PROPAGATION TESTING OF M61 ROCKETS IN SINGLE ROUND CONTAINERS

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ABSTRACT

A need potentially exists for overpack containers for 115mm M55 Rockets. A single round overpack system has been designed and a series of tests were conducted, utilizing M61 Rockets, to determine effect of the overpack on the previously-established MCE for palletized M55 Rockets; and to provide data for storage hazard classification of rockets stored in the overpack containers. This paper presents results of those tests.

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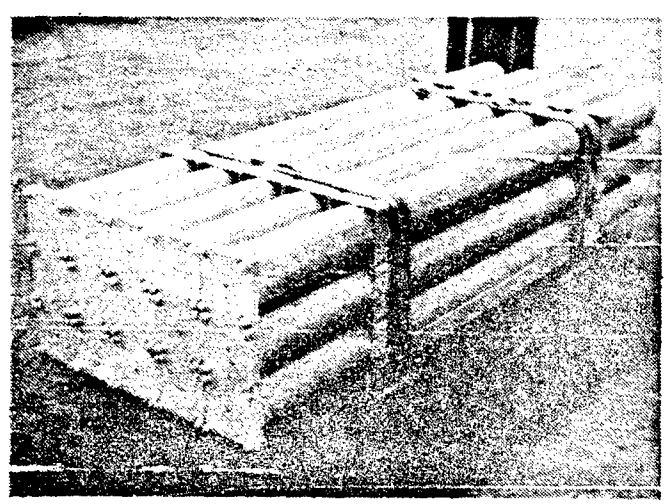
PROPAGATION TESTING OF M61 ROCKETS IN SINGLE ROUND CONTAINERS

INTRODUCTION

This paper presents results of a series of tests conducted to assess the potential for propagation between 115mm rockets confined in newly-designed overpack containers. The tests were conducted by the Ammunition Equipment Directorate at Tooele Army Depot, Utah in late 1985-early 1986.

The 115mm rocket at issue is the obsolete, lethal chemical agent filled M55 rocket. A need potentially exists for some type of overpack to contain agent that may leak from the rocket's existing shipping and firing container. The U.S. Army Defense Ammunition Center and School, acronym USADACS, located at Savanna Depot Activity, Savanna, IL designed an overpack system consisting of stackable, cylindrical steel tubes referred to as Single Round Container (SRC); see Figure 1. In order for the SRC to be qualified as an overpack system for M55 rockets, it must be subjected to a variety of tests, one of which is the subject of this paper.



PALLETIZED SRC

FIGURE 1

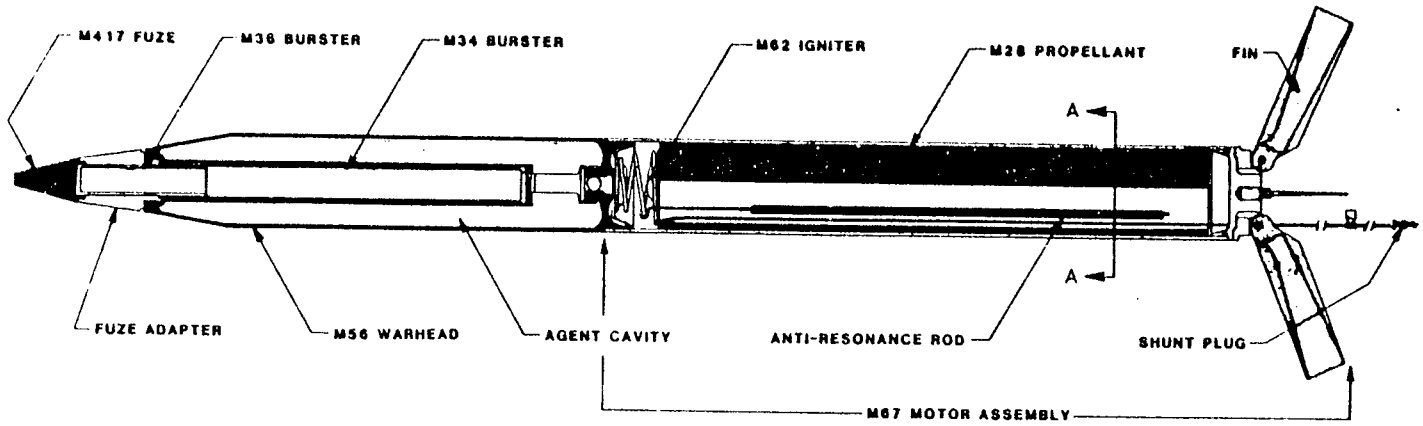
The Army's TB 700-2, entitled Dept. of Defense Explosives Hazard Classification Procedures, outlines the tests required to assign an explosives hazard classification to ammunition and explosives. The tests discussed herein were intended to address only the storage hazard classification requirements. A second major objective of the test program was to determine a "maximum credible event" (MCE) for a pallet of rockets each contained in SRC.

