DEPARTMENT OF THE ARMY
US ARMY ABERDEEN PROVING GROUND Mr. Miller/aem/283-3711
ABERDEEN PROVING GROUND, MARYLAND 21005

STEAP-MT-I

22 SEP 1976

SUBJECT: Final Letter Report for Special Study of Firing Pin Protrusion/ Misfire Relationship in the M16A1 Rifle, TECOM Project No. 8-WE-600-016-021, Report No. APG-MT-4868

Commander
US Army Frankford Arsenal
ATTN: SARFA-MDS-E
Philadelphia, PA 19137

1. REFERENCES

a. Letter, Frankford Arsenal, SARFA-MDS-E, 30 Jan 75, subject: Test Program to Determine Firing Pin Protrusion and Misfire Relationship in M16A1 Rifle, with 1st Ind, TECOM, AMSTE-IN, 12 Feb 75.

b. Letter, TECOM, AMSTE-IN, 4 Dec 75, subject: Customer Test Directive for Determination of Firing Pin Protrusion/Misfire Relationship in M16A1 Rifle, TECOM Project No. 8-WE-600-016-021.

c. MIL-R-45587A, 2 Mar 73, Military Specification for Rifle, 5.56mm: M16 and M16A1.

2. BACKGROUND

a. Frankford Arsenal requested a special study of misfires in the M16A1 rifle via reference a. Reference b assigned the study to US Army Aberdeen Proving Ground (APG).

b. A prior study was done on the dimensional relationship of maximum/ minimum tolerances in the M16A1 rifle and its ammunition which possibly contribute to occurrences of failures to fire (FFR). This study was part of a continuing effort to refine dimensioning of existing weapons, in areas where functional problems are suspected to occur. The results of the study revealed that FFR's would probably occur if: rifle headspace was at the maximum, firing pin protrusion was at the minimum, cartridge case headspace was at the maximum and the primer seating depth was maximum.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

c. The test materiel consisted of:

(1) Six M16A1 rifles each, with bolt and firing pins modified as necessary to provide five different firing-pin protrusion lengths over a ±0.004-inch (±0.1-mm) tolerance about the minimum firing pin protrusion permitted by the rifle drawings (See incl 3). Five firing pins of various lengths were modified for use with each rifle. Bolt modifications were made as necessary to provide the maximum permissible weapon headspace. Further details are discussed in this report. Three modified rifles with firing pins were designated for use with control ammunition, and the other three were designated for use with test ammunition.

(2) The special test ammunition, provided by Lake City Army Ammunition Plant, had a short head-to-shoulder dimension (1.4935 to 1.4945 inches or 37.395 to 37.960 mm) and a primer intrusion dimension tending towards the maximum allowed (0.008 inch or 0.2mm). Control ammunition was also provided from a production lot of cartridge cases, with normal variances in the two dimensions noted.

d. The purpose of the test was to determine if the M16A1 rifle could be induced to misfire by modifying weapon dimensions within tolerable limits so as to maximize the dimension between the firing-pin tip and the cartridge primer. Testing consisted of firing three each modified rifles with test and control ammunition in 120-round test cycles at conditioned temperatures of -65°F, +70°F, and +155°F (-54°C, +21°C, and +68°C), at each of the five firing-pin protrusions. In some cases where it was obvious from the results of testing already conducted that misfires related to the firing pin protrusion would not occur certain of the protrusion lengths were not tested, as noted herein. Testing (weapon modifications) was initiated on 30 Jan 76, and the test was completed on 29 Jul 76.

3. OBJECTIVE

The objective was to ascertain if misfires can occur with the M16A1 rifle due to a stack-up of dimensional tolerances in the ammunition, firing pin, bolt, and barrel assembly.

4. SUMMARY OF RESULTS

Detailed test procedures and summaries of test data are contained in inclosure 1. Test data are contained in inclosure 2. Inclosure 3 contains further details of the test materiel (rifles and ammunition) and the control ammunition.

Results are summarized as follows:

a. Only one failure to fire (FFR) occurred during the firing of test or control ammunition with the firing pin within allowable manufacturing tolerance; this occurred at the minimum allowable tolerance of 0.028 inch (0.71mm), at -65°F(-54°C) conditioned temperature, with test (i.e., short headspace) ammunition.

b. The number of FFR's occurring at the less-than-allowable firing-pin protrusions of 0.026 and 0.024 inch (0.66 and 0.61mm) increased with decreases in conditioned temperature.

c. Functional performance, including cyclic rates of the modified rifles was normal, other than for the induced FFR's.

d. The test for minimum firing-pin indent energy was passed before and after the firing test when using firing pins equal to or greater than the minimum allowable protrusion measurement.

e. The occurrence of FFR's predominated during semiautomatic (SA) fire, as compared to full-automatic (FA) fire. This was probably caused by the cartridge having more time to seat forward in the chamber during SA fire, thereby reducing the effective firing pin intrusion into the primer face to the minimum permitted by the various controlling dimensions of weapon and ammunition.

5. CONCLUSIONS

It is concluded that:

a. The overall test results show that a FFR malfunction can occur only if all unfavorable extreme dimensional variations of the rifle and ammunition are present at the same time. Elimination of one or more of these extreme conditions is sufficient to preclude the occurrence of the FFR malfunction.

b. Revision of the dimensional tolerances of the M16A1 rifle or 5.56-mm ammunition to further preclude the occurrence of FFR's does not appear to be warranted.

FOR THE COMMANDER:

Billy D. Sissom

BILLY D. SISSOM
Associate Director
Materiel Testing Directorate

4 Incl
1. Details of Test
2. Test Data
3. Dimensional Characteristics
4. Report Documentation Page

STEAP-MT-I 22 SEP 1976

SUBJECT: Final Letter Report for Special Study of Firing Pin Protrusion/ Misfire Relationship in the M16A1 Rifle, TECOM Project No. 8-WE-600-016-021, Report No. APG-MT-4868

Copies furnished:	No. of Copies
Cdr, RIA, Rock Island, IL 61201	
ATTN: SARRI-LS-P (Brunton)	2
Cdr, ARMCOM, Rock Island, IL 61201	
ATTN: DRSAR-RDG (Moore)	2
Cdr, TECOM, APG, MD 21005	
ATTN: DRSTE-IN	1
Dir, BRL, APG, MD 21005	
ATTN: DRXBR-TS-ST	2
Cdr, DDC, Alexandria, VA 22314	
ATTN; Document Service Center	1
Cdr, APG, APG, MD 21005	
ATTN: STEAP-MT-I	2
STEAP-MT-X	1

Secondary distribution is controlled by Frankford Arsenal, ATTN: SARFA-MDS-E.

DETAILS OF TEST

Firing Pin Protrusion/Misfire Relationship in the M16A1 Rifle

1. DATA ACQUISITION PROCEDURE

Prior to the start of testing, six M16A1 rifles were modified by a skilled gunsmith by machining the bolt and barrel assembly so that the headspace was at the maximum allowable. Five modified firing pins were provided for each rifle, so that the protrusion could be varied from 0.024 to 0.032 inch (0.61 to 0.81mm) in 0.002-inch (0.05-mm) increments by changing the firing pins. The six modified rifles, which were considered a homogenous sample, were separated into two groups of three, with each group dedicated to firing either test or control ammunition throughout the test.

