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PRIMER SELECTION FOR SMALL ARMS AMMUNITION

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CONTENTS

I. INTRODUCTION

By a letter and accompanying work statement of 17 June 1970, the Institute for Defense Analyses (IDA) was requested to undertake for the Office of the Director of Defense Research and Engineering (ODDR&E) a brief review "of the desirability and need for mandatory standardization of one primer mix for all small arms ammunition." Background for the request was the Army's prospective standardization of primers for 5.56-mm ammunition and concern about "the impact such an action would have on major existing production capabilities." Subsequent to the issuance of the work statement, it developed, as will be seen, that the questions to be studied by IDA related primarily to the 5.56-mm round and only incidentally to <u>all</u> small arms ammunition.

For a number of years the Army has been attempting to standardize the primers in military small arms ammunition. The primer for the 7.62-mm NATO cartridge, among others, has been standardized, and similar action is planned for the 5.56-mm round. In this context standardization is understood to mean the identification of one primer design which is precisely described in suitable Government documentation and the specification of that design, to the exclusion of all others, for use in the manufacture of cartridges of a given configuration.

In the 7.62-mm primer standardization, the specified primer material is a composition known as FA-956, which contains, among other ingredients, <u>normal</u> lead styphnate for the percussion-sensitive initiating explosive. The planned 5.56-mm primer standardization would utilize the same primer composition. This standardization will result in little or no change at six of the eight present sources of 5.56-mm ammunition since these are now using the FA-956 mix. However,

one major supplier, the Federal Cartridge Corporation (Federal or FCC) of Minneapolis, which supplies ammunition from both its company-owned plant at Anoka, Minnesota, and the Government-owned Twin Cities Army Ammunition Plant (TCAAP), has been using another primer composition containing basic lead styphnate in 5.56-mm cartridge production at both sources. Federal considers the prospective standardization unwise and has brought its objections to the attention of ODDR&E.

Specific tasks described in the work statement include:

"I. Review the technical merits of the use of normal lead styphnate versus basic lead styphnate in primers for small arms ammunition, including 7.62 and 5.56 mm, produced for the U.S. Army.

"II. Review the non-technical merits and arguments for and against standardizing on one primer mix for ammunition produced for the U.S. Army. The review should include, but not be limited to, consideration of desirability of standardization, desirability of alternate sources of supply, cost, proprietary rights, manufacturing difficulties and quality control."

In early discussions Army personnel pointed out that the Army's objective is to standardize the primer mix for each type of round--not necessarily to standardize on the same mix for all small arms ammunition, and that only the high-use ammunition is affected. Besides the 7.62-mm primer, a percussion and an electric primer for 20-mm ammunition and the caliber .30 primer have thus far been standardized, the latter simply through adoption of the 7.62-mm primer. While the 20-mm percussion primer uses the same primer composition (FA-956) as does the 7.62-mm, the electric primer uses a different mix. Scheduled for standardization are the 5.56-mm primer, as has been mentioned, and percussion primers for another 20-mm cartridge and a 30-mm round. There are no plans for standardizing primers for the caliber .22, .32, .38, .45 and .50 cartridges and the shot shells which the Army procures, although it is understood that problems in the M41 (a jacketed

caliber .38 cartridge) may lead to specification of the primer for that round. Procurement volume for these rounds is low, and unjacketed cartridges and shot shells are procured to commercial specifications.

Thus the issues in this inquiry are primarily the wisdom of permitting only one primer mix, in lieu of the two now in use, in future production of 5.56-mm ammunition and secondarily the correctness of the choice of the FA-956 mix for the standard composition. These questions have obvious implications for the 7.62-mm primer as well as for those primers whose standardization is not contended. Principal subsidiary questions raised either by the work statement or in early discussions are the following:

1. Relative merits of primer materials
    a. Engineering properties of primer compositions and initiating compounds.
    b. Requirements for primers.
    c. Performance of primers in ammunition in ordinary use.
    d. Performance under extraordinary conditions.
    e. Safety in manufacture and handling.
    f. Cost.
    g. Suitability for automatic inspection.
2. Value of standardization
    a. Testing.
    b. Reduction of the number of variables in cartridges.
    c. Performance.
3. Cost of standardization
    a. Production capability; mobilization capacity.
    b. Effect on Government's procurement position.
    c. Hardship to suppliers.

The remainder of the paper is devoted largely to a discussion of these questions. Most of the information presented was obtained from discussions with experts in the field outside the Institute for Defense Analyses. A list of the principal discussions is shown in Attachment A.

To complete this introduction it is perhaps useful to observe that the cost of primers for 5.56-mm ammunition is approximately $3.50 per thousand, of which about $0.30 is the cost of the primer mix. The cost of complete 5.56-mm cartridges is about $60 per thousand, and the current (July 1970) rate of production is about 200 million rounds monthly.

II. HISTORY OF STANDARDIZATION OF PRIMERS

During World War I primers containing either mercury fulminate or potassium chlorate were generally used; during World War II potassium chlorate primers were used. Since that time the United States has used lead styphnate in its small arms ammunition primers because it is less corrosive than the other types. However, a number of different types of lead styphnate primers have been used. The primer mix contains many ingredients in addition to the lead styphnate and each manufacturer at one time used a different mix. In addition, one of the manufacturers, Federal Cartridge Corporation, has been using basic lead styphnate while all the other manufacturers and the Army used normal lead styphnate. The U.S. Army established the Integration Committee on Small Arms Ammunication during World War II and reactivated this committee during the Korean War. In June 1958, the Primer Subcommittee, which included Federal Cartridge Corporation representation, agreed unanimously to recommend standardization of the FA-961 primer mix but stated that the standardization was not to be implemented immediately (Attachment B). The recommended primer mix contained normal lead styphnate and zirconium, among other ingredients. Subsequent to this agreement, problems were discovered with the FA-961 mix and the Army decided to standardize on the FA-956 mix, which also used normal lead styphnate. The primer made with the FA-956 mix for the 7.62-mm cartridge is designated FA-34 and the primer for the 5.56-mm cartridge is designated FA-41. As a result of the NATO requirement for standardization, the 7.62-mm ammunition has used the FA-34 primer since mid-1963. Prompted by the controversy in 1967 over the M16 rifle (which uses the 5.56-mm cartridge) and the resulting inquiry by a subcommittee of the House Committee on Armed Services chaired by

Representative Ichord of Missouri, the Office of the Chief of Staff of the Army conducted a thorough review of the problems of that rifle. One conclusion of that review* was a recommendation that the 5.56-mm primer be standardized.

