FA-TR-76054

FEASIBILITY DEMONSTRATION OF A LOW COST MODIFICATION TO THE M505A3 20 MM FUZE TO ACHIEVE A 10 METER NON-ARM DISTANCE

by

John P. Hunt

September 1976

Approved for public release; distribution unlimited.

Munitions Development and Engineering Directorate

U.S. ARMY ARMAMENT COMMAND
FRANKFORD ARSENAL
PHILADELPHIA, PENNSYLVANIA 19137

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

NOTICE

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement or approval of such commercial firms, products, or services by the U.S. Government.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

(14)

1. REPORT NUMBER: FA-TR-76054
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER: (9)
4. TITLE (and Subtitle): (6) FEASIBILITY DEMONSTRATION OF A LOW COST MODIFICATION TO THE M505A3 20 MM FUZE TO ACHIEVE A 10 METER NON-ARM DISTANCE.
5. TYPE OF REPORT & PERIOD COVERED: Final Engineering Report.
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): (10) JOHN P. HUNT
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: FRANKFORD ARSENAL, ATTN: SARFA-MDA-D, PHILADELPHIA, PA. 19020
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS CODE: 3652.5000.204; DA PROJECT: 662616.11.H77D
11. CONTROLLING OFFICE NAME AND ADDRESS: Commander, Picatinny Arsenal, Dover, NJ 07801
12. REPORT DATE: (11) Sep[redacted]76
13. NUMBER OF PAGES: 14
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 14p.
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report): (16) DA-66261611-H-77-D
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
    - M505A3 fuze
    - 20 mm fuze
    - Extended non-arm distance
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

This report details the test results of a supporting research effort to extend the minimum arming distance of the M505A3 20 mm point detonating fuze to 10 meters. Minor modifications to the standard M405 resulted in zero functions out of twenty-five (25) fuzes fired at 10 meter targets and zero functions of ten fuzes fired at 15 meter targets.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

142720

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

TABLE OF CONTENTS

	Page
INTRODUCTION	2
Background	2
Current Status	2
IMPLEMENTATION	2
TEST RESULTS	3
CONCLUSIONS	4
RECOMMENDATIONS	5
APPENDIX A	6
APPENDIX B	7
DISTRIBUTION	13

List of Illustrations

Figure

1. M505 Fuze Target Panels (.063 Inch 2024T3 Aluminum) of Typical "No-Go" (Left) and "Go" (Right) Impacts........... 11

2. Breed Test Fuze Target Panels (.063 Inch 2024T3 Aluminum) of Typical "No-Go" (Left) and "Go" Impacts................ 12

INTRODUCTION

Background

The current Joint Services Operational Requirements (JSOR), being staffed through the three services, calls for a 10 meter non-arm distance of all cannon caliber (20 to 40 mm) fuzes. The M505A3 fuze, when fired in the 20 mm Vulcan Air Defense System (VADS) weapon, demonstrates a non-arm distance of 3 to 4 meters. The M505A3 fuze obtains its arming delay when an out-of-line ball rotor is moved into alignment by forces generated in the ballistic environment.

Another requirement of the JSOR, for the Army Air Defense Role, is self destruct and target sensitivity to highly oblique targets (graze sensitivity). The self destruct and graze functions have been successfully demonstrated in previous ball rotor fuzing efforts. If the ten meter non-arm requirement could be demonstrated with a ball rotor fuze and all elements married into one fuze, the intent of the JSOR for air defense role fuzes could be satisfied. This report address a successful demonstration effort at achieving a 10 meter non-arm distance for ball rotor fuzes fired in the VADS weapon.

Current Status

Breed Corporation, a firm that has been investigating ball rotor fuzes for the government for the past 20 years, has developed an analytical computer model of the ball rotor "system" which is more thorough and complete than any, to date. Their Analysis indicates that the non-arming distance of a ball rotor is determined by the rate at which energy is supplied to the ball, through contact of the ball with the cavity in which it is confined. This "contact" action supplies external energy (external to the ball rotor) to the rotor, thus causing the rotor to arm (i.e., align the explosive train). This external energy is proportional to the frictional forces between these two components. Thus, reduction of the frictional forces will result in a longer non-arm distance, since less friction means less energy is being supplied to the rotor by contact with the rotor cavity. Theoretically, the complete lack of friction and other perturbing forces would result in a infinite non-arm distance since the rotor would never align.

