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LARGE CALIBER WEAPON SYSTEMS LABORATORY

ENGINEERING REPORT LCR-E-1004

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DUD INVESTIGATION OF M69 ELECTRIC DETONATOR

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ABSTRACT

During the MIF Investigation on the 105MM M456A1 HEAT Cartridge, it was found that the M509A1 Fuze containing the M48 Detonator was not Detonator Safe when initiated in the unarmed position. Since the M48 Detonator was found to be the primary source of the problem, the smaller M69 Detonator was selected to replace it in the M509A1 Fuze to assure out-of-line detonator safety. Initial Laboratory and ballistic testing of the fuze with the M69 Detonator in the M456A1 Cartridge resulted in an abnormally high dud rate. An intensive investigation of the problem over approximately a two month period revealed an inherent deficiency in the M69 Detonator Technical Data Package which allowed inadequate consolidation of the Lead Azide Charge. This results in a shift of the Lead Azide Charge during high "g" ballistic firing causing a separation at the Carbon Bridge Interface and subsequent non-initiation upon electrical pulsing of the Carbon Bridge. Resolution of the ~~dud~~ problem required implementation of a number of revisions to the TDP, the most significant of which were to increase the Lead Azide Charge thereby increasing the consolidation pressure to the proper level, and to control the manufacturing parameters and loading procedures to guarantee and maintain the integrity of the detonator design during production.

I. INTRODUCTION

The M69 Detonator is a Carbon Bridge Electric Detonator utilized in the M530 Series PIBD Fuzes designed for use in the 90MM and 106MM Recoilless Rifle HEAT Cartridges. The recoilless rifle projectiles are characteristically low acceleration (less than 10,000 g's setback) and low velocity (less than 2,000 fps) projectiles. The M69 Detonator has also been utilized in very limited quantity in a modified M530 Fuze (XM559E1) being developed for use in the 90MM and 105MM HEAT Cartridges fired from the respective tank guns. In contrast, the projectiles fired from these weapons are high acceleration (setback greater than 35,000 g's) and high velocity (greater than 3,800 fps). This program, however, never proceeded to completion, consequently the M69 Detonator was never actually qualified in the tank guns.

A recent malfunction investigation on the 105MM M456A1 HEAT Cartridge, included among other things, an evaluation of the M509A1 Fuze as a potential contributor to the malfunction. One of the results of that investigation was the discovery that the M509A1 Fuze was not out-of-line detonator safe. This condition was traceable to the M48 Detonator, whose output cannot be contained by the fuze metal parts when it functions in the normally safe out-of-line position.

Consequently, a Product Improvement Program was authorized to rectify this condition as well as several others related to reliability.

Since the M530 Series Fuzes are detonator safe utilizing almost identical metal parts, design arrangement and the same explosive components (lead and booster) except for the detonator, it was decided that replacement of the M48 Detonator with the M69 Detonator offered the most expedient resolution of the detonator safety problem. Initial fuzes containing M69 Detonators assembled for test indicated satisfactory resolution of the detonator safety problem, but uncovered an unsatisfactory dud problem during ballistic firings. This report presents the problem experienced, the investigation and evaluation of that problem, the outcome of the corrective actions implemented and a discussion of the results.

II. BACKGROUND

The M509A1 PIBD Fuze (Figure 1) is currently used in a number of HEAT Cartridges, specifically the 105MM M456A1; the 106MM M344A1 and the 90MM M431E2. Recently, the M456A1 and M344A1 Cartridges have been the subjects of in-bore premature malfunction investigations. As such, the M509A1 Fuze became an inherent part of those investigations with regard to its relationship as a potential contributor to the malfunctions. The culmination of the fuze investigation was the discovery of a number of M509A1 Fuze Technical Data Package inadequacies affecting both the safety and reliability of the fuzing system.

The primary discovery relative to safety, was the absence of adequate out-of-line detonator safety in the M509A1 Fuze. Static detonator safety tests conducted during the investigation, resulted in initiation of the HE filler of an M456A1 Cartridge (Figures 2a and 2b). Additional detonator safety tests conducted on the fuze alone, showed that the M48 Detonator, when in the safe out-of-line position, was able to blast through the steel fuze housing shield with sufficient force to initiate the HE projectile filler directly. Research on the past history of the M509A1 Fuze, revealed that the fuze was considered only marginally detonator safe in the out-of-line position because of bulging and cracking of the fuze housing shield. It was also found that during the ensuing years of production, an engineering change was implemented to allow a free machining steel for the housing shield. The higher lead content resulted in a softer more ductile material which in the most recent tests suffered severe damage due to the detonator blast alone (Figure 3). This resulted in an even further degradation of an already marginally safe condition.

Another condition uncovered, was the location of the fuze in the projectile. The original version of the M456A1 Cartridge, was designed such that the fuze was completely encapsulated within the metal of the projectile body as shown for the 90MM Projectile in Figure 4. Only the output end of the fuze booster was exposed to the explosive filler. An engineering change implemented as the result of an earlier (1961) premature investigation modified the projectile assembly from a two piece to a one piece body design (Figure 5). This change shortened the overall projectile length and resulted in the fuze location being shifted such that over half the fuze is now encapsulated within the HE filler. The same situation also exists by design in the 106MM M344A1 HEAT Cartridge (Figure 6). Ultimately it was found that this fuze location combined with the weaker housing shield material and excessive output M48 Detonator, collectively resulted in the M509A1 Fuze not being detonator safe.

In attempting to correct the detonator safety condition, it was considered that the M48 Detonator with its excessive output was basically the problem. It was decided that a lower output detonator would provide the most expeditious resolution. Toward this end, the M69 Detonator used in the M530 Series Fuzes seemed to be the most logical choice for replacement of the M48 Detonator. The M509 and M530 Fuzes are almost identical in size, metal parts design, operation (share common arming mechanism) and electrical characteristics. The explosive trains consist of common lead and booster charge components except for the detonators. The M48 Detonator (Figure 7) is a relatively large (.274" dia x .490") detonator, has wire leads and contains approximately 160 mg's of output charge. The M69 Detonator (Figure 8) is smaller (.195" dia x .370"), has a button lead and approximately an 85 mg output charge. Both detonators were considered to be interchangeable with regard to end item utilization. Consequently, design revisions were instituted in the M509A1 Fuze, to replace the M48 Detonator with the M69 Detonator.

A quantity of 2,000 M69 Detonators (Lot AM2-3-4) was purchased from AMRAM Corporation, Vineland, New Jersey for evaluation purposes in the M509A1E1 Fuze Product Improvement Program. The required acceptance tests were conducted in accordance with the specification, and produced satisfactory results (Table I).

The first group of 100 M509A1E1 Fuzes containing M69 Detonators was assembled for laboratory type tests. Fifty (50) were first subjected to an air gun test for arming evaluation and then divided into two groups; 25 for static detonator only functioning and 25 for complete explosive train propagation (detonator through booster) at ambient temperature. The balance of 50 were to be divided such that 10 would be subjected to detonator safety tests and 40 to complete explosive train propagation, half each at -35°F and +125°F.

These tests were conducted, with the results as shown in Table II. Of the 10 units assembled for static detonator safety, three were unusable due to problems peculiar to the specially modified assembly necessary to initiate the detonator in the out-of-line position. The seven remaining units subjected to the out-of-line detonator safety tests showed successful resolution of the detonator safety problem. The units tested with M69 Detonators (Figure 9) show virtually no parts deformation as compared to those tested with the M48 Detonator (Figure 10) which were completely blown apart.