Test ammunition consisted of a special lot of M193, 5.56-mm ball ammunition which was fabricated by Lake City Army Ammunition Plant. The cartridge cases were manufactured so that the head-to-shoulder dimension (0.3017-inch or 7.663-mm datum reference) ranged from 1.4935 to 1.4954 inches (3.7935 to 3.7960 cm). Primer intrusion depth on the test cartridges tended towards the maximum allowable (0.008 inch or 0.20mm).

In order that the particular prefiring headspace and primer intrusion measurements of any test cartridge which failed to fire during the test could be determined, all test cartridges were subjected to a 100% measurement of these dimensions, which were recorded and kept with the 20-round-magazines into which the measured test ammunition was loaded. When a FFR occurred, the relative position of the misfired cartridge in the magazine was determined, and the headspace and intrusion information could be determined from the accompanying data sheet.

A control ammunition lot was obtained from regular cartridge case production at the same time as the test ammunition.

All testing was done in an environmental test chamber at three conditioned temperatures: +155, +70, and -65°F (-54, +21, and +68°C). Testing was started at the +70°F (+21°C) temperature with each of the six rifles being fired with each of the five different firing pin protrusions. A test cycle, which was the amount of firing specified for each pin protrusion, consisted of six 20-round trials. The first trial was fired fully automatic (FA) and then alternated with semiautomatic (SA) fire every 20 rounds. Three trials were fired with each of the six rifles. Then, starting over with the first rifle fired, the remaining three trials in the cycle were fired. After completing the cycle, the rifles were disassembled, cleaned, inspected and the firing pins changed. After relubrication and reassembly, the rifles were then ready for the next cycle of testing because all maintenance was done within the test chamber.

The rifles were removed from the chamber only during changes in the temperature when firing pin indent measurements were taken prior to the start of each new temperature. Based on results of the +70°F (+21°C) temperature firings, the .032-inch and .030-inch (0.81mm and 0.76mm) protrusion pins were eliminated from the extreme-temperature testing.

Performance of the rifles was monitored throughout testing. Cyclic rate of fire data were recorded for all FA trials.

Firing pin protrusion is not the only (or necessarily the best) measure of the predisposition of a rifle to fire a cartridge. Firing-pin energy is more directly correlatable to cartridge functioning. The energy necessary to function the cartridge primer is influenced by several factors. These include the weight and velocity of the rifle hammer at time of striking the firing pin, weight of the firing pin and profile of the firing pin tip, velocity of the firing pin when striking the primer, rifle headspace, firing pin protrusion, cartridge-case headspace, primer seating depth, primer cup thickness and hardness, priming compound sensitivity (which may vary with temperature changes), primer anvil profile and location of the firing pin indent on the primer cup.

The present method of determining primer sensitivity is described in paragraph 3.4.2 of AMSMU-P 715-501FA1. Basically, it consists of a steel ball of given mass being dropped onto a firing apparatus containing a firing pin and primed cartridge case. The distance from the ball to the firing pin is varied so that the ALL-FIRE and NO-FIRE limits can be determined. This method, while satisfactory for acceptance testing of ammunition, does not provide a determination of absolute values of dynamic conditions as they vary from occasion to occasion during firing. Since no apparatus is currently available for measuring absolute energy levels of the rifle firing pin, the firing pin indent in a copper cylinder was used to compare performance of test and control rifles. For uniformity of evaluation, the location of the round in the chamber at time of firing was assumed to be fully forward, with the bolt locked and fully seated to the rear against the locking lugs of the barrel extension. This assumption is validated (at least for semi-automatic fire) by the presence of a spring-loaded ejector in the bolt face.

2. RESULTS

FFR's occurring during the test are summarized in table 1.

Table 1. FFR Stoppages Occurring During Test

Firing Pin Protrusion, In.	No. of FFR's by Conditioned Temperature, °F[a, b] Test Ammunition +155	+70	-65	Total	Control Ammunition +155	+70	-65	Total
0.032	[c]–	0	[c]–	0	[c]–	0	[c]–	0
.030	[c]–	0	[c]–	0	[c]–	0	[c]–	0
[d].028	0	0	1	1	0	0	0	0
.026	0	1	8	9	0	0	1	1
.024	4	15	51	70	0	1	4	5
Totals	4	16	60	80	0	1	5	6

[a]Test and control ammunition was fired according to the same test schedule, with a separate group of three rifles being used for each ammunition type.
[b]Each data point represents 360 rounds fired.
[c]Indicates testing was not performed.
[d]Minimum allowable rifle firing pin protrusion.

Each of the FFR rounds was radiographed. Review of the radiographs did not indicate the presence of any detectable abnormalities. The next step in evaluation was to measure cartridge headspace, primer seating depth and firing pin indent of each of the FFR rounds. These data were compared with data taken before firing. A summary of the results is given in table 2. Details are contained in inclosure 2.

Table 2. Summary of Cartridge Headspace, Primer Seating Depth, and Firing Pin Intrusion Data for Test and Control Ammunition

Rifle Serial No.	Test Temp., °F	Firing Pin Protrusion, Inches	Average Before-Firing Measurements, Inches: Ctg Case Headspace	Primer Seating Depth	Firing Pin Intrusion Into Primer Cup, Inches: No. FFR's	Type of Measurements: Computed[a] Intrusion	Actual Intrusion: Max.	Min	Avg
		Rifles	Firing Test Ammunition						
5064358	+70	0.032	1.4939	0.0061	0	0.014	-	-	-
		.030	1.4940	.0061	0	.012	-	-	-
		.028	1.4939	.0060	0	.010	-	-	-
		.026	1.4940	.0061	0	.008	-	-	-
		.024	1.4940	.0060	2	.006	0.009	0.006	0.008
	Overall avg	-	1.4940	.0061		-	-	-	-
	+155	.028	1.4943	.0076	0	.009	-	-	-
		.026	1.4942	.0080	0	.006	-	-	-
		.024	1.4940	.0066	2	.005	.007	.005	.006
	Overall avg	-	1.4942	.0074		-	-	-	-
	-65	.028	1.4942	.0064	0	.010	-	-	-
		.026	1.4940	.0069	1	.007	-	-	.009
		.024	1.4940	.0072	13	.005	.008	.006	.007
	Overall avg	-	1.4941	.0068		-	-	-	-
5077888	+70	.032	1.4941	.0054	0	.015	-	-	-
		.030	1.4941	.0060	0	.012	-	-	-
		.028	1.4942	.0060	0	.010	-	-	-
		.026	1.4942	.0062	0	.008	-	-	-
		.024	1.4942	.0062	2	.006	.009	.007	.008
	Overall avg	-	1.4942	.0060		-	-	-	-

[a]Theoretical intrusion based on relationship of rifle headspace, and case headspace and primer seating depth for a given firing pin protrusion.

