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TECHNICAL REPORT NO. 4

RELIABILITY CHARACTERISTICS OF THE M16A1 AND M14 RIFLE SYSTEMS AT LOW TEMPERATURES

by

Weldon F. Willoughby

December 1969

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ABERDEEN PROVING GROUND, MARYLAND

A B E R D E E N R E S E A R C H A N D D E V E L O P M E N T C E N T E R

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Surveillance and Reliability Division

AMCMS Code 2270.1031

A B E R D E E N P R O V I N G G R O U N D, M A R Y L A N D

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ABSTRACT

A special study has been conducted to evaluate the reliability characteristics of the M16A1 Rifle System at low temperatures. Since no standards for reliability at low temperatures are available this study included the firing of a special test, with parallel tests of the M14 Rifle System to provide a basis for comparison. The test was statistically designed, thereby enabling the effects of several factors and their interactions to be studied simultaneously and on a sound technical basis. The factors of prime interest were differences among individual rifles, between rifle types, ammunition mixes, among M16A1 Rifle producers, temperatures, readiness states, and modes of fire. This report presents a summary of the results of this study.

TABLE OF CONTENTS

SUMMARY OF PRINCIPLE FINDINGS

The results of this study indicate the following:

(1) Under the conditions of this test, the M16A1 Rifles had a significantly lower overall malfunction rate than did the M14 Rifles.

(2) Due to significant interactions of effects, this condition was not consistent at all levels of some factors, particularly ammunition mix and temperature.

(3) In general, the M16A1 Rifles performed better when firing all ball rounds while the M14 Rifles performed better when firing the mix of four ball rounds to one tracer round.

(4) Under the temperature conditions studied, both the M16A1 and M14 Rifles malfunctioned less frequently after conditioning with the chamber empty and the bolt closed than under the other two readiness states.

(5) Firing in short automatic bursts produced the best results overall in M16A1 Rifles and firing fully automatic produced the best results overall in M14 Rifles. These conditions, however, were not consistent from one temperature level to another.

(6) The most frequent malfunctions of the M16A1 Rifle System were: failures to lock (1.4/1000 rounds), closing on an empty chamber (1.0/1000 rounds), failures to strip (0.9/1000 rounds), and incidents of the bolt catch stopping the forward movement of the bolt before the last round of a magazine was fired (0.9/1000 rounds). Appropriate actions to correct these malfunctions, when they occur in the field, could be simple and quick.

(7) The most frequent malfunctions of the M14 Rifle System by far were: Closing on an empty chamber (4.0/1000 rounds), and incidents of the bolt overriding the base of the cartridge case (2.4/1000 rounds). The latter type of malfunction, when it occurs in the field, may, in some cases, be difficult to correct.

(8) Both the M16A1 rifle and the M14 rifle reliability is degraded appreciably at temperatures of -20°F and lower.

(9) The probability of a malfunction of a randomly selected M16A1 or M14 Rifle, assuming that the rifle is in a condition as good as new (or relatively new), has been cleaned and lubricated at least every 500 rounds, and is used after exposure to given low temperatures with the chamber empty and the bolt closed (this readiness state gave the best results of those tested), is given in the following table in terms of the predicted number of malfunctions per 1000 rounds fired.

Temperature (T)	Predicted No. Malf/1000 rds/ conditioning w/ chamber empty - bolt closed at temp T	
	M16A1 Rifle System	M14 Rifle System
0°F	0.34	1.05
-20°F	5.10	10.08
-40°F	8.46	15.54

From this table, it can be seen that the chance of a malfunction of an M16A1 Rifle, selected at random from the stockpile and carried in readiness with the chamber empty and the bolt closed, is less than that for an M14 Rifle selected at random and used in the same readiness state at each of the three temperatures.

(10) For a rough comparison of the reliability of these rifles at cold temperature with their performance at ambient temperatures of approximately +70°F, the following table is furnished. It is stressed that the table is furnished only for a rough comparison since: (a) there has been an improvement in the reliability of M16A1 Rifles since

the data from field tests (troop training) and the WSEG Study were obtained and (b) some conditions of the tests conducted at ambient temperatures are not directly comparable with those at low temperatures.

Estimated Reliability (in malf./1000 rounds)		
Type of Test	M16 Rifle System	M14 Rifle System
	Point Estimate	Point Estimate
Acceptance	0.33	-
Field** (Troop Tng)	0.44	-
WSEG**	3.38	1.40

**From ARDC Technical Report No. 1.

INTRODUCTION

At the Fifth Meeting of the AMC M16 Rifle Steering Group, at Frankford Arsenal on 11 and 12 February 1969, discussions were held on the cold temperature reliability characteristics of the M16/M16A1 Rifle System. In these discussions, it was agreed that efforts should be made to assess the functioning reliability of the system in its present configuration throughout the range of cold temperatures of areas in which troops armed with these rifles were likely to be deployed. The lower limit of this temperature range was not expected to be less than -40°F.

At the request of the Project Manager - Rifles, the Surveillance and Reliability Division (SRD) of the Aberdeen Research and Development Center (ARDC) conducted a study of existing test data and information on the functioning reliability of the M16A1 Rifle at low temperatures. There was a sparcity of data available on low temperature tests of the system and when data was available, comparisons of results in reports reviewed had to be made with caution due to differences in methodology from test to test. Following the study, a special test of the system, employing methodology and test procedures proposed by SRD, was initiated.

The special test was designed to provide data from which the effects of several factors and their interactions could be studied simultaneously and on a sound technical basis. These factors included differences among individual rifles, between rifle types, ammunition mixes, among M16A1 Rifle producers, temperatures, rifle readiness states, and modes of fire. To provide a basis for comparison, parallel tests of the M14 Rifle System were also conducted.

The experiment was designed using a Five-Way Classification model with fixed effects (Model I). The tests were conducted in the cold temperature chambers of the Materiel Test Directorate (MTD), U. S. Army Test and Evaluation Command (TECOM), Aberdeen Proving Ground, Maryland.

TEST PROCEDURE

Six rifles and 30 magazines (20 round capacity) were randomly selected from recent production at each of the three M16A1 Rifle producers (Colts, General Motors, and Harrington and Richardson). Six relatively new M14 Rifles and 30 magazines (20 round capacity) were also selected. The rifles were divided into two groups, one of which would fire all ball rounds during the test and the other would fire a mix in which the ratio of ball rounds to tracer rounds was four to one, the first, sixth, eleventh and sixteenth rounds fired from the magazines being tracer rounds.

The ball ammunition fired in the M16A1 Rifles were from three different lots of M193 Cartridges (one lot each produced by Lake City, Remington Arms and Twin Cities), loaded with ball propellant and the tracer ammunition was from one lot of M196 Cartridge produced by Lake City and loaded with IMR propellant. The ball ammunition fired in the M14 Rifles was from one lot of M80 Cartridges produced by Twin Cities and loaded with ball propellant; the tracer ammunition was from one lot of M62 Cartridges produced by Lake City and loaded with ball propellant. Five magazines, from the same producer as the rifle, were used with individual rifles. Once magazines were selected for use with a particular rifle, they were used only with that rifle throughout the test.

The rifles were tested at three different temperature levels: 0°F, -20°F and -40°F. Prior to the initiation of testing, each rifle was thoroughly cleaned to remove all lubricants and rust preventative compounds. Before the initial test phase and at random schedules of 100, 200, 300, 400 or 500 round intervals, rifles were cleaned and lubricated with the lubricant appropriate for the temperature at which they were to be conditioned and fired, i.e. Semi-Fluid Lubricating Oil (LSA) for firings at 0°F and -20°F and Weapons Oil, Lubricating (LAW) for firings at -40°F.

Three rifle readiness states were employed in the test: chamber empty - bolt open, chamber empty - bolt closed, and a round in the chamber - bolt closed. The rifles, magazines and ammunition were conditioned at the appropriate temperature in the designated readiness state for a period of not less than six hours prior to firing 100 round sequences (five magazines of 20 rounds each) in one of three modes of fire (semiautomatic, automatic in bursts of three to five rounds and fully automatic). The order of fire for rifles is given in Table I of the Appendix to this report.

STATISTICAL MODEL

The underlying model for the experiment was that of a Five Way Classification with fixed effects (Model I). Assuming this model for the analysis of the reliability data, an observed malfunction rate was considered to be expressible as

$$
\begin{aligned}
R_{ijk\ell m} = {} & \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_k + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} \\
& + \delta_\ell + (\alpha\delta)_{i\ell} + (\beta\delta)_{j\ell} + (\gamma\delta)_{k\ell} + (\alpha\beta\delta)_{ij\ell} + (\alpha\gamma\delta)_{ik\ell} \\
& + (\beta\gamma\delta)_{jk\ell} + \varepsilon_m + (\alpha\varepsilon)_{im} + (\beta\varepsilon)_{jm} + (\gamma\varepsilon)_{km} + (\delta\varepsilon)_{\ell m} \\
& + (\alpha\beta\varepsilon)_{ijm} + (\alpha\gamma\varepsilon)_{ikm} + (\alpha\delta\varepsilon)_{i\ell m} + (\beta\gamma\varepsilon)_{jkm} \\
& + (\beta\delta\varepsilon)_{j\ell m} + (\gamma\delta\varepsilon)_{k\ell m} + (\alpha\beta\gamma\delta)_{ijk\ell} + (\alpha\beta\gamma\varepsilon)_{ijkm} \\
& + (\alpha\beta\delta\varepsilon)_{ij\ell m} + (\alpha\gamma\delta\varepsilon)_{ik\ell m} + (\beta\gamma\delta\varepsilon)_{jk\ell m} \\
& + (\alpha\beta\gamma\delta\varepsilon)_{ijk\ell m}
\end{aligned}
$$

where $i = 1, 2$; $j = 1, 2, 3$; $k = 1, 2, 3$; $\ell = 1, 2$; and $m = 1, 2, 3$

In this model, R_{ijklm} is the malfunction rate of a rifle of the $\ell^{\underline{th}}$ type when firing the $i^{\underline{th}}$ ammunition mix employing the $j^{\underline{th}}$ mode of fire after conditioning in the $k^{\underline{th}}$ readiness state at the $m^{\underline{th}}$ temperature.

μ is the constant* malfunction rate (i.e. the malfunction rate was assumed to be essentially constant over the range of rounds fired in the test); α_i, β_j, γ_k, δ_ℓ and ε_m are the fixed effects of the i^{th} ammunition mix, the j^{th} mode of fire, the k^{th} readiness state, the ℓ^{th} rifle type (in the separate analysis of the M16A1 data, δ_ℓ was the fixed effect of the ℓ^{th} rifle producer), and the m^{th} temperature, respectively. The other terms of the model equation are two, three, four and five factor interactions of the main effects. For the separate analysis of the data for the M14 Rifles, a four-way classification model with fixed effects was used.

*Plots of the malfunction rates versus the number of rounds fired, in blocks of 300 rounds, indicated no significant trend with an increase in the number of rounds fired.

RESULTS

For each sequence of fire, the number of malfunctions and the number of rounds fired were noted: Cyclic rates and individual cycle times between rounds in a magazine were recorded for the sequences fired in the fully automatic mode.

Summaries of the total number of malfunctions and the malfunction rates, expressed in terms of the number of malfunctions per thousand rounds fired, are given in Tables II through IV for the M16A1 Rifle System and in Table V for the M14 Rifle System. Point estimates of the malfunction rates for the two systems, considering various factors of interest, are given in Table VI. Individual types of malfunctions are summarized in Tables VII through XI, which give the comparative number of various malfunctions which occurred under given conditions in M16A1 and M14 Rifles.

Tables XII and XIII summarize the cyclic rates, in rounds per minute, for the first magazines fired under the various conditions. Only the rates for the first magazines are given since they reflect more nearly the effects of the conditioning states and are not affected by trends due to warming of the rifles.

Figures 1 through 11 depict the relative malfunction rates considering various factors. From these figures, as well as pertinent tables in the Appendix, differences in malfunction rates due to the influence of individual factors and to the interaction of factors can be seen.

Round by round data from the firings are given in [3].

ANALYSIS OF VARIANCE AND DISCUSSION OF RESULTS

The methods of analysis of variance were used to analyze the results of the test and to test hypotheses concerning the significance of the effects of the factors included in the study. The reliability data consisted of a series of counts, i.e. the number of malfunctions encountered under various conditions; and the malfunction rates, computed as the ratio of the number of malfunctions to the number of rounds fired, were binomial type variates. Thus, the variance of the malfunction rates was functionally related to the mean of the distribution. The validity of results obtained by analysis of variance techniques is based on the assumption that the variates have a normal distribution with a constant variance. It was therefore necessary to make a transformation of each variate so that the assumption of normality and a constant variance would be satisfied as nearly as possible before applying the analysis of variance techniques.

An inverse sine transformation of the form

$$\phi = \sqrt{n}\left\{\arcsin\sqrt{x + \frac{\alpha}{n}} - \arcsin\sqrt{p + \frac{\alpha}{n}}\right\}, \quad -\frac{\alpha}{n} \leq x \leq 1 - \frac{\alpha}{n}$$

given by Curtiss [4] was used to transform the observed malfunction rates before the analyses were performed. In this transformation ϕ is the transformed variate in radians, n is the number of rounds fired under a given set of conditions, x is the ratio of malfunctions to the number of rounds fired (i.e. the estimated malfunction rate), and α is an arbitrary constant chosen to be 1/2 in our case in view of Bartlett's [5] findings for values of x near zero or one. The distribution of ϕ , where p is the true average malfunction rate, approaches the normal distribution with mean zero and variance 1/4. The limiting variance of $\sqrt{n} \sin^{-1}\sqrt{x + \frac{\alpha}{n}}$, as n becomes large, also approaches 1/4. Since p was not known, it was estimated from the data.

The complete set of malfunction rates, after applying the transformation, was analyzed as a Five-Way Classification with fixed effects. The main effects were ammunition mix (α), mode of fire (β), readiness state (γ), rifle type (δ), and temperature (ε). The results of this analysis indicated that, in addition to significant differences among levels of other main factors, there were significant differences between rifle types. In view of this, the data from the two rifle systems were analyzed as separate designs, that for the M16A1 Rifle System being a Five-Way Classification with fixed effects (rifle type being replaced by M16A1 Rifle producer as a factor) and that for the M14 Rifle System being a Four-Way Classification with fixed effects (omitting rifle type and rifle producer as factors). Analysis of variance, along with indications of the statistical significance of the various factors are given in Tables XIV - A through XIV - C in the Appendix.

From these tables, it can be seen that each of the main factors under study in the experiment had a significant effect on the malfunction rates of the M16A1 Rifle System. In addition, the effects of several of the factors interacted to cause significant differences in malfunction rates.

The most significant factor affecting the malfunction rates of M16A1 Rifles was temperature - the principle factor under investigation. The lowest overall malfunction rate of these rifles occurred in the firings at 0°F (1.3/1000 rounds) and the highest overall rate occurred at -40°F (16.6/1000 rounds). Differences due to the interaction of the effect of temperature and other factors can be seen by examination of Tables II through IV, Tables XVI through XVIII and Figures 9 and 10.

