ARMY RESEARCH LABORATORY

Water Bag and Concertainer Detonation Barricades

by John D. Sullivan, John Starkenberg,
and Jackie L. Brown

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John D. Sullivan and John Starkenberg
Weapons and Materials Research Directorate, ARL

Jackie L. Brown
Naval Air Warfare Center, China Lake, CA

Abstract

The Munitions Survivability Technology (MST) program was initiated by the Defense Ammunition Logistics Activity to develop a rapidly deployable system of fragment barricades combined with lightweight fire-inhibiting blankets; the guidelines for their use include preventing or reducing the propagation of explosions and fire between stacks of Army munitions.

Two types of expedient barricades were tested in a large-scale, donor-acceptor ammunition setup (Hazard Class 1.1 mass detonation). The setup placed a barricade-acceptor pair symmetrically on either side of the central donor stack. One shot was fired on each type of barricade. One type of barricade contained large tubular bags of water stacked in a three-bag linear pyramid; the other type contained sand bins (Concertainer) stacked one bin on two. The sand bins were easier to set up than the water bags. The donor was a stack of palleted 155-mm HE projectiles, centrally detonated on two layers. An acceptor stack faced the barricade with a mixture of four kinds of storage compatible munitions; the most sensitive were the 15-lb demolition shaped charges. The stack was backed with weighty pallets of the 155-mm projectiles, and one housed a self-recording accelerometer.

The test resulted in one water bag's acceptor stack detonating, while the other acceptor's munitions survived. High speed film shows that the initiation time was late and behind the stack, which makes shock wave, fragment, or water spray impact initiation doubtful. A favored initiating cause is crushing the M2 hole digger. No fragment marks or burn marks were found on munitions after either test. Both of the Concertainer's accepter stacks survived. However, it is conceivable that both barricades are equally protective. The accelerometers read peak accelerations between 3,000 and 5,000 g.

Acknowledgments

Duane S. Scarborough of Defense Ammunition Logistics Agency, Picatinny Arsenal, NJ served as the program manager for these tests. Jerry L. Watson, Robert B. Frey, and Richard E. Lottero of the U.S. Army Research Laboratory's (ARL), Explosives Technology Branch, Aberdeen Proving Ground, MD, and Carl Halsey of the Naval Air Warfare Center's Ordnance Evaluation Branch, China Lake, CA, were instrumental in determining the test setup.

The test was conducted at China Lake; Jackie L. Brown was the test director, and Michael Pryor, Robert B. Sutherlen, and James Nelson prepared the site. The water bags were set up by William Corey and Antonio Santana of Federal Fabrics-Fibers Inc., N. Chelmsford, MA. Cpt. Karen Walters and Toney K. Cummins of the U.S. Army Engineer R&D Center, Waterways Experiment Station (WES), Vicksburg, MS, witnessed the construction of the barricades. Raphael A. Franco of WES was responsible for fielding accelerometers in the acceptor stacks and providing the data.

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1. Background

The Defense Ammunition Logistics Agency has a Munitions Survivability Technology (MST) Program for examining different shielding concepts for the field expedient protection of munitions. Recent MST tests showed the effects of a detonating munition stack (Hazard 1.1) on shielded stacks of mixed munitions. In these tests, barricades were formed from water bags or sand-filled Concertainer® bins to see if a violent reaction would be prevented in the mixed munitions.

2. Overview

Aside from practical considerations like cost, transportability, and constructibility, any barricade must be effective against ammunition hazards such as mass detonation and cookoff. (Water bags were previously tested against cookoff.) In these tests, both barricades were exposed to a mass detonation hazard for the first time.

Due to the energetics weight (i.e., 8,900-lb donor stack) and storage/security problems, tests were conducted at a remote Western site. Contractually, it was easier for another experienced service to work the test, and so the executor was the Weapons Division of the Naval Air Warfare Center, China Lake, CA. The location was the Cactus Flats range, which is off of U.S. Highway 395, 15 miles east of Coso Junction. The test site was a dry lake bed ringed by steep ridges and volcanic hills, 0.5-1 mile away. A four-man labor crew and a Gradall telescopic material handler set up the test on scraped, but not leveled, desert sand in an N-S line crosswise to the line of sight from the observation post. Action was recorded with a television, a still camera, and a high-speed camera. A self-recording accelerometer inside a 155-mm projectile was placed in the top, central, and back row of each acceptor stack. Firing was controlled from a naval gun turret 3,500 ft from ground zero (GZ); observation was from a high ridge 6,000 ft away. One week each was needed for setup, checks, firing, re-entry, evaluation, cleanup, and movement to a new GZ. The water bags were tested on 30 September 1999 and the Concertainer on 7 October 1999.

Construction diagrams are shown in Appendix A, and accelerometer results are in Appendix B. Figure 1 shows the general setup that was used for both concept barricades. Elements were spaced 10-ft apart, a normal allowance for forklift movement. The spacing affects the proportion of fragments intercepted, but not their velocity. The donor stack in Figure 2 was constructed from 576 unserviceable, 155-mm projectiles in an arrangement of 6 x 6 x 2 pallets. It was the symmetrical center between two barricades before acceptor stacks of mixed munitions. Stack initiation was caused by sympathetic detonation from 16 central projectiles. Eight innermost projectiles of four central pallets of both layers had their fuze wells packed with C-4 explosive and a booster; they were initiated by detonating cord that was branching off of a trunk line.

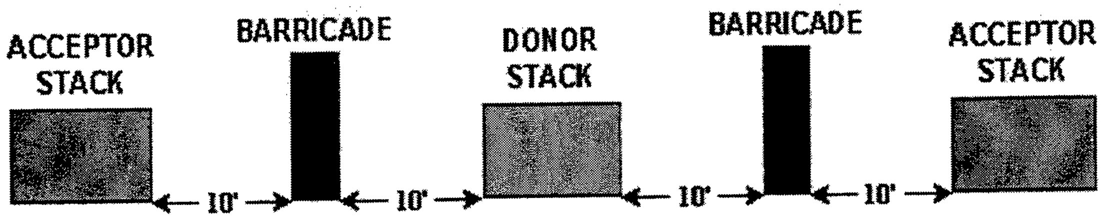


Figure 1. Generic Setup for MST 1.1 Hazard Test.

On the acceptor stack in Figure 3, the side facing a barricade was composed of four kinds of munitions in their shipping containers: M2 hole diggers, M864 Rocket Assisted Projectile (RAP) rounds (unfuzed bomblets), M67 hand grenades (unfuzed), and M203 propelling charges. These were backed up with stacked pallets of M107 projectiles. The munitions used in the acceptor stack were intended to be "worst-case" acceptors, so that a successful test would be representative of the worst situation likely to be seen in the field. Obviously, the choice of a worst-case acceptor is difficult and depends on the mechanism by which reaction propagates. The M864 rounds were selected because of their modernity (bomblet dispensing, extended range) and because they contain a sensitive fill, Composition A5. The hand grenades and the hole digger were identified as worst-case acceptors in a test program that subjected munitions to long duration, low velocity, crushing impacts (Lyman et al. 1994). Propellant charges were included in the stack because they are easily initiated to burning reactions, although not necessarily to detonation. Combining these rounds in one stack provided a severe test for the barricades.

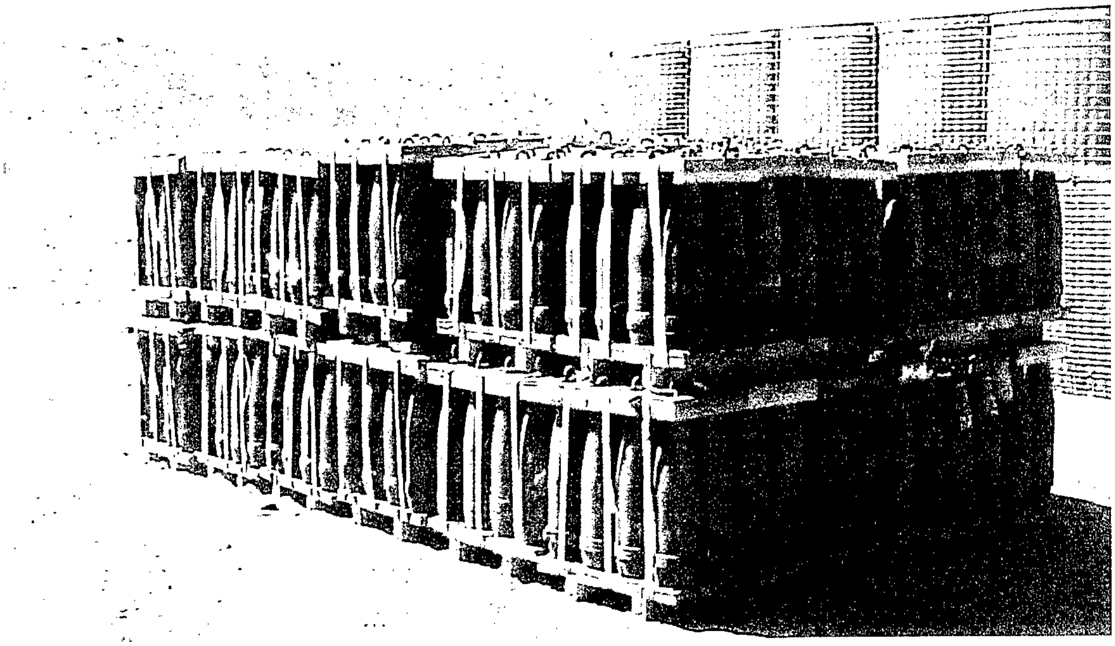


Figure 2. Donor Stack Composed of 155-mm Projectile Pallets.

