AD-A056 015 COMPUTER SCIENCES CORP BAY ST LOUIS MISS ENGINEERIN--ETC F/G 13/12
SHIELD GROUP 5 SUPPRESSIVE SHIELD PLASTIC LINER AND PROPELLANT --ETC(U)
FEB 78 W R WILCOX NAS13-50

UNCLASSIFIED EA-27R1 ARTSD-CR-78001 NL

1 OF 1
AD
A056015

END
DATE
FILMED
8-78
DDC

CONTRACTOR REPORT AR-TSD-CR-78001

SHIELD GROUP 5 SUPPRESSIVE SHIELD PLASTIC LINER AND PROPELLANT TESTING

by
W. R. Wilcox
Computer Sciences Corporation

February 1978

NASA NATIONAL SPACE TECHNOLOGY LABORATORIES
Computer Sciences Corporation
Engineering and Science Services Laboratory
NSTL Station, Mississippi 39529

Contract No. NAS13-50

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Technical Support Directorate
Dover, New Jersey 07801

Approved for public release - distribution unlimited.

Disclaimer

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

Disposition

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

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AR-TSD-CR-78001	2. GOVT ACCESSION NO.
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): SHIELD GROUP 5 SUPPRESSIVE SHIELD PLASTIC LINER AND PROPELLANT TESTING	5. TYPE OF REPORT & PERIOD COVERED: Engineering Study March 1976-May 1977
	6. PERFORMING ORG. REPORT NUMBER: EA-27R1
7. AUTHOR(s): W. R. Wilcox	8. CONTRACT OR GRANT NUMBER(s): NAS13-50; MIPR8166104601F4W5
9. PERFORMING ORGANIZATION NAME AND ADDRESS: NASA National Space Technology Laboratories, Computer Sciences Corporation, Engineering and Science Services Laboratory, Bay St. Louis, Mississippi 39529	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: PEMA Project 5761264
11. CONTROLLING OFFICE NAME AND ADDRESS: COMMANDER, US Army ARRADCOM, ATTN: DRDAR-TSS, Dover, New Jersey 07801	12. REPORT DATE: February 1978
	13. NUMBER OF PAGES: 68
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Director, Large Caliber Weapons Laboratory, US Army ARRADCOM, ATTN: DRDAR-LCM-SP (John Maroni) AV 880-3022, Dover, New Jersey 07801	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release - distribution unlimited. This document may be obtained from the Defense Documentation Center.

12 63p.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18 ARTSD, SBIE 19 CR-78001, AD-E400 148

DDC RECEIVED JUL 7 1978 B

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Suppressive shield	Pyrotechnics	Reaction rate
Illuminant	Testing	
Propellant	Liner	
Overpressure	Safety	

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

A prototype Shield Group 5 Suppressive Shield of modular, prefabricated construction suitable for application to illuminant, propellant and pyrotechnics production lines was used. The testing was to evaluate the performance of plastic and steel liners and to increase the safety certifiable liners for the Group 5 S/S to 22.7 kg of illuminant, 270 kg of propellant and 1.1 kg of high explosive.

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

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

409 884

PREFACE

The investigation described in this report was authorized under MIPR 8166104601 F4Wt, Project 5761264. This work was performed at the NASA National Space Technology Laboratories (NSTL) under the direction of the ARRADCOM Resident Operations Office (AROO) through NASA by the Computer Sciences Corporation as the support contractor. The experimental work was completed November 1976.

This document may be obtained from the Defense Documentation Center and is approved for release to the general public and foreign nationals.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

ACKNOWLEDGEMENT

The author acknowledges the technical assistance of Dr. G. L. McKown, Chief, and Mr. D. M. Koger of the ARRADCOM Resident Operations Office; NASA-NSTL, NSTL Station, MS 39520.

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

SHIELD GROUP 5 SUPPRESSIVE SHIELD PLASTIC LINER AND PROPELLANT TESTING

1.0 INTRODUCTION

1.1 Objective. The primary objective of the subject Shield Group 5 Suppressive Shield (Group 5 S/S) plastic liner and propellant testing was to obtain data sufficient to justify Safety approval of the lined shield for applications involving up to:

- 22.7 kg (50 lb) of illuminant material in bulk
- 270 kg (590) of propellant material in bulk
- 1.1 kg (2.5 lb) or equivalent of high explosives

1.2 Authority. The work described in this report was authorized under MIPR 8166104601F4W5, Project 5761264 and Technical Work Request EA-27R1, and was performed for the ARRADCOM Resident Operations Office at the NASA National Space Technology Laboratories (NSTL) by Computer Sciences Corporation (CSC) under Contract NAS13-50.

1.3 Background. The suppressive shielding program[1] was initiated in 1969 to provide improved, cost-effective, and safety-certified explosion and deflagration suppressing protective structures in the form of homogeneously vented enclosures as alternatives to the use of U.S. Army TM5-1300 walls. The concept feasibility has been demonstrated by previous projects for developing and testing full scale prototype structures.

In 1973 the program was given increased impetus by U.S. Army authorization to provide a sound technological base for the concept. The USA Production Base Modernization and Expansion Office Project Manager directed a program for the simultaneous development of prototype suppressive shields applicable to seven major categories of hazardous munition production operations. The development work was conducted under the cognizance of the Suppressive Shielding Technical Steering Committee. The principal characteristics of the seven shield groups are outlined in table 1.

The prototype Group 5 S/S was designed and fabricated in 1974, and its initial testing was completed in 1975.[2,3] The Group 5 S/S met all of the original performance and design requirements as outlined in table 1. The vented, multilayered panels are, however, subject to the accummulation of explosives, pyrotechnic, and propellant dusts, as well as other foreign materials.

There was a fear that pyrotechnic and propellants dusts could accumulate within the panels in significant quantities over long periods of time in plant operating environments. An explosion within a shield with panels loaded with explosives or other flammable materials could result in the generation of flaming ejecta, thus increasing the explosive hazard.

With the possibility of this increased hazard, a decision was made to develop a system for preventing the accumulation of foreign matter within the panels and for affording environmental protection to the shield.

Table 1. SHIELD GROUP DEFINITIONS FOR SUPPRESSIVE SHIELDS

Shield group	Hazard parameters	Representative operations
1	Extreme blast pressure 3400-8300 kilopascals (500-1200 psi) Severe fragmentation	Melt loading of up to 1100 kilograms (2500 lb) batch Major caliber projectile processing Bulk loading operations
2	High blast pressures 1400-3400 kPa (200-500 psi) Moderate to severe fragmentation	Minute melt applications High explosives processing (boosters, bursters, ect.) High explosives bulk to 340 kg (750 lbs)
3	High blast pressures 1400-3400 kPa (200-500 psi) Light fragments	Munition components, detonators, fuzes
4	Moderate blast pressures 340-1400 kPa (50-200 psi) Moderate to severe fragmentation	Processing of rounds with limited bay capacity Smaller explosives bulk approximately 4.5 kg (10 lbs) in conventional cubicles
5	Light blast pressures less than 340 kPa Light to moderate fragmentation Flame propagation potential	Bulk propellant processing Bulk pyrotechnic processing Light metal or plastic HE components Limited numbers of HE round
6	Ultra high blast pressure 3400-14000 kPa (500-2000 psi) Light to moderate fragmentation	Close in protection of small quantities explosive laboratory, handling and transportation
7	Moderate blast pressure 340-1400 kPa (50-200 psi) Severe fragmentation	Pyrotechnics

As previously stated, the shield successfully met all performance and design requirements in previous test series.[3,4] In these tests relatively small structural loads were observed, and as a result the shield maintained its structural integrity after 16 individual tests.

2.0 EXPERIMENTAL METHODS

2.1 Shield Group 5 Suppressive Structure. As outlined in table 1, the Shield Group 5 Suppressive Structure was designed to provide protection from the hazard parameters of light blast pressures of less than 340 kPa (50 psi), light to moderate fragmentation, and potential flame propagation of bulk pyrotechnic and propellant processing plant operations. The Group 5 Suppressive Structure is fully described in EM-TM-76001.[3] Some physical details of the Group 5 S/S are as follows:

- Internal dimensions: 3.2 m (125.25 in) square by 2.8 m (110.5 in) high
- Total Volume: 30.5 m^3 (1071 ft^3)
- Total surface area: 5 x 9 m^2 (635.6 ft^2)
- Effective Venting Area Ratio, α_e = .0189
- Effective Venting Area: 1.12 m^2 (12.01 $ft.^2$)

Figure 1 is a sectional view through a vented panel. The Group 5 S/S was tested in four basic configurations in the course of this project. The first configuration was as described above, the original shield as built and tested. Six tests were conducted in this original vented configuration.

2.2 Steel Liners. It was thought that completely closing the vented panels would represent a worse case insofar as loading the structural members of the shield were concerned. Further it was believed that a plastic liner would affect performance results somewhere between the vented and completely closed structure. Eight of the tests in this series were conducted with the interior of the panels covered with sheet steel liners 1.60 mm (16 ga) thick. The liners were fastened by screws to facilitate installation and removal. The steel liners provided were relatively well sealed but there were some open areas in the structure around the panel edges, the door, the floor, and instrumentation penetrations. The open vent areas were estimated to be less than .065 m^2 (100 in^2). The resulting calculated effective venting ratio, α_e , was .001093. The door was left open for one test to reduce confinement to an effective venting ratio, α_e , of .07631.

2.3 Plastic Liners. As stated in paragraph 1.3, the purpose of the proposed liners was to prevent the accumulation and eventual ejection of foreign material within the vented panels and to afford environmental protection in the interior of the shield. Providing a smooth easily cleaned surface on the interior and exterior of the Group 5 S/S was another performance requirement of the liner. A plastic film was selected as a candidate liner material due to the relatively low cost and ease of application features. It was felt that a light weight easily frangible material would also result in minimum interference with vented panel function. Safety related considerations of electrostatic hazards required that the liner material be electrically conductive. The specific material selected was Velostat Custom Film 1701, a proprietary product of 3-M Corporation, Nuclear Products Dept., Alpha Industrial Park, Chelmsford, Mass. 01824. It is an electrically conductive, opaque polyethylene film, 4 mil thick. The plastic liner can be adhesively bonded to the interior

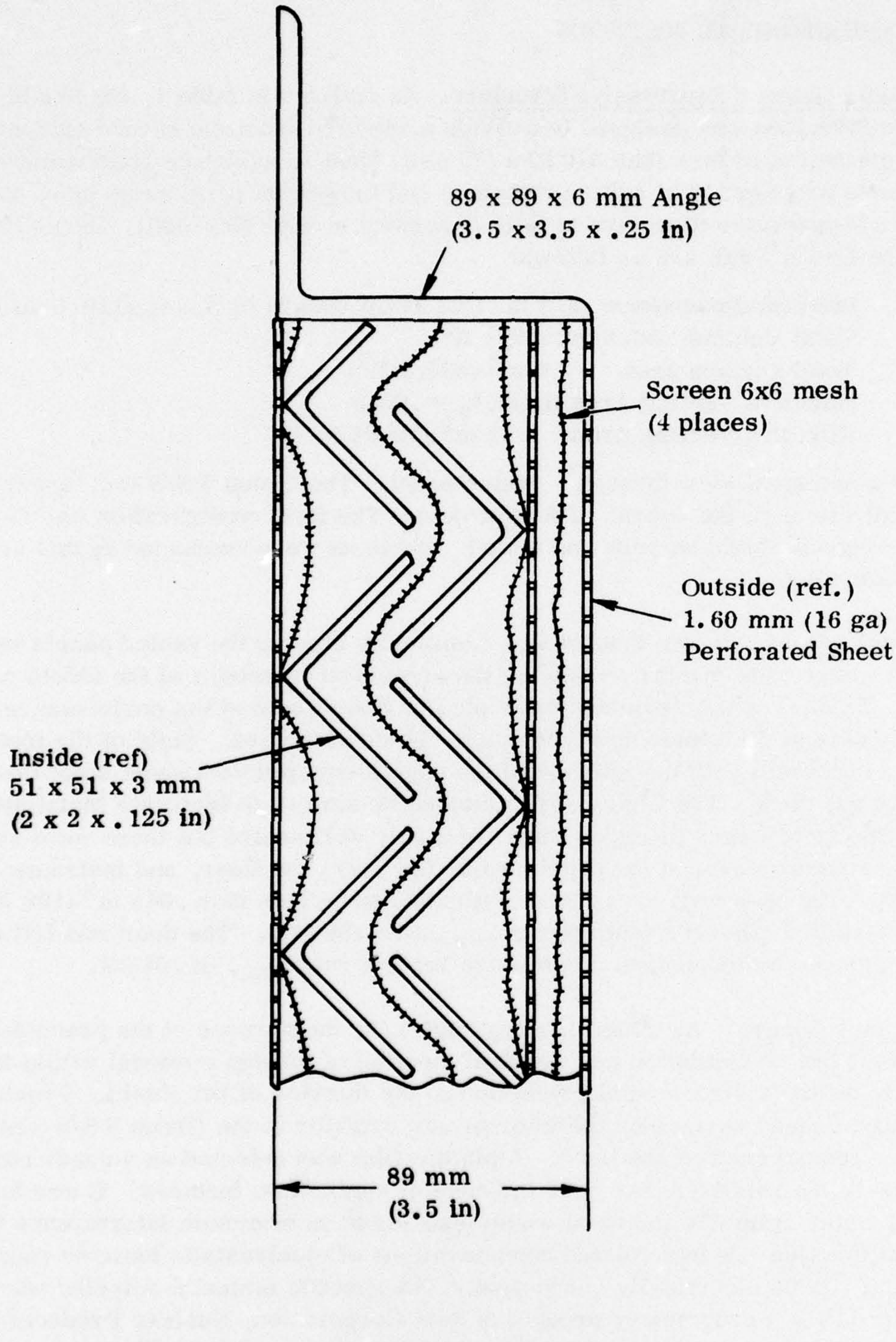


Figure 1. Group 5 Suppressive Shield Panel Section

and exterior of a structure. However, the Group 5 S/S surfaces were so contaminated from previous tests that there was a very poor adhesive bond. Most of the plastic liner material was secured by adhesive tape for the tests described herein. A single test was conducted using the Velostat liners on all 5 walls. The remainder of the tests were conducted with ordinary black polyethylene film plastic liner material because it is much less expensive and had the same performance characteristics as Velostat for testing purposes. The resulting average effective venting ratios, α_e, were between .0011 and .0189.

