6050 grams (1.3252).

Lot B, Rifle SN 843489

This weapon functioned similarly to the weapon used for Lot A. There was a steady increase in flowmeter readings and a coincident decrease in cyclic rate. After 4,600 rounds, 1 FX, 4 BOB, 4 FF-SR and 2 FJ type malfunctions occurred. Highest cyclic rate recorded was 942 spm and the lowest cyclic rate was 592 spm. Excessive fouling residue was noted in the bolt carrier, flash suppressor and barrel bore. Plotted data are shown in Figure 24. The test was discontinued after 4,620 rounds due to inability of the weapon to function in the semiautomatic or automatic firing modes. The total increase in flowmeter readings from 1.38 to 2.79 psi (1.41) and the increase in gas tube weight from 28.3554 to 29.3753 grams (1.0199) evidenced a severely clogged gas tube.

The flash suppressor in the new and used condition was photographed to show the degree of residue buildup in its inner diameter which cooperates with the muzzle end of the barrel. This is shown in Figure 25. Figure 26 indicates the residue buildup "pocket" existent on the standard flash suppressor FSN 1005-933-8089 for the M16A1 rifle.

Lot C, Rifle SN 859742

The weapon functioned normally throughout the test and no malfunctions were encountered. The flowmeter readings were essentially constant from start (1.40 psi) to finish (1.52 psi). Gas tube weight increased from 27.5550 to 27.8918 grams (0.3368 gram). Highest cyclic rate recorded was 950 spm and the lowest cyclic rate was 851 spm. There was no visible fouling in the bolt carrier, flash suppressor or barrel bore. Plotted data are shown in Figure 27.

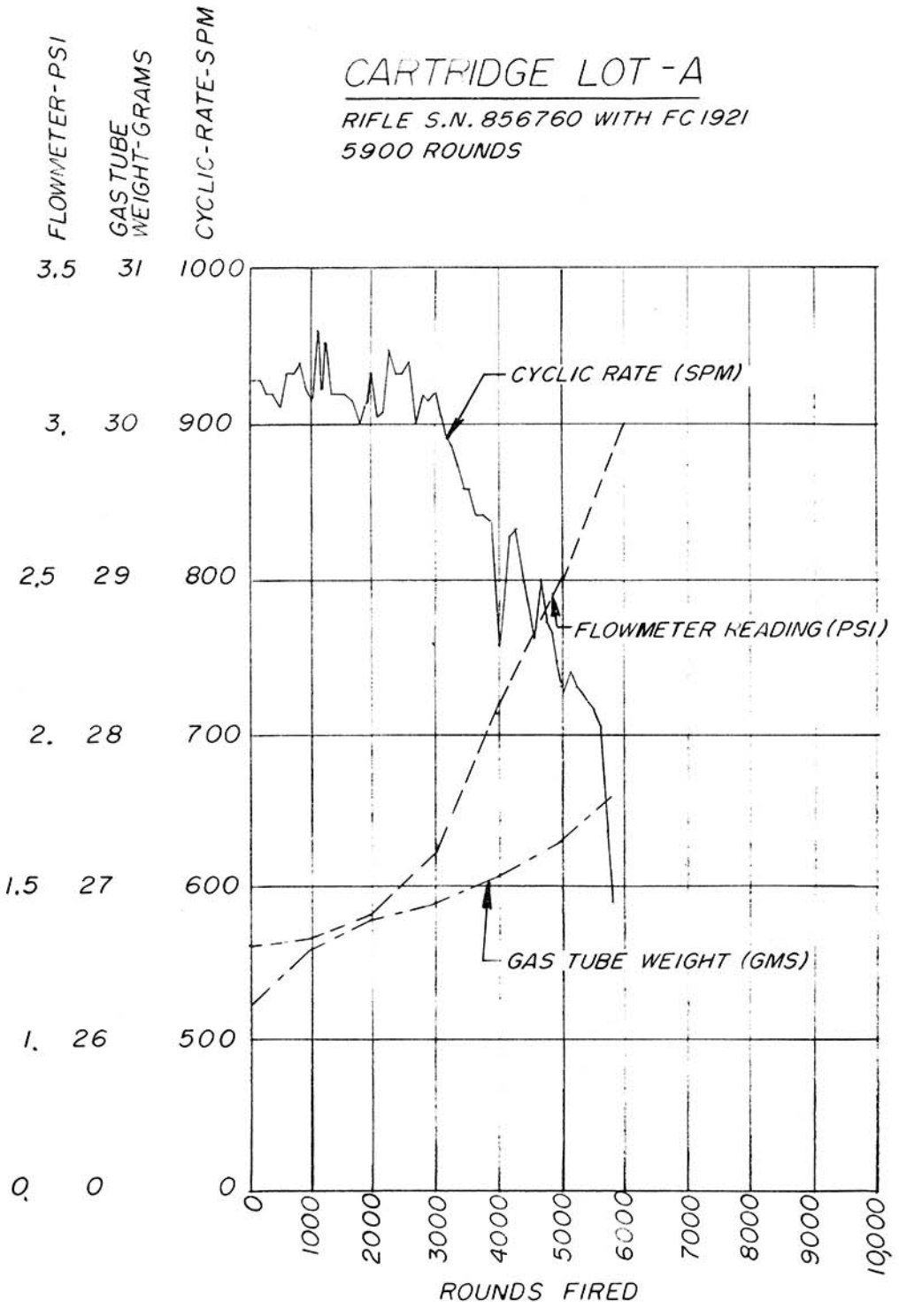


Figure 23. Fouling Test Data, Lot A

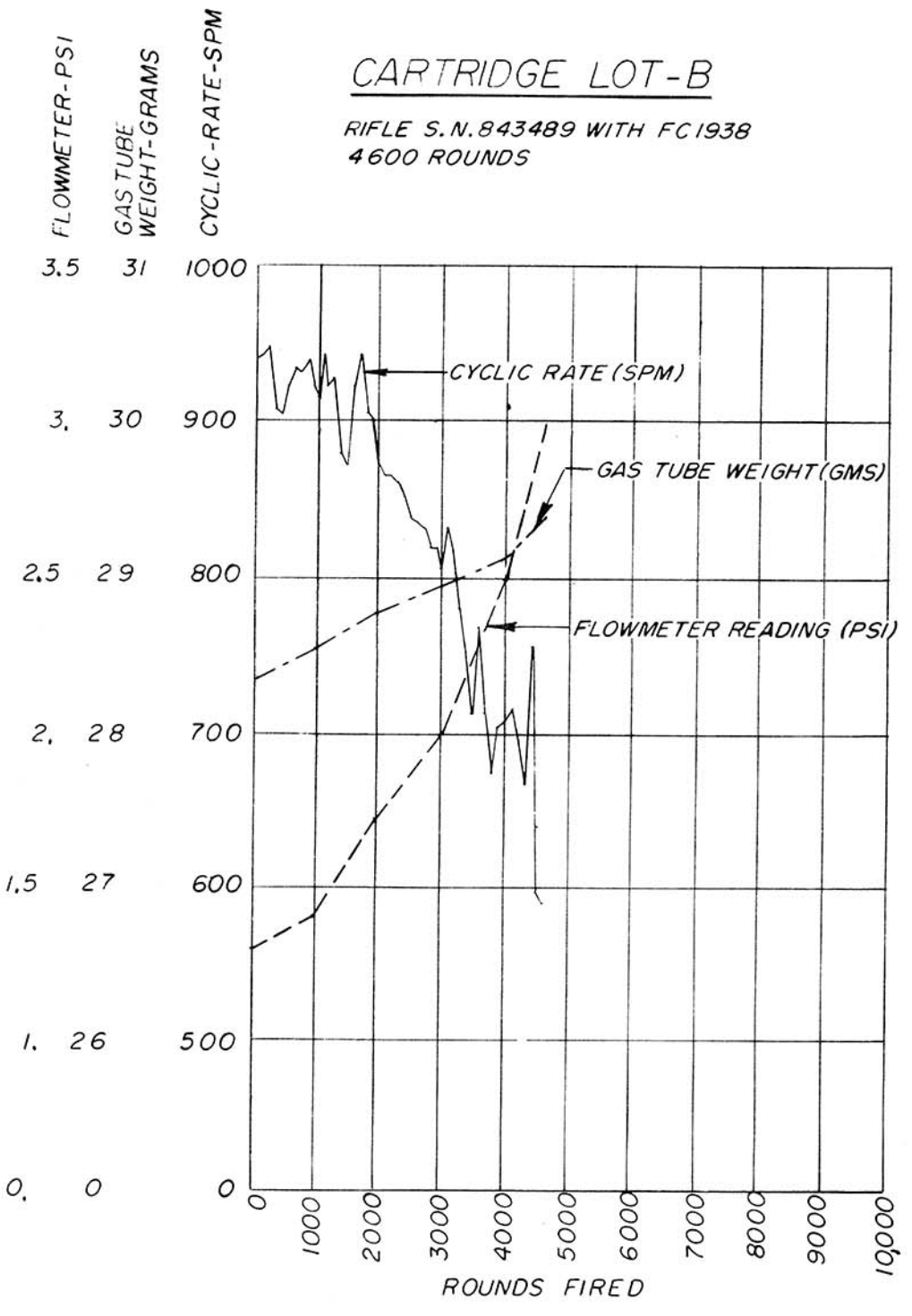
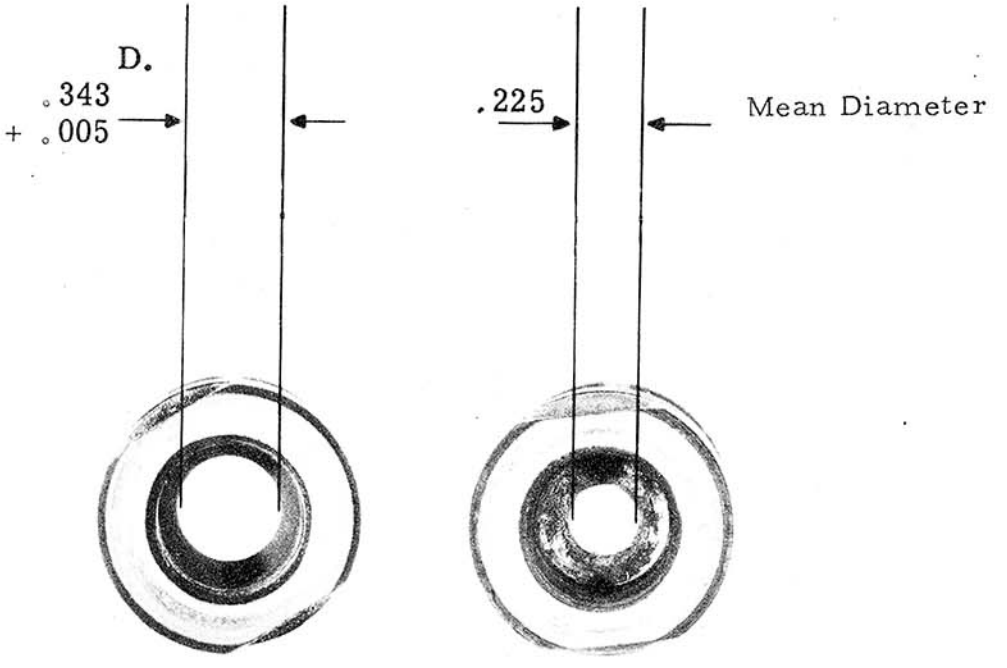


Figure 24. Fouling Test Data, Lot B



New, Unused
Flash Suppressor
M16A1 Rifle

Used Flash Suppressor,
Gun, SN. 843489, FA
Test using Cartridge
Lot A (FC 1938) after
4620 Rounds

Figure 25. Flash Suppressor, New and After Test of Lot B.

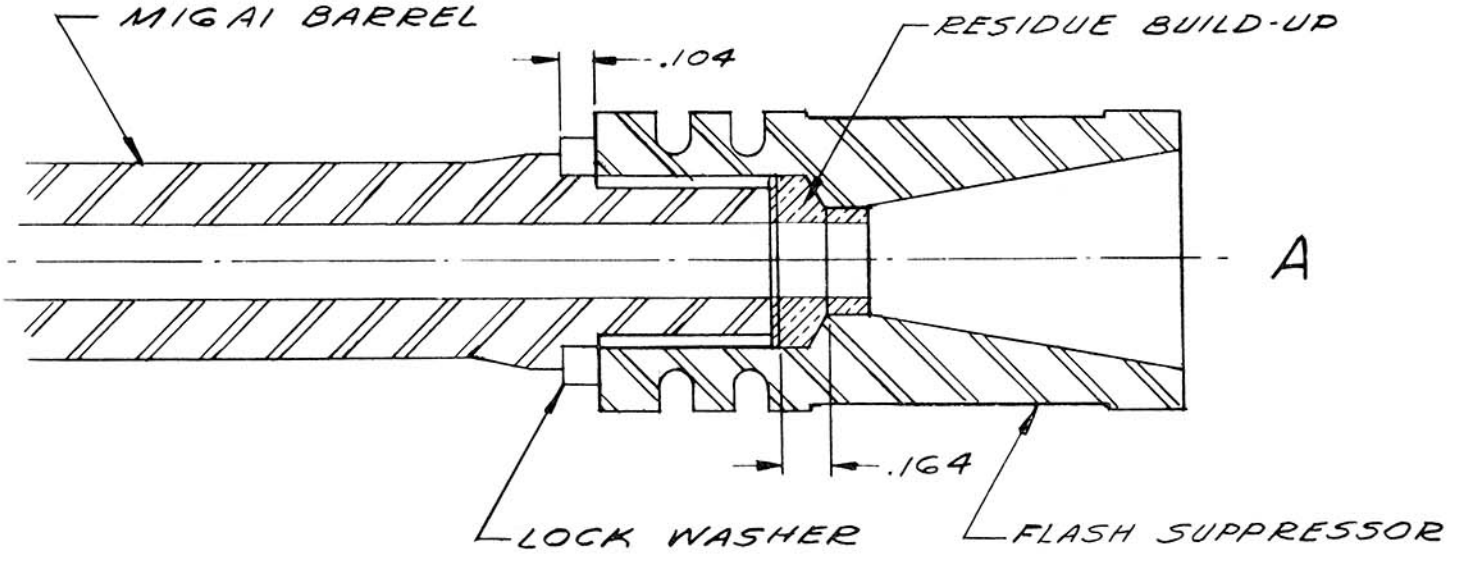


Figure 26. Residue Pocket, Flash Suppressor, FSN-1005-933-8089

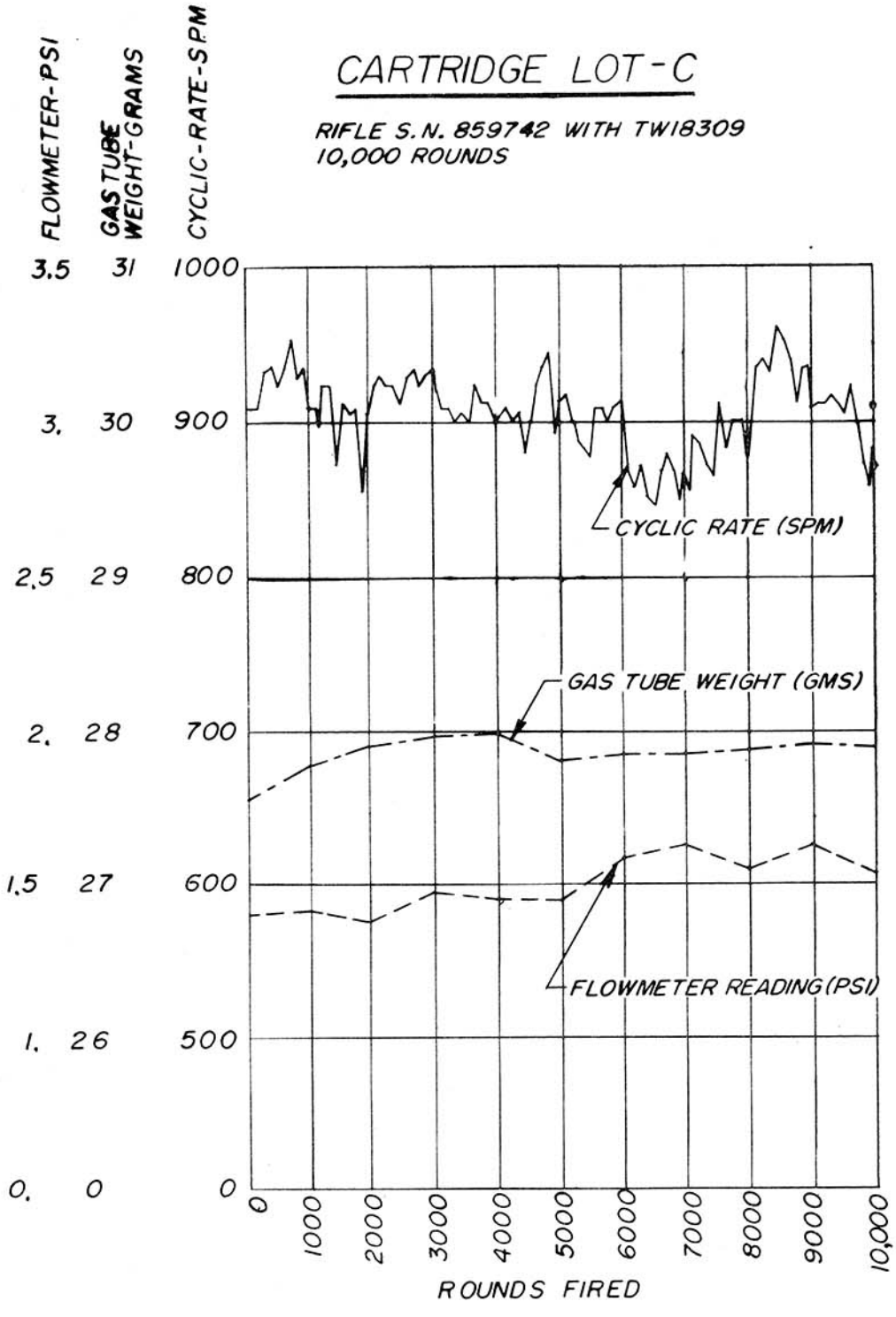


Figure 27. Fouling Test Data, Lot C

Lot D, Rifle SN 1188930

The weapon functioned normally throughout the test without malfunction. Flowmeter readings were essentially constant throughout the test, from start (1.42 psi) to finish (1.55 psi). Gas tube weight increased from 27.8454 to 28.2416 grams (0.3962 gram). Highest cyclic rate recorded was 938 spm and lowest cyclic rate was 850. There was no visible fouling in the bolt carrier, flash suppressor or barrel bore. Plotted data are shown in Figure 28.