Federal has manufactured large quantities of both 5.56-mm and 7.62-mm ammunition at the Twin Cities Army Ammunition Plant (TCAAP), which has never had its own lead styphnate primer mix facility. FA-34 primers for the 7.62-mm ammunition have been provided by the Army from the Lake City Army Ammunition Plant (LCAAP), and Federal has been supplying its own primer mix for the production of primers for the 5.56-mm round from its plant in Anoka, 15 miles distant from TCAAP. The Federal primer for the 5.56-mm round is designated FCC-195. It uses the Federal K-75 mix. Basic lead styphnate is one ingredient of this mix.

The Army is installing a primer facility at TCAAP to eliminate the vulnerability of the plant to a loss of primers provided by other sources. As one more step in its standardization program, the Army designed this primer facility to manufacture normal lead styphnate and the FA-956 primer mix. This facility is nearly completed; however, about another $100,000 in funds is needed to complete the facility and these funds are not presently available. It will require approximately seven months after the availability of these funds to get the primer facility on stream. Total cost of the facility will be about $2.2 million. It is estimated that the facility will be on stream approximately March 1, 1971, if the necessary additional funding is received in the near future.

For convenience in relating the nomenclature to the materials and suppliers, the following table is provided in which are listed all of the primers and primer mixes mentioned in this paper. Of the four mixes shown, the first and the last are the ones of principal interest in this study.

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*Office of the Chief of Staff, Department of the Army, Report of the M16 Rifle Review Panel, 1 June 1968.

PRIMERS AND PRIMER MIXES

Initiating Explosive	Used in Primer Mix	Designation of Primers 5.56-mm	Designation of Primers 7.62-mm	Suppliers	Status
Basic Lead Styphnate	FCC K-75	FCC-195	FCC-205	Federal, TCAAP	FCC-195 in production. FCC-205 production discontinued in 1963.
	FCC K-75A	FCC-195A	FCC-205A	Federal	Experimental; not accepted.
Normal Lead Styphnate	FA-961 (X28)		FA-36	None	Abandoned in favor of FA-956 mix.
	FA-956	FA-41	FA-34	LCAAP Western Winchester Remington Can. Comm. Frankford	Production. FA-34 is standard. FA-41 is prospective standard.

III. TECHNICAL BACKGROUND

The essential function of the primer is to bring about, when subjected to a firing impulse, controlled ignition of the propellant. The firing impulse in all small arms ammunition less than 20 mm in diameter is a mechanical shock or percussion applied by a firing pin. The primer must function with high reliability under all conditions of field use with a minimum of undesirable side effects. Primer defects may cause firing failures that can be very serious in their consequences, and therefore the Army goes to considerable length in production, inspection, and handling to minimize the frequency of such defects. A misfire, meaning a failure of a bullet to move out of the cartridge case due either to failure of the primer to fire or to failure of the propellant to ignite, stops the action in automatic rifles, requiring manual removal of the cartridge. A hangfire, meaning a delayed firing, may injure the gunner if firing occurs after the breech is opened. A bullet in the bore can result from failure of the propellant to ignite or from incomplete burning of the propellant. If a second bullet is fired into the bullet in the bore, the weapon is usually damaged beyond repair, and the rifleman may be injured. Escape of high-pressure gases to the rear, caused by gas leaks in or around the primer, can injure the gunner. Because of the floating firing pin in the M16 rifle, inadvertent firing may occur in that weapon at the instant of loading the chamber if the primer is too sensitive.

The reliability of the round is also dependent on interactions, occasionally very subtle, between the primer and other components of the cartridge. For this reason the Army considers that it is necessary to test thoroughly all variants of a cartridge design.

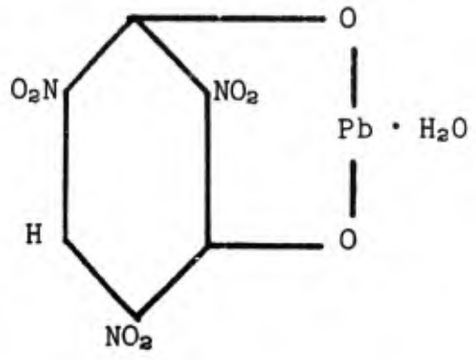
Although a single chemical compound would be preferred for use in primers, no suitable substance is known and all priming compositions used today in military ammunition are mixtures of detonating agents, fuels, oxidizers, sensitizers, and binding agents. As has been noted, lead styphnate in either its normal or basic form is, because of its noncorrosive feature, in general use as the percussion-sensitive ingredient in present-day primers, constituting typically 35-40 percent by weight of the primer mix. The amount of priming composition used in rifle cartridges is very small; the primer pellet weighs about 1/3 grain in the 5.56-mm round, and about 1/2 grain in the 7.62-mm round.