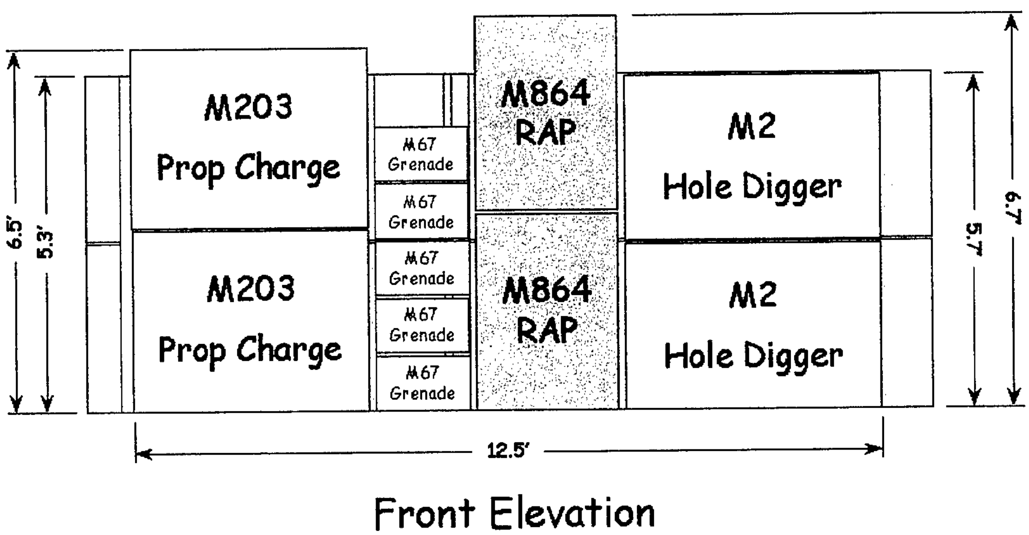


Figure 3. Composition of MST Acceptor Stack.

2.1 Water Bag Test

2.1.1 Filling and Setup. The water bag barricades were tubes constructed and supplied by Federal Fabrics-Fibers, Inc., N. Chelmsford, MA. The tubes have an inner polymer bladder that holds the water and a protective outer casing made of woven Kevlar. The bags are seamless, except at the valve end. The fill valve is close to the seam; before filling, the bag should be rotated so that the valve is at the bottom. The valve is a 3-in ball valve that takes a quick-connect Banjo Insta-Lok® female hose fitting; also, there is a bleed plug on the bag's aft end, 180° from the valve. Figure 4 shows the water bags nearly ready to be tested. The barricade was a 3-bag pyramid of 54-in-diameter, 23-ft-long bags. For stability and initial location, the two ground bags are set inside two smaller tubes ("wedge bags" interconnected by straps). To aid in placement and to unstick the sides, a leaf blower inflated a bag with air. The air was bled as the bag was pumped full of water from one of two tanker trucks that shuttled to a well. A filled bag holds 2,700 gal and weighs 23,000 lb; thus, the top bag presents a linear density of 1,000 lb/ft. These barricades were erected by two factory representatives and test personnel. Waterways Experiment Station personnel, who have conducted constructibility studies on water bags, provided additional guidance. Both barricades could have gone up in one day, but the bladder of the top bag broke. The factory sent a replacement via overnight airfreight, it was on site the next day, and erected the following morning.

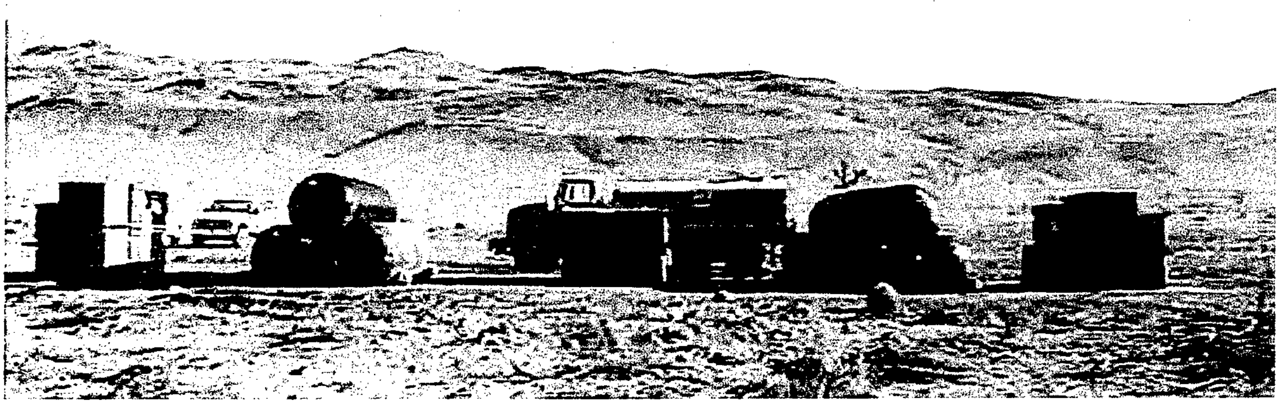


Figure 4. Water Bag Setup for MST 1.1 Hazard Test.

2.1.2 Results. The donor stack fully detonated. Both barricades were destroyed in place, and the water was driven out in a spray at the acceptor stacks. The north end acceptor stack fully detonated, but the south end acceptor stack did not. The secondary explosion is revealed by the smaller dirt column in Figure 5. There was a very large, black-crusted ground area left by the water blast interaction. The cause of the darkening is unknown, but possibly water vapor condenses on carbon particles in the donor explosion TNT after-products and falls as black rain. The particles would have to be very small to be carried by the slight wind and blacken the large area that was observed. Figure 6 shows scattered munitions on the darkened ground.

Other signs of the secondary explosion are the mangled steel witness plates that were under the acceptor stack, the creation of a large crater north of the (separate) donor stack crater and no crater south of the donor stack crater, the disappearance* of all acceptor munitions from the north stack, and the explication of high-speed film. Selected frames of the event are shown in Figure 7. After interpreting the film, we concluded that after a long delay from stack initiation (camera speed unavailable), a single-point intiation occurred on the ground 10 ft behind the acceptor stack face (probably in an M2 munition), and detonation propagated to all other munitions of that stack.

The south end stack items survived being translated close and far, and all were recovered. No munitions had fragment marks. In other words, in at least one test, one water barricade stopped fragments from 155-mm HE projectiles. Some of the lightly packaged and constructed M2 shaped charge hole diggers were ripped open, and crumbled Pentolite explosive was scattered near the item. No baseplate on the RAP projectiles was dislodged, so no submunitions were spilled. The surviving (south stack) accelerometer read 3,000 g.

* Repeated ground sweeps recovered no munitions at all. In particular, the conspicuous, inert 155-mm projectile encasing the accelerometer was not found; its disappearance further signifies that the north stack entirely detonated.

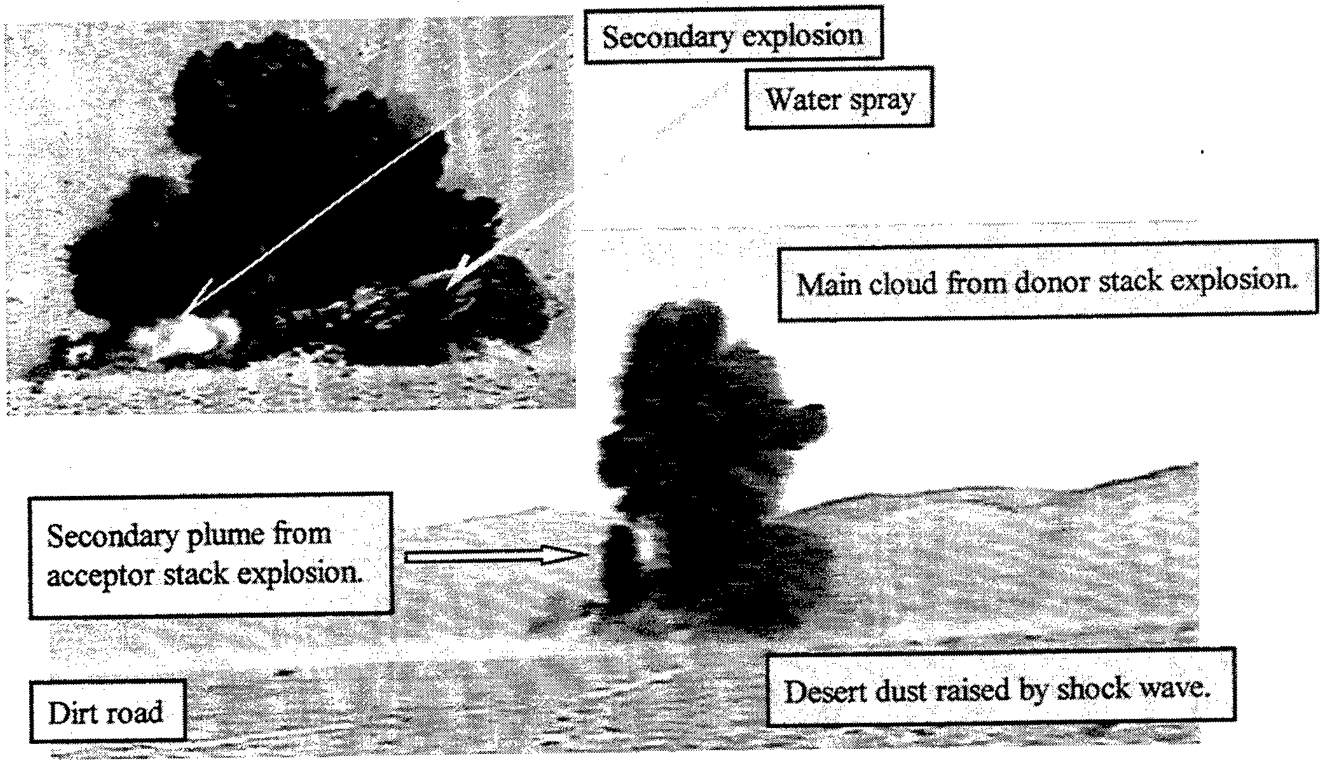


Figure 5. Explosion of North Acceptor Stack Shown by Secondary Dirt Cloud.