Pressure Time Studies (PT)

Ten rounds each from the four test lots were fired in a standard, heavy-walled test fixture. Recorded data included peak chamber pressure, peak port pressure, velocity and action time (AT). Recorded data for all rounds are contained in Table X. Typical examples of PT curves from each of the four test lots are shown in Figure 29.

Instrumental velocity data for all rounds were in general agreement while the mean, peak chamber and mean, peak port pressure histories varied slightly for each of the lots. However, significant differences were noted for the AT values between lots A and B as compared with lots C and D.

The mean, composite AT of lots A and B differed from the mean, composite AT of lots C and D by 0.338 milliseconds, the shorter AT being characteristic of lots A and B. Continued investigation also disclosed a wide variation in time to reach peak chamber pressure for lots A and B as compared to lots C and D. A computer analyses of the PT curves resulting from each of the rounds noted in Table X was conducted to obtain projectile velocity and displacement characteristics. Typical projectile velocity and displacement values for two samples, round 5 of lot B and round 4 of lot D are compared as shown in Figure 30. Peak chamber pressure was reached in 0.66 millisecond for round 5 of lot B and in 0.96 millisecond for round 4 of lot D, a difference of 0.30 millisecond. Projectile velocity at the gas port (after 11.750 inches travel) was computed at approximately 2,890 fps for round 5 of lot B and approximately 2,870 fps for round 4 of lot D.

Remaining ballistic time (AT) after gas port operation was 0.146 millisecond for round 5 of lot B and 0.185 millisecond for round 4 of lot D.

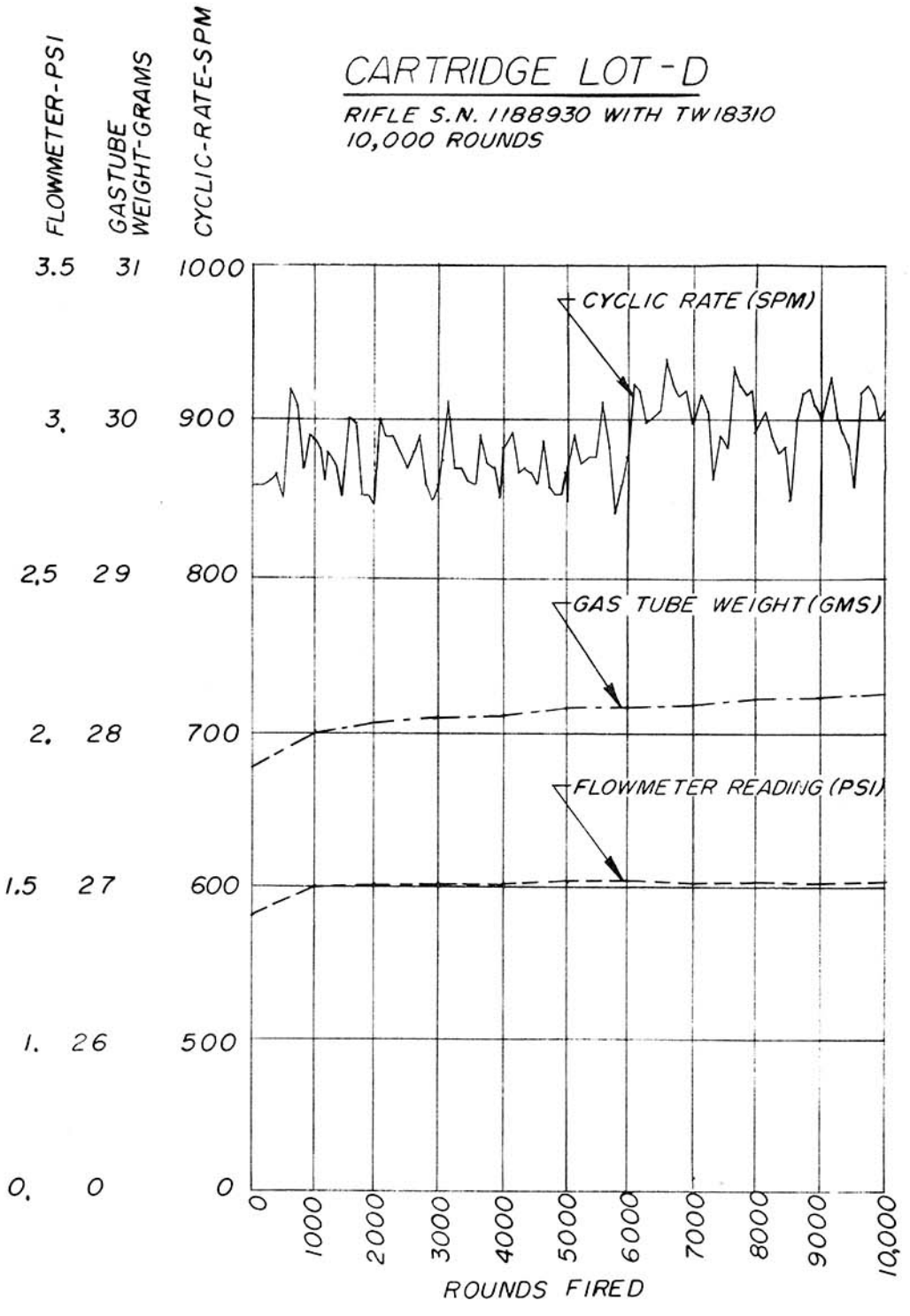


Figure 28. Fouling Test Data, Lot D

TABLE X. Ballistic Data, Pressure Time Study, Lots A, B, C and D

Shot No.	Action Time (ms)	Velocity (fps)	Peak Chamber Pressure (psi)	Peak Port Pressure(psi)
		Lot A		
1	1.223	3160	52,000	11,900
2	1.245	3183	53,500	11,900
3	1.294	3175	52,250	11,320
4	1.212	3162	51,000	11,650
5	1.193	3191	53,500	11,400
6	1.258	3113	47,750	11,820
7	1.210	3141	49,000	11,650
8	1.202*	3169	50,950	11,650
9	1.235	3158	51,000	11,400
10	1.237	3135	49,750	11,820
Mean	1.231	3159	51,070	-
Ext Variation	.101	78	5,750	-
Std Deviation	.03	22	1,860	-
		Lot B		
1	1.227	3121	48,000	11,990
2	1.190	3138	49,750	12,150
3	1.224	3153	51,000	11,650
4	1.167	3167	50,750	11,990
5	1.180*	3176	50,950	11,900
6	1.209	3148	50,000	11,650
7	1.241	3145	50,000	11,990
8	1,302	3129	49,000	11,900
9	1.257	3141	49,750	11,650
10	1.249	3106	48,000	11,740
Mean	1.225	3143	49,720	-
Ext Variation	.077	70	3,000	-
Std Deviation	.04	20	1,096	-

TABLE X. Ballistic Data, Pressure Time Study, Lots A, B, C and D (cont'd)

Shot No.	Action Time (ms)	Velocity (fps)	Peak Chamber Pressure (psi)	Peak Port Pressure (psi)
		Lot C		
1	1.371	3152	49,000	11,990
2	1.434*	3212	53,250	12,490
3	1.372	3154	50,000	12,150
4	1.404	3136	47,000	12,650
5	1.344	3129	47,500	12,490
6	1.463	3110	48,250	12,490
7	1.336	3197	51,250	11,900
8	1.375	3176	50,000	12,490
9	1.377	3162	49,000	12,320
10	1.435	3173	50,250	12,320
Mean Ext	1.391	3161	49,550	-
Variation	.091	102	6,250	-
Std Deviation	.04	29	1,840	-
		Lot D		
1	1.369	3173	52,000	12,740
2	1.358	3172	50,500	12,990
3	1.401	3143	48,000	12,650
4	1.465*	3174	51,300	12,490
5	1.416	3181	51,000	12,240
6	1.427	3153	49,000	12,990
7	1.319	3150	49,000	12,820
8	1.355	3198	49,000	12,650
9	1.433	3138	47,000	12,150
10	1.482	3133	48,500	12,240
Mean Ext	1.403	3162	49,530	-
Variation	.163	65	5,000	-
Std Deviation	.05	20	1,598	-

*Shots used for obtaining PT curves shown in Figure 29

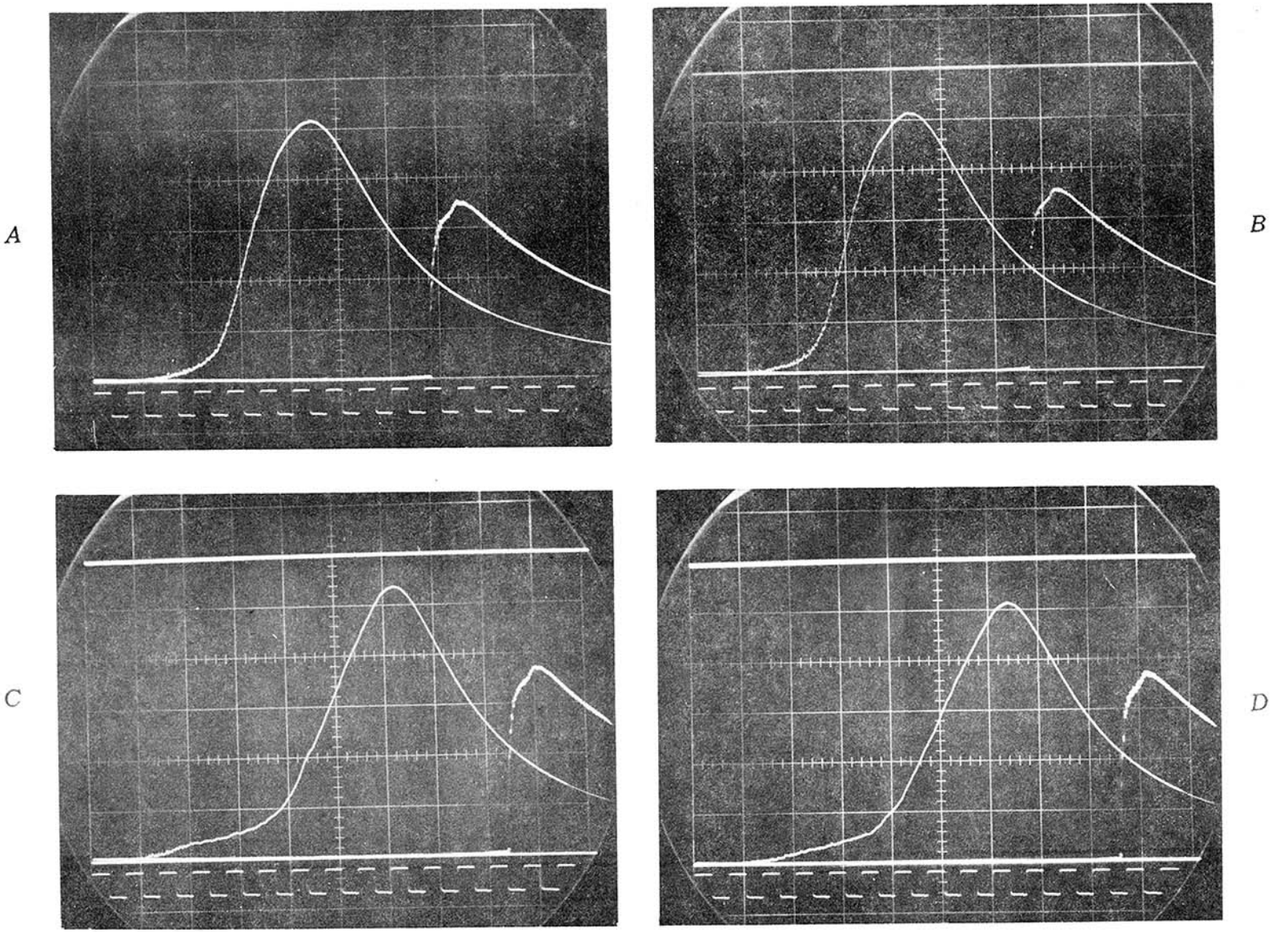


Figure 29. Typical PT Curves, Lots A, B, C and D

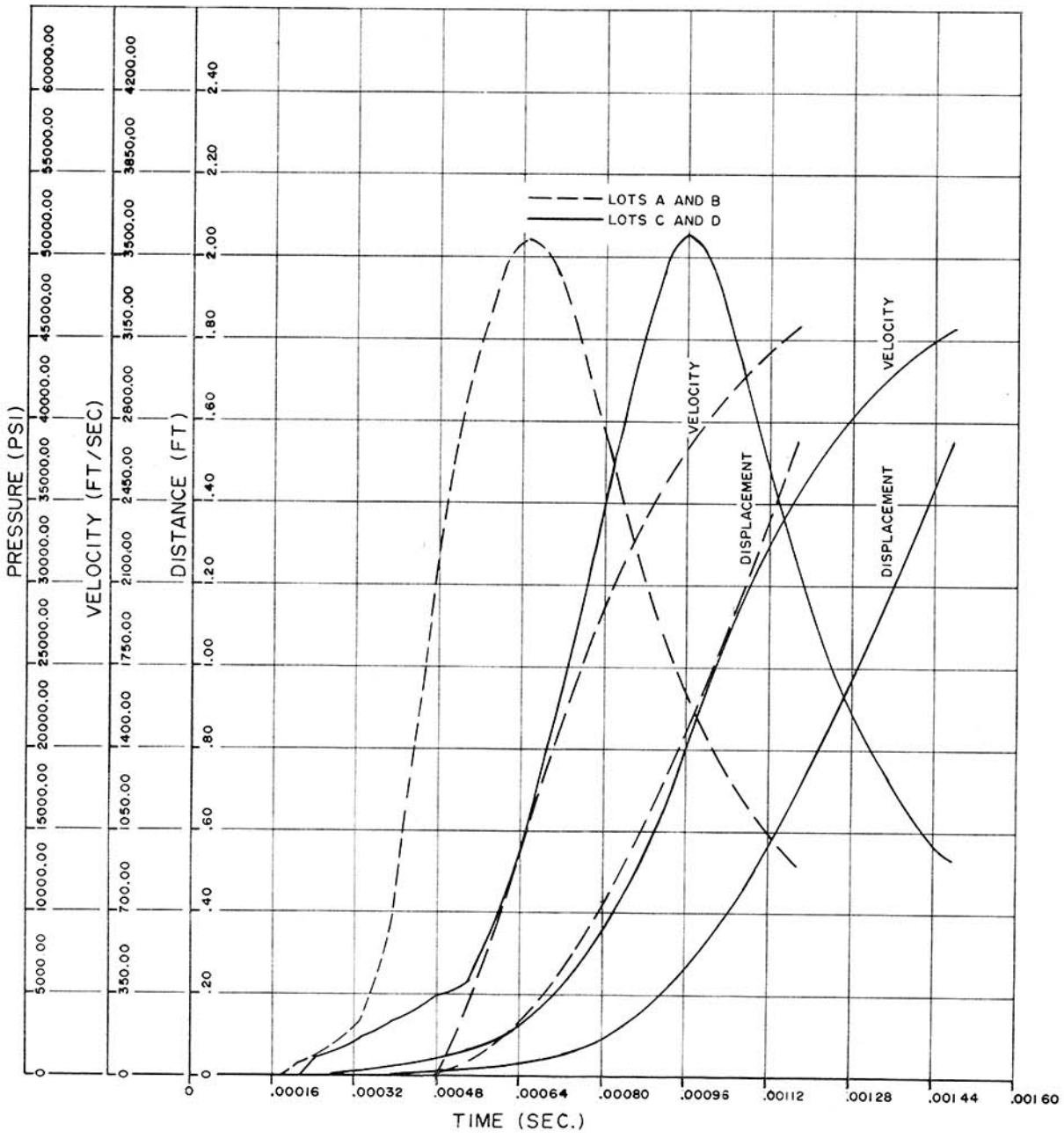


Figure 30. Typical Velocity, Displacement Characteristics Round 5, Lot B and Round 4, Lot D

It would appear from the foregoing data that in the case of lots A and B, the gas tube experienced generally shorter periods of gas flow from shot to shot as compared to lots C and D. The pressure-time data and subsequent test results obtained during these studies correlate satisfactorily with those obtained in previous studies.[6,7]

FINDINGS

Previous studies showed that $CaCO_3$ forms a matrix in which gilding metal from the bullet and primer decomposition products are embedded.[1,2] Therefore, the more gilding metal removed from the bullet jacket the greater will be the amount of gilding metal debris trapped in the localized $CaCO_3$ deposits in the gas tube. This will result in a greater bulk of deposits and a greater likelihood of gas tube clogging and weapon malfunction. Thus, in this detailed examination of four lots of 5.56 mm Ball, M193 ammunition, including both "good" and "bad" lots from the gas tube fouling standpoint, it was found that:

1. Ball ammunition having bullets with poorly made cannelures, high bullet extraction forces and loaded with ball propellant containing .71% to .97% of $CaCO_3$ caused excessive gas tube clogging and weapon fouling when fired in the M16A1 rifle.

2. Ball ammunition having bullets with well made cannelures, low bullet extraction forces and loaded with ball propellant containing .53% $CaCO_3$ caused little or no gas tube clogging and weapon fouling when fired in the M16A1 rifle.