DESCRIPTION OF ROCKET

Because the M55 rocket is filled with lethal chemical agent, the tests were conducted with M61 rockets. The M61 rocket is the practice simulant for the chemical agent-filled M55 rocket. It is used for training personnel in the techniques of loading, preparation for firing, and firing of rockets from the M91 launcher. The fuze, explosive bursters, and propellant are identical in both rockets. The only difference is that the warhead in the M61 rocket is filled with an ethylene glycol simulant for the agent. A description of the M61 rocket follows; see Figure 2:

M67 Motor containing M28 Propellant, 19.3 pounds (M28 propellant is double base solid propellant with a cellulose acetate restrictive container)
M34 Burster, 2.7 pounds Composition B4
M36 Burster, 0.5 pounds Composition B4
M417 Fuze, 190 grains RDX
M56 Warhead, containing approximately 10.7 pounds ethylene glycol
M62 Igniter, 25 grams ignition mixture

The rocket is approximately 4.5" diameter by 78" long and weighs 58 pounds. It requires a 24 volt DC power source for firing the electric squib in the igniter assembly of the motor. The rocket is stored in and fired from its M441 fiberglass shipping and firing container which is approximately 5" diameter by 82" long. The rockets are normally palletized for storage, fifteen rockets to a wooden pallet; see Figure 3.



M55/M61 ROCKET COMPONENTS

M67 MOTOR - 19.3 LBS M28 PROPELLANT (DBL BASE)

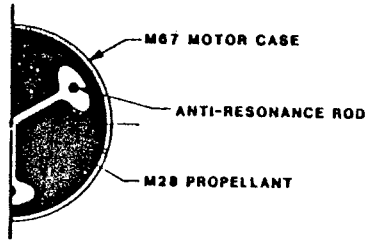
M34 BURSTER - 2.7 LBS COMPOSITION B4

M36 BURSTER - 0.5 LBS COMPOSITION B4

M62 IGNITER - 25 GRAMS IGNITION MIXTURE

M417 FUZE - 190 GRAMS RDX

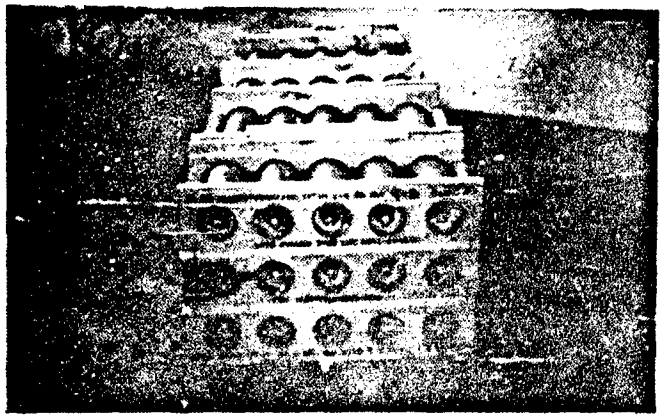
M56 WARHEAD - 10.75 LBS GB
10.1 LBS VX
10.75 LBS EG (SIM)