Formulations of the two primer mixes discussed principally in this study are:

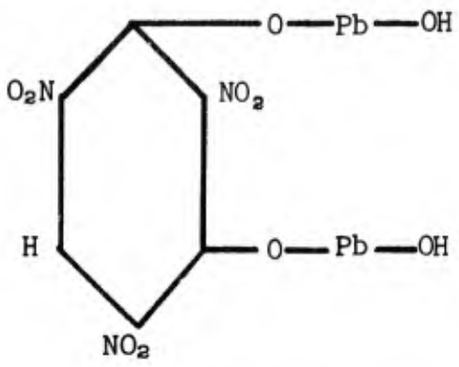
	Frankford Arsenal Mix No. FA-956 (Standard in 7.62-mm ammo; prospective standard in 5.56-mm ammunition)	Federal Cartridge Mix No. K-75 (In use in FCC & TCAAP 5.56-mm ammunition)
Normal Lead Styphnate	37%	
Basic Lead Styphnate		39%
Barium Nitrate	32%	41%
Antimony Sulfide	15%	11%
Tetracene	4%	2%
PETN	5%	
Aluminum	7%	
Nitrocellulose		7%

The two forms of lead styphnate differ in their composition by one additional lead atom and one additional oxygen atom in the basic lead styphnate molecule, which in turn cause differences in molecular weight, heat of combustion, and crystal structure. The structural formulas are as follows:

Normal



Basic



Other properties are:

	Normal	Basic (Type I)*
Molecular Weight	468.3	691.5
Apparent Density**	1.3 to 1.6 gm/cm^3	0.3 to 0.5 gm/cm^3
Heat of Combustion***	1251 cal/gm	890 cal/gm
Heat of Explosion***	457 cal/gm	328 cal/gm
Gas Liberated	357 cm^3/gm	315 cm^3/gm
Crystal Form	Monoclinic (< 0.5-mm length); also hexagonal plates	Needles (< 0.02-mm length)

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* There are two types of basic lead styphnate, but only Type I is used in military small arms ammunition. The two types are chemically identical, but Type II has somewhat larger crystals than Type I, and its apparent density is about that of normal lead styphnate. Type II is used by the U.S. Navy in stab and percussion detonators for naval gun projectiles.

** By "apparent density" is meant the density of the uncompressed powder in contrast with the crystal density, which is higher.

*** As used here, heat of combustion is the heat released by the complete combustion of a unit mass of material, whereas heat of explosion is the heat released per unit mass in auto-combustion or detonation; that is, when no oxidant is supplied other than that contained within the material. The values given are Picatinny Arsenal measurements.

It is seen that there is a significant difference in the energy available per unit weight, both the heats of combustion and heats of explosion differing by about 40 percent in favor of the normal, which is slightly less than the inverse ratio of molecular weights, in rough agreement with the observation that most of the energy of reaction arises from the trinitroresorcinate groups on the left in the above structural formulas.

Experimental data on heats of explosion of the mixes are not available, but it will be noted that the two primer mixes are distinguished not only by the type of lead styphnate used but also by the use of aluminum powder in the FA-956 mix, which would be expected to increase further the energy of combustion. Computations carried out independently at Frankford Arsenal and IDA agree in showing substantially greater values of heats of explosion for the FA-956 mix than for the K-75 mix. It would also be expected that the Federal mix can be made more energetic by the incorporation of aluminum. This has been done on an experimental basis, and the results are reported in the following section.

Although adequate energy content is a sine qua non for a primer, it is not the sole requirement, and indeed it is very difficult to describe the requirements for a primer comprehensively in other than purely functional terms. Gas evolved, gas temperature and pressure, speed of combustion, and energy delivered to the propellant are of interest. In a recent Frankford Arsenal report* 5.56-mm primers using the two mixes identified above are, along with several others, compared in their performance in a number of tests. The primers, identified as FCC-195 and FA-41 (standard), were supplied from normal production at Federal and Frankford Arsenal, respectively. Nominal weights differ by about 17 percent, the Frankford-manufactured primer being heavier. Light output was observed with a photoelectric cell,

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*Department of the Army, Frankford Arsenal, A Comparison of Several Types of 5.56 mm and 7.62 mm Primers, Report R-1932, Michael P. Devine et al., July 1969.

gas temperature was indicated with a fast-response thermocouple, gas pressure was measured in a volume approximately that of the cartridge case, and a measure of energy delivered to the propellant was obtained by observing the loss in weight of a simulated propellant material consisting of a chemically inert polymer that, upon heating, converts to a gaseous monomer. Results of these measurements are summarized below.

	FA-41 (std)	FCC-195
Peak photocell output (mv)	19.25	1.45
Time integral of photocell output (mv-μsec)	5,830	320
Peak thermocouple output (arbitrary units)	1,445	1,065
Peak gas pressure (psi)	49,250	23,170
Weight loss in inert simulated propellant (grams)	.0112	.0089

From this it seems clear that the FA-41 primer delivers more energy and provides a larger volume of gas at a higher temperature and pressure than does the FCC-195 primer. This comparison of course does not address the question, "What primer energy and gas temperature are required for reliable operation of the 5.56-mm cartridge?" This question is illuminated in Section IV (pp. 13-15) and Section VI (pp. 24, 25).

IV. THE ARMY POSITION

The Army wants to use a standard primer for each family of small arms cartridges.* The Army's principal reasons for wanting to convert all 5.56-mm ammunition to primers containing FA-956 mix are: (1) to obtain a primer with better performance; (2) to prepare for introduction of 100 percent inspection of primer charging; (3) to reduce the chance of problems developing from changes to the cartridges or the weapons in which they are used; and (4) to reduce the testing required by two different types of primers.

All sources of U.S. military small arms ammunition except Federal are using primers containing normal lead styphnate. The Army felt that the cost of standardization would be minimized if only Federal had to convert to normal lead styphnate rather than forcing all other manufacturers to convert to basic lead styphnate. Further, the Army felt that the FA-956 mix was superior to the Federal K-75 mix because of its higher energy content.

To provide information on the performance of the two primers under adverse conditions, Frankford Arsenal conducted firing tests at -65°F with a light propellant load (24 grains versus the normal 27 grains). The following data show a higher frequency of ignition failures under these conditions with the Federal primer than with the FA-956 primer:**

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*The Army excludes from this objective .22 cal., .38 cal., .45 cal., and shot shells.

**Frankford Arsenal, Report of Trip to LCAAP, Internal Memorandum, C.E. Shindler, 16 January 1967 (supplemental data attached thereto).

Primer	Propellant	Number Fired	Number of Ignition Failures
WCC (FA-41)	IMR 8208	100	0
	WC 846	320	0
FCC-195	IMR 8208	220	1
	WC 846	320	7

Notes: All failures were bullets-in-bore.

WCC (FA-41) primers contain FA-956 primer mix and are the Olin version of the FA-41 primer (with metallic fuel).