3. Extreme variation of bullet extraction force in the M193 ball cartridge can influence pressure-time relationships in the M16A1 rifle.

RECOMMENDATIONS

It is recommended that:

1. Investigations be conducted to determine whether the "knurl" type cannelure on the bullet from the M193 Ball cartridge can be replaced by a smooth "roll" type cannelure.

2. Effort be made to develop upper and lower specification limits on bullet extraction values in order to reduce lot to lot performance variability.

3. Closer controls be maintained on knurl pitch, knurl quality, outside diameter and width, if the present "knurl" type cannelure is retained.

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5. Small Arms Purchase Description, "Rifles, 5.56 mm: M16 and M16A1," SAPD-253F, 22 November 1968.

6. Fulton, C. L., Shindler, C. E., Shinaly, F. J. "Special Tests of 5.56 mm Ammunition," Frankford Arsenal Report R-1883, February 1968.

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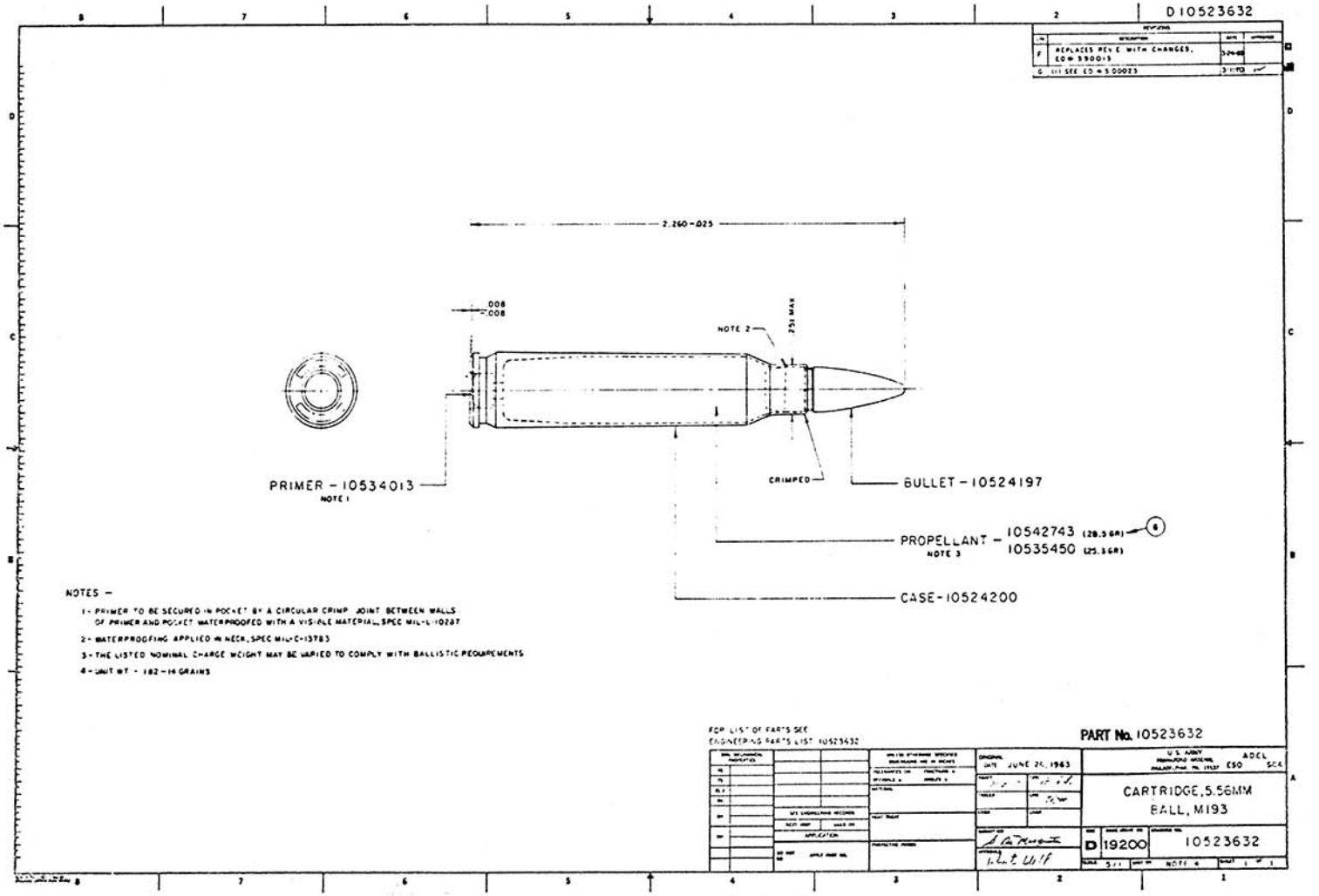
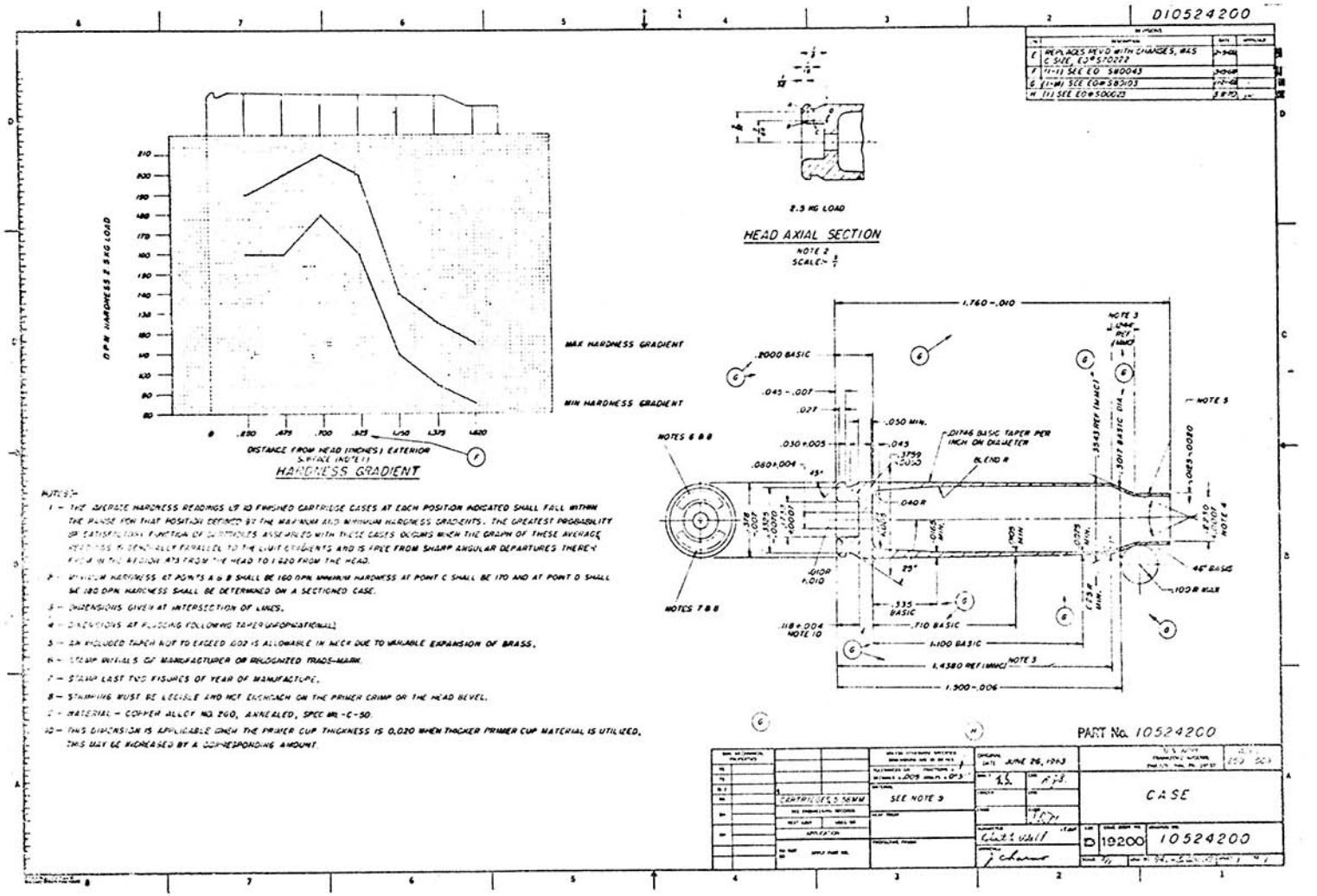

D10523632
REVISIONS
F REPLACES REV E WITH CHANGES, ECO # 590015
G SEE ECO # 500023
2.260-.025
.008
.008
.251 MAX
NOTE 2
PRIMER - 10534013
NOTE 1
CRIMPED
BULLET - 10524197
PROPELLANT - 10542743 (28.5 GR) 6
NOTE 3 10535450 (25.5 GR)
CASE - 10524200
NOTES -
1 - PRIMER TO BE SECURED IN POCKET BY A CIRCULAR CRIMP. JOINT BETWEEN WALLS OF PRIMER AND POCKET WATERPROOFED WITH A VISIBLE MATERIAL, SPEC MIL-L-10287
2 - WATERPROOFING APPLIED IN NECK, SPEC MIL-C-13783
3 - THE LISTED NOMINAL CHARGE WEIGHT MAY BE VARIED TO COMPLY WITH BALLISTIC REQUIREMENTS
4 - UNIT WT - 182-14 GRAINS
FOR LIST OF PARTS SEE ENGINEERING PARTS LIST 10523632
PART No. 10523632
ORIGINAL DATE JUNE 24, 1963
U.S. ARMY
ADCL
CARTRIDGE, 5.56MM
BALL, M193
D 19200
10523632

Figure A-1



NOTES:-

1 – THE AVERAGE HARDNESS READINGS OF 10 FINISHED CARTRIDGE CASES AT EACH POSITION INDICATED SHALL FALL WITHIN THE RANGE FOR THAT POSITION DEFINED BY THE MAXIMUM AND MINIMUM HARDNESS GRADIENTS. THE GREATEST PROBABILITY OF SATISFACTORY FUNCTION OF CARTRIDGES ASSEMBLED WITH THESE CASES OCCURS WHEN THE GRAPH OF THESE AVERAGE HARDNESS IS GENERALLY PARALLEL TO THE LIMIT GRADIENTS AND IS FREE FROM SHARP ANGULAR DEPARTURES THEREFROM IN THE REGION 475 FROM THE HEAD TO 1.620 FROM THE HEAD.

2 – MINIMUM HARDNESS AT POINTS A & B SHALL BE 160 DPH MINIMUM HARDNESS AT POINT C SHALL BE 170 AND AT POINT D SHALL BE 180 DPH. HARDNESS SHALL BE DETERMINED ON A SECTIONED CASE.

3 – DIMENSIONS GIVEN AT INTERSECTION OF LINES.

4 – DIMENSIONS AT PLUGGING FOLLOWING TAPER UNPOPULATIONALL

5 – AN INCLUDED TAPER NOT TO EXCEED .002 IS ALLOWABLE IN NECK DUE TO VARIABLE EXPANSION OF BRASS.

6 – STAMP INITIALS OF MANUFACTURER OR RECOGNIZED TRADE-MARK.

7 – STAMP LAST TWO FIGURES OF YEAR OF MANUFACTURE.

8 – STAMPING MUST BE LEGIBLE AND NOT ENCROACH ON THE PRIMER CRIMP OR THE HEAD BEVEL.

9 – MATERIAL – COPPER ALLOY NO. 260, ANNEALED, SPEC MIL-C-50.

10 – THIS DIMENSION IS APPLICABLE WHEN THE PRIMER CUP THICKNESS IS 0.020 WHEN THICKER PRIMER CUP MATERIAL IS UTILIZED, THIS MAY BE INCREASED BY A CORRESPONDING AMOUNT.

Figure A-2

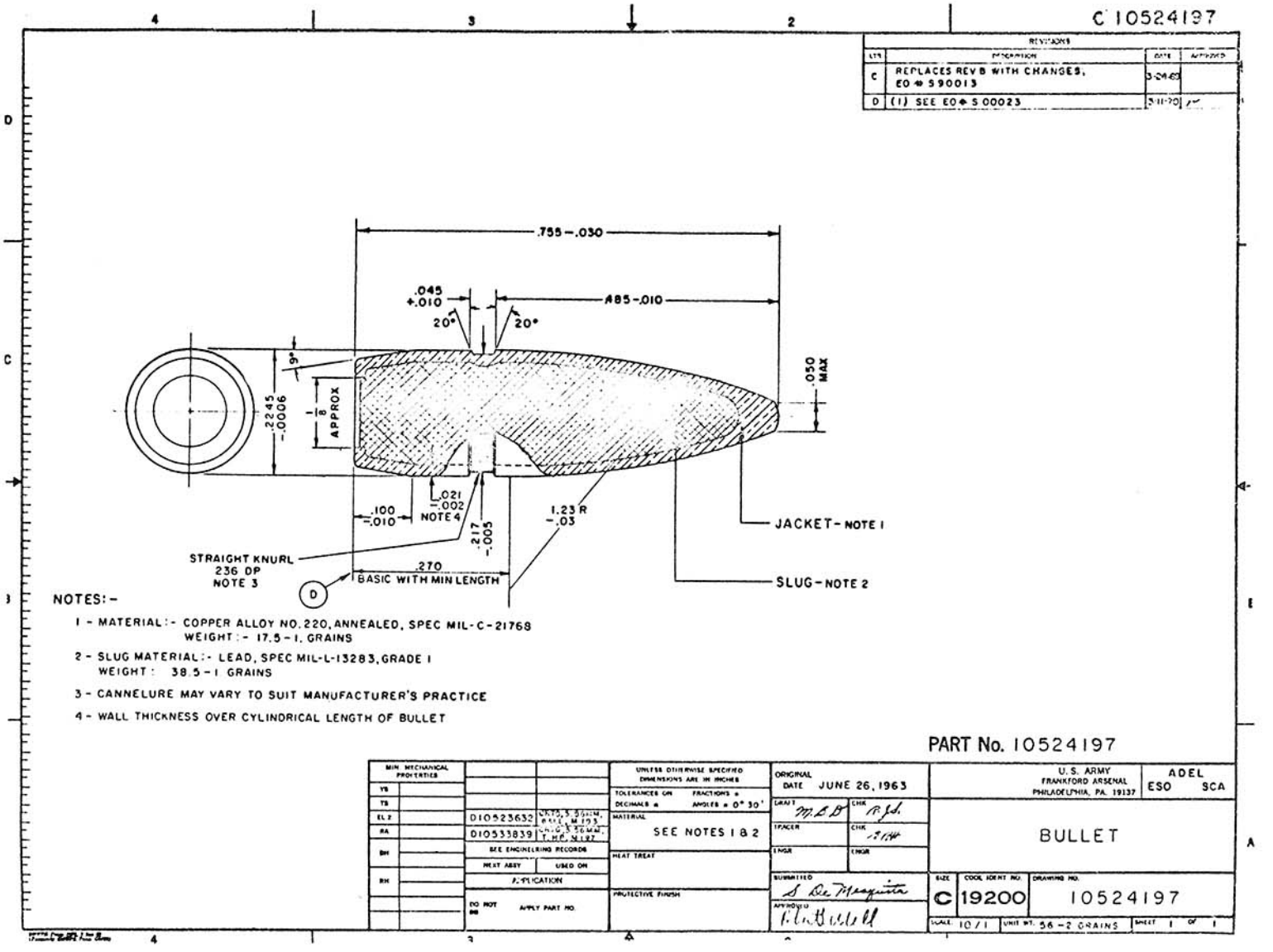

C 10524197
REVISIONS
LTR DESCRIPTION DATE APPROVED
C REPLACES REV B WITH CHANGES, EO ⊕ 590013 3-24-65
D (1) SEE EO ⊕ S 00023 5-11-70
.755 -.030
.045 +.010
.485 -.010
20°
20°
9°
.2245 -.0006
1/8 APPROX
.050 MAX
.021 -.002
NOTE 4
.100 -.010
.217 -.005
1.23 R -.03
JACKET - NOTE 1
SLUG - NOTE 2
STRAIGHT KNURL 236 DP NOTE 3
.270 BASIC WITH MIN LENGTH
D
NOTES:-
1 - MATERIAL:- COPPER ALLOY NO. 220, ANNEALED, SPEC MIL-C-21768 WEIGHT:- 17.5 - 1. GRAINS
2 - SLUG MATERIAL:- LEAD, SPEC MIL-L-13283, GRADE 1 WEIGHT: 38.5 - 1 GRAINS
3 - CANNELURE MAY VARY TO SUIT MANUFACTURER'S PRACTICE
4 - WALL THICKNESS OVER CYLINDRICAL LENGTH OF BULLET
PART No. 10524197
MIN. MECHANICAL PROPERTIES
YS
TS
EL 2
RA
BH
RH
D10523632
D10533839
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
DO NOT USE
APPLY PART NO.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±
DECIMALS ± ANGLES ± 0° 30'
MATERIAL
SEE NOTES 1 & 2
HEAT TREAT
PROTECTIVE FINISH
ORIGINAL DATE JUNE 26, 1963
DRAFT M.D.D
CHK R.J.L.
TRACER
CHK
ENGR
ENGR
SUBMITTED S. De Mesquita
APPROVED T. Bullard
U.S. ARMY FRANKFORD ARSENAL PHILADELPHIA, PA. 19137
ADEL ESO SCA
BULLET
SIZE C
CODE IDENT NO. 19200
DRAWING NO. 10524197
SCALE 10/1
UNIT WT. 56 - 2 GRAINS
SHEET 1 OF 1