Table 2. (Cont'd)

Rifle Serial No.	Test Temp., °F	Firing Pin Protrusion, Inches	Average Before-Firing Measurements, Inches: Ctg Case Headspace	Average Before-Firing Measurements, Inches: Primer Seating Depth	No. FFR's	Firing Pin Intrusion Into Primer Cup, Inches — Type of Measurements: Computed[a] Intrusion	Actual Intrusion: Max.	Actual Intrusion: Min	Actual Intrusion: Avg
		Rifles	Firing Test	Ammunition					
5077888	+155	0.028	1.4942	0.0069	0	0.009	-	-	-
		.026	1.4941	.0070	0	.007	-	-	-
		.024	1.4942	.0067	1	.006	-	-	.007
	Overall avg	-	1.4942	.0069		-	-	-	
	-65	.028	1.4942	.0068	0	.009	-	-	-
		.026	1.4943	.0072	3	.007	.009	.008	.008
		.024	1.4944	.0074	18	.005	.008	.006	.007
	Overall avg	-	1.4943	.0072		-	-	-	-
5081486	+70	.032	1.4941	.0060	0	.014			
		.030	1.4942	.0064	0	.012	-	-	-
		.028	1.4940	.0066	0	.009	-		-
		.026	1.4940	.0075	1	.006	-	-	.006
		.024	1.4941	.0067	11	.005	.009	.005	.007
	Overall avg	-	1.4941	.0066	-	-	-	-	-
	+155	.028	1.4942	.0068	0	.009			
		.026	1.4941	.0063	0	.008	-	-	-
		.024	1.4941	.0063	1	.006	-	-	.008
	Overall avg	-	1.4941	.0065	-	-	-	-	-
	-65	.028	1.4943	.0074	1	.009	-	-	.010
		.026	1.4943	.0070	4	.007	.008	.007	.008
		.024	1.4944	.0071	20	.005	.009	.007	.008
	Overall avg	-	1.4943	.0072	-	-	-	-	-

Table 2. (Cont'd)

Rifle Serial No.	Test Temp., °F	Firing Pin Protrusion, Inches	Average Before-Firing Measurements, Inches: Ctg Case Headspace	Average Before-Firing Measurements, Inches: Primer Seating Depth	No. FFR's	Firing Pin Intrusion Into Primer Cup, Inches — Type of Measurements: Computed[a] Intrusion	Actual Intrusion: Max.	Actual Intrusion: Min	Actual Intrusion: Avg
		Rifles Firing Control Ammunition							
All	All	.032	1.4973	0.0030	0	.020	-	-	-
		.030	1.4973	.0030	0	.018	-	-	-
		.028	1.4973	.0030	0	.016	-	-	-
		.026	1.4973	.0030	1	.014	-	-	.011
		.024	1.4973	.0030	4	.012	.012	.005	.010

The method of computing the theoretical firing pin intrusion into the primer is as follows:

The primer intrusion (into the cartridge case) value is subtracted from the headspace measurement (before firing) of the cartridge case which failed to fire. This value is then subtracted from the headspace of the rifle in which it was fired (taking into account as necessary the different datum diameters used in headspacing the rifles and ammunition; see inclosure 3). This dimension then represents the space between the bolt face and the primer impact surface. When the firing pin protrusion is subtracted from this value, the difference (presumably negative) represents the interference between the primer surface and the fully forward firing pin.

Cyclic rate data from the 20-round burst FA firings are summarized in table 3.

Table 3. Summary of Cyclic Rate of Fire Data

Test Temp., °F	Cyclic Rate, spm Avg	Max	Min
	Test Ammunition		
+155	875	973	807
+ 70	803	893	710
- 65	689	747	630
	Control Ammunition		
+155	873	904	829
+ 70	793	853	737
- 65	701	775	630

Table 4 gives the typical dimensions of the various regulated rifle components and ammunition used in this test. Further details of the manufacturing specifications and tolerances are contained in inclosure 3.

Table 4. Typical Values of Regulated Dimensions of Rifle Components and Ammunition

Item and Measurement	Dimensions, inches Test	Control
Rifle, firing pin protrusion	0.032	Same as test
	.030	Same as test
	[a].028	Same as test
	.026	Same as test
	.024	Same as test
[b]Rifle, headspace		
GO gage	1.506	Same as test
NO-GO gage	1.507	Same as test
Ammunition		
Case headspace	1.4940	1.4970
Primer seating depth	.006	.003

[a]Minimum protrusion allowed during manufacture.

[b]Rifle headspace measured using ammunition headspace-gage dimensions. Subtract 0.0333 inch to convert to rifle gage measurement.

Firing-pin copper-cylinder indent data are summarized in table 5. Detailed data are contained in inclosure 2.

Table 5. Firing-Pin Indent Measurements in Copper Cylinders

Firing-Pin Protrusion, in.	Copper-Cylinder Firing-Pin Indent, Inch, by M16A1 Rifle Serial No.					
	Test Rifles			Control Rifles		
	5064358	5077888	5081486	5083911	5084491	5086365
		Before Firing				
[a]0.032	0.026	0.021	0.022	0.022	0.026	0.025
[b] .032	.022	.021	.021	.022	.024	.023
[b] .030	.022	.021	.021	.021	.024	.023
[b,c] .028	.021	.020	.020	.020	.022	.021
[b] .026	.020	[d] .018	[d] .019	[d] .019	.021	.020
[b] .024	[d] .019	[d] .018	[d] .018	[d] .019	[d] .019	[d] .019
		After 1100 rounds of firing				
[a]0.032	0.025	0.021	0.022	0.022	0.025	0.024
[b,c] .028	.021	.020	.020	.020	.022	.022
[b] .026	.020	[d] .018	[d] .018	[d] .019	.020	.020
[b] .024	[d] .019	[d] .017	[d] .017	[d] .018	[d] .019	[d] .019

[a]Control firing pin and bolt (not fired during the test).
[b]Test firing pin and bolt.
[c]Minimum firing pin protrusion for rifle in production.
[d]Below 0.020 minimum indent required by reference c.

3. ANALYSIS

Examination of table 1 indicates the following:

a. Only one FFR occurred during the firing of test or control ammunition with the firing pin protrusion within allowable manufacturing tolerance; this occurred at the minimum tolerance of 0.028 inch (0.71mm), at -65°F(-54°C) conditioned temperature, with test ammunition.

b. FFR's at the less-than-allowable firing pin protrusions of 0.026 and 0.024 inch (0.066 and 0.61mm) increased with decreases in conditioned temperature.

Table 2 presents a correlation between firing pin intrusion data based on measured dimensional values of rifle and cartridge, and the actual intrusion of FFR cartridges as measured from the primer. These data indicate that the firing pin was traversing forward more nearly to its full protrusion position during the firing of test cartridges, but was not during firing of control cartridges (as was apparently caused by physical resistance of the primer).

The difference between average cyclic rates of fire for test and control rifles (table 3) was small, indicating that the effects of short firing pin protrusion, maximum rifle headspace, and the various ammunition dimensions did not have any large influence on rifle cyclic rate. Variations in cyclic rate as caused by changes in conditioned temperature were within the range normally expected for the M16A1 rifle. Functioning performance of the rifles, excluding the induced FFR malfunctions, was normal. There was a total of four malfunctions with the three test rifles and ammunition. One was charged to gunner error and three were charged to the rifle. Two malfunctions were charged to gunner error during firing of the three control rifles and ammunition. Details are given in inclosure 2.

The data in table 5 show that firing-pin indent before and after firing was equal or greater than the 0.020-inch (0.50mm) minimum required for pins within the normal manufacturing tolerance of 0.028 to 0.036 inch (0.71 to 0.91mm). Only those pins with below-minimum protrusion had out-of-specification indent values.

Examination of the detailed FFR data in inclosure 2 indicates that for the test ammunition, 55 FFR's occurred during SA fire, and 25 FFR's occurred during FA fire. For the control ammunition, five FFR's occurred during SA fire and one FFR occurred during FA fire. Testing was evenly divided between FA and SA fire. These data probably indicate that the cartridge did not always have time to seat forward in the chamber during FA fire before being struck by the firing pin.

