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STRUCTURAL ADEQUACY STUDY OF THE XM27 FIN FOR CARTRIDGE, 60 MM:--ETC(U)
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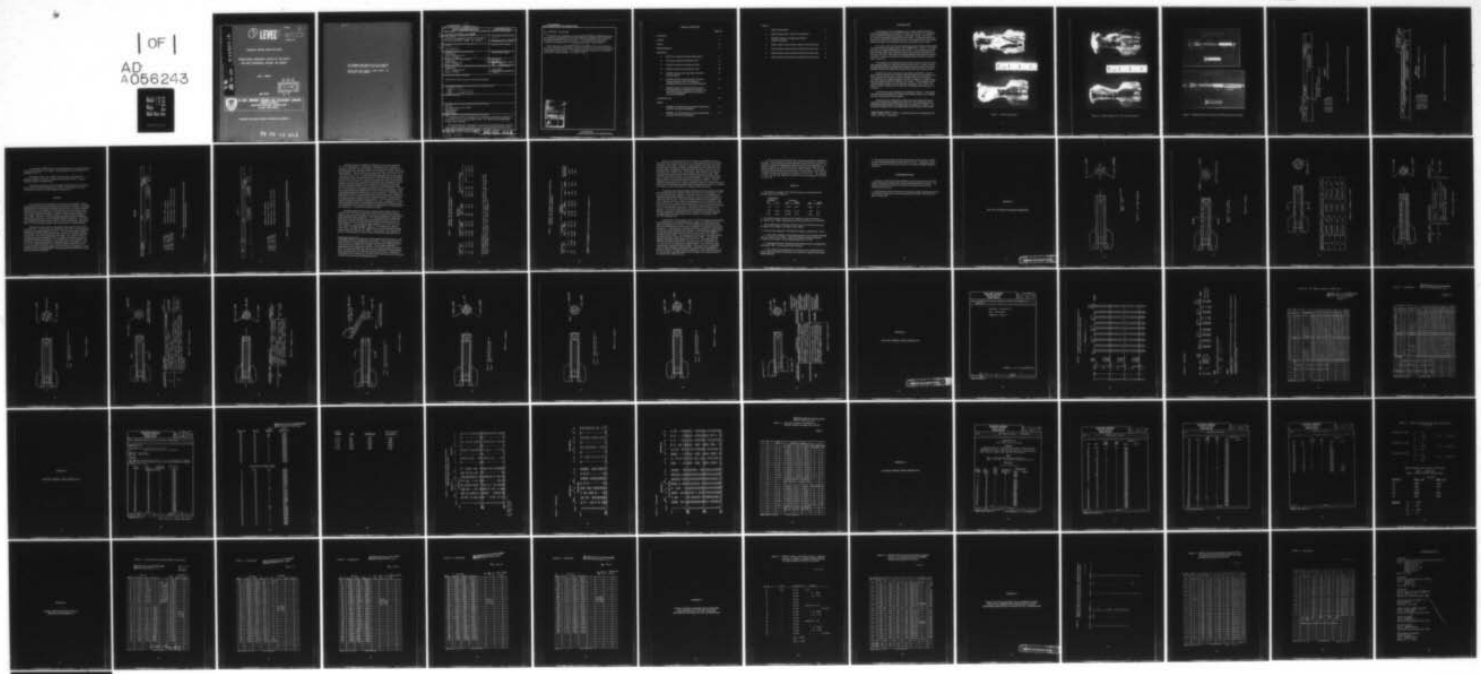

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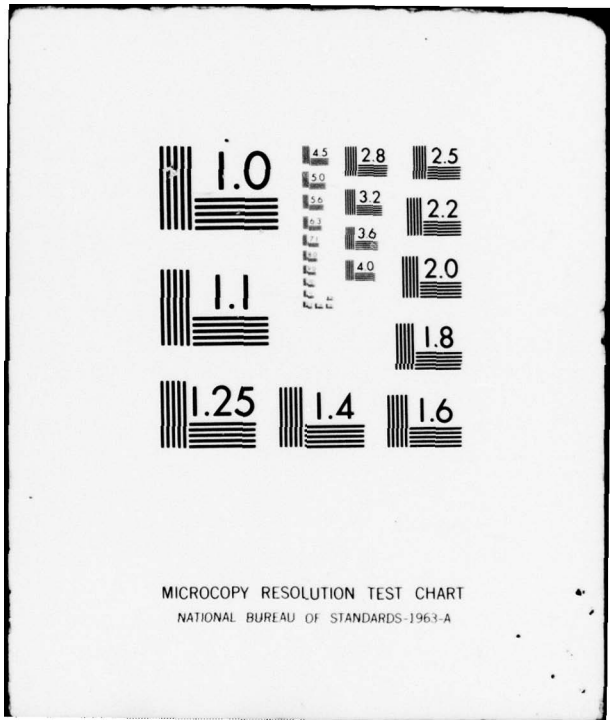
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TECHNICAL REPORT ARLCD-TR-77036

STRUCTURAL ADEQUACY STUDY OF THE XM27 FIN FOR CARTRIDGE, 60 MM: HE, XM720

JOHN J. FENECK

MAY 1978

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

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

The purpose of this investigation was to determine the structural adequacy of the XM27 fin used with Cartridge, 60 mm: HE, XM720 for the Lightweight Company Mortar System.

Stress analyses were conducted on several fins which tested three aluminum alloys (6061T6, 6070T6, and 7075T6) as well as dual material designs using a steel insert inside the aluminum fin boom. → Next Page

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20. ABSTRACT (Continued)

Fin sections were subjected to tensile tests by Frankford Arsenal to determine the mechanical properties of the fin stock (6061T6 and 6070T6) and to determine the actual properties of the fin extrusion. It is noted that the actual tensile strengths were approximately 10.7% higher than the minimum specified.

Static testing was conducted at Picatinny Arsenal to verify analytical predictions and to establish the physical strength of the XM27 fin, which is manufactured from 6070T6 aluminum alloy. The results showed that the XM27 fin's structural safety factor is approximately 1.9 at 70°F (21.1°C).

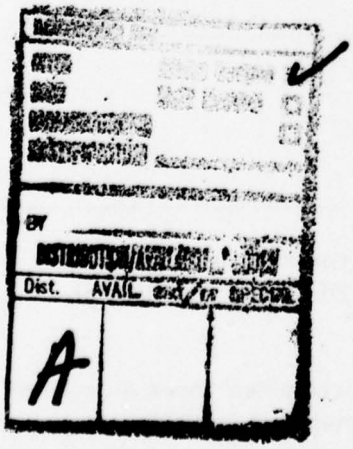


TABLE OF CONTENTS

Figures

INTRODUCTION

The purpose of this investigation was to experimentally determine the structural adequacy of the XM27 fin which is to be used, in conjunction with the XM702E1 ignition cartridge, on Cartridge, 60 mm: HE, XM720 for the New Lightweight Company Mortar System.[1] Several problems were encountered with the fin and the cartridge. The testing done on these items and the solutions to the problems form an intricate part of this report.

Fin rupture was initially encountered during the Product Improvement Testing (PIT) of Cartridge, 60 mm: HE, M49A4E1 (fig. 1 and 2). The XM27 fins were extruded from 6061T6 aluminum alloy. It was determined at that time that the problem was related to erratic burning rates associated with the very small web (.003 inch) of the M9 propellant used inside the ignition cartridge. This was corrected by increasing the M9 propellant web thickness to .006 inch.

The problems of end ignition and a runaway reaction due to the small web were alleviated by crimping the XM702 cap in place. Figure 3 shows the XM702E2 ignition cartridge with the paper tube and paper liner and the XM702E1 ignition cartridge with the brass tube and cap crimped in place.

Several tests were conducted on the XM27 and XM702E1. Elastic-Plastic Stress Analysis (fig. 4 and 5) determined that the yield point of the fin is reached at an internal ignition cartridge pressure of 18,000 psi (124 MPa) and the ultimate strength of the fin is reached at an internal ignition cartridge pressure of 32,000 psi (220.5 MPa). This is based on published minimum values of tensile strength, 48,000 psi (330.7 MPa), and yield strength, 45,000 psi (310.1 MPa) for the 6070T6 aluminum alloy extrusions.

Tensile tests were conducted on extruded fin sections. The results showed a tensile strength of 53,000 psi (365.2 MPa) which is 10.7% higher than the advertised minimum property.

Static tests were conducted to verify analytical predictions and to establish the physical strength of the XM27 fin. The yield point was experimentally determined to be greater than 22,000 psi (151.6 MPa). The ultimate strength of the fin was determined to be 32,000 psi (220.5 MPa).

[1] Model numbers XM27, XM702E1, and XM720 have been redesignated M27, M702, and M720, respectively.