Differences in rifle producers also had a significant effect on the malfunction rates. The rifles produced by Colt's had the lowest overall malfunction rate (5.2/1000 rounds) and those produced by GM had the highest overall malfunction rate (9.9/1000 rounds). To examine the differences caused by the interaction of the effects of rifle producers with other factors, reference may be made to Tables II through IV, Tables XVII through XIX, and Figures 6 and 9.

The readiness state in which rifles were conditioned also significantly affected the malfunction rates. Rifles conditioned with the chamber empty and the bolt closed had the lowest overall malfunction rate (5.8/1000 rounds) and those conditioned with the chamber empty and the bolt open had the highest overall malfunction rate (8.4/1000 rounds). Due to the significant interaction of the effect of readiness state with other factors, malfunction rates changed with different levels of these factors. This can be seen by examination of Tables XIV and XIX and Figure 8.

The mode of fire employed contributed significantly to differences in malfunction rates although not as much as the other main factors. The best mode, over all other factors, was firing in short automatic bursts. Malfunctions occurred in M16A1 Rifles when employing this mode of fire at an overall rate of 4.9/1000 rounds as compared to overall rates of 9.1/1000 rounds when firing semiautomatically and 7.9/1000 rounds when firing fully automatic. The mode of fire effect also interacted significantly with other factors such as readiness state, rifle producer, temperature and combinations of these factors. Differences caused by these interactions may be seen in Tables XVI, XVII and XIX and Figure 10.

The other main factor which had a significant effect on the malfunction rates of the M16A1 Rifles was the ammunition mix. Firing all ball ammunition produced fewer malfunctions (6.5/1000 rounds) over all conditions than did the firing of the mix of four ball rounds to one tracer round. With the latter mix, malfunctions occurred at the rate of 8.1/1000 rounds. Due to significant interactions of this effect with effects of other factors, this characteristic (i.e. firing of all ball rounds producing fewer malfunctions than firing the four to one, mix of ball to tracer rounds) changed with different rifle producers, and combinations of different temperature levels and modes of fire. This can be seen in Tables XVI and XVIII.

From an overall standpoint, the analysis of the M16A1 Rifle malfunction data indicated that considering the factors under study, the best conditions were: Ammunition mix - all ball; mode of fire - automatic bursts; readiness state - chamber empty - bolt closed; rifle producer - Colt's.

For the cyclic rate data for the M16A1 Rifles, a replicated Four-Way Classification model with fixed effects was used since mode of fire was not applicable as a factor. The four main factors were ammunition mix, M16A1 Rifle producer, readiness state, and temperature. The analysis of variance is given in Table XV - A. Of these four main factors, only M16A1 Rifle producer and temperature had a significant effect on the cyclic rates when considered over all other factors. The rifles produced by H&R had the lowest overall average cyclic rate (693 rpm) and those produced by Colt's had the highest overall average cyclic rate (736 rpm). As would be expected, the average cyclic rate at -40°F was the lowest (677 rpm) and that at 0°F was the highest (752 rpm). There were significant interactions of ammunition mix and M16A1 Rifle producer and of temperature and readiness state. For the rifles produced by Colt's and H&R, the average cyclic rates were lower when firing the mix of four ball rounds to one tracer round while the average cyclic rate for rifles produced by GM was lower when firing all ball rounds. At 0°F, higher cyclic rates occurred in rifles conditioned with a round in the chamber and the bolt closed. At -20°F, higher cyclic rates occurred in rifles conditioned with the chamber empty and the bolt closed and at -40°F, higher rates occurred in rifles conditioned with the chamber empty and the bolt open. Regarding the dispersion of cyclic rate, the standard deviation among rifles within producers was estimated to be 36.6 rounds per minute.

The analysis of the malfunction data for the M14 Rifle System, as a Four-way Classification with fixed effects, indicated that ammunition mix and temperature were the only two main factors which had significant effects on the malfunction rates. The malfunction rate for M14 Rifles which fired a mix of four ball rounds to one tracer round was considerably lower than that for rifles which fired all ball rounds (viz. 2.3/1000 rounds as compared to 13.1/1000 rounds). This characteristic was just the opposite of the case for M16A1 Rifles. The difference may be attributable, in part, to the fact that the 5.56 mm tracer rounds fired in the M16A1 Rifles were loaded with IMR propellant (which gives a lower cyclic rate in the current rifle - buffer configuration) whereas the 7.62 mm tracer rounds fired in the M14 Rifles were loaded with ball propellant. It has been established (see [1]) that propellant type has a significant effect on the functioning characteristics of these rifles. The effect of ammunition mix also interacted with mode of fire and readiness state. For the differences due to this interaction, reference may be made to Table XVI and Tables XX through XXII.

With regard to the effect of temperature, M14 Rifles malfunctioned less frequently (3.8/1000 rounds) at 0°F and most frequently (11.2/1000 rounds) at -40°F. The effect of temperature also interacted with readiness state and mode of fire. Regarding the latter interaction, fewer malfunctions (1.7/1000 rounds) occurred at 0°F when firing in short automatic bursts while, at -20°F and at -40°F, fewer malfunctions (3.7 and 8.9/1000 rounds for -20°F and -40°F, respectively) occurred when firing in the fully automatic mode. Differences in malfunction rates due to the interaction of various factors may be seen by examination of Table XVI, Tables XX, XXI and XXIII and Figure 11.

Overall, the analysis of the M14 Rifle malfunction data indicated that, considering the factors under study, the best conditions were: ammunition mix - 4/1 ball to tracer rounds; mode of fire - fully automatic; readiness state - chamber empty - bolt closed.

The cyclic rate for the M14 Rifle System was analyzed as a replicated Three-way Classification with fixed effects. The three main factors were ammunition mix, readiness state and temperature. The analysis of variance is given in Table XV - B. Of the three main factors, only temperature had a significant effect on the cyclic rates. The overall average cyclic rate was lowest at -40°F (766 rpm) and highest at 0°F (791 rpm). The standard deviation among rifles was estimated to be 27.9 rpm.

DISCUSSION OF INDIVIDUAL MALFUNCTION TYPES

Tables VII through XI summarize the number of various types of malfunctions observed in the test. For the M16A1 Rifles, the most frequent malfunctions were failures to lock (1.4/1000 round), bolts closing on an empty chamber (1.0/1000 rounds), failures to strip (0.9/1000 round), and bolt catches stopping the forward movement of bolts before the last round of a magazine was fired (0.9/1000 rounds). Usually, each of these types of malfunctions can be cleared by either use of the forward assist device or the charging handle.

For the M14 Rifles, the most frequent malfunctions by far were bolts closing on an empty chamber (4.0/1000 rounds), and bolts overriding the base of cartridge cases (2.4/1000 rounds). Of these two types, the bolt overrides are usually the more serious type of malfunction. Incidents of the bolt closing on an empty chamber can usually be cleared in M14 Rifles by retracting the operating rod and then releasing it to feed a round into the chamber. However, for the bolt overrides, incautious use of the operating rod may compound the problem. This type of malfunction can usually be cleared in M14 Rifles by retracting the operating rod just far enough to allow the base of the cartridge case to move up in front of the bolt and then releasing it to feed the round into the chamber.

Over half (58%) of the failures to lock and all of the occurrences of bolt catches stopping the forward movement of the bolt before the last round of a magazine was fired in M16A1 Rifles were in rifles produced by GM when firing at -40°F. Twenty-five failures to fire (80% of the total for M16A1 Rifles) were also observed in rifles produced by GM when firing at -40°F. Eighty-four percent of the failures to strip in M16A1 Rifles occurred after conditioning with the chamber empty and the bolt open.

More than half (59%) of the incidents of the bolt closing on an empty chamber in M16A1 Rifles occurred in those produced by H&R when firing at -40°F. These rifles also had 17 incidents (41% of the total for M16A1 Rifles) of bolts overriding the base of cartridge cases.

COMPARISON OF M16A1 AND M14 RIFLE SYSTEMS

Since there were significant differences in the malfunction rates of the two systems at the three temperatures, comparisons of the probabilities of malfunctions of rifles selected at random from the stockpile of rifles in the two systems were made for each of the three temperatures in this study.

To determine the probability of a malfunction of an M16A1 Rifle selected at random from stockpile, the following procedure was used. Let R_i (i = 1, 2, 3) be the event a rifle from the $i^{\underline{th}}$ producer is selected, F_j (j = 1, 2, 3) be the event that the $j^{\underline{th}}$ firing mode is to be employed, A_k (k = 1, 2) be the event that the $k^{\underline{th}}$ ammunition mix is to be fired (here only the all ball and mix of 4/1 ball to tracer rounds in 20 round magazines are considered), and M_{ijk} be the event a malfunction occurs when firing a rifle from the $i^{\underline{th}}$ producer while employing the $j^{\underline{th}}$ mode to fire the $k^{\underline{th}}$ ammunition mix. The events within the $\{R_i\}$, $\{F_j\}$, $\{A_k\}$, and $\{M_{ijk}\}$ are mutually exclusive and the first three sets are independent of each other while the $\{M_{ijk}\}$ is dependent upon these three sets. From these conditions, the probability of a malfunction of an M16A1 Rifle selected from the stockpile at random, when firing at a given temperature can be expressed as

$$P\,(\text{malfunction} \mid \text{temperature}) = \sum_i^3 \sum_j^3 \sum_k^2 P\{(R_i \cap F_j \cap A_k) \cap M_{ijk}\}$$

$$= \sum_i^3 \sum_j^3 \sum_k^2 P\{R_i \cap F_j \cap A_k\}\, P\{M_{ijk} \mid (R_i \cap F_j \cap A_k)\}$$

$$= \sum_i^3 \sum_j^3 \sum_k^2 P\{R_i\}\, P\{F_j\}\, P\{A_k\}\, P\{M_{ijk} \mid (R_i \cap F_j \cap A_k)\}$$

For the M14 Rifle System, the stockpile was assumed to consist of equal proportions of rifles from M14 Rifle producers. The expression for the probability of a malfunction of a rifle selected from the stockpile at random was therefore considered to be of the form

$$P\,(\text{malfunction} \mid \text{temperature}) = \sum_{j}^{3} \sum_{k}^{2} P\left\{ (F_j \cap A_k) \cap M_{jk} \right\}$$

$$= \sum_{j}^{3} \sum_{k}^{2} P\left\{ F_j \cap A_k \right\} P\left\{ M_{jk} \mid (F_j \cap A_k) \right\}$$

$$= \sum_{j}^{3} \sum_{k}^{2} P\left\{ F_j \right\} P\left\{ A_k \right\} P\left\{ M_{jk} \mid (F_j \cap A_k) \right\}$$

Estimates of the $P\{R_i\}$ were based on the proportion of rifles produced and accepted at the three manufacturers during the period November 1968 through September 1969. The estimates of the $P\{F_j\}$ were based on data obtained in a survey of M16 Rifle usage in the Republic of Vietnam [2]. Estimates of the $P\{A_k\}$ were based on the survey data, in addition to data from the production of ball and tracer ammunition. Estimates of the $P\{M_{ijk}\}$ and $P\{M_{jk}\}$ were obtained from the test data. The $P\{R_i\}$, $P\{F_j\}$ and $P\{A_k\}$ used to compute the probabilities of a malfunction are given in the following table

i	R_i	$P\{R_i\}$	j	F_j	$P\{F_j\}$	k	A_k	$P\{A_k\}$*
1	Colt's	0.776	1	Semiauto	0.661	1	20/0 mix	0.667
2	GM	0.167	2	auto (bursts)	0.204	2	4/1 mix	0.333
3	H&R	0.057	3	auto (full)	0.135			

*Based on an estimated consumption ratio of 2:1 all ball magazines to 4/1 ball to tracer mix.

The table below summarizes the computed probabilities, assuming that the randomly selected rifle was in a condition as good as new (or relatively new), had been cleaned and lubricated at least every 500 rounds, and was used after exposure to the given temperatures with the chamber empty and the bolt closed (this readiness state gave the best results of those tested).

Temperature (T)	P{malfunction $\mid$ conditioning w/chamber empty - bolt closed at temp T}	
	M16A1 Rifle System	M14 Rifle System
0°F	0.0003	0.0011
-20°F	0.0051	0.0101
-40°F	0.0085	0.0155

From this table, it can be seen that the chance of a malfunction of an M16A1 Rifle, selected at random from the stockpile and carried in readiness with the chamber empty and the bolt closed, is less than that for an M14 Rifle selected at random and used in the same readiness state at each of the three temperatures.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Mr. O. P. Bruno for his direction and many helpful suggestions throughout this study and the members of the Infantry Ammunition Section of the Surveillance and Reliability Division for their efforts in the conduct of the study and the analyses of the data. Mr. Samuel Padula Jr. incorporated the transformation used into computer programs for the analysis of variance of the reliability data and assisted in other facets of the overall analysis of the data. Mr. Harold Pasini compiled the data, and assisted in the overall analysis, including the construction of tables and figures. Miss Anne Deimel also contributed in the analysis of the test data.

APPENDIX

TABLES AND FIGURES

LEGEND FOR INDIVIDUAL MALFUNCTIONS

Failures to Feed:

FS	-	Failure to strip round from magazine
FS/PS	-	Partially stripped round from magazine
COEC	-	Bolt closed on an empty chamber
FC	-	Failure to fully chamber round
FL	-	Failure to lock bolt
BFE	-	Bolt failed to engage base of round in magazine
BCS	-	Bolt catch stopped forward movement of bolt before last round of magazine was fired
BLE	-	Bolt lacked sufficient energy to force round from magazine
PRM	-	Round prematurely released from magazine feeding lips

Other:

BOB	-	Bolt overrode base of round in feeding from magazine
F2R	-	Fired two rounds on one rearward movement of trigger
FBR	-	Failure of the bolt to remain at rear after last round
FFR	-	Failure to fire
FJ	-	Failure to eject
FX	-	Failure to extract
FTR	-	Failure of trigger to return to forward position

TABLE I

Order of Fire for Rifles

Temp. (F.)	Mode of Fire	Chamber Empty-Bolt Open								Chamber Empty-Bolt Closed								Round in Chamber-Bolt Closed							
		Ball Ammunition Lot																							
		1		2		3		-		1		2		3		-		1		2		3		-	
		Ammo. Mix (Ratio of Ball Cartridges w/Ball Propellant to Tracer Cartridges w/IMR Propellant)																							
		20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
0°	Auto (bursts) Auto (full) Semiauto	HR5	HR6	C5	C6	GM5	GM6	14-5	14-6	C1	C2	GM1	GM2	HR1	HR2	14-1	14-2	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4
-20°	Auto (bursts) Auto (full) Semiauto	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6	HR1	HR2	C1	C2	GM1	GM2	14-1	14-2	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4
-40°	Auto (bursts) Auto (full) Semiauto	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2	HR3	HR4	C3	C4	GM3	GM4	14-3	14-4
0°	Auto (full) Semiauto Auto (bursts)	HR5	HR6	C5	C6	GM5	GM6	14-5	14-6	C1 *	C2 *	GM1 *	GM2 *	HR1 *	HR2 *	14-1 *	14-2 *	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4
-20°	Auto (full) Semiauto Auto (bursts)	GM5 *	GM6 *	HR5 *	HR6 *	C5 *	C6 *	14-5 *	14-6 *	HR1	HR2	C1	C2	GM1	GM2	14-1	14-2	* C3	* C4	* GM3	* GM4	* HR3	* HR4	* 14-3	* 14-4
-40°	Auto (full) Semiauto Auto (bursts)	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2	HR3	HR4	C3	C4	GM3	GM4	14-3	14-4
0°	Semiauto Auto (bursts) Auto (full)	HR5	HR6	C5	C6	GM5	GM6	14-5	14-6	C1	C2	GM1	GM2	HR1	HR2	14-1	14-2	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4
-20°	Semiauto Auto (bursts) Auto (full)	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6	* HR1	* HR2	* C1	* C2	* GM1	* GM2	* 14-1	* 14-2	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4
-40°	Semiauto Auto (bursts) Auto (full)	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6	* GM1	* GM2	* HR1	* HR2	* C1	* C2	* 14-1	* 14-2	* HR3	* HR4	* C3	* C4	* GM3	* GM4	* 14-3	* 14-4

Legend:

C1, C2, C3, C4, C5, C6 — Colt M16 Rifles (1-6)
GM1, GM2, GM3, GM4, GM5, GM6 — General Motors M16 Rifles (1-6)
HR1, HR2, HR3, HR4, HR5, HR6 — Harrington & Richardson M16 Rifles (1-6)
14-1, 14-2, 14-3, 14-4, 14-5, 14-6 — **M14 Rifles (1-6)**

*Clean at end of this test phase.