The propellants used in these tests and those reported below are the only two that have been used in 5.56-mm ammunition. The IMR (for Improved Military Rifle) propellant is a du Pont "single-base" powder composed largely of nitrocellulose which is formed by extrusion into small cylindrical grains with a single axial perforation. The WC (Western Cartridge) propellant, also known as Olin "ball" powder, is double-base (i.e., it contains nitroglycerin as well as nitrocellulose) and is produced in a process which makes spherical grains of about 0.020-in. diameter. Use of the IMR propellant was discontinued following tests in January 1968 made under simulated combat conditions which showed higher malfunction rates for 5.56-mm ammunition loaded with IMR propellant than with ball powder.* Hence, only the Olin ball powder is presently used in 5.56-mm ball cartridges. Current efforts to develop alternate propellants (and thus suppliers) are alluded to on page 26.

Federal, apparently reacting to the Army's interest in higher energy primers, then reduced the antimony sulfide and added 5 percent aluminum powder to their mix (calling the new mix the K-75A and the new primer the FCC-195A) to increase the energy output. Frankford

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* George E. James, "The Operational Reliability Test of the M16A1 Rifle System," Journal of Defense Research, Series B, Tactical Warfare, pp. 30-45, Spring 1969.

then tested both Federal mixes and the FA-956 mix at -65°F with one-half propellant charge, with the following results:*

Primer	Propellant	Number Fired	Number of Ignition Failures
FA-41	IMR 8208	100	0
	WC 846	100	0
FCC-195	IMR 8208	60	31[a]
	WC 846	50	22[b]
FCC-195A	IMR 8208	150	0
	WC 846	150	1[c]

[a] 30 were bullets-in-bore, 1 was a misfire.
[b] 3 were bullets-in-bore, 19 were misfires.
[c] Hangfire.

Frankford's reason for testing at one-half propellant charge is that it is possible for the inspection process to pass a round with a propellant charge this light. The cumulative weight tolerances on each part plus the accuracy of the gage and weigh machine would permit such a round to pass inspection. However, because of the accuracy and reliability of the volumetric propellant loading machine, such an occurrence is rare.

These tests indicate that the new K-75A mix improves the performance of the Federal primer to about the level of the FA-41 primer. Federal by letter of 10 June 1970 to Frankford Arsenal requested approval of primers made with this new mix as a process change. Frankford views the change as a product change and as such a complete engineering test of the new primer would be necessary. In view of the Army's desire to standardize on the FA-41 primer, it is turning down Federal's request. Cost of testing required for adoption of a new primer is estimated at $98,500.

* Data supplied orally to authors by Frankford Arsenal personnel on 15 June 1970, and subsequently reviewed at FA.

The Army wants to go to 100 percent inspection of primer charges. It plans to do this by compressing each primer charge to a given load and measuring the thickness of the primer pellet at this load. To make this inspection meaningful, it is necessary to compress and consolidate the primer charge with a consistent and substantial force. For example, when the FA-956 mix is of the proper consistency (wetness) for charging into cups during the manufacture of FA-34 primers, the appropriate consolidating force is on the order of 100 pounds. A thin disc of paper foiling is ordinarily interposed between the primer mix and the flat-end punch which applies the consolidating force to ensure that fragments of the consolidated mixture do not adhere to the punch when the punch is withdrawn. The Army feels that the process of compressing the mix, under sufficient force to ensure its uniform consolidation, would not be practicable with the Federal K-75 composition having the consistency that has previously been used in Federal production of 5.56-mm primers. The Army feels that the mixture is too wet and would squeeze out (along with excess water) around the punch. This feeling is based only on judgment, not on test data, because the Army has had no occasion to investigate process modifications with the Federal proprietary K-75 mixture.

V. THE FEDERAL CARTRIDGE CORPORATION POSITION

Federal does not want to be forced to use normal lead styphnate instead of basic lead styphnate for the 5.56-mm ammunition that it is manufacturing at TCAAP and Anoka because it feels that the normal lead styphnate primer is less safe to handle in the manufacturing process, that its cost is higher, and that it has no offsetting advantages. At present (April 1970) Federal is manufacturing approximately 77 million rounds of this ammunition per month at TCAAP and 6.5 million at Anoka. It feels that if it is forced to convert to FA-41 primers at TCAAP it may then lose its production of 5.56-mm ammunition at Anoka because the Army would probably not want to continue buying such a small part of the total 5.56-mm procurement with an alternate primer mix. Federal is also worried that the Army may extend the requirement for normal lead styphnate primers to the .22 cal., .38 cal., .45 cal. and shot shells that it manufactures for the Army at Anoka. It fears that if the costs at TCAAP are increased, then TCAAP is more likely to be closed down or operated at a lower level because of its poorer competitive position relative to the other producers.

Federal estimated a cost saving of $594,000/yr by manufacturing all 5.56- and 7.62-mm primers at TCAAP using basic instead of normal lead styphnate.* In both cases it was assumed that the lead styphnate mix would be made in the new facility presently under construction and that the monthly production rates would be:

5.56 mm:	85,400,000
7.62 mm:	18,000,000

*Federal Cartridge Corp. letter of June 12, 1970, to Contracting Officer's Representative, TCAAP.

Federal estimates that the cost to complete the facility for the manufacture of basic lead styphnate is $44,000 greater than for the manufacture of normal lead styphnate. Based on Federal's estimated cost saving per year, this added initial cost would be recouped in the first month's manufacture of basic lead styphnate primers.

Federal feels that records are available that show the quality of their 5.56-mm ammunition using basic lead styphnate primers is equal to or better than that of other 5.56-mm ammunition being manufactured with normal lead styphnate primers.

Federal says that the normal lead styphnate process appears to create a more serious disposal problem than does the basic lead styphnate process insofar as pollution of the environment is concerned.