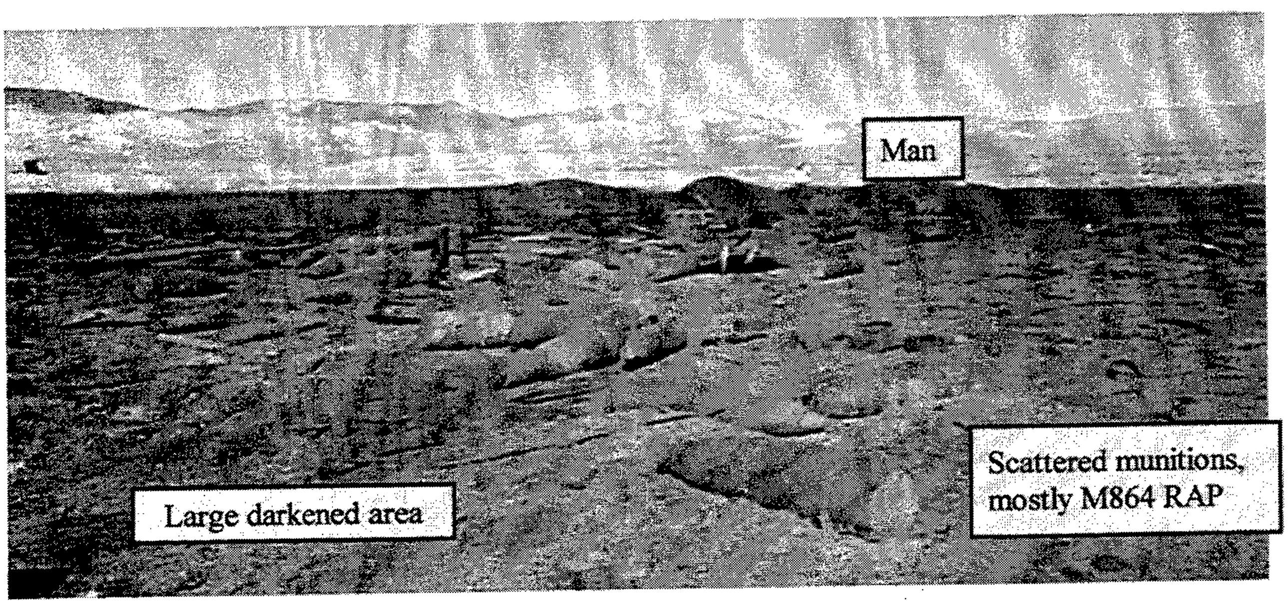


Figure 6. Scattered Munitions and Darkened Ground From Water Bag Test.

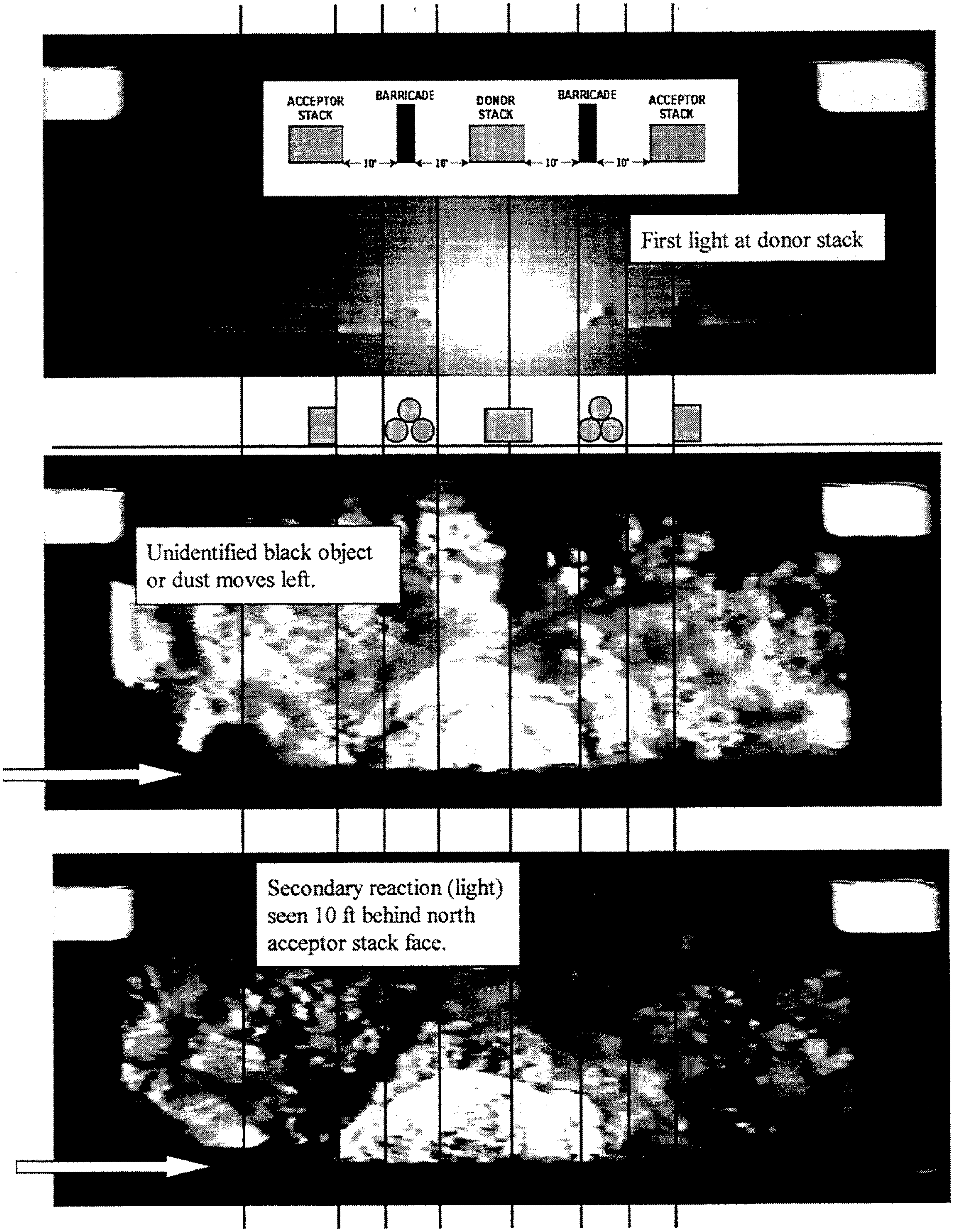


Figure 7. Secondary Explosion in North Acceptor Stack of Water Bag Test.

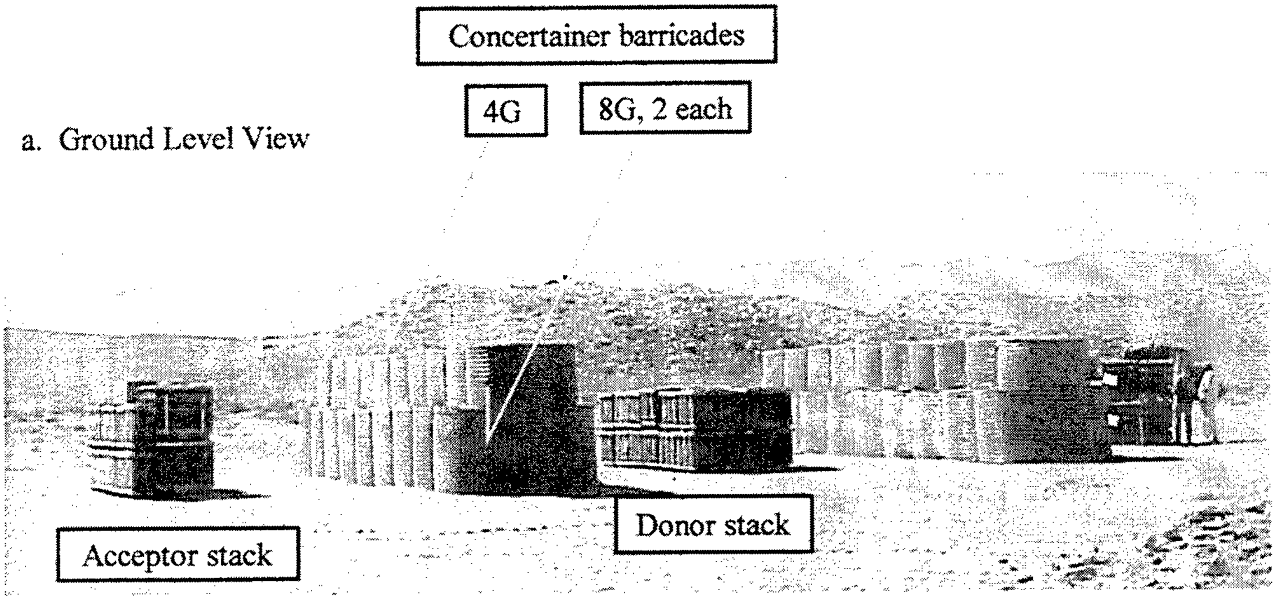
2.2 Concertainer Test

*2.2.1 **Filling and Setup.*** The barricade was constructed from selected elements of the Hesco Bastion Concertainer® Defense Wall System. This is a revetment system consisting of liquid-draining, geofabric-lined, wire mesh bins. The bins may be filled with soil, sand, gravel, ice, or any other available material. The wall is transported in folded lightweight units that extend concertina style up to 100 ft. A sand barricade was designed as an 8-ft-thick base of two contiguous Concertainer 8G bins with a 5-ft-thick, crosswise, 4G bin centered on them. This created a stepped barricade that was above the height of the acceptor stack. A photo of the setup is shown in Figure 8. A barricade was 32-ft long, and 28 bins were filled with blast sand by a Gradall mover with a 1-yd^3 bucket. A driver and two workers were needed. Blowing sand made the job difficult; a larger bucket would have been better. Barricades were up in less than a day.