IMPLEMENTATION

The M505A3 fuze utilizes a ball rotor for arming delay, however, the non-arm distance of this fuze can be as close on 3 meters or as far as 25 to 40 meters. The ball rotor analysis has indicated that the non-arm distance is proportional to the frictional forces. These frictional forces are the result of many factors, the three most important being: the spin eccentricity of the round, that is, the tendency of the round to spin about its center of mass rather than its geometric center; the clearance between critical parts in the fuze specifically, the rotor and the ogive inner cavity varying as a result of the range of manufacturing tolerances allowed by the Technical Data Package of the fuze; and the variability of the value of the coefficient of friction as a result of material properties and surface finishes. When existing eccentricity, clearance variations and the coefficient of friction were inputted into the computerized ball rotor analysis, theoretical results indicated a wide non-arm band which coincides with test and operational observations. To both reduce the width of the non-arm band and to guarantee a minimum non-arm distance, numberous design modification concepts were evaluated with the aim being to maintain the producibility of the current M505A3 at no (or minor) increase in cost. The modifications being evaluated here consist of: reducing eccentricity between the fuze ogive threads and ogive inner cavity; reducing the tolerance build-up of the rotor and cavity clearance to a set clearance value plus or minus 0.001 inches; and reducing and stabilizing the coefficient of friction by coating the rotor with a 0.5 mil thickness of "Emralon" (a dry film lubricant manufactured by Acheson Colloids).

The modifications were initiated by first screening standard M505A3 bodies to obtain those parts manufactured to minimum values of the dimensional tolerance bands of certain critical dimensions. Ball rotors were similarly screened for consistant diameter values. The inner cavity of the bodies were then remachined with a one tool operation which simultaneously: corrected eccentricity; provided a smoother cavity finish of better than 63 microinches roughness value; and opened up the original cavity to produce a cavity of a known consistant value. The final dimensions of the inner cavity as a result of this one operation are all within the dimensional and tolerance bands of the existing technical manufacturing drawing of the body and the capability of screw machine manufacturing technology.

The ball rotors that were screened to obtain a certain diameter ball were subsequently coated with a 0.5 mil thickness of "Emralon." This is the only alteration of this element from the standard ball rotor. These two screened and slightly modified parts were then assembled with all other standard components to produce 45 live, modified M505A3 fuzes.

Three bodies and coated ball rotors of this lot of fuzes were randomly selected and independently checked by government inspectors. Results indicate that the final dimensions and configuration are within the dimension and tolerance bands of the standard components.

TEST RESULTS

The forty-five (45) fuzes were assembled to M56A4 HEI rounds and fired from the 7° progressive-twist Mann barrel at 0.063 inch aluminum 2024T3 targets in two groups. The first group of 15 fuzes was a comfirmatory test to verify computer predictions. There were zero functions for ten rounds fired at 10 meter targets and five for five functions high order when fired at 60 meters. For the second test group, a group of standard M505A3 fuzes were fired at 60 meter, 15 meter and 10 meter targets as a control group. The remaining modified M505A3 fuzes were then fired, 10 each, at 60 meters, 15 meters and 10 meters. Results were as follows:

Distance to Target	Control (Standard M505A3)	Modified Fuze
60 meters	10/10*	10/10
15 meters	4/10	0/10
10 meters	1/10	0/10

* - number functioned on target impact versus the number tested

All rounds that functioned on the target functioned high order and all rounds that did not function on the target functioned on the earth mound behind the target. The firing records from the independent testing laboratory for the two tests are reproduced in Appendices A and B respectively.

For both tests, the combined results for the modified fuze are:

Distance to Target	Fuzes Functioned/Fuzes Fired
60 meters	15/15
15 meters	0/10
10 meters	0/20

CONCLUSIONS

The results of these test indicate that it may be possible to achieve a more consistant and more desirable 10 meter non-arming distance from the M505A3 fuze with minor modifications, minor cost increase and no loss of a production base. Quality control will probably be the primary cost increase because of the reduced tolerance bands.

The effort involved in this test is indeed not exhaustive and a need for subsequent in depth testing is required to verify if this approach is indeed viable and/or desirable.

RECOMMENDATIONS

It is recommended that an additional minimum quantity of 1,000 fuzes be obtained and tested to establish a trend of performance for this modified fuze. Concurrent with this effort, the modifications being proposed for this fuze should be reviewed by the current vendors to determine cost variations, if any, with current parts. This concept could have applicability to the Air Force 20 mm Lightweight Program.