TABLE I (Cont'd)

Order of Fire for Rifles

Temp. (F.)	Mode of Fire	Chamber Empty-Bolt Open								Chamber Empty-Bolt Closed								Round in Chamber-Bolt Closed							
		Ball Ammunition Lot																							
		1		2		3		-		1		2		3		-		1		2		3		-	
		Ammo. Mix (Ratio of Ball Cartridges w/Ball Propellant to Tracer Cartridges w/ IMR Propellant)																							
		20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
0°	Semiauto Auto (bursts) Auto (full)	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4	* HR5	* HR6	* C5	* C6	* GM5	* GM6	* 14-5	* 14-6	C1	C2	GM1	CM2	HR1	HR2	14-1	14-2
-20°	Semiauto Auto (bursts) Auto (full)	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6	HR1	HR2	C1	C2	GM1	GM2	14-1	14-2
-40°	Semiauto Auto (bursts) Auto (full)	HR3 *	HR4 *	C3 *	C4 *	GM3 *	GM4 *	14-3 *	14-4 *	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2
0°	Auto (bursts) Auto (full) Semiauto	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4	* HR5	* HR6	* C5	* C6	* GM5	* GM6	* 14-5	* 14-6	* C1	* C2	* GM1	* GM2	* HR1	* HR2	* 14-1	* 14-2
-20°	Auto (bursts) Auto (full) Semiauto	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4	* GM5	* GM6	* HR5	* HR6	* C5	* C6	* 14-5	* 14-6	HR1	HR2	C1	C2	GM1	GM2	14-1	14-2
-40°	Auto (bursts) Auto (full) Semiauto	HR3	HR4	C3	C4	GM3	GM4	14-3	14-4	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2
0°	Auto (full) Semiauto Auto (bursts)	GM3 *	GM4 *	HR3 *	HR4 *	C3 *	C4 *	14-3 *	14-4 *	HR5	HR6	C5	C6	GM5	GM6	14-5	14-6	C1	C2	GM1	GM2	HR1	HR2	14-1	14-2
-20°	Auto (full) Semiauto Auto (bursts)	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6	HR1	HR2	C1	C2	GM1	GM2	14-1	14-2
-40°	Auto (full) Semiauto Auto (bursts)	HR3	HR4	C3	C4	GM3	GM4	14-3	14-4	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6	* GM1	* GM2	* HR1	* HR2	* C1	* C2	* 14-1	* 14-2

*Clean at end of this test phase.

TABLE I (Cont'd)

Order of Fire for Rifles

Temp. (F.)	Mode of Fire	Chamber Empty-Bolt Open								Chamber Empty-Bolt Closed								Round in Chamber-Bolt Closed							
		Ball Ammunition Lot																							
		1		2		3		-		1		2		3		-		1		2		3		4	
		Ammo. Mix (Ratio of Ball Cartridges w/Ball Propellant to Tracer Cartridges w/IMR Propellant)																							
		20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
0°	Auto (full) Semiauto Auto (bursts)	C1	C2	GM1	GM2	HR1	HR2	14-1	14-2	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4	* HR5	* HR6	* C5	* C6	* GM5	* GM6	* 14-5	* 14-6
-20°	Auto (full) Semiauto Auto (bursts)	HR1 *	HR2 *	C1 *	C2 *	GM1 *	GM2 *	14-1 *	14-2 *	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6
-40°	Auto (full) Semiauto Auto (bursts)	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2	* HR3	* HR4	* C3	* C4	* GM3	* GM4	* 14-3	* 14-4	* C5	* C6	* GM5	* GM6	* HR5	* HR6	* 14-5	* 14-6
0°	Semiauto Auto (bursts) Auto (full)	C1 *	C2 *	GM1 *	GM2 *	HR1 *	HR2 *	14-1 *	14-2 *	GM3	GM4	HR3	HR4	C3	C4	14-3	14-4	HR5	HR6	C5	C6	GM5	GM6	14-5	14-6
-20°	Semiauto Auto (bursts) Auto (full)	HR1	HR2	C1	C2	GM1	GM2	14-1	14-2	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6
-40°	Semiauto Auto (bursts) Auto (full)	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2	HR3 *	HR4 *	C3 *	C4 *	GM3 *	GM4 *	14-3 *	14-4 *	* C5	* C6	* GM5	* GM6	* HR5	* HR6	* 14-5	* 14-6
0°	Auto (bursts) Auto (full) Semiauto	C1	C2	GM1	GM2	HR1	HR2	14-1	14-2	GM3	GM4	HR3	HR4	C3	C4	14-2	14-4	HR5	HR6	C5	C6	GM5	GM6	14-5	14-6
-20°	Auto (bursts) Auto (full) Semiauto	HR1 *	HR2 *	C1 *	C2 *	GM1 *	GM2 *	14-1 *	14-2 *	C3	C4	GM3	GM4	HR3	HR4	14-3	14-4	GM5	GM6	HR5	HR6	C5	C6	14-5	14-6
-40°	Auto (bursts) Auto (full) Semiauto	GM1	GM2	HR1	HR2	C1	C2	14-1	14-2	HR3	HR4	C3	C4	GM3	GM4	14-3	14-4	C5	C6	GM5	GM6	HR5	HR6	14-5	14-6

*Clean at end of this test phase.

TABLE II

Summary of Malfunction Rates for M16A1 Rifles Produced by Colt's

Readiness State		Chamber Empty - Bolt Open						Chamber Empty - Bolt Closed						Round in Chamber - Bolt Closed					
Mode of Fire		Semiauto		Auto (bursts)		Auto (full)		Semiauto		Auto (bursts)		Auto (full)		Semiauto		Auto (bursts)		Auto (full)	
Ammo. Mix		20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
Temperature 0°F	No. Malf.	0	0	0	1	0	2	0	0	0	0	0	0	0	3	0	2	0	2
	No. Rds. Cons.	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	301
	Malf./1000 rds.	0	0	0	3.33	0	6.67	0	0	0	0	0	0	0	10.00	0	6.67	0	6.67
-20°F	No. Malf.	0	1	2	5	1	5	1	1	0	0	0	1	0	0	0	3	0	3
	No. Rds. Cons.	300	300	300	300	300	357	300	300	300	300	300	300	300	300	300	300	300	338
	Malf./1000 rds.	0	3.33	6.67	16.67	3.33	14.01	3.33	3.33	0	0	0	3.33	0	0	0	10.00	0	8.88
-40°F	No. Malf.	4	7	3	3	2	1	1	3	1	3	4	4	0	5	0	3	1	7
	No. Rds. Cons.	300	300	300	300	320	300	300	300	300	300	301	302	300	301	300	300	301	307
	Malf./1000 rds.	13.33	23.33	10.00	10.00	6.25	3.33	3.33	10.00	3.33	10.00	13.33	13.25	0	16.61	0	10.00	3.32	22.80

TABLE III

Summary of Malfunction Rates for M16A1 Rifles Produced by GM

Readiness State		Chamber Empty - Bolt Open						Chamber Empty - Bolt Closed						Round in Chamber - Bolt Closed					
Mode of Fire		Semiauto		Auto(bursts)		Auto(full)		Semiauto		Auto(bursts)		Auto(full)		Semiauto		Auto(bursts)		Auto(full)	
Temperature	Ammo. Mix	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
0°F	No. Malf.	0	0	2	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0
	No. Rds. Cons	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Malf/1000 rds.	0	0	6.67	3.33	3.33	0	0	6.67	0	0	0	0	0	0	0	0	0	0
-20°F	No. Malf.	1	1	3	2	2	1	4	0	1	0	0	0	3	0	1	0	1	0
	No. Rds. Cons	300	300	300	300	301	300	300	300	300	300	300	300	300	300	300	300	316	300
	Malf/1000 rds	3.33	3.33	10.00	6.67	6.64	3.33	13.33	0	3.33	0	0	0	10.00	0	3.33	0	3.16	0
-40°F	No. Malf.	20	5	4	4	4	1	6	0	4	2	14	14	25	20	0	0	11	1
	No. Rds. Cons	300	304	300	301	302	300	300	300	300	300	305	337	301	328	300	300	328	301
	Malf/1000 rds.	66.67	16.45	13.33	13.33	13.25	3.33	20.00	0	13.33	6.67	45.90	41.54	83.06	60.98	0	0	33.54	3.32

TABLE IV

Summary of Malfunction Rates for M16A1 Rifles Produced by H&R

Readiness State		Chamber Empty - Bolt Open						Chamber Empty - Bolt Closed						Round in Chamber - Bolt Closed					
Mode of Fire		Semiauto		Auto(bursts)		Auto(full)		Semiauto		Auto(bursts)		Auto(full)		Semiauto		Auto(bursts)		Auto(full)	
Ammo. Mix		20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
Temperature 0°F	No. Malf.	0	0	0	1	0	0	0	2	0	1	0	0	0	0	1	0	0	0
	No. Rds. Cons.	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Malf/1000 rds.	0	0	0	3.33	0	0	0	6.67	0	3.33	0	0	0	0	3.33	0	0	0
-20°F	No. Malf.	1	2	2	1	1	1	0	5	0	0	0	3	0	2	0	1	1	1
	No. Rds. Cons.	300	300	300	300	300	300	300	300	300	300	300	302	300	300	300	300	300	300
	Malf/1000 rds.	3.33	6.67	6.67	3.33	3.33	3.33	0	16.67	0	0	0	9.93	0	6.67	0	3.33	3.33	3.33
-40°F	No. Malf.	4	4	6	8	2	15	2	3	3	4	3	3	3	6	1	1	1	16
	No. Rds. Cons.	300	300	300	300	300	330	300	301	300	300	300	301	300	300	300	300	301	331
	Malf/1000 rds.	13.33	13.33	20.00	26.67	6.67	45.45	6.67	9.97	10.00	13.33	10.00	9.97	10.00	20.00	3.33	3.33	3.32	48.34

TABLE V

Summary of Malfunction Rates for M14 Rifles

Temperature	Readiness State	Chamber Empty - Bolt Open						Chamber Empty - Bolt Closed						Round in Chamber - Bolt Closed					
	Mode of Fire	Semiauto		Auto(bursts)		Auto(full)		Semiauto		Auto(bursts)		Auto(full)		Semiauto		Auto(bursts)		Auto(full)	
	Ammo. Mix	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
0°F	No. Malf.	3	0	2	0	5	0	0	0	1	0	2	0	3	0	0	0	4	1
	No. Rds. Cons.	300	300	300	300	373	320	300	300	300	300	300	300	300	300	300	300	302	316
	Malf/1000 rds.	10.00	0	6.67	0	13.40	0	0	0	3.33	0	6.67	0	10.00	0	0	0	13.25	3.16
-20°F	No. Malf.	3	0	9	2	3	0	5	0	5	0	1	1	5	0	8	1	2	0
	No. Rds. Cons.	300	300	300	300	349	320	300	300	300	300	300	300	300	300	300	300	315	300
	Malf/1000 rds.	10.00	0	30.00	6.67	8.60	0	16.67	0	16.67	0	3.33	3.33	16.67	0	26.67	3.33	6.35	0
-40°F	No. Malf.	2	4	3	2	5	1	6	1	11	2	2	0	6	0	6	2	8	2
	No. Rds. Cons.	300	300	300	300	360	334	300	300	300	300	328	300	300	300	300	300	386	316
	Malf/1000 rds.	6.67	13.33	10.00	6.67	13.89	2.99	20.00	3.33	36.67	6.67	6.10	0	20.00	0	20.00	6.67	20.73	6.33

TABLE VI

Point Estimates of Malfunction Rates by Factor and Rifle Type

Factor	Levels	M16A1 Rifles			M14 Rifles		
		No. Rds. Cons.	No. Malf./1000 Rds.		No. Rds. Cons.	No. Malf./1000 Rds.	
			Average	Std. Dev.*		Average	Std. Dev.*
Rifle Type		48,918	7.3	1.6	16,619	7.8	1.7
Rifle Producer	Colt's	16,328	5.2	1.4			
	GM	16,324	9.9	1.9			
	H&R	16,266	6.8	1.6			
Temperature	0°F.	16,201	1.3	0.7	5,511	3.8	1.2
	-20°F.	16,314	3.9	1.2	5,484	8.2	1.7
	-40°F.	16,403	16.6	2.4	5,624	11.2	2.0
Rifle Readiness State	Chamber Empty - Bolt Open	16,315	8.4	1.7	5,656	7.8	1.7
	Chamber Empty - Bolt Closed	16,249	5.8	1.5	5,428	6.8	1.6
	Round in Chamber - Bolt Closed	16,354	7.6	1.7	5,535	8.6	1.8
Mode of Fire	Semiautomatic	16,235	9.0	1.8	5,400	7.0	1.6
	Automatic (bursts)	16,201	4.9	1.3	5,400	10.0	1.9
	Automatic (full)	16,482	7.9	1.7	5,819	6.4	1.5
Ammunition Type Mixes	20/0, Ball/Tracer	24,377	6.5	1.5	8,413	13.1	2.2
	4/1, Ball/Tracer	24,541	8.1	1.7	8,206	2.3	0.9

*Computed using malfunction rate as a binomial variate.