Some minor difficulties were encountered in measuring the cartridge headspace because of the presence of raised areas of the cartridge base around the headstamp markings. The dial indication gage used was calibrated and accurate to 0.0001 inch (0.0025mm). Frequently, the maximum headspace readings were found to be near the rim of the cartridge, as the cartridge case heads were not perfectly perpendicular to the major axis (typically the headspace varied by 0.0002 or 0.0003 inch (0.005 or 0.008mm) across the base of the cartridge). The accuracy of the headspace measurement, and therefore of the primer intrusion measurement which is derived from the headspace measurement, is estimated to be 0.0002 inch (0.005mm), (two standard deviations) based upon the repeatability of the measurements. Should a need for additional manufacture of special ammunition for similar tests arise in the future, it is suggested that if possible, the headstamp markings be eliminated.

Table 1. Tabulation of FFR's by Test
Condition and Rifle No.

Temp. °F	Rifle S/N	Firing Pin Protrusion, In.	No. of FFR Stoppages in 120-Rd Firing Cycle by Magazine and Mode of Fire						
			FA	SA	FA	SA	FA	SA	Total
	Test Rifles								
+70	5064358	0.032							0
		.030							0
		.028							0
		.026							0
		.024		2					2
+155		.028							0
		.026							0
		.024		2					2
-65		.028							0
		.026						1	1
		.024		7		2		4	13
Subtotal	5064358	-	0	11	0	2		5	18
+70	5077888	.032							0
		.030							0
		.028							0
		.026							0
		.024			1			1	2
+155		.028							0
		.026							0
		.024				1			1
-65		.028							0
		.026		1				2	3
		.024	2	6	0	6	2	2	18
Subtotal	5077888	-	2	7	1	7	2	5	24

Table 1. (Cont'd)

Temp. °F	Rifle S/N	Firing Pin Protrusion, In.	No. of FFR Stoppages in 120-Rd Firing Cycle by Magazine and Mode of Fire FA	SA	FA	SA	FA	SA	Total
	Test Rifles								
+70	5081486	0.032							0
		.030							0
		.028							0
		.026				1			1
		.024		5	2	2	2		11
+155		.028							0
		.026							0
		.024						1	1
-65		.028			1				1
		.026	2					2	4
		.024	5	1		5	8	1	20
Subtotal	5081486	-	7	6	3	8	10	4	38
Total - Three test rifles			9	24	4	17	12	14	80
	Control Rifles								
+70	5083911	.032							0
		.030							0
		.028							0
		.026							0
		.024							0
+155		.028							0
		.026							0
		.024							0
-65		.028							0
		.026		1					1
		.024	1	1		1		1	4
Subtotal	5083911	-	1	2	0	1	0	1	5

Table 1. (Cont'd)

Temp. °F	Rifle S/N	Firing Pin Protrusion, In.	No. of FFR Stoppages in 120-Rd Firing Cycle by Magazine and Mode of Fire FA	SA	FA	SA	FA	SA	Total
+70	5084491	0.032							0
		.030							0
		.028							0
		.026							0
		.024							0
+155		.028							0
		.026							0
		.024							0
-65		.028							0
		.026							0
		.024							0
Subtotal	5084491	-	0	0	0	0	0	0	0
+70	5086365	.032							0
		.030							0
		.028							0
		.026							0
		.024		1					1
-65		.028							0
		.026							0
		.024							0
Subtotal	5086365	-	0	1	0	0	0	0	1
3 - Control Rifle Total			1	3	0	1	0	1	6

SA - Semiautomatic Fire
FA - Full Automatic Fire

Table 2. Summary of FFR's by Test and Control Rifles

	Test						Control					
	5064358		5077888		5081486		5083911		5084491		5086365	
Temp. °F	SA	FA	SA	FA	SA	FA	SA	FA	SA	FA	SA	FA
					0.028-inch firing pin protrusion							
+155												
+70												
-65						1						
Subtotal	0	0	0	0	0	1	0	0	0	0	0	0
					.026-inch firing pin protrusion							
+155												
+70					1							
-65	1		3		2	2	1					
Subtotal	1	0	3	0	3	2	1	0	0	0	0	0
					.024-inch firing pin protrusion							
+155	2		1		1							
+70	2		1	1	7	4					1	
-65	13		14	4	7	13	3	1				
Subtotal	17	0	16	5	15	17	3	1	0	0	1	0
Total	18	0	19	5	18	20	4	1	0	0	1	0

Table 3. Functioning Performance of M16A1 Rifles, Exclusive of FFR Stoppages

Rifle S/N	Test Temp. °F	Malf. Type	Cycle No.	Rd. of Occurrence Mag.	Cycle	Test	Mode of Fire	Charged to
Test Rifles and Ammunition								
5064358	+70	FBR	3	20	100	340	FA	Rifle
5077888	+155	BOB	7	7	47	767	FA	Rifle
		FFS	8	3	23	863	SA	Pers.
		FCDR	8	5	45	885	FA	Rifle
Control Rifles and Ammunition								
5083911	+155	FFS	7	3	23	743	SA	Pers.
5084491	+70	FFA	2	1	41	161	FA	Pers.

FBR - Failure of bolt to remain to rear after last round from magazine has been fired.

BOB - Bolt override of base of cartridge case (a type of feeding failure).

FCDR - Failure to chamber a round damaged during funding (a type of feeding failure).

FFS - Failure to fire rifle seimautomatically.

FFA - Failure to fire rifle automatically.

Table 4. Cyclic Rate of Fire Data for 20-Round Bursts, spm

Test Temp. °F	Firing Cycle No.	M16A1 Rifle Serial No.					
		Test			Control		
		5064358	5077888	5081486	5083911	5084491	5086365
+155	6	847	891	825	836	869	863
		883	913	883	863	895	897
		877	912	829	851	883	883
	7	863	904	824	829	873	851
		973	[a]908	857	863	904	883
		873	[a]933	832	855	897	887
			926				
	8	853	899	807	836	883	861
		871	[a]857	857	863	904	887
		887	[a]917	820	863	904	883
			926				
Avg	6 - 8	881	908	837	851	890	877
+70	1	731	793	710	737	762	752
		749	847	762	762	813	780
		743	834	749	752	803	770
	2	775	856	767	791	827	811
		811	869	773	791	844	836
		775	844	755	753	801	791
	3	815	836	788	778	840	815
		825	864	761	762	853	813
		788	825	756	741	791	770
	4	818	873	794	832	849	820
		834	893	808	801	838	791
		786	844	752	776	791	762
	5	[a]867	851	784	773	816	781
		[a] –	[a]832	[a]764	780	808	788
		799	[a]866	[a]775	762	791	767
		775	851	[b]738			
				[b]799			
				[b]799			
Avg	1 - 5	792	849	768	773	815	790

spm - shots per minute

[a,b] These rates in a cycle total 20 rounds of firing.
[c] No rate recorded.