SECTION A-A

M55/M61 ROCKET

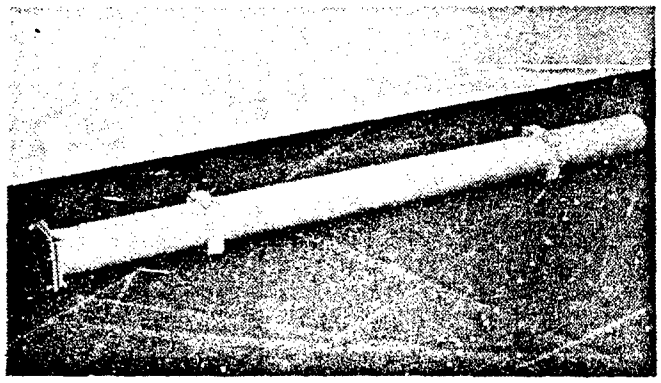
FIGURE 2



PALLETIZED M55/M61 ROCKETS
FIGURE 3

DESCRIPTION OF SRC

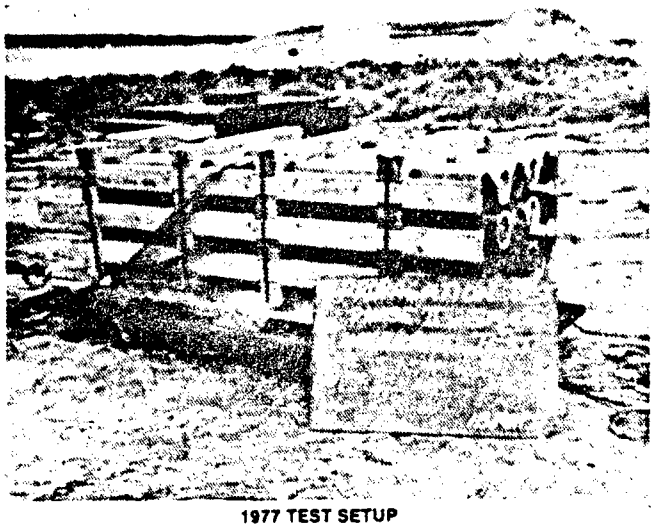
The SRC is fabricated from low carbon cold rolled steel, 5 3/8" inside diameter, 16 gage wall thickness. A dome is welded to one end; and a square flange is welded to the other end, with four bolts welded to the flange for affixing a blind flange for closure. An o-ring is installed in the face of the blind flange to effect a liquid and vapor tight seal. Further, a spring is attached to the blind flange to apply retention pressure to the rocket contained within the SRC. Square stacking brackets with guide pins permit stacking of fifteen SRC in a three row array similar to the standard pallet of rockets without SRC; see Figure 4.



SINGLE ROUND CONTAINER
FIGURE 4

DISCUSSION

In early 1977, a series of tests were conducted at Tooele Army Depot to determine the MCE for a standard pallet of 15 M55 rockets contained only in their standard fiberglass shipping and firing containers. Those tests, conducted with M61 rockets, established the MCE as the spontaneous detonation of one rocket with a sympathetic detonation of another rocket warhead, and massive leakage of agent from the remaining thirteen rockets. See Figures 5 and 6. These tests were reported in AED Report 24-77 (Ref. 1).



1977 TEST SETUP
FIGURE 5

1977 TEST RESULTS
FIGURE 6

One objective of the recent 1985-1986 series of tests was to see if the SRC overpack altered the MCE.

The tests conducted on the SRC were as follows:

*three baseline tests - for establishing baseline pressure data for single rockets contained in SRC
*three single package tests (IAW TB 700-2) - tests were conducted with nine rockets per pallet
*fragment search - conducted after each single package test

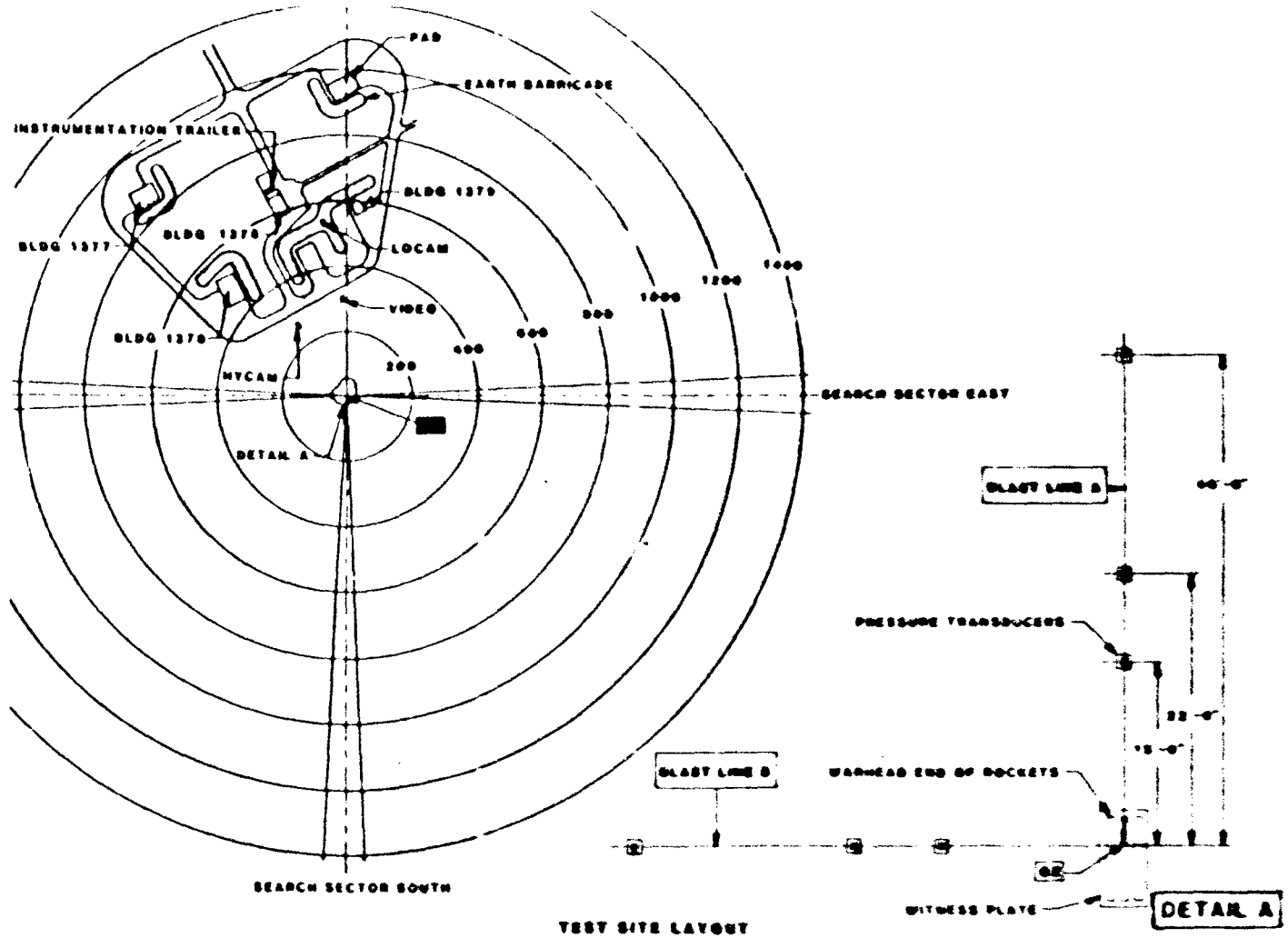
The tests yielded the following results:

*No propagation from donor rocket to in-pallet acceptors; i.e. total explosive yield of only one warhead burster.
*Complete rupture of all acceptor warheads.
*Propellant grain ejected from donor in two of the three pallet tests and burned freely; i.e. non-propulsive.
*No propellant initiated or burned in any acceptor rocket.
*Significant damage to all acceptor SRC.
*Massive fireball.

TEST PREPARATIONS

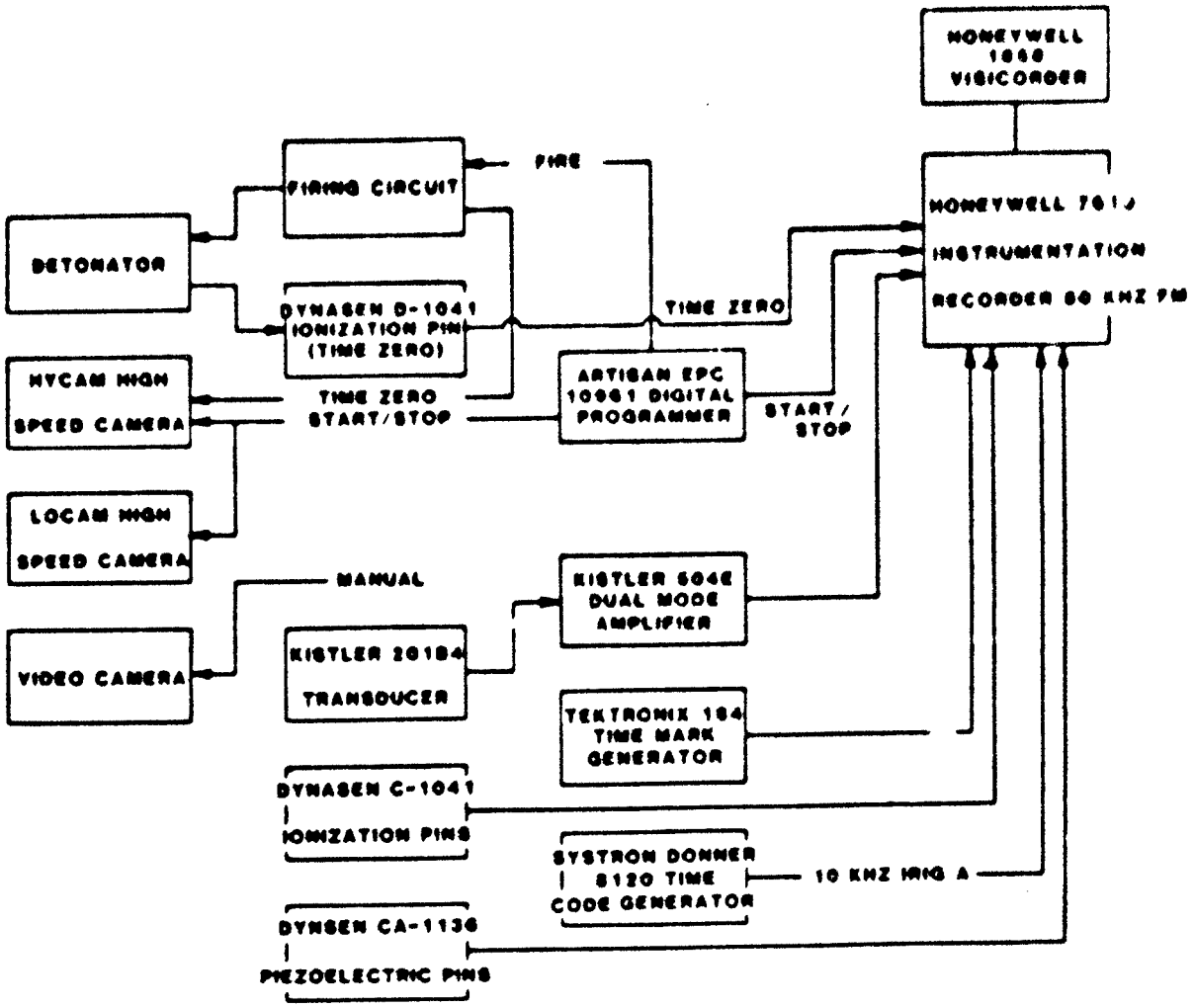
Setup for all tests was as shown in Figure 7. A piezoelectric pressure transducer array measured free-field overpressures along two blast lines: one parallel to, and one at right angles to the burster in the initiated rocket. All test items were placed on heavy steel witness plates. The test site was prepared by clearing a large area of vegetation and setting stakes to define three search sectors as described in TB 700-2 for fragment search. Tests were controlled and monitored from the data acquisition trailer. Two high-speed movie cameras and one video camera were used for documentation.