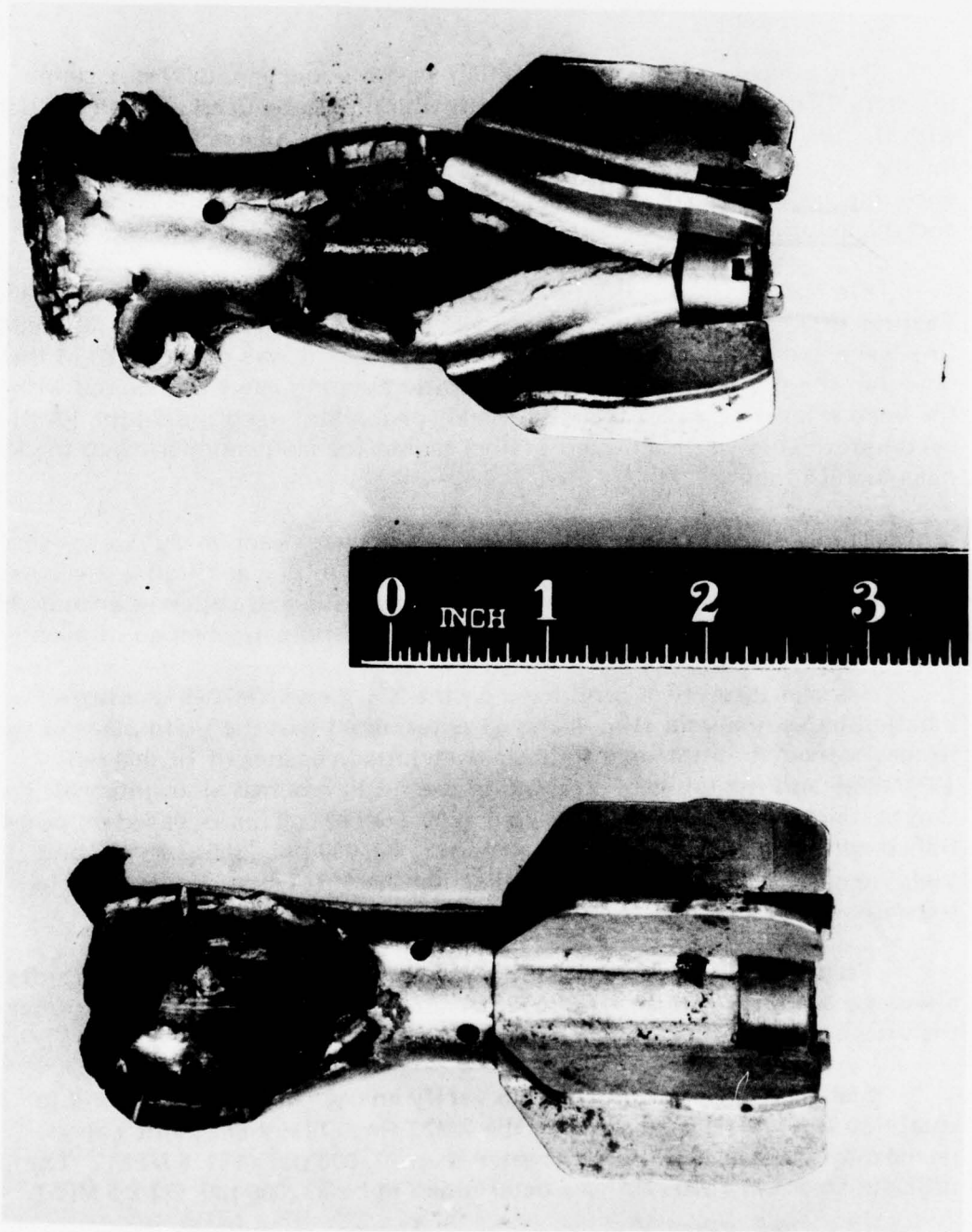


Figure 1. 6061T6 ruptured fin

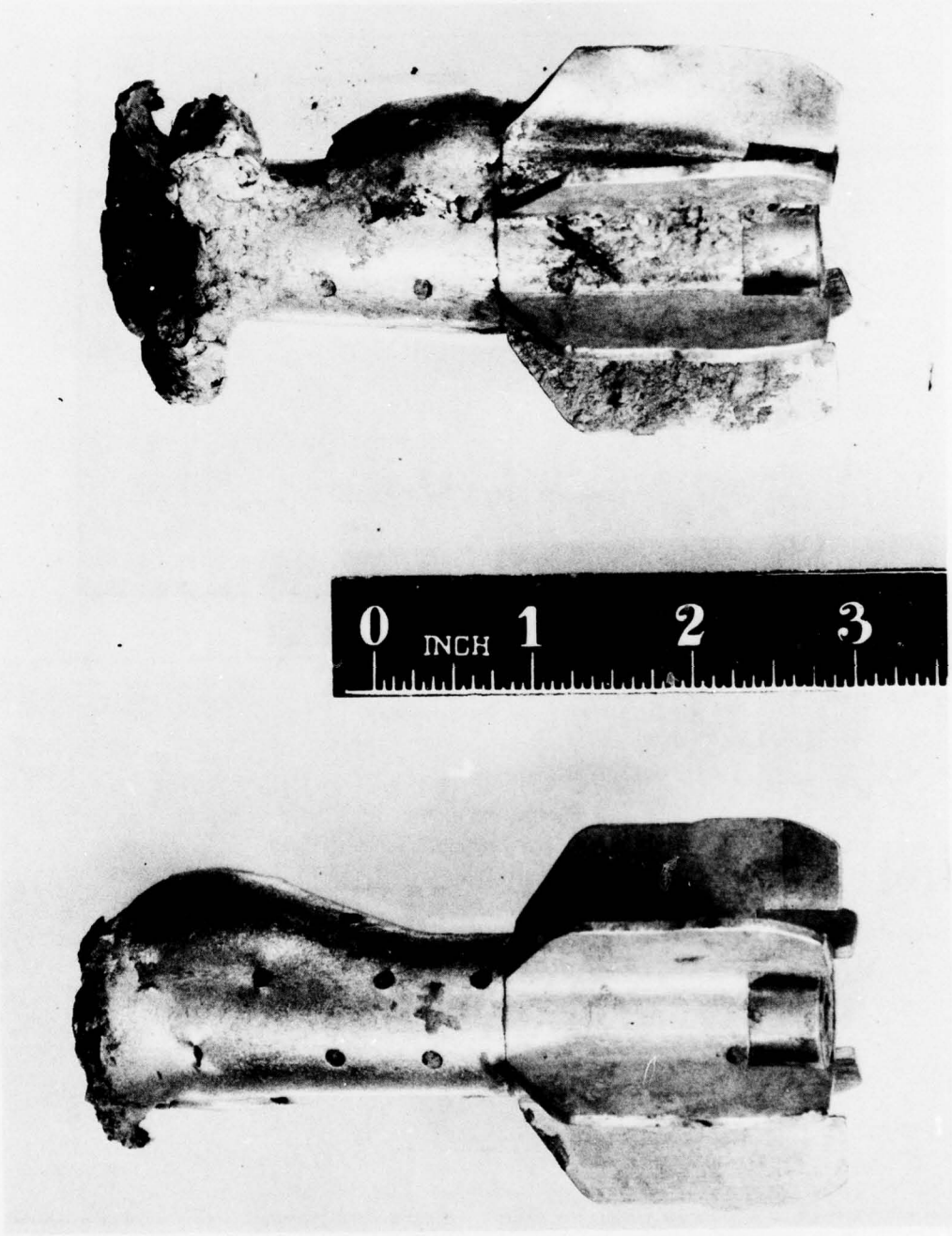


Figure 2. 6061T6 ruptured fin, 180° view from figure 1

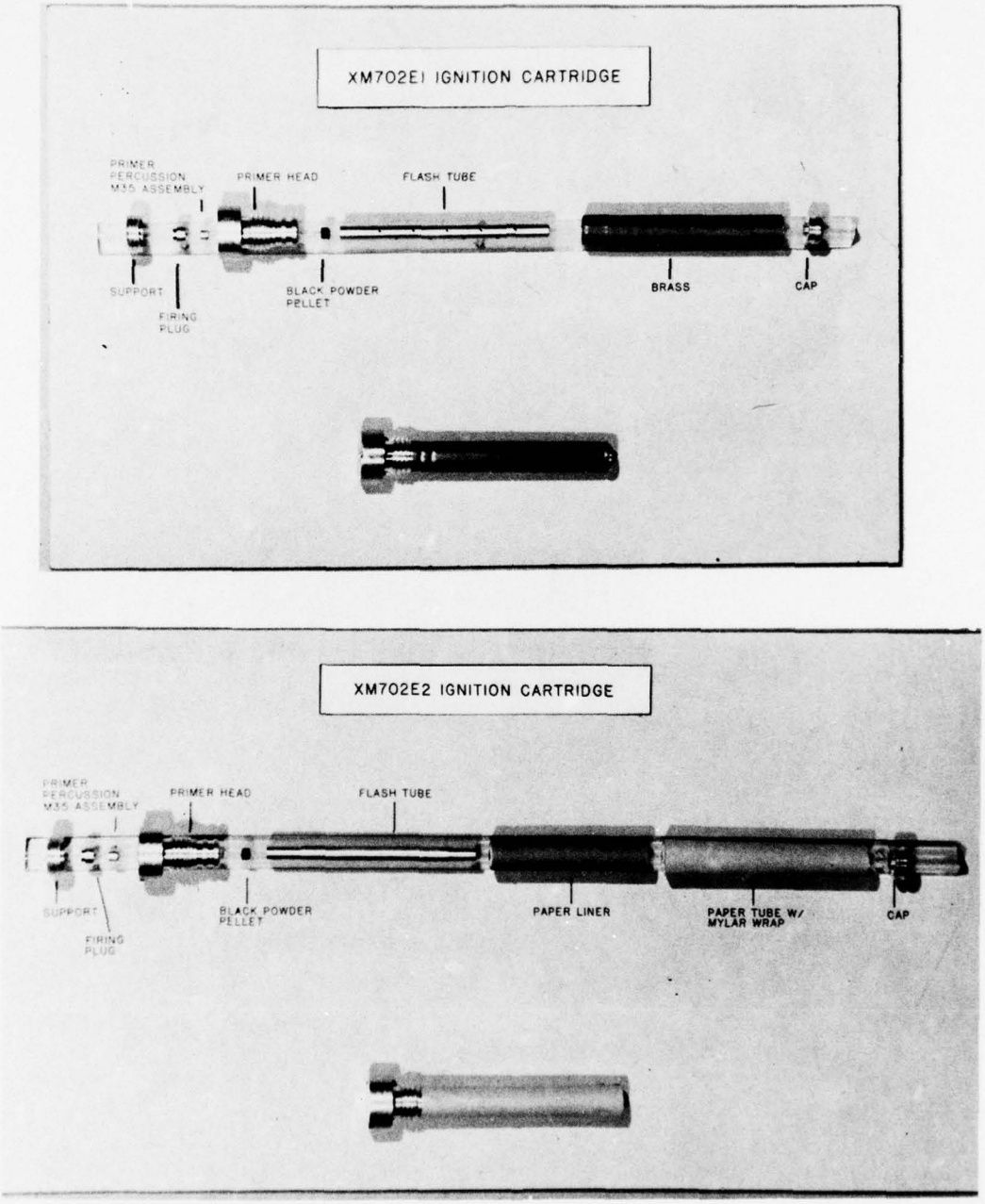
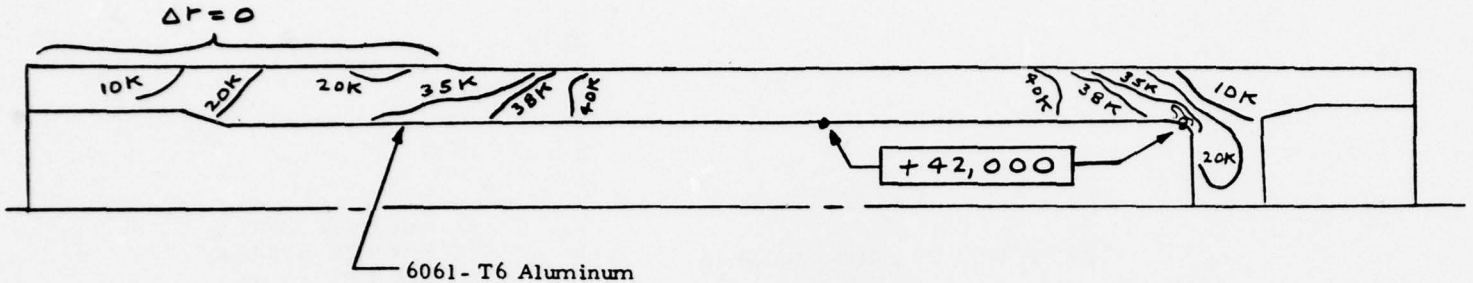


Figure 3. XM702E1 ignition cartridge and XM702E2 ignition cartridge



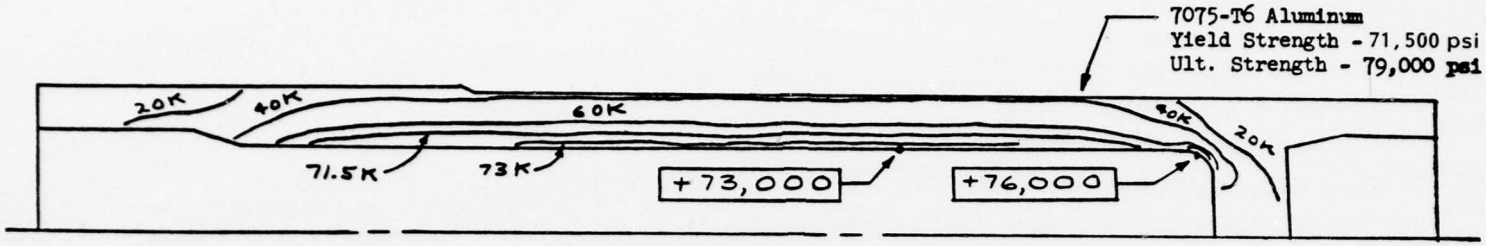
6061-T6 Aluminum
Yield Strength - 35,000 psi
Ult. Strength - 42,000 psi (289.38 MPa)

10 kpsi = 68.9 MPa
20 kpsi = 137.8 MPa
35 kpsi = 241.15 MPa
38 kpsi = 261.82 MPa
40 kpsi = 275.6 MPa

60MM FIN

INTERNAL PRESSURE - 23,000 psi (158.47 MPa)

Figure 4. Elastic-Plastic Stress Analysis 6061T6 Aluminum Alloy



20 kpsi = 137.8 MPa
40 kpsi = 275.6 MPa
60 kpsi = 431.4 MPa
71.5 kpsi = 492.6 MPa
73 kpsi = 503.0 MPa
76 kpsi = 523.6 MPa
79 kpsi = 544.3 MPa

60MM FIN

INTERNAL PRESSURE - 33,000 psi (227.37 MPa)

0.100" (2.54×10^{-4} m) fillet radius

Figure 5. Elastic-Plastic Stress Analysis 7075T6 Aluminum Alloy

The standard XM702E1 ignition cartridge generates an average internal pressure of 16,330 psi (112.5 MPa), which demonstrates a safety factor for the XM27 fin of 1.9.

Cartridge, 60 mm: HE, XM720, capitalizing on the experience gained from the PIT program, changed from the 6061T6 alloy to a higher strength, 6070T6, aluminum alloy.

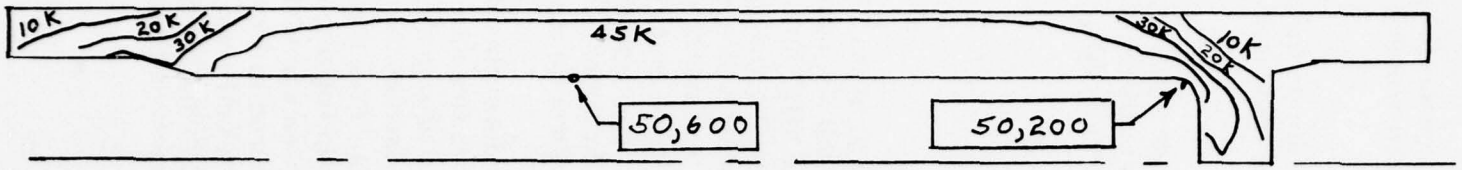
This study was done to verify the upper design pressure limit of the new fin material under the functional condition of the ignition cartridge firing and to confirm fin design adequacy (Appendix A).

TESTING

At the onset of this investigation the design of the XM702E1 ignition cartridge was finalized utilizing 52 grains of 6 mil M9 propellant. Sufficient testing had been conducted to establish that the XM27 fin, made from 6070T6 aluminum alloy, was capable of withstanding the internal pressures generated by this ignition cartridge. The elastic-plastic stress analysis (fig. 6 and 7) shows that the fin should be capable of withstanding 32,000 psi (220.5 MPa). However, no actual testing had been conducted to establish how much pressure the fin could withstand without rupturing. This study was designed to determine the strength of the fin under actual firing conditions, to verify the upper design limit, and confirm fin design adequacy.

The first series of tests was designed to determine the failure point of the XM27 fin. A test series was constructed to fire four 10-round groups of ignition cartridges statically in the fin. The 10-round groups started with 52 grains of 6 mil M9 propellant and increased by 10 grain increments to 82 grains, which filled the ignition cartridge. Five rounds in each of the four groups were equipped with a ring clamp housing and a pressure transducer to measure pressure. Five rounds were uninstrumented. All of the fins in each group had their booms measured in four places, at the fin, 1 inch (.003 m) from the fin, 1½ inches (.004 m) from the fin, and 2 inches (.005 m) from the fin before and after firing for comparison. The flash holes were also gauged after firing to determine the amount of erosion that took place during firing.