Table 4. (Cont'd)

Test Temp. °F	Firing Cycle No.	M16A1 Rifle Serial No. Test 5064358	5077888	5081486	Control 5083911	5084491	5086365
-65	9	686	716	670	630	744	682
		730	723	[a]677	705	744	716
		708	703	[a]689	679	706	690
				663			
	10	[c]–	673	[a]621	658	730	684
		747	726	[a]638	695	775	744
		710	694	[a]662	666	726	698
				693			
				684			
	11	[c]–	666	[c]–	638	715	706
		690	642	[c]–	684	719	717
		705	668	[c]–	673	707	690
Avg		711	690	666	670	730	703

Table 5. Firing Pin Indent Measurements in Copper Cylinders, Using Gage No. 8440219(A)[a]

Rifle S/N	Cumulative No. of Rds Fired	Measurement No.	Firing Pin Indent, inches, by Firing Pin Protrusion, inches					
			0.032[b]	0.032	0.030	0.028	0.026	0.024
			Test Rifles					
5064358	0	1	0.025	0.022	0.023	0.021	0.020	0.019
		2	.026	.022	.022	.021	.020	.019
		3	.026	.023	.022	.021	.020	.019
		Avg	.026	.022	.022	.021	.020	.019
	600	1	.025	-	-	.022	.020	.018
		2	.025	-	-	.021	.020	.019
		3	.025	-	-	.021	.020	.020
		Avg	.025	-	-	.021	.020	.019
	960	1	.025	-	-	.021	.020	.018
		2	.025	-	-	.021	.020	.019
		3	.025	-	-	.021	.020	.019
		Avg	.025	-	-	.021	.020	.019
	1100	1	.025	-	-	.021	.020	.019
		2	.025	-	-	.021	.020	.019
		3	.025	-	-	.021	.020	.019
		Avg	.025	-	-	.021	.020	.019
5077888	0	1	.022	.021	.020	.020	.018	.017
		2	.021	.021	.021	.020	.019	.019
		3	.021	.021	.021	.020	.018	.018
		Avg	.021	.021	.021	.020	.018	.018
	600	1	.021	-	-	.020	.019	.016
		2	.021	-	-	.020	.019	.018
		3	.021	-	-	.020	.020	.018
		Avg	.021	-	-	.020	.019	.017
	960	1	.021	-	-	.020	.019	.017
		2	.021	-	-	.020	.020	.017
		3	.021	-	-	.020	.019	.017
		Avg	.021	-	-	.020	.019	.017
	1100	1	.021	-	-	.020	.018	.018
		2	.021	-	-	.020	.018	.017
		3	.021	-	-	.021	.018	.017
		Avg	.021	-	-	.020	.018	.017

Table 5. (Cont'd)

Rifle S/N	Cumulative No. of Rds Fired	Measurement No.	Firing Pin Indent, inches, by Firing Pin Protrusion, inches					
			0.032[b]	0.032	0.030	0.028	0.026	0.024
			Test Rifles					
5081486	0	1	0.022	0.021	0.021	0.020	0.018	0.018
		2	.023	.021	.021	.020	.019	.018
		3	.022	.021	.021	.021	.019	.018
		Avg	.022	.021	.021	.020	.019	.018
	600	1	.022	-	-	.020	.018	.018
		2	.022	-	-	.020	.018	.018
		3	.022	-	-	.020	.018	.018
		Avg	.022	-	-	.020	.018	.018
	960	1	.023	-	-	.020	.018	.017
		2	.022	-	-	.020	.018	.018
		3	.022	-	-	.020	.018	.018
		Avg	.022	-	-	.020	.018	.018
	1100	1	.022	-	-	.020	.018	.017
		2	.022	-	-	.020	.017	.017
		3	.022	-	-	.021	.019	.017
		Avg	.022	-	-	.020	.018	.017
			Control Rifles					
5083911	0	1	.022	.022	.021	.020	.019	.019
		2	.022	.022	.021	.020	.019	.019
		3	.022	.022	.021	.020	.020	.018
		Avg	.022	.022	.021	.020	.019	.019
	600	1	.021	-	-	.021	.020	.020
		2	.022	-	-	.020	.020	.019
		3	.021	-	-	.020	.020	.018
		Avg	.021	-	-	.020	.020	.019
	960	1	.021	-	-	.020	.020	.018
		2	.021	-	-	.020	.019	.018
		3	.022	-	-	.020	.019	.018
		Avg	.021	-	-	.020	.019	.018
	1100	1	.022	-	-	.020	.019	.018
		2	.022	-	-	.020	.019	.018
		3	.022	-	-	.020	.019	.018
		Avg	.022	-	-	.020	.019	.018

Table 5. (Cont'd)

Rifle S/N	Cumulative No. of Rds Fired	Measurement No.	Firing Pin Indent, inches, by Firing Pin Protrusion, inches 0.032[b]	0.032	0.030	0.028	0.026	0.024
					Control	Rifles		
5084491	0	1	0.026	0.023	0.023	0.022	0.020	0.019
		2	.026	.024	.024	.022	.021	.019
		3	.025	.024	.024	.022	.023	.019
		Avg	.026	.024	.024	.022	.021	.019
	600	1	.026	-	-	.022	.021	.020
		2	.026	-	-	.022	.020	.020
		3	.025	-	-	.022	.021	.020
		Avg	.026	-	-	.022	.021	.020
	960	1	.025	-	-	.022	.021	.020
		2	.025	-	-	.021	.021	.019
		3	.025	-	-	.022	.020	.019
		Avg	.025	-	-	.022	.021	.019
	1100	1	.025	-	-	.022	.020	.019
		2	.025	-	-	.022	.020	.019
		3	.025	-	-	.022	.020	.019
		Avg	.025	-	-	.022	.020	.019
5086365	0	1	.025	.023	.023	.021	.020	.019
		2	.026	.023	.023	.021	.020	.019
		3	.025	.023	.023	.021	.021	.019
		Avg	.025	.023	.023	.021	.020	.019
	600	1	.025	-	-	.022	.020	.019
		2	.025	-	-	.021	.021	.019
		3	.026	-	-	.021	.021	.019
		Avg	.025	-	-	.021	.021	.019
	960	1	.025	-	-	.021	.020	.019
		2	.025	-	-	.020	.020	.019
		3	.025	-	-	.021	.020	.019
		Avg	.025	-	-	.021	.020	.019
	1100	1	.024	-	-	.022	.020	.019
		2	.024	-	-	.022	.020	.019
		3	.024	-	-	.022	.020	.019
		Avg	.024	-	-	.022	.020	.019

[a]There are two gages used for firing pin indent in copper cylinders: Gage No. 8440219(A) is used for recording indents caused by hammer fall on the firing pin with the bolt in the locked position. This is the gage used in this test. The other gage, No. 8440220(A) is used to record inertia indent of the firing pin caused by releasing the bolt from the bolt stop position onto a chambered round. This gage was not used in this test.

[b]Control firing pin and standard bolt. All others were test firing pins, and bolts modified to produce maximum headspace.