Figure A-3

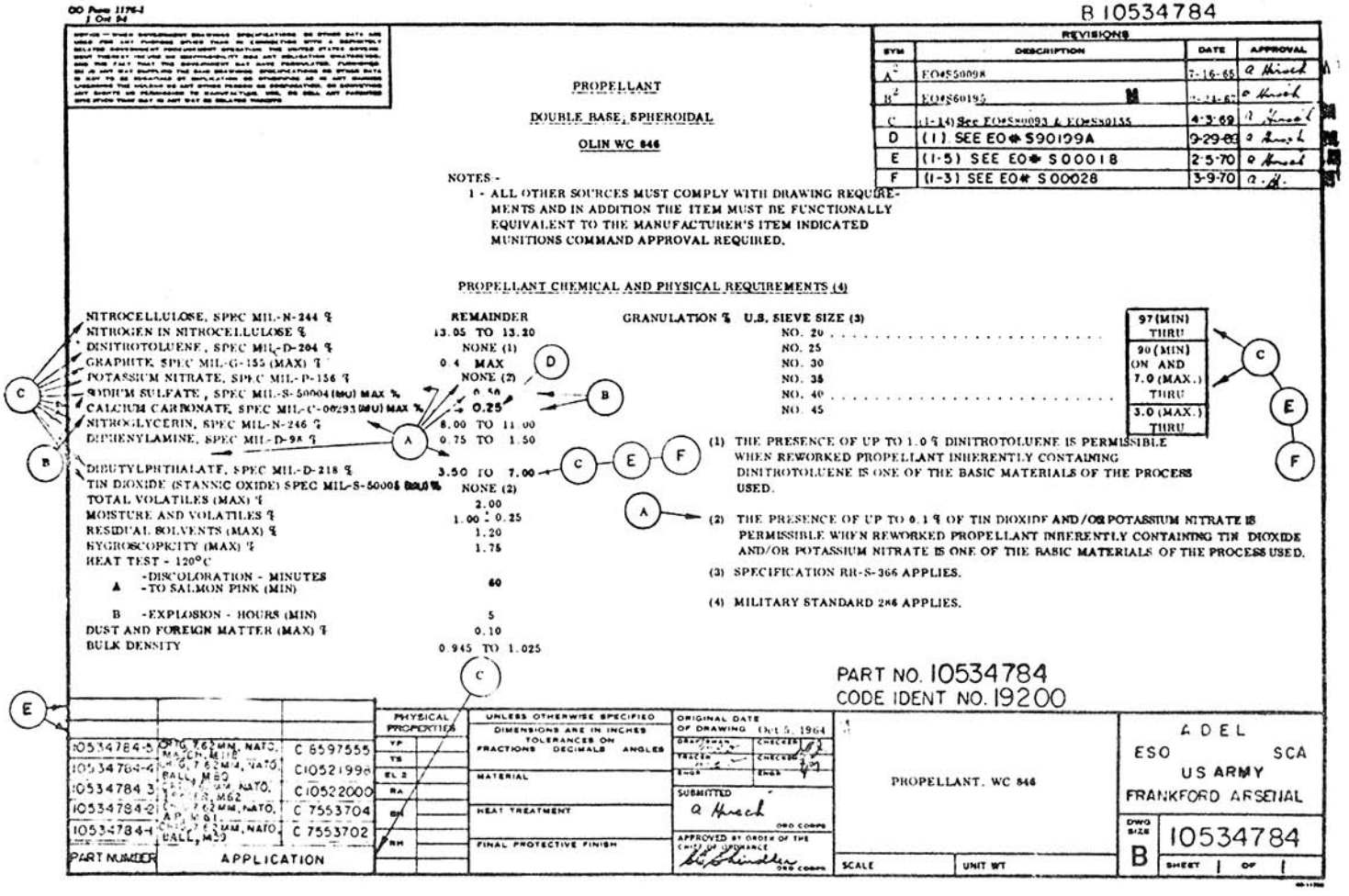
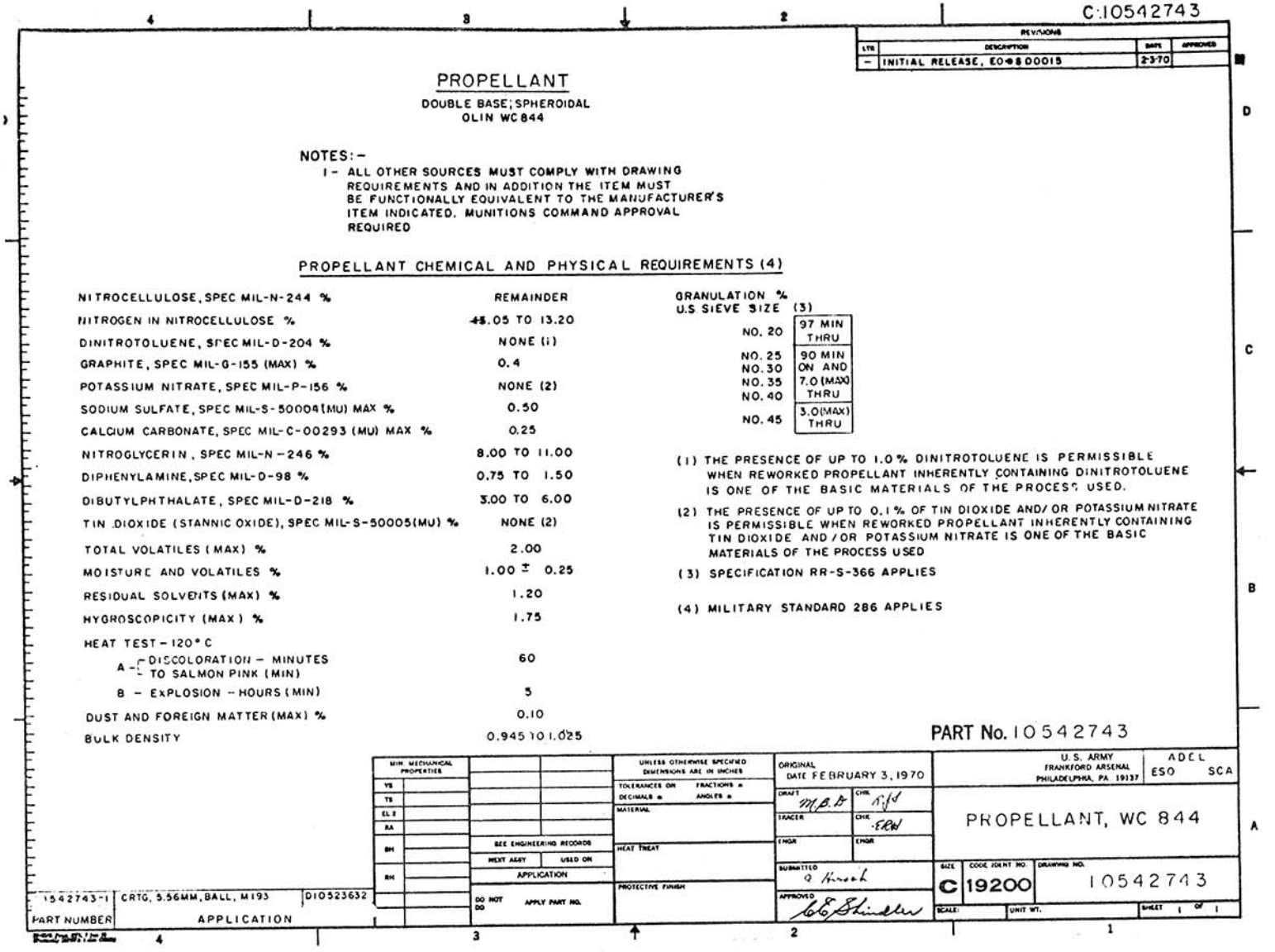

DD Form 1176-1
1 Oct 64
B 10534784
REVISIONS
SYM | DESCRIPTION | DATE | APPROVAL
A | EO#S50098 | 7-16-68 | Q Hirsch
B | EO#S60195 | 11-21-67 | Q Hirsch
C | (1-14) See EO#S00093 & EO#S00155 | 4-3-69 | Q Hirsch
D | (1) SEE EO# S90199A | 9-29-69 | Q Hirsch
E | (1-5) SEE EO# S00018 | 2-5-70 | Q Hirsch
F | (1-31) SEE EO# S00028 | 3-9-70 | Q.H.
PROPELLANT
DOUBLE BASE, SPHEROIDAL
OLIN WC 846
NOTES -
1 - ALL OTHER SOURCES MUST COMPLY WITH DRAWING REQUIREMENTS AND IN ADDITION THE ITEM MUST BE FUNCTIONALLY EQUIVALENT TO THE MANUFACTURER'S ITEM INDICATED MUNITIONS COMMAND APPROVAL REQUIRED.
PROPELLANT CHEMICAL AND PHYSICAL REQUIREMENTS (4)
NITROCELLULOSE, SPEC MIL-N-244 % REMAINDER
NITROGEN IN NITROCELLULOSE % 13.05 TO 13.20
DINITROTOLUENE, SPEC MIL-D-204 % NONE (1)
GRAPHITE, SPEC MIL-G-155 (MAX) % 0.4 MAX
POTASSIUM NITRATE, SPEC MIL-P-156 % NONE (2)
SODIUM SULFATE, SPEC MIL-S-50004 (MU) MAX % 0.50
CALCIUM CARBONATE, SPEC MIL-C-00293 (MU) MAX % 0.25
NITROGLYCERIN, SPEC MIL-N-246 % 8.00 TO 11.00
DIPHENYLAMINE, SPEC MIL-D-98 % 0.75 TO 1.50
DIBUTYLPHTHALATE, SPEC MIL-D-218 % 3.50 TO 7.00
TIN DIOXIDE (STANNIC OXIDE) SPEC MIL-S-50005 (MU) % NONE (2)
TOTAL VOLATILES (MAX) % 2.00
MOISTURE AND VOLATILES % 1.00 ± 0.25
RESIDUAL SOLVENTS (MAX) % 1.20
HYGROSCOPICITY (MAX) % 1.75
HEAT TEST - 120°C
A -DISCOLORATION - MINUTES -TO SALMON PINK (MIN) 60
B -EXPLOSION - HOURS (MIN) 5
DUST AND FOREIGN MATTER (MAX) % 0.10
BULK DENSITY 0.945 TO 1.025
GRANULATION % U.S. SIEVE SIZE (3)
NO. 20 ..... 97 (MIN) THRU
NO. 25
NO. 30 90 (MIN) ON AND 7.0 (MAX.) THRU
NO. 35
NO. 40 ..... 3.0 (MAX.) THRU
NO. 45
(1) THE PRESENCE OF UP TO 1.0 % DINITROTOLUENE IS PERMISSIBLE WHEN REWORKED PROPELLANT INHERENTLY CONTAINING DINITROTOLUENE IS ONE OF THE BASIC MATERIALS OF THE PROCESS USED.
(2) THE PRESENCE OF UP TO 0.1 % OF TIN DIOXIDE AND/OR POTASSIUM NITRATE IS PERMISSIBLE WHEN REWORKED PROPELLANT INHERENTLY CONTAINING TIN DIOXIDE AND/OR POTASSIUM NITRATE IS ONE OF THE BASIC MATERIALS OF THE PROCESS USED.
(3) SPECIFICATION RR-S-366 APPLIES.
(4) MILITARY STANDARD 286 APPLIES.
PART NO. 10534784
CODE IDENT NO. 19200
PART NUMBER | APPLICATION
10534784-5 | 7.62 MM, NATO, MATCH, M118 | C 6597555
10534784-4 | 7.62 MM, NATO, BALL, M80 | C1052199e
10534784 3 | 7.62 MM, NATO, M62 | C1052200
10534784-2 | 7.62 MM, NATO, AP, M61 | C 7553704
10534784-1 | 7.62 MM, NATO, BALL, M59 | C 7553702
PHYSICAL PROPERTIES
YP
YS
EL 2
RA
BH
RH
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES
MATERIAL
HEAT TREATMENT
FINAL PROTECTIVE FINISH
ORIGINAL DATE OF DRAWING Oct 5, 1964
DRAWN
CHECKED
TRACED
CHECKED
ENGR
ENGR
SUBMITTED
Q Hirsch
ORD CORPS
APPROVED BY ORDER OF THE CHIEF OF ORDNANCE
ORD CORPS
PROPELLANT, WC 846
SCALE
UNIT WT
ADEL
ESO SCA
US ARMY
FRANKFORD ARSENAL
DWG SIZE B
10534784
SHEET 1 OF 1

Figure A-4



C:10542743

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
-	INITIAL RELEASE, EO #80018	2-3-70	

PROPELLANT

DOUBLE BASE; SPHEROIDAL
OLIN WC 844

NOTES: -

1 - ALL OTHER SOURCES MUST COMPLY WITH DRAWING REQUIREMENTS AND IN ADDITION THE ITEM MUST BE FUNCTIONALLY EQUIVALENT TO THE MANUFACTURER'S ITEM INDICATED. MUNITIONS COMMAND APPROVAL REQUIRED

PROPELLANT CHEMICAL AND PHYSICAL REQUIREMENTS (4)

NITROCELLULOSE, SPEC MIL-N-244 %	REMAINDER
NITROGEN IN NITROCELLULOSE %	13.05 TO 13.20
DINITROTOLUENE, SPEC MIL-D-204 %	NONE (1)
GRAPHITE, SPEC MIL-G-155 (MAX) %	0.4
POTASSIUM NITRATE, SPEC MIL-P-156 %	NONE (2)
SODIUM SULFATE, SPEC MIL-S-50004(MU) MAX %	0.50
CALCIUM CARBONATE, SPEC MIL-C-00293 (MU) MAX %	0.25
NITROGLYCERIN, SPEC MIL-N-246 %	8.00 TO 11.00
DIPHENYLAMINE, SPEC MIL-D-98 %	0.75 TO 1.50
DIBUTYLPHTHALATE, SPEC MIL-D-218 %	3.00 TO 6.00
TIN DIOXIDE (STANNIC OXIDE), SPEC MIL-S-50005(MU) %	NONE (2)
TOTAL VOLATILES (MAX) %	2.00
MOISTURE AND VOLATILES %	1.00 ± 0.25
RESIDUAL SOLVENTS (MAX) %	1.20
HYGROSCOPICITY (MAX) %	1.75
HEAT TEST - 120° C	
A - DISCOLORATION - MINUTES TO SALMON PINK (MIN)	60
B - EXPLOSION - HOURS (MIN)	5
DUST AND FOREIGN MATTER (MAX) %	0.10
BULK DENSITY	0.945 TO 1.025

GRANULATION % U.S SIEVE SIZE (3)

NO. 20	97 MIN THRU
NO. 25	90 MIN ON AND 7.0 (MAX) THRU
NO. 30	
NO. 35	
NO. 40	
NO. 45	3.0 (MAX) THRU

(1) THE PRESENCE OF UP TO 1.0% DINITROTOLUENE IS PERMISSIBLE WHEN REWORKED PROPELLANT INHERENTLY CONTAINING DINITROTOLUENE IS ONE OF THE BASIC MATERIALS OF THE PROCESS USED.

(2) THE PRESENCE OF UP TO 0.1% OF TIN DIOXIDE AND/OR POTASSIUM NITRATE IS PERMISSIBLE WHEN REWORKED PROPELLANT INHERENTLY CONTAINING TIN DIOXIDE AND/OR POTASSIUM NITRATE IS ONE OF THE BASIC MATERIALS OF THE PROCESS USED

(3) SPECIFICATION RR-S-366 APPLIES

(4) MILITARY STANDARD 286 APPLIES

PART No. 10542743

MIN MECHANICAL PROPERTIES: YS, TS, EL 2, RA, BH, RH

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±
DECIMALS ± ANGLES ±
MATERIAL
HEAT TREAT
PROTECTIVE FINISH

SEE ENGINEERING RECORDS
NEXT ASSY | USED ON
APPLICATION
DO NOT APPLY PART NO.