XM27 FIN



10 kpsi = 68.9 MPa
20 kpsi = 137.8 MPa
30 kpsi = 206.7 MPa
45 kpsi = 300.05 MPa
50.2 kpsi = 345.88 MPa
50.6 kpsi = 348.63 MPa

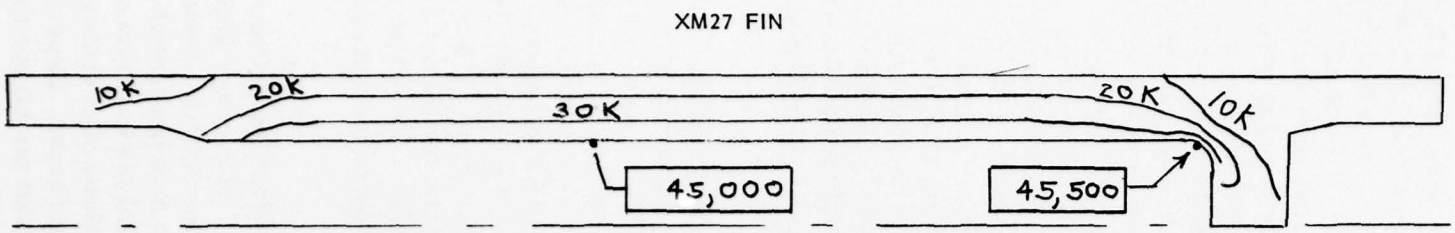
Material-- 6070-T6 Aluminum

Yield Strength-- 45,000 psi

Ultimate Strength-- 48,000 psi (330.72 MPa)

Internal Pressure-- 32,000 psi (220.48 MPa)

Figure 6. Elastic-Plastic Stress Analysis 6070T6 Aluminum Alloy
(32,000 psi internal pressure)



10 kpsi = 68.9 MPa
20 kpsi = 137.8 MPa
30 kpsi = 206.7 MPa
45 kpsi = 310.05 MPa
45.5 kpsi = 313.5 MPa

Material-- 6070-T6 Aluminum

Yield Strength-- 45,000 psi

Ultimate Strength-- 48,000 psi (330.72 MPa)

Internal Pressure-- 18,000 psi (124.02 MPa)

Figure 7. Elastic-Plastic Stress Analysis 6070T6 Aluminum Alloy (18,000 psi internal pressure)

The test results are detailed in Picatinny Arsenal Firing Record No. 3744, Appendix B[1]. No permanent deformation of the fin boom occurred in the 52 and 62 grain groups. In the group which had 72 grains, the deformation was .001 inch (3×10^{-6} m) to .019 inch (4.8×10^{-5} m) on the boom diameter. The 82 grain group bulged from .004 inch (1×10^{-5} m) to .018 inch (4.6×10^{-5} m). In this group the combination of pressure gauge ring clamp restraint and blockage of four of the flash holes by the clamp was enough to cause the fin to rupture whenever the clamp was employed. However, the test results showed that the 6070T6 fin was capable of withstanding pressures generated by a completely filled ignition cartridge which is a 58% overcharge. Since no failures occurred during the first test with the ignition cartridges containing as much as 72 grains, a second test, using ignition cartridges with 72 grains of 6 mil M9 propellant, was conducted at temperature extremes in 15-round groups. This test was to determine the effect of extreme temperatures on the structural integrity of the XM27 fin and, at the same time, permit monitoring of internal ignition cartridge pressures without causing ruptures. The test results are detailed in Picatinny Arsenal Firing Record No. 3744-1, Appendix C. These results showed that the fin was capable of withstanding the internal pressure generated by the 72-grain ignition cartridge even at extreme temperature conditions. The results are located in table 1.

Permanent deformation of the fin boom outside diameter (OD) of .002 inch (5.1×10^{-6} m) to .003 inch (7.62×10^{-6} m) occurred in this test. However, the pressure data here must be qualified because of the pressure gauge difficulty cited in Footnote 1. The results obtained in subsequent tests with the normal XM702E1 ignition cartridge (52 grains of 6 mil M9 propellant), wherein the pressure gauge difficulty was overcome, are found in table 2. In assessing the data, addition of 3 σ to the 17,719 psi (122.1 MPa) functional average at 70°F (21.1°C) equates to 21,000 psi (144.7 MPa). At 145°F (62.8°C), addition of 3 σ to the functional average pressure gives 22,080 psi (152.1 MPa). Of particular note is that no fin failure or deformation occurred in the 80-round group (see Appendix D).

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[2] Subsequent ignition cartridge test results showed that the pressure readings obtained in early testing were not reliable. The average pressure values initially recorded with the 52-grain ignition cartridge were found to be low by up to 4,000 psi (27.6 MPa). The test data presented in Appendixes E and F should be referred to for actual pressure level reference. The early difficulty was traced to the technique of pressure gauge fixturing which left a burr that the pressure could reseal. Experience showed that it was necessary to pre-drill rather than punch out the ignition cartridge tube in pressure gauge application.

Table 1. XM702E1 with drilled pressure tap at temperature extremes (72 grains propellant)

Temperature, °F	°C	Average pressure,* psi	(MPa)	Standard deviation, σ, psi	(MPa)	Maximum fin diameter inch	(m)
70	(21.1)	17,949	(123.7)	750	(5.2)	.001 to .021	3×10^{-6} to 5.3×10^{-5}
-50	(-45.6)	17,606	(121.3)	690	(4.8)	.000 to .006	0 to 1.5×10^{-5}
+145	(62.8)	18,696	(128.8)	849	(5.8)	.000 to .010	0 to 1.54×10^{-5}

*The XM702E1 ignition cartridge lot used in this test (Lot PA-E-09917) was the one that gave the highest pressure level of the five lots tested. Pressure averages ranged from 15,847 (109.2 MPa) to 16,855 psi (116.1 MPa) (Appendix E).

Table 2. XM702E1 with drilled pressure tap at temperature extremes (52 grains propellant)*

Temperature		Pressure						Fin failure or deformation
		Average		Maximum		σ		
°F	°C	psi	(MPa)	psi	(MPa)	psi	(MPa)	
70	(21.1)	17,719	(122.1)	19,800	(136.4)	1,092	(7.5)	None
-50	(-45.6)	16,225	(111.8)	18,700	(128.8)	935	(6.4)	None
145	(62.8)	18,050	(124.4)	20,700	(142.6)	1,345	(9.3)	None

*Table 2 is a summary of the information found in Appendix D.

While the internal pressure that stresses the 6070T6 fin to the yield point was not definitely fixed, it was established that it lies above 20,700 psi (142.6 MPa). From the 72-grain ignition cartridge series that contained the first slight evidence of deformation and from the other test pressure data, the pressure relating to the yield point could lie near the 22,000-psi (151.6 MPa) level. Accordingly, there appears to be a possibility that the yield point could be exceeded at the most extreme, 145°F (62.8°C) functional condition. Some slight bulging of the fin boom might occur, however, this would not present a problem in regard to structural adequacy and would not affect ballistic performance; however, it does indicate the advisability of a fracture mechanics analysis to define the nature and size of the manufacturing defect that could potentially result in a problem of fin failure in the event the fin is stressed to the yield point.

Tests were also conducted using standard 52-grain ignition cartridges with fins that had their original .982 inch (2.5×10^{-3} m) OD modified. The fin wall thickness was reduced in .025 inch (6.4×10^{-5} m) increments to determine the minimum thickness required. The nominal wall thickness is .194 inch (4.9×10^{-4} m). The results showed that one of five passed at an OD of .782 inch (2×10^{-3} m) which corresponds to a wall thickness of .094 inch (2.4×10^{-4} m). With an OD of .832 inch (2.1×10^{-3} m) and a wall thickness of .119 inch (3×10^{-4} m) five of five passed, and with an OD of .882 inch (2.2×10^{-3} m) and wall thickness of .144 inch (4.7×10^{-4} m) four of four passed. The results of this series of tests showed that the XM27 fin, as currently designed, is 63% thicker than required to contain the functional average ignition cartridge pressure of 16,330 psi (112.5 MPa) at 70°F (21.1°C) (Appendix E).

A test series with 82 grain 6-mil (1.5×10^{-5} m) M9 ignition cartridges, was conducted to try to avoid the pressure gauge ring clamp constraint, which contributed to fin rupture. The fin blades were machined off and a hole was drilled below the vent holes to accept the ring gauge and pressure transducer. In this manner, the boom was free to expand in a normal fashion and at the same time afford full venting. The test results (Appendix F) showed that the threshold level of failure lies at 31,000 (213.6 MPa) to 32,000 psi (220.5 MPa). Two failures occurred in the 15 cartridges tested and both had peak pressures of 31,860 psi (219.5 MPa). The average bulging of these fins was .005 inch (1.3×10^{-5} m). An observation was that the vent holes eroded from a .093 inch (2.4×10^{-4} m) diameter to a .117 inch (3×10^{-4} m) maximum average diameter. No erosion was experienced with a standard 52-grain charge. The results are in agreement with the Elastic-Plastic Stress Analysis conducted by the Engineering Science Division of Feltman Research Laboratory, which indicated that the fin was capable of withstanding an internal ignition cartridge pressure of 32,000 psi (220.5 MPa) (fig. 6).

A test was conducted with 82-grain ignition cartridges at temperature extremes. No pressures were taken because of the potential for a high incidence of rupture accompanied by destruction of the instrumentation. The results, Appendix G, showed that 10 out of 15 blew up at +145°F (62.8°C) and there were no failures out of the 20 at -50°F (-45.6°C). The average increase in OD for the five that did not fail at +145°F (62.8°C) was .019 inch (4.8×10^{-5} m) and the maximum was .028 inch (7.1×10^{-5} m). The average at -50°F (-45.6°C) was .003 inch (7.6×10^{-6} m) with a maximum of .016 inch (4.1×10^{-5} m).

RESULTS

1. The XM27 fin is subject to an internal pressure, generated by the XM702E1 Ignition Cartridge, of:

Temperature condition		Pressure		σ	
°F	°C	psi	(MPa)	psi	(MPa)
70	21.1	17,719	122.1	1,092	7.5
-50	-45.6	16,225	111.8	935	6.4
+145	62.8	18,050	124.4	1,345	9.3

2. The upper functional pressure limit that the fin must withstand is 22,100 psi (152.3 MPa), based upon the 145°F (62.8°C) plus 3 σ condition.

3. The threshold level of failure of the fin lies at an internal pressure of 31,000 psi (213.6 MPa) to 32,000 psi (220.5 MPa).

4. The structural adequacy of the XM27 fin design is satisfactory, since:

a. At the 70°F condition, the average pressure of five ignition cartridge lots is 16,330 psi (112.5 MPa). With the ultimate strength assessed at 31,000 psi (213.6 MPa), the fin design safety factor is 1.90.

b. Adequate structural integrity has been demonstrated at temperature extremes of -50°F (-45.6°C) and +145°F (62.8°C).

c. The results of the analytical stress analysis are in agreement with the test data and support an affirmative conclusion in regard to structural design adequacy.

5. The pressure attained at the most extreme functional condition (145°F) (62.8°C) could approximate the yield point of the fin. Metal parts' manufacturing defects could thus play a part in the ultimate strength capability of the fin.

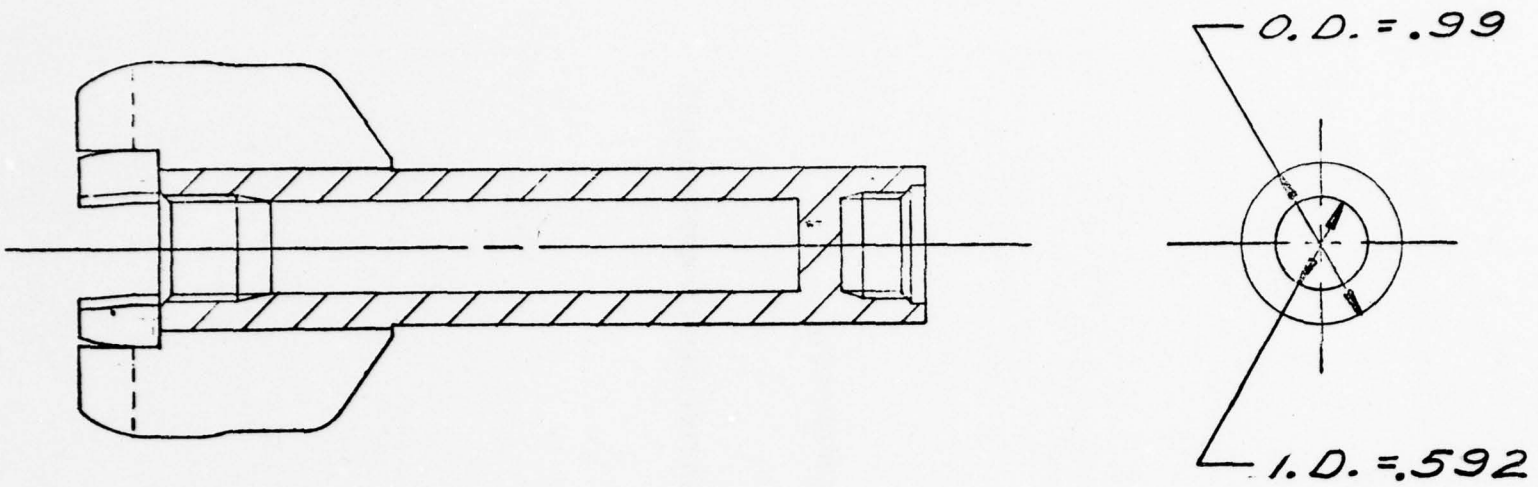
RECOMMENDATIONS

1. Conduct an XM27 fin fracture mechanics study to assess the nature and extent of metal parts defects that could represent potential fin failure. The results could then be analyzed in relation to the need and severity of manufacturing controls.

2. Continue examining the potential for employing higher strength aluminum (7075 and 2014 aluminum) in the manufacture of the XM27 fins in the one-piece configuration.