TABLE 6. PHYSICAL CHARACTERISTICS OF FFR CARTRIDGES

Test Temp, °F	Rifle S/N	Rifle Measurements, Inches: Headspace[a]	Firing Pin: Protrusion	Firing Pin: Indent	Ctg No.	Ammunition Measurements, Inches — Before Firing Attempt: Headspace	Before Firing Attempt: Primer Seating Depth	After Firing Attempt: Headspace	After Firing Attempt: Primer Measurements: Seating Depth	After Firing Attempt: Primer Measurements: Indent
		Test Rifles and Ammunition								
+155	5064358	1.507	0.024	0.019	872	1.4944	0.0073	1.4925	0.0080	0.005
					877	1.4943	.0074	1.4918	.0074	.007
	5077888	1.506	.024	.017	916	1.4940	.0079	1.4926	.0075	.007
	5081486	1.506	.024	.018	947	1.4937	.0069	1.4927	.0068	.008
+70	5064358	1.507	.024	.019	497	1.4935	.0062	1.4926	.0062	.009
					510	1.4943	.0063	1.4931	.0077	.009
					512	1.4938	.0066	1.4929	.0059	.009
					536	1.4941	.0064	1.4924	.0063	.006
	5077888	1.506	.024	.018	524	1.4938	.0060	1.4925	.0062	.007
					587	1.4945	.0063	1.4931	.0057	.009
	5081486	1.506	.026	.018	430	1.4920	.0065	1.4918	.0078	.006
			.024		502	1.4936	.0069	1.4925	.0067	.008
					504	1.4935	.0061	1.4935	.0069	.008
					506	1.4940	.0069	1.4927	.0070	.008
					511	1.4942	.0073	1.4925	.0068	.006
					520	1.4943	.0074	1.4925	.0072	.007
					531	1.4944	.0065	1.4934	.0071	.009
					539	1.4944	.0076	1.4930	.0073	.007
					557	1.4943	.0079	1.4934	.0073	.005
					559	1.4944	.0066	1.4934	.0067	.005
					573	1.4940	.0072	1.4929	.0066	.008
					577	1.4941	.0066	1.4933	.0074	.007

[a] "No Go" gage. "Go" gage reading is 0.001-inch less. Frankford Arsenal gage type was used (0.3017-inch datum dia.).

TABLE 6. PHYSICAL CHARACTERISTICS OF FFR CARTRIDGES

Test Temp, °F	Rifle S/N	Rifle Measurements, Inches			Ctg No.	Ammunition Measurements, Inches: Before Firing Attempt		After Firing Attempt		
		Headspace	Firing Pin Protrusion	Indent		Headspace	Primer Seating Depth	Headspace	Primer Measurements Seating Depth	Primer Measurements Indent
-65	5064358	1.507	.026	.019	1200	1.4941	.0064	1.4937	.0061	.009
		1.507	.024		1222	1.4945	.0087	1.4941	.0071	.007
					1226	1.4933	.0073	1.4935	.0069	.008
					1228	1.4943	.0085	1.4927	.0073	.008
					1230	1.4938	.0083	1.4940	.0075	.008
					1234	1.4945	.0086	1.4939	.0067	.008
					1238	1.4938	.0082	1.4937	.0066	.007
					1240	1.4942	.0089	1.4931	.0074	.007
					1270	1.4934	.0062	1.4932	.0071	.008
					1277	1.4939	.0077	1.4933	.0068	.008
					1305	1.4943	.0084	1.4936	.0071	.006
					1307	1.4938	.0073	1.4935	.0071	.007
					1311	1.4945	.0073	1.4939	.0069	.006
					1318	1.4936	.0063	1.4932	.0066	.008
	5077888	1.507	.026	.017	1116	1.4945	.0083	1.4924	.0082	.009
					1194	1.4942	.0072	1.4935	.0074	.008
					1197	1.4944	.0084	1.4938	.0076	.008
			.024		1208	1.4949	.0081	1.4939	.0069	.008
					1218	1.4947	.0072	1.4940	.0071	.007
					1222	1.4945	.0073	1.4941	.0072	.006
					1224	1.4941	.0073	1.4938	.0073	.006
					1226	1.4943	.0068	1.4948	.0075	.007
					1228	1.4937	.0066	1.4933	.0074	.007
					1235	1.4949	.0082	1.4942	.0081	.008
					1236	1.4941	.0073	1.4936	.0075	.007
					1263	1.4946	.0091	1.4924	.0079	.007

TABLE 6. PHYSICAL CHARACTERISTICS OF FFR CARTRIDGES

Test Temp, °F	Rifle S/N	Rifle Measurements, Inches: Headspace	Firing Pin Protrusion	Firing Pin Indent	Ctg No.	Before Firing Attempt: Headspace	Before Firing Attempt: Primer Seating Depth	After Firing Attempt: Headspace	After Firing Attempt: Primer Seating Depth	After Firing Attempt: Primer Indent
					1270	1.4943	.0076	1.4928	.0066	.007
					1271	1.4941	.0075	1.4938	.0077	.006
					1272	1.4945	.0073	1.4934	.0077	.006
					1274	1.4947	.0081	1.4932	.0079	.007
					1278	1.4937	.0076	1.4943	.0075	.007
					1281	1.4939	.0073	1.4932	.0072	.007
					1282	1.4949	.0084	1.4944	.0075	.007
					1302	1.4944	.0077	1.4934	.0069	.007
					1308	1.4946	.0078	1.4936	.0071	.006
-65	5081486	1.507	.028	.018	1012	1.4943	.0065	1.4936	.0080	.010
			.026		1088	1.4941	.0077	1.4934	.0089	.008
					1093	1.4937	.0070	1.4928	.0093	.008
					1190	1.4940	.0069	1.4933	.0081	.008
					1192	1.4940	.0078	1.4940	.0078	.007
			.024		1206	1.4944	.0074	1.4937	.0066	.008
					1209	1.4945	.0070	1.4941	.0074	.009
					1212	1.4949	.0076	1.4935	.0067	.009
					1214	1.4943	.0074	1.4937	.0072	.007
					1216	1.4944	.0073	1.4930	.0065	.007
					1237	1.4948	.0080	1.4940	.0070	.007
					1268	1.4940	.0063	1.4934	.0060	.008
					1271	1.4945	.0058	1.4933	.0054	.009
					1275	1.4940	.0066	1.4932	.0064	.008
					1277	1.4947	.0069	1.4935	.0063	.008
					1278	1.4946	.0067	1.4934	.0070	.007
					1283	1.4941	.0069	1.4938	.0074	.007
					1288	1.4944	.0076	1.4940	.0075	.008

TABLE 6. PHYSICAL CHARACTERISTICS OF FFR CARTRIDGES

Test Temp, °F	Rifle S/N	Rifle Measurements, Inches			Ctg No.	Ammunition Measurements, Inches				
			Firing Pin			Before Firing Attempt		After Firing Attempt		
							Primer Seating		Primer Measurements	
		Headspace	Protrusion	Indent		Headspace	Depth	Headspace	Seating Depth	Indent
					1289	1.4949	.0084	1.4939	.0069	.008
					1291	1.4945	.0079	1.4938	.0074	.007
					1294	1.4949	.0067	1.4945	.0068	.008
					1297	1.4940	.0071	1.4933	.0072	.007
					1298	1.4943	.0076	1.4929	.0063	.009
					1299	1.4949	.0081	1.4934	.0073	.007
					1320	1.4948	.0071	1.4940	.0065	.009
		Control Rifles and Ammunition								
+70	5086365	1.507	.024	.019	515	-	-	1.4955	.0071	.005
-65	5083911	1.507	.026	.019	1105	-	-	1.4939	.0044	.011
			.024	.018	1201	-	-	1.4967	.0029	.009
					1234	-	-	1.4963	.0038	.012
					1261	-	-	1.4957	.0026	.011
					1303	-	-	1.4971	.0038	.011

DIMENSIONAL CHARACTERISTICS
OF STANDARD M16A1 RIFLES AND 5.56-MM CARTRIDGE CASES

The tolerable dimensional variations of components of rifles and ammunition which influence FFR-type stoppages were taken from the drawings of those items and are shown in the following figures and tables. The hammer spring (Dwg 8448611) for the rifle (which is not shown) can also contribute to FFRs should the radial torsion type spring weaken (i.e., falls below 6.0 lb/in. (10.5 N/cm) within the range of $170^{\circ} \pm 14^{\circ}$ from an untorqued position.