TABLE VII

Summary of Individual Malfunctions vs. Rifle Producer and Temperature

Rifle Producer	Temperature	Failures to Feed									Others							Total
		FS	FS/PS	COEC	FC	FL	BFE	BCS	BLE	PRM	BOB	F2R	FBR	FFR	FJ	FX	FTR	
Colt's	0°F				1					5			3		1			10
	-20°F	5	1	1				1		9	2		3	1				23
	-40°F	8	9	9		12			3	2	3	1	3	1	1			52
	Subtotal	13	10	10	1	12		1	3	16	5	1	9	2	2			85
GM	0°F		1										5					6
	-20°F	5				1		3	1				10					20
	-40°F	10	13	4		38		38					7	25				135
	Subtotal	15	14	4		39		41	1				22	25				161
H&R	0°F	1		1							2		1					5
	-20°F	4		6		2		1			3		3	2				21
	-40°F	11	4	30	3	13	1				17		1	2	2		1	85
	Subtotal	16	4	37	3	15	1	1			22		5	4	2		1	111
M16A1 Total	0°F	1	1	1	1					5	2		9		1			21
	-20°F	14	1	7		3		5	1	9	5		16	3				64
	-40°F	29	26	43	3	63	1	38	3	2	20	1	11	28	3		1	272
		44	28	51	4	66	1	43	4	16	27	1	36	31	4		1	357
M14	0°F	1		6		2					8		2			2		21
	-20°F		1	21							18	2	2		1			45
	-40°F	1		40		3					15		2	1	1			63
		2	1	67		5					41	2	6	1	2	2		129
Total	0°F	2	1	7	1	2				5	10		11		1	2		42
	-20°F	14	2	28		3		5	1	9	23	2	18	3	1			109
	-40°F	30	26	83	3	66	1	38	3	2	35	1	13	29	4		1	335
		46	29	118	4	71	1	43	4	16	68	3	42	32	6	2	1	486

TABLE VIII

Summary of Individual Malfunctions vs. Rifle Producer, Temperature, and Ammo. Mix

Rifle Producer	Temperature	Ammo. Mix	Failures to Feed								Others							Total
			FS	FS/PS	COEC	FC	FL	BFE	BCS	BLE	PRM	BOB	F2R	FBR	FFR	FJ	FX	FTR	
Colt's	0° F	20/0																	0
		4/1				1					5			3		1			10
	-20° F	20/0	3												1				4
		4/1	2	1	1				1		9	2		3					19
	-40° F	20/0	5	5	3		1			1	1								16
		4/1	3	4	6		11			2	1	3	1	3	1	1			36
GM	0° F	20/0		1										2					3
		4/1												3					3
	-20° F	20/0	2						3	1				10					16
		4/1	3				1												4
	-40° F	20/0	4	8	2		29		38					5	2				88
		4/1	6	5	2		9							2	23				47
H&R	0° F	20/0			1														1
		4/1	1									2		1					4
	-20° F	20/0	2				1		1						1				5
		4/1	2		6		1					3		3	1				16
	-40° F	20/0	7	2	2	1	8	1				1		1	1			1	25
		4/1	4	2	28	2	5					16			1	2			60
M16A1 Rifles	0° F	20/0		1	1									2					4
		4/1	1			1					5	2		7		1			17
	-20° F	20/0	7				1		4	1				10	2				25
		4/1	7	1	7		2		1		9	5		6	1				39
	-40° F	20/0	16	15	7	1	38	1	38	1	1	1		6	3			1	129
		4/1	13	11	36	2	25			2	1	19	1	5	25	3			143
M14	0° F	20/0	1		6		2					7		2			2		20
		4/1										1							1
	-20° F	20/0		1	19							17	2	2					41
		4/1			2							1				1			4
	-40° F	20/0			32		2					13		2					49
		4/1	1		8		1					2			1	1			14

TABLE IX

Summary of Individual Malfunctions vs. Ammo Mix

AMMO MIX	MALFUNCTION TYPE / RIFLE TYPE	FAILURES TO FEED									OTHERS							TOTAL
		FS	FS/PS	COEC	FC	FL	BFE	BCS	BLE	PRM	BOB	F2R	FBR	FFR	FJ	FX	FTR	
20/0	M16A1	23	16	8	1	39	1	42	2	1	1		18	5			1	158
	M14	1	1	57		4					37	2	6			2		110
	SUBTOTAL	24	17	65	1	43	1	42	2	1	38	2	24	5		2	1	268
4/1	M16A1	21	12	43	3	27		1	2	15	26	1	18	26	4			199
	M14	1		10		1					4			1	2			19
	SUBTOTAL	22	12	53	3	28		1	2	15	30	1	18	27	6			218
	TOTAL	46	29	118	4	71	1	43	4	16	68	3	42	32	6	2	1	486

TABLE X

Summary of Individual Malfunctions vs. Rifle Readiness State

Rifle Readiness State	MALFUNCTION TYPE / RIFLE TYPE	FAILURES TO FEED									OTHERS							TOTAL
		FS	FS/PS	COEC	FC	FL	BFE	BCS	BLE	PRM	BOB	F2R	FBR	FFR	FJ	FX	FTR	
CE-BO[a]	M16A1	37	8	23	3	14		21	3	8	5		11	3			1	137
	M14	1		21		2					16		3		1			44
	SUBTOTAL	38	8	44	3	16		21	3	8	21		14	3	1		1	181
CE-BC[b]	M16A1	5	20	11		26	1	1	1	1	9	1	14	5				95
	M14			24							6	2	3			2		37
	SUBTOTAL	5	20	35		26	1	1	1	1	15	3	17	5		2		132
RC-BC[c]	M16A1	2		17	1	26		21		7	13		11	23	4			125
	M14	1	1	22		3					19			1	1			48
	SUBTOTAL	3	1	39	1	29		21		7	32		11	24	5			173
	TOTAL	46	29	118	4	71	1	43	4	16	68	3	42	32	6	2	1	486

a. Chamber Empty-Bolt Open
b. Chamber Empty-Bolt Closed
c. Round in Chamber-Bolt Closed

TABLE XI

Summary of Individual Malfunction Rates for Rifle Producers

Malfunction		M16A1 RIFLES						TOTAL M16A1 RIFLES		M14 RIFLES	
		COLT'S		GM		H&R					
		No.	No./1000 RDS	No.	No./1000 RDS	No.	No./1000 RDS	No.	No./1000 RDS	No.	No./1000 RDS
Failures	FS	13	0.80	15	0.92	16	0.98	44	0.90	2	0.12
	FS/PS	10	0.61	14	0.86	4	0.25	28	0.57	1	0.06
	COEC	10	0.61	4	0.25	37	2.27	51	1.04	67	4.03
to	FC	1	0.06			3	0.18	4	0.08		
	FL	12	0.74	39	2.39	15	0.92	66	1.35	5	0.30
Feed	BFE					1	0.06	1	0.02		
	BCS	1	0.06	41	2.51	1	0.06	43	0.88		
	BLE	3	0.18	1	0.06			4	0.08		
	PRM	16	0.98					16	0.33		
		66	4.04	114	6.98	77	4.73	257	5.25	75	4.51
Others	BOB	5	0.31			22	1.35	27	0.55	41	2.47
	F2R	1	0.06					1	0.02	2	0.12
	FBR	9	0.55	22	1.35	5	0.31	36	0.74	6	0.36
	FFR	2	0.12	25	1.53	4	0.25	31	0.63	1	0.06
	FJ	2	0.12			2	0.12	4	0.08	2	0.12
	FX									2	0.12
	FTR				-	1	0.06	1	0.02		
		19	1.16	47	2.88	34	2.09	100	2.04	54	3.25

TABLE XII

Summary of Cyclic Rates (in rounds per minute) for the First Magazine of M16A1 Rifles

Readiness State	Chamber Empty - Bolt Open						Chamber Empty - Bolt Closed						Round in Chamber - Bolt Closed					
Mfr.	Colt's		GM		H&R		Colt's		GM		H&R		Colt's		GM		H&R	
Ammo. Mix	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1	20/0	4/1
Temperature 0°F	736	695	756	787	714	691	760	754	781	793	780	741	756	745	768	784	699	657
	742	755	778	782	707	627	738	677	759	762	744	671	774	788	803	821	804	772
	757	760	782	799	788	778	745	754	798	796	733	676	737	709	806	791	768	742
Ave.	745.0	736.7	772.0	789.3	736.3	698.7	747.7	728.3	779.3	783.7	752.3	696.0	755.7	747.3	792.3	798.7	757.0	723.7
-20°F	687	635	679	717	622	619	685	723	693	739	712	697	732	720	739	781	725	686
	709	726	735	764	711	630	742	745	786	769	751	713	640	665	720	741	703	693
	658	683	676	703	706	785	696	716	704	724	685	629	718	702	710	729	697	629
Ave.	684.7	681.3	696.7	728.0	679.7	678.0	707.7	728.0	727.7	744.0	716.0	679.7	696.7	695.7	723.0	750.3	708.3	669.3
-40°F	738	738	744	773	721	692	634	650	630	658	619	647	638	631	645	681	665	614
	681	665	649	687	637	635	722	693	742	740	731	705	604	617	620	645	610	651
	722	725	768	772	728	710	607	654	681	763	661	606	713	707	671	619	692	615
Ave.	713.7	709.3	720.3	744.0	695.3	679.0	654.3	665.7	684.3	720.3	670.3	652.7	651.7	651.7	645.3	648.3	655.7	626.7

Average Cyclic Rates

Mfr.	Ammo. Mix	
	20/0	4/1
Colt's	706.3	704.9
GM	726.8	745.2
H&R	707.9	678.2

Average Cyclic Rates

Rifle Readiness State	Temperature		
	0°F	-20°F	-40°F
Chamber Empty - Bolt Open	746.3	691.4	710.3
Chamber Empty - Bolt Closed	747.9	717.7	674.6
Round in Chamber - Bolt Closed	762.4	707.2	646.6

TABLE XIII

Summary of Cyclic Rates (in rounds per minute) for the First Magazine of All M14 Rifles

Temperature	Readiness State	Chamber Empty - Bolt Open		Chamber Empty - Bolt Closed		Round in Chamber - Bolt Closed	
	Ammo. Mix	20/0	4/1	20/0	4/1	20/0	4/1
0°F		817	806	796	773	760	772
		764	804	810	803	803	787
		771	774	774	807	807	809
	Ave.	784.0	794.7	793.3	794.3	790.0	789.3
-20°F		792	800	785	776	758	764
		772	793	816	810	786	773
		788	786	719	751	801	809
	Ave.	784.0	793.0	773.3	779.0	781.7	782.0
-40°F		814	810	731	727	757	777
		698	789	813	827	766	783
		774	789	722	768	721	725
	Ave.	762.0	796.0	755.3	774.0	748.0	761.7

Average Cyclic Rate

Temp.	Ammo. Mix 20/0	Ammo. Mix 4/1
0°F	789.1	792.8
-20°F	779.7	784.7
-40°F	755.1	777.2

TABLE XIV-A

ANALYSIS OF VARIANCE OF RELIABILITY DATA
(M16A1 and M14 Rifles Combined)

Source of Variation		Sum of Squares	Degrees of Freedom	Mean Squares	F-Ratio
Ammo. Mix	A	2.5109	1	2.5109	14.03*
Mode of Fire	B	0.3136	2	0.1568	0.82
Readiness State	C	2.0288	2	1.0144	5.67*
Rifle Type	D	1.7037	1	1.7037	9.52*
Temperature	E	49.9691	2	24.9846	139.58*
2-Factor Interactions					
	AB	0.4980	2	0.2490	1.30
	AC	0.0507	2	0.0254	0.13
	AD	13.2592	1	13.2592	74.07*
	AE	0.5007	2	0.2504	1.31
	BC	2.6731	4	0.6683	3.73*
	BD	2.7150	2	1.3575	7.58*
	BE	2.9318	4	0.7330	4.10*
	CD	0.6733	2	0.3366	1.88
	CE	0.4074	4	0.1018	0.53
	DE	18.1900	2	9.0950	50.81*
3-Factor Interactions					
	ABC	0.6052	4	0.1513	0.79
	ABD	0.1905	2	0.0952	0.50
	ABE	1.5573	4	0.3893	2.18
	ACD	0.5608	2	0.2804	1.47
	ACE	1.2521	4	0.3130	1.64
	ADE	0.2037	2	0.1018	0.53
	BCD	2.2376	4	0.5594	3.12*
	BCE	6.7221	8	0.8403	4.69*
	BDE	5.7777	4	1.4444	8.07*
	CDE	0.5816	4	0.1454	0.76
4-Factor Interactions					
	ABCD	0.8897	4	0.2224	1.16
	ABCE	1.0140	8	0.1267	0.66
	ABDE	1.0461	4	0.2615	1.37
	ACDE	0.7493	4	0.1873	0.98
	BCDE	8.3372	8	1.0422	5.82*
5-Factor Interaction					
	ABCDE	1.3371	7**	0.1910	
Total		131.4873	106**		

*Statistically significant at the 95% level of confidence.

**One degree of freedom was lost due to the necessity of estimating a parameter of the transformation from the data.

NOTE: The 5-Factor Interaction mean squares was used to test the significance of the other factors. The procedure suggested by Paull [6] was used as a decision rule for pooling mean squares.

TABLE XIV-B

ANALYSIS OF VARIANCE OF RELIABILITY DATA
(M16A1 Rifles)

Source of Variation		Sum of Squares	Degrees of Freedom	Mean Squares	F-Ratio
Ammo. Mix	A	1.4204	1	1.4204	7.50*
Mode of Fire	B	1.1953	2	0.5976	3.15*
Readiness State	C	1.7514	2	0.8757	4.62*
M16A1 Producer	D	1.2463	2	0.6252	3.29*
Temperature	E	44.1532	2	22.0766	116.50*
2-Factor Interactions					
	AB	0.1851	2	0.0926	0.43
	AC	0.5757	2	0.2878	1.34
	AD	9.1974	2	4.5987	24.27*
	AE	0.0184	2	0.0092	0.04
	BC	3.1472	4	0.7868	4.15*
	BD	2.3616	4	0.5904	3.12*
	BE	3.7464	4	0.9366	4.94*
	CD	0.1083	4	0.0271	0.13
	CE	0.4923	4	0.1231	0.57
	DE	3.9607	4	0.9902	5.23*
3-Factor Interactions					
	ABC	0.1260	4	0.0315	0.15
	ABD	0.8604	4	0.2151	1.00
	ABE	0.5046	4	0.1262	0.59
	ACD	1.3269	4	0.3317	1.55
	ACE	0.6143	4	0.1536	0.72
	ADE	2.8081	4	0.7020	3.71*
	BCD	3.8796	8	0.4850	2.56*
	BCE	9.6245	8	1.2031	6.35*
	BDE	4.2261	8	0.5283	2.79*
	BDE	2.6525	8	0.3316	1.55
4-Factor Interactions					
	ABCD	1.0996	8	0.1374	0.64
	ABCE	1.2763	8	0.1595	0.74
	ABDE	3.5955	8	0.4494	2.37*
	ACDE	2.2915	8	0.2864	1.34
	BCDE	8.2244	16	0.5140	2.71*
5-Factor Interaction					
	ABCDE	3.2170	15**	0.2145	
Total		119.8870	160**		

*Statistically significant at the 95% level of confidence.
**One degree of freedom was lost due to the necessity of estimating a parameter of the transformation from the data.