Mr. Frank J. Jervey, a consultant to Federal and World War II head of small arms ammunition procurement in the Office of the Chief of Ordnance, considers the prospective standardization undesirable, observing that to continue supplying ammunition to the Government from the Anoka plant Federal would have to construct a normal styphnate plant at Anoka at a cost of about a million dollars. Mr. Jervey feels that the following advantages result from permitting alternate primers:

1. Improved product because of competition, which standardization would inhibit.
2. A company has more incentive to do a good job if it is permitted to use its own designs and processes.
3. The Army will learn more by supporting alternates.
4. "Know-how" of alternate processes will be preserved.

Mr. Jervey feels that the above advantages outweigh any disadvantages to the Army in continuing the use of both types of lead styphnate primers. He feels that the Army should be careful not to eliminate the Federal Anoka plant as an Army supplier if it forces Federal to convert to normal lead styphnate primers.

VI. ANALYSIS OF THE TWO POSITIONS

The merits of the Army and Federal positions are discussed in the following subsections.

A. INCREASED COSTS TO FEDERAL AT ANOKA

The 5.56-mm production at Anoka is a very small percentage of the total production of this round. When the TCAAP production is converted to normal lead styphnate all 5.56-mm production except that at Anoka will be using normal lead styphnate primers. At that time it is highly probable that the Army will want to complete the standardization of the 5.56-mm round to normal lead styphnate primers and will either convert the 5.56-mm production at Anoka to normal lead styphnate primers or discontinue this production at Anoka and replace it with production from TCAAP or elsewhere.

Federal could obtain normal lead styphnate primers as Government-furnished material (GFM) for the 5.56-mm round from TCAAP or elsewhere, could convert the primer facility at Anoka to normal lead styphnate, or could add a new normal lead styphnate facility at Anoka. As noted previously, Mr. Jervey estimated a cost of one million dollars for construction of a normal lead styphnate plant at Anoka. In discussing this problem, Army personnel say that there is no reason why Federal could not be provided with normal lead styphnate primers for the 5.56-mm round from TCAAP or elsewhere. However, if the Army provided normal lead styphnate primers for the 5.56-mm round at Anoka as GFM, Federal would have to incur some additional expenditures at Anoka to handle these dry primers. The expenditures would involve storage and unpacking facilities and the installation of guards and different feed mechanisms on the priming machines. Similar provisions at TCAAP when

the 7.62-mm round was standardized to the FA-34 primer cost about $400,000. Based on this cost and the comparative scale of operation, Federal estimates the cost at Anoka would amount to roughly $100,000. In addition to this investment cost, the production costs at Federal would be increased by about $0.35 per thousand and the cost to the Government for packing and transportation of GFM primers to Anoka would be about $1.50 per thousand.

Instead of providing finished FA-41 primers to Anoka as GFM, it may be possible to provide the FA-956 wet mix. Federal now ships its K-75 wet mix from Anoka to TCAAP, and it is highly probable that the FA-956 wet mix could be shipped in the opposite direction. However, it is less probable that the wet mix could be shipped from distant out-of-state sources because of Interstate Commerce Commission shipping regulations and the danger involved if the mix should dry out in transit. If mix instead of primers can be provided, the Government would save much of the $1.50 per thousand packing and transportation costs and Federal would save much of its storage and unpacking facilities costs.

In view of these increased costs to both Federal and the Army (especially if TCAAP is closed), it is possible that production of the 5.56-mm round at Anoka would be discontinued if the Army required use of the FA-41 primer in it.

The cost of the normal lead styphnate facility at TCAAP is being borne by the Army, and Federal, as the company operating TCAAP, will be covered by the Army for all costs involved in getting into production with this facility.

The Army says that it has no intention of extending the requirement for normal lead styphnate primers to the .22 cal., .38 cal., .45 cal., and shot shells that Federal manufactures for the Army at Anoka. Hence, it appears that Federal would probably continue to produce .22 cal., .38 cal., .45 cal., and shot shells for the Army as well as its commercial production at Anoka with the basic lead styphnate primers.

B. SAFETY

The following safety information on the normal lead styphnate was obtained from LCAAP. The primer mixing at LCAAP is done remotely, whereas it is done manually at Federal. The primer mix is charged into the primer cup in a wet condition in a very similar manner at both plants. At Federal the primer pellet is left wet in the cup; the primer is inserted into the cartridge case in this condition and is dried in the case. At LCAAP and all other plants the primer is first dried and is then inserted into the case. Federal claims that the handling of the primer in the dried condition and particularly the insertion of the primer into the case is much more hazardous than the Federal method. It is true that at LCAAP the primer insertion machines have guards around them to protect the operators from primer detonation, whereas the machines at Federal do not. However, LCAAP reported that it had never had an injury due to primer detonation, either in transporting the dry primers from the storage to the manufacturing area or within the manufacturing area itself. LCAAP did admit that primers occasionally detonate during insertion into the case, but the guards provide complete protection to the operating personnel. The cost of the guards relative to the costs of the machines themselves appears by inspection to be insignificant.

In addition to the above information obtained from LCAAP, Frankford Arsenal informed us that there have been no injuries involving normal lead styphnate at any plant in the last six years. IDA's conclusion on the safety point is that there is a factor here in Federal's favor, but that with proper safeguards, whose costs appear to be minimal, the level of safety of the LCAAP production method with the normal lead styphnate is excellent.

C. COST

The relative cost of the two types of lead styphnate primers, based on cost information provided by Federal, shows an advantage in favor of the basic type. However, Mr. Albert Hill, Technical Consultant--Ammunition Engineering for Olin's Western Cartridge Company

at East Alton, Illinois, feels that the normal type is less costly. He reported that his company has used both types of styphnate, but uses the normal in its commercial production because of its cost advantage. He stated that the higher energy content of the normal lead styphnate permits a 25 percent reduction in the amount of primer mix used relative to that required with the basic. This difference in views on the relative costs could be due to several factors:

1. Olin covers its primer charge with foil; Federal does not.
2. The East Alton plant produces normal lead styphnate in larger batches than those produced in the TCAAP process (35 lb produced at one time in one vessel versus 20 lb produced at one time in eight vessels).
3. Federal did not assume any reduction in the amount of primer mix required if normal instead of basic lead styphnate is used.
4. Federal's expertise lies with the basic type, whereas East Alton's is mainly with the normal type.