ORIGINAL DATE FEBRUARY 3, 1970
DRAFT M.B.D CHK
TRACER CHK
ENGR ENGR
SUBMITTED Q. Hirsch
APPROVED L.E. Shiller

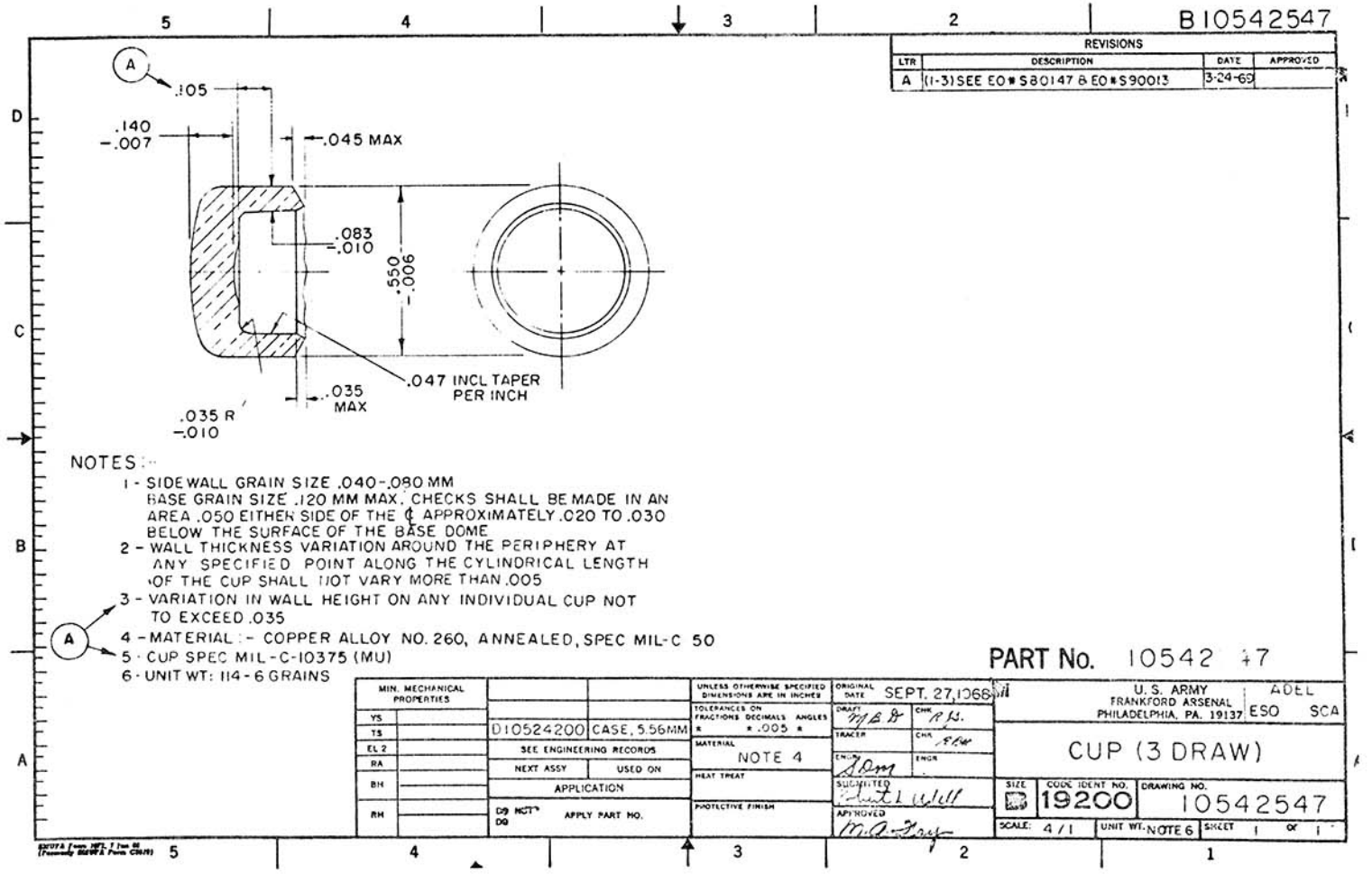
U.S. ARMY FRANKFORD ARSENAL PHILADELPHIA, PA. 19137
ADEL ESO SCA

PROPELLANT, WC 844

SIZE C | CODE IDENT NO. 19200 | DRAWING NO. 10542743
SCALE: | UNIT WT. | SHEET 1 OF 1

1542743-1	CRTG, 5.56MM, BALL, M193	D10523632
PART NUMBER	APPLICATION	

Figure A-5


B10542547
REVISIONS
LTR DESCRIPTION DATE APPROVED
A (1-3)SEE EO#S80147 & EO#S90013 3-24-69
.105
.140 -.007
.045 MAX
.083 -.010
.550 -.006
.047 INCL TAPER PER INCH
.035 MAX
.035 R -.010
NOTES:
1 - SIDEWALL GRAIN SIZE .040-.080 MM BASE GRAIN SIZE .120 MM MAX. CHECKS SHALL BE MADE IN AN AREA .050 EITHER SIDE OF THE ℄ APPROXIMATELY .020 TO .030 BELOW THE SURFACE OF THE BASE DOME
2 - WALL THICKNESS VARIATION AROUND THE PERIPHERY AT ANY SPECIFIED POINT ALONG THE CYLINDRICAL LENGTH OF THE CUP SHALL NOT VARY MORE THAN .005
3 - VARIATION IN WALL HEIGHT ON ANY INDIVIDUAL CUP NOT TO EXCEED .035
4 - MATERIAL :- COPPER ALLOY NO. 260, ANNEALED, SPEC MIL-C 50
5 - CUP SPEC MIL-C-10375 (MU)
6 - UNIT WT: 114-6 GRAINS
PART No. 10542 47
MIN. MECHANICAL PROPERTIES
YS
TS
EL 2
RA
BH
RH
D10524200 CASE, 5.56MM
SEE ENGINEERING RECORDS
NEXT ASSY USED ON
APPLICATION
DO NOT DO APPLY PART NO.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES
x .005 x
MATERIAL NOTE 4
HEAT TREAT
PROTECTIVE FINISH
ORIGINAL DATE SEPT. 27,1968
DRAFT MBB CHK R.H.
TRACER CHK F.H.
ENGR Dam ENGR
SUGGESTED
APPROVED M.A. Fay
U. S. ARMY FRANKFORD ARSENAL PHILADELPHIA, PA. 19137 ADEL ESO SCA
CUP (3 DRAW)
SIZE B CODE IDENT NO. 19200 DRAWING NO. 10542547
SCALE: 4/1 UNIT WT. NOTE 6 SHEET 1 OF 1

A Figure A-6

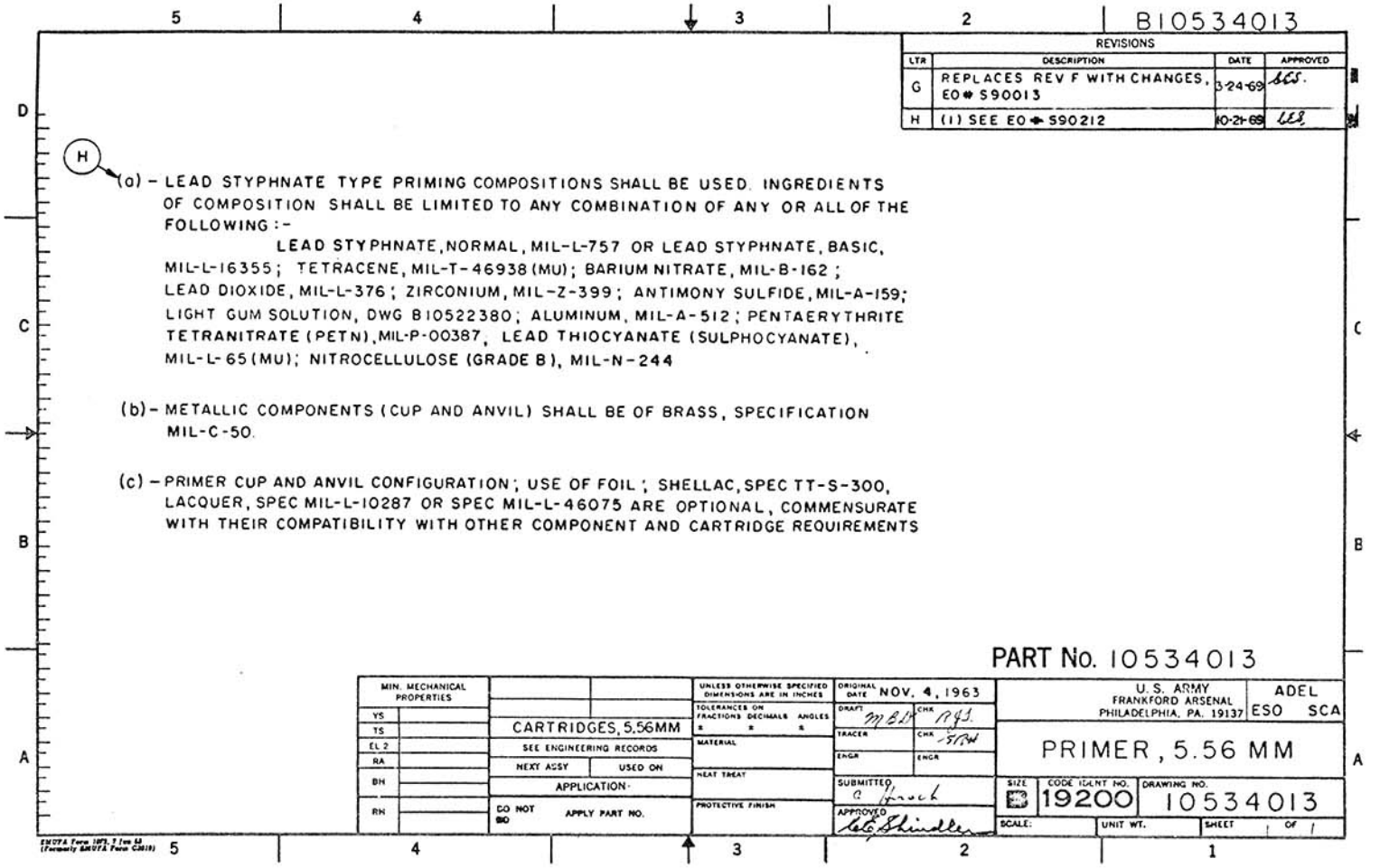

B10534013
REVISIONS
LTR | DESCRIPTION | DATE | APPROVED
G | REPLACES REV F WITH CHANGES, EO# S90013 | 3-24-69 | LES.
H | (1) SEE EO # S90212 | 10-21-69 | LES
(H)
(a) - LEAD STYPHNATE TYPE PRIMING COMPOSITIONS SHALL BE USED. INGREDIENTS OF COMPOSITION SHALL BE LIMITED TO ANY COMBINATION OF ANY OR ALL OF THE FOLLOWING :-
LEAD STYPHNATE, NORMAL, MIL-L-757 OR LEAD STYPHNATE, BASIC, MIL-L-16355; TETRACENE, MIL-T-46938 (MU); BARIUM NITRATE, MIL-B-162; LEAD DIOXIDE, MIL-L-376; ZIRCONIUM, MIL-Z-399; ANTIMONY SULFIDE, MIL-A-159; LIGHT GUM SOLUTION, DWG B10522380; ALUMINUM, MIL-A-512; PENTAERYTHRITE TETRANITRATE (PETN), MIL-P-00387, LEAD THIOCYANATE (SULPHOCYANATE), MIL-L-65 (MU); NITROCELLULOSE (GRADE B), MIL-N-244
(b) - METALLIC COMPONENTS (CUP AND ANVIL) SHALL BE OF BRASS, SPECIFICATION MIL-C-50.
(c) - PRIMER CUP AND ANVIL CONFIGURATION; USE OF FOIL; SHELLAC, SPEC TT-S-300, LACQUER, SPEC MIL-L-10287 OR SPEC MIL-L-46075 ARE OPTIONAL, COMMENSURATE WITH THEIR COMPATIBILITY WITH OTHER COMPONENT AND CARTRIDGE REQUIREMENTS
PART No. 10534013
MIN. MECHANICAL PROPERTIES
YS
TS
EL 2
RA
BH
RH
CARTRIDGES, 5.56MM
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
DO NOT APPLY PART NO.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES
MATERIAL
HEAT TREAT
PROTECTIVE FINISH
ORIGINAL DATE NOV. 4, 1963
DRAFT MBH CHK RJS
TRACER CHK
ENGR ENGR
SUBMITTED C Franck
APPROVED Peter Shindler
U.S. ARMY
FRANKFORD ARSENAL
PHILADELPHIA, PA. 19137
ADEL
ESO SCA
PRIMER, 5.56 MM
SIZE B
CODE IDENT NO. 19200
DRAWING NO. 10534013
SCALE:
UNIT WT.
SHEET 1 OF 1
EMUTA Form 1073-7 Jun 64 (Formerly EMUTA Form C3619)

Figure A-7

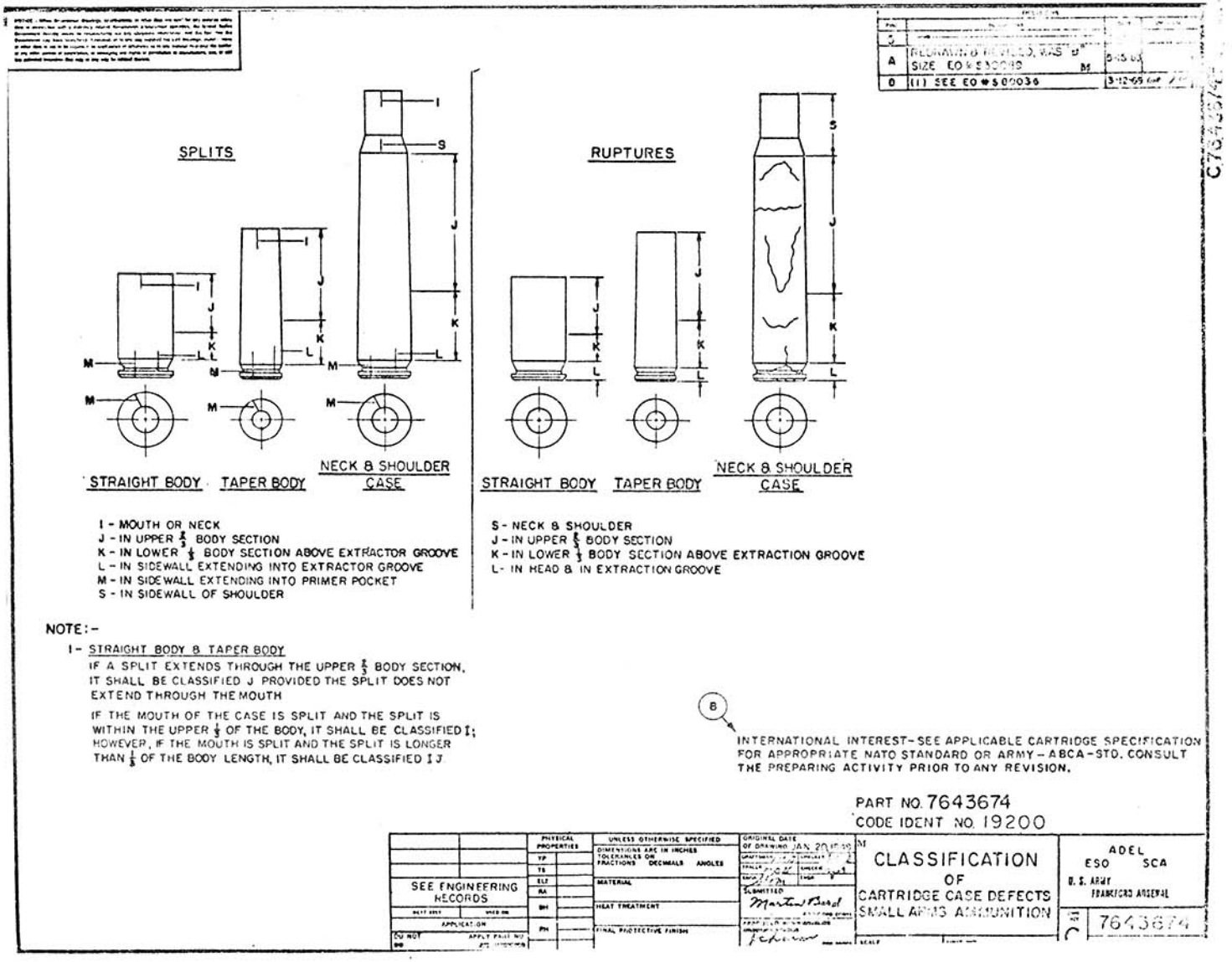

SPLITS
RUPTURES
STRAIGHT BODY
TAPER BODY
NECK & SHOULDER CASE
I - MOUTH OR NECK
J - IN UPPER 2/3 BODY SECTION
K - IN LOWER 1/3 BODY SECTION ABOVE EXTRACTOR GROOVE
L - IN SIDEWALL EXTENDING INTO EXTRACTOR GROOVE
M - IN SIDEWALL EXTENDING INTO PRIMER POCKET
S - IN SIDEWALL OF SHOULDER
S - NECK & SHOULDER
J - IN UPPER 2/3 BODY SECTION
K - IN LOWER 1/3 BODY SECTION ABOVE EXTRACTION GROOVE
L - IN HEAD & IN EXTRACTION GROOVE
NOTE:-
1 - STRAIGHT BODY & TAPER BODY
IF A SPLIT EXTENDS THROUGH THE UPPER 2/3 BODY SECTION, IT SHALL BE CLASSIFIED J PROVIDED THE SPLIT DOES NOT EXTEND THROUGH THE MOUTH
IF THE MOUTH OF THE CASE IS SPLIT AND THE SPLIT IS WITHIN THE UPPER 1/3 OF THE BODY, IT SHALL BE CLASSIFIED I; HOWEVER, IF THE MOUTH IS SPLIT AND THE SPLIT IS LONGER THAN 1/3 OF THE BODY LENGTH, IT SHALL BE CLASSIFIED I J
8
INTERNATIONAL INTEREST-SEE APPLICABLE CARTRIDGE SPECIFICATION FOR APPROPRIATE NATO STANDARD OR ARMY-ABCA-STD. CONSULT THE PREPARING ACTIVITY PRIOR TO ANY REVISION.
PART NO. 7643674
CODE IDENT NO. 19200
SEE ENGINEERING RECORDS
CLASSIFICATION OF CARTRIDGE CASE DEFECTS SMALL ARMS AMMUNITION
ADEL
ESO SCA
U.S. ARMY
FRANKFORD ARSENAL
7643674

Figure A-8

APPENDIX B
Propellant Description and Cartridge Acceptance Sheets
Lots A, B, C and D

FEDERAL CARTRIDGE CORPORATION
Anoka, Minnesota

FINAL ACCEPTANCE REPORT - (PART 1)
Cartridge, 5.56MM Ball, M193

LOT NO. FC-1921 DATE 29 February 1968

Accepted X Rejected ____ 1st Test X Retest ____ Waiver ____ *Waiver Details

1. Date Accepted:	29 February 1968	10. Primer:	#195
2. Quantity Packed:	1,108,800	11. Primer Mix No:	K75
3. Stock Number:	1305-926-3930(A071)	12. Propellant:	WC846 Lot 1100
4. Contract No:	DAAA25-68-C-0159	13. Type: 11	Class: 3
5. Specification:	MIL-C-9963D	14. Army Lot No: A. --	B.
6. Rev. No: -- Date:	1 June 1963	15. Avg.Chg. (Gr.) A.	27.47 B.
7. Dwg. No: 10523632 Date:	26 June 1963	16. Case: BRASS Headstamp (yr.)	FC-68
8. Rev. No: E Date:	11 August 1966	17. Bullet Jacket:	GILDING
9. Primer Type:	STYPHNATE	18. Bullet Weight:	55 grains