NOTE: The 5-Factor Interaction mean squares was used to test the significance of the other factors. The procedure suggested by Paull [6] was used as a decision rule for pooling mean squares.

TABLE XIV-C

ANALYSIS OF VARIANCE OF RELIABILITY DATA
(M14 Rifle)

Source of Variation		Sum of Squares	Degrees of Freedom	Mean Squares	F-Ratio
Ammo. Mix	A	13.6430	1	13.6430	157.64*
Mode of Fire	B	0.7193	2	0.3596	4.16*
Readiness State	C	0.3393	2	0.1696	1.96
Temperature	D	4.4085	2	2.2042	25.47*
2-Factor Interactions					
	AB	0.0402	2	0.0201	0.20
	AC	0.1392	2	0.0696	0.68
	AD	0.4946	2	0.2473	2.86
	BC	0.4476	4	0.1119	1.09
	BD	2.5707	4	0.6427	7.43*
	CD	0.2971	4	0.7428	0.72
3-Factor Interactions					
	ABC	1.0923	4	0.2731	3.16*
	ABD	1.1301	4	0.2825	3.26*
	ACD	1.4636	4	0.3659	4.23*
	BCD	2.3333	8	0.2917	3.37*
4-Factor Interaction					
	ABCD	0.7202	7**	0.1029	
Total		29.8390	52**		

*Statistically significant at the 95% level of confidence.

**One degree of freedom was lost due to the necessity of estimating a parameter of the transformation from the data.

NOTE: The 5-Factor interaction mean squares was used to test the significance of the other factors. The procedure suggested by Paull [6] was used as a decision rule for pooling mean squares.

TABLE XV-A

ANALYSIS OF VARIANCE OF CYCLIC RATE DATA
(M16A1 Rifles)

Source of Variation		Sum of Squares	Degrees of Freedom	Mean Squares	F-Ratio
Ammo. Mix	A	730.47	1	730.47	0.43
M16A1 Producer	B	52644.46	2	26322.23	19.68*
Readiness State	C	13257.83	2	1628.91	0.97
Temperature	D	155373.68	2	77686.84	58.07*
2-Factor Interactions					
	AB	15783.12	2	7891.56	5.90*
	AC	467.01	2	233.51	0.14
	AD	2362.12	2	1181.06	0.70
	BC	815.91	4	203.98	0.12
	BD	4170.73	4	1042.68	0.62
	CD	42388.25	4	10597.06	7.92*
3-Factor Interactions					
	ABC	931.17	4	232.79	0.14
	ABD	148.73	4	37.18	0.02
	ACD	1229.28	4	307.32	0.18
	BCD	5204.35	8	650.54	0.39
4-Factor Interaction					
	ABCD	1257.09	8	157.14	0.09
Error (Among Rifles)		181439.99	108	1680.00	
Total		468204.20	161		

*Statistically significant at the 95% level of confidence.

NOTE: The error mean squares was used to test the significance of the other factors. The procedure suggested by Paull [6] was used as a decision rule for pooling mean squares.

TABLE XV-B

Analysis of Variance of Cyclic Rate Data
(M14 Rifles)

Source of Variation		Sum of Squares	Degrees of Freedom	Mean Squares	F-Ratio
Ammo. Mix	A	1420.91	1	1420.91	1.82
Readiness State	B	994.04	2	497.02	0.51
Temperature	C	5681.93	2	2840.96	3.63*
2-Factor Interactions					
	AB	428.93	2	214.46	0.22
	AC	952.15	2	476.07	0.49
	BC	1311.07	4	327.77	0.33
3-Factor Interaction					
	ABC	77.52	4	19.38	0.02
Error (Among Rifles)		35261.35	36	979.48	
Total		46127.87	53		

*Statistically significant at the 95% level of confidence.

NOTE: The error mean squares was used to test the significance of the other factors. The procedure suggested by Paull [6] was used as a decision rule for pooling mean squares.

TABLE XVI

Summary of Total Malfunctions of M16A1 and M14 Rifles by
Mode of Fire, Readiness State, Rifle Type and Temperature

		M16A1 Rifles								
		Chamber Empty - Bolt Open			Chamber Empty - Bolt Closed			Round in Chamber - Bolt Closed		
Temp.		Semiauto	Auto(bursts)	Auto(full)	Semiauto	Auto(bursts)	Auto(full)	Semiauto	Auto(bursts)	Auto(full)
0°F	No. Malf.	0	5	3	4	1	0	3	3	2
	No. Rds. Cons.	1800	1800	1800	1800	1800	1800	1800	1800	1801
	No Malf/1000 rds	0	2.78	1.67	2.22	0.56	0	1.67	1.67	1.11
-20°F	No. Malf.	6	15	11	11	1	4	5	5	6
	No. Rds. Cons.	1800	1800	1858	1800	1800	1802	1800	1800	1854
	No Malf/1000 rds	3.33	8.33	5.92	6.11	0.56	2.22	2.78	2.78	3.24
-40°F	No. Malf.	44	28	25	15	17	42	59	5	37
	No. Rds. Cons.	1804	1801	1852	1801	1800	1846	1830	1800	1869
	No Malf/1000 rds	24.39	15.55	13.50	8.33	9.44	22.75	32.24	2.78	19.80

		M14 Rifles								
		Chamber Empty - Bolt Open			Chamber Empty - Bolt Closed			Round in Chamber - Bolt Closed		
Temp.		Semiauto	Auto(bursts)	Auto(full)	Semiauto	Auto(bursts)	Auto(full)	Semiauto	Auto(bursts)	Auto(full)
0°F	No. Malf.	3	2	5	0	1	2	3	0	5
	No. Rds. Cons.	600	600	693	600	600	600	600	600	618
	No Malf/1000 rds	5.00	3.33	7.22	0	1.67	3.33	5.00	0	8.09
-20°F	No. Malf.	3	11	3	5	5	2	5	9	2
	No. Rds. Cons.	600	600	669	600	600	600	600	600	615
	No Malf/1000 rds	5.00	18.33	4.48	8.33	8.33	3.33	8.33	15.00	3.25
-40°F	No. Malf.	6	5	6	7	13	2	6	8	10
	No. Rds. Cons.	600	600	694	600	600	628	600	600	702
	No Malf/1000 rds	10.00	8.33	8.65	11.67	21.67	3.18	10.00	13.33	14.25

TABLE XVII

Summary of Total Malfunctions of M16A1 Rifles By
Mode of Fire, Temperature, and Rifle Producer

M16A1 Rifle Producer		Temperature								
		0°F			-20°F			-40°F		
		Mode of Fire			Mode of Fire			Mode of Fire		
		Semiauto	Auto(bursts)	Auto(full)	Semiauto	Auto(bursts)	Auto(full)	Semiauto	Auto(bursts)	Auto(full)
Colt's	No. Malf.	3	3	4	3	10	10	20	13	19
	No. Rds. Cons.	1800	1800	1801	1800	1800	1895	1801	1800	1831
	No. Malf./1000 rds.	1.67	1.67	2.22	1.67	5.56	5.28	11.10	7.22	10.38
GM	No. Malf.	2	4	0	9	7	4	76	13	46
	No. Rds. Cons.	1800	1800	1800	1800	1800	1817	1833	1801	1873
	No. Malf./1000 rds.	1.11	2.22	0	5.00	3.89	2.20	41.46	7.22	24.56
H&R	No. Malf.	2	2	1	10	4	7	22	24	39
	No. Rds. Cons.	1800	1800	1800	1800	1800	1802	1801	1800	1863
	No. Malf./1000 rds.	1.11	1.11	0.56	5.56	2.22	3.88	12.22	13.33	20.93

TABLE XVIII

Summary of Total Malfunctions of M16A1 Rifles By Ammunition Mix, Temperature, and Rifle Producer

M16A1 Rifle Producer		Temperature					
		0°F		-20°F		-40°F	
		Ammo. Mix		Ammo. Mix		Ammo. Mix	
		20/0	4/1	20/0	4/1	20/0	4/1
Colt's	No. Malf.	0	10	4	19	16	36
	No. Rds. Cons.	2700	2701	2700	2795	2723	2709
	No. Malf/1000 rds.	0	3.70	1.48	6.80	5.88	13.29
GM	No. Malf.	3	3	16	4	88	47
	No. Rds. Cons.	2700	2700	2717	2700	2734	2773
	No. Malf/1000 rds.	1.11	1.11	5.89	1.48	32.19	16.95
H&R	No. Malf.	1	4	5	16	25	60
	No. Rds. Cons.	2700	2700	2700	2702	2702	2762
	No. Malf/1000 rds.	0.37	1.48	1.85	5.92	9.25	21.72

TABLE XIX

Summary of Total Malfunctions of M16A1 Rifles by
Mode of Fire, Readiness State, and Rifle Producers

M16A1 Rifle Producer		Readiness State								
		Chamber Empty - Bolt Open			Chamber Empty - Bolt Closed			Round in Chamber - Bolt Closed		
		Mode of Fire			Mode of Fire			Mode of Fire		
		Semiauto	Auto (bursts)	Auto (full)	Semiauto	Auto (bursts)	Auto (full)	Semiauto	Auto (bursts)	Auto (full)
Colt's	No. Malf.	12	14	11	6	4	9	8	8	13
	No. Rds. Cons.	1800	1800	1877	1800	1800	1803	1801	1800	1847
	No. Malf/1000 rds.	6.67	7.78	5.86	3.33	2.22	4.99	4.44	4.44	7.04
GM	No. Malf.	27	16	9	12	7	28	48	1	13
	No. Rds. Cons.	1804	1801	1803	1800	1800	1842	1829	1800	1845
	No. Malf/1000 rds.	14.97	8.88	4.99	6.67	3.89	15.20	26.24	0.56	7.05
H&R	No. Malf.	11	18	19	12	8	9	11	4	19
	No. Rds. Cons.	1800	1800	1830	1801	1800	1803	1800	1800	1832
	No. Malf/1000 rds.	6.11	10.00	10.38	6.66	4.44	4.99	6.11	2.22	10.37

TABLE XX

Summary of Total Malfunctions of M14 Rifles By Ammunition Mix, Temperature, and Mode of Fire

Mode of Fire	Observations	Temperature					
		0°F		-20°F		-40°F	
		Ammo. Mix		Ammo. Mix		Ammo. Mix	
		20/0	4/1	20/0	4/1	20/0	4/1
Semi-auto	No. Malf.	6	0	3	0	11	1
	No. Rds. Cons.	900	900	900	900	975	936
	No. Malf./1000 rds.	6.67	0	3.33	0	11.28	1.07
Auto (bursts)	No. Malf.	13	0	22	3	6	1
	No. Rds. Cons.	900	900	900	900	964	920
	No. Malf./1000 rds.	14.44	0	24.44	3.33	6.22	1.09
Auto (full)	No. Malf.	14	5	20	10	15	3
	No. Rds. Cons.	900	900	900	900	1074	950
	No. Malf./1000 rds.	15.56	5.56	22.22	11.11	13.97	3.16

TABLE XXI

Summary of Total Malfunctions of M14 Rifles By Ammunition Mix, Temperature and Readiness State

Readiness State		Temperature 0°F Ammo. Mix 20/0	0°F 4/1	-20°F Ammo. Mix 20/0	-20°F 4/1	-40°F Ammo. Mix 20/0	-40°F 4/1
Chamber Empty - Bolt Open	No. Malf.	10	0	15	2	10	7
	No. Rds. Cons.	973	920	949	920	960	934
	No. Malf./1000 rds.	10.28	0	15.81	2.17	10.42	7.49
Chamber Empty - Bolt Closed	No. Malf.	3	0	11	1	19	3
	No. Rds. Cons.	900	900	900	900	928	900
	No. Malf/1000 rds.	3.33	0	12.22	1.11	20.47	3.33
Round in Chamber-Bolt Closed	No. Malf.	7	1	15	1	20	4
	No. Rds. Cons.	902	916	915	900	986	916
	No. Malf/1000 rds.	7.76	1.10	16.39	1.11	20.28	4.37

TABLE XXII

Summary of Total Malfunctions of M14 Rifles By Ammunition Mix, Mode of Fire, and Readiness State

Readiness State		Mode of Fire					
		Semiauto		Auto (bursts)		Auto (full)	
		Ammo. Mix		Ammo. Mix		Ammo. Mix	
		20/0	4/1	20/0	4/1	20/0	4/1
Chamber Empty - Bolt Open	No. Malf.	8	4	14	4	13	1
	No. Rds. Cons.	900	900	900	900	1082	974
	No. Malf/1000 rds.	8.89	4.44	15.56	4.44	12.01	1.03
Chamber Empty - Bolt Closed	No. Malf.	11	1	17	2	5	1
	No. Rds. Cons.	900	900	900	900	928	900
	No. Malf/1000 rds.	12.22	1.11	18.89	2.22	5.39	1.11
Round in Chamber-Bolt Closed	No. Malf.	14	0	14	3	14	3
	No. Rds. Cons.	900	900	900	900	1003	932
	No. Malf/1000 rds.	15.56	0	15.56	3.33	13.96	3.22

TABLE XXIII

Summary of Total Malfunctions of M14 Rifles By Mode of Fire, Temperature, and Readiness State

Readiness State	Observations	Temperature 0°F Mode of Fire Semiauto	0°F Auto(bursts)	0°F Auto(full)	-20°F Mode of Fire Semiauto	-20°F Auto(bursts)	-20°F Auto(full)	-40°F Mode of Fire Semiauto	-40°F Auto(bursts)	-40°F Auto(full)
Chamber Empty - Bolt Open	No. Malf.	3	2	5	3	11	3	6	5	6
	No. Rds. Cons.	600	600	693	600	600	669	600	600	694
	No Malf/1000 rds	5.00	3.33	7.22	5.00	18.33	4.48	10.00	8.33	8.65
Chamber Empty - Bolt Closed	No. Malf.	0	1	2	5	5	2	7	13	2
	No. Rds. Cons.	600	600	600	600	600	600	600	600	628
	No Malf/1000 rds	0	1.67	3.33	8.33	8.33	3.33	11.67	21.67	3.18
Round in Chamber-Bolt Closed	No. Malf.	3	0	5	5	9	2	6	8	10
	No. Rds. Cons.	600	600	618	600	600	615	600	600	702
	No Malf/1000 rds	5.00	0	8.09	8.33	15.00	3.25	10.00	13.33	14.24