The results of the detonator and complete explosive train functioning tests, both static and after being subjected to the simulated setback of the air gun, demonstrated an uncharacteristically high number of duds. A number of these duds were subsequently fired by subjecting the detonator to voltage levels in excess of the detonator specification level. Upon investigation as to the cause of this abnormal dud rate, it was found that one of the electrical cables being used for the firing lines was faulty. This resulted in an unreliable voltage signal being delivered to the detonator, thereby causing a corresponding degradation in functioning performance.

In order to confirm this fact, the faulty cable was replaced and a number of retests conducted for verification (Table III). A group of 50 detonators from Lot AM2-3-4, not in fuzes, was temperature conditioned at +125^{o}F and subjected to functioning tests. All 50 functioned properly, with no duds. An additional quantity of 60 detonators was assembled into fuzes and subjected to static initiation tests, 20 each at -35^{o}F, ambient and +125^{o}F. Again all 60 functioned properly, with no duds. A final group of 60 detonators was also assembled into fuzes and subjected to a simulated ballistic environment in the air gun. This was followed by static initiation after temperature conditioning at -35^{o}F, ambient and +125^{o}F. Functioning performance was within acceptance level requirements with two duds occurring in the ambient group. At this point, however, there was still some apprehension over the two duds experienced after the air gun tests. Consequently, it was decided to evaluate the product improved M509A1E1 Fuze with the M69 Detonator for performance in an actual ballistic environment.

A total of 150 M509A1E1 Fuzes was delivered to Camp Edwards, Massachusetts, for assembly into 105MM M456A1 HEAT Cartridges. These rounds were to be tested for an evaluation of fuze arming distance and armor plate functioning performance. The results of this test are detailed in Table IV. A total of 42 rounds was fired to determine the arming distance limits. This test was considered necessary since the addition of the M69 Detonator resulted in a change in the rotor and detonator contact assembly. The results, however, indicated no change in the arming distance due to these configuration changes. The balance of the test consisted of an evaluation of functioning performance against armor plate at 60° obliquity. Here again, as can be seen in the test data, an unacceptable dud rate (4 duds in 29 rounds fired) was experienced.

Evaluation of the results at that time indicated that the performance may have been influenced by the yaw of the round during flight. Excessive yaw combined with the 60° obliquity of the plate could result in an angle of impact such that the piezoelectric element in the nose of the projectile makes contact at such a shallow angle that insufficient voltage is generated to reliably initiate the detonator. In order to evaluate this theory, the armor plate target was raised to 0° obliquity. A total of 20 rounds was fired at this condition resulting in only one dud, well within acceptable performance limits.

In an attempt to further verify this theory, 25 product improved M456A1E2 Projectiles were assembled for test. This projectile design utilizes the Full Frontal Area Impact Switch (FFAIS), which contains a stored energy power supply (independent of impact angle for voltage generation) and has an 80° obliquity functioning capability. Fifteen (15) of these projectiles were assembled with M509A1E1 Fuzes having M69 Detonators, and the remaining 10 with Standard M509A1 Fuzes containing M48 Detonators. Ballistic tests of these rounds against 60° obliquity plate again resulted in approximately a 20% dud rate (3/15) with the M69 Detonators and no duds with the M48 Detonators, Table V. At this point it was concluded that a dud problem unquestionably existed in the M509A1E1 Fuze that appeared to be related to the use of the M69 Detonator. Consequently, an intensive investigation was initiated to analyze and resolve the problem.

III. ANALYSIS OF PROBLEM

A review of the data available at the start of this investigation revealed the following facts about the problem:

a. Statically, the M69 Detonator performs satisfactorily.

b. All failures occurred after the detonators had been subjected to simulated or real ballistic firing environments.

c. Problem appeared to be predominant when tested against 60° obliquity plate where the voltage generated due to impact is minimal. Results of tests against 0° obliquity plate where voltage generated is maximum, showed little or no indication of a dud problem.

d. Dud analysis of those detonators which failed to fire, showed that the Carbon Bridge had been pulsed electrically and for all purposes should have resulted in explosive initiation.

e. X-ray analysis of two duds, indicated what appeared to be a crack in the Lead Azide Charge emanating from the corner of the pin and plug assembly in one of the detonators.

f. Problem appeared to be localized at the Carbon Bridge/Lead Azide Charge Interface.

A meeting was held to disseminate the details of the problem and the above data to the most knowledgeable detonator experts at ARRADCOM, namely; Mr. W. Voreck, Mr. D. Seeger and Mr. J. Hershkowitz. Upon reviewing this information, the general consensus of opinion was that the explosive column was shifting or shearing under setback, at the interface with the Carbon Bridge. In the normal out-of-line position, the detonator is in a horizontal position, such that the acceleration force due to firing is applied transversely or perpendicular to the explosive column. It was also indicated that this condition would result in duds when voltage levels are at or below specification levels. However, it was further explained that significantly higher than normal voltages, such as would occur at 0^{o} obliquity impacts, would override the problem by causing an extremely vigorous breakdown of the Carbon Bridge.

Consequently, it was decided that a test program should be outlined to investigate the cause of the duds and evaluate its resolution. Figure 11 represents the test plan implemented. The basic intent of this plan was to evaluate the present M69 Detonator Lot AM2-3-4 with which the problem occurred, an existing supposedly acceptable lot of M69 Detonators as loaded in M530A1 Fuzes and a quantity of Lot AM2-3-4 modified to correct the hypothesized problem.

In accordance with the test plan, 500 M69 Detonators (Lot AM2-3-4) were set aside for evaluation. Of the 500, a sample of 200 were serialized, weighed and subjected to an electrical resistance check of the Carbon Bridge. These 200 detonators were then x-rayed prior to any subsequent testing. Following x-ray, 100 units were subjected to a simulated ballistic firing environment of 35,000 - 38,000 g's in the air gun. Upon completion of the air gun tests, the detonators were re-x-rayed to determine if any visual damage could be detected. The x-rays showed no visibly detectable flaws due to the simulated ballistic tests. The 100 units were then subjected to static functioning tests using the specification level voltage for all fire conditions. As can be seen in Table VI, 2 of the 100 units failed to function. Again, an electrical check of the Cabron Bridges in the duds, showed a change in resistance values indicative of the fact that the bridges had been electrically pulsed, but the explosive had failed to initiate.

In order to obtain a comparison with previous M69 Detonators produced, a sample of 120 M530A1 Fuzes from Lot AKT-3-2 containing this detonator was down-loaded to remove the lead and booster charges. The rotors containing the detonators were removed from the fuze housings, serialized and checked electrically for bridge resistance. All detonators showed resistances in the acceptable range. Sixty (60) of the 120 were then subjected to static functioning tests resulting in 60/60 proper functioning. The remaining 60 detonators were subjected to air gun tests at 35,000 g's to simulate the ballistic environment. Following the air gun tests the bridge resistance electrical check was repeated with all values still checking out within the acceptable ranges. The sample was then subjected to static functioning tests resulting in one dud out of the 60 tested. These results appeared to indicate that the dud problem experienced was not peculiar to the new Lot AM2-3-4, but was rather an inherent deficiency existent within this detonator.

On the basis of this data, it was recommended by Mr. W. Voreck that a sample of Lot AM2-3-4 detonators be reconsolidated to a fixed pressure. It was his theory that the Technical Data Package as it existed did not adequately control the consolidation pressure of the Lead Azide Charge. The drawings control the loading to a dimension, thereby resulting in a situation where the explosive is pressed to a fixed stop, resulting in a variation in pressures due to metal parts tolerances and charge weights. Consequently, when the consolidation pressure is too low, the setback force, being applied perpendicular to the explosive column in the unarmed position, causes a shifting or separation to occur between the Carbon Bridge and the explosive, where a tight interface must be maintained.