2.4 Composite Liner. It was observed (see 3.0 below) that the total plastic liner configuration resulted in the reaction energy and products being relieved principally through the roof. The walls did not vent significantly since the roof liner failed first, thus relieving the pressure on the walls. For this reason, testing was continued with a composite configuration, consisting of plastic liners on the inside and outside surfaces of the walls and steel liners on the inside of the roof. Three tests were conducted in the composite configuration with an effective venting average ratio, α_e , between .0011 and .0151.

2.5 Sample Materials. One test was performed using the same sodium nitrate-powdered magnesium (45 percent - 55 percent by weight) illuminant composition used in previous testing.[3,4,5] This composition is representative of typical metal fuel and oxidizer compositions currently in production. It differs from the production material only by the exclusion of binders and moderators. This material suits the purpose of these studies very well since it is relatively sensitive to thermal initiation and has a very vigorous output. Precision cast pentolite spheres were used for the seven high explosive tests.

Two M10 propellants were used for twenty-two tests. Twelve tests were performed with a 470 micron (.018 in) web, single perforated grain, and ten tests were performed with a 740 micron (.029 in) web, multiple perforated grain. These specific propellants were selected since they represented a typical production gun propellant.

2.6 Instrumentation. The instrumentation used for the tests performed in the Group 5 S/S are described in table 2. Sensor locations are shown schematically in figure 2. The burning time photocells were used extensively in previous testing[3,4] with excellent results. They were also employed for these tests because of their proven reliability and performance.

The burn rate iron-constantan thermocouples were employed as developmental sensors, primarily to evaluate their performance. They were placed near the top and bottom of the propellant charge to detect the initiation and termination of the high temperature of the reaction. A burn rate breakwire was also employed as a developmental sensor. The breakwire sensor consisted of three individual fusible links of standard solder wire. They were placed in the sample material near the top, middle and bottom. Each link indicated the high temperature arrival by opening a circuit.

The wall mounted Susquehanna ST-2 blast pressure transducer was employed to measure the reflected blast overpressure at the Group 5 S/S wall for high explosive tests and to obtain the same data in the case of a pyrotechnic explosion or detonation.

The PCB101A02 pressure transducers were used to measure static pressure inside the shield. These transducers are installed in the baffle mounts and acquire excellent data

Table 2. INSTRUMENTATION FOR GROUP 5 S/S TESTS

Measurement number	Parameter	Transducer	Amplifier	Installed time constant	Recorder
00	Timing	N/A	N/A	-	Sangamo 4700
01	Burning time	Photocell	Transdata	1 msec	Sangamo 4700
02	Burning time	Monsanto MT-2	NEFF109-6	1 msec	Sangamo 4700
03	Burn rate	Fe-Constantan	NEFF109-6	100 msec	Sangamo 4700
04	Burn rate	Thermocouple	NEFF109-6	100 msec	Sangamo 4700
05	Burn rate	Breakwire	N/A	1 msec	Sangamo 4700
06	Static press.	MB151-DBZ-177	NEFF109-6	10 msec	Sangamo 4700
07		in tube			Sangamo 4700
08		PCB101A02 in			Sangamo 4700
09	Static press.	Baffle mount	NEFF109-6	10 msec	Sangamo 4700
10	Blast press. (face-on)	ST-2 in Wall mount	PCB401A13	200 msec	Sangamo 4700
11	Heat flux	Keithley 860	N/A	1 sec	Sangamo 4700
12					
13					
14	Heat flux	Keithley 860	N/A	1 sec	Sangamo 4700
41	Blast press.	ST-7H in Aerodynamic probe	PCB401A11	200 msec	Biomation 610B
42	"				
43	"				
44	"				

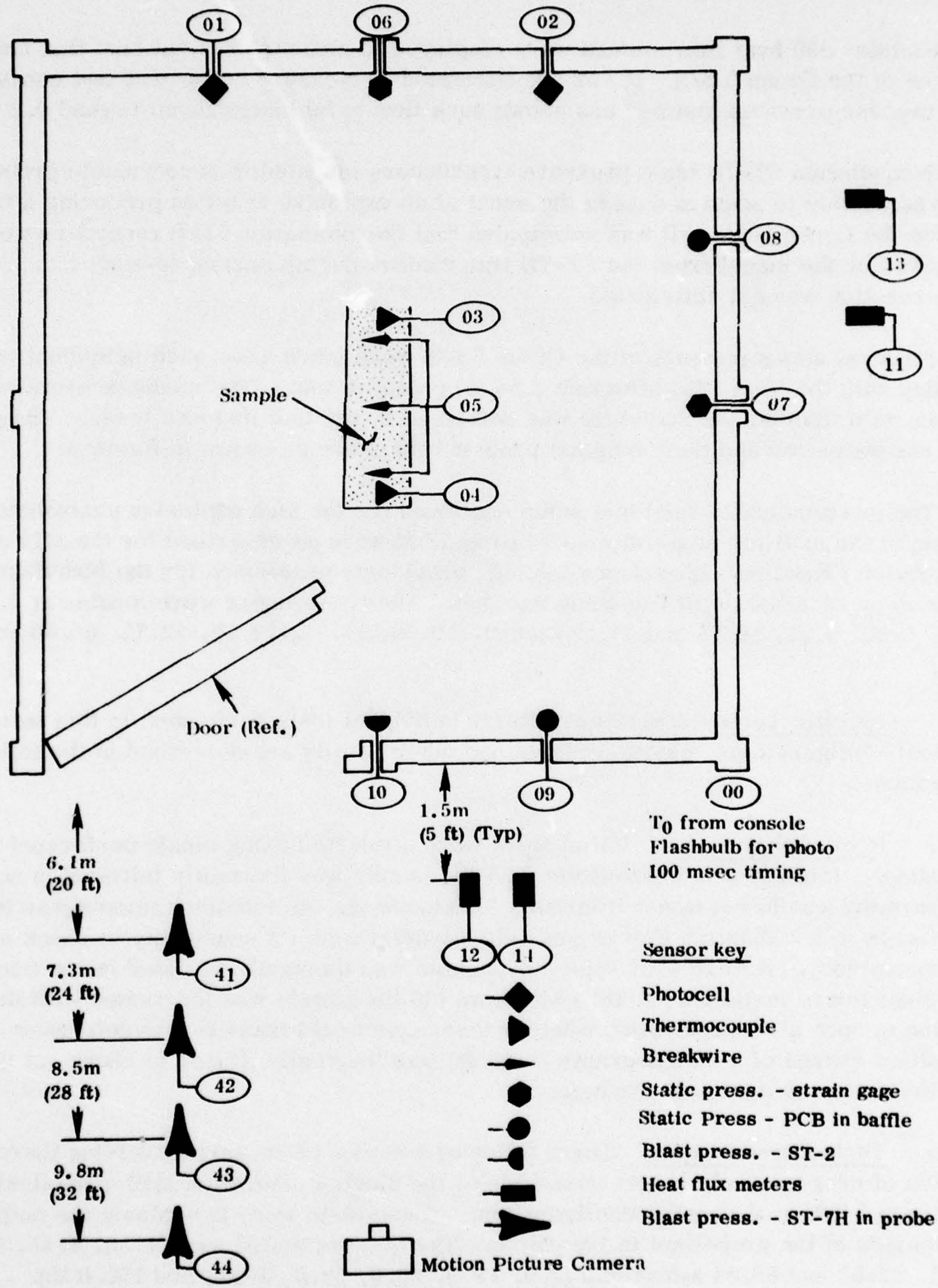


Figure 2. Sensor Locations for Group 5 S/S Tests

when the pressure pulse has a duration of less than 100 milliseconds. Strain gage transducers, MB151-DBZ-177, were mounted in a tube one half meter to one meter long for tests which involved longer and more intense flames.

Kiethley 860 heat flow meters were employed to measure radiant heat flux from the surface of the Group 5 S/S. It was not attempted to measure conductive and convective heat flow because previous testing[3] has shown such flow to be insignificant beyond 0.2 meters.

Susquehanna ST-7H blast pressure transducers mounted in aerodynamic probes were arrayed outside to acquire data in the event of an explosive reaction producing a blast wave outside the Group 5 S/S. It was anticipated that the Biomation 610B recorders would not be triggered by the signal from the ST-7H transducers during normal testing; i.e., a blast wave reaction was not anticipated.

Physical measurements of the Group 5 S/S were taken after each individual test starting with the first .254 kilogram (.56 lb) pentolite test. The measurements were taken to ascertain whether the structure was deformed by the test imposed loads. The physical features measured and their original pretest values are as shown in figure 3.

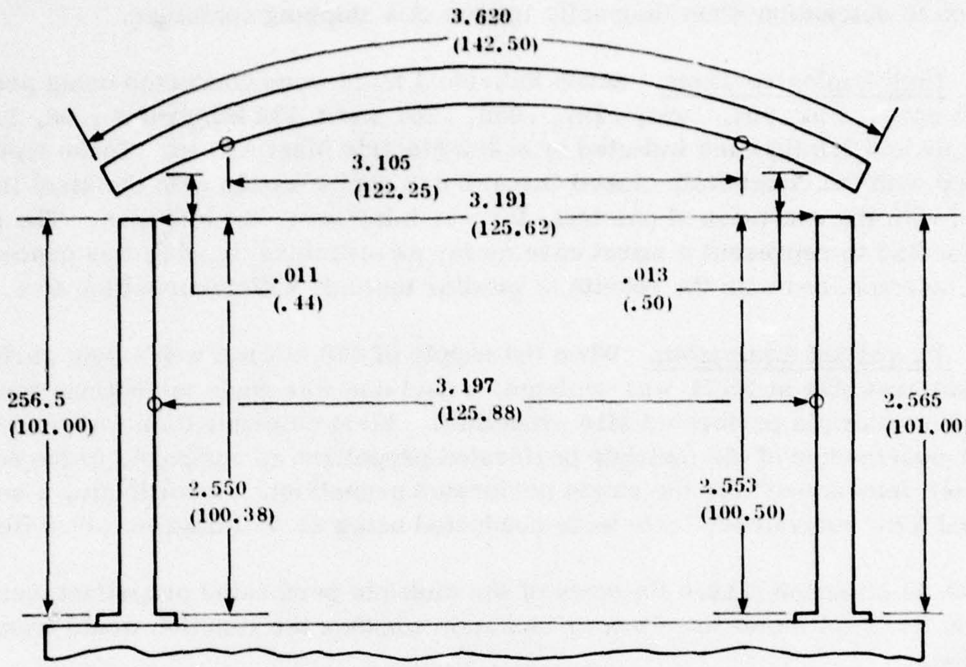
The instrumentation and test setup employed for the high explosive equivalency testing of the multiple perforation M10 propellant were as described for the M10 single perforation propellant equivalency testing[6] previously performed for the Manufacturing Technology Directorate of Picatinny Arsenal. The transducers were located at 3.32, 4.49, 5.96, 9.97, 19.94 and 44.29 meters (10.90, 14.72, 19.55, 32.71, 65.43 and 145.37 feet).

2.7 <u>Specific Tests.</u> There were thirty individual tests performed in this test series. The test configurations, charge weights and other details are described in the following paragraphs.

2.7.1 <u>Preliminary Tests.</u> Initial tests were conducted using single perforated M10 propellant. Initially a 1.36 kilogram (3.0 lb) sample was thermally initiated in open air to determine whether it would transition to detonation. An identical sample was then initiated by a J-2 Blasting Cap to qualitatively determine its sensitivity to shock initiative and equivalency. A third 1.36 kilogram sample was thermally initiated in the Group 5 S/S with steel liners installed. A 16.3 kilogram (36 lb) sample was functioned with thermal ignition in open air to determine whether that mass would transition to detonation. A propellant charge of 3.75 kilograms (8.26 lb) was thermally ignited to check out the burn rate breakwire system performance.