APPENDIX A

H. P. WHITE LABORATORY
Box [illegible] Bel Air Maryland 21014 (301) 838-6550

10 June 1976

Commander
Frankford Arsenal
ATTN: SARFA-ISE, Bldg 44-1
(Mr. John Hunt)
Philadelphia, PA 19137

Gentlemen:

In accordance with the direction of your Technical Representative, H.P. White Laboratory, Inc., conducted firing tests of fifteen (15) experimental 20mm fuzes on 7 June 1976.

The test fuzes were assembled to M56A4, HEI cartridges and were fired from a 20mm Mann Barrel, 60 inches long with progressive twist and an exit angle of 7°03'.

Five (5) of these fuzes were fired over a range of 60 meters to impact a .063", aluminum (2024T3) target at 0° obliquity--all of which were observed to function properly.

Ten (10) test cartridges were fired as above at a range of 10 meters--all of which were observed to penetrate the target without explosive reaction.

Should you have any questions regarding this matter, or if we may be of any further service, please do not hesitate to contact us.

Very truly yours,

H.P. WHITE LABORATORY, INC.

D.R.Dunn

DRD/gd

APPENDIX D

H. P. WHITE LABORATORY, INC.
[illegible] 14 (301) 838-6550

16 June 1976

Commander
Frankford Arsenal
ATTN: SARFA-MDA-D, Building 200-3
(Mr. John Hunt)
Philadelphia, Pennsylvania 19137

Dear Sir:

In accordance with the direction of your technical representative and the provisions of Purchase Order No. DAAA25-76-M-2590, H.P. White Laboratory, Inc. conducted comparative fuze functioning tests on thirty (30) of each of two (2) types of 20mm fuzes—the standard M505 (Lot No. LC-SP-1532) and an experimental Breed Corporation fuze.

All fuzes were assembled to M56A4, HEI, 20mm cartridges from Lot LC-SP-1531 and were fired from a 60-inch long, 20mm Mann barrel with progressive twist rifling and an exit angle of 7° 3'. Firings were conducted against 1 foot square panels of .063 inch 2024T3 aluminum.

Ten (10) rounds fitted with the M505 and ten (10) rounds fitted with the Breed fuze were fired at each of three (3) ranges—60, 15 and 10 meters from the gun muzzle. Velocities at 60, 20 and 20 feet from the muzzle were determined for the 60, 15 and 10-meter firings, respectively, from lumiline screens over a distance of 10 feet.

Proper fuze action was determined from observations and inspection of the target panels subsequent to each firing. Figures 1 and 2 are representative of M505 and Breed "go" and "no-go" hits, respectively.

Table I is a summary of the results of these firings. The attached data record provides the details upon which this summary is based.

Commander, Frankford Arsenal
16 June 1976
Page 2

TABLE I. SUMMARY OF RESULTS

	Average Velocity (fps) of 10 Rounds	Go/No-Go
M505 Fuze (Target Distance)		
60 meters	3381	10/0
15 meters	3412*	4/6
10 meters	3401*	1/9
Total	3398	15/15
Breed Fuze (Target Distance)		
60 meters	3369*	10/0
15 meters	3415*	0/10
10 meters	3407	0/10
Total	3397	10/20

*Nine (9) rounds only.

Should you have any questions regarding this data or if we may be of any further service, please do not hesitate to contact us.

Very truly yours,

H.P. WHITE LABORATORY, INC.

D.R. Dunn

DRD:lc

1 enclosure

TEST DATA

Round	Velocity (fps) @ 60 Feet	Velocity (fps) @ 20 Feet	Target Range (M)	Go/No-Go
1	3354.5		60	Go
2	3397.8		60	Go
3	3367.0		60	Go
4	3355.7		60	Go
5	3385.2		60	Go
6	3350.0		60	Go
7		3414.1	60	Go
8		3395.5	60	Go
9		3393.2	60	Go
10		3381.8	60	Go
T-1	3392.1		60	Go
T-2	3351.2		60	Go
T-3	3364.7		60	Go
T-4	3363.6		60	Go
T-5	3369.2		60	Go
T-6	3367.0		60	Go
T-7	3393.2		60	Go
T-8	3374.9		60	Go
T-9	3342.2		60	Go
T-10	no reading		60	Go
11		no reading	10	No-Go
12		3408.3	10	Go
13		3403.6	10	No-Go
14		3395.5	10	No-Go
15		3392.1	10	No-Go
16		3409.4	10	No-Go
17		3378.3	10	No-Go
18		3400.2	10	No-Go
19		3409.4	10	No-Go
20		3412.9	10	No-Go
T-11		3422.0	10	No-Go
T-12		3427.0	10	No-Go
T-13		3408.3	10	No-Go
T-14		3386.3	10	No-Go
T-15		3386.3	10	No-Go
T-16		3370.4	10	No-Go
T-17		3429.6	10	No-Go
T-18		3405.9	10	No-Go
T-19		3417.6	10	No-Go
T-20		3421.1	10	No-Go