*2.2.2 **Results.*** The donor stack fully detonated. Both barricades were destroyed in place and the sand was driven out in a spray far beyond the acceptor stacks, as shown in Figure 9. Neither acceptor stack detonated, as revealed by the curled but intact steel witness plates under the stack, the lack of acceptor craters, the recovery of the acceptor munitions, and a review of high-speed film. All stack items survived being translated close and far, and all were recovered. Views of thrown munitions are shown in Figure 10. The heavy RAP projectiles from the front of the acceptor stack are the closest to the witness plate. No baseplate on the RAPs was dislodged, so no submunitions were spilled. Figure 11a shows that the blast damaged the light packaging of the M2 hole digger, which is three nestled SCs wrapped in plastic and put in a narrow wood box. Bunches of boxes are banded together. Figure 11b shows an SC broken open, exposing the driver explosive.

No munitions from either stack had fragment marks. In other words, the upper (4G) bin at a thickness of 60 in and linear density of 1,600 lb/ft stopped fragments from the 155-mm HE projectiles. This result was expected from Johnson (1966), who found that fragments off of the 8-in howitzer projectile M106 penetrated less than 4 ft of sand; therefore, the Concertainer barricade we designed (Appendix A) was thicker than needed. The accelerometers read 5,000 g on the north stack and 3,200 g on the south stack.

a. Ground Level View



b. Aerial View

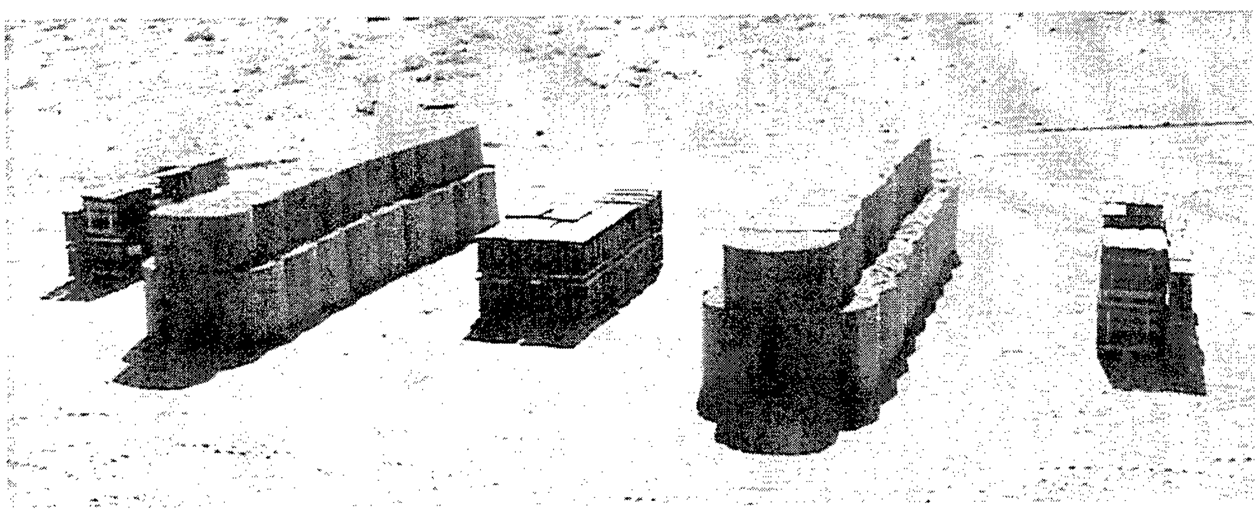
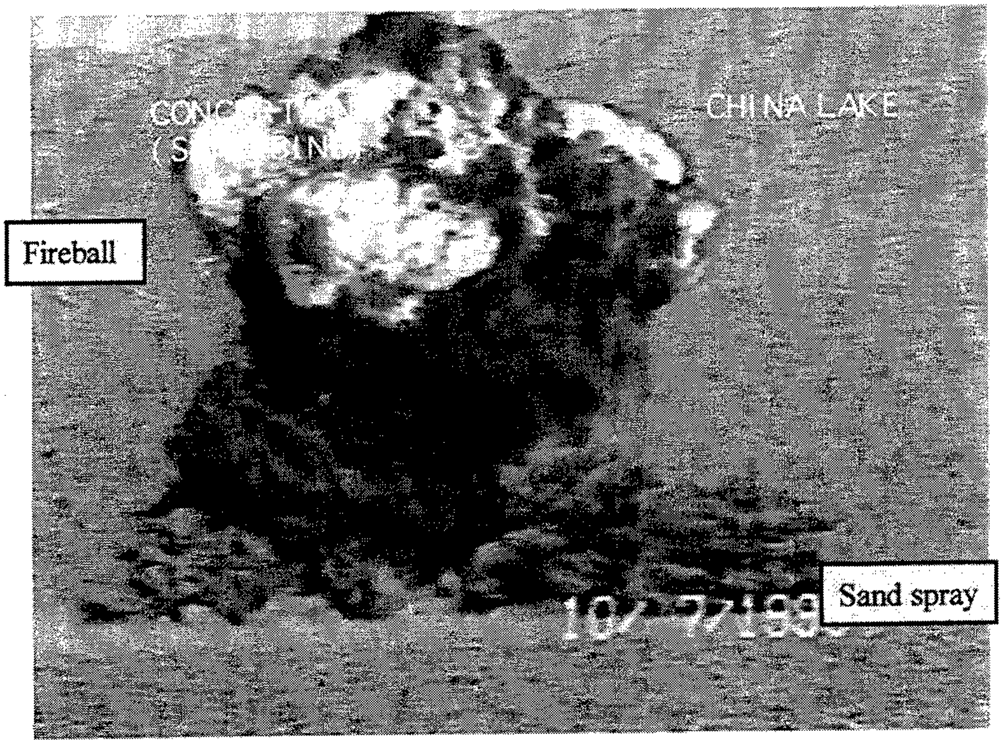
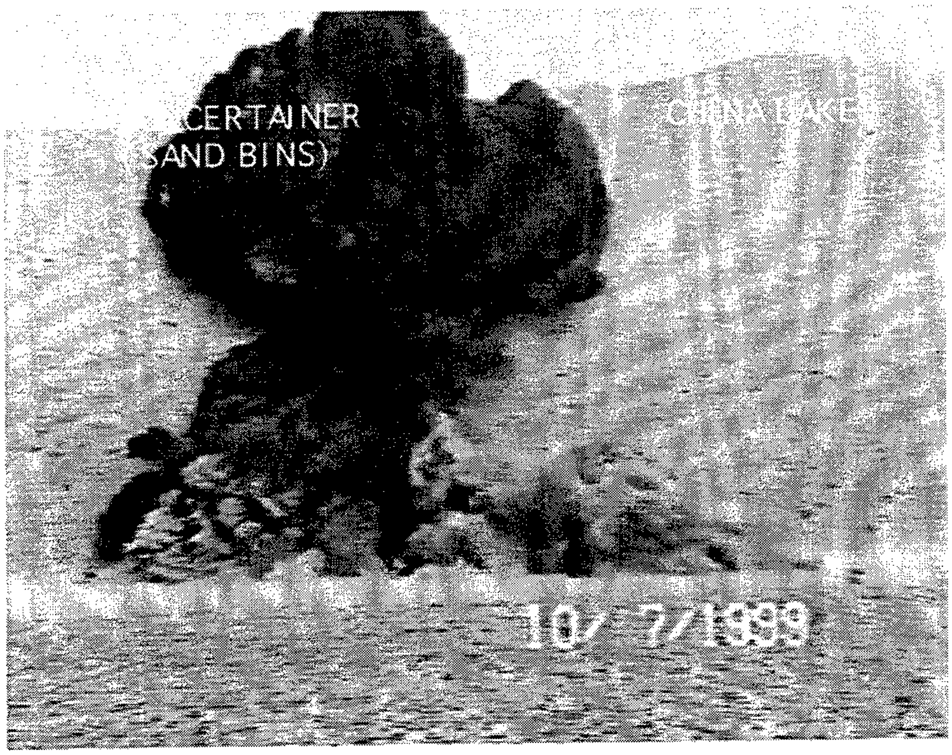


Figure 8. Concertainer Setup for MST 1.1 Hazard Test.



a. Early time showing fireball and large sand spray to right.



b. Later time showing fireball nearly gone and sand at maximum throw.

Figure 9. Explosion Cloud and Sand Spray From Concertainer Test.