A total of 100 M69 Detonators from Lot AM2-3-4 was provided for reconsolidation. The reconsolidation pressure was set at the maximum allowable on the drawing, 13,000 psi. A sample of 100 was serialized, weighed and dimensionally checked prior to reconsolidation. The first 10 detonators were subjected to 13,000 psi and checked. One of the 10 showed an open circuit during the electrical resistance check and was discarded. The remaining 9 showed acceptable resistance readings and were subjected to static functioning tests. All 9 functioned properly.

On the basis of these results, the remaining 90 detonators were subjected to the reconsolidation pressure of 13,000 psi. Following the pressing operation, the detonators were dimensionally and electrically checked. As a result of the reconsolidation, the length of the detonators was reduced a minimum of .006" to a maximum of .019". The average reduction in length was .013". All electrical resistance readings were acceptable. The 90 detonators were also x-rayed and showed no noticeable effects from the reconsolidation operation. The detonators were then subjected to air gun tests at 35,000 g's prior to static functioning. All 90 detonators were then tested for functioning at specification level voltage, resulting in 90/90 proper functioning with no duds.

These results seemed to substantiate the basic theory that the explosive charge separates from the Carbon Bridge due to the rigorous ballistic environment of the 105MM Tank Gun. The separation apparently was caused by inadequate consolidation of the Lead Azide Charge due to deficient controls within the TDP. At this point it was decided that verification of this condition could best be accomplished by a ballistic test of a sample of M69 Detonators fabricated and assembled to a revised loading procedure to control the consolidation pressure of the Lead Azide.

IV. CORRECTIVE DESIGN REVISIONS

With the aid of Mr. Voreck, a revised loading procedure was established to control the consolidation of the Lead Azide Charge with minimal effect on the manufacturing process. This was done by increasing the nominal Lead Azide Charge weight by 15 mg. This weight was calculated by Mr. Voreck on the basis of the reconsolidation data previously generated and the requirement to maintain a pressure of approximately 13,000 psi. This effort was discussed with the detonator manufacturer (AMRAM Corporation, Vineland, New Jersey) and a quantity of 500 units was fabricated for tests.

The 500 revised M69 Detonators were delivered to the fuze metal parts contractor and assembled into fuzes for tests. Since the dud rate experienced during ballistic tests was relatively high for the small number of rounds fired as compared to the dud rate experienced during laboratory tests, it was decided that a ballistic test would provide a more positive indication of resolution of the problem. Therefore, on the basis of the dud rate previously experienced against 60° obliquity armor, it was considered that a 25 round sample was sufficient to verify resolution. The fuzes were assembled into 105MM M456A1 HEAT Cartridges. One cartridge was rejected during inspection for a damaged obturator, leaving 24 rounds for the test. The 24 rounds were ballistically tested against 60° obliquity armor at Camp Edwards, Massachusetts (Table VII) under test conditions identical to those which had previously produced the unacceptable dud rate. The test results were highly successful in that 24/24 functioned properly with no duds. These results were in marked contrast to the previous tests in which four duds were experienced in 29 rounds. Consequently, it would appear that the dud problem was properly diagnosed as being attributable to the M69 Detonator, and could be eliminated by the application and control of the proper level of consolidation pressure for the Lead Azide Charge. Subsequent testing in larger quantity further confirmed this.

V. DISCUSSION OF RESULTS

The results of the investigation conducted to determine the cause of the duds experienced with the M69 Detonator in the M509A1E1 Fuze application, have shown the problem to be directly related to a basic inadequacy in the Technical Data Package. The problem was not related to any defect in the detonator design, but rather to the lack of adequate controls in the TDP on the method or process of manufacture. Moreover, from the limited data available in this area, it is felt that this problem was not restricted to any individual lot of detonators produced. In all likelihood it would appear that the majority of M69 Detonators produced to date contain the same basic defect to some degree. Only the use of this detonator exclusively in low acceleration weapons has prevented its being noticed previously.

The problem is the result of two basic factors. First, the TDP for the detonator does not specify and control the loading pressure of the Lead Azide Charge which is critical to maintaining the integrity of the loaded assembly. In addition, the present specification for the detonator requires only a static test sequence for acceptance. If a dynamic test sequence had been in force, the detonator deficiency would have been discovered much earlier and the time and cost expended in firing complete fuzed projectiles could have been avoided. Consequently, this also is viewed as an additional TDP deviciency.

The second factor relative to this problem is the method of manufacture. In simplified terms, the loading of these detonators consists first of the assembly and pressing of an 80-84 mg PETN pellet into the detonator cup to a height of .128" - .140". The colloidal Lead Azide spot is then applied to the bridge assembly. Then 82-92 mg of dextrinated Lead Azide is added to the cup and the bridge assembly is pressed to a stop, to produce a header height of .353" - .358". If the Lead Azide by weight is on the low side and the metal parts assembly is at maximum metal conditions (detonator cup diameter and length is at the maximum end) a low density charge will result. During acceleration this low density charge can slide sideways over the spotting charge, breaking it away from the bridge, and causing misfires. Thus the present method of manufacture is geared to assemble and check detonators to heights by fixed stops in the loading presses. This facilitates manufacturing and inspection, but does not guarantee adequate charge consolidation pressure. Consequently, to provide and maintain an acceptable detonator revisions to one or both of these factors must be addressed.

VI. RECOMMENDATIONS

Based upon the findings of this investigation, it is recommended that the M69 Detonator TDP be revised to correct the deficiencies discovered. Briefly, these changes will include an increase in the weight of the Lead Azide Charge (Dwg No. 8857199) to guarantee, under the fixed stop loading procedure, that the consolidation pressure would be no less than 12,000-13,000 psi. This method would not require any revision in present manufacturing or inspection procedures in order to maintain the required loading density. In addition, the specification acceptance criteria (Spec No. MIL-D-60031) will be revised to incorporate a series of dynamic functioning tests as well as the usual static functioning tests. The dynamic tests will simulate the acceleration levels associated with the most severe ballistic environment in which the detonator will be used, and will be patterned after those successfully utilized in Navy detonator specifications. Implementation of these changes will result in a high quality, reliable detonator capable of uniform performance across its ballistic utilization spectrum. It is additionally recommended that TDPs for other detonators, requiring operation within similar ballistic environments, be given consideration for incorporation of dynamic tests for acceptance. Implementation of such a procedure would conceivably reject potentially defective detonators prior to costly fuze or projectile acceptance tests.