Pressure transducers used in the free-field blast measurement array were low-impedance piezoelectric devices, Kistler Piezotron Model 210B4 (100 kHz



TEST SITE LAYOUT
FIGURE 7

frequency response). The instrumentation recorder was Honeywell Model 7810 (80 kHz frequency response). Dynasen Model CA-1136/1137 piezoelectric blast pins were used in the acceptor warheads to detect burster function if propagation occurred; and Dynasen Model CA-1041 ionization probes were used in the rocket motors to detect motor initiation; see Figure 8.

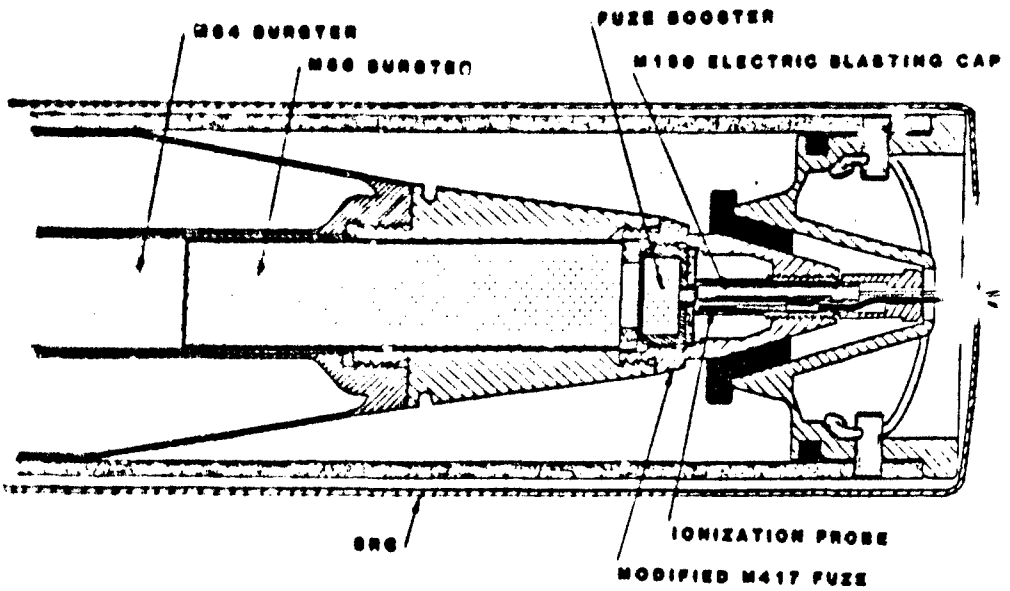


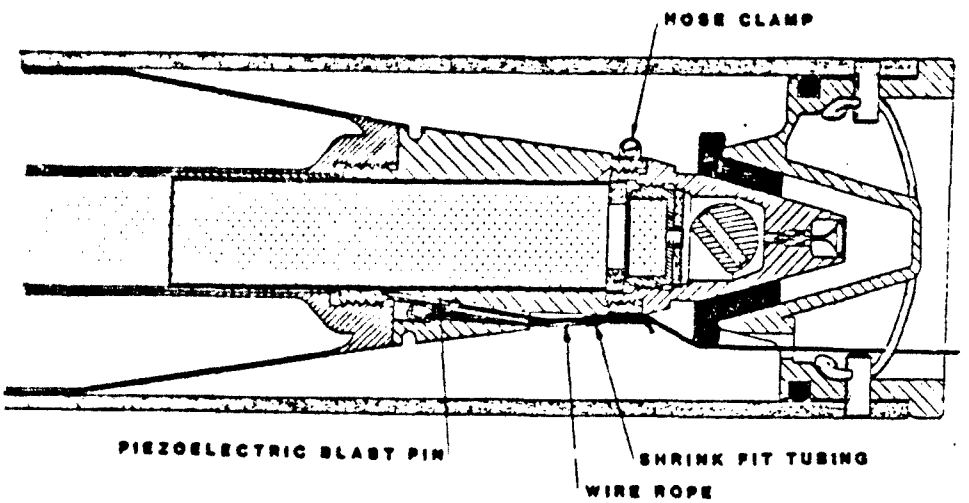
INSTRUMENTATION SCHEMATIC
FIGURE 8

Single M61 rocket/SRC configurations were used for the baseline tests (three replicates); see Figure 9. The M417 fuze was modified to accept an electric blasting cap clamped against the fuze booster charge; and an ionization probe adjacent to the blasting cap to provide a Time Zero generator for instrumentation; see Figure 10. No explosive overcharge was used. The threads were machined from the fin-nozzle assembly of the rocket motor to preclude propulsion if the M28 propellant had ignited.

BASELINE TEST SETUP
FIGURE 9

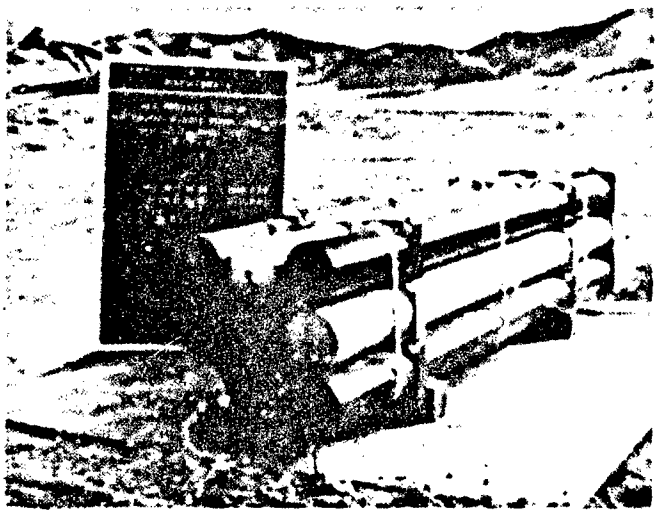
The pellets, or single packages, were configured, colored, and numbered as shown in Figure 11. The donor, or central rocket was modified as described for the baseline test rockets. The eight acceptor rockets, for the first test only, were prepared as follows (see Figure 10). The fuze adapter was modified to allow insertion of a piezoelectric blast pin against the M36 burster. The blast pin was held tightly against the burster by attaching its electrical lead to a short length of wire rope with shrink-fit tubing, and then clamping the assembly to the fuze adapter with a hose clamp. The electrical lead was passed through the existing inspection hole in the fiberglass container's





M61 ROCKET MODIFICATIONS
FIGURE 16