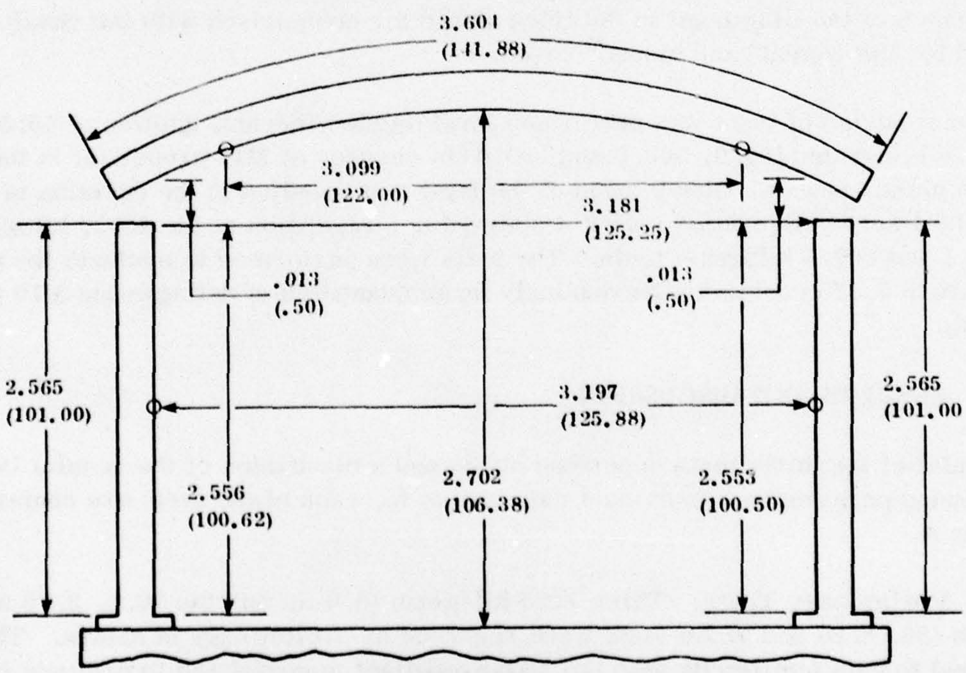
2.7.2 <u>Vented Shield Tests.</u> There followed a series of six tests involving thermal ignition of progressively larger quantities of the single perforation M10 propellant inside the Group 5 S/S in the vented configuration. These tests were to evaluate the output parameters of the propellant in the shield. The masses tested were 1.36, 4.45, 9.07, 13.61, 22.68 and 68.04 kilograms (3.0, 10.0, 20.0, 30.0, 50.0, and 150.0 lb).

A propellant charge of 16.78 kilograms (37.0 lb) of propellant was thermally ignited in the M-24 metal lined wooden box in which the material is shipped and stored. Ordinarily the box contains 49.90 kilograms (100.0 lb) but for this test the bottom was filled with inert material, perlite, to raise the propellant to the same height as if the box were filled



Section looking north

All dimensions in meters (inches)



Section looking east

Figure 3. Group 5 S/S Physical Measurements

with propellant. This test was performed to determine whether the propellant would transition to detonation when thermally ignited in a shipping container.

2.7.3 High Explosive Tests. Seven individual tests were conducted using precision cast pentolite spheres at .254, .494, .227, .680, .907 and 1.134 kilograms (.56, 1.09, .50, 1.50, 2.00 and 2.0 lb) each initiated by a J-2 electric blasting cap. These tests were conducted with the completely closed Group 5 S/S configuration with the steel liners installed with the exception of one test, for which the door was left open. The results were expected to represent a worst case as far as structural loading was concerned, and were to be compared with the results of similar testing[3] with composition C-4.

2.7.4 Propellant Evaluation. When the supply of 470 micron web single perforated M10 propellant available at NSTL was depleted, a decision was made to continue testing with 740 micron web multiple perforated M10 propellant. First determination was made relative to the TNT equivalency of the multiple perforated propellant as compared to the equivalency previously determined[6] for the single perforated propellant. Accordingly, a series of five individual TNT equivalency tests were conducted using 21.77 kilogram (48.0 lb) samples.

A 49.90 kilogram (110.0 lb) mass of the multiple perforated propellant was thermally ignited in its M-24 metal lined box to ascertain whether the reaction would transition to detonation.

2.7.5 Plastic Liner Tests. A 13.61 kilogram (30.0 lb) charge of the magnesium-sodium nitrate illuminant composition was thermally ignited in the Group 5 S/S with Velostat film applied to the inside and outside surfaces. The test was performed to evaluate the performance of the illuminant in the lined shield for comparison with the results previously obtained for the vented[3] and closed[4] cases.

A final series of tests was performed involving the thermal ignition of 45.36, 136.1 and 267.6 kilogram (100.0, 300.0 and 590.0 lb) charges of M10 propellant in the Group 5 S/S with plastic liners. Observation of the first test resulted in the decision to utilize the composite liner configuration (see 2.4 above) for a repetition of the 45.36 kilogram test and the 136.1 and 267.6 kilogram tests. The tests were performed to evaluate the performance of the Group 5 S/S containing increasingly large quantities of deflagrating M10 propellant material.

3.0 RESULTS AND DISCUSSION

The results of the thirty tests described above and a discussion of the results is detailed in the following paragraphs. Individual data sheets for each of the tests are contained in Appendix A.

3.1 Preliminary Tests. Three 1.36 kilogram (3.0 lb) and the 16.3, 3.75 and 16.78 kilogram (36, 8.26 and 37 lb) tests were regarded as preliminary in nature. They were performed to gain familiarity with the M10 propellant material and to evaluate its performance. In no case did the M10 propellant transition to detonation after thermal ignition. When the 16.78 kilogram charge of propellant was thermally ignited in the M-24 metal lined wooden box, it generated enough pressure to pneumatically rupture the box. This occurred at the end of the burn, when the reaction apparently backfired into the box. The open air tests were observed on a closed circuit television system. In all cases the fireball was observed to be a few meters above the charge with a clear area between the charge and the fireball. This indicates that the M10 propellant goes through a gas phase prior to combustion, which is consistent with and illustrative of the solid propellant burning theory.[7]

Results of the 1.36 kilogram (3.07 lb) equivalency test are shown in table 3. The high explosive equivalency was determined relative to pentolite[8] using routine calculating techniques.[6]

Table 3. AVERAGE HIGH EXPLOSIVE EQUIVALENCY OF 1.36 KG M10 PROPELLANT

Distance m (ft)	Scaled distance $m/kg^{1/3}$ $(ft/\#^{1/3})$	Overpressure (kpa psi)	High explosive equivalency (%)	Time of arrival $msec/kg^{1/3}$ $(sec/\#^{1/3})$	High explosive equivalency (%)
3.01	2.71	31.05	12	2.12	59
(9.86)	(6.84)	(4.50)			
				(1.03)	
3.96	3.57	13.53	6	4.42	52
(12.98)	(9.00)	(1.96)		(3.40)	
4.81	4.34	18.66	16	6.50	50
(15.78)	(10.94)	(2.71)		(4.99)	

The overpressure data are probably the less reliable because of the low levels involved both in terms of pressure amplitude and signal levels. This compares favorably with TNT equivalencies for M10 of about 65 percent[6] at similar scaled distances, but with larger charge weights.

The 3.75 kilogram test was primarily for evaluating a breakwire burn rate sensor. The sensor functioned satisfactorily. The overall indicated reaction rate was .0109 meter/sec (.428 in/sec).

3.2 <u>Vented Shield Tests.</u> The thermal ignition of up to 68.04 kilograms (150.0 lb) of M10 propellant produced no measurable pressure rise in the vented Group 5 S/S. Radiant heat flux measurements were at insignificant amplitudes, and were significantly less than those values obtained with illuminant.[3] The reduced pressure and radiant flux values obtained are doubtless the result of the M10's slower reaction rate (.9 kg/sec for 13.61 kg versus 1.9 kg/sec for illuminant composition of the same mass). It was observed both on closed circuit television and from motion picture coverage, that the reaction products of flame and smoke were emitted from the shield mainly through the roof and through the openings at the roof to wall joints. No measurable blast pressure was recorded outside the shield. The most significant data obtained were relative to reaction rate. These values are shown in table 4 and figures 4 and 5.

3.3 <u>High Explosive Tests</u>. The results of detonating precision cast pentolite spheres within the Group 5 Suppressive Shield, with steel liners installed, yielded results essentially the same as the results obtained previously[3] with composition C-4 in the vented structure. There was no apparent increase in loading resulting from the steel liner installation. There was no change in the physical measurements taken after each test. That indicates that the loads imposed by the tests were not sufficient to distort the structure. Table 5 shows the comparison between the lined and vented shield results.

Table 4. REACTION RATES FOR M10 PROPELLANT IN THE GROUP 5 S/S

Charge Mass (kg)	Charge Height (m)	Effective venting area ratio, α_e	Reaction time (msec)	Mass reaction rate (kg/sec)	Reaction rate m/sec
1.36	.317	.0011	1625	.84	.20
1.36	.337	.019	1895	.72	.18
3.75	.610	.80	56,070	.067	.011
4.54	.257	.019	12,900	.35	.020
9.07	.518	.019	23,140	.39	.022
13.61	.267	.019	14,490	.94	.018
22.68	.438	.019	21,190	1.07	.021
68.04	.625	.019	26,090	2.61	.024
16.78	.219	.014	8540	1.96	.026
49.90	.651	.80	16,000	3.12	.041
45.36	.318	.012	8655	5.24	.037
45.36	.318	.0074	8236	5.51	.039
136.10	.254	.0074	9350	14.56	.027
267.6	.241	.0074	9417	28.42	.026