VII. FIGURES

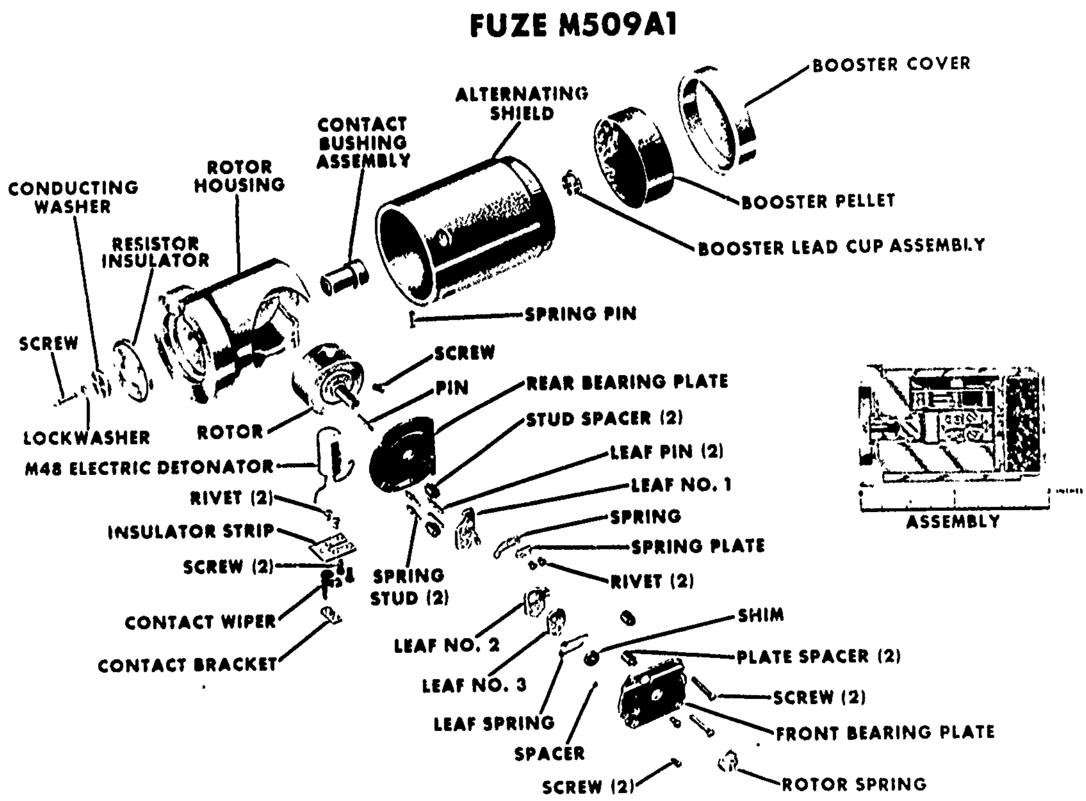

FUZE M509A1
BOOSTER COVER
ALTERNATING SHIELD
CONTACT BUSHING ASSEMBLY
ROTOR HOUSING
CONDUCTING WASHER
RESISTOR INSULATOR
BOOSTER PELLET
BOOSTER LEAD CUP ASSEMBLY
SPRING PIN
SCREW
SCREW
PIN
REAR BEARING PLATE
LOCKWASHER
ROTOR
STUD SPACER (2)
M48 ELECTRIC DETONATOR
LEAF PIN (2)
LEAF NO. 1
RIVET (2)
SPRING
INSULATOR STRIP
SPRING PLATE
SCREW (2)
SPRING STUD (2)
RIVET (2)
CONTACT WIPER
SHIM
LEAF NO. 2
CONTACT BRACKET
PLATE SPACER (2)
LEAF NO. 3
SCREW (2)
LEAF SPRING
FRONT BEARING PLATE
SPACER
SCREW (2)
ROTOR SPRING
ASSEMBLY