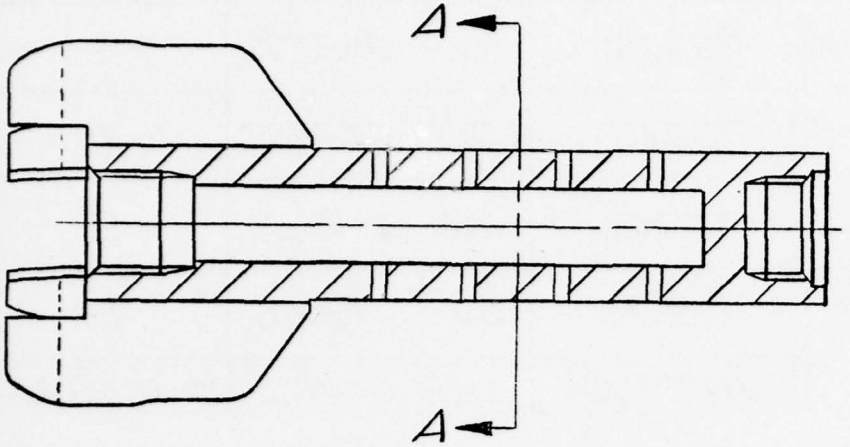
APPENDIX A

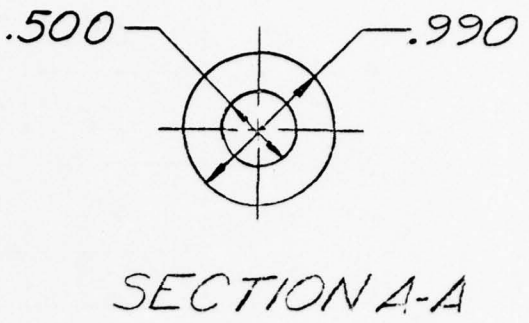
XM27 FIN, ALTERNATIVE DESIGN APPROACHES



Material: aluminum extrusion
Weight: .28 lb

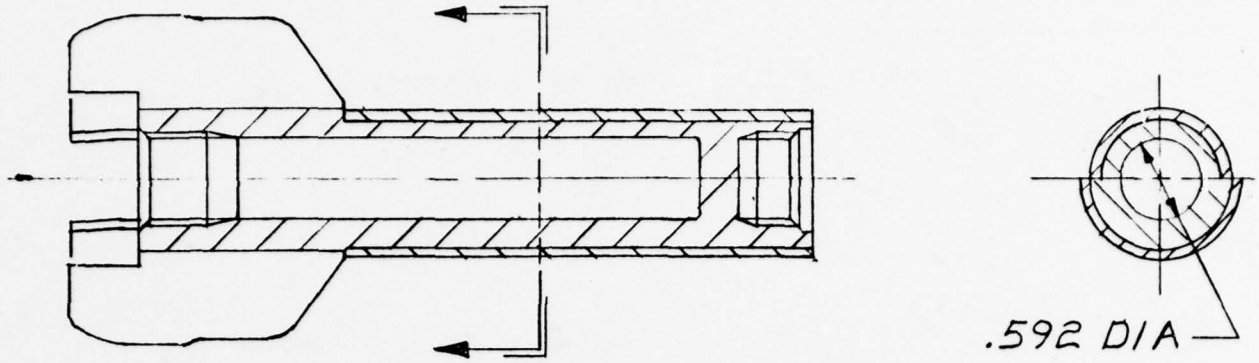
Figure A-1. Fin, XM25 (standard)





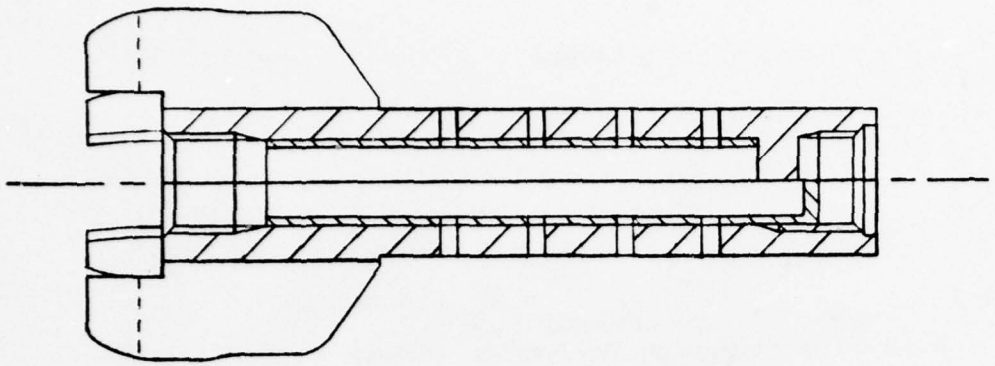
Material: 1 piece aluminum
Weight: 31 lb approximately

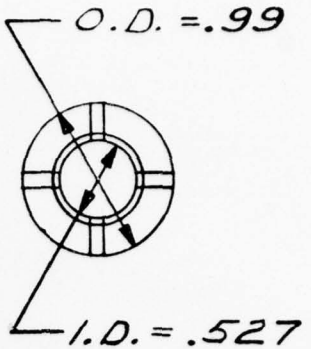
Figure A-2. Design 1



DESIGN No.	COMPONENT	MATERIAL	Wt	O.D.
2	SLEEVE .02	STEEL	.318 Lbs	.99
3	SLEEVE .04	STEEL	.354 Lbs	.99
4	SLEEVE .06	STEEL	.389 Lbs	.99
5	SLEEVE .04	STEEL	.404 Lbs	1.07

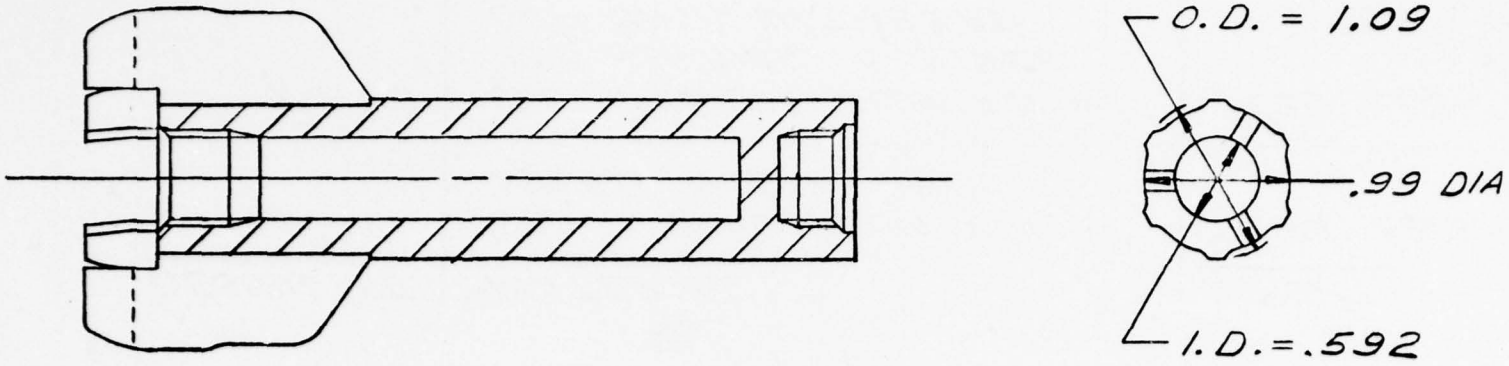
Figure A-3. Designs 2, 3, 4, and 5





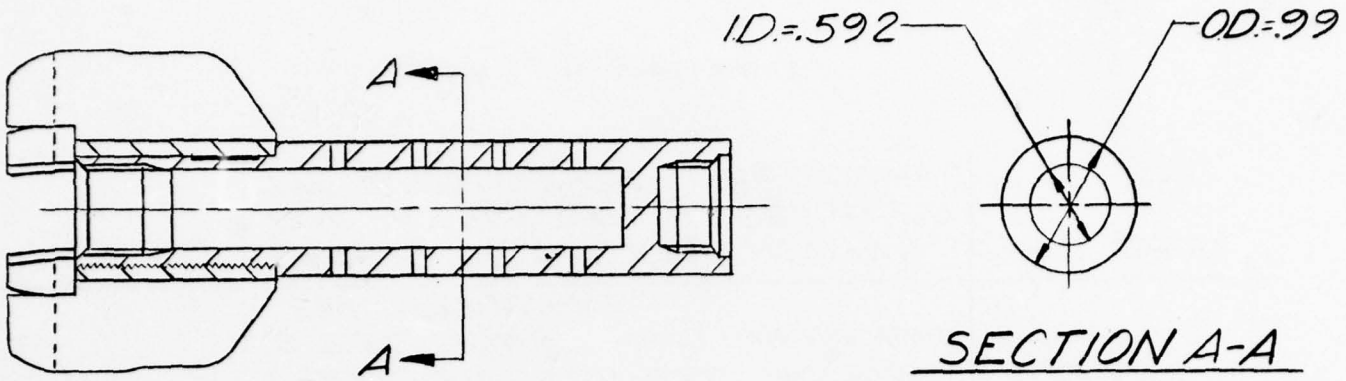
DESIGN NO.	MATERIAL	WEIGHT
6	STD 1-PIECE ALUM FIN & STEEL SLEEVE (INT.)	.34 LBS.
7	STD 1- PIECE ALUM FIN W/ WEB REMOVED & STEEL CUP (INT.) W/THREAD	.35 LBS

Figure A-4. Designs 6 and 7



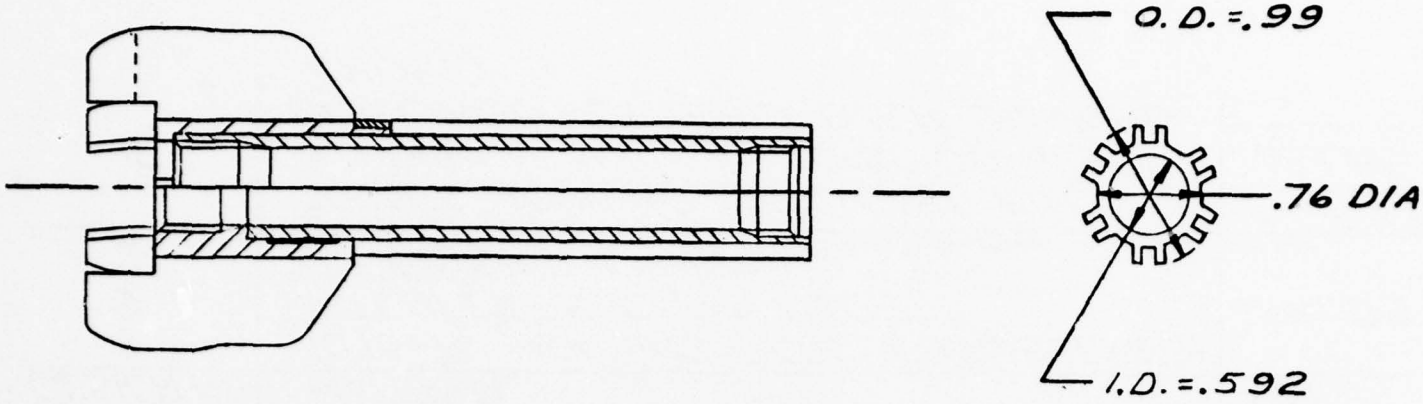
Material: standard XM25 fin with fin stubs remaining for propellant standoff
Weight: .29 lb

Figure A-5. Design 8



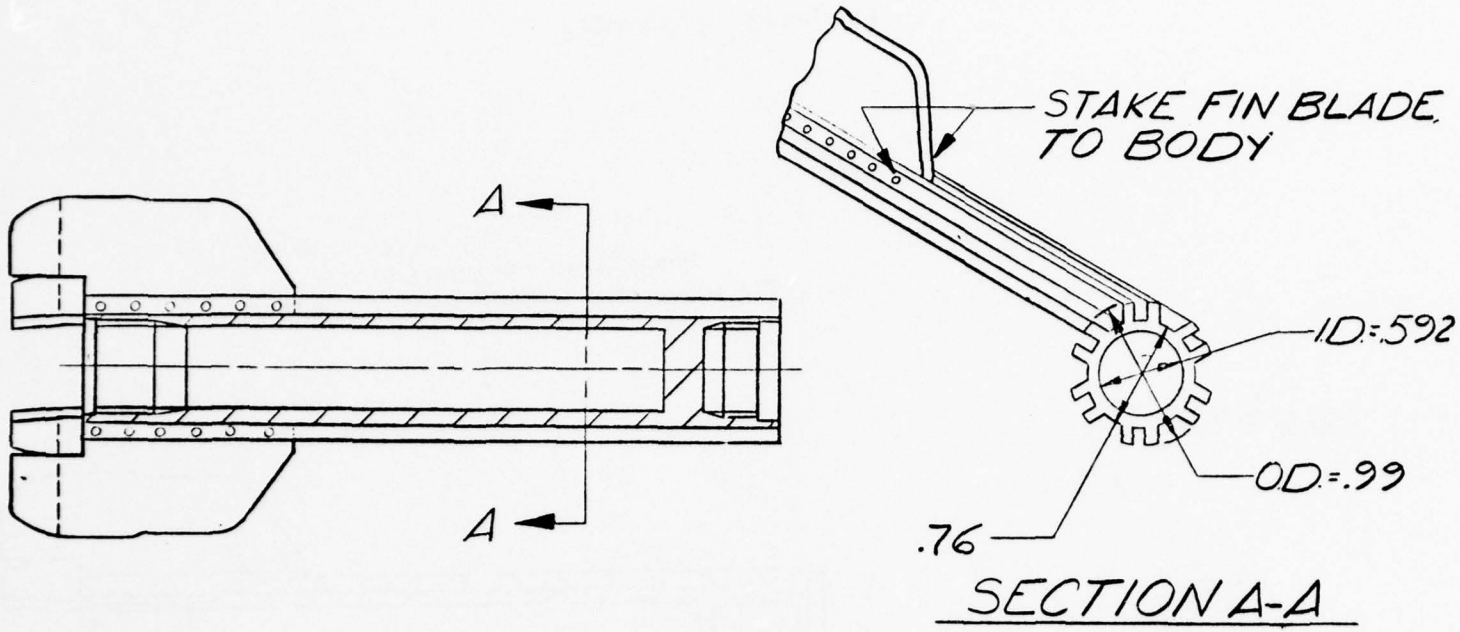
DESIGN NO.	MATERIAL	WT.
9	7075-T6 HOUSING & 6061 FIN (ASSEMBLY INTERFERENCE FIT OVER STRAIGHT KNURL)	.28 LBS.
9A	1-piece 7075T6 (Alcoa)	.28 lbs
10	7075-T6 HOUSING & DIE CAST FIN, ALUMINUM ALLOY A13, SPEC QQ-A-591 (ASSEMBLY-DIE CAST OVER DIAMOND KNURL)	not acceptable due to problems encountered .28 LBS. under [illegible] additional time.