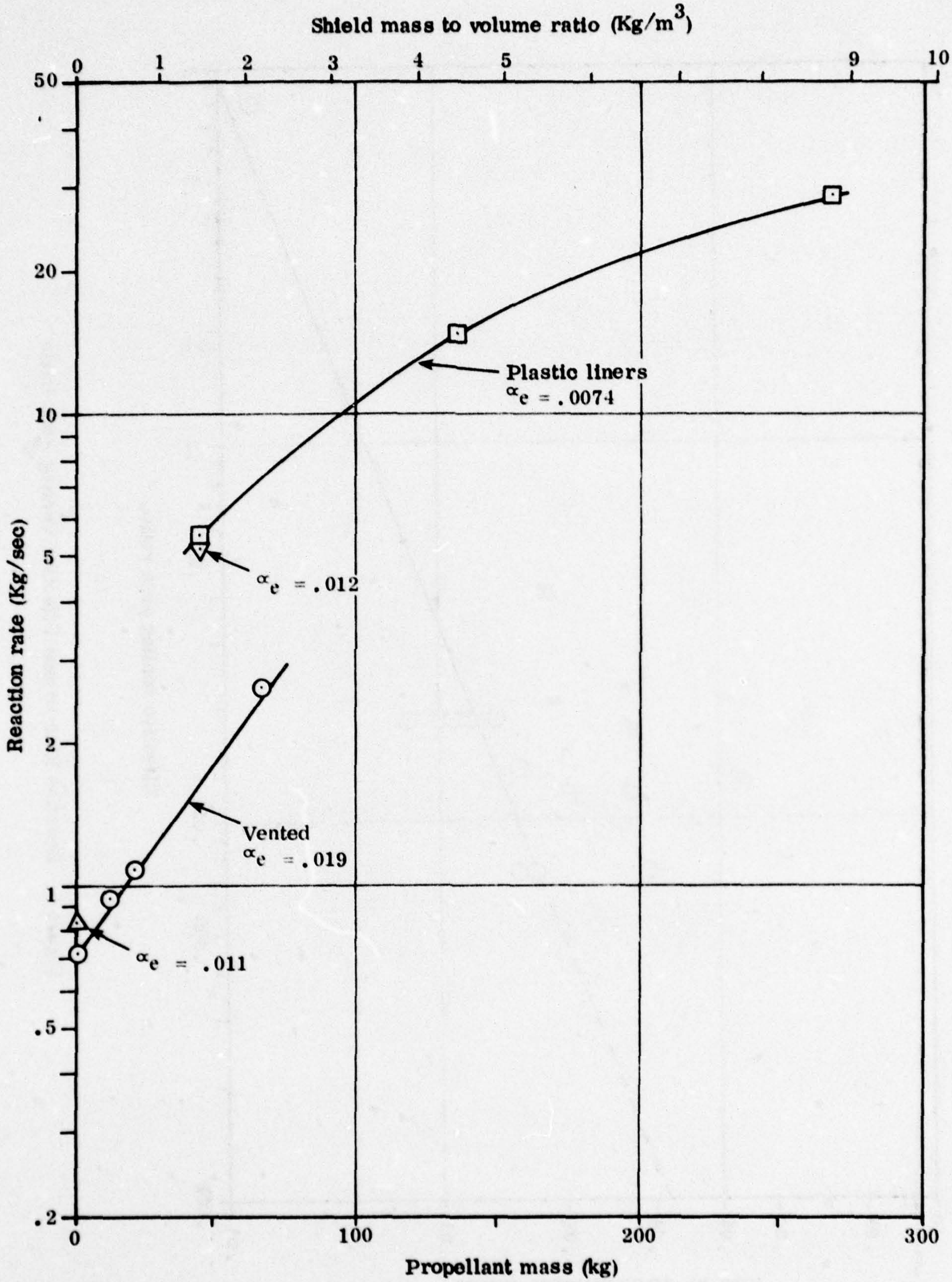


Figure 4. Mass Reaction Rate versus Propellant Mass

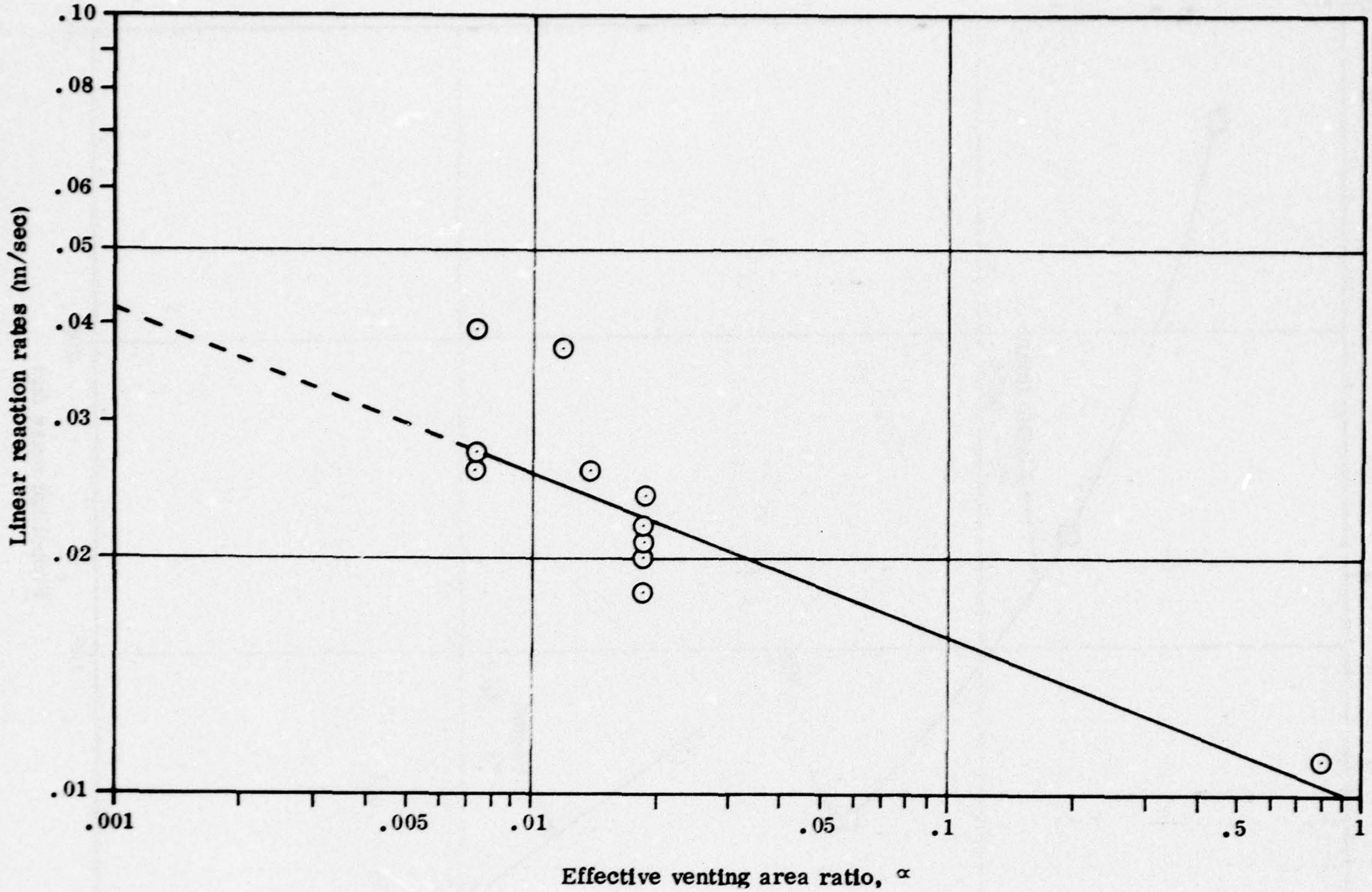


Figure 5. Reaction Rate versus Effective Venting Area Ratio

Table 5. HIGH EXPLOSIVE TEST RESULTS AND COMPARISONS

Lined configuration with pentolite charges					Vented configuration with C-4[3] charges				
	Overpressure					Overpressure			
Charge mass	Wall 1.58 m kPa (psi)	Corner 2.24 m kPa (psi)	Static pressure kPa (psi)	Duration (msec)	Charge mass kg (lb)	Wall 1.58 m kPa (psi)	Corner 2.24 m kPa (psi)	Static pressure kPa (psi)	Duration (msec)
.254 kg (.56 lb)	414 kPa (60.0 psi)	282 (40.9)	41, 2 (6.0, .3)	36	.259 (.572)	324 (47)	262 (38)		4
.494 (1.09)	780 (113)	492 (71.4)	74, 3 (10.7, .4)	36.5	.440 (.970)	965 (140)	434 (63)	39 (5.6)	40
.680 (1.50)	1103 (160)	659 (95.6)	103, 11 (14.9, 1.6)	48	.835 (1.84)	1669 (242)	758 (110)	75 (10.9)	44
.907 (2.00)	1478 (214)	836.8 (125)	147, 13 (21.3, 1.9)						
1.134 (2.50)	1862 (270)	1103 (160)	232, 42 (33.7, 6.1)	33	1.107 (2.44)	2386 (346)	1207 (175)	131 (19)	38

For the .227 kilogram (.50 lb) test the Group 5 S/S door was left open. The blast pressure results at 344.8 kPa (50.0 psi) at the wall and 263.2 kPa (38.2 psi) in the corner do not differ significantly from the closed door case. There was no measurable rise in static pressure when the door was open, indicating an immediate relief of the potential pressure.

3.4 Propellant Evaluation. As noted above, it became desirable to evaluate the TNT equivalency of the 740 micron web multiple perforated M10 propellant. The first two charges were boosted with approximately one percent of C-4, .227 kilogram (.50 lb). The resulting craters were smaller than anticipated and there was about ten percent unconsumed propellant scattered about the test area. In addition, lower than expected pressures were recorded.

The C-4 booster mass was increased to .454 kilogram (1.00 lb), or about two percent, for the last three tests. Rather than calculating TNT equivalency of the 740 micron web multiple perforated propellant, it was decided to compare these test results directly with the corresponding test results obtained for 470 micron web single perforated M10 propellant.[6] Table 6 shows the comparison of peak overpressure and time of arrival results.

When a 49.90 kilogram (110.0 lb) mass of multiple perforated M10 propellant was thermally ignited in the M-24 metal lined box there was no recorded overpressure. It was observed from closed circuit television and motion picture coverage to have burned only. There was no evidence of transition to detonation.

3.5 Plastic Liner Tests. The reaction time and average rate obtained from the 13.61 kilogram (30 lb) illuminant test of 7.160 second and 13.61/7.60 = 1.90 kg/sec compare reasonably with the previous unvented Group 5 S/S results.[4] The plot of data from the vented Group 5 S/S shown in figure 4 was interpolated to obtain an average reaction rate of 2.50 kg/sec. The unvented shield rate of 76 percent of the vented rate does not differ significantly. The radiant heat flux of .01 cal/cm^2 sec is more than the value of .003 cal/cm^{2}sec obtained for the closed shield;[4] and the value of .02 cal/cm^{2}sec obtained for the vented shield.[3] The flame and smoke of the reaction was observed to be emitted mainly through the roof and the gaps between the roof and walls of the shield.

Figures 6 and 12 are photographs of the Group 5 S/S showing the Velostat installation prior to the illuminant test. Figures 7 through 11 and 13 through 16 are photographs of the Group 5 S/S showing the condition of the Velostat liners after the illuminant test. There was no significant (measureable) change in the physical dimensions of the structure.

The final series of tests involving thermal ignition at 45.36, 126.1 and 267.6 kilogram (100.0, 300.0 and 590.0 lb) of M10 propellant in the Group 5 S/S with plastic liners overall and in the composite configuration are described under 2.7, Specific Tests. The pertinent reaction data are included in table 4.

Effective venting area ratios, α_e, for the two configurations were estimated to be between the closed value of .0011 and the vented value of .0189.

Table 6. MULTIPLE PERFORATED PROPELLANT OVERPRESSURE RESULTS AND COMPARISONS

Scaled dist., Z $m/kg^{1/3}$ $(ft/\#^{1/3})$	740 Micron Web multiple perforated peak overpressure kPa (psi)	Time of arrival $(ms/kg^{1/3})$	470 Micron single perforated[6] peak overpressure kPa (psi)	Time of arrival $ms/kg^{1/3}$ $(ms/\#^{1/3})$	Standard deviation, multiple vs. single perforated propellant	
					Pressure	Time of arrival
1.19 (3.0)	100.6, 109.4 (145, 16)	.408, .041	1130.7, 159 (164, 23)	.43, .03	.48	.31
1.61 (4.05)	868.6, 127.3 (126, 181)	.740, .084	595, 103 (86, 15)	.76, .04	1.19	.16
2.13 (5.38)	441.8, 59.3 (64, 9)	1.397, .185	255.8, 83 (37, 12)	1.36, .05	1.31	.16
3.57 (9.0)	70.3, 4.3 (10.2, .6)	4.250, .113	76.5, 10 (11.1, 1.5)	3.80, .24	.43	1.27
7.15 (18.0)	16.7, 1.1 (2.4, .2)	13.597, .141	18.8, 2.1 (2.4, .3)	13.14, .32	.66	.99
15.87 (40.0)	4.5, .6 (.65, .09)	39.27, 1.59	7.1, 1.4 (1.0, .2)	37.43, .04	1.30	1.13

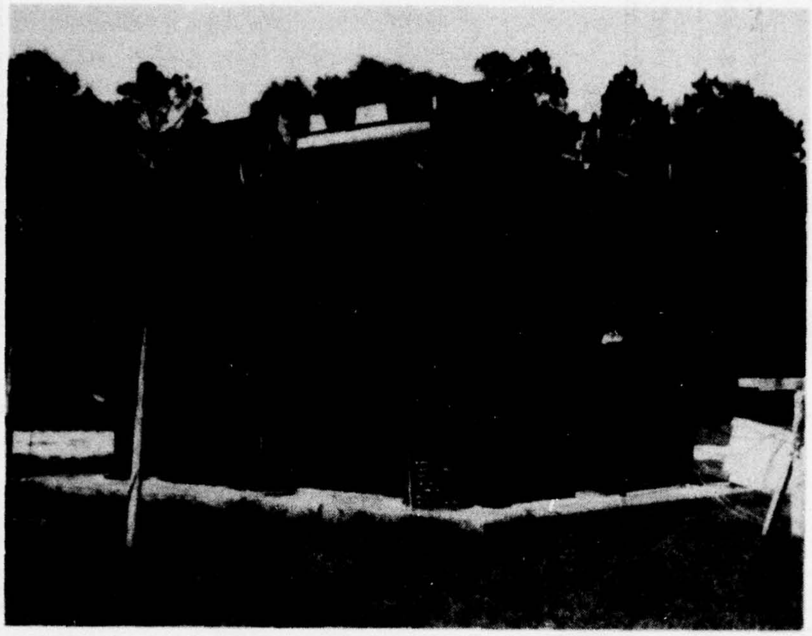


Figure 6. Exterior of Southeast Corner of Group 5 S/S With Plastic Liners Prior to Testing

Figure 7. Southeast Corner After 13.6 kg Illuminant Test (Group 5 S/S)

Figure 8. Northwest Quadrant of Roof After Test (Group 5 S/S)

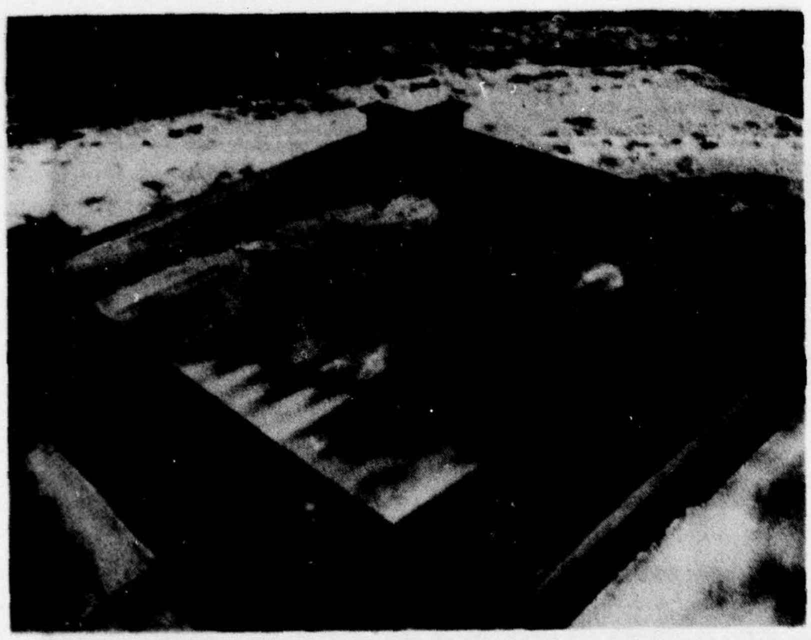


Figure 9. Southwest Quadrant of Roof After Test (Group 5 S/S)

Figure 10. Southeast Quadrant of Roof After Test (Group 5 S/S)

Figure 11. Northeast Quadrant of Roof After Test (Group 5 S/S)