	FIRING TESTS	NUMBER ROUNDS	RECORD	LIMIT
A)	VELOCITY (FT./SEC.)			
1.	Corr. Inst. Mean @ 15 ft.	20	3,247	3250 ± 40 Ft./Sec.
2.	Standard Deviation		16.7	40 Ft./Sec.
	VARIATION IN VELOCITY FROM NORMAL TEMPERATURE SAMPLE		VARIATION	VARIATION
3.	Corr. Inst. Mean @ 15 Ft. +125°	10	+21	-250 Ft./Sec.
4.	Corr. Inst. Mean @ 15 Ft. +160°	10	+19	-250 Ft./Sec.
5.	Corr. Inst. Mean @ 15 Ft. -65°	20	-69	-250 Ft./Sec.
6.	Corr. Inst. Mean @ 15 Ft. -80°			
B)	CHAMBER PRESSURE (PSI)		AVG. AVG. +3 S.D.	AVG. AVG. +3 S.
7.	Normal Temperature	20	49,925 53,735	52,000 58,000
	VARIATION IN CHAMBER PRESSURE (PSI) FROM NORMAL TEMPERATURE SAMPLE		VARIATION	VARIATION
8.	+125°	10	+530	+5,000
9.	+160°	10	+2,970	+5,000
10.	-65°	20	+420	+5,000
11.	-80°			+5,000
C)	PORT PRESSURE			AVG OR
12.	Normal Temperature	20	14,475	15,000 ±2,000 PSI
13.	+125°	10	+80	±2,000
14.	+160°	10	-80	±2,000
15.	-65°	20	-475	±4,000
16.	-80°			±2,000
D)	ACCURACY			
17.	Mean Radius @ 200 Yards	90	1.14 (Actual)	NT 2 Inches
E)	ACTION TIME (MS)			
18.	Normal Temperature	50	1.18 (Actual)	4 MS
F)	PENETRATION & CASUALTY - RIFLE, M16			
19.	Ambient Temperature	240	0	
20.	+125°	120	0	
21.	+160°	120	0	

FEDERAL CARTRIDGE CORPORATION
Anoka, Minnesota

FINAL ACCEPTANCE REPORT - (PART 2)
Cartridge, 5.56mm Ball, M193

LOT NO. FC-1921 DATE 29 February 1968

Accepted X Rejected ____ 1st Test X Retest ____ Waiver ____ *Waiver Details

		NUMBER TESTED	RECORD		LIMIT	
(G)	MERCUROUS NITRATE TEST	50	0		NO FAILURES	
(H)	BULLET EXTRACTION	25	110 (MIN)		35 POUNDS MINIMUM	
(I)	WATERPROOF	50	1 **		3/1st TEST-6/2nd TE	
(J)	PRIMER SENSITIVITY *** Lot 280	350	$\bar{H} + 3\sigma$ 8.10	$\bar{H} - 3\sigma$ 3.18	$\bar{H} + 3\sigma$ <12	$\bar{H} - 3\sigma$ >3

(K) CARTRIDGE INSPECTION	NUMBER INSPECTED	DATE COMPLETED
1st Sample	5,500	28 February 1968
2nd Sample		

CLASSIFICATION OF DEFECTS	CRITICAL	MAJOR	MINOR
1. Acceptable Quality Level (%)	0%	0.25%	1.50%
2. Percent Defective	0		0
DEFECT:			
3. No. 39		0.017%	
4.			
5.			
6.			
7.			
8.			
9.			
10. TOTAL	0%	0.017%	0%

(L) PACKING INSPECTION

Defect Classification	MAJOR		MINOR	
Phase:	% Defect	AQL %	% Defect	AQL %
1. CONTAINER CONTENT: Bandoleer	8	1.0	1.32	2.5
2. PACKED CONTAINER	0	1.0	0	2.5
3. LEAK TEST	0	1.0	--	---
4. OVER PACK	0	1.0	0	2.5
5. PALLETIZING	0	100	0	100

REMARKS: ** 1 Slow Mouth Leak
*** Lot 281(250) 7.91, Lot 282(250) 7.67, Lot 283(250) 8.31, Lot 284(250) 7.81

(WESTERN BRASS) 3.53 3.89 3.81 4.39

THIS LOT HAS BEEN INSPECTED IN ACCORDANCE WITH CONTRACT REQUIREMENTS (EXCEPT AS OTHERWISE AUTHORIZED AND NOTED HEREON).

*WAIVER DETAILS:

R. J. Hornsby
Contractor Representative
R. J. Hornsby

Edmund C. Moren
Government Representative
Edmund C. Moren

OO FORM 1204 15 Apr. 52	ORDNANCE CORPS PROPELLANT DESCRIPTION SHEET	Supersedes OO Form 1204 dated 1 Jul. 49 which is obsolete.

U.S. Army Lot No. WC 846 Lot 1100 of 1968 Composition No. _____ For 5.56 mm.

Manufactured at: Olin Mathieson Chemical Corp., East Alton, Ill. Packed Weight 23,400 lbs.

Contract No. 36074A Date Feb. 1, 1968 Specification No. MIL-P- Revision of _____

Accepted blends (Nos.) NITROCELLULOSE 3984C dated 5 Jan. 1965 and Drawing 10534784 dated 16 July 1965

Blend of rework material

Nitrogen Content	K. I. Starch Test (65.5° C.)	Stability Test (135° C.)
Maximum ___ %	Maximum ___ Mins.	Maximum ___ Mins.
Minimum ___ %	Minimum ___ Mins.	Minimum ___ Mins.
Average ___ %	Average ___ Mins.	Average ___ Mins.
		Explosion ___ Mins.

MANUFACTURE OF PROPELLANT

Total weight of solvent per pound NC _____ Consisting of _____ pounds alcohol and _____ pounds ether per 100 pound solvent. Percentage of remix to whole _____

TEMPS. °C. From	TEMPS. °C. To	PROCESS—SOLVENT RECOVERY AND DRYING	TIMES Days	TIMES Hours
		The following analyses are an average of two tests.		

TESTS OF FINISHED PROPELLANT

COMPOSITION Constituent	Formula	Mfr.	Inspr.
Nitroglycerin		9.80	
Dinitrotoluene		0.78	
Diphenylamine		0.97	
Dibutyl phthalate		5.04	
Methylene Chloride Extract		16.59	
Nitrocellulose		82.40	
Total volatiles		1.34	
Moisture & Volatiles		1.01	
Residual Solvent		0.51	
Calcium Carbonate		0.71	
Sodium Sulfate		0.13	

STABILITY AND PHYSICAL TESTS 120°C.	Mfr.	Inspr.
135° C heat test, S. P.	70	
Explosion	300+	
Dust & Foreign Material	.02	
Web	.0152"	
Graphite	.17	
Burning surface per pound (sq. inches)		
Grav. density, ~~of pounds per cu. in.~~	.991	
Specific gravity		
Hygroscopicity		
Nitrogen	13.10	

GRAIN DIMENSIONS	DIE (INCHES)	FINISHED GRAIN (INCHES) Manufacturer Opening	FINISHED GRAIN (INCHES) Inspector % Retained	MEAN VARIATION IN PER CENT OF MEAN DIMENSION Manufacturer	MEAN VARIATION IN PER CENT OF MEAN DIMENSION Inspector
Length (L) Granulation		U.S. # 20	0.17		
Diameter (D)		25	2.91		
Diameter of perforations (d)		30	25.10		
Web: Inner		35	28.40		
Web: Outer		40	39.11		
Web: Average		45	3.99		
Web: Calculated		50	0.20		
Difference between inner and outer web in per cent of web average		Pan	0.07		
L:D (Y)		Total	99.95		
D:d (X)					

Date packed 1/29/68 Date offered _____ Date sampled 1/29/68

Date test finished 1/30/68 Date description sheets forwarded 2/2/68

Type of Packing Box Fiber Pak

Remarks: This lot meets the requirements of MIL-P-3984C dated 5 Jan. 1965 and Drawin 10534784 dated 16 July 1965 with exceptions as noted in the applicable contract.

Superintendent Quality Control	Inspector of Ordnance	U. S. Chemist

ORDNANCE CORPS

BALLISTIC ACCEPTANCE TEST FOR SMALL ARMS PROPELLENT POWDER

Lot No. WC846lot1100
Caliber 5.56mm
Type
Date 1-31-68

TESTED IN ACCORDANCE WITH SPECIFICATION MIL-P-3984C dated 5 Jan 65 & drawing 10534784 dated 16 Jul 65

PROPELLENT POWDER		GUNS	VEL. RIFLE	VEL. RIFLE	PRESS. GAGE
Mfr.	Olin Mathieson Chemical Corp	Receiver No.	121		32
Lot No.	WC846lot1100	Barrel No.	17		13
Made At	E. Alton, Ill	Barrel Length	20"		20"
Net Wt. of Lot	23.400 Lbs.	Head Space	1.499"		1.499"
Charge	27.3 Grs.	Times Fired	1872		620
Air Space	+.112 Ins.				

Proof Fired By
Bullet Type Fed M193 BALL
Bullet Wt. 55 Grs.
Primer Federal
Cartridge Case Federal
Temperature 70 °F.

DATE FIRED	BLEND TEST	GUN OR GAGE NUMBER	NO. OF RODS	CORRECTED MEAN VELOCITY AT 15 FT.	VARIATION IN VELOCITY EXTR.	VARIATION IN VELOCITY STD. DEV.	CORRECTED PRESSURE MEAN	CORRECTED PRESSURE MAX.
	Blend of 6	17	20	3255	62	17	—	—
1-29-68	Samples 13		20		—	—	46600	47900

INDIVIDUAL BOX SAMPLES	BOX NO.	GUN NUMBER	NO. OF RODS	UNCORRECTED MEAN VELOCITY AT FT.	MEAN VARI. IN VELOCITY	MEAN VEL. FROM AV. OF ALL BOXES
	Action Time		10	Temperature Tests		
	(Milliseconds)		10	Stored Fired	Max Indiv Change	P
	Av	Max	10	at at	Press	Press Vel Pr
		Indiv	10	-65°F -65°F	47000	-2500 -159 -
	1.19	1.24	10	160°F 70°F	48500	-1700 - 7 +2
			10	125°F 125°F	49300	+ 200 + 57 +

REMARKS:

Port Pressure Test

		No Rds	Actual Av	Corrected Av
	TW18000	20	14680	14800
36074A	WC846Lot1100	20	14665	14785

DATE FIRED	LOG NUMBER TW18000	CHARGE Grains	GUN OR GAGE NUMBER	NO. OF RODS	MEAN VELOCITY AT 15 FT.	MEAN PRESSURE
	Standardization				3248	
1-29-68	Standard Firing		17	20	3220	
	Correction				+ 28	
	Standardization					47500
1-29-68	Standard Firing		13	20		47300
	Correction					+ 200

THIS LOT PROPELLENT POWDER meets THE BALLISTIC TEST REQUIREMENTS.

(Signature) J. C. Hugg CONTRACTOR

(Signature) ORDNANCE CORPS OFFICIAL

(Signature) ORDNANCE INSPECTOR

TITLE AND INSTALLATION

74469

DD FORM 1 Feb 63 1566

FEDERAL CARTRIDGE CORPORATION

Anoka, Minnesota

FINAL ACCEPTANCE REPORT - (PART I)

Cartridge, 5.56MM Ball, M193

LOT NO. FC-1938 DATE 10 June 1968

Accepted X Rejected _____ 1st. Test X Retest _____ Waiver _____ *Waiver Details

1.	Date Accepted: 5 June 1968	10.	Primer: #195
2.	Quantity Packed: 1,209,600	11.	Primer Mix No: K75
3.	Stock Number: 1305-926-3930(A071)	12.	Propellant: WC846, Lot 1130
4.	Contract No: DAAA25-68-C-0159	13.	Type: II Class: 3
5.	Specification: MIL-C-9963D	14.	Army Lot No: A. - - - - - - - B.
6.	Rev. No:- - - - Date: 1 June 1963	15.	Avg. Chg. (Gr.) A. 28.08 B.
7.	Dwg. No:10523632 Date: 26 June 1963	16.	Case: BRASS Headstamp (yr.) FC-68
8.	Rev. No: E Date: 11 August 1966	17.	Bullet Jacket: GILDING
9.	Primer Type: STYPHNATE	18.	Bullet Weight: 55 grains

	FIRING TESTS	NUMBER ROUNDS	RECORD	LIMIT
A)	VELOCITY (FT./SEC.)			
1.	Corr. Inst. Mean @ 15 ft.	20	3,247	3250 ± 40 Ft./Sec.
2.	Standard Deviation		19.7	40 Ft./Sec.
	VARIATION IN VELOCITY FROM NORMAL TEMPERATURE SAMPLE		VARIATION	VARIATION
3.	Corr. Inst. Mean @ 15 Ft.+125°	10	+15	-250 Ft./Sec.
4.	Corr. Inst. Mean @ 15 Ft.+160°	10	-10	-250 Ft./Sec.
5.	Corr. Inst. Mean @ 15 Ft.- 65°	20	-133	-250 Ft./Sec.
6.	Corr. Inst. Mean @ 15 Ft.- 80°			
B)	CHAMBER PRESSURE (PSI)		AVG. AVG.+3 S.D.	AVG. AVG.+3 S.D.
7.	Normal Temperature	20	47,020 49,990	52.000 58.000
	VARIATION IN CHAMBER PRESSURE (PSI) FROM NORMAL TEMPERATURE SAMPLE		VARIATION	VARIATION
8.	+125°	10	+1,860	+ 5.000
9.	+160°	10	+2,540	+ 5.000
10.	- 65°	20	-3,555	+ 5.000
11.	- 80°			+ 5.000
C)	POST PRESSURE			AVERAGE
12.	Normal Temperature	20	14,645	15.000 ± 2.000 psi
13.	+125°	10	+480	± 2.000
14.	+160°	10	+130	± 2.000
15.	- 65°	20	-170	± 2.000
16.	- 80°			± 2.000
D)	ACCURACY			
17.	Mean Radius @ 700 Yards	90	1.22(Actual)	MR 2 Inches
E)	ACTION TIME (MS)			
18.	Normal Temperature	50	1.17(Actual)	4 MS
F)	FUNCTION & CASUALTY - RIFLE, M16			
19.	Ambient Temperature	240	0	
20	+ 125°	120	0	
21.	+ 160°	120	1**	

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FEDERAL CARTRIDGE CORPORATION
Anoka, Minnesota

FINAL ACCEPTANCE REPORT - (PART 2)
Cartridge, 5.56mm Ball, M193
LOT NO. FC-1938 DATE 10 June 1968

Accepted X Rejected ____ 1st Test X Retest ____ Waiver ____ *Waiver Details

	NUMBER TESTED	RECORD	LIMIT
(G) MERCUROUS NITRATE TEST	50	0	NO FAILURES
(H) BULLET EXTRACTION	25	88 (Min)	35 POUNDS MINIMUM
(I) WATERPROOF	50	0	3/1st TEST-6/2nd TEST
(J) PRIMER SENSITIVITY *** Lot 315	200	$\bar{H}+3\sigma$ 6.81 $\bar{H}-3\sigma$ 3.39	$\bar{H}+3\sigma$ <12 $\bar{H}-3\sigma$ 3>

(K) CARTRIDGE INSPECTION	NUMBER INSPECTED	DATE COMPLETED
1st Sample	6,000	3 June 1968
2nd Sample		

CLASSIFICATION OF DEFECTS	CRITICAL	MAJOR	MINOR
1. Acceptable Quality Level (%)	0%	0.25%	1.50%
2. Percent Defective	0		0
DEFECT:			
3. No. 40		.06%	
4.			
6.			
7.			
8.			
9.			
10. TOTAL	0%	.06%	0%

(L) PACKING INSPECTION

Defect Classification	MAJOR		MINOR	
Phase:	% Defect	AQL %	% Defect	AQL %
1. Container Content				
(a) Bandoleer	0	1.0	0.41%	2.5
(b) Clip and/or carton	0	1.0	0.33%	2.5
(c) Miscellaneous	---	----	0	2.5
2. Gasket Sealed Ammunition Box				
(a) Physical Characteristics, Paint and Markings:	0	1.0	0	2.5
(b) Gasket sealing (Leak Test)	0	1.0	---	----
3. Overpack and Overpack Contents	0	1.0	0	2.5
4. Palletizing (Inspected 100%)	0	N/A	0	N/A

REMARKS:
ASE HARDNESS DATA ATTACHED ** 1 Body Split (J) *** Lot 316 (250) 7.81 3.40
TESTED B

THIS LOT HAS BEEN INSPECTED IN ACCORDANCE WITH CONTRACT REQUIREMENTS (EXCEPT AS OTHERWISE AUTHORIZED AND NOTED HEREON).

*WAIVER DETAILS:

FEDERAL CARTRIDGE CORPORATION

INFORMATION TEST RESULTS DIAMOND PYRAMID HARDNESS											DATE June 6, 1968
TYPE: 5.56MM							LOT NO. FCC-1938				
HARDNESS GRADIENT - EXTERIOR OF CASE											
POSITION	NO 1	NO 2	NO 3	NO 4	NO 5	NO 6	NO 7	NO 8	NO 9	NO 10	AVG OF 10 PCS
.250	188	180	183	193	180	187	191	191	187	182	186
.475	185	184	184	181	190	185	193	189	194	185	187
.700	200	204	207	202	202	200	199	206	197	202	202
.925	153	176	156	177	176	187	156	198	197	200	177
1.150	133	128	124	131	136	134	124	138	133	133	131
1.375	111	103	100	107	114	110	97	108	108	109	107
1.620	121	96	104	98	102	103	96	100	103	95	102

AXIAL HEAD HARDNESS											
POSITION	NO 1	NO 2	NO 3	NO 4	NO 5	NO 6	NO 7	NO 8	NO 9	NO 10	
A	182	169	177	180	172	176	175	173	169	176	175
B	178	180	180	183	169	171	178	180	185	182	179
C	195	199	188	193	200	199	192	197	196	198	196
D	213	197	215	213	220	210	216	212	211	212	212

LOCATIONS PER DWG -D1052L200

Edmund E. Noreen
Q. A. REPRESENTATIVE

Hazel Bliss
INSPECTOR

812-02-66

R. A. Ray
SENIOR METALLURGICAL ENGINEER

OO FORM 1204 15 Apr. 52

ORDNANCE CORPS

PROPELLANT DESCRIPTION SHEET

Supersedes OO Form 1204 dated 1 Jul 49 which is obsolete.