Figure 1 and table 1 illustrate the important headspace dimensions of the M16A1 rifle barrel-bolt interface using, and comparing, the results obtained with rifle and ammunition headspace gages. Firing pin length is presented in figure 2 and table 2. Figure 3 and table 3 give these data on the bolt body and extractor. Figure 4 and table 4 present the characteristics on the 5.56-mm cartridge case.

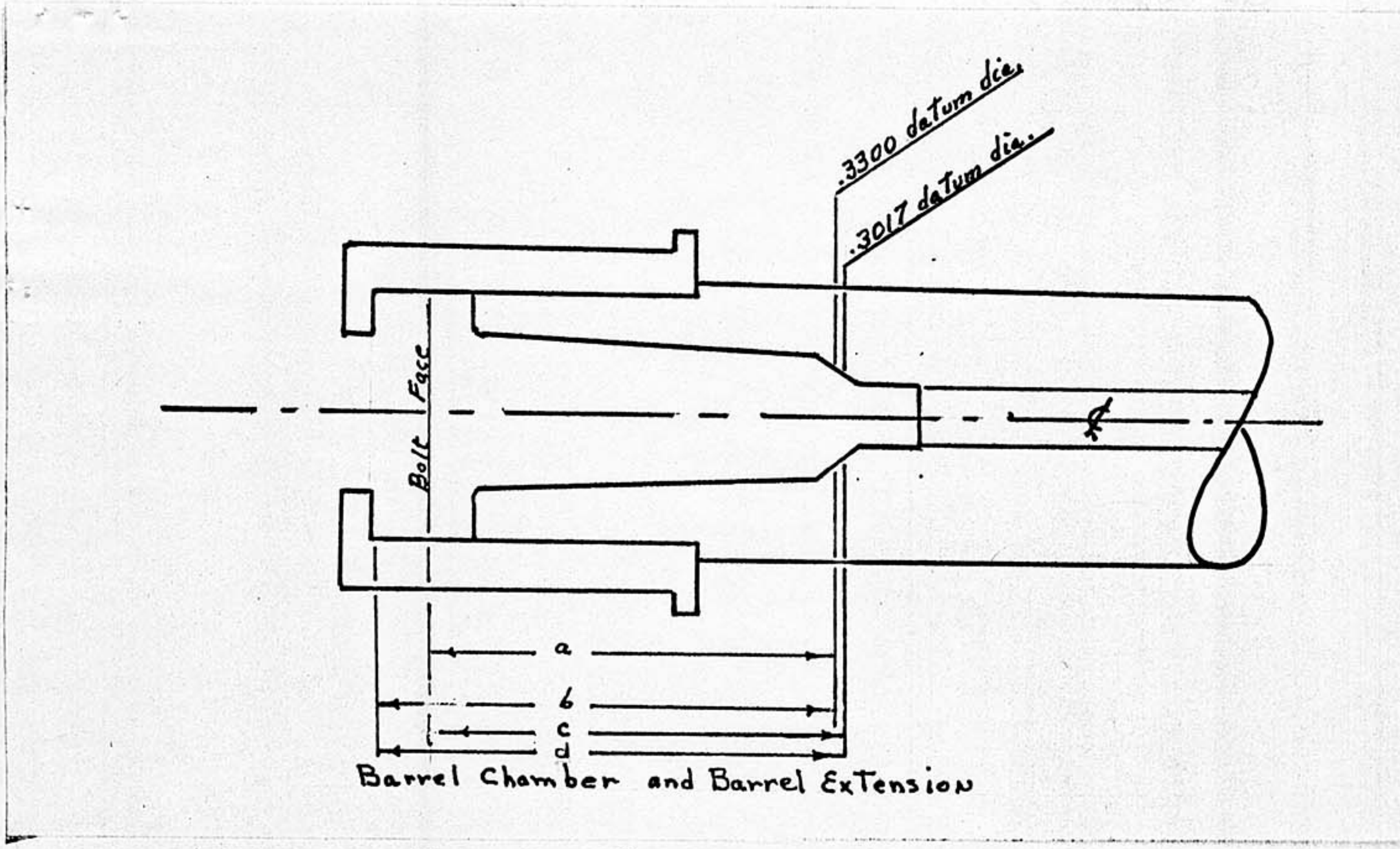

Figure 1: M16A1 Rifle Barrel Assembly
(Ref Drawing No. 8448649 and 10524200)

TABLE 1. CONTROLLING DIMENSION LIMITS OF HEADSPACE USING WEAPON AND AMMUNITION DATUM DIAMETER REFERENCE POINTS[a]

	Measurement, Inches				
			Range		
Dimension	Basic	Tolerance	Lower	Upper	Type Of Headspace Gage Used
a	1.4646	+0.006	1.4646	1.4706	Rifle
b	1.6206	+ .003	1.6206	1.6236	Rifle
c	1.4979	+ .006	1.4979	1.5039	Ammunition
d	1.6539	+ .003	1.6539	1.6542	Ammunition

[a]Datum diameter is 0.3300 inch for weapon chamber and 0.3017 inch for cartridge case. To convert weapon headspace measurement to ammunition dimensioning, add 0.0333 inch.

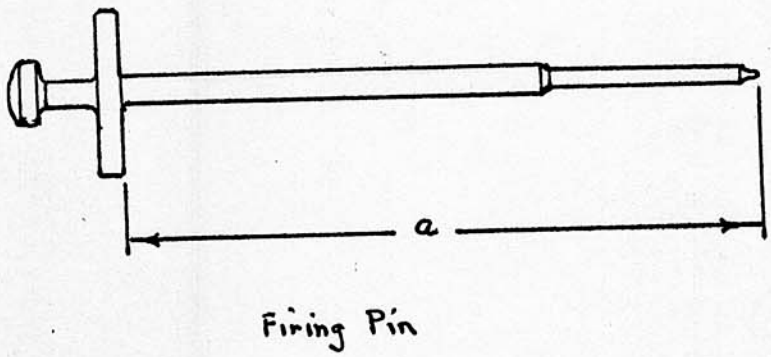

Figure 2: M16A1 Rifle Firing Pin
(Drawing No. 8448503)

TABLE 2. CONTROLLING DIMENSION LIMITS
OF FIRING PIN PROTRUSION

	Measurement, Inches			
			Range	
Dimension	Basic	Tolerance	Lower	Upper
a	2.707	±0.002	2.705	2.709

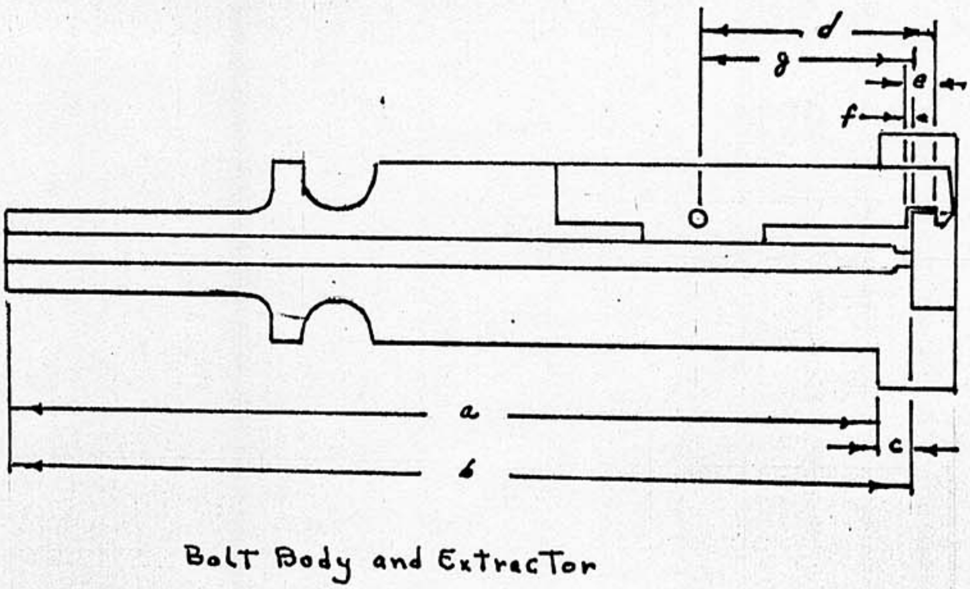

Figure 3. M16A1 Rifle Bolt Body and Extractor
(Ref Drawing No. 8448510 and 8448512)