endcap and then through a hole drilled in the dome end of the SRC. An ionization probe (to detect motor ignition) was inserted into a void in the M28 propellant grain, near the vicinity of the black powder igniter charge; and its electrical lead passed through inspection ports in the fiberglass container endcap and the SRC flanged end. The blast pins were not used for the next two tests because of a false indication of propagation given in the first test. The ionization probes were determined to be unnecessary instrumentation because visual inspection would reveal if a motor initiated. The threads were machined from the fin-nozzle assembly in all rockets for all tests to preclude propulsion in event of motor ignition. The rockets were then placed in SRC and the flanged end plates secured with the nuts tightened to 20 ft-lbs. The nine SRC for each test were palletized and banded in three locations with 3/4" banding. The pallet was then placed on wooden 4 x 4s on a witness plate, oriented as shown in Figure 11.



PALLET TEST SETUP
FIGURE 11

TEST/RESULTS

Problems were encountered in the three single-rocket baseline tests; see Figure 12. One test failed because the M34 burster did not detonate when the blasting cap was functioned; and the pressure measurements from Blast Line B

(stations 4, 3, and 6) on the other two tests were unuseable because of pressure transducer problems. There was sufficient confidence in the remaining data, however, to proceed with the single package or pellet tests. That decision was made based on validation of the Blast Line A pressure transducers with bare spherical charge tests, and comparison with data from baseline tests conducted in 1977.

BASELINE TEST RESULTS
FIGURE 12

In the three pallet tests, both blast lines were functioning properly. Pressure yields in the three pallet tests were consistent with, and in some cases slightly lower than the pressure yields from the baseline tests. The conclusion, based on comparison of pressure yields with those of the baseline tests, is that there was no propagation from the donor to any acceptor, i.e. total explosive yield of only one warhead; and that propagation is unlikely.