U.S. Army Lot No. WC 846 Lot 1130 of 1968 Composition No. — For 5.56 mm.

Manufactured at: Olin Mathieson Chemical Corp., East Alton, Ill. Packed Weight 22,000 lbs.

Contract No. 36074A Date April 1, 1968 Specification No. MIL-P- Revision of —

Accepted blends (Nos.) NITROCELLULOSE 3984C dated 5 Jan. 1965 and Drawing ~~10534784 dated 16 July 1965~~

Blend of rework material

Nitrogen Content	K. I. Starch Test (65.5° C.)	Stability Test (135° C.)
Maximum ___ %	Maximum ___ Mins.	Maximum ___ Mins.
Minimum ___ %	Minimum ___ Mins.	Minimum ___ Mins.
Average ___ %	Average ___ Mins.	Average ___ Mins.
		Explosion ___ Mins.

MANUFACTURE OF PROPELLANT

Total weight of solvent per pound NC ___ Consisting of ___ : ___ pounds alcohol and ___ pounds ether per 100 pound solvent. Percentage of remix to whole ___

TEMPS., °C. From	TEMPS., °C. To	PROCESS—SOLVENT RECOVERY AND DRYING	TIMES Days	TIMES Hours
		The following analyses are an average of two tests		

TESTS OF FINISHED PROPELLANT

COMPOSITION

Constituent	Formula	Mfr.	Inspr.
Nitroglycerin		10.30	
Dinitrotoluene		0.84	
Diphenylamine		1.13	
Dibutyl phthalate		4.75	
Methylene Chloride Extract		17.02	
Nitrocellulose		81.63	
Total volatiles		1.11	
Moisture & Volatiles		0.86	
~~Ash~~ Residual Solvent		0.28	
Calcium Carbonate		0.97	
Sodium Sulfate		0.15	

STABILITY AND PHYSICAL TESTS

120°C.	Mfr.	Inspr.
~~135° C~~ heat test, S. P.	80	
Explosion	300+	
~~Foreign matter~~ Dust & Foreign Material	.02	
~~No. of perforations~~ Web	.0160"	
~~Weight per pound~~ Graphite	.23	
Burning surface per pound (sq. inches)		
Grav. density, ~~pounds per cubic~~	1.002	
Specific gravity		
Hygroscopicity		
~~Combustibles~~ Nitrogen	13.08	

GRAIN DIMENSIONS	DIF. (INCHES)	FINISHED GRAIN (INCHES) Manufacturer	FINISHED GRAIN (INCHES) Inspector	MEAN VARIATION IN PER CENT OF MEAN DIMENSION Manufacturer	MEAN VARIATION IN PER CENT OF MEAN DIMENSION Inspector
Length (L) Granulation		Opening	% Retained		
Diameter (D)		U.S. # 20	0.17		
Diameter of perforations (d)		25	5.11		
Web: Inner		30	24.30		
Web: Outer		35	37.04		
Web: Average		40	30.75		
Web: Calculated		45	2.25		
Difference between inner and outer web in per cent of web average		50	0.21		
L:D (Y)		Pan	0.19		
D:d (X)		Total	100.02		

Date packed 3/25/68 Date offered — Date sampled 3/25/68

Date test finished 3/27/68 Date description sheets forwarded 4/2/68

Type of Packing Box Fiber Pak

Remarks: This lot meets the requirements of MIL-P-3984C dated 5 Jan. 1965 and Drawi 10534784 dated 16 July 1965 with exceptions as noted in the applicable contract.

Superintendent	Inspector of Ordnance	U. S. Chemist
Quality Control		

ORDNANCE CORPS

BALLISTIC ACCEPTANCE TEST
FOR
SMALL ARMS PROPELLENT POWDER

MIL-P-3984C dated 5 Jan. 1965
TESTED IN ACCORDANCE WITH SPECIFICATION and Drawing 10534784 dated 16 July 1965

Lot No. WC 846 Lot 130
Caliber 5.56 mm.
Type
Date Mar. 26, 1968

PROPELLENT POWDER		GUNS	VEL. RIFLE	VEL. RIFLE	PRESS. GAGE
Mfr.	Olin Mathieson Chemical Corp.				
Lot No.	WC 846 Lot 1130				
Made At	East Alton, Ill.	Receiver No.	121		32
Net Wt. of Lot	22,000 Lbs.	Barrel No.	17		13
Charge	28.2 Grs.	Barrel Length	20"		20"
Air Space	+.018 Ins.	~~Head Space~~ Breeching	1.499"		1.499"
		Times Fired	3330		1910

Proof Fired By
Bullet Type Fed. M193 Ball
Bullet Wt. 55 Grs.
Primer Federal
Cartridge Case Federal
Temperature 70 °F.

DATE FIRED	BLEND TEST	GUN OR GAGE NUMBER	NO. OF RODS	CORRECTED MEAN VELOCITY AT 15 FT.	VARIATION IN VELOCITY EXTR.	VARIATION IN VELOCITY STD. DEV.	CORRECTED PRESSURE MEAN	CORRECTED PRESSURE MAX.
3/25/68	Blend of 6	17	~~20~~ 10	3236	51	14	—	—
	Samples	13	~~20~~ 10	20	—	—	47300	48900

	BOX NO.	GUN NUMBER	NO. OF RODS	UNCORRECTED MEAN VELOCITY AT FT.	MEAN VARI. IN VELOCITY	MEAN VEL. FROM AV. OF ALL BOXES
INDIVIDUAL BOX SAMPLES			10	Temperature Tests		
			10	Stored Fired	Max. Indiv. Changes	Port
			10	at at	Press.	Press. Vel. Press
			10	-65°F. -65°F.	44000	-5900 -186 -520
			10	160°F. 70°F.	48800	-1500 - 5 - 70
			10	125°F. 125°F.	53200	+1900 + 72 +120

REMARKS:

Federal Order No. 36074A

Port Pressure Test	No. Rds.	Actual Av.	Corrected Av.
TW 18000	20	14870	14800
WC 846 Lot 1130	20	15400	15330

DATE FIRED	LOG NUMBER TW 18000	CHARGE Grains	GUN OR GAGE NUMBER	NO. OF RODS	MEAN VELOCITY AT 15 FT.	MEAN PRESSURE
	Standardization				3248	—
3/25/68	Standard Firing		17	20	3221	—
	Correction				+27	—
	Standardization					47500
3/25/68	Standard Firing		17	20		47500
	Correction					0

THIS LOT PROPELLENT POWDER meets THE BALLISTIC TEST REQUIREMENTS.

(Signature) D. P. Faidley
CONTRACTOR

(Signature)
ORDNANCE INSPECTOR

(Signature)
ORDNANCE CORPS OFFICIAL

TITLE AND INSTALLATION

Date Presented 29 March 1968
Quantity Packed 3,002,160 Rds.*
FSN 1305-926-3930-(A071)
Functional Lot Nos.
AMCMS Code 4810.16.0229.2.04
Spec. No. MIL-C-9963 D Rev. A/4
ECO Date
Dwg. No. D 10525632
Rev. D Date 2-17-65

TWIN CITIES ARMY AMMUNITION PLANT
INSPECTION REPORT – 5.56MM

ITEM CTGS 5.56mm Ball M193
Lot No. TW- 18309
Accepted ☐ 1st Test ☐
Rejected ☐ Retest ☐
Waiver ☐
Acceptance Date 10 April 1968

Contractor: Federal Cartridge Corp.
Contract No. DA-36-038-AMC-1099(A)
Primer No. DA-36-038-AMC-1099(A)195
Primer Lot Nos. TW 387A 386A
Tracer Mix
Igniter Mix
Propellant Type WC 846 ✓
A.L. No. 44978 ✓
Chg. (Grs) 27.9
Case - Steel ☐ Brass ☐
Headstamp (Yr) 1967 - 1968
Bullet Jacket Gilding Metal

FIRING TESTS

CHAMBER PRESSURE (PSI)	AMB	125°	160°	-65°
RDS FIRED	20	10	10	20
RECORD	47,900	+1800	-2100	-4100
LIMIT - MAX	52,000	+ 5,000	+ 5,000	+ 5,000
AVG + 3 SD	52,300			
LIMIT - MAX	58,000			
PORT PRESSURE (PSI)				
RECORD	15,080	+40	+10	-610
LIMIT	15,000 ± 2,000	+-2,000	+-2,000	+-2,000
VELOCITY @ 15 FT. (FS)				
RDS FIRED	20	10	10	20
RECORD	3238	+30	-20	-145
LIMIT - BALL	3250 ± 40	-250	-250	-250
LIMIT - TRACER	3200 ± 40	-250	-250	-250
STD DEV	20.8			
LIMIT	40			

ACCURACY (INCHES)	RDS FIRED	RECORD	LIMIT
MEAN RADII @ 200 YDS	90	1.0	2.0
ACTION TIME (MS)	50	1.29	4.0

FUNCTION & CASUALTY	RDS FIRED	RECORD	LIMIT
RIFLE, 5.56MM, XM16E1	720		
CASUALTIES		None	

TRACE PERFORMANCE	NO. RDS.	RECORD	LIMIT
% TRACING @ 500 YDS.	100		80%
NO. TOTAL BLINDS	[redacted]		
NO. SHORT TRACE			
NO. LATE TRACE			

WATERPROOF TEST

NO. TESTED	NO. FAILED	SPEC. LIMIT
50	0	3

DESCRIPTION OF DEFECTS

BULLET EXTRACTION TEST (Lbs.)

No. Tested	SPEC. MIN.	NO. FAILED	MAX.	MIN.	MEAN
25	35	0	82	48	6

MERCUROUS NITRATE TEST

NO TESTED	NO. FAILED	SPEC. LIMIT
50	0	0

BASE CLOSURE SEAL TEST

NO. TESTED	NO. FAILED	SPEC. LIMIT
		3

VISUAL GAGE & WEIGH INSPECTION

1st SAMPLE 2400 DATE 3-29-68
2nd SAMPLE

	CRITICAL	MAJOR	MINOR
AQL %	.04	.25	1.50
% DEFECTIVE		0	1
DEFECT NO. & DESCRIPTION			1/28
TOTAL		0	

PACKING INSPECTION - CONTAINER CONTENT

SUB-LOT	MAJOR % DEFECTIVE	MAJOR AQL %	MINOR % DEFECTIVE	MINOR AQL %
		1.0		2.5
1ST	0		0	
2ND	0		0	

TOTAL AUTHORIZED RDS EXPENDED IN TESTS: 1040

REMARKS: Ten additional rounds tested for case hardness (information only) as per SMUAP - AMM dated 12-5-67.

*In addition, 1000 rounds (1 crate) shipped to Lake City Army Ammunition Plant for Fouling Test.

CHIEF BALLISTICIAN TCAAP

L. M. NOBLET 10 Apr 68
CHIEF, GOVERNMENT QA DIVISION

SMUTC.Q FORM 5
25 APR. 67

REPLACES SMUTC FORM 116 WHICH IS OBSOLETE

Date Presented 3 April 1968
Quantity Packed 3,017,280 Rds. *
FSN 1305-926-3930-A071

Functional Lot Nos.

AMCMS Code 4810.16.0229.2.04

Spec. No. MIL-C-9963D Rev. A/4
ECO Date
Dwg. No. D10523632
Rev. D Date 2-17-65

TWIN CITIES ARMY AMMUNITION PLANT
INSPECTION REPORT – 5.56MM
ITEM CTGS 5.56mm Ball M193
Lot No. TW- 18310

Accepted [X] 1st Test [X]
Rejected [ ] Retest [ ]
Waiver [ ]

Acceptance Date 12 April 1968

Contractor: Federal Cartridge Corp.
Contract No. DA-36-038-AMC-1099(A)
Primer No. 195
Primer Lot Nos. 387A 388A 389A 386A
Tracer Mix
Igniter Mix
Propellant Type WC 846
A.L. No. 44978 – 45481
Chg. (Grs) 27.9 -28.3 28.4
Case - Steel [ ] Brass [ ]
Headstamp (Yr) 1968
Bullet Jacket

FIRING TESTS

CHAMBER PRESSURE (PSI)	AMB	125°	160°	-65°
RDS FIRED	20	10	10	20
RECORD	49,400	+1000	-1500	-5300
LIMIT - MAX	52,000	+ 5,000	+ 5,000	+ 5,000
AVG + 3 SD	55,800			
LIMIT - MAX	58,000			
PORT PRESSURE (PSI)				
RECORD	15,500	-220	+480	-50
LIMIT	15,000 ± 2,000	+-2,000	+-2,000	+-2,000
VELOCITY @ 15 FT. (FS)				
RDS FIRED	20	10	10	20
RECORD	3234	+44	-53	-213
LIMIT - BALL	3250 ± 40	-250	-250	-250
LIMIT - TRACER	3200 ± 40	-250	-250	-250
STD DEV	19.6			
LIMIT	40			

ACCURACY (INCHES)	RDS FIRED	RECORD	LIMIT
MEAN RADII @ 200 YDS	90	.8	2.0
ACTION TIME (MS)	50	1.66	4.0

FUNCTION & CASUALTY	RDS FIRED	RECORD	LIMIT
RIFLE, 5.56MM, XM16E1	720		
CASUALTIES		None	

TRACE PERFORMANCE	NO. RDS.	RECORD	LIMIT
% TRACING @ 500 YDS.	100		80%
NO. TOTAL BLINDS			
NO. SHORT TRACE			
NO. LATE TRACE			

WATERPROOF TEST

NO. TESTED	NO. FAILED	SPEC. LIMIT
50	0	3

DESCRIPTION OF DEFECTS

BULLET EXTRACTION TEST (Lbs.)

No. Tested	SPEC. MIN.	NO. FAILED	MAX.	MIN.	MEAN
25	25	0	116	52	82

MERCUROUS NITRATE TEST

NO TESTED	NO. FAILED	SPEC. LIMIT
50	0	0

BASE CLOSURE SEAL TEST

NO. TESTED	NO. FAILED	SPEC. LIMIT
		3

VISUAL GAGE & WEIGH INSPECTION

1st SAMPLE 2400 DATE 4-3-68
2nd SAMPLE

	CRITICAL	MAJOR	MINOR
AQL %	.04	.25	1.50
% DEFECTIVE		0	1
DEFECT NO. & DESCRIPTION			1731
TOTAL		0	1

PACKING INSPECTION - CONTAINER CONTENT

SUB-LOT	MAJOR % DEFECTIVE	MAJOR AQL %	MINOR % DEFECTIVE	MINOR AQL %
		1.0		2.5
1ST	0		1	
2ND	0		0	

TOTAL AUTHORIZED RDS EXPENDED IN TESTS: 1040

REMARKS: Ten additional rounds tested for case hardness: (information only) as per SMUAP - AMM dated 12-5-67.

*In addition 1,000 rounds (1 crate) shipped to Lake City Army Ammunition Plant for Fouling Test.

12 Apr 68

CHIEF BALLISTICIAN TCAAP

CHIEF, GOVERNMENT QA DIVISION

SMUTC.Q FORM 5
25 APR. 67

REPLACES SMUTC FORM 116 WHICH IS OBSOLETE

AMC PROPELLANT DESCRIPTION SHEET
(AMC 715-503)

U. S. ARMY LOT NO. BAC-44978 & COMPOSITION NO. WC 846 FOR 5.56 mm BALL

MANUFACTURED AT BADGER ARMY AMMUNITION PLANT PACKED WEIGHT 60,000 lbs.