Figure 1

NUMBER OF MALFUNCTIONS/1000 ROUNDS

BY

RIFLE MANUFACTURER

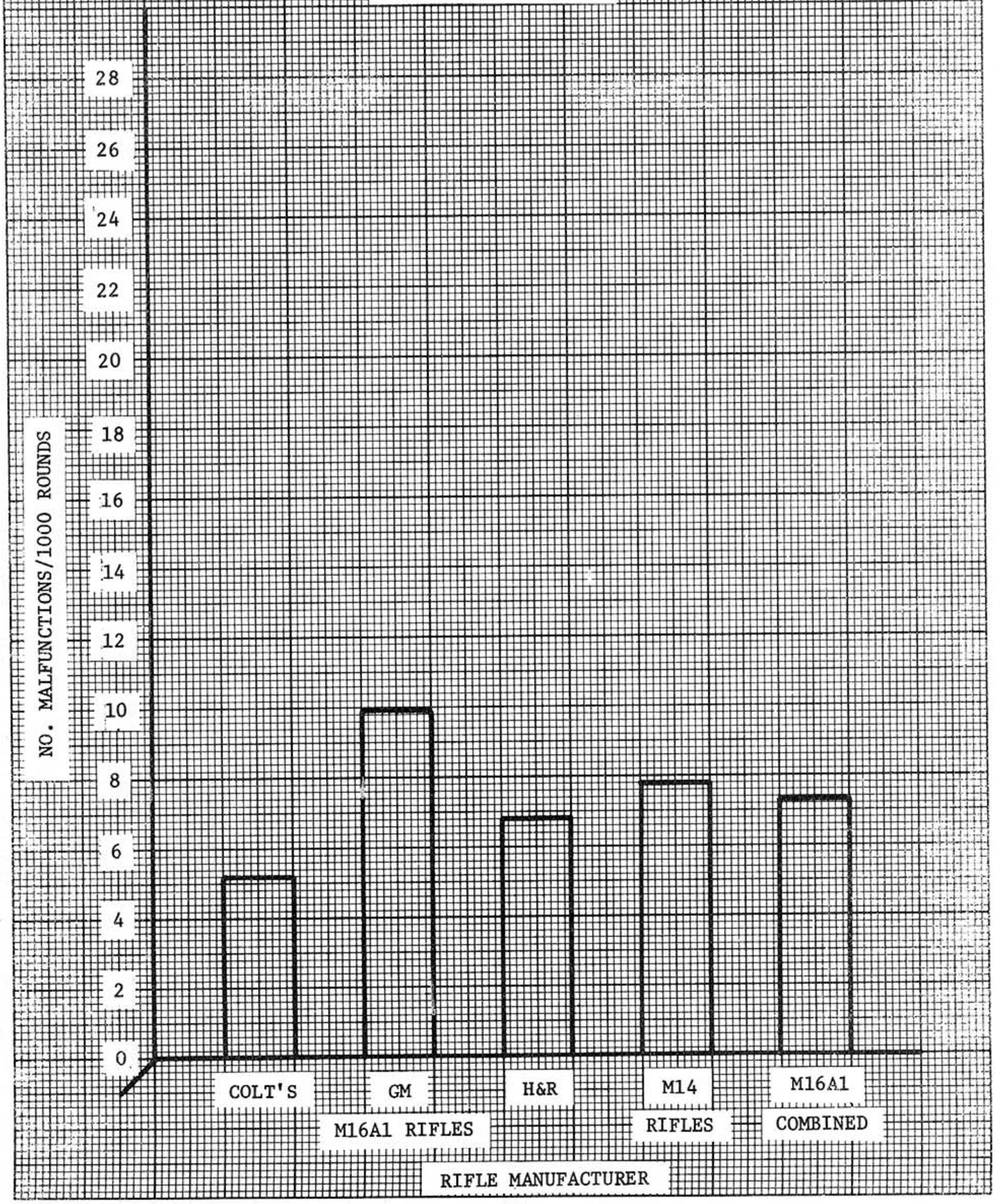
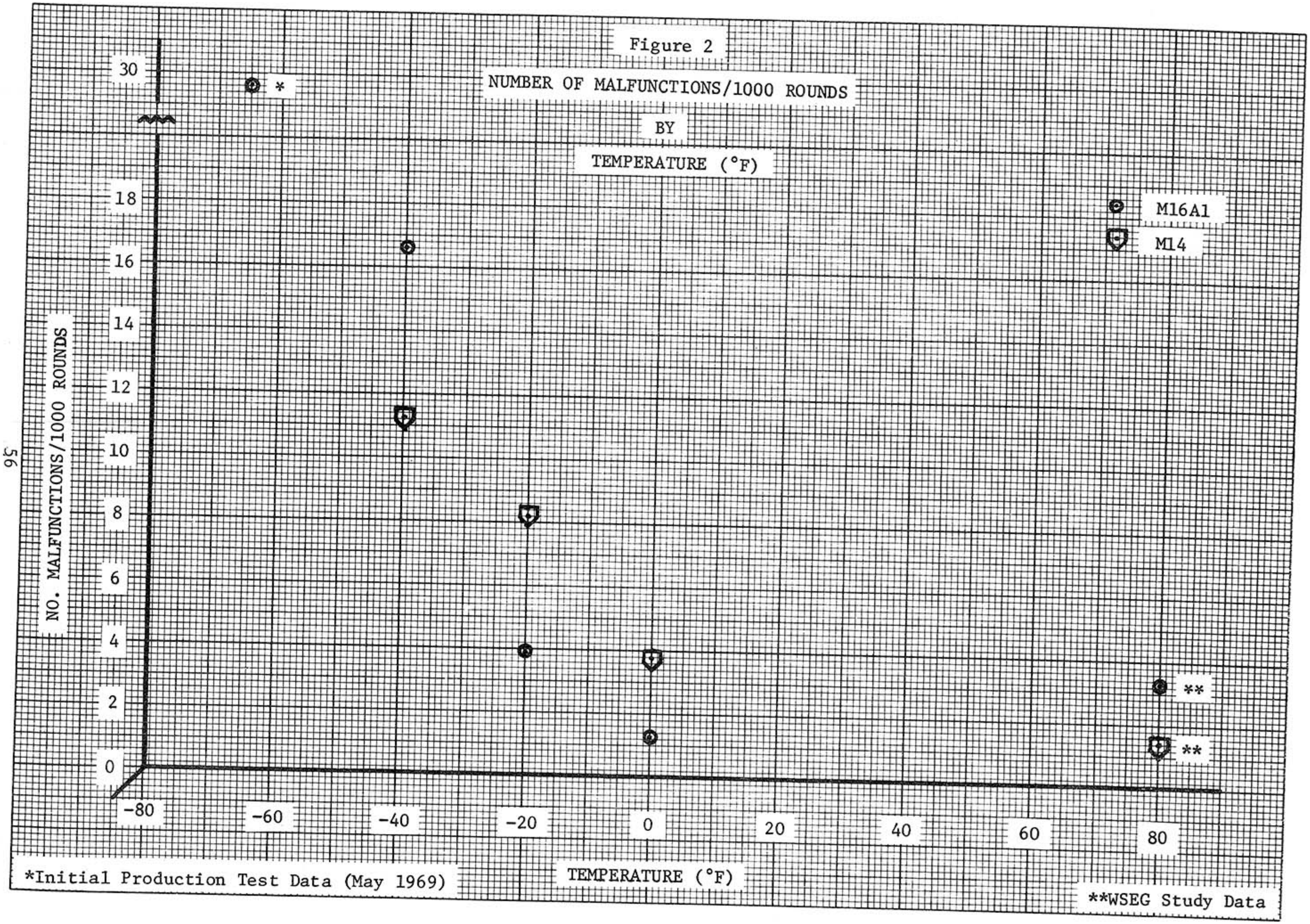


Figure 2

NUMBER OF MALFUNCTIONS/1000 ROUNDS

BY

TEMPERATURE (°F)



*Initial Production Test Data (May 1969)

**WSEG Study Data

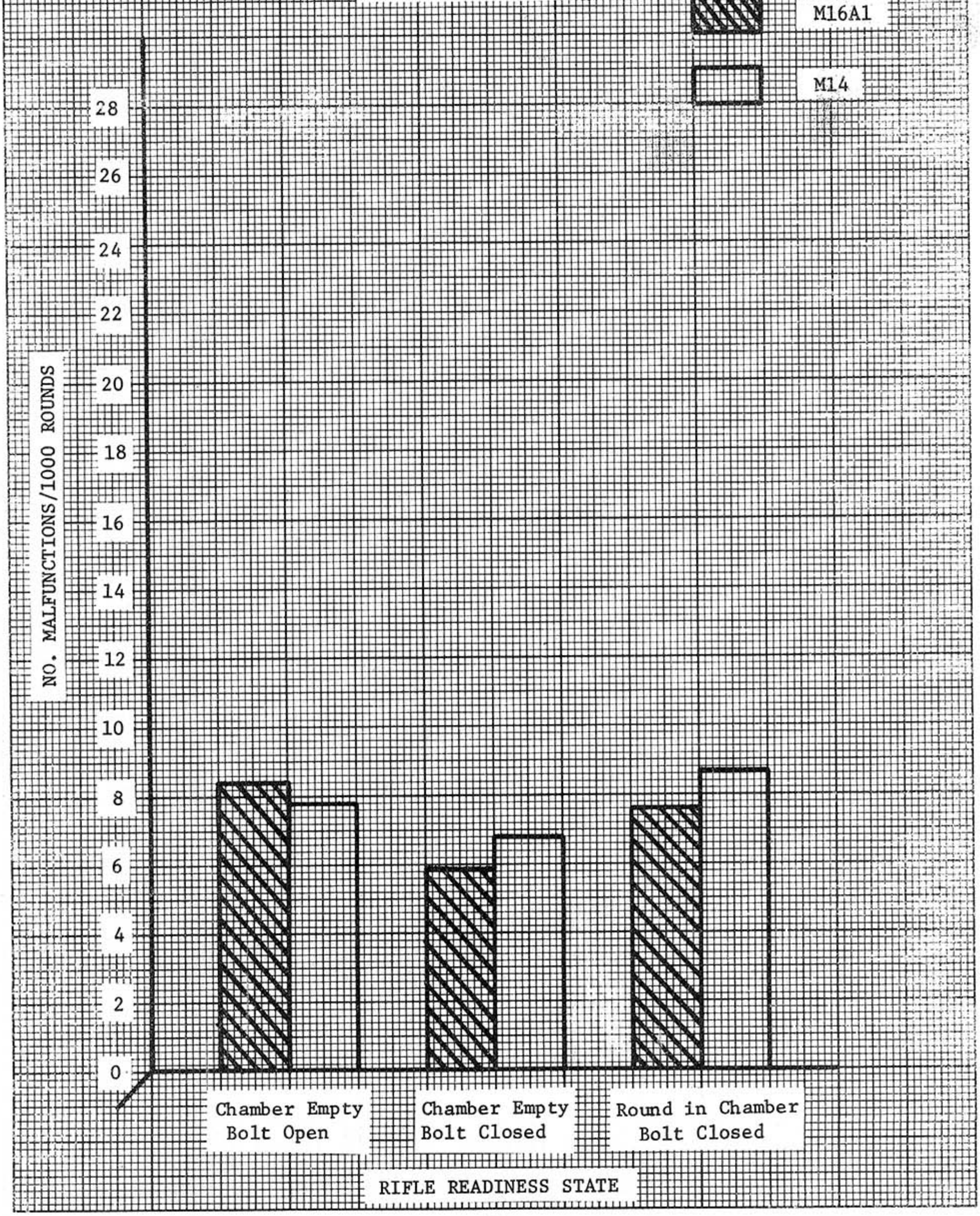


Figure 3

NUMBER OF MALFUNCTIONS/1000 ROUNDS

BY

RIFLE READINESS STATE

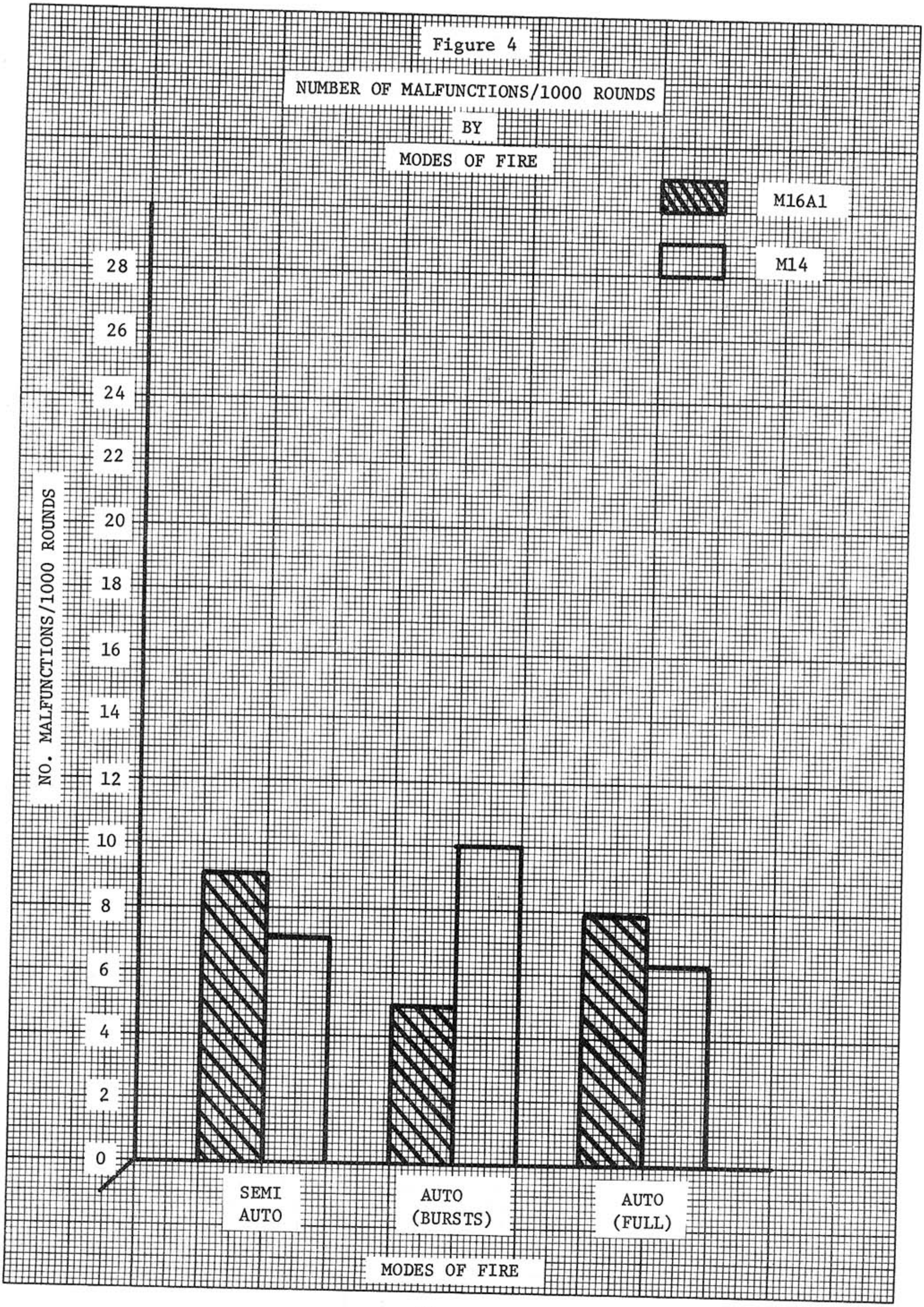


Figure 4
NUMBER OF MALFUNCTIONS/1000 ROUNDS
BY
MODES OF FIRE
M16A1
M14
NO. MALFUNCTIONS/1000 ROUNDS
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
SEMI AUTO
AUTO (BURSTS)
AUTO (FULL)
MODES OF FIRE