APPENDIX B (Cont)

TEST DATA (Continued)

Round	Velocity (fps) @ 60 Feet	@ 20 Feet	Target Range (M)	Go/No-Go
21		3415.3	15	No-Go
22		3429.3	15	No-Go
23		3427.0	15	No-Go
24		3403.6	15	Go
25		3393.2	15	No-Go
26		3414.1	15	Go
27		3424.6	15	No-Go
28		3397.8	15	Go
29		3408.3	15	No-Go
30		no reading	15	Go
T-21		3405.9	15	No-Go
T-22		3423.4	15	No-Go
T-23		3401.3	15	No-Go
T-24		3422.3	15	No-Go
T-25		3414.1	15	No-Go
T-26		3389.8	15	No-Go
T-27		3414.1	15	No-Go
T-28		3422.3	15	No-Go
T-29		3447.0	15	No-Go
T-30		no reading	15	No-Go

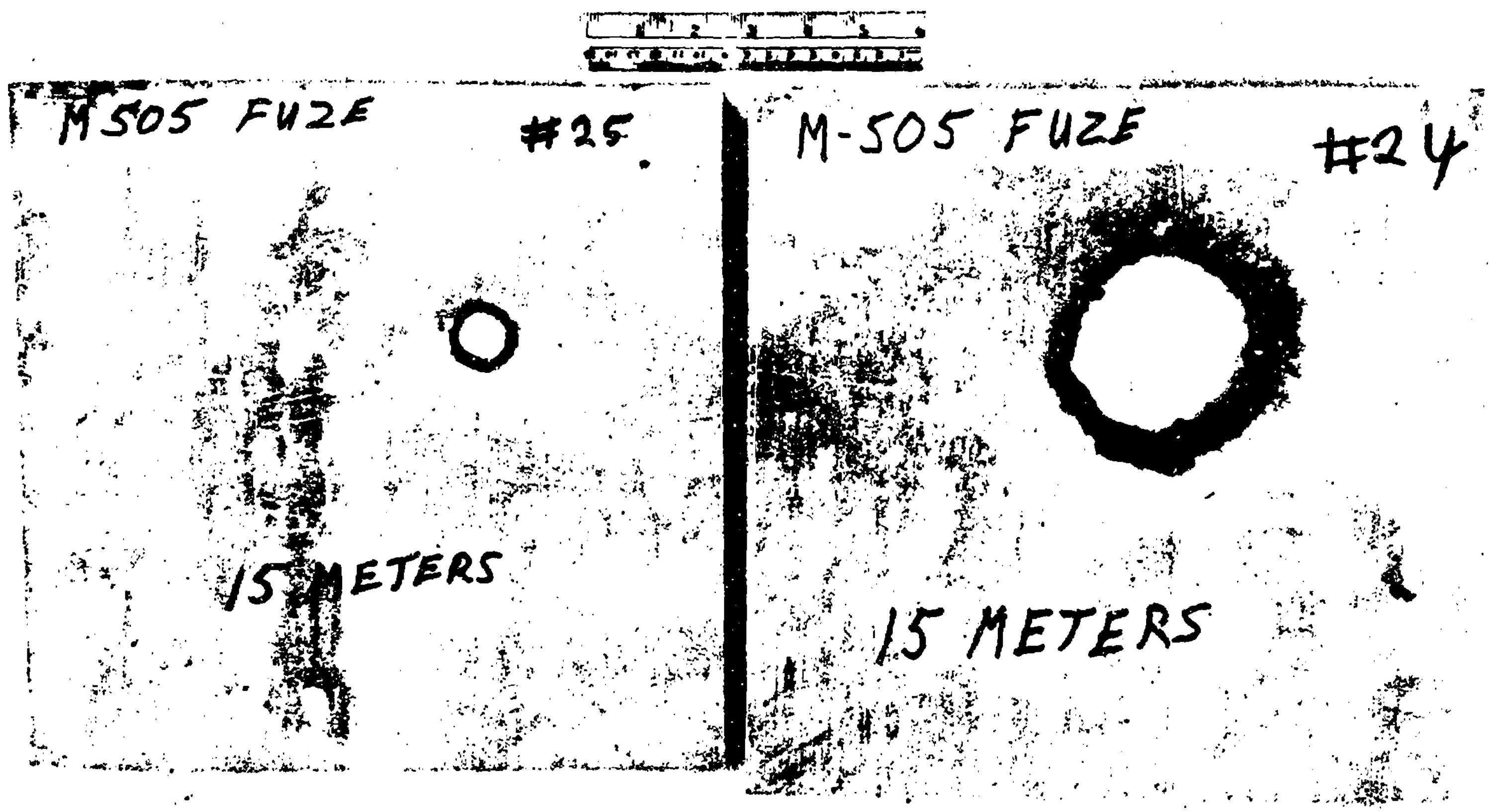

Figure 1. M505 Guze Target Panels (.063 Inch - 2024T3 Aluminum) of Typical "No-Go" (Left) and "Go" (Right) Impacts.

Figure 2. Breed Test Fuze Target Panels (0.063 Inch 2024T3 Aluminum)

DISTRIBUTION

Commander
US Army Research & Development
Center
Ballistic Research Laboratory
Aberdeen Proving Ground
Aberdeen, MD 21005

1 Attn: AMXBR-DL

1 Attn: Tech Ref Sec

Commander
Army Material Systems Analysis
Agency
Attn: AMXSY-GS, R. Scungio
Aberdeen Proving Ground
Aberdeen, MD 21005

Commander
Aberdeen Proving Ground
Attn: Technical Library
Aberdeen, MD 21005

Commander
Picatinny Arsenal
Dover, NJ 07801

1 Attn: SARPA-MD-F-D,
R. Goldstein

1 Attn: SARPA-MD-F-D,
F. Tepper

2 Attn: Tech Library

Commander
US Army Material Development &
Readiness Command
Attn: DRCRD-BN, W. Ralph