The Army also feels that the normal lead styphnate primer is cheaper. In a study dated 15 November 1967, the Army estimated costs for 7.62-mm primers inserted in the cartridge cases as follows:

Basic lead styphnate	$8.0446/thousand
Normal lead styphnate	$6.5717/thousand

These figures assumed production of the primers at TCAAP.*

IDA's conclusion is that the costs are nearly equal for the two types. Analysis of cost studies supporting the different points of view shows that, aside from differences in overhead which favor LCAAP, the cost of producing normal primers at LCAAP is substantially the same as the cost of producing basic primers at TCAAP. No reason is

*Frankford Arsenal, Memorandum for Record, Cost Comparison at TCAAP, Wet Primer Insert vs. Dry (GFM) Primer Insert, R.E. Donnard, 15 November 1967.

evident for a significant increase in TCAAP cost in changing to the normal mix, although initially a rise might be expected until Federal develops its production techniques.

D. COMPETITIVE ADVANTAGES OF PERMITTING ALTERNATE PRIMERS

The following plants make 5.56-mm ammunition:

1. Western Division of Olin, East Alton, Illinois
2. Lake City Army Ammunition Plant, Independence, Missouri
3. Twin Cities Army Ammunition Plant, Minneapolis, Minnesota
4. Federal Cartridge Corporation, Anoka, Minnesota
5. Winchester Division of Olin, New Haven, Connecticut
6. Remington, Bridgeport, Connecticut
7. Frankford Arsenal, Philadelphia, Pennsylvania
8. Canadian Commercials, Valcartier, Quebec

Principal suppliers are the two Government-owned plants, each of which furnishes about 40 percent of the total requirement for 5.56-mm ammunition. The Federal plant at Anoka produced about 6,500,000 5.56-mm cartridges in April 1970, just over 3 percent of the total.

Only Federal, at Anoka and TCAAP, uses basic lead styphnate primers. Federal, as operator of TCAAP, will learn the manufacture of normal lead styphnate primers at Army expense. Cost competition should remain virtually unchanged if Federal converts to the use of normal lead styphnate.

There is no advantage insofar as critical material considerations are concerned since both types of lead styphnate are manufactured from the same raw materials.

As Mr. Jervey observed, there is probably some advantage to company motivation by permitting use of a company-developed design.

E. ENVIRONMENTAL POLLUTION

Federal claims an advantage for the basic lead styphnate in this regard. We did not analyze this claim.

F. COMPARATIVE PRIMER PERFORMANCE

The Frankford Arsenal laboratory tests showed an advantage with the FA-956 over the K-75 mix under low temperature and light propellant loading conditions. However, in firing tests at -65°F of rounds loaded normally, the TCAAP 5.56-mm ammunition using K-75 primer mix shows a somewhat lower failure rate than ammunition using the FA-956 primer mix. Official records from lot acceptance testing of 5.56-mm ammunition show the following comparisons:*

IGNITION FAILURES IN 5.56-MM M193 BALL CARTRIDGE ACCEPTANCE TESTING

Producer	No. Ctgs. Tested	No. of Ignition Failures	Nature of Failures	Apparent Cause of Failures
Federal (Anoka & TCAAP)	633,400	2	1 MF at 70°F 1 BIB at -65°F	Inverted primer anvil Cause not reported
All others	1,115,840	15	2 MF at 70°F 1 BIB at -65°F 7 MF at -65°F 5 MF at temperatures not reported	No primer pellets Cause not reported 4 Light firing pin blows 3 Contaminated primers 1 Inverted primer anvil 1 No primer pellet 3 Causes not reported

Notes: One-third the number tested were fired at -65°F, one-half at 70°F and one-sixth at 125°F.

BIB means "bullet-in-bore."
MF means "misfire."

Obviously, from the defects identified above, the performance of cartridges depends on many factors other than the primer composition, and no inferences can be drawn from these data regarding the relative merits of the primer mix. However, it does appear clear that the Federal product exhibits good quality control and that with this level

*Frankford Arsenal letter to NJA of 6 August 1970, supplemented by telephone conversation between C.E. Shindler and FSA, 21 Aug. 1970.

of quality control the incidence of failures is quite low, even at low temperature. Therefore, performance of the presently delivered ammunition in the present M16 rifle does not appear to be a valid reason for changing the type of primer. It is possible, in view of the laboratory firings at low temperature and light propellant loading, that the FA-956 mix would perform better in future modifications to the ammunition and weapons.

G. 100 PERCENT INSPECTION

According to the Army, the 100 percent inspection technique should include foiling of the primer charge to ensure that fragments of the consolidated mixture do not adhere to the punch when the punch is withdrawn. Federal does not foil the 5.56-mm round at present. However, Federal has foiled the following ammunition, all using the present K-75 mix and degree of wetness:

1. At Anoka from 1951 until June 1960 all .45 cal. and 7.62-mm ammunition manufactured for the Army. All shot shells manufactured to date.
2. At TCAAP from 1951 until June 1957 3,644 million rounds of .30, .45 and .50 cal. ammunition.

Federal claims, and the Army does not contest the claim, that it could foil the 5.56-mm round using the present K-75 mix and degree of wetness. In recently run tests, recorded in a report dated 12 May 1970, Federal compressed its unfoiled mix with up to 50 pounds of force and encountered no problems with mix being forced up the sidewall or with mix sticking to the punch. In view of these tests, Federal feels that its mix would be suitable for the 100 percent inspection technique even without foiling. However, Federal could foil if required to do so by the Army.

The Army feels that even with foiling, the Federal mix is so wet that it would squeeze out around the punch, particularly if a consolidating force as high as 100 pounds were necessary to ensure uniform density of the pellet.

Since Federal has conducted some successful consolidation tests, while the Army position is based only on judgment, no conclusion can be reached regarding the Army's claim in the absence of additional test data.

H. REDUCTION IN PROBLEMS DEVELOPING FROM FUTURE CHANGES

The Army has a valid point here. The more variants in the elements of the cartridge, the greater the chance of problems developing if design changes are made in the cartridge or in the weapons in which it is used. This would also hold true, of course, for completely new weapons.