CONTRACT NO. DA-11-173-AMC-106(A) DATE 30 April 1951 SPECIFICATION NO. MIL-P-3984D and Dwg. 10534784 REVISION OF Rev. A

ACCEPTED BLENDS (Nos.) Blend of Rework Material NITROCELLULOSE

NITROGEN CONTENT	R.L. STARCH TEST (65.5° C)	STABILITY TEST (135° C)
MAXIMUM ____ % ____	MAXIMUM ____ MINS.	MAXIMUM ____ MINS
MINIMUM ____ % ____	MINIMUM ____ MINS	MINIMUM ____ MINS
AVERAGE ____ % ____	AVERAGE ____ MINS	AVERAGE ____ MINS
		EXPLOSION ____ MINS

MANUFACTURER OF PROPELLANT

TOTAL WEIGHT OF SOLVENT PER POUND NC ____ CONSISTING OF ____ POUNDS ACOHOL AND ____

POUNDS OTHER PER 100 POUND SOLVENT. PERCENTAGE OF REMIX TO WHOLE ____

TEMPS. °C. FROM	TEMPS. °C. TO	PROCESS-SOLVENT RECOVERY AND DRYING	TIME DAYS	TIME HOURS

TESTS OF FINISHED PROPELLANT

COMPOSITION CONSTITUENT	SPECS.		INSPR.	STABILITY AND PHYSICAL TESTS	XXXXREQ	INSPR.
Nitroglycerin	8.00 - 11.00		10.01	xxxx HEAT TEST, S. P. Minutes (Min.)	60	70
Dinitrotoluene	1%	Max.	0.37	No EXPLOSION Hours (Min.)	5	5+
Diphenylamine	.75 -	1.50	1.06	xxxxxxxxxxxDust&Foreign Mat. (Max).	10	0.02
Dibutylphthalate	4.0 -	7.0	5.37	xxxxxxxxxxxxxxx Average Web		0.01
Methylene Chloride Ext.			16.81	xxxxxxxxxxxxxxxxxx Graphite (Max)	.40	0.17
Nitrocellulose	Remainder		82.41	BURNING SURFACE PER POUND (sq. inches)		
TOTAL xxxxxxxVolatiles	2.00	Max.	1.02	GRAV. DENSITY, OR POUNDS PER CU. FT.	.945-1.025	0.97
MOISTURE & Volatiles	.75 -	1.25	0.96	SPECIFIC GRAVITY		
xxx Residual Solvent	1.20	Max.	0.34	HYGROSCOPICITY		
Calcium Carbonate			0.53	xxxxxxxxxxxxx Nitrogen	13.05 - 13.20	13.11
Sodium Sulfate			0.08			

GRAIN DIMENSIONS	DIE (Inches)	FINISHED GRAIN (Inches) MANUFACTURER	FINISHED GRAIN (Inches) INSPECTOR	MEAN VARIATION IN PER CENT OF MEAN DIMENSIONS MANUFACTURER	MEAN VARIATION IN PER CENT OF MEAN DIMENSIONS INSPECTOR
LENGTH (L) Granulation		Opening	Required	% Retained	
DIAMETER (D)		U.S. # 20	95 Min. thru	0.2	
DIAMETER OF PERFORATIONS (d)		# 25	90 Min.	13.9	
WEB INNER		# 30	on and	48.4	
WEB OUTER		# 35	5.0 Max.	25.0	
WEB AVERAGE		# 40	thru	12.3	
WEB CALCULATED		# 45	3.0 Max.	0.5	
DIFFERENCE BETWEEN INNER AND OUTER		Pan	thru	0.0	
WEB IN PER CENT OF WEB AVERAGE		Total		100.3	
L:D (Y)					
D:d (X)					

DATE PACKED 1-23-68 DATE OFFERED ____ DATE SAMPLED 1-23-68

DATE TEST FINISHED 1-25-68 DATE DESCRIPTION SHEETS FORWARDED 1-25-68

TYPE OF PACKING BOX Copper Lined M-24 Boxes

REMARKS: ____

LABORATORY SUPERINTENDENT R J Thuss

xxxx TECHNICAL DIRECTOR George Hogan

U. S. CHEMIST Harold E. Carlson

AMC FORM 10 JUN 64 1047

BAJ 44978
5.56 mm.
WC846
25 January 1968

MIL-P-3984D
Drawing 10534784, Rev. A

TESTED IN ACCORDANCE WITH [illegible]

PROPELLANT POWDER

Mfr. Olin Mathieson Chemical Corporation
Lot No. BAJ 44978
Made at BAAP
Net Wt. of Lot 60,000 Lbs.
Charge 26.8 Grs.
Air Space .12 Ins.

[illegible]	B 3	B 3
[illegible]	26	30
[illegible]	20"	20"
Head Space	1.499"	1.499"
Times Fired	1807	663

BAAP

Ball, M193
55 Grs.
TC
TC
70 °F.

DATE FIRED	BLEND TEST		WEIGHT GAGE NUMBER	NO. OF RDS.	CORRECTED MEAN VELOCITY AT 15 FT.	VARIATION IN VELOCITY		CORRECTED PRESSURE	
						EXTR.	STAND.	MEAN	MAX.
1-24-68	Blend of	6	26		3247	62	20.05	—	—
	Cylinders		30			—	—	44300	46200

ACTION TIME (MILLISECONDS)		TEMPERATURE TESTS				CHANGES			PORT PRESSURE			
AVE.	MAX. IND.	NO. OF RDS.										
1.38	1.47	20	+125°	+125°	52100	+73	+49	+2	TW18000R	20	15500	14800
		20	+160°	+ 70°	46600	-69	-16	-2	BAJ 44978	20	15400	14700
		20	- 65°	- 65°	47600	-19	-26	-4				

REMARKS: Pressure and Port Pressure Changes of Temperature Tests are expressed in 100's psi.

Acceptance performed with Twin City Components.

DATE FIRED	LOG NUMBER Std. Ref. Cartridge TW18000R	CHARGE GRAINS	GUN OR GAGE NUMBER	NO. OF RDS.	MEAN VELOCITY AT 15 FT.	MEAN PRESSURE	
	Standardization				3248	—	
1-24-68	Standard Firing		26	20	3251	—	
	Correction				-3		
	Standardization					47500	14800
1-25-68	Standard Firing		30	20		45500	15500
	Correction					+2000	-700

THIS LOT PROPELLANT POWDER meets THE BALLISTIC TEST REQUIREMENTS.

Mfr. (Signature) R. J. Meeker
[illegible]

(Signature) William J. [illegible]
GOVERNMENT OFFICIAL

(Signature) George Hagan
[illegible]

OD-[illegible] Incl. 2

Caliber [illegible]	SMALL ARMS PROPELLANT	Lot No. [illegible]
Type WC 846	ACCEPTANCE SHEET	Date 29 January 1968
Item Stock No. W3-01065	Badger Army Ammunition Plant Baraboo, Wisconsin	MDR. #10534784 dated 5 May 1966

Mfd. By Olin Mathieson Chemical Corp.	Proof Fired At [illegible]
At Badger Army Ammunition Plant	Cartridge Reference Propellant Lot No. [illegible]
Baraboo, Wisconsin	Inspected In Accordance With Spec.
Contract No. DA-11-173-AMC-106(A)	No. [illegible] Dtd. [illegible]
Packed Weight 60,000 lbs.	Dwg. #10534784 Rev. A Dtd. 16 [illegible]

BALLISTIC DATA

Bullet Type	Charge (Grains)	Temp. of Powder (Deg. F.)	Air Space (Inches)	Corrected Mean Velocity @ [illegible] Feet (Ft/Sec)	Corrected Mean Pressure (Lbs./Sq. In.)
M193, Ball	26.8	70	.12	3247	44,300

Remarks:

PRON NOS: F6-8-A0044-01-F0-GF

This lot of smokeless propellant is hereby accepted for loading cartridges.

E. G. JOHNSON
Chief, Quality Assurance Division

SMUEO-Q Form 10 (June 66)

BALLISTIC ACCEPTANCE TEST
FOR
SMALL ARMS PROPELLANT POWDER

TESTED IN ACCORDANCE WITH SPECIFICATION MIL-P-3984D, Amendment 2
Drawing 10534784, Rev. B

Lot No. BAJ 45481
Caliber 5.56 mm.
Type WC846
Date 22 March 1968

PROPELLANT POWDER

Mfr. Olin Mathieson Chemical Corporation
Lot No. BAJ 45481
Made at BAAP
Net Wt. of Lot 60,000 Lbs.
Charge 27.0 Grs.
Air Space .15 Ins.

GUNS

	VEL. RIFLE	VEL. RIFLE	PRESS. GAGE
Receiver No.	B 1		B 8
Barrel No.	34		31
Barrel Length	20"		20"
Head Space	1.499"		1.498"
Times Fired	1548		856

Proof Fired By BAAP
Hand Blend # 687
Bullet Type Ball, M193
Bullet Wt. 55 Grs.
Primer TC
Cartridge Case TC
Temperature 70 °F.

DATE FIRED	BLEND TEST	GUN OR GAGE NUMBER	NO. OF RDS.	CORRECTED MEAN VELOCITY AT 15 FT.	VARIATION IN VELOCITY EXTR.	VARIATION IN VELOCITY STD. DEV.	CORRECTED PRESSURE MEAN	CORRECTED PRESSURE MAX.
3-21-68	Blend of 6	34	20	3243	37	11.72	—	—
	Samples	31	20		~~62~~ —	~~17.09~~ —	49800	52200

ACTION TIME (MILLISECONDS) AVE.	ACTION TIME (MILLISECONDS) MAX. I SD.	TEMPERATURE TESTS NO. OF RDS.	STORED AT	FIRED AT	MAX. I SD. PRESS.	CHANGES VEL.	CHANGES PRESS.	CHANGES PORT T. ENLOR.	PORT PRESSURE TEST	NO. RDS.	ACTUAL AVG.	CORR. AVE.
1.73	1.81	20	+125°	+125°	54100	+77	+28	+2	TW18000R	20	14900	14800
		20	+160°	+ 70°	48700	-84	-70	+5	BAJ 45481	20	15000	14900
		20	- 65°	- 65°	47700	-125	-53	0				

REMARKS: Pressure and Port Pressure changes of Temperature Tests are expressed in 100's psi.

Acceptance performed with Twin Cities Components.

DATE FIRED	LOG NUMBER Std. Ref. Cartridge TW18000-R	CHARGE GRAINS	GUN OR GAGE NUMBER	NO. OF RDS.	MEAN VELOCITY AT 15 FT.	MEAN PRESSURE Chamber	MEAN PRESSURE Port
	Standardization				3248	—	
3-21-68	Standard Firing		34	20	3267	—	
	Correction				-19		
	Standardization					47500	14800
3-22-68	Standard Firing		31	20		44600	14900
	Correction					+2900	-100

THIS LOT PROPELLANT POWDER meets THE BALLISTIC TEST REQUIREMENTS.

(Signature) THC
BALLISTIC ENGINEER

(Signature)
GOVERNMENT OFFICIAL

(Signature) George Hogan
TECHNICAL DIRECTOR

Caliber 5.56MM Type WC 846 Item Stock No. V3- 01065	SMALL ARMS PROPELLANT ACCEPTANCE SHEET Badger Army Ammunition Plant Baraboo, Wisconsin	Lot No. BAJ 45481 Date 26 March 1968 TDPL #10534784 dated 5 May 1966

Mfd. By Olin Mathieson Chemical Corp.
At Badger Army Ammunition Plant
Baraboo, Wisconsin
Contract No. DA-11-173-AMC-106(A)
Packed Weight 60,000 Lbs.

Proof Fired At BAAP
Cartridge
Reference XXXXXXXXX Lot No. TW 18000-R
Inspected In Accordance With Spec.
No. MIL-P-3984D Amend 2 Dtd. 27 Nov 67
Dwg. #10534784 Rev. B Dtd. 24 Feb 67

BALLISTIC DATA

Bullet Type	Charge (Grains)	Temp. of Powder (Deg. F.)	Air Space (Inches)	Corrected Mean Velocity @ 15 Feet (Ft/Sec)	Corrected Mean Pressure (Lbs./Sq. In.)
M193, Ball	27.0	70	.15	3243	49,800

Remarks:

PRON NOS: F6-8-A0044-02-F0-GF

This lot of smokeless propellant is hereby accepted for loading cartridges.

R. C. JOHNSON
Chief, Quality Assurance Division

SMUBO-Q Form 10 (June 66)

Incl 3

AMC PROPELLANT DESCRIPTION SHEET

(AMCR 715-509)

U. S. ARMY LOT NO. BAJ-45481 OF _____ COMPOSITION NO. WC 846 FOR 5.56 mm BALL

MANUFACTURED AT Badger Army Ammunition Plant PACKED WEIGHT 60,000 lbs.

CONTRACT NO. DA-11-173-AMC-106(A) DATE 30 April 1951 SPECIFICATION NO. MIL-P-3984D and Dwg. 10534784 REVISION OF Amendment 2 Rev. B

ACCEPTED BLENDS (Nos.) Blend of Rework NITROCELLULOSE Material

NITROGEN CONTENT	R.L. STARCH TEST (65.5° C)	STABILITY TEST (135° C)
MAXIMUM _____ % _____	MAXIMUM _____ MINS.	MAXIMUM _____ MINS.
MINIMUM _____ % _____	MINIMUM _____ MINS	MINIMUM _____ MINS.
AVERAGE _____ % _____	AVERAGE _____ MINS	AVERAGE _____ MINS.
		EXPLOSION _____ MINS.

MANUFACTURER OF PROPELLANT

TOTAL WEIGHT OF SOLVENT PER POUND NC _____ CONSISTING OF _____ POUNDS ACOHOL AND _____ POUNDS OTHER PER 100 POUND SOLVENT. PERCENTAGE OF REMIX TO WHOLE _____

TEMPS. °C. FROM	TEMPS. °C. TO	PROCESS-SOLVENT RECOVERY AND DRYING	TIME DAYS	TIME HOURS

TESTS OF FINISHED PROPELLANT

COMPOSITION CONSTITUENT	SPECS.		INSPR.	STABILITY AND PHYSICAL TESTS 120°C	REQ	INSPR.
Nitroglycerin	8.00 -	11.00	9.80	HEAT TEST, S. P. Minutes (Min)	60	65
Dinitrotoluene	1%	Max.	0.58	No EXPLOSION Hours (Min)	5	5+
Diphenylamine	.75 -	1.50	1.05	Dust&Foreign Mat. (Max)	.10	0.02
Dibutylphthalate	4.0 -	7.0	5.87	Average Web		0.014
Methylene Chloride Exc.			17.30	Graphite (Max)	.40	0.18
Nitrocellulose	Remainder		81.86	BURNING SURFACE PER POUND (sq. inches)		
TOTAL Volatiles	2.00	Max.	0.90	GRAV. DENSITY, OR POUNDS PER CU. FT.	94 - 5-1.025	0.974
MOISTURE & Volatiles	.75 -	1.25	0.85	SPECIFIC GRAVITY		
Residual Solvent	1.20	Max.	0.35	HYGROSCOPICITY		
Calcium Carbonate	1.00	Max.	0.53	Nitrogen 13.05 -	13.20	13.13
Sodium Sulfate	0.50	Max.	0.13			

GRAIN DIMENSIONS	DIE (Inches)	FINISHED GRAIN (Inches) MANUFACTURER	FINISHED GRAIN (Inches) INSPECTOR	MEAN VARIATION IN PER CENT OF MEAN DIMENSIONS MANUFACTURER	MEAN VARIATION IN PER CENT OF MEAN DIMENSIONS INSPECTOR
LENGTH (L) Granulation		Opening	Required	% Retained	
DIAMETER (D)		U. S. # 20	95 Min. thru	0.0	
DIAMETER OF PERFORATIONS (d)		# 25	90 Min.	3.1	
WEB INNER		# 30	on and	14.0	
WEB OUTER		# 35	5.0 Max.	41.2	
WEB AVERAGE		# 40	thru	39.2	
WEB CALCULATED		# 45	3.0 Max.	2.1	
DIFFERENCE BETWEEN INNER AND OUTER		Pan	thru	0.0	
WEB IN PER CENT OF WEB AVERAGE		Total		99.6	
L:D (Y)					
D:d (X)					

DATE PACKED 3-21-68 DATE OFFERED _____ DATE SAMPLED 3-21-68

DATE TEST FINISHED 3-25-68 DATE DESCRIPTION SHEETS FORWARDED 3-25-68

TYPE OF PACKING BOX Copper Lined M-24 Boxes.

REMARKS: _____

LABORATORY

SUPERINTENDENT R. J. Thiede

TECHNICAL DIRECTOR George Hogan

U. S. CHEMIST Donald E. Wahlgren

AMC FORM. 1961

APPENDIX C

TABLE C-1. Bullet Pull Test, Lots A, B, C and D

Sample No.	Lot No.			
	A (lb)	B (lb)	C (lb)	D (lb)
1	137	183	91	88
2	158	150	110	97
3	164	191	99	85
4	123	185	108	83
5	137	173	84	95
6	142	157	92	80
7	115	183	120	102
8	146	169	91	91
10	138	152	98	101
11	147	208	95	96
12	135	196	100	84
13	138	168	107	66
14	141	208	115	99
15	173	163	102	91
16	147	172	98	78
17	131	175	96	114
18	206	152	94	96
19	171	173	110	93
20	157	203	103	91
Min	115	150	84	66
Max	206	208	120	114
Avg	149	177	101	91

TABLE C-2. Bullet Pull Test, Lots A_1, B_1, C_1 and D_1

Sample No.	A_1		B_1		C_1		D_1	
	w/Collar	w/o Collar	w/Collar	w/o Collar	w/ Collar	w/o Collar	w/Collar	w/o Collar
	(lb)		(lb)		(lb)		(lb)	
1	181*	158	170	144	109	95	91	99
2	162	161	148	135	104	93	85	108
3	195	171	157	138	98	101	92	116
4	156	165*	165	170	102	113	97	101
5	163	148	159	130	101	95	85	120
6	190	171	150	162	106	103	96	97
7	178	169	182	201*	111	101	90	94
8	186	151	165	144	96	83	107	98
9	180	160	163	146	93	100	93	103
10	154	148	204	141	96	110	100	76
11	205*	168	160	143	98	103	80	100
12	181	170	189	175*	112	108	90	97
13	172	163	162	136*	103	95	105	122
14	194	157	153	169	98	115	101	98
15	139	156	191*	139	102	94	115	111
16	174	183	171	142	87	98	98	99
17	172	154	153	186	110	93	89	120
18	137	161	124	145	88	103	108	85
19	175	165	155*	136	105	121	81	91
20	177	174	171*	153	110	93	88	83
Min	137	148	124	130	87	83	80	76
Max	205	183	204	201	112	121	115	122
Avg	174	163	165	152	101	101	95	101

* small sliver of brass on case mouth

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2b. GROUP

3. REPORT TITLE

CONTRIBUTION OF THE 5.56 MM BALL M193 CARTRIDGE METAL COMPONENTS TO GAS TUBE FOULING IN THE M16A1 RIFLE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
final technical report

5. AUTHOR(S) *(First name, middle initial, last name)*

ANDREW J. GRANDY

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

A study was made of 5.56 mm Ball, M193 Cartridge metal parts and their contribution to gas tube fouling in the M16A1 rifle. Previous studies have identified calcium carbonate ($CaCO_3$) as the matrix which traps metallic debris resulting in gas tube fouling in the M16A1 rifle. It was the purpose of this study to identify the origin of the gilding metal residue found to be trapped in the $CaCO_3$ matrix. In the case of four lots of 5.56 mm Ball, M193 ammunition examined, it was found that cartridge lots associated with excessive gas tube and general weapon fouling can be characterized as having bullets with poorly formed, oversized cannelures and excessive bullet extraction forces. Cartridge lots with well made, dimensionally correct bullet cannelures with relatively low bullet extraction forces contributed little or nothing to gas tube or weapon fouling.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
5.56 mm M16A1 rifle 5.56 mm M193, Ball Cartridge gas tube fouling cannelures gilding metal bullet jacket bullet extraction force pressure-time cartridge metal components bore fouling						