FIGURE 1

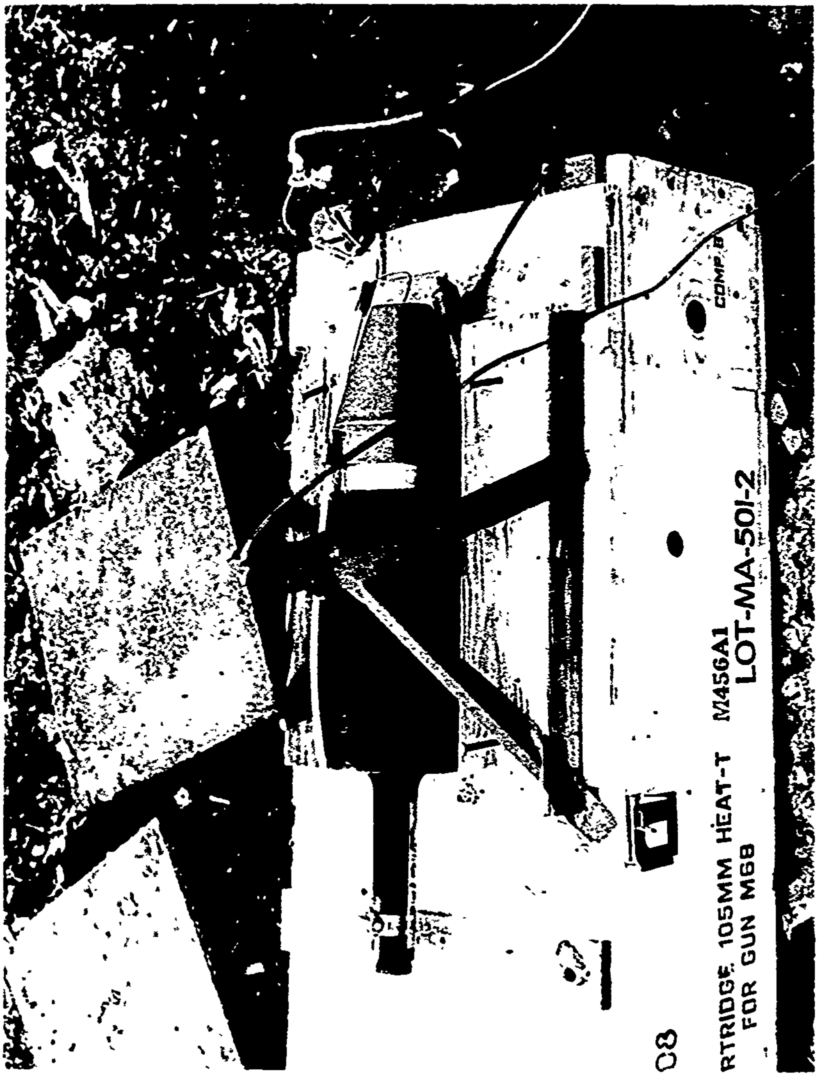


FIGURE 2a

FIGURE 2b

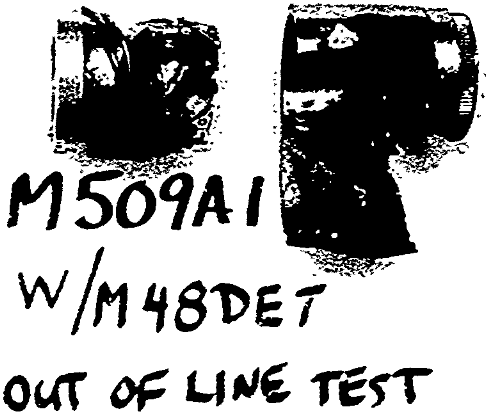


FIGURE 3

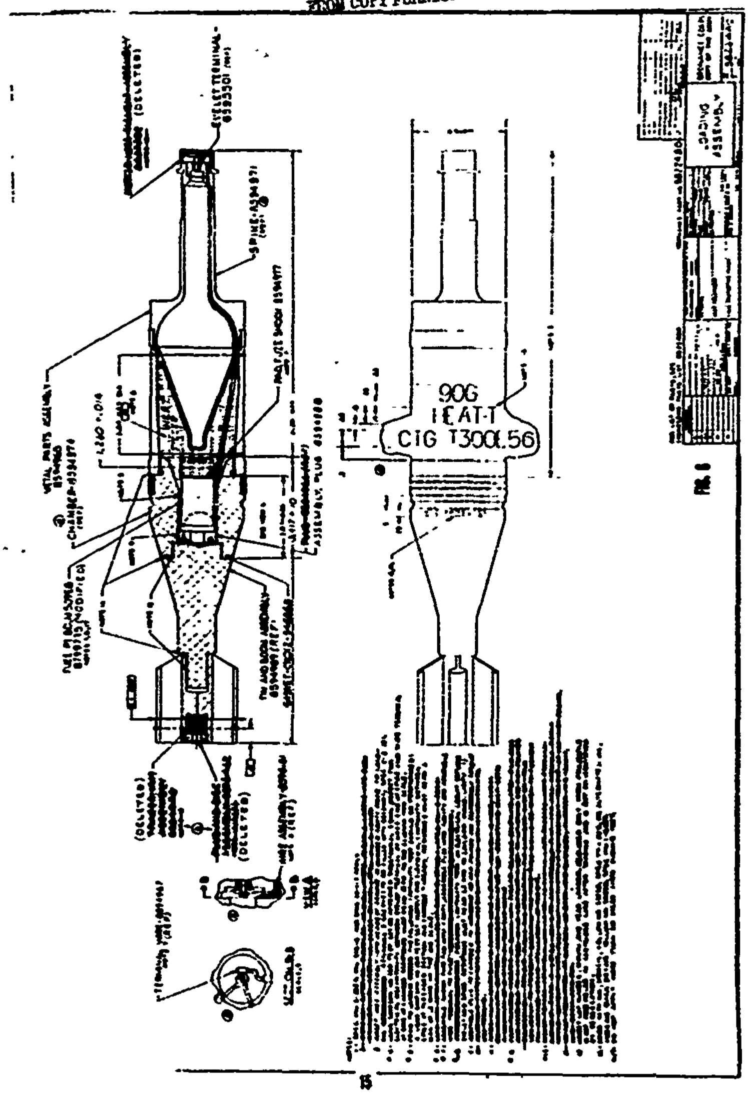


FIGURE 4

105MM M456 HEAT PROJECTILE
W/M509A1 PIBD FUZE

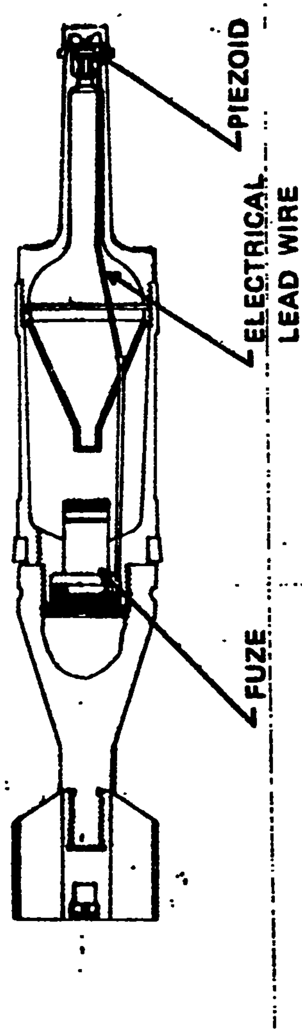


FIGURE 5

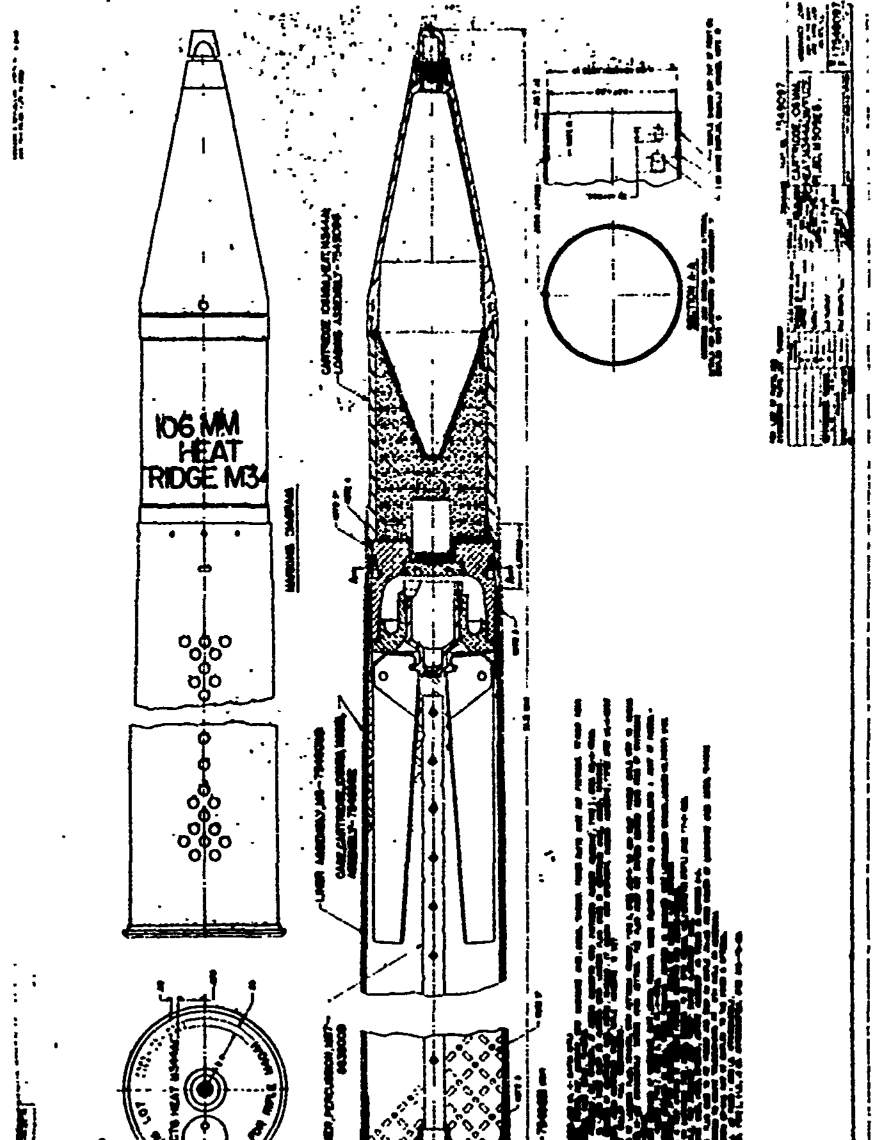
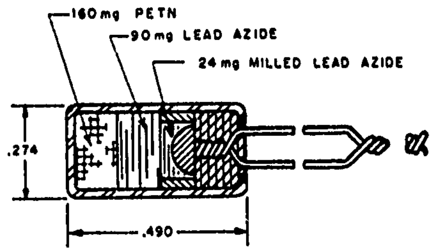


FIGURE 6

M48 (T18E4) DETONATOR



DESCRIPTION

CUP	Aluminum
CONTACTS	Stainless steel wire leads
BRIDGE	Carbon
RESISTANCE	1000 - 10,000 ohms
CODE NO.	Wnt7efm
DWG. NO.	73-1-240
SPEC. NO.	NO. PA-PD-197
MANUF.	Atlas Powder Co.

SENSITIVITY

SPECIFICATION
0.0022 μf
300 volt

FUNCT. PROB'Y	CHARGED CAPACITOR		
0.95* 0.50 0.05*	0.0022 μf 195 v 0.0022 μf 85 v 0.0022 μf 37 v		
DATE FIRED	March 1954		

RELIABILITY WITH 90% CONF. TEST CONDITIONS LOT NO.

NO. TESTED FIRED NO. MISFIRED AVG. FUNCT. TIME AVG. RESIST.

OUTPUT **Minimum hole in lead disk is 5/8 in.

REFERENCES

* With 90% confidence.
** These data were not obtained at Franklin Institute.

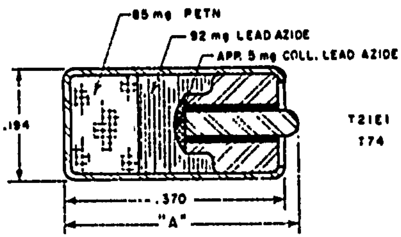
FIGURE 7

T21E1 (T74) DETONATOR

M69

DESCRIPTION

CUP	Stainless steel
CONTACTS	Stainless steel button
BRIDGE	Carbon
RESISTANCE	1000 - 10,000 ohm
CODE NO.	SJQ7efm
DWG. NO.	P-85443
SPEC. NO.	X-PA-PD-686 (assembly) X-PA-PD-841 (metal parts)
MANUF.	Atlas Powder Co.