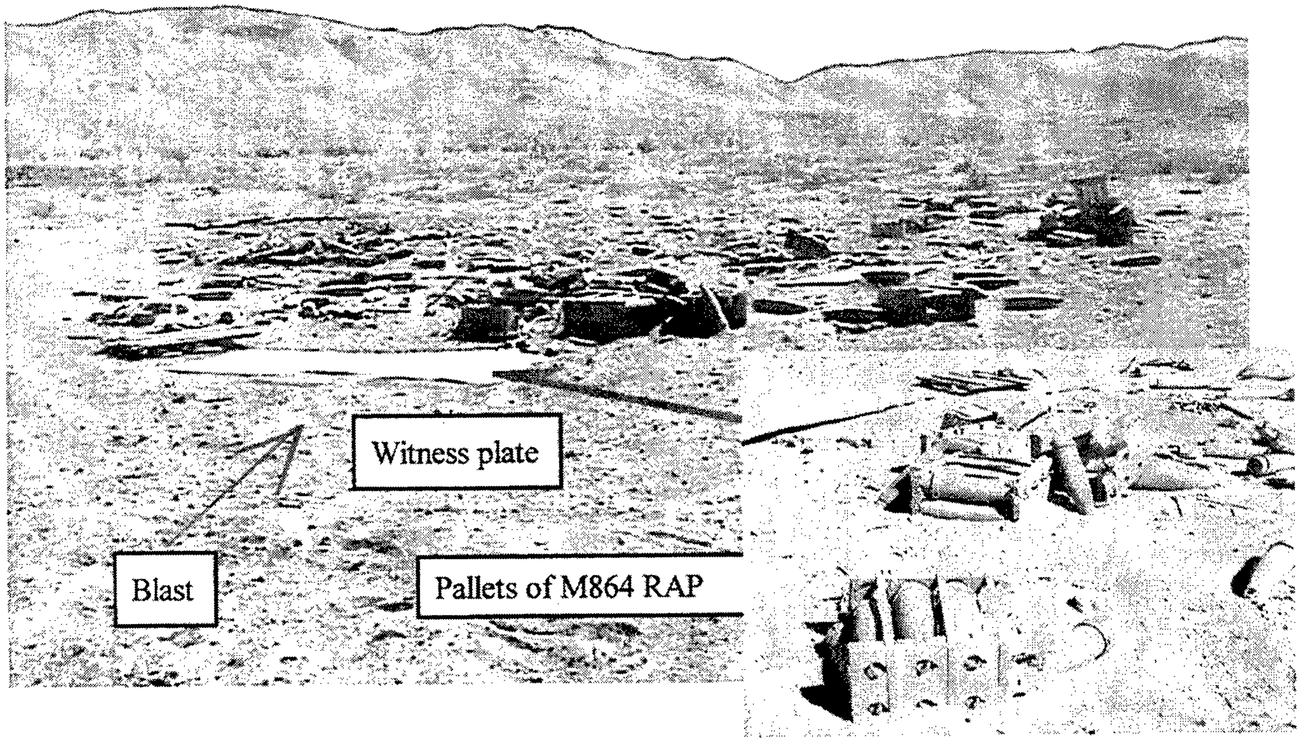
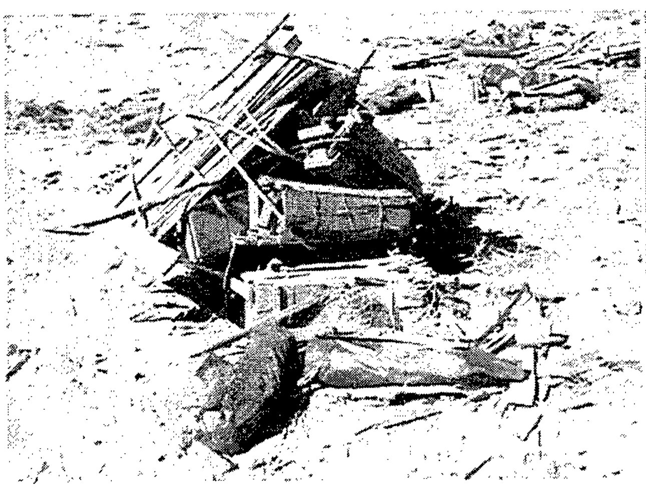
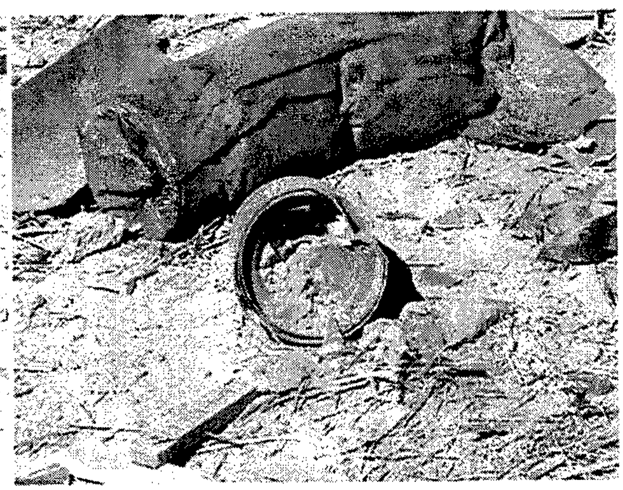


Figure 10. Field of Thrown Munitions From Concertainer Test.



a. Smashed shipping container of M2s.



b. Exposed explosive from broken SC.

Figure 11. Crumpled M2 Hole Digger in Concertainer Test.

3. Discussion of Initiation

3.1 Consideration of Facts. In the water bag test, one acceptor stack detonated and one did not. (In the Concertainer test, neither acceptor stack detonated.) The donor stack blast translated the acceptor munitions, and delayed initiation occurred at one place.

Neither air shock nor ground shock is strong enough to cause an initiation. Since these phenomena should cause prompt initiation, the observed late-time initiation also rules out those possibilities.

In neither barricade test did any recovered munitions have fragment marks. The barricades' densities and top paths are similar (water is 62 lb/ft^3 and 54 in; dry sand is 100 lb/ft^3 and 60 in), so fragment velocities should be similarly retarded. Also, fragment impact should cause prompt initiation. Thus, fragment impact is an unlikely cause of initiation.

The acceptor stack that detonated did so after a considerable delay, as indicated by the fact that the point of initiation is seen on film to be 10 ft behind the barricade side of the stack. It is clear that water impact did not cause prompt initiation. In both barricade tests, some of the lightly packaged and constructed M2 shaped charge hole diggers were ripped open, and crumbled Pentolite explosive was scattered near the item (see Figure 11). It is possible that a deflagration to detonation transition occurred in this broken Pentolite, but this is unlikely. M2A3 hole diggers (Composition B fill) were shown by Lyman et al. (1994) to be very sensitive to crushing impacts. This is because the explosive is almost completely unprotected. We suspect that the crushing of the hole diggers caused the initiation. The likeliest cause of the initiation was mutual impacts in a group of translating munitions that crushed the explosive. Possibly the light and sensitive M2 hole digger collided with others or with the backing, which were heavy, semistationary M107 projectile pallets, and the Pentolite was crushed* and initiated. If collision and crushing caused the initiation, then it could just

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* In a preceding (Waterways) test, an M2 is thought to have initiated (by a deflecting wall striking it) and blown out, destroying munitions in an ISO shipping container.

as well have occurred in the Concertainer test. In other words, there might be no protective difference in the barricades.

3.2 Tables of Estimates. Tables 1 and 2 estimate what caused initiation and which munition initiated.

Table 1. Possible Modes of Initiating Munitions

Barricade	Initiation Mode					
	Likeliest → Least Likely					
	Collisions [a]	DDT [b]	Fragment Impact [c]	Barricade Contents Impact [d]	Air Shock [e]	Ground Shock [e]
Water Bag	Pr	not Pl	P	P	U	U
Concertainer	Pr	Pl	P	P	U	U

Pr = Probable, Pl = Plausible, P = Possible, U = Unlikely

[a] Munitions hit each other and pile into heavy backup pallets of M107 (155-mm) projectiles. Crushing and initiation occurs.

[b] Late initiation occurs behind stack face on water bag test. Deflagration to detonation (DDT) should have been quenched by water spray, but DDT can be completed in a sand spray.

[c] Fragment impact marks not seen on surviving stacks' munitions.

[d] Water or sand are flung by the blast. See large water spray front, inset Figure 4, and large sand spray front, Figure 8. Barricades do not impact acceptor stacks as a sliding, intact object. Impact on acceptor stack may be low.

[e] Shock strength is too low to initiate the explosive.

Table 2. Estimates of Which Munition Initiated

Barricade	Munition Initiated				
Water Bag	Prop. charge	Hand grenades	RAP	SC hole digger	M107 rnd
Likelihood	U [a]	P [b]	P [c]	Pr [d]	U [d]

[a] Propellant will not detonate in the test conditions. Metal charge containers were recovered.

[b] Numerous intact grenades were found outside the packaging. The grenade body is rigid and will resist any causes of initiation.

[c] The thick steel wall resists any causes of initiation.

[d] Because of weak packaging and weak casing, the explosive will likely be crushed from the collisions. Also, exposing HE to the fireball is possible, allowing DDT to occur. Water spray will likely douse DDT, but this initiation mode remains a possibility with sand bins (Concertainer).

4. Summary and Conclusions

A stack of 155-mm projectiles was detonated (Hazard 1.1) before shielded stacks of mixed munitions. Two barricades, each of a different type, were separately tested with donor stacks. These tests approximate a barricade's ability to prevent a reaction from propagating through munition stacks at an ammunition supply point.

In the first barricade test, 54-in diameter water bags from Federal Fabrics-Fibers, Inc. were stacked in a 3-bag linear pyramid. One acceptor stack detonated, while the other did not. In the second barricade test, Hesco Bastion Concertainer bins were filled with sand and set in a single-step (60-in thickness) profile. Neither acceptor stack detonated.

The acceptor stack probably detonated because the M2 shaped charge hole diggers collided with themselves or against other slower traveling munitions; the driver explosive was then crushed and initiated, exploding the swarm.

The setup conditions were similar in the two barricade tests, other than the possible effect that water and sand impact have on the acceptor stacks. Therefore, it is conceivable that both barricades are equally protective. If this is the case, a decision to develop either barricade should be based on logistics desiderata and not terminal effects.

5. References

Johnson, J. R. "Investigation of the Protection Afforded by Sandbag Barricades." BRL-TN-1627, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, p. 19, September 1966.

Lyman, O., R. Frey, and W. Lawrence. "Determination of a Worst-Case Acceptor for Large Scale Sympathetic Detonation Testing." ARL-TR-490, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, July 1994.