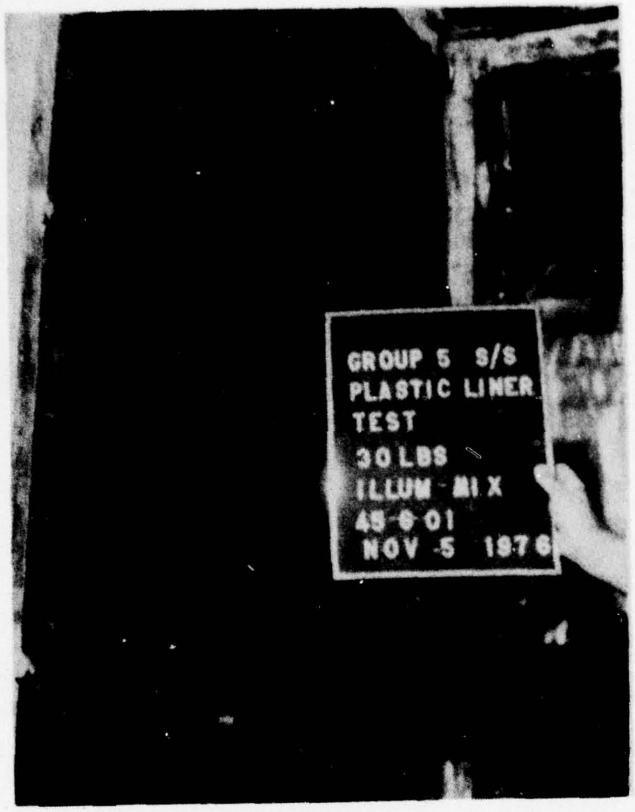


Figure 12. Typical (Northwest Corner) Interior View Showing Application of Plastic Liner Material (Group 5 S/S)

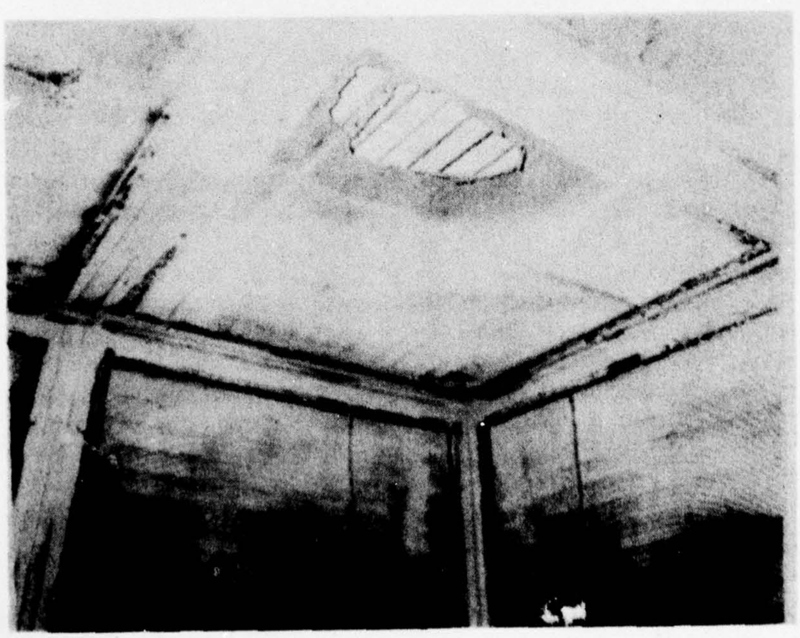


Figure 13. Interior of Northeast Corner After 13.6 kg Illuminant Test (Group 5 S/S)

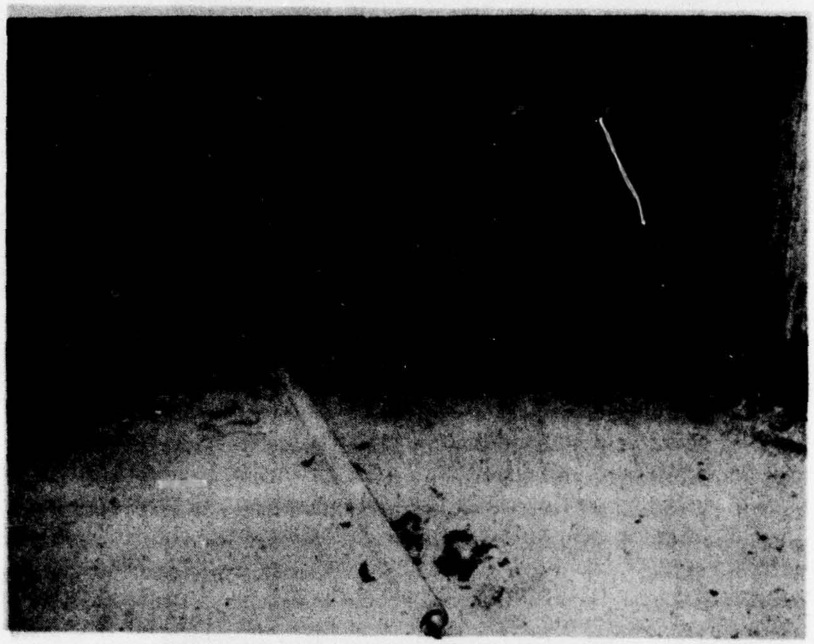


Figure 14. Interior of Northwest Corner After Test (Group 5 S/S)

Figure 15. Interior of Southwest Corner After Test (Door is on Left Side and Partly Open) (Group 5 S/S)

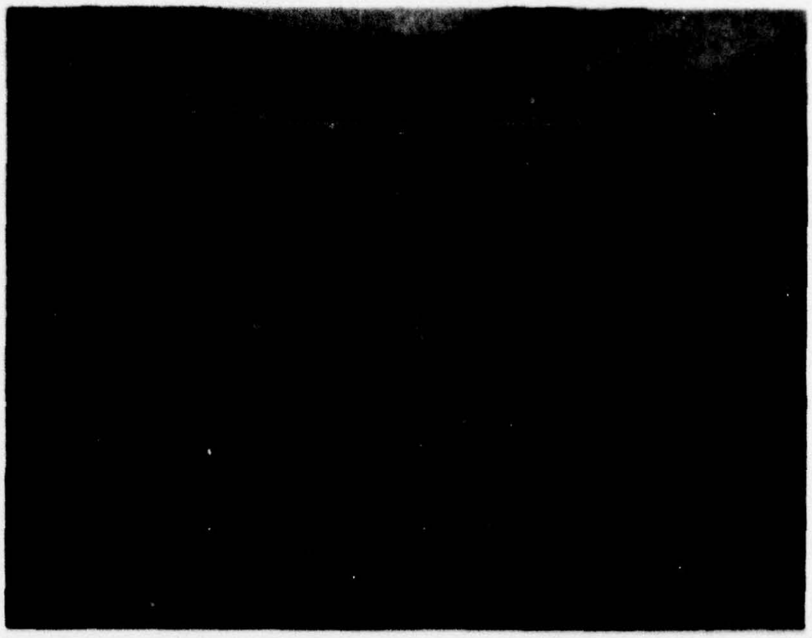


Figure 16. Interior of Southeast Corner After Test (Group 5 S/S)

The estimates were further refined by assuming that the plastic liner opened to the vented condition on two sides and the top for an effective venting area ratio of .0116. The addition of the steel ceiling liner for the composite configuration reduced the estimated vented area to an effective venting area ratio of .0074.

There was no significant change in the physical dimensions of the structural members during the course of this testing.

3.6 Reaction Rates. The reaction rates were calculated on the basis of both average mass reaction rates and average liner reaction rates in figures 4 and 5. It appears that average mass reaction rate might be a function of charge mass (and mass/volume) and effective venting area ratio. It also appears from the data at hand that linear reaction rate might be a function of effective venting area ratio.

4.0 CONCLUSIONS

It is concluded from the results of the testing of this project that the Group 5 Suppressive Shield can be completely lined and covered with a plastic film material without adversely affecting its performance characteristics. It is also concluded from these tests that the Group 5 S/S could be modified by the inclusion of a solid steel roof without degrading its performance.

It is concluded from the results of the testing herein and previously[3,4] that the subject Shield Group 5 Suppressive Shield with plastic or composite liners is certifiable by the cognizant safety office for applications involving up to the following:

- 22.7 kg (50 lb) of illuminant (or similar) material in bulk
- 270 kg (590 lb) of M10 (or similar) propellant material in bulk
- 1.1 kg (2.5 lb) of high explosive material (or its equivalent)

It is concluded that the performance of the 470 micron web single perforated M10 propellant is equivalent to the 740 micron web multiple perforated M10 propellant for unconfined burning at low ambient pressures only.

5.0 RECOMMENDATIONS

It is recommended that consideration be given to a Group 5 S/S concept in which the skin is solid steel and the venting is concentrated in one or more relatively large openings instead of being distributed. Significant cost savings should be realized over the multiple layered panels now in use.

It is recommended that the masses of propellant and illuminant materials be increased until there is evidence of material damage to the Group 5 S/S. The present quantity limitations seem to be too conservative in light of the low loads observed to date.

It is recommended that additional M10 propellant testing be conducted to obtain the reaction rate data necessary to complete or resolve the plot of figure 4 between the vented and the plastic liner configuration.

It is recommended that additional M10 propellant testing be conducted to verify the linear reaction rates of figure 5 at large effective venting area ratios.

REFERENCES

1. PEMA 4932, Project 5751264 "Advanced Technology for Suppressive Shielding of Hazardous Production and Supply Operations."

2. Koger, D. M. and G. L. McKown, EM-TR-75001, Edgewood Arsenal Technical Memorandum, Category 5 Suppressive Shield, May 1975.

3. Koger, D. M. and G. L. McKown, EM-TR-76001, Edgewood Arsenal Technical Report, Category 5 Suppressive Shield, October 1975.

4. Wilcox, W. R., EM-CR-77041, Edgewood Arsenal Contractor Report, Effect of Confinement on Pyrotechnic Hazards, April 1977.

5. Lasseigne, A. H. and F. L. McIntyre, EA-SP-5600, Edgewood Arsenal Special Report, Critical Diameter Testing of Metal Fuel/Oxidizer Type Pryotechnics, July 1975.

6. McIntyre, F. L. and Paul Price, Picatinny Arsenal Preliminary Report (unpublished), TNT Equivalency of M10 Propellant, March 1977.

7. Military Pyrotechnic Series, AMCP 705-185, Part I, Theory and Application US Army Material Command, April 1967.

8. Goodman, H. J., BRL Report No. 1092, Compiled Free Air Blast Data on Bare Spherical Pentolite, with Soroka's Air Blast Tables, Computed therefrom.

APPENDIX

TEST DATA SHEETS

DATA SHEET

0	3	M 1	T	

(Ref.)

Test Log #14-6-01A
Date 31 Mar 76

Charge: M10, .019 s.p.
1.36 kg (3.0 lb)
.114 m sq. x .122m

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001

Group 5 Suppressive Structure

Wall Liner: / Ceiling Liner: } N/A

Open Air: α_e = .8

Parameter	Cal. 30 Mar 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-		10 msec
Burnrate B/W	Open	5.20							Did not function
Airblast 3.01m	137.90kPa	1.52	-	-			0		No meas. rise
Airblast 3.96m	103.43 "	1.15	-	-			0		No meas. rise
Airblast 4.81m	103.43 "	1.34	-	-			0		No meas. rise

Approximately 10 percent unburned propellant strewn around area. Visual observation of CCTV - Burning only; no evidence of explosion or detonation.

DATA SHEET

0	3	M 1	J	

(Ref.)

Test Log # 14-6-01B
Date 31 Mar 76

Charge: M10, .019 s.p.
1.36 kg (3.0 lb)
.114m sq x .122m

Initiation:
J-2 Blasting Cap

Booster:
None

Group 5 Suppressive Structure

Wall Liner: N/A
Ceiling Liner:

Open Air α_e = .8

Parameter	Cal. 31 Mar 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	-	-	-	-	-	10 msec
Airblast 3.01m	137.90kPa	1.51	2.35			1.65	.34	31.05kPa	(4.50 psi)
Airblast 3.96 m	103.43kPa	1.16	4.90			1.60	.17	13.53kPa	(1.96 psi)
Airblast 4.81m	103.43kPa	1.33	7.20			1.85	.24	18.68kPa	(2.71 psi)

DATA SHEET

SL	3	M 1	T	

(Ref.)

Test Log # 14-6-01C
Date 1 Apr 16

Charge: M10, .019 s.p.
1.36 kg (3.0 lb)
.114m sq x .112m

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001
Propellant

Group 5 Suppressive Structure

Wall Liner:
Ceiling Liner: Steel Sheet

α_e = .001093

Parameter	Cal. 1 Apr 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	-	-	-	-	-		10 msec
Burn Time	Saturated	4.24	4.05	516	2054	1649	4.25	Saturated	Photocell
	Saturated	3.70	419	545	2019	1600	3.70	Saturated	Photocell
Average			412	-	2037	1625	-	-	Photocell
Burnrate B/W	Open	5.25	-	-	1275		0		End of burn
Static Pressure	103.4 kPa	1.25					0		No meas. rise
	103.4 kPa	1.35					0		No meas. rise
Temp. (IRCON)	100%	.81							No meas. rise
Radiant Flux	30 B/hr ft^2	.67	1828	2332	under		1.74	.59 cal/cm^2	sec (78 B/hr ft^2
Temperature	22.2°C over 26.7°	1.32					0		No meas. rise
		.85					0		No meas. rise
		1.35					0		No meas. rise
		1.28					0		No meas. rise
Airblast 1.6m	103.4 kPa	1.33					0		No meas. rise

Approximately 5 percent material strewn above inside of S/S unburned.

DATA SHEET

0	36	M 1	T	

(Ref.)