	"A"
T21E1	.425 MAX
T74	.485 MAX

SENSITIVITY

SPECIFICATION
0.0022 uf
300 volt

FUNCT. PROB'Y	CHARGED CAPACITOR	CONSTANT VOLTAGE	
0.95*	0.0022 μf 93 v	18 v Pulse	
0.50	0.0022 μf 47 v	10 v Duration	
0.05*	0.0022 μf 26 v	6.0 v 1 msec	
DATE FIRED	December, 1953	January 1958	

RELIABILITY WITH 90% CONF. 99.5% TEST CONDITIONS .0022 mfd capacitor at 300 v LOT NO. AAP 65-6
NO. TESTED 500 FIRED 100% NO. MISFIRED 0 AVG. FUNCT. TIME 1.79 μsec AVG. RESIST. 4400 ohms

OUTPUT **Initiates tetryl lead across 0.090 in. air gap.

REFERENCES Notes on Development Type Materiel, Detonator, Electric, Picatinny Arsenal Notes No. 113.

* With 90% confidence.
** These data were not obtained at Franklin Institute.

FIGURE 8

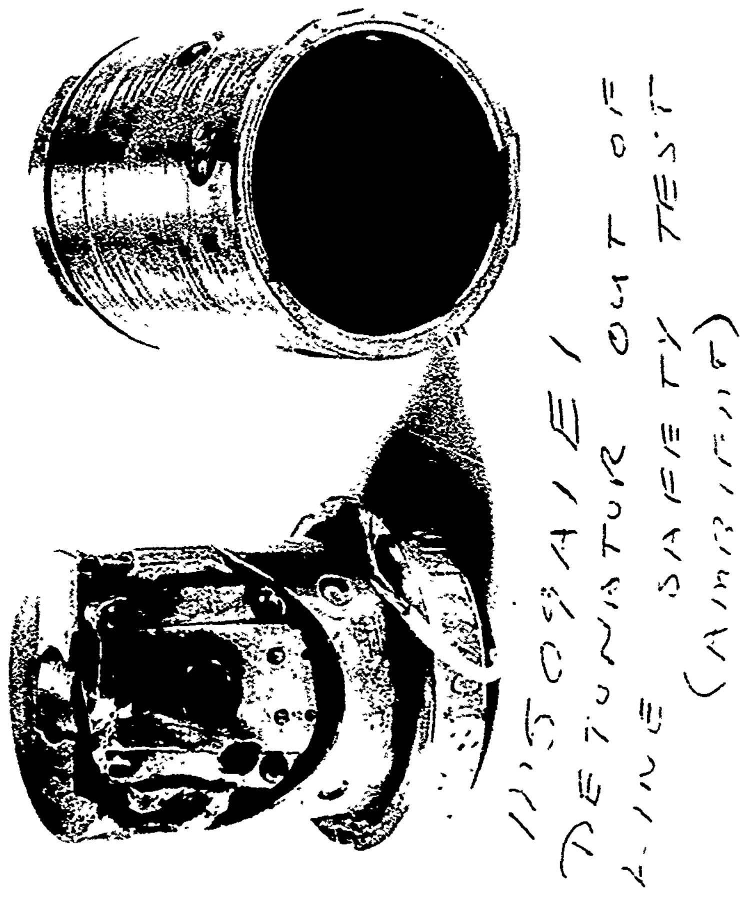


FIGURE 9

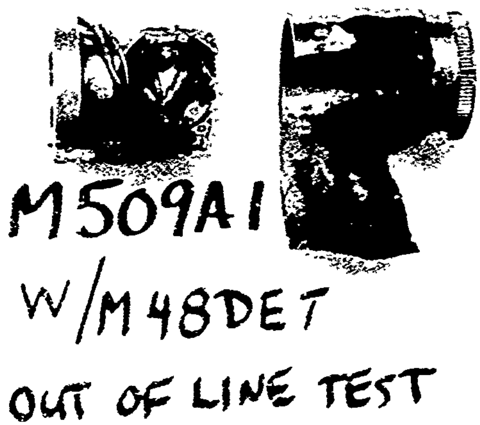


FIGURE 10

M69 DETONATOR INVESTIGAION PLAN

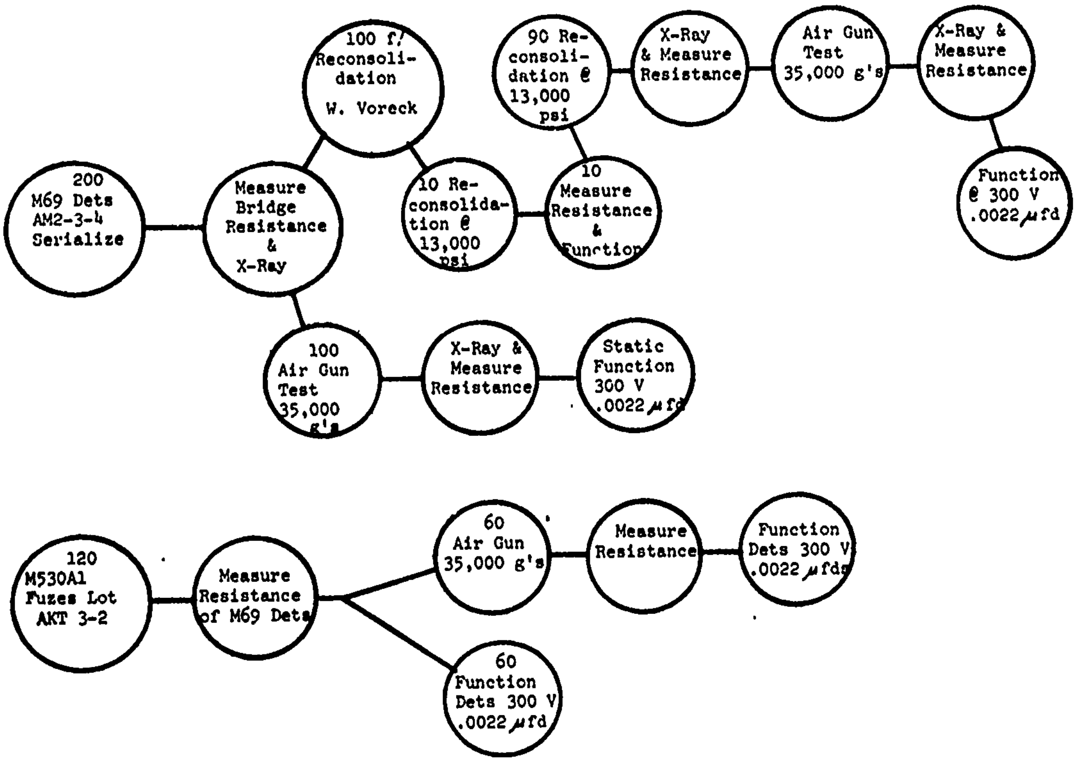


FIGURE 11

VIII. DATA 'ABLES

TABLE I.

M69 DETONATOR ACCEPTANCE TESTS
SPECIFICATION MIL-D-60031 (MU)
AMRAM LOT AM-2-3-4

A. SPECIFICATION TEST REQUIREMENT: Functioning Time, Para. 4.3.4

Requirement - Functioning within 5 microseconds
Units Tested - 35
Mean Functioning Time - 2.115 microseconds

B. SPECIFICATION TEST REQUIREMENT: Waterproofness and Output, Para. 4.3.5

Requirement - Reject on one or more duds
Units Tested - 50
Conditions - Immersion in water maintained @20°C for not less than 48 hours at a depth of 2-3 inches
Functioning - 50/50, no duds

C. SPECIFICATION TEST REQUIREMENT: Duds, Para. 4.3.6

Requirement - Accept on one dud, reject on two or more
Units Tested - 100
Functioning - 99/100, 1 dud

TABLE II.