Figure A-6. Designs 9 and 10



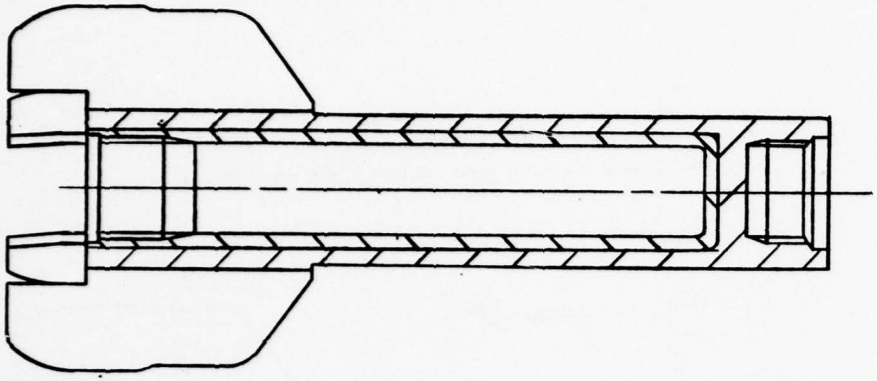
DESIGN NO.	MATERIAL	WEIGHT
11	THREE-PIECE: STEEL HOUSING, STEEL RING AND ALUMINUM FIN STAMPING.	.43 LBS.
12	TWO-PIECE; STEEL HOUSING, FIN EXTRUSION ASSEMBLED BY INTERFERENCE OVER KNURL.	.41 LBS.

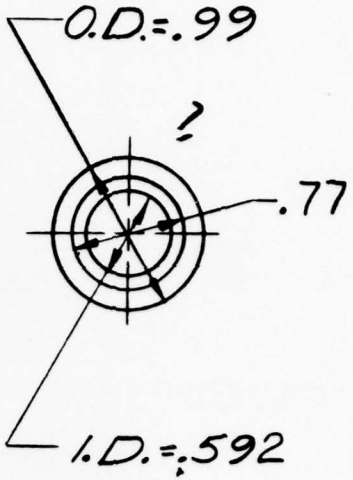
Figure A-7. Designs 11 and 12



Material: two-piece; steel housing and aluminum fin stamping (assembly-staking)
Weight: .43 lb.

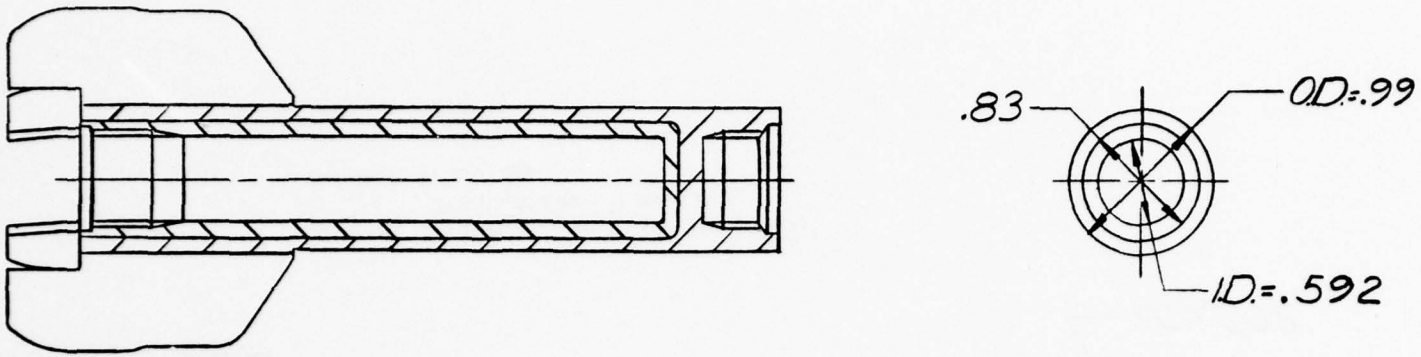
Figure A-8. Design 13





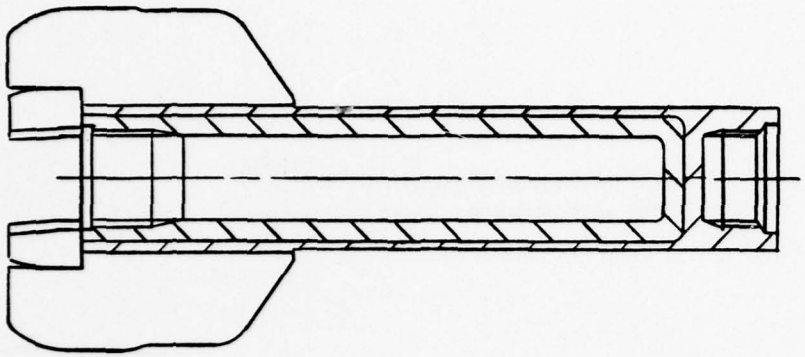
Material: 2 piece; standard XM25 (MOD) and .089 thick internal steel cup
Weight: .43 lb

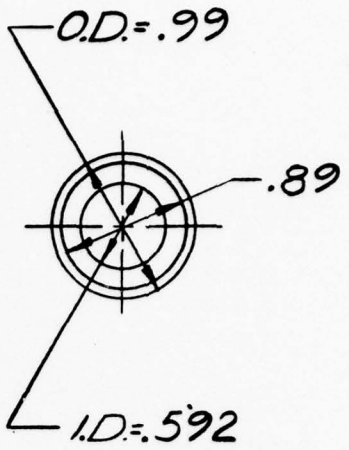
Figure A-9. Design 14



Material: 2 piece; standard XM25 (MOD) and .119 thick internal steel cup
Weight: .49 lb

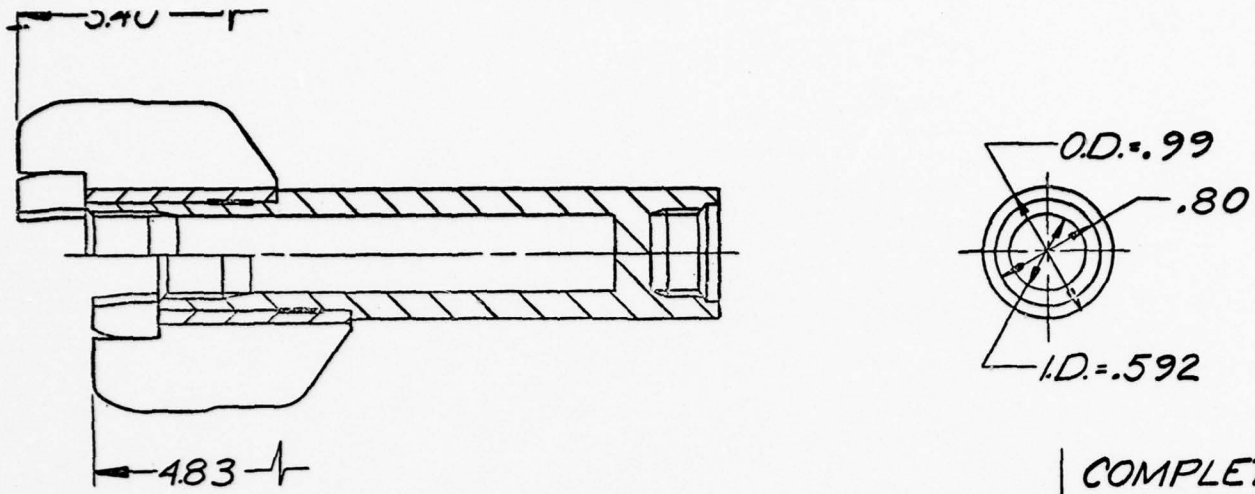
Figure A-10. Design 15





Material: 2 piece; standard XM25 (MOD) and .149 thick internal steel cup
Weight: .57 lb

Figure A-11. Design 16



DESIGN NO.	MATERIAL	WT. OF FIN	COMPLETE ROUND C.G FROM REAR OF FIN
17	TWO PIECE; STEEL HOUSING AND FIN EXTRUSION(ALUM.) (ASSEMBLY-INTERFERENCE FIT OVER STRAIGHT KNURL)	.62 LBS.	WAS 9.09" NOW 8.55" .54 REARWARD
18	TWO PIECE; STEEL HOUSING AND FIN EXTRUSION(ALUM) (ASSEMBLY-INTERFERENCE FIT OVER STRAIGHT KNURL)	.54 LBS.	WAS 8.55" NOW 8.21" .34 REARWARD

Figure A-12. Designs 17 and 18

APPENDIX B

PICATINNY ARSENAL FIRING RECORD 3744

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801
FIRING RECORD

Date 30 September 1974
Sheet 1 of 3 sheets
F. R. No. 3744

Subject: To determine the structural integrity of the XM25E1 fin (w/6070T6) for 60M/M Mortar

Date Fired: 26 September 1974

Gage: 70K Piezo-1267

Calibration: 25000 psi

REQUESTED BY: Mr. Fennick/ADED/Bldg #94

Submitted by: [signature] Approved by: [signature]

SMUPA-R FORM 1130B MAY 70

Table B-1. Comparison of the diameter of the boom before and after firing and the flash hole after firing

Rd#	Group	Film #	Peak Press, PSI	Body diam, in. At fin Before	At fin After	1" from fin Before	1" from fin After	1½" from fin Before	1½" from fin After	2" from fin Before	2" from fin After	Hole Diam inches (after firing)	Remarks
1	A	No Instr		.983	.983	.984	.983	.981	.983	.984	.984	.092	
2	"	" "		.987	.983	.986	.983	.984	.983	.984	.983	.092	
3	"	" "		.983	.983	.983	.983	.983	.983	.984	.983	.093	
4	"	" "		.984	.983	.984	.983	.984	.985	.984	.985	.095	
5	"	" "		.982	.983	.982	.983	.983	.983	.982	.983	.092	
6	"	26071	13,300	.983	.983	.983	.983	.983	.984	.984	.984	.092	
7	"	72	13,500	.986	.985	.986	.986	.986	.987	.987	.986	.095	
8	"	73	11,800	.983	.983	.984	.983	.983	.983	.983	.983	.092	
9	"	74	12,900	.984	.983	.983	.983	.983	.983	.983	.983	.092	
10	"	75	13,200	.983	.983	.983	.983	.983	.983	.983	.983	.092	
11	B	No Instr		.984	.984	.986	.984	.985	.984	.984	.984	.097	
12	"	" "		.984	.983	.984	.983	.984	.984	.984	.984	.098	
13	"	" "		.983	.983	.983	.983	.983	.983	.983	.983	.098	
14	"	" "		.984	.984	.985	.984	.985	.984	.984	.984	.104	
15	"	" "		.984	.984	.984	.984	.984	.984	.984	.984	.098	
16	"	26076	16,000	.981	.981	.981	.982	.981	.982	.981	.982	.097	
17	"	77	16,100	.984	.983	.983	.985	.983	.985	.983	.985	.097	
18	"	78	16,000	.984	.984	.984	.985	.984	.986	.984	.988	.109	
19	"	79	14,900	.984	.984	.984	.984	.985	.984	.984	.984	.105	
20	"	80	15,100	.985	.984	.984	.984	.984	.984	.984	.984	.104	
21	C	No Instr		.984	.985	.984	.985	.984	.986	.984	.986	.109	
22	"	" "		.983	.984	.983	.985	.983	.986	.983	.986	.110	
23	"	" "		.983	.984	.983	.985	.984	.987	.984	.986	.110	
24	"	" "		.984	.985	.984	.986	.984	.986	.984	.986	.110	
25	"	" "		.983	.983	.983	.984	.983	.984	.983	.984	.109	
26	"	26081	17,600	.983	.989	.984	.984	.984	1.00	.984	1.01	.118	
27	"	82	16,700	.984	.986	.984	.987	.984	.989	.984	.990	.112	
28	"	83	17,600	.984	.985	.984	.986	.984	.988	.984	.988	.112	
29	"	84	15,000	.983	.984	.983	.983	.983	.993	.983	.998	.110	
30	"	85	16,900	.984	.986	.984	.986	.984	.988	.984	.987	.110	
31	D	No Instr		.983	1.01	.983	.998	.984	1.00	.984	.997	.117	
32	"	" "		.982	.987	.982	.990	.982	.993	.982	.993	.118	
33	"	" "		.984	1.01	.984	1.00	.985	1.01	.985	1.01	.120	
34	"	" "		.985	1.00	.987	1.01	.986	1.01	.985	1.00	.118	

Table B-1. (Continued)

Rd#	Group	Film #	Peak Press, PSI	At fin Before	At fin After	1" from fin Before	1" from fin After	1½" from fin Before	1½" from fin After	2" from fin Before	2" from fin After	Hole Diam inches (after firing)	Remarks
35	D	No Instr		.984	.998	.984	1.00	.985	.997	.984	.994	.119	
36	"	26086	Lost	.984	1.01	.986	1.00	.984		.984		.110	Body ruptured
37	"	Not Instr		.983	.999	.984	1.00	.983	1.02	.984	1.02	.121	
38	"	26087	Lost	.984	1.00	.984	.988	.984	-	.983	-	.108	Body ruptured
39	"	Not Instr		.983	.997	.983	1.00	.983	1.00	.983	.996	.120	
40	"	" "		.983	.987	.983	.989	.982	.999	.982	.995	.122	

NOTES:

Group A contained 52 grains of 6 mil M-9 Propellant
" B " 62 " " " " " "
" C " 72 " " " " " "
" D " 82 " " " " " "

COMMENT:

It should be noted that 8 of the items from Group D fired satisfactorily. However, the 2 items, which were instrumented, ruptured.

It may, therefore, be concluded the pressures in Group D were so high that, when one hole was closed off by the pressure gage, the item ruptured.