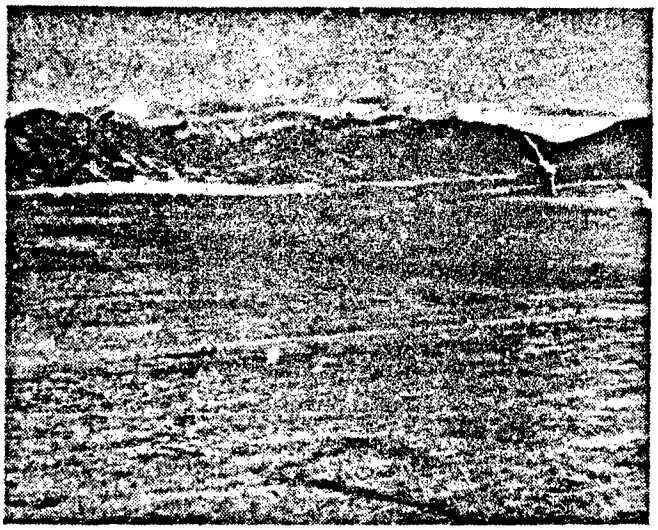
Table 1 provides comparisons of blast pressure data from the 1977 tests and the recent, 1986 tests. For convenience of comparison only, the values

presented are numerical averages of several tests in each series; e.g. the values for each peak positive incident overpressure and positive incident impulse for the 1977 baseline series is a numerical average of 4 tests. Four pressure measurements, at each transducer location, were averaged for the value presented in the table. The reader is referred to the final report of these tests for detailed presentation of data (Ref. 2).

TABLE 1 - PRESSURE DATA

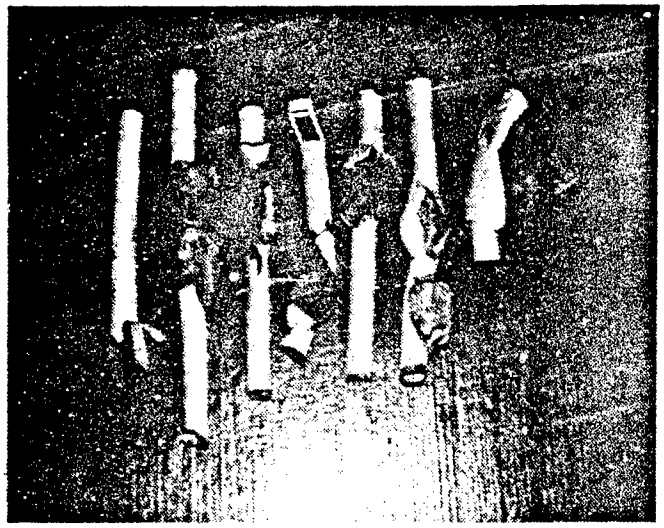
	TRANSDUCER	1977		1986	
	No.	Baseline	Pallet	Baseline	Pallet
	1	7.22	7.86	6.80	6.19
	2	3.74	3.88	3.64	3.47
PEAK POSITIVE	3	1.47	1.49	1.42	1.41
INCIDENT OVERPRESSURE	4	4.47	5.13	—	5.48
psi	5	2.47	3.18	—	3.17
	6	1.32	1.45	—	1.54
	1	6.88	8.66	6.31	6.19
	2	4.79	5.59	4.80	4.14
POSITIVE INCIDENT	3	2.38	2.72	3.14	2.42
IMPULSE	4	5.10	7.14	—	5.50
psi-ms	5	3.58	5.00	—	3.55
	6	1.93	2.96	—	2.05

All acceptor warheads were totally destroyed with the exception of acceptor number 8 in each pallet test (acceptor number 8 being directly beneath the donor); see Figure 13. Those acceptors, however, were badly ruptured, releasing their ethylene glycol fill. The conclusion is that in a pallet of rockets contained in SRC, all warheads can be expected to be ruptured in event of a detonation of one warhead.



PALLET TEST RESULTS
FIGURE 13

Large quantities of unburned or unexploded explosive burster were found in all three tests; see Figure 14. The burster cases show evidence of secondary partial detonation or pressure rupture. Review of high speed films reveals sporadic flashes within the fireball of the initial detonation that may be burning or detonating pieces of explosive. Burster cases recovered in the 1977 tests did not show similar evidence of low-order detonations.