STATIC LABORATORY TESTS
M509A1E1 FUZE W/M69 DETONATOR

A. DETONATOR SAFETY: MIL-STD-331A, Test 115

10 units assembled for test, 3 rejected electrically for malassembly

7 units tested and found completely acceptable in accordance with MIL-STD-331 requirement

B. DETONATOR FUNCTIONING: (300V @ .0022 μfd Firing Pulse)

25 units initiated @ ambient temperature

22/25 functioned properly
3/25 duds

* Attempts to fire 3 duds @ 500V - failed 0/3

C. PROPAGATION: Detonator Through Booster

25 units initiated @ ambient temperature

18/25 functioned properly
7/25 detonator duds

* Attempts to fire 7 duds @ 500V

2/7 functioned @ 500V
5/7 duds @ 500V

20 units initiated @ -35°F

14/20 functioned properly
6/20 detonator duds

* Attempts to fire 6 duds @ 500V - failed 0/6

20 units initiated @ 125°F

12/20 functioned properly
8/20 detonator duds

* Attempts to fire 8 duds @ 500V

4/8 functioned
4/8 duds

TABLE III.

STATIC LABORATORY RETEST
M69 DETONATORS

A. DETONATOR FUNCTIONING (Bare Detonators)

50 units initiated @ +125°F

50/50 functioned properly
0/50 duds

B. DETONATOR FUNCTIONING (Detonators Assembled in Fuzes)

20 units initiated @ -35°F

20/20 functioned properly
0/20 duds

20 units initiated @ ambient temperature

20/20 functioned properly
0/20 duds

20 units initiated @ +125°F

20/20 functioned properly
0/20 duds

C. DETONATOR FUNCTIONING AFTER AIR GUN TESTING

60 units subjected to 35,000 g's

All fuzes armed properly

20 units conditioned @ -35°F & initiated

20/20 functioned properly; 0 duds

20 units initiated @ ambient temperature

18/20 functioned properly
2 duds

20 units conditioned @ +125°F and initiated

20/20 functioned properly; 0 duds

BALLISTIC DATA SHEET

TABLE IV

SHEET 1 OF 3

TEST ITEM:	PURPOSE OF TEST:	ADDITIONAL COMMENTS
FUZE PIBD M509A1E1	EVALUATE PRODUCT IMPROVED M509A1E1 FUZE FOR: - 1. ARMOR PLATE FUNCTIONING & PENETRATION 2. MODIFIED LANGLIE FOR ARMING DISTANCE VERIFICATION	

GUN	TUBE	RECOIL	TEST SITE	DATE 15-18 NOV 77	OBSERVERS
105mm M68	# 18567	M116A # 747	LOCATION CAPE, MASS. CAMP EDWARDS RANGE J-1	PROJ. NO. DATA BOOK NO. TASK & AMEND. NO.	J. JULIANO/M CANNER PROOF OFFICER R. WOODBURY

	ROUND NO.		PROJECTILE		FUZE		TARGET	RANGE	TEMP. CONDITION	RESULTS
	TEST	PROJ.	TYPE	LOT	TYPE	LOT				
11/15	· 1	1237	M456A1	MA-77K000	M509A1E1	MT 77K	1¼" PLYWOOD	40'	AMBIENT	ARMED & FUNCTIONED
11/16	2	1238		E029		ORE002	6" WHITE · 60°	225'	+125°F	COMPLETE PENETRATION
	3	1239		MA-896			"	"	"	" "
	4	1240					"	"	"	" "
	5	1241					"	"	"	" "
	6	1242					"	"	"	" "
	7	1243					"	"	"	" "
	8	1244					"	"	"	" "
	9	1245					"	"	"	" "
	10	1246					"	"	"	" "
	11	1247					"	"	"	" "
	12	1248					1¼" PLYWOOD	40'	AMBIENT	ARMED & FUNCTIONED
	13	1249					"	"	"	" "
	14	1250					"	"	"	" "
	15	1251					"	"	"	" "
	16	1252					"	30'	"	NOT ARMED
	17	1253					"	"	"	ARMED & FUNCTIONED
	18	1254					"	"	"	" "
	19	1255					"	"	"	" "
	20	1256					"	"	"	" "
	21	1257					"	25'	"	" "

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TEST ITEM: FUZE PIBD M509A1	PURPOSE OF TEST: 1. ARMOR PLATE FUNCTIONING & PENETRATION 2. ARMING DISTANCE VERIFICATION			ADDITIONAL COMMENTS	
GUN	TUBE	RECOIL	TEST SITE	DATE 15-18 NOV 77	OBSERVERS
105mm M68	# 18567	M116A #747	LOCATION CAMP EDWARDS, MASS. RANGE T-1	PROJ. NO. ____ DATA BOOK NO. ____ TASK & AMEND. NO. ____	J. JULIANO/M. CONNOR; PROOF OFFICER: R. WOODBURN

ROUND NO. TEST	ROUND NO. PROJ.	PROJECTILE TYPE	PROJECTILE LOT	FUZE TYPE	FUZE LOT	TARGET	RANGE	TEMP. CONDITION	RESULTS
·22	1258	M456A1	MA-77K000	M509A1	NIT 77K	1 1/4" PLATE	25'	AMBIENT	ARMED & FUNCTIONED
23	1259		E029		OHE002	"	15'	"	NOT ARMED
24	1260		MA-896			"	"	"	" "
25	1261					"	20'	"	ARMED & FUNCTIONED
26	1262					"	"	"	" "
27	1263					"	"	"	" "
28	1264					"	"	"	NOT ARMED
29	1265					"	"	"	ARMED & FUNCTIONED
30	1266					"	"	"	" "
11/17 31	1267		MA-77K000			"	"	"	" "
32	1268		E02B			"	"	"	" "
33	1269		MA-896			"	"	"	NOT ARMED
34	1270					"	"	"	" "
35	1271					"	15'	"	" "
36	1272					"	"	"	" "
37	1273					"	"	"	" "
38	1274					"	"	"	" "
39	1275					"	"	"	" "
40	1276					"	"	"	" "
41	1277					"	"	"	" "
42	1278					"	"	"	" "

·BALLISTIC DATA SHEET

TEST ITEM:	PURPOSE OF TEST	ADDITIONAL COMMENTS
FUZE PIBD M509A1E1	1. ARMOR PLATE FUNCTIONING & PENETRATION 2 ARMING DISTANCE VERIFICATION.	

GUN	TUBE	RECOIL	TEST SITE	DATE 15-18 NOV 77	OBSERVERS
105mm M68	# 18567	M116A #747	LOCATION CAPE, MASS. CAMP EDWARDS RANGE J-1	PROJ. NO. DATA BOOK NO. TASK & AMEND. NO.	J. JULIANO / M CONNOR PROOF OFFICER R. WOODARCH

ROUND NO. TEST	ROUND NO. PROJ.	PROJECTILE TYPE	PROJECTILE LOT	FUZE TYPE	FUZE LOT	TARGET	RANGE	TEMP. CONDITION	RESULTS
·43	1279	M456A1	MA-77E000	M509A1E1	NIT 77K	6" ARMOR-60°	325'	-30°F	DUD - NO PENETRATION
44	1280		E019		01BE002	"	"	"	COMPLETE PENETRATION
45	1281					"	"	"	" "
46	1282					"	"	"	" "
47	1283					"	"	"	" "
48	1284					"	"	"	" "
49	1285					"	"	"	" "
50	1286					"	"	"	" "
51	1287					"	"	"	DUD - NO PENETRATION
52	1288					"	"	"	COMPLETE PENETRATION
53	1289					"	"	AMBIENT	" "
54	1290					"	"	"	" "
55	1291					"	"	"	PARTIAL W/ BULGE
56	1292					"	"	"	DUD - NO PENETRATION - HIGH ON PLATE
57	1293					"	"	"	COMPLETE PENETRATION
58	1294					"	"	"	DUD - NO PENETRATION - HIGH ON PLATE
59	1295					"	"	"	COMPLETE PENETRATION
60	1296					"	"	"	" "
61	1297					10" ARMOR-0°	"	"	" "
62	1298					"	"	"	" "
11/21 63-80	1299-1316					"	"	"	17/18 COMPLETE PENETRATION, 1-DUD

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TABLE V

SHEET 1 OF 2

TEST ITEM:	PURPOSE OF TEST			ADDITIONAL COMMENTS
FUZE, PIBD, M509A1E1	COMPARE PERFORMANCE OF 105mm M456A1E1/FFAIS CARTRIDGE WITH M509A1E1 AND M509A1 FUZES.			