Table B-2. Fin, XM25E1 structural integrity test

26 Sept 74

Rd. No	Group	Peak Press psi	Body Dimensions (inches) At Fin		1" fm. Fin		1½" fm. Fin		2" fm. Fin		Hole dia after firing (Inches)
			Before	After	Before	After	Before	After	Before	After	
1	A	-	.983	.983	.984	.983	.981	.983	.984	.984	.092
2		-	.987	.983	.986	.983	.984	.983	.984	.983	.092
3		-	.983	.983	.983	.983	.983	.983	.984	.983	.093
4		-	.984	.983	.984	.983	.984	.985	.984	.985	.095
5		-	.982	.983	.982	.983	.983	.983	.982	.983	.092
6		13,300	.983	.983	.983	.983	.983	.984	.984	.984	.092
7		13,500	.986	.986	.986	.986	.986	.982	.987	.986	.095
8		11,900	.983	.983	.984	.983	.983	.983	.983	.983	.092
9		12,900	.984	.983	.983	.983	.983	.983	.983	.983	.092
10		13,200	.983	.983	.983	.983	.983	.983	.983	.983	.092
	Average	P=12,700	.984	.983	.984	.983	.983	.983	.984	.984	.093
11	B		.984	.984	.984	.984	.985	.984	.984	.984	.094
12			.984	.983	.984	.983	.984	.984	.984	.984	.099
13			.983	.983	.983	.983	.983	.983	.983	.983	.098
14			.984	.984	.984	.984	.985	.984	.984	.984	.104
15			.984	.984	.984	.984	.984	.984	.984	.984	.099
16		16,000	.981	.981	.981	.982	.981	.982	.981	.982	.097
17		16,100	.984	.983	.983	.984	.983	.985	.983	.985	.097
18		16,000	.984	.984	.984	.985	.984	.986	.984	.988	.109
19		14,900	.984	.984	.984	.984	.985	.984	.984	.984	.105
20		15,100	.985	.984	.984	.984	.984	.984	.984	.984	.104
	Average	P=15,690	.984	.983	.984	.984	.984	.984	.984	.984	.101

Group A - 52 grains of 6mil M9

Group B - 62 grains of 6mil M9

SMUPA Form 1157 May 66 CALCULATION SHEET

Table B-2. (Continued)

26 Sept 74

Rd. No.	Group	Peak Pressure (psi)	Body Dimensions (Inches)						Hole dia (Inches)
			AT Fin		1" fm. Fin		½" fm. Fin		2" fm. Fin		
			Before	After	Before	After	Before	After	Before	After	
21	C	-	.994	.995	.994	.995	.994	.996	.994	.986	.109
22		-	.983	.984	.983	.995	.983	.986	.993	.986	.110
23		-	.983	.994	.993	.995	.994	.997	.994	.996	.110
24		-	.994	.996	.994	.996	.994	.996	.994	.996	.110
25		-	.993	.993	.993	.994	.983	.994	.993	.994	.109
26		17,000	.983	.997	.994	.994	.994	1.00	.994	1.01	.118
27		16,700	.994	.996	.994	.997	.994	.999	.994	.996	.112
28		12,600	.994	.996	.994	.996	.994	.996	.994	.998	.112
29		15,[illegible]	.983	.994	.993	.993	.993	.993	.993	.997	.110
30	↓	16,[illegible]	.994	.996	.994	.996	.994	.996	.994	.997	.110
AVERAGE		A=15,500	.994	.995	.994	.995	.994	.997	.994	.996	.111
31	D	-	.983	1.01	.993	1.00	.993	1.00	.993	.997	.117
32		-	.982	.987	.992	.990	.992	.993	.992	.993	.118
33		-	.994	1.01	.994	1.00	.995	1.01	.995	1.01	.120
34		-	.995	1.00	.997	1.01	.994	1.01	.995	1.00	.117
35		-	.994	.998	.994	1.00	.995	.997	.994	.994	.117
36		FIN BLEW	.994	1.01	.994	1.00	.992	-	.994	-	.110
37		-	.983	.997	.994	1.00	.993	1.02	.994	1.02	.121
38		FIN BLEW	.994	1.00	.994	.998	.994	-	.993	-	.107
39		-	.993	.997	.993	1.00	.993	1.00	.993	.996	.120
40	↓	-	.993	.997	.993	.993	.992	.994	.993	.995	.120
AVERAGE			.994	1.000	.994	.998	.994	1.003	.994	1.000	.117

Group C - 72 grains of 6 mil M9

* Group D - 82 grains of 6 mil M9

* 82 grains of 6 mil M9 fills Tgn. Ctg.

SMUPA Form 1157 May 66 CALCULATION SHEET

APPENDIX C

PICATINNY ARSENAL FIRING RECORD 3744-1

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801
FIRING RECORD

Date 21 February 1975
Sheet 1 of 6 sheets
F. R. No. 3744-1

Subject: Structural Integrity Test on the XM25E1 Fin for 60mm Mortar

Received for Test

45 ea XM25E1 Fins (w/72 grs powder) Lot PA-E-09500
30 " " " w/steel insert (w/82 grs powder) Lot PA-E-09501

Date Fired: 17-19 Dec 74
Gage Used: 70K1267 (Piezo)

Procedure

The items were conditioned at the temperatures noted, then functioned. Pressures were measured with the aforementioned gage. Boom and hole diameters were measured before and after firing.

Primer Number	Film Number	Temperature condition, °F	Peak pressure psi
1	26568	Standard Lot -50	17950
2	69	"	17520
3	70	"	17950
4	71	"	18805
5	72	"	17520
6	73	"	17520
7	74	"	17950
8	75	"	17520
9	76	"	16665
10	77	"	15810
11	78	"	18375
12	79	"	17520
13	80	"	17950
14	81	"	17520
15	82	"	17520
16	83	70	17095
17	84	"	18375
18	85	"	18805
19	86	"	17950
20	87	"	Lost
21	88	"	17520
22	89	"	17950
23	90	"	16665
24	91	"	18375
25	92	"	17095
26	93	"	19660
27	94	"	17950
28	95	"	17950
29	96	"	17950

Submitted by: _____ Approved by: _____

SMUPA-R FORM 11203 MAY 70

TEST REQUESTED BY: J Fenick, ADED, Bldg 94

Primer #	Film #	Cond Temp °F	Peak Press, PSI
30	97	70	17950
31	53	145	19165
32	54	"	18535
33	55	"	19395
34	56	"	19395
35	57	"	18535
36	58	"	18535
37	59	"	19395
38	60	"	16810
39	61	"	19395
40	62	"	19395
41	63	"	19230
42	64	"	18375
43	65	"	17950
44	66	"	19230
45	67	"	17095
	Standard fin w/steel insert		
1	26542	-50	18335
2	43	"	20835
3	44	"	21665
4	45	"	19165
5	46	"	20835
6	47	"	21250
7	48	"	20835
8	49	"	20835
9	50	"	19585
10	51	"	20415
11	17	70	Lost
12	18	"	17155
13	19	"	18135
14	20	"	19120
15	21	"	19120
16	22	"	17155
17	23	"	20590
18	24	"	20100
19	25	"	Lost
20	26	"	Lost
21	27	145	18135
22	28	"	19120
23	29	"	18135
24	30	"	20590
25	31	"	16665
26	32	"	20100
27	33	"	19610
28	34	"	19120
29	35	"	18135
30	36	"	18625

Primer number	Type	Temperature	Peak pressure, avg (psi)
1-15	Std	-50°F	17606
16-30	Std	70°F	17949
31-41	Std	145°F	18696
1-10	Expt	-50°F	20376
11-20	Expt	70°F	18768
21-30	Expt	145°F	17824

Table C-1. Comparison of the diameter of the boom and flash hole before and after firing

		Boom Diam, In								Hole Diam, In							
		Fin		1"		1½"		2"		1		2		3		4	
	Boom #	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
		Standard Fins															
-50°F	1	.982	.985	.985	.985	.983	.985	.984	.985	.092	.110	.092	.108	.092	.108	.092	.108
	2	.983	.988	.983	.986	"	.987	.983	"	"	.104	"	.106	"	.109	"	.106
	3	"	.985	.984	"	.984	.986	.984	"	"	.108	"	.109	"	.110	"	.104
	4	.984	"	"	.985	"	.985	"	"	"	.109	"	.108	"	"	"	.105
	5	.982	.987	.982	.987	.982	.987	.982	.988	"	.106	"	.104	"	.109	"	.106
	6	"	.984	.983	.985	.983	.984	.983	.985	"	"	"	.109	"	.110	"	"
	7	"	"	"	.984	"	.983	"	.984	"	.108	"	"	"	.107	"	.104
	8	.983	.983	"	.986	"	.985	.984	.985	"	.109	"	.110	"	.110	"	.107
	9	"	.986	"	"	"	.986	.983	"	"	.110	"	.108	"	.109	"	.108
	10	.982	.987	"	.984	.982	.987	"	"	"	.108	"	.093	"	"	"	.104
	11	.981	.983	.982	.983	"	.983	.982	.983	"	"	"	.108	"	.108	"	.105
	12	.983	"	.983	.982	.983	"	.983	.984	"	"	"	.110	"	.110	"	.107
	13	"	.984	"	.984	"	.984	"	"	"	"	"	.109	"	.109	"	.103
	14	.982	"	"	"	"	"	"	"	"	.106	"	.107	"	.110	"	.107
	15	"	"	.982	"	.982	.985	"	"	"	.108	"	.109	"	"		"
AVG		.982	.985	.983	.985	.983	.985	.983	.985	.092	.108	.092	.108	.092	.109	.092	.106
70°F	16	.982	.993	.982	.990	.983	1.004	.983	1.004	.092	.111	.092	.111	.092	.115	.092	.109
	17	"	.985	.983	.986	"	.986	"	.985	"	.110	"	"	"	.111	"	.110
	18	"	.986	.982	"	"	.988	"	.987	"	.109	"	.109	"	.110	"	.109
	19	"	.983	"	.983	"	.983	"	.984	"	.111	"	.107	"	.109	"	.107
	20	"	"	.983	"	"	.985	"	"	"	.109	"	.111	"	.111	"	.109
	21	.983	"	"	.982	"	.986	"	.988	"	"	"	"	"	.115	"	.115
	22	"	"	"	"	"	.984	"	.984	"	.107	"	.110	"	.111	"	.111
	23	.982	"	.982	"	"	"	"	"	"	.109	"	"	"	.110	"	.107
	24	.983	.985	.983	.985	"	.988	"	.986	"	.110	"	"	"	.113	"	.109
	25	"	.986	"	.986	"	"	"	.987	"	"	"	"	"	"	"	.108
	26	"	.985	"	"	"	.991	"	.990	"	"	"	.113	"	.115	"	.113
	27	.982	.990	.982	.987	.982	.993	"	.992	"	"	"	"	"	.113	"	"
	28	"	.987	"	.988	.983	.998	"	.996	"	"	"	.110	"	.116	"	.108
	29	.983	"	.983	.987	"	"	"	.987	"	.111	"	.113	"	.113	"	.107
	30	"	.983	.984	.983	.984	.984	.984	.985	"	.113	"	.110	"	.110	"	.110
AVG		.982	.985	.983	.985	.983	.989	.983	.988	.092	.110	.092	.111	.092	.112	.092	.110

(a) Before firing
(b) After firing

Table C-1. (Continued)

		Boom Diam, In.								Hole Diam, In							
	Boom #	Fin (a)	Fin (b)	1" (a)	1" (b)	1½" (a)	1½" (b)	2 (a)	2 (b)	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)	4 (a)	4 (b)
		Standard Fins															
+145°F	31	.983	.983	.983	.983	.984	.983	.984	.984	.092	.113	.092	.112	.092	.112	.092	.108
	32	"	.985	"	.987	"	.989	"	.982	"	"	"	.113	"	.115	"	.113
	33	.982	"	.982	.986	.982	.988	.982	.987	"	"	"	"	"	.113	"	.112
	34	"	.986	.983	"	"	.986	"	.986	"	.115	"	.115	"	.116	"	.110
	35	"	.983	"	.982	.983	.985	.983	.985	"	.113	"	.115	"	.115	"	.113
	36	"	"	.982	.981	"	"	"	"	"	.110	"	.111	"	.113	"	.106
	37	.983	"	.983	.982	"	.984	"	"	"	"	"	.112	"	"	"	.109
	38	.982	.989	.982	"	"	.990	"	.990	"	.115	"	.113	"	.114	"	.110
	39	"	.987	"	.986	"	.988	"	.987	"	"	"	.112	"	.113	"	.109
	40	.983	.983	.983	.982	"	.985	"	.985	"	.113	"	.113	"	.115	"	"
	41	"	.985	"	.986	"	.986	"	"	"	"	"	"	"	.113	"	.111
	42	.982	.988	"	.987	"	.989	"	.988	"	.115	"	"	"	"	"	.110
	43	"	.990	"	.981	"	.989	"	.989	"	"	"	.111	"	.115	"	"
	44	.983	.985	"	.985	"	.985	"	.984	"	.113	"	.115	"	.114	"	.111
	45	.982	.986	.982	.984	.982	.992	.982	.989	"	"	"	.113	"	.115	"	.113
	AVG	.982	.985	.983	.984	.983	.987	.983	.986	.092	.113	.092	.113	.092	.114	.092	.110

Table C-1. (Continued)