I. REDUCTION IN TESTING REQUIRED

The Army has a valid point here. The more variants in the elements of the cartridge, particularly in the primer which is critical to the performance of the cartridge, the more testing must be done to prove out changes to the cartridge or to the weapons in which it is used. In addition to the cost (covered below), the Army is concerned about the time required for these tests (getting on the firing range at Aberdeen, etc.).

J. REDUCTION IN TESTING COSTS

Testing costs will naturally be lower with less testing. The Army has a continuing program of product improvement for each type of ammunition. Over the next two years the Army has a planned test program for the 5.56-mm round. The tests mainly involve testing alternate propellants developed by the various manufacturers. Because of the critical interaction between the primer and the propellant, much more testing will be required because this round is presently being produced with two types of primers. Frankford estimates the added testing cost due to the second primer will be about $200,000 over the next two years. Frankford indicated that this extra testing cost would probably continue at about this level as long as the second primer type is retained in production.

The considerations discussed above are summarized in Table 1. There is no way to reduce all these considerations to an overall quantitative measurement of the advantages and disadvantages of the two courses of action. The final choice must be based on a subjective weighing of these considerations.

TABLE 1. SUMMARY OF CONSIDERATIONS INVOLVED IN STANDARDIZATION OF NORMAL LEAD STYPHNATE IN 5.56-MM PRIMER

Consideration	Favors Standardization of Normal Lead Styphnate in 5.56-mm Primer	Favors Continuation of Basic and Normal Lead Styphnate in 5.56-mm Primers
1. Increased cost to Federal at Anoka		Minimal if Federal obtains normal lead styphnate primers or primer mix from TCAAP
2. Safety		Minor advantage
3. Costs of primers	About the same	
4. Federal loss of .22 cal., .38 cal., .45 cal., and shot shell production for Army	Army says this is not at issue	
5. Better competitive environment		Minor advantage
6. Environmental pollution	Not analyzed	
7. Primer performance	Minor advantage	
8. 100 percent inspection	Probably not an important consideration; information lacking.	
9. Reduction in problems associated with future changes	Significant advantage	
10. Reduction in testing required (time and cost)	Significant advantage	

ATTACHMENT A

LIST OF DISCUSSIONS

1. June 10, Washington, D.C. N. J. Asher and F. S. Atchison, IDA, with Messrs. A. E. Dellastatious and S. A. Ferraro, Army Materiel Command.

2. June 15, Frankford Arsenal. N. J. Asher and F. S. Atchison, IDA, with Messrs. S. W. Spaulding, MUCOM, and W. C. Davis, C. E. Shindler, R. E. Donnard, and W. R. Kurzenberger, Frankford Arsenal.

3. June 16, Anoka, Minnesota. N. J. Asher and F. S. Atchison, IDA, with Messrs. H. W. Ward, R. B. Lynn, and R. E. Swanson, Federal Cartridge.

4. June 16, TCAAP. N. J. Asher and F. S. Atchison, IDA, with Messrs. R. B. Lynn and W. R. Glenn, Federal Cartridge, and Maj. Sisterman, U.S.A., Contracting Officer's Representative, TCAAP.

5. June 17, LCAAP. F. S. Atchison and N. J. Asher, IDA, with Messrs. E. E. Campbell, J. C. Ward, and E. Tellin, Remington Arms Co., and E. Meyer, Technical Advisor to C. O., LCAAP.

6. June 19, East Alton, Illinois. F. S. Atchison, IDA, with Messrs. A. S. Hill, W. H. Otten, and S. A. White, Winchester-Western.

7. June 22, Clemson, South Carolina. F. S. Atchison and N. J. Asher, IDA, with Mr. F. J. Jervey, Consultant to Federal Cartridge.

8. June 26, Frankford Arsenal. F. S. Atchison and N. J. Asher, IDA, with Messrs. S. W. Spaulding, MUCOM, and W. C. Davis, C. E. Shindler, R. E. Donnard, W. R. Kurzenberger, and W. H. Squire, Frankford Arsenal.

ATTACHMENT B

MINUTES OF THE SIXTH MEETING

OF THE

PRIMER SUBCOMMITTEE

TO THE

INTEGRATION COMMITTEE ON SMALL ARMS AMMUNITION

FRANKFORD ARSENAL
Philadelphia, Pa.

19 & 20 June 1958

This type of storage includes the possibility of chemical reaction causing breakdown of the primer. These tests represent only a quick accelerated test of primers only. Dr. Brun stated Remington Arms Company makes an accelerated test with primed shells stored at 90% R.H. and 120 deg. F. On such a test the barrel time was 285 ms max. vs. 277 ms on the original test. Mr. Hill (OMCC) considers 85 to 90% R.H. at 115 deg. F. better than the saturated test because of the possibility of actual wetting which can occur through changes in the temperature. The question was raised by Mr. MacKnight (OAC) as to how these tests compared with Military Standard Requirements. Mr. Fry (FA) stated there are three different requirements. Materials shall be stored (1) at -65 deg. F. for 3 days; (2) at +165 deg. F. for 4 hours; and (3) at standard storage +125 deg. F. with no time specified. No adverse reaction is permitted.

A question was raised regarding the several reactions which might take place under these high humidity/heat tests with different materials. The following possibilities were suggested:

Fulminate releases cyanate

Lead Azide and Potassium Chlorate are not compatible

Calcium Silicide can become hot and set up like cement and give off carbides under some conditions

21. TOPIC 10-C-58 - was consideration of a Recommendation for Standardization of the X28 Primer for Military Use.

Dr. Brun (RAC) stated that with reference to the establishment of the range of pellet weight, he believes that in establishing the pellet weight, the extreme variations cannot be held within the 10%. The experience at Lake City Arsenal and Bridgeport (with wet charging the pellet) indicates ± 10% of the mean is the extreme variation and with the utmost care to ± 8%.

Mr. Hill (OMCC) recommended a control on an average of 10 (dry weights) that specification be a control chart based on the ability to hold charge weights with styphnate primers.