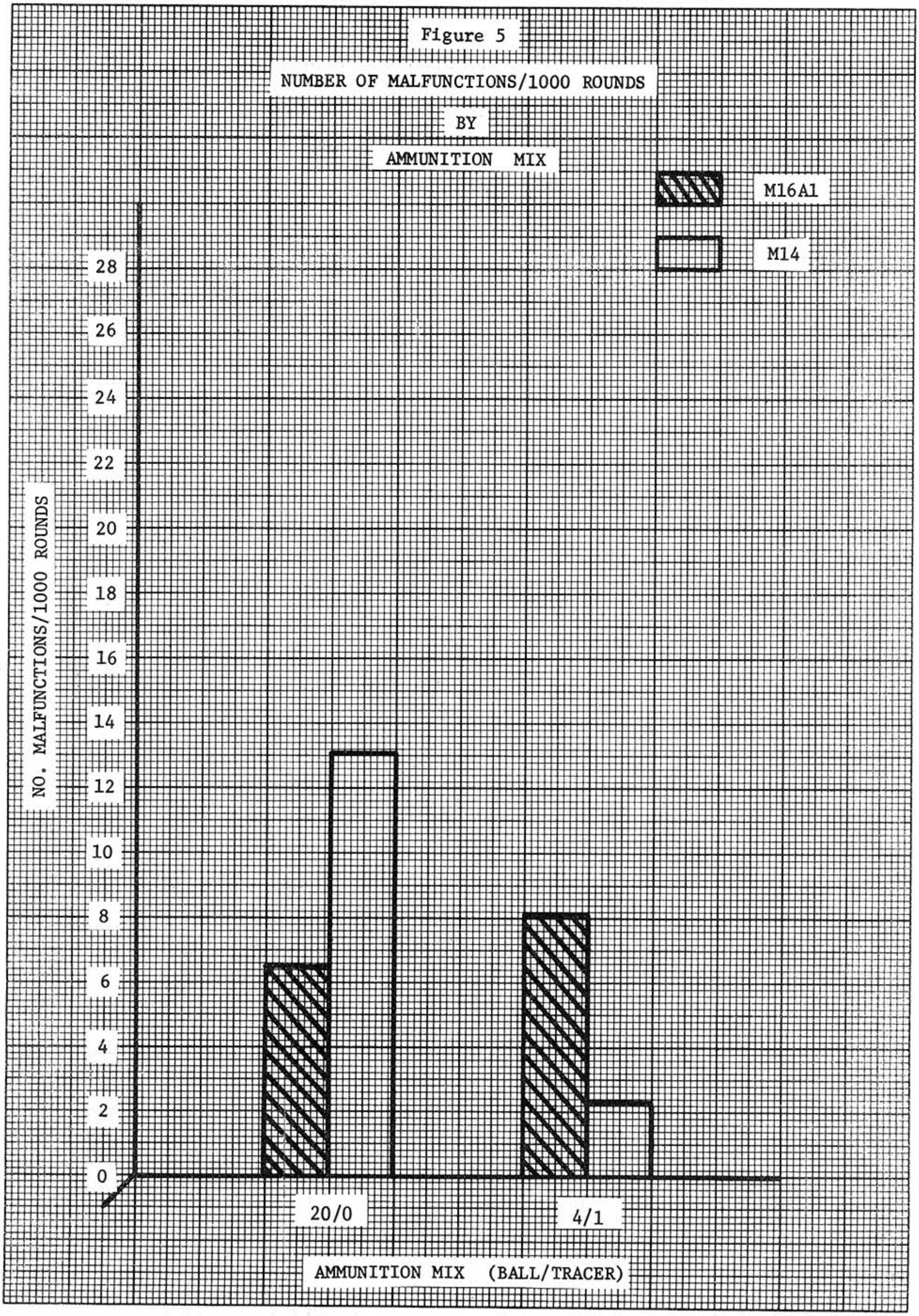


Figure 5
NUMBER OF MALFUNCTIONS/1000 ROUNDS
BY
AMMUNITION MIX
M16A1
M14
NO. MALFUNCTIONS/1000 ROUNDS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
20/0
4/1
AMMUNITION MIX (BALL/TRACER)

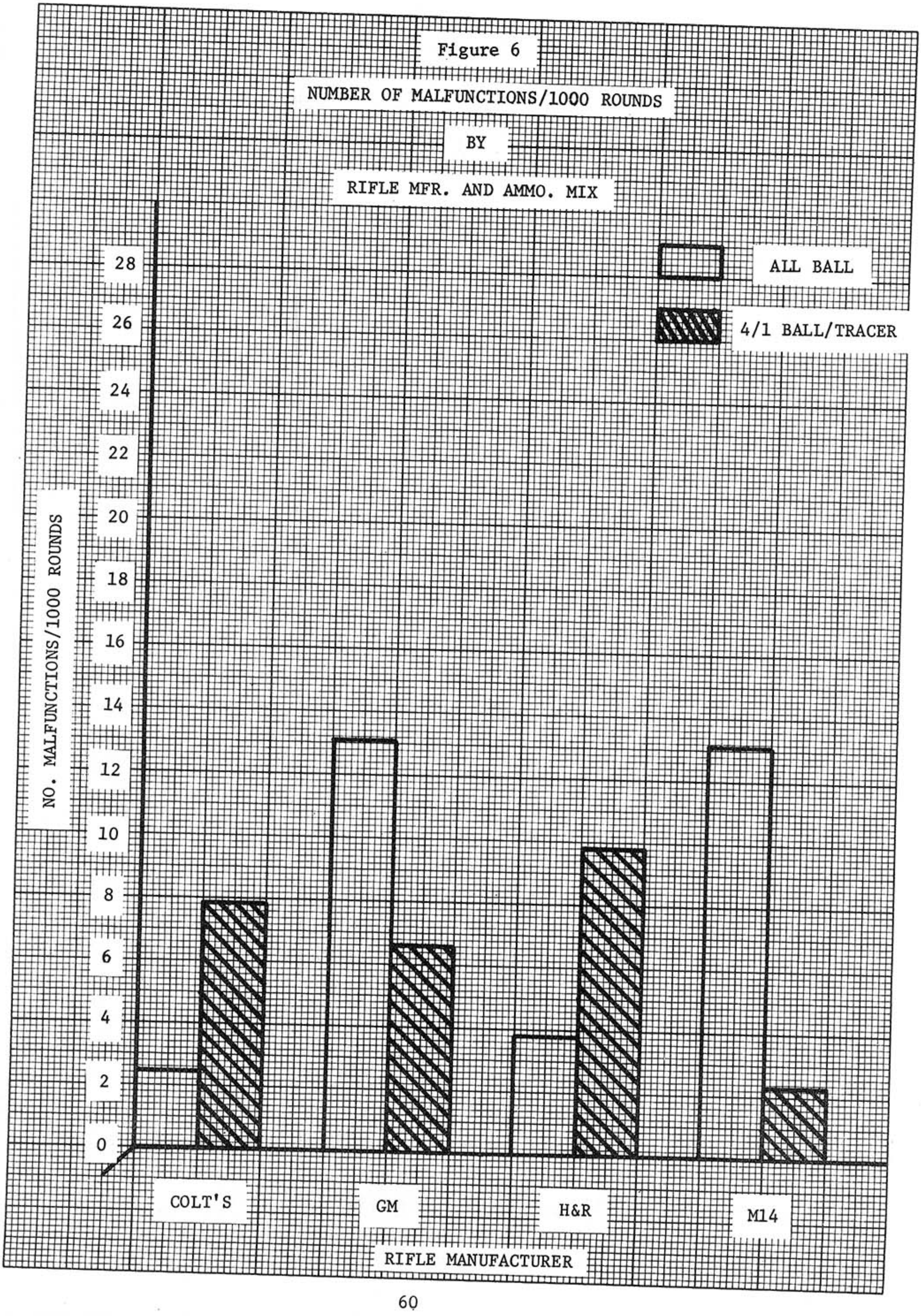


Figure 6

NUMBER OF MALFUNCTIONS/1000 ROUNDS

BY

RIFLE MFR. AND AMMO. MIX

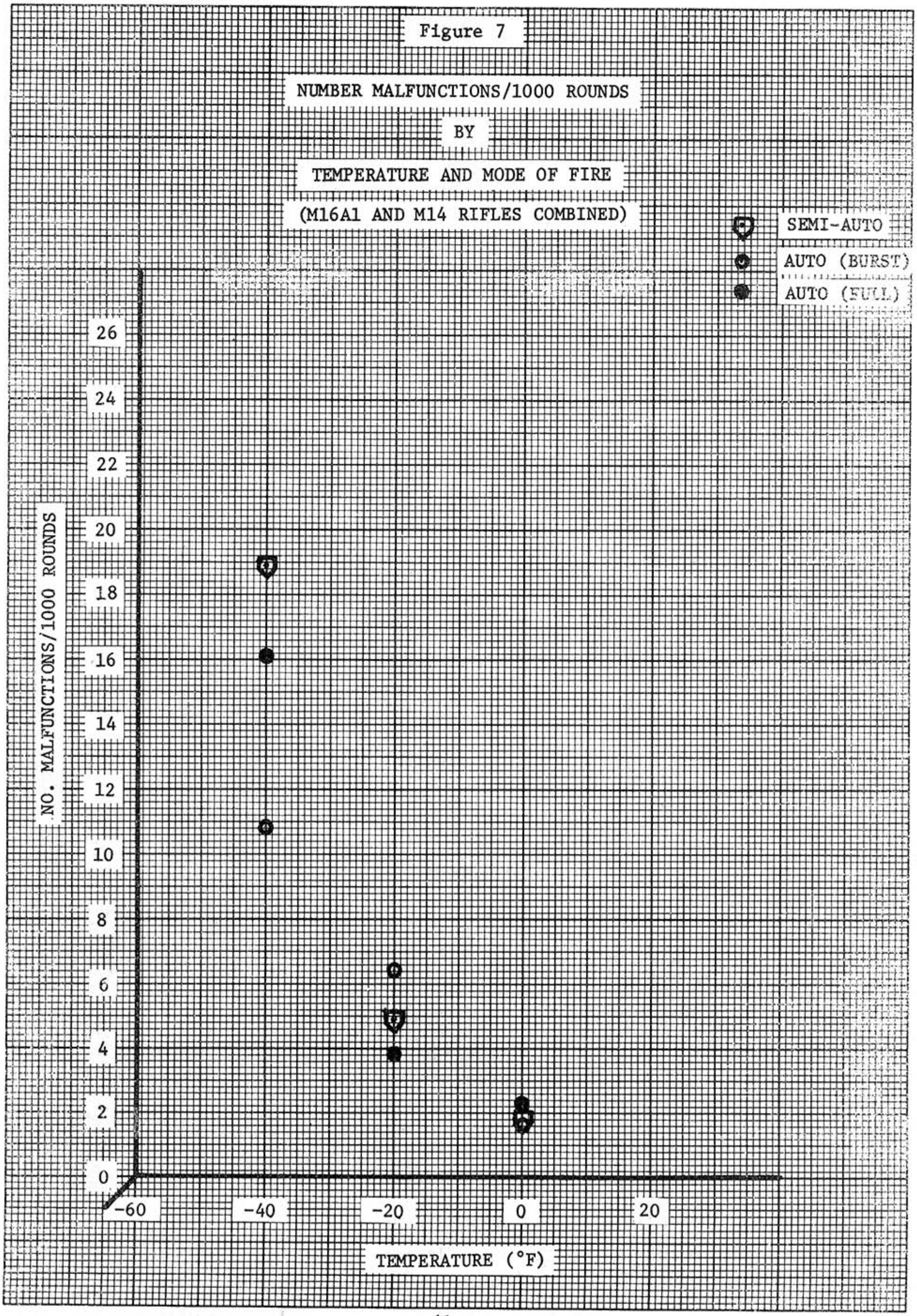


Figure 7
NUMBER MALFUNCTIONS/1000 ROUNDS
BY
TEMPERATURE AND MODE OF FIRE
(M16A1 AND M14 RIFLES COMBINED)
SEMI-AUTO
AUTO (BURST)
AUTO (FULL)
NO. MALFUNCTIONS/1000 ROUNDS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
-60
-40
-20
0
20
TEMPERATURE (°F)

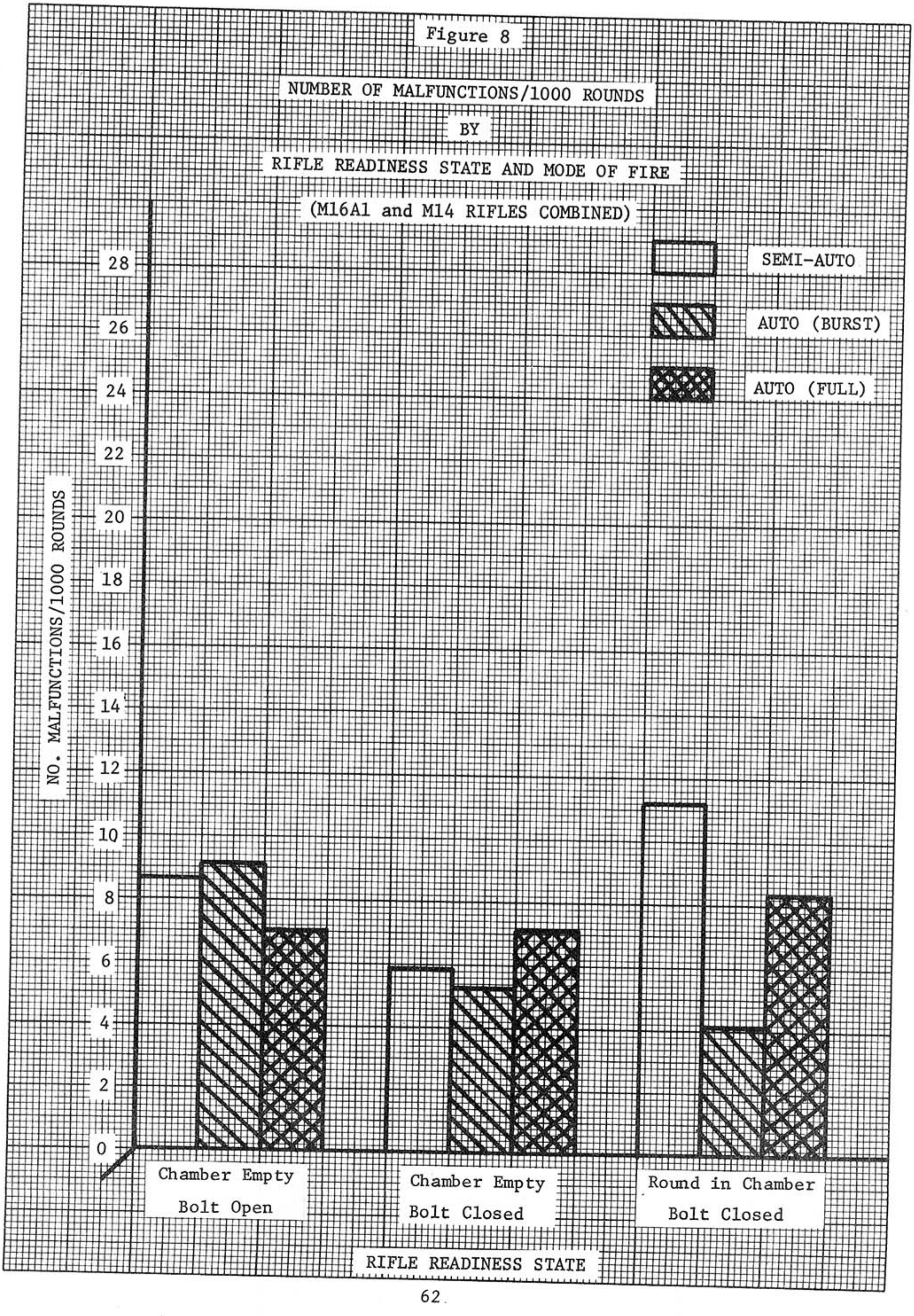


Figure 8
NUMBER OF MALFUNCTIONS/1000 ROUNDS
BY
RIFLE READINESS STATE AND MODE OF FIRE
(M16A1 and M14 RIFLES COMBINED)
SEMI-AUTO
AUTO (BURST)
AUTO (FULL)
NO. MALFUNCTIONS/1000 ROUNDS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Chamber Empty
Bolt Open
Chamber Empty
Bolt Closed
Round in Chamber
Bolt Closed
RIFLE READINESS STATE