Test Log # 24-6-03
Date 10 Jun 76

Charge: M10, .019 s.p. 16.3 kg (36.0 lb) .279m dia x .317m deep
Initiation: Elec. Match
Booster: 5 gm ± UTC 3001 Propellant

Group 5 Suppressive Structure
Wall Liner: N/A Ceiling Liner: Open Air: α_e = .8

Parameter	Cal. 10 Jun 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
									10.16 cm/sec
Radiant Heat Flux	30 b/hr ft^2	2.00	1880	7000±			.19	.22(10)$^{-3}$ cal/cm^2	
									15.24m.6m high
	30 "	2.01	1665	7000±			1.77	1.99(10)$^{-3}$"	15.24m3.0 high
	30 "	2.00	2730	7000±			.19	.22(10)$^{-2}$"	15.24m.9m high

Visual observation of CCTV - Burning only; no evidence of explosion or detonation.
Approximately 20 percent of unburned propellant strewn around area.

DATA SHEET

O	3	M 1	T	X

(Ref.)

Test Log # 25-6-08
Date 18 Jun 76

Charge: M10, .019 sp
3.75 kg (8.26 lb)
.075 mdia. x .610m high

Initiation:
Elec. Match

Booster: 5 mg ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner:
Ceiling Liner: N/A
Open Air α_e = .8

Parameter	Cal. Input	Cal. In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	10 msec
Breakwire 0	Over	0	0				0	-	
" .152 m	Short	.06	7447				.06	Arrival	
" .305 m	Short	.15	26113				.15	Arrival	
" .457 m	Short	.27	42008				.27	Arrival	

DATA SHEET

V	3	M 1	T	

(Ref.)

Test Log # 26-6-01A
Date 24 Jun 76

Charge: M10, .019 sp
1.36 kg (3.0 lb) .075 m
dia x .337 m high

Initiation: Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None
α_e = .01890

Parameter	Cal. 24 Jun 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	50-80 cm/sec
Burn Time	Saturated	1.05	631	706	2045	1914	1.05	Saturated	Photocell
	Saturated	1.05	635	705	2510	1875	1.05	Saturated	Photocell
Average			633		2528	1895			Photocell
T'plr Burnrate	15 mv	1.02	1156					Arrival	
	15 mv	1.04			1805	649		Arrival	.140 m
			.098m	.168m	.238m				
Burnrate B/W	Shorts .06,								
	.15	27	1275	1629	1925	650	.27	Arrival	.140 m
St. Pres.	34.8 kPa	.69					0	No meas. rise	
	69.0 "	.39					0		
	137.9 "	1.00					0		
	137.9 "	.49					0		
Ave									
Rad. Heat Flux	30 btu/hr ft^2	1.40	index	1000±			.12	.19(10)$^{-3}$ cal/cm^2 sec	1.5m
	300 "	1.00	"	"			.08	1.00(10)$^{-3}$	" 1.5m
Airblast 1.5m	34.8 kPa	1.80					0	No meas. rise	
6.1m	34.8 kPa	30ct					0	No rise	
7.3m	34.8 "	30ct					0	No rise	No trigger
8.5m	34.8 "	30ct					0	No rise	
Airblast 9.8m	34.8 "	30ct					0	No rise	

DATA SHEET

V	10	M 1	T	

(Ref.)

Test Log # 26-6-01B
Date 24 Jun 76

Charge: M10, .19 sp
4.54 kg (10.0 lb)
.165x dia x .257m high

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None

α_e = .01890

Parameter	Cal. 24 Jun 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	100 msec
Burn Time	Saturated	.66	lost		13500		.66	Sat	Photocell
	Saturated	.50	lost		13580		.50	Sat	Photocell
Average						est. 12900			
T'ple Burnrate	15 mv	1.02	lost					Arrival	
	15 mv	1.04			lost			Arrival	.174 m
		.017m	.127m	.191m					
Burnrate B/W	Short, .06,								
	.15, 27			4900	7500	2600	.27	Arrival	.064 m
St. Pres.	34.8 kPa	.69					0	No meas. rise	
	69.0 "	.39					0		
	137.9 "	1.00					0		
	137.9 "	.49					0		
Rad. Flux	30 b/hr ft^2	1.40	indef				.10	$2(10)^{-4}$ cal/cm^2 sec	
	300 "	1.80	indef				.05	$6(10)^{-4}$ cal/cm^2 sec	
Airblast 1.5m	34.8 kPa	1.80					0	No meas. rise	
6.1	34.8 kPa	3.0ct					0	No rise	
7.3	34.8 "	30 ct					0		No Trigger
8.5	34.8 "	30 ct					0		
9.8	34.8 "	30 ct					0		

First 3000 msec approx. missed by tape recorder.

DATA SHEET

V	20	M 1	T	

(Ref.)

Test Log # 26-6-01C
Date 25 Jun 76

Charge: M10, .019 sp
9.07 kg (20.0 lb)
.165 m dia x .518m high

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None

α_e = .01890

Parameter	Cal. 25 Jun 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	-	-	-	-	-	100 msec
Burn Time	Saturated	.66	697	1398	24000	23300	.66	Sat.	Photocell
	Saturated	.50	623	1204	23600	22980	.50	Sat.	Photocell
Average			660		23800	23140			Photocell
T'ple Burnrate	15 mv	.30	474					Arrival	
		.20			6672	1933		Arrival	.254 m
			.127m	.254m	.381m				
Burnrate B/W	Short .17,								--
	.89	1.85		15507			.89	Arrival	Leads burned
St. Pres.	34.8 kPa	.69					0	No meas. rise	
	69.0 "	.39					0		
	137.9 "	1.00					0		
	137.9 "	.49					0		
Rad. Flux	30 b/hr ft^2	1.40	indet				.10	.15(10)$^{-3}$ cal/cm 2 sec	
	300 "	1.80					-		Erratic
Airblast 1.5m	34.8 kPa	1.80					0	No meas. rise	
6.1	34.8 kPa	30 ct					0	No rise	
7.3	34.8 "	30 ct					0		No Trigger
8.5	34.8 "	30 ct					0		
Airblast 9.8	34.8 "	30 ct					0		

DATA SHEET

V	30	M 1	T	

(Ref.)

Time Log: 26-6-01D
Date 25-June 76

Charge: M10, .019 sp
13.61 kg (30.0 lb)
.279 m dia x .267 m high

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None.

α_e = .01890

Parameter	Cal. 25 Jun 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	–	0	–	–	–	–	–	100 msec
Burn Time	Saturated	.66	250	690	14800	14550	.66	Sat.	Photocell
	Saturated	.50	250	760	14680	14430	.50	Sat.	Photocell
Average			250		14740	14490			Photocell
T'ple Burnrate	15 mv	.30	9480					Arrival	.102 wrong
	15 mv	.20	4900					Arrival	.356m order
Burnrate S/W	Shorts .17,								
	.89,	1.85							Burned leads
St. Pres.	34.8 kPa	.69					0	No meas.	rise
	69.0 "	.39					0		
	137.9 "	1.00					0		
	137.9 "	.49					0		
Rad. Flux	30 b/hr ft^2	1.40						Lost	
	300 "	1.80	indet				.12	$1.51(10)^{-3}$	cal/cm 2 sec
Airblast 1.5m	34.8 kPa	1.80					0	No meas.	rise
6.1m	34.8 kPa	30 ct					0	No rise	
7.3	34.8 "	30 ct					0		No Trigger
8.5	34.8 "	30 ct					0		
Airblast 9.8	34.8 "	30 ct					0		

MOPIC 50 pps; smoke appears (top) 2860 msec; flame appears (top) 4780 msec, .5 high max.

DATA SHEET

V	50	M 1	T	

(Ref.)

Charge: M10, .019 sp 27.68 kg (750.0 lb) .279 m dia x .438 m high
Initiation: Elec. Match
Booster: 5 gm ± UTC 3001 Propellant

Test Log 26-6-01E Date 25 Jun 76

Group 5 Suppressive Structure
Wall Liner: None Ceiling Liner: None α_e = .01890

Parameter	Cal. 25 Jun 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	-	-	-	-	-	
Burn Time	Saturated	.66	700	1240	21800	21100	.55	Sat.	Photocell
	Saturated	.50	690	1250	21970	21280	.50	Sat.	Photocell
Average			700		20490	21190			
T'ple Burnrate	15 mv	.30	7480			5060		Arrival	.254 m
	15 mv	.20			12540			Arrival	
			.102m	.229m	.356m				
Burnrate B/W	Shorts .17,								
	.89	1.85	5800	8460	13400	7600	1.85	Arrival	.254 m
St. Pres.	34.8 kPa	.69					0	No meas. rise	
	69.0 "	.39					0		
	137.9 "	1.00					0		
	137.9 "	.49					0		
Rad. Flux	300 b/hr ft^2	1.80	indet.	indet.			.12	$.16(10)^3$ cal/cm^2 sec	
Airblast 1.5m	34.5 kPa	1.80					0	No meas. rise	
6.1m	34.5 kPa	30 c					0	No rise	
7.3m	34.5 "	30 c					0		No Trigger
8.5	34.5 "	30 c					0		
Airblast 9.8m	34.5 "	30 c					0		

MOPIC 50 pps; smoke appears (top) 5380 msec, flame appears (top) 10,000 msec, 1m high max.

DATA SHEET

V	150	M 1	T	

(Ref.)

Test Lot 27-6-01
Date 28 Jun 75

Charge: M10, .019 sp
68.04 kg (150 lb)
.406x dia x .625m high

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None

α_e = .01890

Parameter	Cal. 25 Jun 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	–	0	–	–	–	–	–	
Burn Time	Saturated	.66	640	970	26750	26110	.66	Sat	Photocell
Burn Time	Saturated	.50	630	980	26700	26070	.50	Sat	Photocell
Average			640		26730	26090			Photocell
T'pl Burnrate	15mv	.30	4390					Arrival	
	15mv	.20			9100	4710		Arrival	.254m
			.089m	.216m	.343m				
Burnrate B/W	Shorts .17,								
	.89	1.85							Burn around outside
St. Pres.	34.8 kPa	.69					0	No meas. rise	
	69.0 "	.39					0		
	137.9 "	1.00					0		
Rad. Flux	300 b/hr ft^2	1.80	indef	indef			.21	3(10)$^{-3}$ cal/cm^2 sec	
Airblast 1.5m	34.8 kPa	1.80							
6.1m	34.8 kPa	30 ct					0	No rise	
7.3m	34.8 "	30 ct					0		No Trigger
8.5m	34.8 "	30 ct					0		
Airblast 9.8m	34.8 "	30 ct					0		

MOPIC 50 pps; smoke and flame appear (top) 3680 msec; flame ends 10,000 msec, 2m high max.

DATA SHEET

OC	37	M 1	T	

(Ref.)

Test Log 27-6-02
Date 28 Jun 76

Charge: M10, .019 sp 16.78 kg (37.0 lb) .4763m x .4143m x .2189m high
Initiation: Elec. Match
Booster: 5 gm ± UTC 3001 Propellant

Group 5 Suppressive Structure
Wall Liner: N/A Ceiling Liner: in shipping container $\alpha_e = \frac{1.131(10)^{-2}}{7.846(10)^{-1}} = .01442$

Parameter	Cal. 28 Jun 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	
Burn Time	Ck		0	-	8540	8540			Mopic
Rad. Flux	300 b/hr ft^2	1.80	870	1830	7430	6560	1.23	.0154 col/cm^2	sec(205 b/ft hr)

Container pneumatically ruptured as result of backfire; there was no evidence of detonation. MOPIC 50 pps; flame appears 1.220 sec; flame 8m high max.; backfire in ctnr 8.540 sec.

DATA SHEET

SL	.56	P	J	

(Ref.)

Test Log 30-6-01
Date 20 Jul 76

Charge: Pentolite
.2540 kg (.56 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner: Steel Sheet
Ceiling Liner:

α_c = .001093

Parameter	Cal. 20 Jul 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	
Airblast	689.50 kPa	1.10	2.7	2.7	4.1	1.4	.45	282.1 kPa	Corner 2.24m
	689.50 "	.80	1.7	1.7	2.8	1.1	.48	413.7 "	Wall 1.58m
St. Pres. 06	68.95 kPa	.94	4	6	42	38	.55	40.34 kPa	(5.9 psi)
07		.86	5	8	39	34	.54	43.29 "	(6.3) "
08		.78	4	7	40	36	.48	42.43 "	(6.2) "
09		.82	5	7	41	30	.46	33.68 "	(5.6) "
Mean, 5						36		41, 2 "	(6.0, .3) "
Airblast	34.48 kPa	45ct					0		No Trigger
		50ct					0		
		48ct					0		
		52ct					0		

No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

SL	1	P	J	112

(Ref.)

Test Log 30-6-02
Date 20 Jul 76

Charge: Pentolite
.4944 kg (1.09 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner: Steel Sheet
Ceiling Liner: Steel Sheet

$\alpha_e = .00193$

Parameter	Cal. 20 Jul 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	-	-	-	-	-	1 msec
Airblast	689.50kPa	1.10	2.2	2.4	3.6	1.4	.78	488.9 kPa	Corner 2.24m
		.80	1.4	1.4	2.4	1.0	.90	775.7 kPa	Wall 1.58m
St. Pres. 06	68.95 kPa	.94	2	3	38	36	.98	71.88 kPa	(10.4 psi)
07		.86	3	5	42	39	.96	76.97 "	(11.2) "
08		.78	2	4	38	36	.85	75.14 "	(10.9) "
09		.82	3	4	40	37	.83	69.79 "	(10.1) "
Mean						37	-	73, 3 "	(10.7, .5) "
Airblast	34.48 kPa	45ct							No Trigger
		50ct							
		48ct							
Airblast	34.48 kPa	52ct							

No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

SL	1	P	J	212

(Ref.)