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Appendix A:

Designs

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A-1. Donor Stack

Table A-1. MST Donor Stack Items

Item	Name	DODIC	NSN	Pallet	L x W x H (in^3)	Pallet Wt (lb)	NEW* EA (lb)	NEW Pallet (lb)	NEW Stack (lb)
1	PROJ, 155MM, M107, COMP B	D544	1320-01-257-4222	2 x 72	27.1x13.5x31.2	797	15.4	123.2	8870.4
							*Net Explosive Weight		
				Unit Issue	Unit Cost	Stack Qty	Stack Cost	Two-Stack Cost	
				EA	$189.00	576	$108,864.00	$217,728.00 Note: No actual cost expected.	
						(2 x 1 stacks req'd)			
2	CORD, DET	Note: 8 lengths from each layer.							
3	DETONATOR, ELECTRIC	Note: one det for each shot. Min. two req'd.							

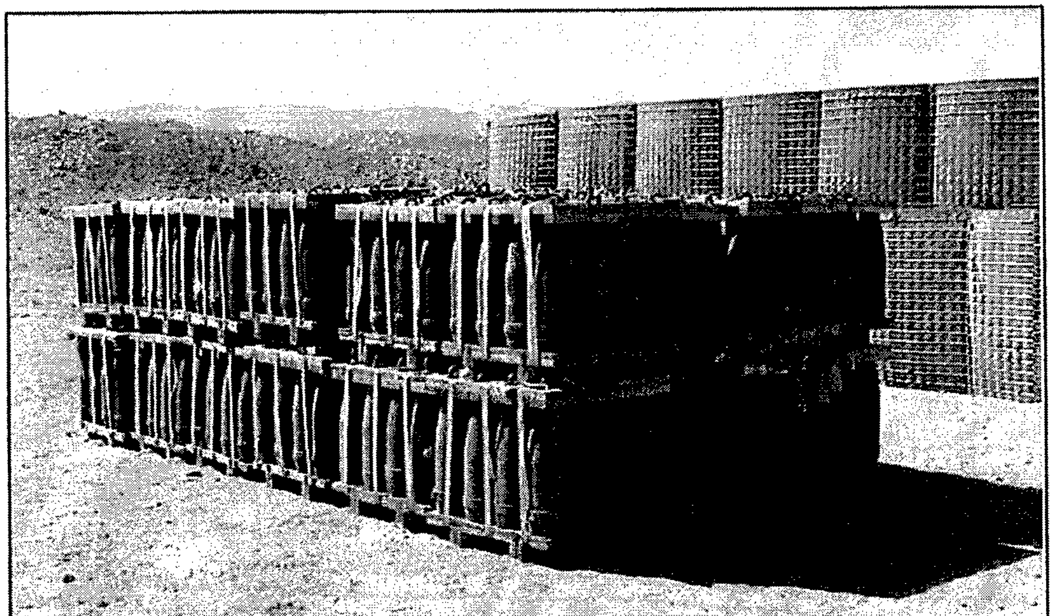
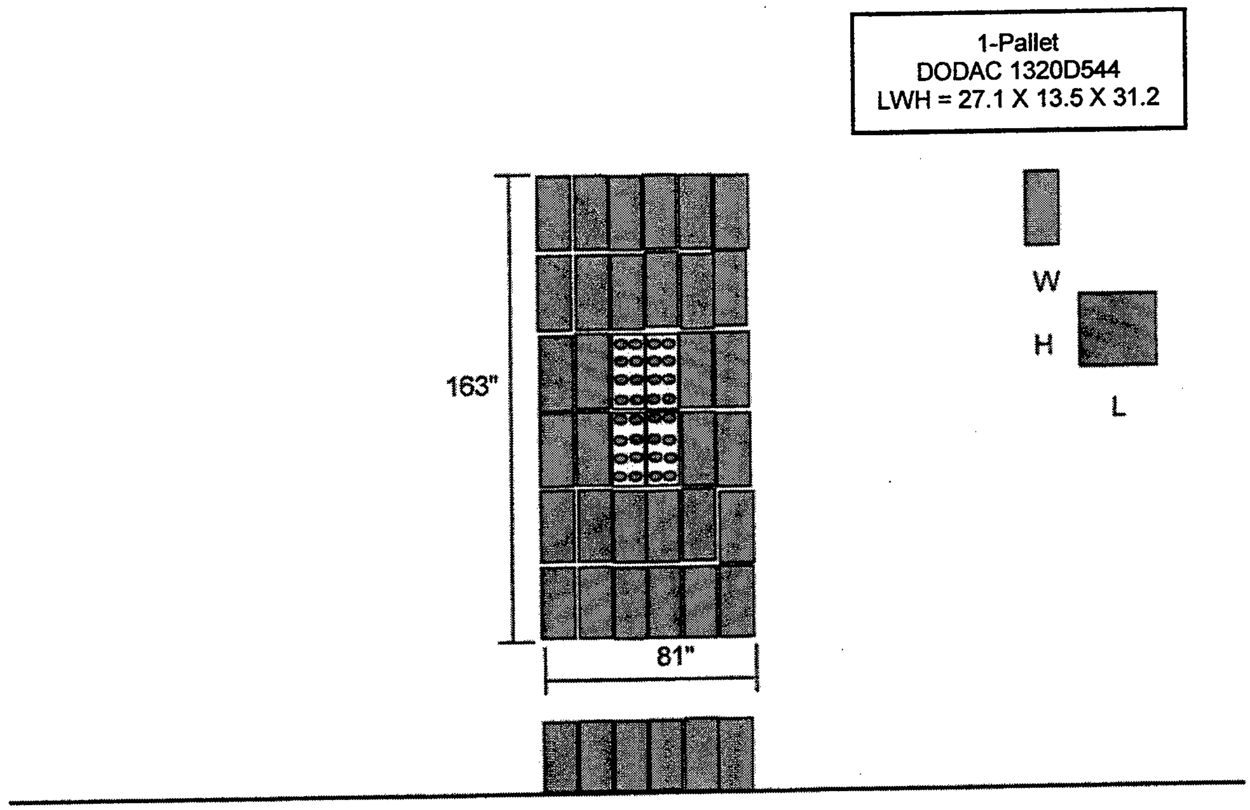


Figure A-1. List and View of Donor Stack Items.

MST Donor Stack

PROJ 155MM, 8 X 72 = 576 EA
36-Pallet Layout (6 x 6)
One layer of two; other layer directly above.



Initiate eight (red) shells from the ends of four central pallets.

Same initiation on second layer.

Suggestion: Pack nose fuze well with C4 and lead out with det cords to a place beside the stack.

Figure A-2. Layout of Pallets for Donor Stack.

A-2. Acceptor Stack

Table A-2. MST Acceptor Stack Items

Name	DODIC	NSN	Pallet	L x W x H (in^3)	Pallet Wt (lb)	NEW* EA (lb)	Pallet Qty
CHG, PROP,155MM, M203	D532	1320-012028938	2	47.8 x 38.0 x 36.2	1370	30	24
GRENADE, HAND FRAG, M67	G881	1330-001338244	5 (SC)	18.9 x 11.2 x 11.1	51 (SC)	0.372	30
PROJ,155MM, M864, RAP	D864	1320-012311697	2	29.1 x 14.6 x 39.4	870	7	8
CHG, DEMO SHAPED M2, 15 LB	M420	1375-000285237	2	52.1 x 42.6 x 33.3	1418	11.5	60
PROJ, 155MM, M107, COMP B	D544	1320-012574222	18	27.1 x 13.5 x 31.2	797	15.4	8

*Net Explosive Weight

Stack Width (IN.)	Stack Wt (LB)	Stack NEW (LB)
68.4	21917	5205.4

(2 x 2 stacks req'd)

Figure A-3. List and View of Acceptor Stack Items.