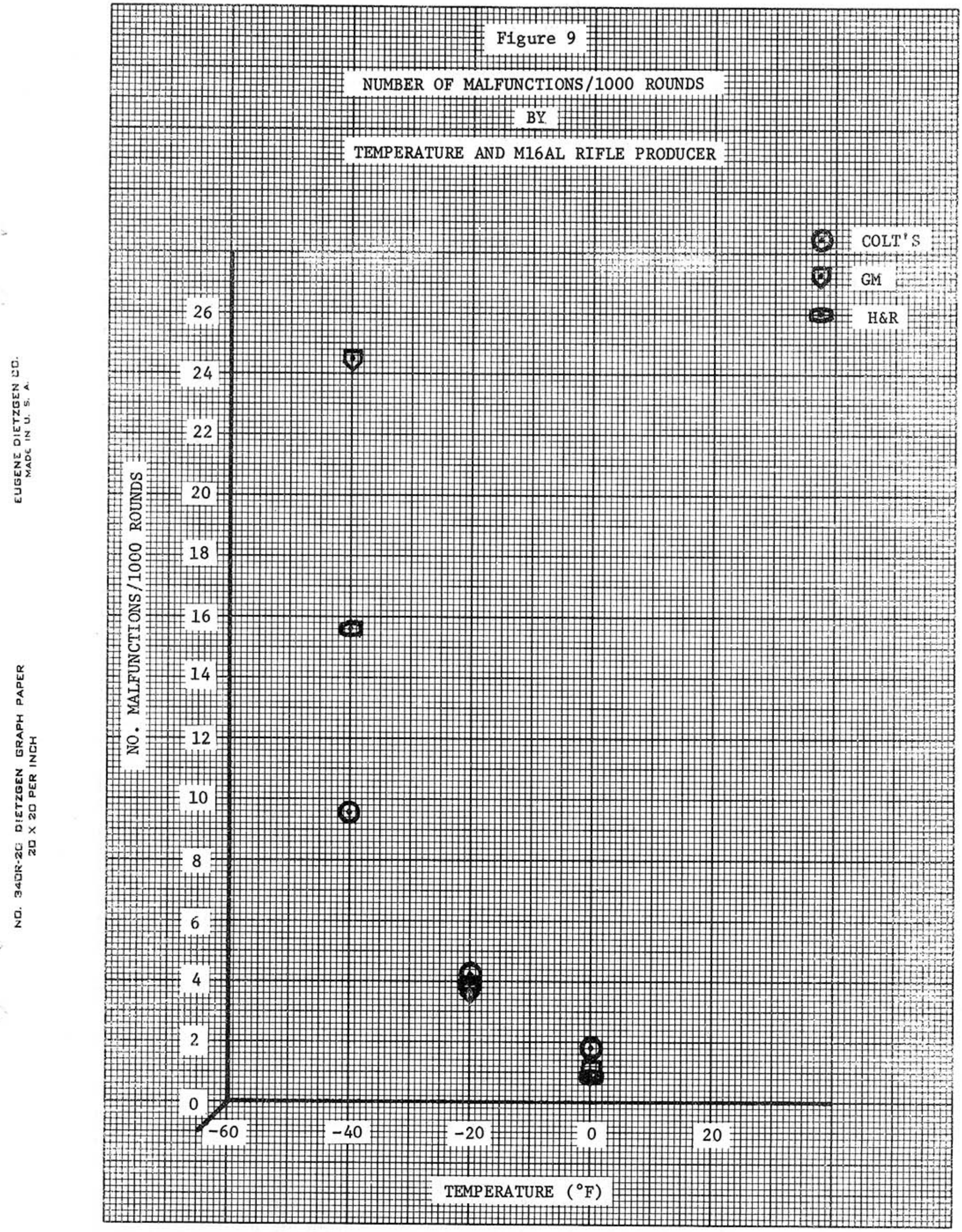


Figure 9
NUMBER OF MALFUNCTIONS/1000 ROUNDS
BY
TEMPERATURE AND M16AL RIFLE PRODUCER
COLT'S
GM
H&R
NO. MALFUNCTIONS/1000 ROUNDS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
-60
-40
-20
0
20
TEMPERATURE (°F)
NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.

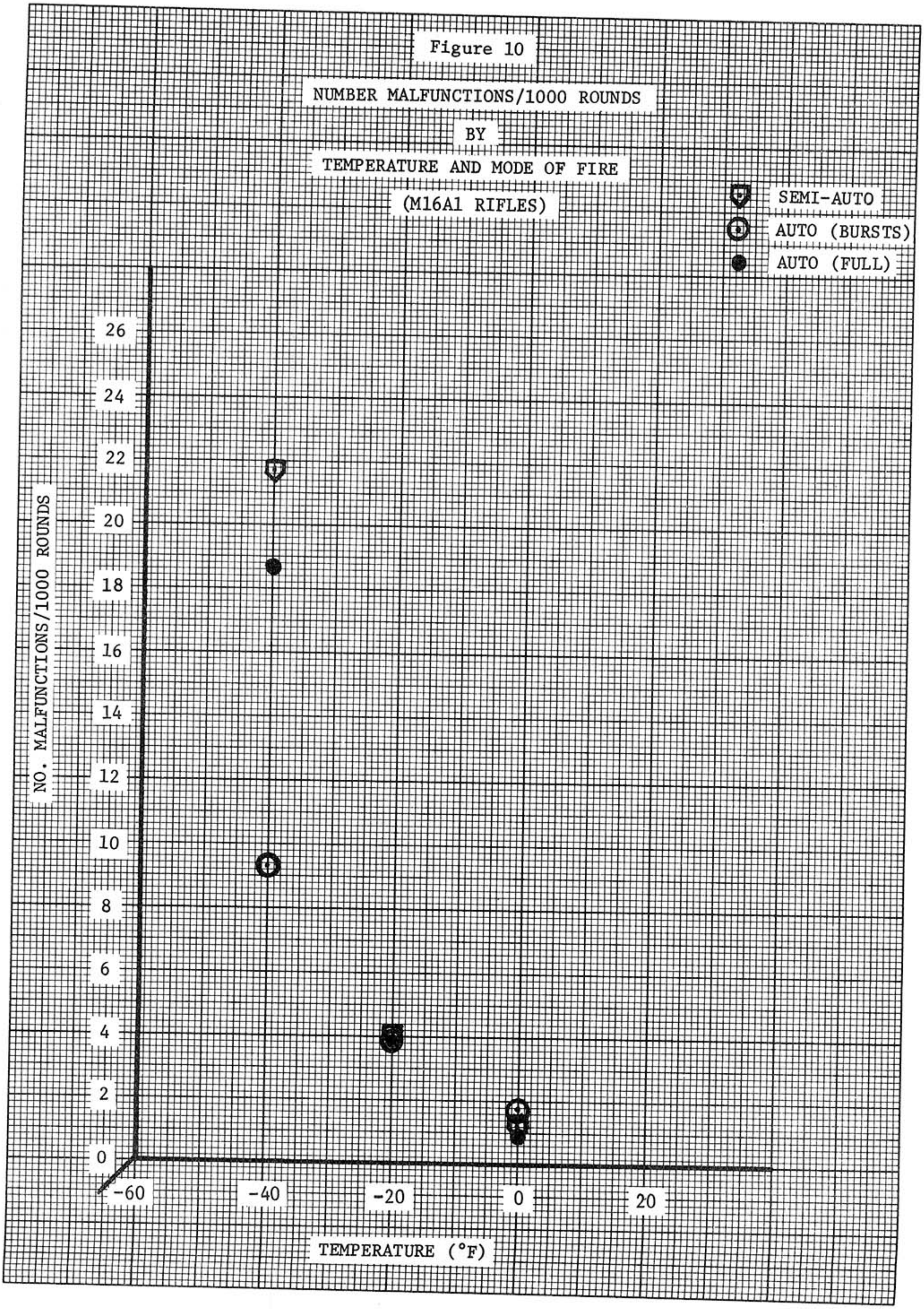


Figure 10
NUMBER MALFUNCTIONS/1000 ROUNDS
BY
TEMPERATURE AND MODE OF FIRE
(M16A1 RIFLES)
SEMI-AUTO
AUTO (BURSTS)
AUTO (FULL)
NO. MALFUNCTIONS/1000 ROUNDS
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-60
-40
-20
0
20
TEMPERATURE (°F)

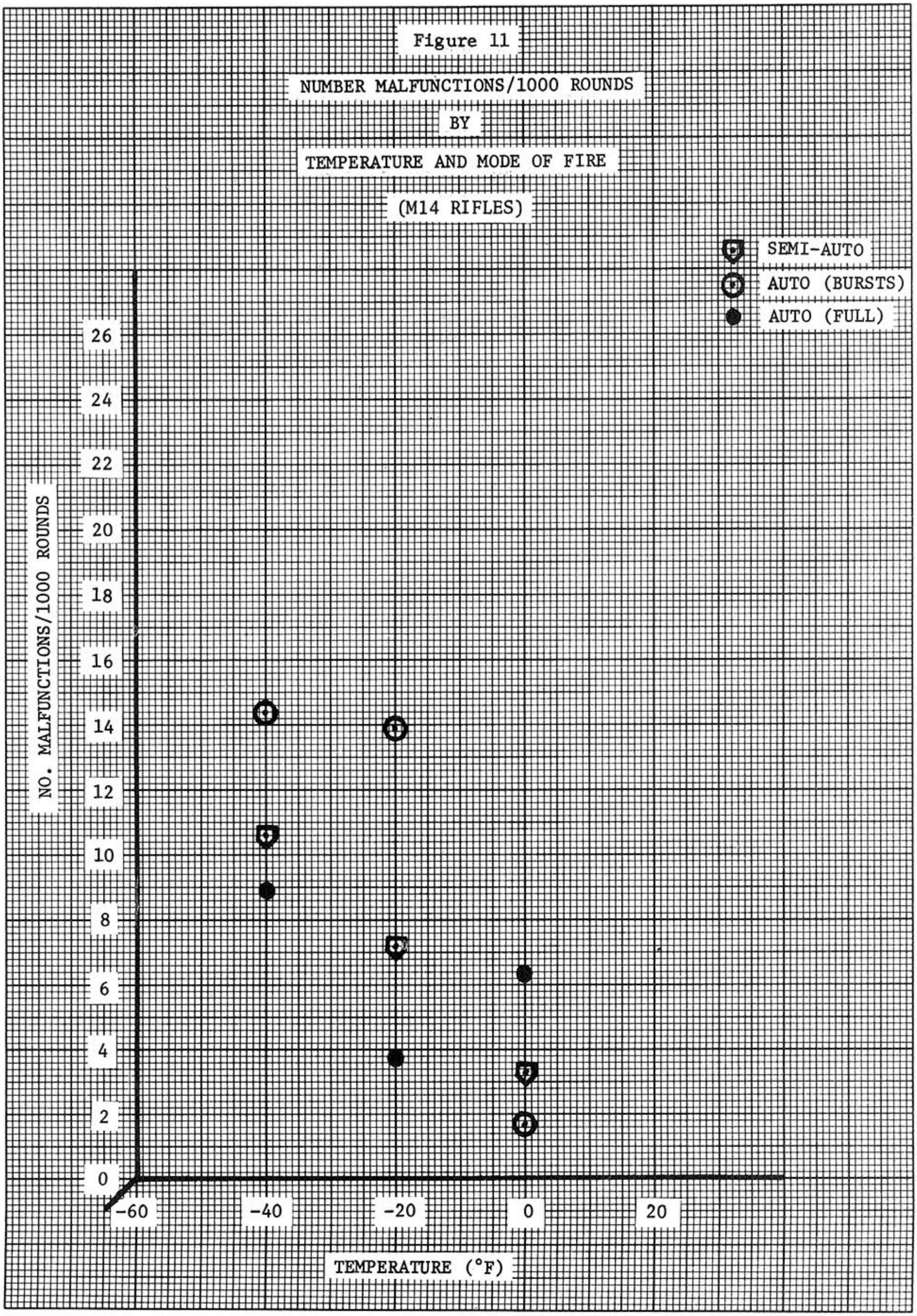


Figure 11

NUMBER MALFUNCTIONS/1000 ROUNDS
BY
TEMPERATURE AND MODE OF FIRE
(M14 RIFLES)

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Aberdeen Research and Development Center/ Aberdeen Proving Ground, Md.	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A

3. REPORT TITLE

Reliability Characteristics of the M16A1 and M14 Rifle Systems at Low Temperatures

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

ARDC Technical Report

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

Weldon F. Willoughby

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1969		6

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No.
b. PROJECT NO.	
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13. ABSTRACT

A special study has been conducted to evaluate the reliability characteristics of the M16A1 Rifle System at low temperatures. Since no standards for reliability at low temperatures are available this study included the firing of a special test, with parallel tests of the M14 Rifle System to provide a basis for comparison. The test was statistically designed, thereby enabling the effects of several factors and their interactions to be studied simultaneously and on a sound technical basis. The factors of prime interest were differences among individual rifles, between rifle types, ammunition mixes, among M16A1 Rifle producers, temperatures, readiness states, and modes of fire. This report presents a summary of the results of this study.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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M14 Rifle						
Low Temperature Reliability						
Analysis of Variance						
Statistical Analysis						