GUN	TUBE	RECOIL	TEST SITE	DATE 13-15 DEC. 77	OBSERVERS
105mm M68	#18567	M116A, #747	LOCATION CAFB, MASS CAMP EDWARDS	PROJ. NO.	H MAYER / J JULIANO
			RANGE J-1	DATA BOOK NO.	PROOF OFFICER
				TASK & AMEND. NO.	R WOODBURN

	ROUND NO.		PROJECTILE		FUZE		TARGET	RANGE	TEMP. CONDITION	RESULTS
	TEST	PROJ.	TYPE	LOT	TYPE	LOT				
12/13	1	1498	M456A1E2	MA-77K000	M509A1E1	WIT-77K018	6" ARMOR	300'	+125°F	Functioned, Complete Point
	2	1517		E042		E002	@ 60° OBL.			" " "
	3	1522								Dud, No Functioning
	4	1502								Functioned, Complete Point
	5	1519								Dud, No Functioning
	6	1514								Functioned, Complete Point
	7	1507								Dud, No Functioning
	8	1511								Functioned, Complete Point
	9	1508								" " "
	10	1515								Functioned, Partial w/ Bulge
	11	1527	M456A1E2	MA-77K000	M509A1	WIT 14-11				" , Complete Point
	12	1547		E027						" " "
	13	1527								" " "
	14	1544								" , Partial w/ Bulge
12/14	15	1541								" " "
	16	1555								" " "
	17	1516	M456A1E2	MA-77K000	M509A1E1	WIT-77K018				" Complete Point
	18	1505		E042		E002				" Partial w/ Bulge
	19	1531	M456A1E2	MA-77K000	M509A1	WIT 14-11				" Complete Point
	20	1530		E027						" Complete Point
	21	1529								" Partial w/ Bulge

·BALLISTIC DATA SHEET

TEST ITEM:	PURPOSE OF TEST	ADDITIONAL COMMENTS
Fuze, PIBD, M509A1E1	Compare performance of 105mm M456A1E2/FM415 Cartridge with M509A1E1 and M509A1 Fuzes	

GUN	TUBE	RECOIL	TEST SITE	DATE 13-18 Oct 77	OBSERVERS
			LOCATION	PROJ. NO.	
			RANGE	DATA BOOK NO.	PROOF OFFICER
				TASK & AMEND. NO.	

ROUND NO.		PROJECTILE		FUZE		TARGET	RANGE	TEMP. CONDITION	RESULTS
TEST	PROJ.	TYPE	LOT	TYPE	LOT				
22	1542								Functioned, Complete Point
13/14 23	1501	M456A1E2	MA-77K000	M509A1E1	WIT-77K018				" Partial Point
24	1512		6042		6002				" Complete Point
25	1518								" Partial Point

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TABLE VI

M69 DETONATOR INVESTIGATION TESTS

1. <u>M69 Detonator (Lot AM2-3-4) Functioning</u>

   100 Detonators:

Air Gun Test:	35,000 g's
Resistance:	All between 1000 - 10,000Ω
X-ray:	No visible defects
Function:	98/100 functioned properly, 2 duds

2. <u>M69 Detonator Functioning from M530A1 Fuze Lot AKT 3-2</u>

   a. 60 Detonators:

Function:	60/60 functioned properly

   b. 60 Detonators:

Air Gun Test:	35,000 g's
Resistance:	9/10 between 1,000 - 10,000Ω
Function:	59/60 functioned properly, 1 dud

3. <u>M69 Detonator (Lot AM2-3-4) Reconsolidation and Functioning</u>

   a. 10 Detonators:

Reconsolidation:	13,000 psi
Resistance:	9/10 between 1,000 - 10,000Ω 1 open circuited and rejected
Function:	9/9 functioned properly

   b. 90 Detonators:

Reconsolidation:	13,000 psi
Length Reduction:	.006"-.019", avg .013"
X-ray	No Visible defects
Resistance:	All between 1,000 - 10,000Ω
Air Gun Test:	35,000 g's
Resistance:	All between 1,000 - 10,000Ω
Function:	90/90 functioned properly

BALLISTIC DATA SHEET
TABLE VII

SHEET 1 OF 2

TEST ITEM:	PURPOSE OF TEST	ADDITIONAL COMMENTS
FUZE PIBD M509A1E1	EVALUATE MODIFIED M69 DETONATOR FOR ELIMINATION OF DUDS IN M509A1E1 FUZE	

GUN	TUBE	RECOIL	TEST SITE	DATE 2 FEB 78	OBSERVERS
M68 - 105mm	#22487	M116 #147	LOCATION CAMP EDWARDS OAFB RANGE J-2	PROJ. NO. DATA BOOK NO. TASK & AMEND. NO.	JULIANO/MOORE/NELSON PROOF OFFICER R. WOODBURN

ROUND NO.		PROJECTILE		FUZE		TARGET	RANGE	TEMP. CONDITION	RESULTS
TEST	PROJ.	TYPE	LOT	TYPE	LOT				
1376	D9	105mm M456	MA 500-5	M509A1E1	MIT 74E018	6" ARMOR	400'	AMB	Complete
1377	D42	HEAT			C004	60°			"
1378	D11								"
1379	D147								"
1380	D7								"
1381	D57								"
1382	D56								"
1383	D151								"
1384	D166								"
1385	D15								"
1386	D126								"
1387	D27								"
1388	D39								"
1389	D56								"
1390	D10								"
1391	D34								"
1392	D05								"
1393	D12								"
1394	D46								"
1395	D4								"
1396	D53								"

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SHEET 1 OF 2

TEST ITEM: FUZE, PIBD, M509E1

PURPOSE OF TEST EVALUATE MODIFIED M69 DETONATOR FOR ELIMINATION OF DUDS IN M509E1 FUZE.

ADDITIONAL COMMENTS

GUN	TUBE	RECOIL	TEST SITE	DATE 2 FEB 78	OBSERVERS
105mm M68	#22487	M118A #747	LOCATION Camp Edwards ORPS RANGE J-2	PROJ. NO. ___ DATA BOOK NO. ___ TASK & AMEND. NO. ___	Johnson/Morris/Batson PROOF OFFICER R. Woodburn

ROUND NO.		PROJECTILE		FUZE		TARGET	RANGE	TEMP. CONDITION	RESULTS
TEST	PROJ.	TYPE	LOT	TYPE	LOT				
1342	1296	105mm M456A1	MA 500-5	M509E1	W/T TRACER	6" ARMOR 6	42°	AMA	Compl. Hi
1345	1291	HEAT			MT M564	60°			"
1349	1249								"

IX. REFERENCES

1. Technical Memorandum ORDBB-DR2-59, "Investigation of M509E6, PIBD Fuze in Relation to Malfunction of T300E56, 90mm HEAT-T and T384E2 105mm Heat Cartridge", dated March 1962.

2. Product Improvement Proposal GG67630, Fuze, PIBD, M509A1E2 Safety and Reliability.

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