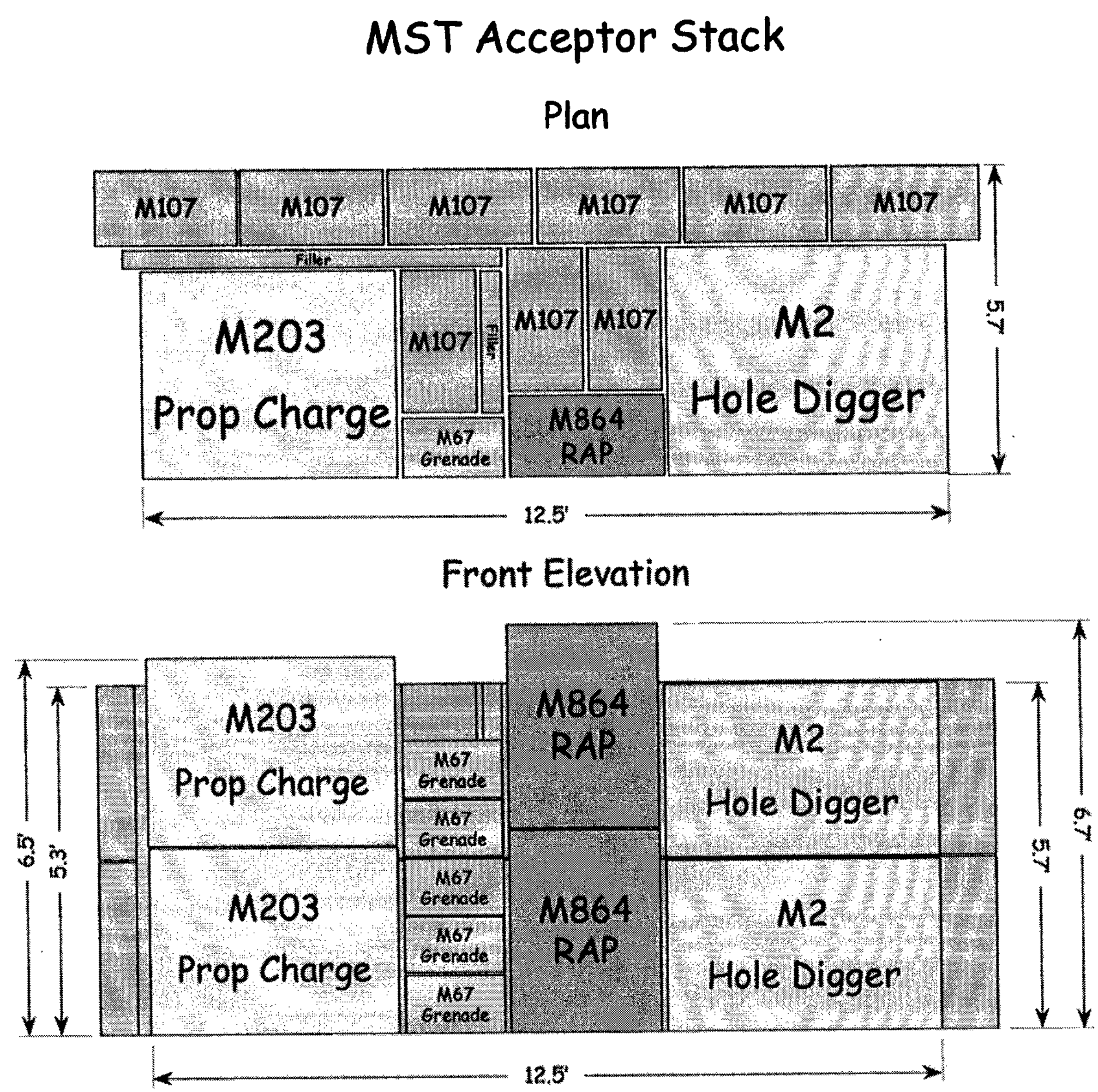


Figure A-4. Arrangement of Acceptor Stack Packaging.

A-3. Water Bag Barricade

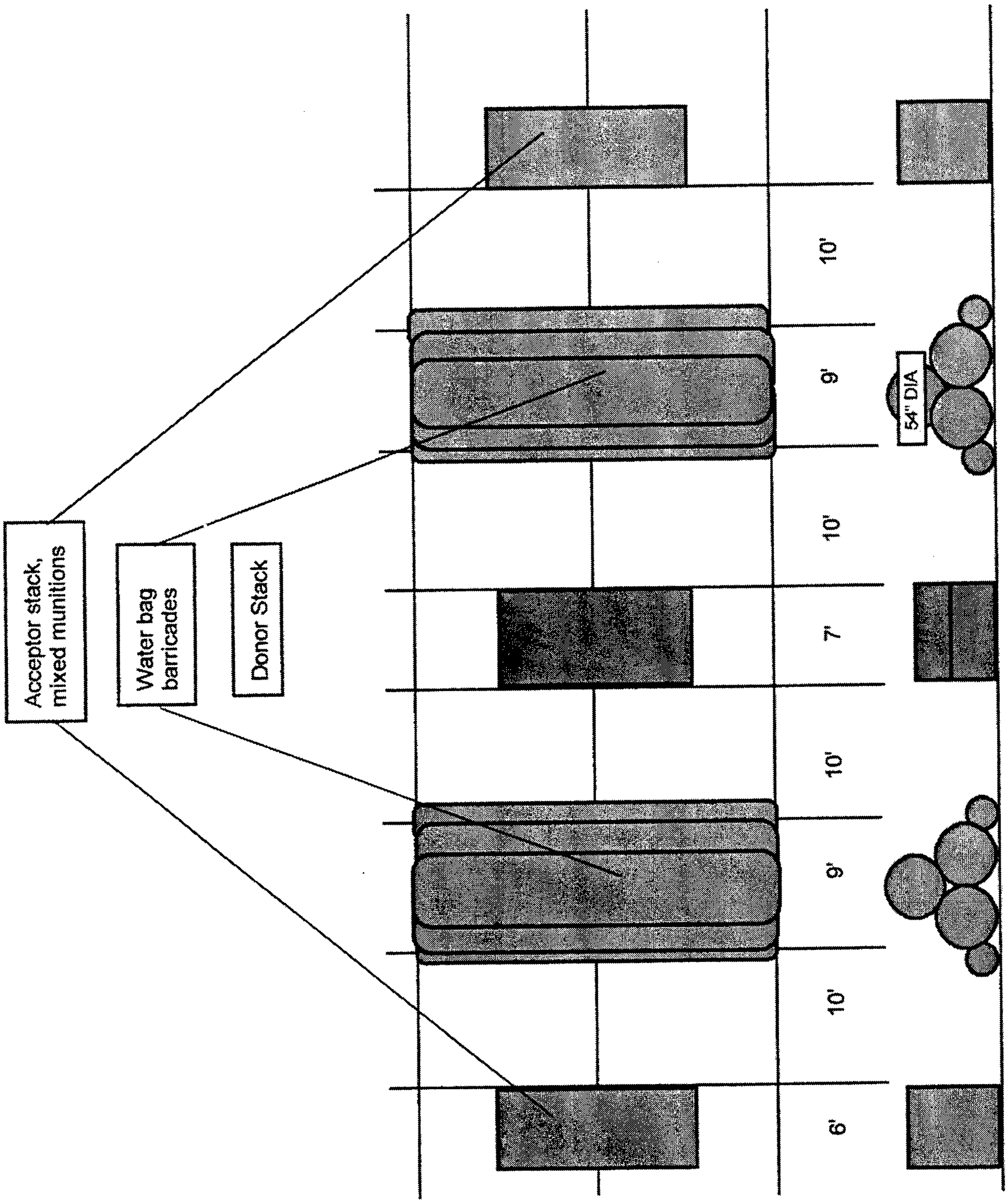


Figure A-5. MST Water Barricade Layout.

A-4. Concertainer Barricade

Table A-3. MST Concertainer Barricade Items

Item	Model	Color	H x W x L (ft^3)	NSN	Unit Cost	Qty	Total Cost
1	4G	Green	3.25 x 5 x 32	2590-99-001-9399	$887.00	4	$3,548.00
2	8G	Green	4.5 x 4 x 32	2590-99-517-3281	$796.03	8	$6,368.24

(1 x 2 barricades req'd)

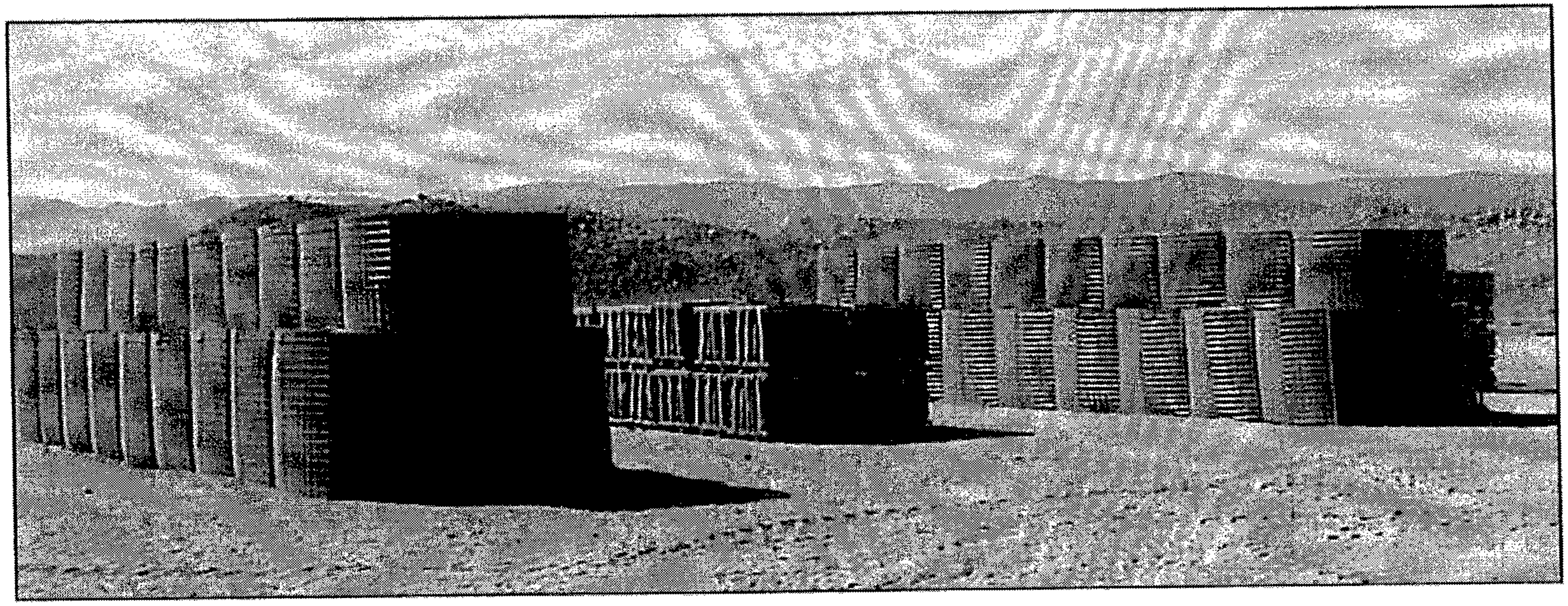


Figure A-6. List and View of Concertainer Barricade Items.