Test Log 30-5-03
Date 21 Jul 76

Charge: Pentolite
.4944 kg (1.09 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner: Steel Sheet
Ceiling Liner:

α_e = .00193

Parameter	Cal. 20 Jul 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
Airblast	689.50 kPa	1.10	2.4	2.4	4.0	1.6	.79	495.2 kPa	Corner 2.24m
		.80	1.4	1.4	2.4	1.0	.91	784.3 "	Wall 1.58m
St. Pres. 06	68.95 kPa	.94	2	4	36	34	1.00	73.35 kPa	(10.6 psi)
07		.86	2	3	37	35	.95	76.17 "	(11.0) "
08		.78	3	5	40	37	.84	74.25 "	(10.8) "
09		.82	3	4	41	38	.84	70.63 "	(10.2) "
Mean						36		74, "	(10.7, .3) "
Airblast	34.48 kPa	45ct					0		No Trigger
		50ct					0		
		48ct					0		
Airblast		52ct					0		No Trigger

No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

SL	1	P	J	2

(Ref.)

Test Log 30-6-02, 03
Date 20, 21 Jul 76

Charge: Pentolite
.4944 kg (1.09 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner:
Ceiling Liner: Steel Sheet

α_e = .00193

Parameter	Cal. 20 Jul 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
Airblast			2.3			1.5		492.1 kPa	Corner 2.24m
Airblast			1.4			1.0		780.0 kPa	Wall 1.58m
St. Pres.									
Mean						36.5		74, 3 kPa	(10.7, .4)

There was no observed exterior airblast.
Physical measurements: No change within .5cm (.19 in) of S/S.

DATA SHEET

SD	.5	P	J	

(Ref.)

Test Log 30-6-04
Date 21 Jul 76

Charge: Pentolite
.227 kg (.50 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner: Sheet Steel
Ceiling Liner: $\frac{4.442+.065}{59.051}$
Door Open

α_e = .07631

Parameter	Cal. 20 Jul 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
Airblast	689.50 kPa	1.10	3.2	3.2	4.6	1.4	.42	263.2 kPa	Corner 2.24m
		.80					.40	344.8 "	Wall 1.58m
St. Pres. 06	68.95 kPa	.94					0	No meas. rise	
07		.86					0		
08		.78					0		
09		.82					0		
Mean								No rise	
Airblast	34.48 kPa	45ct					0		No Trigger
		50ct					0		
		48ct					0		
		52ct					0		

No change ± .5m (.19 in) to physical measurements of S/S.

DATA SHEET

SL	1.5	P	J	

(Ref.)

Test Log 30-6-05
Date 23 Jul 76

Charge: Pentolite .680 kg (1.50 lb) sphere
Initiation: J-2 Blasting Cap
Booster: None

Group 5 Suppressive Structure
Wall Liner: Sheet Steel Ceiling Liner: α_e = .00193

Parameter	Cal. 23 Jul 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
Burn Time	Saturated	1.50	0	0	82	85	1.50	Sat	Photocell
Airblast	1034.25 kPa	.95	2.2	2.2	33.7	1.5	.58	659.2 kPa	Corner 2.24m
	1379.00 "	1.25	1.3	1.3	1.4	.1	1.00	1103.2 "	Wall 1.58m
St. Pres. 06	344.75 kPa	.95	1	2	49	48	.28	101.61 kPa	(14.7 psi)
07		.82	2	3	-	-	.21	88.29 "	(12.8) "
08		.61	2	3	49	47	.20	113.03 "	(16.4) "
09		1.65	2	4	51	49	.52	108.65 "	(15.8) "
Mean						48		103, 11 "	(14.9, 1.6) "
Airblast	34.48 kPa	37ct					0		No Trigger
		44ct					0		
		40ct					0		
Airblast		42ct					0		No Trigger

No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

SL	2.0	P	J	

(Ref.)

Test Log 30-6-06
Date 23 Jul 76

Charge: Pentolite
.907 kg (2.00 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner: Sheet Steel
Ceiling Liner: Sheet Steel

α_e = .00193

Parameter	Cal. 23 Jul 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
Burn Time	Saturated	1.50	0	0	82	82	1.50	Sat.	Photocell
Airblast	1034.25 kPa	.91	2.0	2.0	3.5	1.5	.76	863.8 kPa	Corner 2.24m
	1379.00 "	1.25	1.2	1.2	3.1	.9	1.34	1478.3 "	Wall 1.58m
St. Pres. 06	344.75 kPa	.95	2	5	52	50	.4	148.79 kPa	(21.6 psi)
07		.82	3	4	54	51	.33	138.74 "	(20.1) "
08		.61	3	5	55	52	.24	135.64 "	(19.7) "
09		1.65	2	3	49	47	.79	165.06 "	(23.9) "
Mean								147., 13 "	(21.3, 1.9) "
Airblast	34.48 kPa	37ct					0		No Trigger
		44ct					0		
		40ct					0		
Airblast		42ct					0		

No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

SL	2.5	P	J	

(Ref.)

Test Log 30-6-07
Date 23 Jul 76

Charge: Pentolite
1.134 kg (2.50 lb)
sphere

Initiation:
J-2 Blasting Cap

Booster: None

Group 5 Suppressive Structure

Wall Liner:
Ceiling Liner: Sheet Steel

α_e = .00193

Parameter	Cal. 23 Jul 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	--	-	-	-	-	1 msec
Burn Time	Saturated	1.50	0	0	64	64	1.50	Sat.	Photocell
Airblast	1034.25 kPa	.91	1.9	1.9	3.4	1.5	.97	1103.2kPa	Corner 2.24m
	1379.00 "	1.25	1.1	1.1	2.0	.9	1.69	1861.7 "	Wall 1.58m
St. Pres. 06	344.75 kPa	.95	3	5	36	35	.71	257.66kPa	(37.4 psi)
07		.82	3	4	34	31	.60	252.26 "	(36.6) "
08		.61	5	6	40	35	.30	169.55 "	(24.6) "
09		1.65	4	6	37	33	1.20	250.73 "	(36.4) "
Mean						33		232, 42 "	(33.7, 6.1) "
Airblast	34.48 kPa	37ct					0		No Trigger
		44ct					0		
		40ct					0		
Airblast		42ct					0		

No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

Q	48	M 2	J	

(Ref.)

Test Log 38-6-01
Date 14 Sept 75

Charge: M10, .029mp
21.77 kg (48.0 lb)
.305m sq x .284m

Initiation:
J-2 Blasting Cap

Booster: C-4 conical
.227 kg (.50 lb)

Group 5 Suppressive Structure

Wall Liner:
Ceiling Liner: N/A
Open Air Equivalency
$\alpha_e = .8$

Parameter	Cal. 14 Sep 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks	
Timing	Check	-	0	-	-	-	-	-	1 msec	
	kPa (psi)								m(ft)	m/kg 1/3 (ft./lb 1/3)
	pressure								Dist	
Airblast 1	689	2.6	.931				.40	599.1 kPa	3.32	1.19
7	(100)	3.9	1.397				.80	552.0 kPa	(10.90)	(3.0)
2	414	6.1	2.185				.71	189.3 kPa	4.49	1.61
8	(60)	15.2	5.443				.39	53.8 kPa	(14.72)	(4.05)
3	208	41.2	14.155				.25	15.1 kPa	5.96	2.13
9	(30)	109.1	39.07				.10	5.5 kPa	(19.55)	(5.38)
4	69	2.7	.967						9.97	3.57
10	(10)	4.0	1.432				1.15	490.8 kPa	(32.71)	(9.0)
5	34.5	6.7	2.399				.58+	177.4+ kPa	19.94	7.14
11	(5)	15.9	5.694				.46	49.6 kPa	(65.42)	(18.0)
6	34.5	42.2	15.113				.22	13.3 kPa	44.29	15.87
Airblast 12	(5)	110.0	39.39				.13	3.9 kPa	(145.37)	(40.0)

Scattered propellant - 10 percent; Crater -25m dia. x .4m deep; Appears to be too small a booster.

DATA SHEET

Q	48	M 2	J	215

(Ref.)

Test Log 38-6-02
Date 14 Sep 76

Charge: M10, .029 mp
21.77 kg (48.0 lb)
.305m sq x .285m

Initiation:
J-2 Blasting Cap

Booster: C-4 conical
.227 kg (.50 lb)

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner:

Open Air Equivalency
$\alpha_e = .8$

Parameter	Cal. 14 Sep 76		Test Data						Remarks	
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in			
Timing	Check	-	0	-	-	-	-	-	1 msec	
	Pressure								Dist	
	kPa (psi)								m(ft)	m/kg 1/3 (ft/lb 1/3)
Airblast 1	689	2.1	.752				.42	629.1 kPa	3.32	1.19
7	(100)	3.5	1.253				.83	579.6 kPa	(10.90)	
2	414	5.9	2.113				.92	245.3 kPa	4.49	1.61
8	(60)	14.9	5.336				.36	49.7 kPa	(14.72)	(4.05)
3	208	41.2	14.755				.25	15.1 kPa	5.96	2.13
9	(30)	109.1	39.07				.10	5.5 kPa	(19.55)	(5.38)
4	69	1.9	.680						9.97	3.57
10	(10)	3.2	1.145				1.20+	512.2+ kPa	(32.71)	(9.0)
5	34.5	5.4	1.934				.66	201.9 kPa	19.94	7.14
11	(5)	14.8	5.300				.40	43.1 kPa	(65.42)	(18.0)
6	34.5	41.5	14.862				.20	12.1 kPa	44.29	15.87
Airblast 12	(5)	109.6	39.25				.11	3.3 kPa	(145.2)	(40.0)

Scattered propellant - 10 percent; Crater 2.8m dia. x .3m deep; Appears to be too small a booster.

DATA SHEET

Q	48	M 2	J	315

(Ref.)

Test Log 38-6-03 Date 16 Sep 76

Charge: M10, .029 mp 21.77 kg (48.0 lb) .305m sq x .285m
Initiation: J-2 Blasting Cap
Booster: C-4 conical .454 kg (1.00 lb)

Group 5 Suppressive Structure
Wall Liner: None Ceiling Liner: Open Air Equivalency $\alpha_e = .8$

Parameter	Cal. 14 Sep 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks	
Timing	Check	-	0	-	-	-	-	-	1 msec	
	Pressure								Dist	
	kPa (psi)								m(ft)	m/kg 1/3 (ft/lb 1/3)
Airblast 1	689		1.3	.466			.75	1123.4	3.32	1.19
7	(100)								(10.90)	(3.0)
2	414		2.3	.824			1.40+	966.0+	4.49	1.61
8	(60)		2.2	.788					(14.72)	(4.05)
3	208		3.8	1.361			1.62	432.0	5.96	2.13
9	(30)		3.8	1.361			1.63	498.6	(19.55)	(5.38)
4	69		11.7	4.190			.53	73.1	9.97	3.57
10	(10)		11.6	4.154			.70	75.5	(32.71)	(9.0)
5	34.5		38.2	13.680			.30	18.2	19.94	7.14
11	(5)		37.8	13.587			.27	16.3	(65.42)	(18.0)
6	34.5		106.9	38.28			.09	4.9	44.29	15.87
Airblast 12	(5)		106.4	38.10			.13	3.9	(145.37)	(40.0)

Crater 3.4m dia. x .5m deep.

DATA SHEET

Q	48	M 2	J	415

(Ref.)

Test Log 38-6-04
Date 16 Sep 76

Charge: M10, .029 mp
21.77 kg (48.0 lb)
.305m sq x .285m

Initiation:
J-2 Blasting Cap

Booster: C-4 conical
.454 kg (1.00 lb)

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None
Open Air Equivalency
$\alpha_e = .8$

Parameter	Cal. 14 Sep 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
	Pressure kPa (psi)								Dist m(ft) m/kg 1/3 (ft./lb 1/3)
Airblast 1	689	.46	1.1	.394			.61	913.7 kPa	3.32m 1.19
7	(100)	.70	1.0	.358					(10.90) (3.00)
2	414	.60	1.8	.645			1.50+	1035.0+ "	4.49 1.61
8	(60)	.97	1.8	.645					(14.72) (4.05)
3	208	.78	3.2	1.146			1.65	440.0 "	5.96 2.13
9	(30)	.68	3.8	1.361			1.10	336.5 "	(19.55) (5.38)
4	69	.50	12.0	4.297			.46	63.5 "	9.97 3.57
10	(10)	.64	12.3	4.405			.67	72.2 "	(32.71) (9.0)
5	34.5	.57	38.4	13.752			.29	17.6 "	19.94 7.14
11	(5)	.57	38.3	13.716			.28	16.9 "	(65.42) (18.0)
6	34.5	.63	107.3	38.43			.09	4.9 "	44.29 15.87
Airblast 12	(5)	1.16	106.6	38.18			.13	3.9 "	(145.37) (40.0)

Crater 3.4 m dia. x .4 m deep.

DATA SHEET

Q	48	M 2	J	515

(Ref.)