		Boom Diam, In								Hole Diam, In.							
		Fin		1"		1½"		2		1		2		3		4	
	Boom #	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
		Fins w/ Steel Inserts															
-50°F	1	.984	.980	.982	.980	.980	.975	.980	.977	.099	.110	.099	.115	.099	.115	.099	.115
	2	.982	"	.983	"	.985	.987	.985	.987	.096	"	.096	.110	"	"	"	"
	3	.981	.981	.980	"	.980	.981	.980	.986	.092	"	.096	"	.092	.110	.092	.109
	4	.980	.980	.981	.982	.981	.985	.981	.985	"	.107	.092	.109	"	"	"	.110
	5	"	"	"	.983	"	.982	.982	.980	"	.110	"	.110	"	"	"	"
	6	"	"	"	.980	.980	.980	.980	"	"	"	"	"	.093	"	"	"
	7	.981	"	.979	"	"	"	"	"	"	.109	"	"	.092	"	"	"
	8	.980	"	.975	"	.975	.979	.975	"	"	"	"	.109	"	.109	"	.109
	9	"	"	.980	"	.980	.981	.981	.980	.096	.110	.096	.110	.096	.110	.096	.110
	10	.984	"	.982	.981	.984	.980	.985	.981	"	.115	"	.115	.092	.115	.092	.115
AVG.		.981	.980	.981	.981	.981	.981	.982	.982	.094	.110	.094	.111	.094	.111	.094	.111
70°F	11	.981	.980	.982	.976	.982	.980	.982	.994	.096	.110	.096	.110	.096	.110	.096	.110
	12	.982	"	.980	.980	.981	.977	.980	.980	.099	.116	.099	.119	.099	.119	.099	.116
	13	.981	.982	.982	.982	.989	.983	.985	.987	.092	.109	.092	.110	.092	.110	.092	.110
	14	.980	.980	.980	.980	.981	.980	.980	.980	"	"	"	.113	"	"	"	"
	15	.981	.981	"	.982	.982	.985	.982	.985	"	.110	"	"	"	.113	"	"
	16	.979	.980	.981	.980	.985	.985	.985	.986	.099	.116	.099	.119	.099	.119	.099	.119
	17	.980	.982	"	.985	.984	.986	.984	"	.096	.109	.096	.113	.096	.115	.096	.115
	18	.977	.980	.980	.980	.981	.985	.980	"	.092	"	.092	.109	.092	.109	.092	.109
	19	.981	"	.985	.984	"	.982	.982	.985	"	.115	"	.115	"	.115	.096	.115
	20	.979	.982	.983	.983	.982	.988	.982	.986	"	.116	"	.119	"	.119	.092	.116
AVG		.980	.981	.981	.981	.983	.983	.983	.986	.094	.112	.094	.115	.094	.117	.095	.113
+145°F	21	.978	.985	.984	.988	.984	.988	.986	.985	.092	.115	.092	.115	.092	.115	.092	.115
	22	.985	.988	.988	.981	.985	.982	.985	.987	.096	"	.096	"	.096	"	.096	"
	23	"	.983	.979	.975	.979	.980	.979	.980	.092	.109	.092	.110	.092	.110	.092	.108
	24	.981	.980	.984	.988	.984	.987	.984	.987	"	.110	"	.113	"	.113	"	.113
	25	.985	.982	.982	.979	.982	.983	.982	.985	.099	.115	.099	.119	.099	.119	.099	.119
	26	.980	.980	.981	.980	.981	.980	.981	.982	.096	.113	.096	.115	.096	.115	.096	.115
	27	.983	.983	.983	.986	.983	.982	.983	.983	.096	.119	.096	.119	.092	.119	"	.119
	28	.982	.982	.980	.983	.982	.985	.981	.985	.092	.109	.092	.110	"	.113	.092	.110
	29	.980	.980	.983	.984	.980	.982	.980	.981	"	.115	"	.115	"	.115	"	.115
	30	"	"	.982	.980	.982	"	.984	.984	"	"	"	"	"	.113	"	.113
AVG		.982	.982	.983	.982	.982	.983	.983	.984	.094	.114	.094	.115	.094	.115	.094	.114

Table C-2. Structural integrity test XM25E1 fin
XM702E1 ignition cartridge with 6 mil M9

1/6/75

Rd No	Peak Pressure (psi)			Fin Mat'l	No. grains
	-50°F	70°F	+145°F		
1	17,950	17,095	19,165	6070 T6	72
2	17,520	18,375	18,535		
3	17,950	18,805	19,395		
4	18,805	17,950	19,395		
5	17,520	Lost	18,535		
6	17,520	17,520	18,535		
7	17,950	17,950	19,395		
8	17,520	16,665	16,810		
9	16,665	18,375	19,395		
10	15,810	17,095	19,395		
11	18,375	19,660	19,230		
12	17,520	17,950	18,375		
13	17,950	17,950	17,950		
14	17,520	17,950	19,230		
15	17,520	17,950	17,095	↓	↓
	$\bar{P}$=17,606	$\bar{P}$=17,949	$\bar{P}$=18,696		
	σ_p = 690	σ_p = 750	σ_p = 849		
1	18,335	Lost	18135	STEEL INSERT	82
2	20,835	17,155	19,120		
3	21,665	18,135	18135		
4	19,165	19,120	20590		
5	20,835	19,120	16,665		
6	21,250	17,155	20100		
7	20,835	20,590	19,610		
8	20,835	20,100	19,120		
9	19,585	Lost	18,135		
10	20,415	Lost	18,625	↓	↓
	$\bar{P}$=20,375	$\bar{P}$=18,768	$\bar{P}$=18,824		
	σ_p = 1029	σ_p = 1351	σ_p = 1139		

SMUPA Form 1157 May 66 CALCULATION SHEET

APPENDIX D

PICATINNY ARSENAL FIRING RECORD 3766

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801

FIRING RECORD

Date _____
Sheet 1 of 4 sheets
F. R. No. 3766

Subject: 60mm Ignition Cartridge PA-E-09917

Received for Test

125 ea subject ignition cartridges

Procedure

Items were placed in a fixture and were fired by a solenoid-released spring-loaded firing pin. Gage I was placed over one of the holes in the next-to-last row. Gage II (when used) was placed over a specially drilled hole. Holes were drilled through the liners in both cases.

Gages

Gage I: 30K Piezo #980 (calibrated @ 20,000 psi)
Gage II (when used): 30K Piezo #937 (calibrated @ 20,000 psi)

Dates fired

7, 12, 14, 15 & 18 Oct 76

Round Number	Film Number	Date fired (1976)	Temperature condition, °F	Pressure (psi) Gage I	Gage II
1	31128	12 Oct	+145	20700	
2	29	"	"	20000	
3	30	"	"	18600	
4	31	"	"	"	
5	32	"	"	20200	
6	33	"	"	19500	
7	34	"	"	19600	
8	35	"	"	18400	
9	36	"	"	20200	
10	37	"	"	19800	
11	38	"	"	18600	
12	39	"	"	Lost	
13	40	"	"	20200	
14	41	"	"	19300	
15	42	"	"	18900	
16	43	"	"	18400	
17	44	"	"	18200	
18	45	"	"	19600	
19	46	"	"	16900	
20	47	"	"	17500	
21	48	"	"	18700	
22	49	"	"	19800	

Submitted by: _____ Approved by: _____

SMUPA-TS Form 1130B Oct 71

TEST REQUESTED BY: Mr. Ribe/ADED/Bldg 94

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801

FIRING RECORD

Date

Sheet 2 of 4 sheets

F. R. No. 3766

Subject: 60mm Ignition Cartridge

Rd#	Film#	Date Fired (1976)	Cond Temp (°F)	Pressure (PSI) Gage I	Gage II
23	31150	12 Oct	+145	16600	
24	51	"	"	18000	
25	52	"	"	14600	
26	53	"	"	20000	
27	54	"	"	18000	
28	55	"	"	17800	
29	56	"	"	17800	
30	57	"	"	19300	
31	31190	14 Oct	"	18500	
32	91	"	"	18400	
33	92	"	"	20700	
34	93	"	"	18700	
35	94	"	"	16900	
36	95	"	"	17800	
37	96	"	"	18200	
38	97	"	"	20000	
39	98	"	"	17300	
40	99	"	"	17100	
41	31200	"	"	17500	
42	01	"	"	20400	
43	02	"	"	18200	
44	03	"	"	19800	
45	04	"	"	16500	
46	05	"	"	17500	
47	06	"	"	16200	
48	07	"	"	17300	
49	08	"	"	16900	
50	09	"	"	17100	
51	10	"	"	17500	
52	11	"	"	16700	
53	12	"	"	18200	
54	13	"	"	19600	
55	14	"	"	16400	
56	15	"	"	17900	
57	16	"	"	17300	
58	17	"	"	17500	
59	18	"	"	18500	
60	19	"	"	19800	
61	20	"	"	17700	
62	21	"	"	17600	
63	22	"	"	17500	

Submitted by: _____ Approved by: _____

SMUPA-TS Form 1130B Oct 71

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801

FIRING RECORD

Date _____
Sheet 3 of 4 sheets
F. R. No. 3766

Subject: 60mm Ignition Cartridge

Rd#	Film#	Date Fired (1976)	Cond Temp (°F)	Pressure (PSI) Gage I	Gage II
64	23	15 Oct	+145	18500	
65	24	"	"	17800	
66	25	"	"	15600	
67	26	"	"	17300	
68	27	"	"	18200	
69	28	"	"	16400	
70	29	"	"	17500	
71	30	"	"	17800	
72	31	"	"	17300	
73	32	"	"	17100	
74	33	"	"	15800	
75	34	"	"	17300	
76	35	"	"	16700	
77	36	"	"	16000	
78	37	"	"	17300	
79	38	"	"	17600	
80	39	"	"	14900	
81	40	"	-50	14900	
82	41	"	"	15100	
83	42	"	"	16400	
84	43	"	"	16000	
85	44	"	"	15600	
86	45	"	"	18700	
87	46	"	"	15600	
88	47	"	"	17500	
89	48	"	"	14700	
90	49	"	"	15800	
91	50	"	"	16000	
92	51	"	"	16400	
93	52	"	"	16700	
94	53	"	"	16900	
95	54	"	"	16400	
96	55	"	"	16000	
97	56	"	"	16900	
98	57	"	"	17300	
99	58	"	"	16200	
100	59	"	"	16000	
101	31108	7 Oct	70	18200	
102	09	"	"	19800	
103	10	"	"	18600	
104	11	"	"	17900	
105	12	"	"	17700	
106	13	"	"	15500	

Submitted by: _____ Approved by: _____

SMUPA-TS Form 1130B Oct 71

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801

FIRING RECORD

Date

Sheet 4 of 4 sheets

F. R. No. 3766

Subject: 60mm Ignition Cartridge

Rd#	Film#	Date Fired (1976)	Cond Temp (°F)	Pressure (PSI) Gage I	Gage II
107	31114	7 Oct	70	Lost	
108	15	"	"	"	
109	16	"	"	19300	
110	17	"	"	17500	
111	18	"	"	17500	
112	19	"	"	18200	
113	20	"	"	16900	
114	21	"	"	18200	
115	22	"	"	16900	
116	23	"	"	9900	
117	24	"	"	Lost	
118	25	"	"	16900	
119	26	"	"	18200	
120	27	"	"	16200	
121	31280	18 Oct	"	16800	17700
122	81	"	"	17300	17700
123	82	"	"	17700	Lost
124	83	"	"	16800	16700
125	84	"	"	18700	16300

Submitted by: _____ Approved by: _____

SMUPA-TS Form 1130B Oct 71

Table D-1. Static firing test, 60 mm XM27 with 52 grains (18 Oct 76)

80 each hot (+145)	N = 79		
	$\bar{P}$ = 18052	$\bar{P} + 3\sigma$ =	22,081 psi
	σ_p = 1343		
20 each cold (-50)	N = 20		
	$\bar{P}$ = 16255	$\bar{P} + 3\sigma$ =	19,060 psi
	σ_p = 935		
20 each amb (+70)	N = 16		
	$\bar{P}$ = 17719	$\bar{P} + 3\sigma$ =	20,995 psi
	σ = 1092		

Static firing test with 2 gages (+70°F (Cond)

Gage 1 - Primer end
Gage 2 - Next to last hole (normal place)

Round No.	Pressure Gage 1 (P_1)	Gage 2 (P_2)
121	16800	17700
122	17300	17700
123	17700	--
124	16800	16700
125	18700	16300

Summary			
	$\bar{P}_1$ =	17460	
	σ_{p_1} =	789	
	$\bar{P}_2$ =	17100	
	σ_{p_2} =	712	

APPENDIX E

XM702E1 IGNITION CARTRIDGE STATIC PRESSURE TESTING RESULTS

Table E-1. 60 mm ignition cartridge XM702E1 pressure test

6/23-28/76

IGN CART LOT: PA-E-09782

ROUND	DIAMETER BEFORE	DIAMETER AFTER	PRESSURE		FIN LOT	
1	0.983	0.983	—		1-1-74	
2	0.982	0.982	—	ROUNDS 1 THRU 13 WERE NOT DRILLED FOR PRESSURE TAPS	1-2-75	
3	0.982	0.983	—		1-2-75	
4	0.982	0.982	—		1-1-74	
5	0.982	0.9825	—		1-1-74	
6	0.982	0.9825	—		1-1-74	
7	0.9835	0.984	—		1-2-75	
8	0.983	0.983	—		1-2-75	
9	0.982	0.9825	—		1-2-75	
10	0.982	0.9825	—		1-2-75	
11	0.982	0.9825	—		1-2-75	
12	0.982	0.9825	—		1-2-75	
13	0.982	—	—		1-2-75	
14	0.982	0.982	15300		1-2-75	
15	0.982	0.982	16800		1-1-74	
16	0.983	0.983	15700		1-2-75	N=17
17	0.983	0.983	16300		1-1-74	$\bar{P}$=16,235
18	0.9825	0.983	15700		1-2-75	σ= 662
19	0.9825	0.982	16200		1-2-75	
20	0.983	0.983	15300		1-2-75	
21	0.9825	0.983	15900		1-2-75	
22	0.9825	0.9825	15700		1-2-75	
23	0.982	0.9825	16600		1-1-74	
24	0.982	0.982	16000		1-2-75	
25	0.9835	0.9835	17700		1-1-74	
26	NOT TAKEN	0.983	16000		1-2-75	
27	0.983	0.983	15500		1-1-74	
28	0.983	0.983	16900		1-2-75	
29	0.983	0.984	16900		1-2-75	
30	0.983	0.983	16300		1-1-74	
			AVG FOR ALL 5 lots was 16,330 psi			
					σ = 674 psi	