NATO 7.62 m/m on an average of 10 has a spread of .510 to .550. It was formerly .580 to .620 on Cal..30 with a spread of .04 grains. The minimum individual should be 4 sigma below the lower control limit for individuals which, based on .510 would be .480. This confirms the ± 10%.

In experimental work, weights stated are based on 3 pellet weights in groups of 5 and 15 weights for each experiment with

510 primers per plate. Mr. Hill made the suggestion that perhaps we are not ready to establish the final charge weight for primer pellet. Frankford Arsenal will have to decide one pellet weight for cal..30 and for purposes of economy to settle on one pellet weight for both, if possible. He advised a little more spread on individual pellet weights. Mr. R. Donnard (FA) noted the pellet weight with #34 primer was based on 1500 samples and believes X28 will act no differently, since the weight depends on the skill of the charger. Mr. B. Franz (OMCC) pointed out that the Bar X on the charts give the charge, and too much weight causes trouble with inspection. He believed it better to get the range of individuals along with the Bar X average. This is the method used throughout industry. Much discussion ensued on the best method of establishing the pellet weight without a definite method being chosen.

The Chairman - "Is anyone prepared to make recommendation for adoption or standardization?" Mr. A. Hill (OMCC) - "I propose this Committee RECOMMENDS ADOPTION OF X28 AS THE NON-PROPRIETARY U. S. ARMY ORDNANCE PRIMER. We all recognize there are shortcomings and high cost and certain things that are not working out with the dry charge method not being entirely satisfactory, but the formulation appears to be basically sound. We would like to at least have a period of several years to include on the Ordnance Drawing as a fall back, the alternate primer mixture FA is using with the Type II, Class 3 propellant, or as an alternate Nos. 210 and R-5061. Frankford Arsenal could send the new primer out for offshore procurement. Industry would like to retain a reservation to use its own priming mixtures if cheaper and better. The standard and an alternate have always been accepted. FA should change to the new primer, and recommend through channels that each facility make an experimental run. This should be the next step." Dr. Brun (RAC) will want to evaluate the dry charge method of making the primer. He is sure all companies would be willing to take small contracts for evaluation of the X28 in the field, so that FA results would be augmented and confirmed. Mr. Donnard (FA) agreed that it is desirable to gradually ease into a new formulation. Some of the new materials are more expensive than materials now in use. It is wise to start with experimental production and then as this expands to a wider basis, develop stockpile of the new materials and eventually make the new primer mandatory in military ammunition, but evolve into it gradually. Mr. King (FCA) "Could Federal get enough of material "F" now?" Mr.Fry (FA) - "I believe by a contractual change Federal could be authorized to load present order for 7.62 m/m using X28 primers. Anything under one million rounds would not provide enough experience." Mr. Donnard believes at least 5 million rounds will be necessary and speaking for FA, we have same type of approach. Mr. Hill suggested that FA get the drawing out. Dr. Brun (RAC)- "This Committee set out to do a job and it has been done on cal..30. In the next 3 months, we should do the same for 7.62 m/m. When

that is done, we can feel proud of ourselves, and U.S. Army Ordnance because it has a primer for procurement, and I think we will ease into the picture". Mr. A. Hill- The change will involve only the primer mixture, as we are satisfied with existing metal parts and dimensions. Drawings will be corrected and have the parts agree to the drawing.

Col. B. R. Lewis (FA) - We would like to use the primer in 7.62 m/m cartridges in loading NATO Match. We have delivered 50,000 rounds with X5 primer for National Match.

At this point the Chairman read - "Mr. A. Hill has proposed this Committee recommend the adoption of mixture X28 (FA #961) for a Standard Non-proprietary U.S. Army Ordnance lead styphnate non-corrosive primer, but to retain as alternates on the official drawings the present approved mixtures with appropriate pellet weight, in order to provide opportunity for gradual transition to the new mixture as more experience is gained. The resulting primer is to be that shown on the drawings, as revised, covering the #36 primer Drawing B-8594094."

Comments: Dr. Brun said there is one addition - "The last sentence should add 'for use of Cal..30' - as it is believed we will require different primer for 7.62 m/m." Mr. A. Hill - "I recommend mixture and dimensions for both Cal..30 and 7.62 m/m. We should specify these mixtures as alternates. When pellet weights are established they should be shown on the drawing, otherwise we will get in trouble with density. The No. 257 W primer mixture is now shown as an alternate. We can establish the pellet charge weight for the Primer #36." Mr. W. King seconded the recommendation. The motion was put and unanimously carried.

Meeting recessed at 1200 hours, 20 June 1958
resumed at 1230 hours

ADDENDUM 2

18 August 1958

SIXTH MEETING
of the
PRIMER SUBCOMMITTEE
to the
INTEGRATION COMMITTEE ON SMALL ARMS AMMUNITION

at

FRANKFORD ARSENAL
Philadelphia, Pa.

19 and 20 June 1958

LIST of ATTENDEES

INTEGRATION COMMITTEE ON SMALL ARMS AMMUNITION OFFICIALS

Mr. Walter Fang	Secretary	Ordnance Ammunition Command

PRIMER SUBCOMMITTEE OFFICIALS

Geo. A. Miller, Jr.	Chairman	Frankford Arsenal
Milo A. Fry	Deputy Chairman	Frankford Arsenal

CONTRACTOR REPRESENTATIVES

Dr. W. E. Brun	Remington Arms Corp. Bridgeport, Conn.	
Mr. A. S. Hill	Olin Mathieson Chemical Corp. East Alton, Illinois	
Mr. Burvee M. Franz	Olin Mathieson Chemical Corp. New Haven, Conn.	
Mr. W. N. King	Federal Cartridge Corp. Anoka, Minn.	
Mr. Donald A. Coder	Remington Arms Corp.	Lake City Arsenal
Mr. A. F. Heldmann	U. S. Defense Corp.	St. Louis Ordnance Plant

ORDNANCE REPRESENTATIVES

Brig. Gen. James A. Richardson III	Commanding General	Frankford Arsenal
Mr. W. J. MacKnight		Ordnance Ammunition Command
Mr. Joseph Cymbolista		Ordnance Ammunition Command