5001 Eisenhower Avenue
Alexandria, VA 22333

Commander
US Army Armaments Command
Rock Island, IL 62201

1 Attn: Dir. Rsch, Dev & Engr

1 Attn: DASAR-RDF,
G. Taylor

Commander
Naval Weapons Center
China Lake, CA 93555

1 Attn: Code 4023,
Paul Miller

1 Attn: Tech Library

Commander
Harry Diamond Laboratories
Attn: Tech Ref Library
2800 Powder Mill Road
Adelphia, MD 20783

Commander
Eglin Air Force Base
Eglin, FL 32542

1 Attn: AFATL/DLDD,
A. Welle

1 Attn: AFATL/DLDD,
Mr. Slotkin

1 Attn: AFATL/DCDD,
R. Blair

1 Attn: AFATL/DCDD,
Lt. Col. J. D'Arey

Commander
Lake City Army Ammunition Plant
Independence, MO 64056

1 Attn: ATD-ED

1 Attn: ATD-IED

DISTRIBUTION (Cont)

Breed Corporation
20 Spielman Road
Fairfield, NJ 07006

Defense Documentation Center (12)
Cameron Station
Alexandria, VA 22314

Commander
Frankford Arsenal
Philadelphia, PA 19137

1 Attn: SARFA-AOA-M

1 Attn: SARFA-TD

1 Attn: SARFA-MDA,
Mr. G. Bornheim

1 Attn: SARFA-PA

1 Attn: SARFA-GC

1 Attn: SARFA-QAA-R,
Mr. E. Glowacki

1 Attn: SARFA-MDA-D,
Project File

6 Attn: SARFA-MDA-D,
Mr. J. Hunt

1 Attn: SARFA-MDA-D,
Mr. F. Luke

1 Attn: SARFA-MDC-A,
Mr. B. Siegel

1 Attn: SARFA-MDC-E,
Mr. R. Trifiletti

3 Attn: SARFA-TSP-L,
1 - Reference Copy
1 - Circulation Copy
1 - Tech Reports Editing

Printing & Reproduction Division
FRANKFORD ARSENAL
Date Printed: 27 Sept 1976