SARPA Form 1157 Dec 73 CALCULATION SHEET

Table E-1. (Continued)

Round	Diameter Before	Diameter After	Pressure	Fin Lot	IGN Cart Lot PA-E-09451		
31	0.9835	0.984	16100	1-1-74			
32	0.984	0.984	14800				
33	0.983	0.9835	15500				
34	0.983	0.983	16100				
35	0.983	0.983	15700				
36	0.983	0.983	15500				
37	0.983	0.983	14400				
38	0.983	0.983	15300				
39	0.9825	0.9825	15100				
40	0.983	0.9835	15700				
41	0.983	0.9835	15400				
42	0.983	0.9835	15400				
43	0.983	0.982	16600		N=30		
44	0.9825	0.983	16400		$\bar{P}$=15847		
45	0.983	0.983	16200		σ= 631		
46	0.983	0.9835	15600				
47	0.982	0.982	16400				
48	0.984	0.984	16200				
49	0.982	0.982	15600				
50	0.982	0.982	15400				
51	0.983	0.984	15800				
52	0.983	0.983	15200				
53	0.983	0.983	16400				
54	0.982	0.983	16200				
55	0.983	0.984	16400				
56	0.983	0.984	17100				
57	0.9825	0.9825	16200				
58	0.982	0.982	15600				
59	0.9825	0.9825	15600				
60	0.982	0.982	17300	1-1-74			

SARPA Form 1157 Dec 73 CALCULATION SHEET

Table E-1. (Continued)

IGN CART LOT - PA-E-09917
FIN LOT - 1-1-74

ROUND	DIAMETER BEFORE	DIAMETER AFTER	PRESSURE				
61	0.983	0.984	16400				
62	0.983	0.983	17300				
63	0.982	0.9825	17700				
64	0.983	0.9825	18700				
65	0.983	0.983	16000				
66	0.982	0.983	17700				
67	0.983	0.983	18100				
68	0.983	0.983	15800				
69	0.983	0.984	17900				
70	0.983	0.983	15800		N = 29		
71	0.982	0.9825	15800		$\bar{P}$ = 16855		
72	0.9825	0.983	16500		σ = 831		
73	0.982	0.9825	17100				
74	0.983	0.984	15800				
75	0.983	0.983	16200				
76	0.982	0.983	17100				
77	0.9825	0.984	18300				
78	0.983	0.9835	16700				
79	0.9825	0.983	17100				
80	0.983	0.9835	16700				
81	0.983	0.9835	16500				
82	0.983	0.9835	16900				
83	0.9825	0.9825	16500				
84	0.983	0.9835	15400				
85	0.983	0.984	-LOST-				
86	0.983	0.983	17300				
87	0.983	0.984	16200				
88	0.983	0.984	17300				
89	0.983	0.983	16700				
90	0.983	0.983	17300				

SARPA Form 1157 Dec 73 CALCULATION SHEET

Table E-1. (Continued)

IGN CART LOT PA-E-09738
FIN LOT 1-1-74

ROUND	DIAMETER BEFORE	DIAMETER AFTER	PRESSURE				
91	0.9825	0.9825	16700				
92	0.9835	0.984	16700				
93	0.9825	0.983	16900				
94	0.982	0.9825	15600				
95	0.982	0.9825	15800				
96	0.982	0.9825	17100				
97	0.9835	0.984	16500				
98	0.983	0.984	16000				
99	0.982	0.9825	15400				
100	0.982	0.983	16900				
101	0.983	0.983	15400		N=30		
102	0.982	0.983	15460		$\bar{P}$=16080		
103	0.982	0.9835	15600		σ= 636		
104	0.982	0.983	16700				
105	0.983	0.984	14460				
106	0.983	0.984	15400				
107	0.9825	0.984	16200				
108	0.982	0.983	15600				
109	0.9825	0.983	16500				
110	0.983	0.984	16000				
111	0.983	0.984	15600				
112	0.983	0.984	16000				
113	0.983	0.9835	15200				
114	0.983	0.9835	16000				
115	0.983	0.984	16500				
116	0.983	0.9835	16900				
117	0.983	0.984	16200				
118	0.983	0.984	16700				
119	0.983	0.9835	15800				
120	0.983	0.9835	16500				

SARPA Form 1157 Dec 73 CALCULATION SHEET

Table E-1. (Continued)

16N CART LOT PAE-09394
FIN LOT 1-1-74

ROUND	DIAMETER BEFORE	DIAMETER AFTER	PRESSURE				
121	0.983	0.9835	16000				
122	0.983	0.9835	16700				
123	0.983	0.984	16900				
124	0.983	0.9835	-LOST-				
125	0.982	0.983	16500				
126	0.982	0.982	16200				
127	0.982	0.9825	16200				
128	0.983	0.9835	15800				
129	0.982	0.983	-LOST-				
130	0.983	0.983	15800		N = 25		
131	0.983	0.9835	17300		$\bar{P}$ = 16,626		
132	0.9815	0.982	16500		σ = 610		
133	0.9825	0.983	16700				
134	0.983	0.984	16900				
135	0.9825	0.983	16700				
136	0.983	0.983	16700				
137	0.9825	0.983	16500				
138	0.9825	0.983	18100				
139	0.982	0.983	16000				
140	0.983	0.984	18100				
141	0.9825	0.983	17100				
142	0.982	0.9835	16200				
143	0.982	0.983	16200				
144	0.982	0.9835	16200				
145	0.983	0.984	17100				
146	0.983	0.983	17100				
147	0.982	0.983	16200				

SARPA Form 1157 Dec 73 CALCULATION SHEET

APPENDIX F

XM702E1 IGNITION CARTRIDGE STATIC PRESSURE TESTING RESULTS AT 70°F WITH IGNITIONS MODIFIED WITH 82 GRAINS OF 6 MIL M9 PROPELLANT

Table F-1. XM25E1 fin failure test fired at B/1501 - quadrant elevation 45° (static) at ambient XM702E1 ignition cartridge modified with 82 grains 6 mil M9

4 Feb 1976

RD. NO.	TEMP	PRESSURE (psi)	REMARKS
71	70°F	32,655	Flush
72	"	28,140	" $\bar{P}$ = 29682
73	"	29,205	" σ_p = 1725
74	"	29,205	"
75	"	29,205	"
76	"	28,940	Backed out 1/16"
77	"	31,860	" - Fin Blew
78	"	29,205	" $\bar{P}$ = 29629
79	"	30,795	" σ_p = 1747
80	"	27,345	"
81	"	28,140	Backed Out 1/8"
82	"	31,330	"
83	"	28,140	" $\bar{P}$ = 30106
84	"	31,060	" σ_p = 1818
85	"	31,860	" - Fin Blew

$\bar{P}_{tot}$ = 29806

σ_{ptot} = 1648

Table F-2. XM25E1 fin failure test at B/150l static quadrant elevation 45° at ambient temperature XM702E1 modified with 82 grains of 6 mil M9

4 Feb 1976

RD. NO.	½" FROM FIN END	1"	1½"	2"		REMARKS	AVG
71	.117	.118	.118	.115	Hole Dia	Flush	.117
	.990	.989	.988	.985	Boom Dia		.988
72	.113	.118	.119	.113	Hole Dia		.1
	.990	.990	.990	.991	Boom Dia		.99
73	.115	.115	.115	.110	Hole Dia		.114
	.984	.988	.985	.984	Boom Dia		.995
74	.114	.119	.116	.111	Hole Dia		.115
	.990	.989	.990	.984	Boom Dia		.988
75	.110	.117	.117	.112	Hole Dia		.114
	.984	.990	.992	.990	Boom Dia		.989
76	.118	.119	.117	.111	Hole Dia	Backed Out 1/16 Inch	.116
	.986	.985	.985	.985	Boom Dia		.985
77	B L E W						
78	.112	.118	.116	.110	Hole Dia		.114
	.986	.985	.988	.986	Boom Dia		.986
79	.113	.113	.113	.109	Hole Dia		.112
	.985	.986	.989	.990	Boom Dia		.988
80	.114	.121	.118	.108	Hole Dia		.115
	.990	.989	.988	.988	Boom Dia		.989
81	.113	.114	.111	.110	Hole Dia	Backed Out 1/8 Inch	.112
	.985	.984	.984	.985	Boom Dia		.985
82	.115	.118	.109	.112	Hole Dia		.114
	.986	.984	.984	.985	Boom Dia		.985
83	.117	.114	.115	.110	Hole Dia		.114
	.988	.986	.989	.985	Boom Dia		.987
84	.117	.120	.114	.117	Hole Dia		.117
	989	988	989	.990	Boom Dia		.989
85	B L E W						
AVG HOLE	.114	.117	.115	.111			
AVG BOOM	987	987	988	987			

SARPA Form 1157 Dec 73 CALCULATION SHEET

APPENDIX G

XM702E1 IGNITION CARTRIDGE STATIC PRESSURE TESTING RESULTS AT TEMPERATURE EXTREMES WITH IGNITION CARTRIDGES MODIFIED WITH 82 GRAINS OF 6 MIL M9 PROPELLANT

Table G-1. XM25E1 fin failure test fired at B/1501 - quadrant elevation 45°
XM702E1 ignition cartridge modified with 82 grains 6 mil M9

6 & 7 Jan 1976

RD. NO.	TEMP	REMARKS
41	+145°F	Blew
42	"	OK
43	"	Blew
44	"	OK
45	"	OK
46	"	OK
47	"	Blew
48	"	Blew
49	"	OK
50	"	Blew
51	'	Blew
52	"	Blew
53	"	Blew
54	"	Blew
55	"	Blew

RD. NO.	TEMP	REMARKS
1	-50°F	OK
2	"	OK
3	"	OK
4	"	OK
5	"	OK
6	"	OK
7	"	OK
8	"	OK
9	"	OK
10	"	OK
11	"	OK
12	"	OK
13	"	OK
14	"	OK
15	"	OK
16	"	OK
17	-50°F	OK
18	"	OK
19	"	OK
20	"	OK

Table G-2. XM25E1 fin failure test statically tested at B/1501 - 45° quadrant elevation XM702E1 ignition cartridge modified with 82 grains of 6 mil M9

6-7 Jan 1976

RD. NO.	TEMP.	½" FROM FIN	1"	1½"	2"		AVG
42	+145°F	.122	.125	.119	.119	Hole Dia	.121
		1.006	1.007	1.004	1.000	Boom Dia	1.004
44		.118	.119	.120	.119	Hole Dia	.119
		.985	.996	.994	.992	Boom Dia	.992
45		.124	.123	.121	.121	Hole Dia	.122
		1.010	1.005	1.001	.988	Boom Dia	1.001
46		.127	.131	.131	.130	Hole Dia	.130
		1.001	1.004	1.004	1.001	Boom Dia	1.003
49		.124	.124	.123	.121	Hole Dia	.123
	↓	1.005	1.008	1.010	1.000	Boom Dia	1.006
1	-50°F	.111	.112	.112	.112	Hole Dia	.112
		.985	.984	.980	.981	Boom Dia	.983
2		.118	.119	.120	.119	Hole Dia	.119
		.985	.984	.980	.981	Boom Dia	.983
3		.113	.112	.114	.112	Hole Dia	.113
		.986	.985	.987	.986	Boom Dia	.986
4		.110	.113	.114	.113	Hole Dia	.113
		.984	.985	.985	.986	Boom Dia	.985
5		.110	.109	.110	.113	Hole Dia	.111
		.986	.986	.985	.984	Boom Dia	.985
6		.111	.110	.112	.113	Hole Dia	.112
		.986	.981	.984	.984	Boom Dia	.984
7		.109	.110	.111	.112	Hole Dia	.111
		.985	.984	.984	.985	Boom Dia	.985
8		.112	.111	.112	.112	Hole Dia	.112
		.980	.980	.983	.980	Boom Dia	.981
9		.109	.108	.109	.109	Hole Dia	.109
		.982	.988	.985	.986	Boom Dia	.985
10		.111	.111	.110	.111	Hole Dia	.111
	↓	.991	.991	.998	.998	Boom Dia	.995

SARPA Form 1157 Dec 73 CALCULATION SHEET Page 1 of 2

Table G-2. (Continued)

6-7 Jan 1976

RD. NO	TEMP.	½" FROM FIN	1"	1½"	2"		AVG
11	-50°F	.109	.110	.110	.110	Hole Dia	.110
		.984	.981	.982	.982	Hole Dia	.111
12		.111	.111	.111	.112	Hole Dia	.111
		.982	.980	.983	.984	Boom Dia	.982
13		.110	.110	.109	.111	Hole Dia	.110
		.983	.984	.985	.985	Boom Dia	.984
14		.109	.109	.109	.110	Hole Dia	.109
		.985	.985	.985	.985	Boom Dia	.985
15		.113	.112	.116	.114	Hole Dia	.114
		.990	.996	.995	.997	Boom Dia	.995
16		.110	.109	.111	.111	Hole Dia	.110
		.987	.985	.986	.984	Boom Dia	.986
17		.109	.110	.110	.110	Hole Dia	.110
		.984	.983	.985	.985	Boom Dia	.984
18		.110	.110	.110	.110	Hole Dia	.110
		.984	.982	.982	.985	Boom Dia	.983
19		.110	.110	.110	.111	Hole Dia	.110
		.985	.985	.986	.985	Boom Dia	.985
20		.108	.108	.108	.110	Hole Dia	.109
	▼	.983	.985	.984	.986	Boom Dia	.985
	AVG OD	.985	.985	.985	.985		
	AVG Hole	.111	.111	.111	.112		
	AVERAGES COMPUTED FOR -50°F FIRINGS ONLY						

SARPA Form 1157 Dec 73 CALCULATION SHEET Page 2 of 2

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