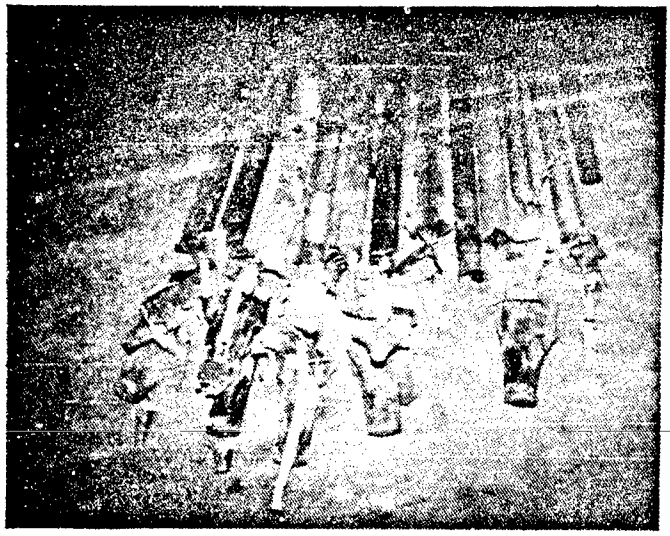


TYPICAL BURSTER RESIDUE
FIGURE 14

No motors burned within their SRC. Only two motors ignited...in two tests, the propellant grains were ejected from the donors at initial detonation and burned up completely on the ground. Review of the high speed films does not reveal when or where ignition occurred. In one test, the inside of the donor motor casing was charred and blackened as though the motor may have been burning while in the case, whereas the motor casing of acceptor number 2, from which a propellant grain also ejected, was clean. Inasmuch as the burning propellant grain remained at ground zero, it apparently was not confined sufficiently to be propulsive. The conclusion is that propellant burning can occur and that hazard must be considered.

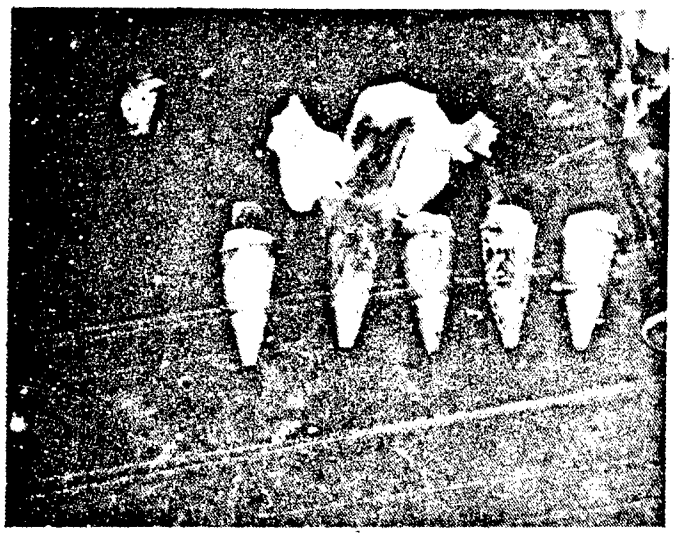
All tests, including baseline, exhibited tremendous fireballs (burning ethylene glycol) which were not seen in reviewing high speed films of the Mar-Jun 1977 tests. The fireball in the first pallet test was significantly larger than was seen in the other pallet tests, particularly the third in which more liquid ethylene glycol was observed at ground zero than in the other tests. The absence of fireball in the 1977 tests, suggests that brief confinement by the SRC when the warheads ruptured caused vaporization of the ethylene glycol, enhancing ignition into the fireball observed in these tests.

Fragmentation patterns and distances appeared to be similar to those in the 1977 tests except that more fragments were recovered in those tests. The majority of fragments in both series (1977 and current) were in a 200-600 ft. radius of ground zero, and to the east and west of ground zero. One piece, in the recent series, was found at 1190 feet. The greatest distance recorded in the 1977 test report was 1030 feet. There was a greater scattering of major components (SRC, shipping/firing container, motor casing) around ground zero in the current series of tests. Figure 15 shows that significant damage was incurred by all the acceptor SRC. The motor half of the SRC generally remained intact with the motor housing and propellant grain staying within the SRC while the warhead half was totally destroyed. In all three tests the acceptor immediately beneath the donor remained completely assembled; i.e. the entire rocket remained within the SRC. The warhead and warhead end of the SRC were flattened and ruptured; and the burster burned up completely within the warhead.



TYPICAL PALLET TEST RESIDUE
FIGURE 15

Figure 16 shows unfunctioned fuzes and fuze adapters recovered in one of the tests. Two of the fuzes remain in their respective SRC. The photo depicts 7 fuzes. The eighth fuze belonged to the donor, thereby accounting for all but one fuze in one test. Results were similar in a second test; 3 fuzes were not found in the third test.



RECOVERED FUZES
FIGURED 16

SUMMARY

In conclusion, it appears that the Single Round Container does not significantly alter the MCE for fifteen palletized 115mm rockets:

MCE

Original Configuration	In SRC Overpack
*Spontaneous detonation of one warhead, sympathetic detonation of another	*Spontaneous detonation of one warhead
*Leakage of agent from remaining thirteen warheads	*Leakage of agent from remaining fourteen warheads

Test data was provided to the AMCCOM Safety and AMC Field Safety Activity offices for their use in establishing storage hazard classification for M55 Rockets overpacked in SRC.

REFERENCES

1. Smith, Kenneth T., Propagation Between Munitions for Palletized M61 Rockets, AED Report No. 24-77, 3 October 1977.

2. Hill, D. B., Tests to Determine Extent of Propagation Between 115mm M61 Rockets Confined in Single Round Containers, AED Report No., 01-86.