Test Log 38-6-05
Date 17 Sep 76

Charge: M10, .029 mp
21.77 kg (48.0 lb)
.305m sq. x .285m

Initiation:
J-2 Blasting Cap

Booster: C-4 conical
.454 kg (1.00 lb)

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None
Open Air Equivalency
$\alpha_e = .8$

Parameter	Cal. 17 Sep 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	1 msec
									Dist m/kg 1/3
									m(ft) (ft/lb 1/3)
	kPa (psi)								
Airblast 1	689	.55	1.2	.430			.77	964.6 kPa	3.32 1.19
7	(100)	.86	1.1	.394			1.75±	1402.0±	(10.90) (300)
2	414	.60	2.3	.824			1.05±	724.5±	4.49 1.61
8	(60)	.95	2.0	.716			2.10±	915.2±	(14.72) (4.05)
3	208	.76	4.0	1.432			1.82	498.1	(5.96 2.13
9	(30)	.70	4.8	1.719			1.50	445.7	(19.55) (5.38)
4	69	.50	12.1	4.333			.49	67.6	9.97 3.57
10	(10)	.64	11.5	4.118			.65	70.1	(32.71) (9.0)
5	34.5	.59	37.7	13.501			.26	15.2	19.94 7.13
11	(5)	.58	37.4	13.394			.27	16.1	(65.42) (18.0)
6	34.5	.64	115.6	4.140			.10	5.4	44.29 15.87
Airblast 12	(5)	1.17	115.1	41.22			.14	4.1	(145.37) (40.0)

Crater was filled without having been measured. Appeared as small detonation followed by buring of material.
Mopic 1500 pps: Fireball 11.5m dia. x. 2.5m high at 4msec; 14m dia x 1m high at 6msec.

DATA SHEET

Q	48	M 2	J	3

(Ref.)

Test Log 38-6-3,4,5
Date 16/17 Sep 76

Charge: M10, .029 mp
21.77 kg (48.0 lb)
.305m sq x .285m

Initiation:
J-2 Blasting Cap

Booster: C-4 conical
.454 kg (1.00 lb)

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner:
Open Air Equivalency
$\alpha_e = .8$

Parameter	Cal. --		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	-	-	-	-	-	
Airblast Pressure m/kg$^{1/3}$(ft/lb$^{1/3}$)							(N)	(kPa)	
1.19		5	.408	.041				1000.6,109.4	
(3.0)									
1.61		6	.740	.084			3	868.6,127.3	
(4.05)									
2.13		6	1.397	.185			6	441.8,59.3	
(5.38)									
3.57		6	4.250	.113			6	70.3, 4.3	
(9.0)									
7.15		6	13.597	.141			6	16.7,1.1	
(18.0)									
15.87		6	39.27	1.59			6	4.5, .6	
(40.0									

Summary of .454 kg booster tests.

DATA SHEET

Q	110	M 2	T	

(Ref.)

Test Log 41-6-01
Date 7 Oct 76

Charge: M10, .029 mp
49.90 kg (110.0 lb)
.476 x .414 x .651m

Initiation:
Elec. Match

Booster: 10 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: None
Ceiling Liner: None
Open Air Equivalency
$\alpha_e = .8$

Parameter	Cal.		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
									Distance
									m (ft.)
Airblast 1									4.38
7									(14.35)
2									5.97
8									(19.59)
3									7.85
9									(25.77)
4									13.14
10									(43.13)
5									26.29
11									(86.25)
6									58.42
Airblast 12									(191.66)

Signals too small to be recorded. No blast data.
MOPIC 1000 pps, slow burn lasting longer than 16 seconds.

DATA SHEET

PV	30	I	T	

(Ref.)

Test Log 45-6-01
Date 5 Nov 76

Charge: $Mg/NaNO_3$
13.61 kg (30.0 lb)
Illuminant

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: Velostat Film
Ceiling Liner: Velostat Film
$.001093 < \alpha_e < .01890$

Parameter	Cal. 5 Nov 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	-	-	-	-	-	10 msec
Burn Time									Photocell lost
	Saturated	.72	785	847	7945	7160	.72	Saturated	Photocell
Burn Rate	Short. 11, .23,	.35	595(1)		1713(1)	1118	.35		Breakwire
St. Pres	137.9 kPa	.315	1250-						No indication fine
	137.9 kPa	.370							No. of Pres.
Rad. Flux 1.52	m 300b/h-ft^2	.98	500±	4000±			.65	$1.51(10)^{-2}$	(200btu/h-ft^2)
								cal/cm^2 sec	
	300 "	.66	1000±	4500±			.11	$3.77(10)^{-3}$ "	(50)
	1000 "	1.04						0	No signal
	100 "	.95	1700	3925			1.61	$1.28(10)^{-2}$ "	Saturated 170

Flame around door at 1583 msec; inside fire appears out at 7458 msec.
24pps; flame and smoke appear at top window 83 msec; 2.5m dia. fireball over roof in 750 msec. No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

PP	100	M 2	T	

(Ref.)

Test Log 46-6-01
Date 10 Nov 76

Charge: M10, .029 mp
45.35 kg (100.0 lb)
.406m sq. x .318m

Initiation:
Electric Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: Polyethylene
Ceiling Liner: Film

$.001093 < \alpha_e < .01890$

Parameter	Cal. 5, Nov 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		
Timing	Check	-	0	--	-	-	-	-	10 msec
Burn Time	Sat	1.07	808		9463	8655	1.07	Saturated	Photocell
	Saturated	1.58	803		indef		1.58	Saturated	Photocell
Average			806			8655			Photocell
St. Pres	137.9 kPa	.315					0	0	No indication
	137.9 kPa	.370					0	0	of pressure
Rad. Flux 1.52m									
	1000b/h-ft^2	0.97	1500+	7000+	indef		.49	$3.81(10)^{-2}$	(505 btu/hr ft^2)
								cal/cm^2 sec	
	300 "	1.20	2000±	7500±	15k	7500	.96	$1.81(10)^{-2}$ "	(240) "
	300 "	1.05	100	3470			2.42	$5.21(10)^{-2}$ "	(691) "
	100 "	.95	2180	2440			1.75	$1.39(10)^{-2}$ "	(184) "
Airblast 6.1m	34.48 kPa	20ct					0	0	No Trigger
7.3							0	0	
8.5							0	0	
Airblast 9.8							0	0	

No change ± .5cm (.19 in) to physical measurements of S/S.
MOPIC 700 pps; flame and fireball happen at top of S/S at 2233 msec; interior fire appears out at 14183msec.

DATA SHEET

PC	100	M 2	T	

(Ref.)

Charge: M10, .029 mp 45.36 kg (100.0 lb) .406m sq x .318m
Initiation: Elec. Match
Booster: 5 gm ± UTC 3001 Propellant

Test Log 47-6-01
Date 19 Nov 76

Group 5 Suppressive Structure
Wall Liner: Polythylene Film Ceiling Liner: Sheet Steel $.001093 < \alpha_e < .0151$

	Cal. 19 Nov 76		Test Data						
Parameter	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	10 msec
Burn Time	Sat	1.36	848	967	16670	15820	1.86	Sat	Photocell
Burn Time	Sat	1.04	848	897	33070	32220	1.04	Sat	Photocell
Average			848			24020			Photocell
St. Pres.	103.4 kPa	.34					0	0	No indicated
		.64					0	0	pressure
Burn Rate	Short .15,.20,.38								
Rad. Flux	300 b/h ft^2	.71	1000+	8000+			.24	.76(10)$^{-2}$	(101 b/h ft^2)
								cal/cm^2 smec	
	300 "	.48	3370	3620			.48	2.26(10)$^{-2}$ "	(300) sat.
	1000 "	.42					0±	0	(0)
	1000 "	.75	2000±	5000±			.20	2.01(10)$^{-2}$ "	(267)
Airblast 6.10m	34.5 kPa	20ct							No Trigger
7.32		20ct							
8.53		20ct							
Airblast 9.75		20ct							

MOPIC 24 ffp; flame appears on top edge at 1792 msec. Fire appears out at 8236 msec. No fireball as such extend not more than .5m from walls.
MOPIC 499 pps; firelight appears at top edge - 1733 msec flame appears to go out. No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

PC	300	M 2	T	

(Ref.)

Test Log 48-6-01
Date 23 Nov 76

Charge: M10, .029 mp
136.1 kg (300.0 lb)
.813m sq x .254m

Initiation:
Elec. Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: Polyethylene Film
Ceiling Liner: Sheet Steel

$.001093 < \alpha_e < .0151$

Parameter	Cal. 23 Nov 76		Test Data						Remarks
	Input	In	TO msec	TPK msec	End msec	TDUR msec	Peak Value in	Peak Value	
Timing	Check	-	0	-	-	-	-	-	10 msec
Burn Time	Sat	1.92	1275	1355	10625	9350	1.92	Sat	Photocell
Burn Time	Sat	1.80	1255	1270	indef		1.80	Sat	Photocell
Average			1265	1310	10625	9350			Photocell
St. Pres.	103.4 kPa	.35					0	0	No indication
	103.4	.63					0	0	pressure
Burn Rate	Short. 15, . 2	0.38							Breakwire loads
									burned
Rad. Flux	300 b/h ft^2	.66	2375	5550			1.86	$6.37(10)^{-2}$	(845 b/h ft^2)
								cal/cm^2 sec	
	300 "	.45	2750	4050			.55	$2.77(10)^{-2}$ "	(367) sat "
	1000 "	.46	3000+	8000+			.54	$8.85(10)^{-2}$ "	(1174) "
	1000 "	.70	2250	4025			1.66	$17.87(10)^{-2}$ "	(2371) sat "
Airblast 6.10m	34.5 kPa	20ct							No Trigger
7.32m		20ct							
8.53m		20ct							
Airblast 9.75m		20ct							

Flame does not extend beyond .5m from walls; smoke extends to above 1m.
MOPIC 1500 pps; flame appears at top at about 8000 msec.
No change ± .5cm (.19 in) to physical measurements of S/S.

DATA SHEET

PC	590	M 2	T	

(Ref.)

Test Log 49-6-01
Date 30 Nov 76

Charge: M10, .029 mp
267.6 kg (590 lb)
1.092m sq. x .241m

Initiation:
Elec Match

Booster: 5 gm ±
UTC 3001 Propellant

Group 5 Suppressive Structure

Wall Liner: Polyethylene Film
Ceiling Liner: Sheet Steel

$.001093 < \alpha_e < .0151$

Parameter	Cal. 30 Nov 76 Input	In	Test Data TO msec	TPK msec	End msec	TDUR msec	Peak Value in		Remarks
Timing	Check	-	0	-	-	-	-	-	10 msec
Burn Time	Sat	1.68	983	1010	30k	30K	1.68	Sat	Photocell
Burn Time	Sat	1.85	943	970	30k	30k	1.85	Sat	Photocell
Average			963	990	30	30k		15.4	Photocell
St. Pres.	103.4 kPa	.67	indef	indef			.10		(2.24 psi)
St. Pres.	103.4 kPa	1.17	2104	2128	2290	126	.15	13.3 kPa	(1.92) * "
Av. Pres.								14	(20 psi) *
*Believed to be thermally stimulated; transducer subsequently became erratic and eventually the circuit opened at above 14,000 msec.									
Airblast 6.10m	34.5 kPa	20ct							No Trigger
7.32m		20ct							
8.53m		20ct							
Airblast 9.75m		20ct							

MOPIC 24 pps: Flame appears at top edge at 1583 msec. No flame beyond .5m from wall. Camera #2: Flame appears at top edge at 1750 msec. Flame and smoke jet 5m from top edge and appears out at 11, 167 msec (except P. E. film burning). MOPIC 1500 pps; flame appears at top edge at 1600 ± msec. No change ± .5cm (.19 in) to physical measurements.

DISTRIBUTION LIST

Addressee	No. of Copies
Commander US Army Armament Research and Development Command Attn: DRDAR-LCM Dover, NJ 07801	1
Commander Pine Bluff Arsenal Attn: Safety Officer	1
Engineering and Technology Pine Bluff, AR 71601	1
Director National Aeronautics and Space Administration Attn: Safety Office Washington, DC 20546	1
Director NASA National Space Technology Laboratories Attn: Safety Office NSTL Station, MS 39529	1
Chairman Department of Defense Explosives Safety Board Forrestal Building, GV-270 Washington, DC 20314	1
Commander US Army Materiel Development and Readiness Command Attn: Safety Office 5001 Eisenhower Avenue Alexandria, VA 22333	2
Project Manager, Munitions Production Base Modernization and Expansion Attn: DRCPM-PBM-E/Mr. Dybacki USA Material Development and Readiness Command Dover, NJ 07801	1

DISTRIBUTION LIST (Cont.)

Addressee	No. of Copies
Director US Army Ballistics Research Laboratories Attn: Safety Office Aberdeen Proving Ground, MD 21005	1
Director Defense Research and Engineering Pentagon Washington, DC 20310	1
Administrator Defense Documentation Center Attn: Accessions Division Cameron Station Alexandria, VA 22314	2
Commander Chemical Systems Laboratory Attn: DRDAR-CLF DRDAR-CLN Aberdeen Proving Ground, MD 21010	1 3
Commander Aberdeen Proving Ground Attn: STEAP-AD-R/RHA DRSAR-MAS-C Aberdeen Proving Ground, MD 21010	1 5
Commander US Army ARRADCOM Attn: DRDAR-SF DRDAR-TSF DRDAR-LCM Dover, NJ 07801	1 5 5
Commander US Army Armament Research and Development Command Attn: DRDAR-TSS Dover, NJ	2