TABLE 3. CONTROLLING DIMENSION LIMITS OF
HEADSPACE AND CARTRIDGE POSITIONING

Dimension	Measurement, Inches: Basic	Tolerance	Range: Lower	Upper	Measured Item
a	[a]-	[a]-	2.524	2.519	Bolt
b	2.675	±0.002	2.677	2.673	Bolt
c	.156	- .003	.156	.153	Bolt
d	.719	± .002	.717	.721	Extractor
e	.064	± .002	.062	.066	Extractor
f	[a]-	[a]-	.004	.016	Bolt/Extractor
g	.665	± .002	.663	.667	Bolt

[a]Not given directly on the drawing. The dimensional range was computed based on limits specified in the drawings.

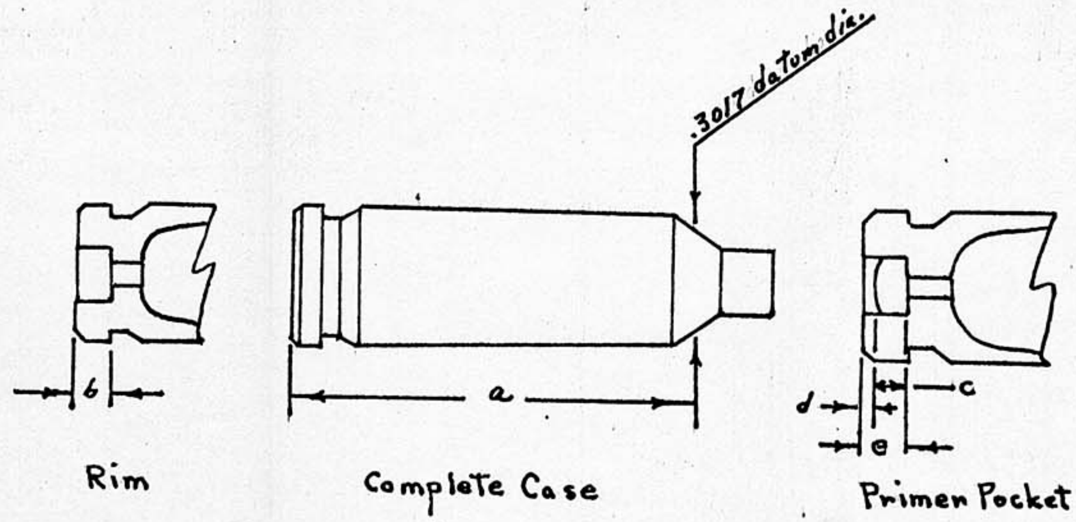

Figure 4: 5.56-MM Cartridge Case and Primer Assembly
(Drawing No. 10524200, 10534013 and 10523632)

TABLE 4. CONTROLLING DIMENSION LIMITS OF HEADSPACE AND PRIMER SEATING DEPTH

Dimension	Measurement, Inches: Basic	Tolerance	Range: Lower	Upper	Description Of Measurement
	Standard (Control) Cartridge Cases				
a	1.500	-0.006	1.494	1.500	Case Headspace (Ammunition Gage)
b	.045	- .007	.038	.045	Rim Thickness
c	.000	- .008	.000	.008	Primer Height
d	.008	- .008	.000	.008	Primer Seating Depth
e	.118	+ .004	.118	.122	Primer Pocket Depth
	Test Ammunition (Where Different)				
a	-	-	1.4935	1.4945	
d	-	-	[a] -	.008	

[a] Primer seating depth tended towards the maximum in the test ammunition.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER TECOM Project No. 8-WE-600-016-021	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Final Report of Special Study of Firing Pin Protrusion/Misfire Relationship in M16A1 Rifle, TECOM Project No. 8-WE-600-016-021	5. TYPE OF REPORT & PERIOD COVERED Final Letter Report, 30 January 1976 to 29 July 1976
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Franklin H. Miller	8. CONTRACT OR GRANT NUMBER(s) None
9. PERFORMING ORGANIZATION NAME AND ADDRESS Materiel Testing Directorate Aberdeen Proving Ground, MD 21005 ATTN: STEAP-MT-I	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS None
11. CONTROLLING OFFICE NAME AND ADDRESS Commander Frankford Arsenal Philadelphia, PA 19137 ATTN: SARFA-MDS-E	12. REPORT DATE September 1976
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) None	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U.S. Government Agencies only, Test and Evaluation; September 1976. Other requests for this document must be referred to Frankford Arsenal, ATTN: SARFA-MDS-E.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

None

18. SUPPLEMENTARY NOTES

None

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

M16A1 rifle, misfires
5.56-mm ammunition, misfires
Firing pin protrusion, rifle misfires
Primer sensitivity, 5.56-mm ammunition
Misfires, rifle, M16A1
Rifle, M16A1, misfires

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

The special study of the firing pin protrusion/misfire relationship of the M16A1 rifle was conducted at US Army Aberdeen Proving Ground, Maryland, from 30 January to 29 July 1976. Six M16A1 rifles were modified so that the weapon headspace was at the maximum permitted by the engineering drawings, and five firing pins for each weapon were each modified so that the firing pin protrusion varied about the minimum specification value in increments of 0.002 inch (0.05 mm). Test ammunition, which had the headspace at the minimum allowable

value and primer intrusion near the maximum value, was fired in three of the weapons, and control ammunition with cases from a regular production lot was fired in the other three rifles. Each rifle fired 360 rounds with each of the five firing pins, at conditioned temperatures of -65, +70, and +155°F (-54, +21, and 68°C). Only one failure to fire (FFR) occurred during the firing of test or control ammunition with the firing pin within allowable manufacturing tolerance; this occured at the minimum allowable tolerance of 0.028 inch (0.71 mm), at -65°F (-54°C) conditioned temperature, with test (i.e., short-headspace) ammunition. FFRs occurring at the less than allowable firing pin protrusion of 0.026 and 0.024 inches (0.066 and 0.061 mm) increased with decreases in conditioned temperature. Functional performance, including cyclic rates, of the modified rifles was normal, other than for the induced FFRs. It was concluded that the overall test results show that a FFR malfunction can occur only if all unfavorable extreme dimensional variations of the rifle and ammunition are present at the same time (elimination of one or more of these extreme conditions is sufficient to preclude the occurrence of the FFR malfunction); revision of the dimensional tolerances of the M16A1 rifle or 5.56-mm ammunition to further preclude the occurrence of FFRs does not appear to be warranted.