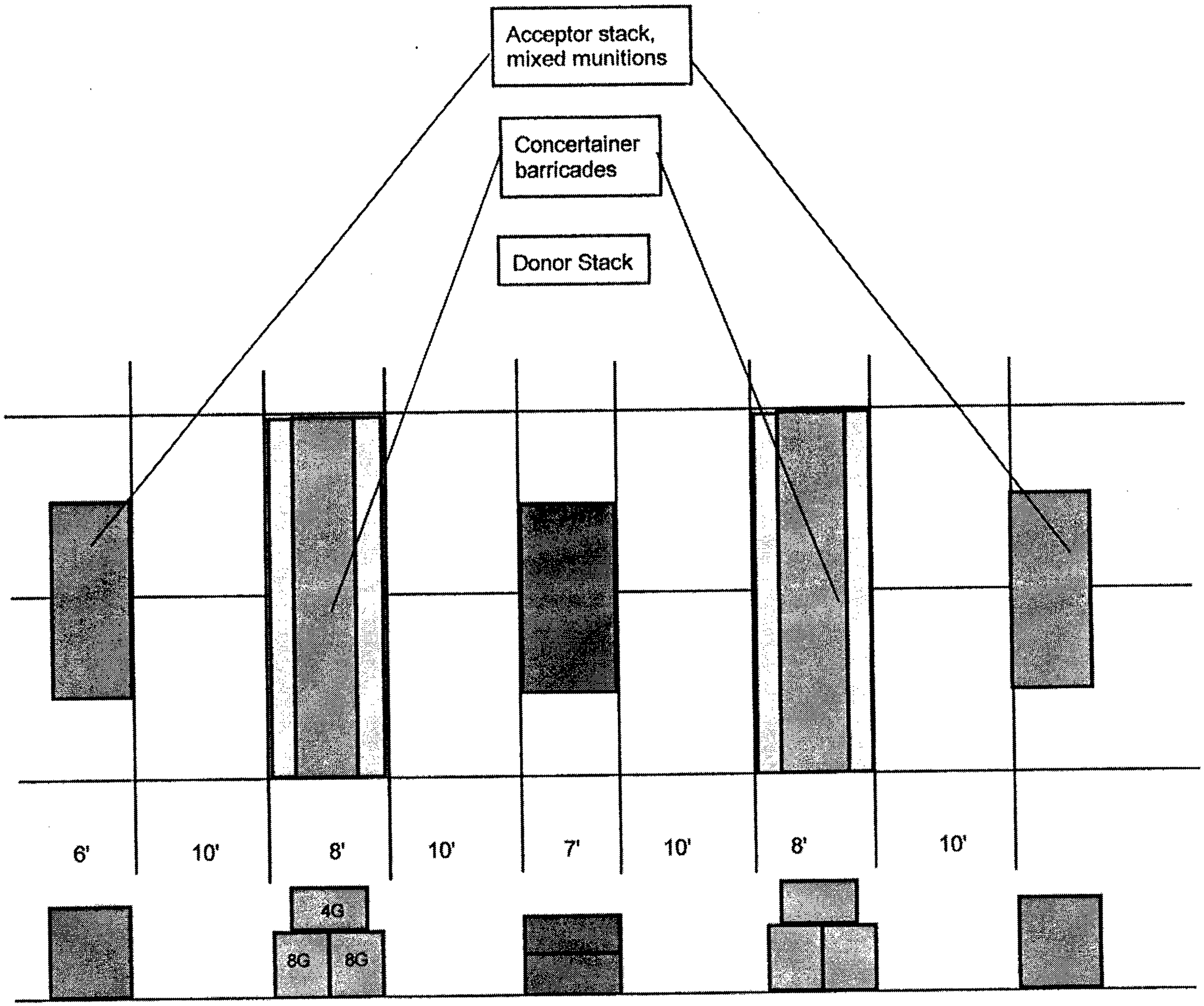


Figure A-7. MST Concertainer Barricade Layout.

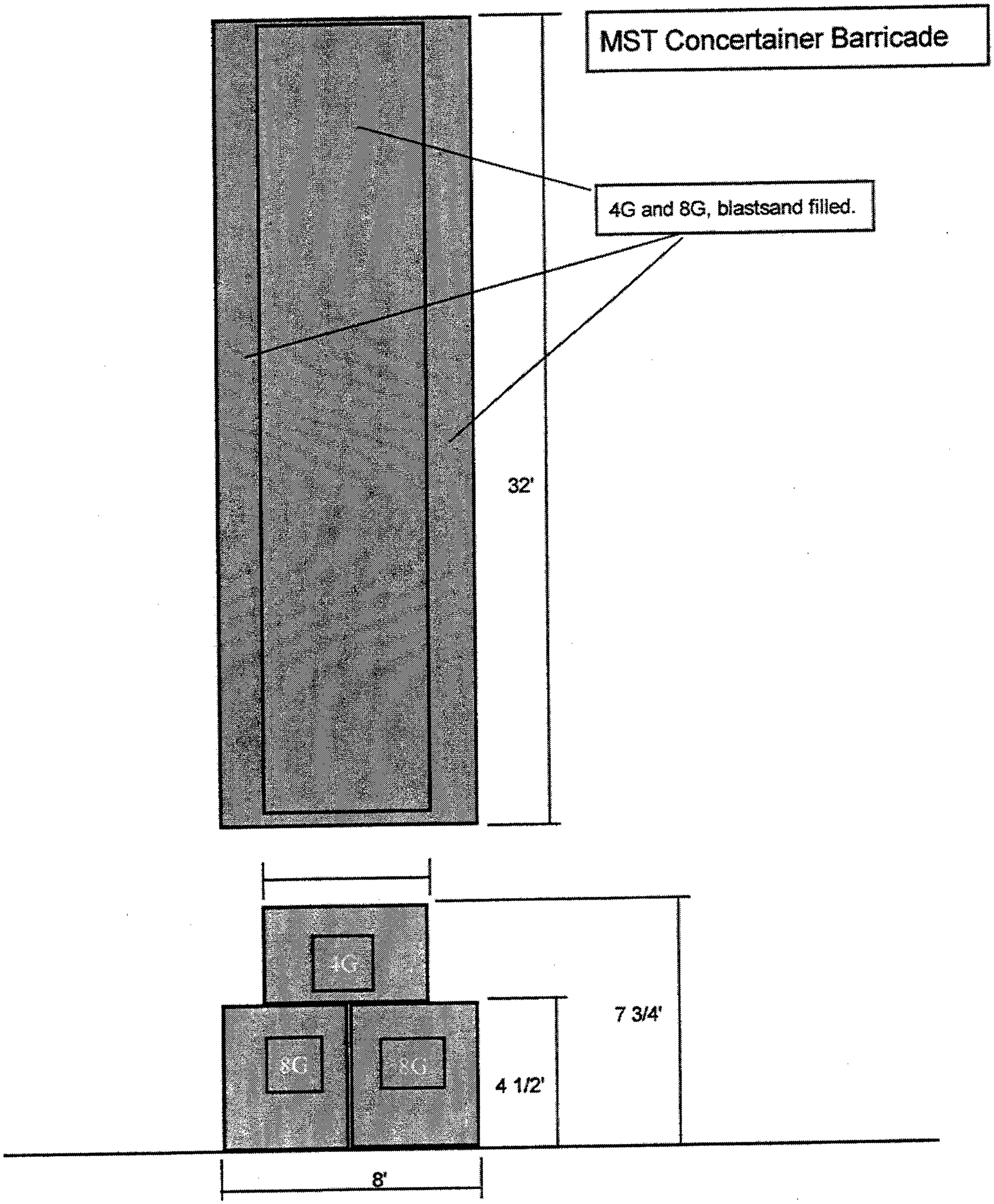


Figure A-8. Design of Concertainer Barricade.

Appendix B:

Accelerometer Records

Raphael A. Franco

U.S. Army Engineer Research and Development Center
Waterways Experiment Station
Information Technology Laboratory
Vicksburg, MS 39180-6199

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The U.S. Army Engineer Research and Development Center (ERDC), Waterways Experiment Station has developed a Hardened Data Acquisition System (HDAS). This miniature, self-contained, transient data recorder can withstand shock levels of 100,000 g. The recorder contains all of the necessary electronics, including the excitation voltage to interface with bridge-type transducers. The frequency response of the analog section is flat to 100 kHz. The analog signal is digitized by an 11-bit (2,048 steps) analog-to-digital converter at a fixed rate, which can be set by an external resistor to any value between 1 kHz and 1 MHz. The digital data is stored in onboard 131,072 word memory. Approximately 90% of memory is posttrigger data, while the remaining 10 % is pretrigger data. The recorder can be triggered from an external cable or an internal g-sensitive switch. After acquiring data, the recorder goes into a low power sleep. Data is retrieved via a laptop PC. The recorder is cylindrical, 69 mm in length and 30 mm in diameter. The small size and low standby current, 0.1 mA, allow it to be placed inside of a munition or protective canister months before a test. The recorder and the shock hardening techniques are described in Franco.[1,2]

Two of the HDAS were used for each barricade test. A full-bridge piezoresistive accelerometer, Endevco 7270A, was shock mounted in the nose of an empty 155-mm (M107) projectile. The acceleration axis was in the direction of the blast. For the water bag test, a 20-kg full range accelerometer was selected; for the Concertainer test, a 60-kg full range accelerometer was selected. For both tests, the sample period of the HDAS was set to 5μs, and the HDAS was triggered from a g-sensitive switch that closed between 7 and 12 g. Shock isolation microballoons were poured into the vacant space, and the projectile was closed with the nose plug. The special projectile, painted red for easy recovery, was put on a pallet of seven live M107s in the center top of the backup row of an acceptor stack (see Figure B-1).

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[1] Franco, R. A. U.S. Patent 5,317,914, June 1994.

[2] Franco, R. A., and J. K. Owens. "A Miniature, Shock Hardened, Transient Data Recorder." *66th Shock & Vibration Symposium*, Biloxi, MS, October 1995.

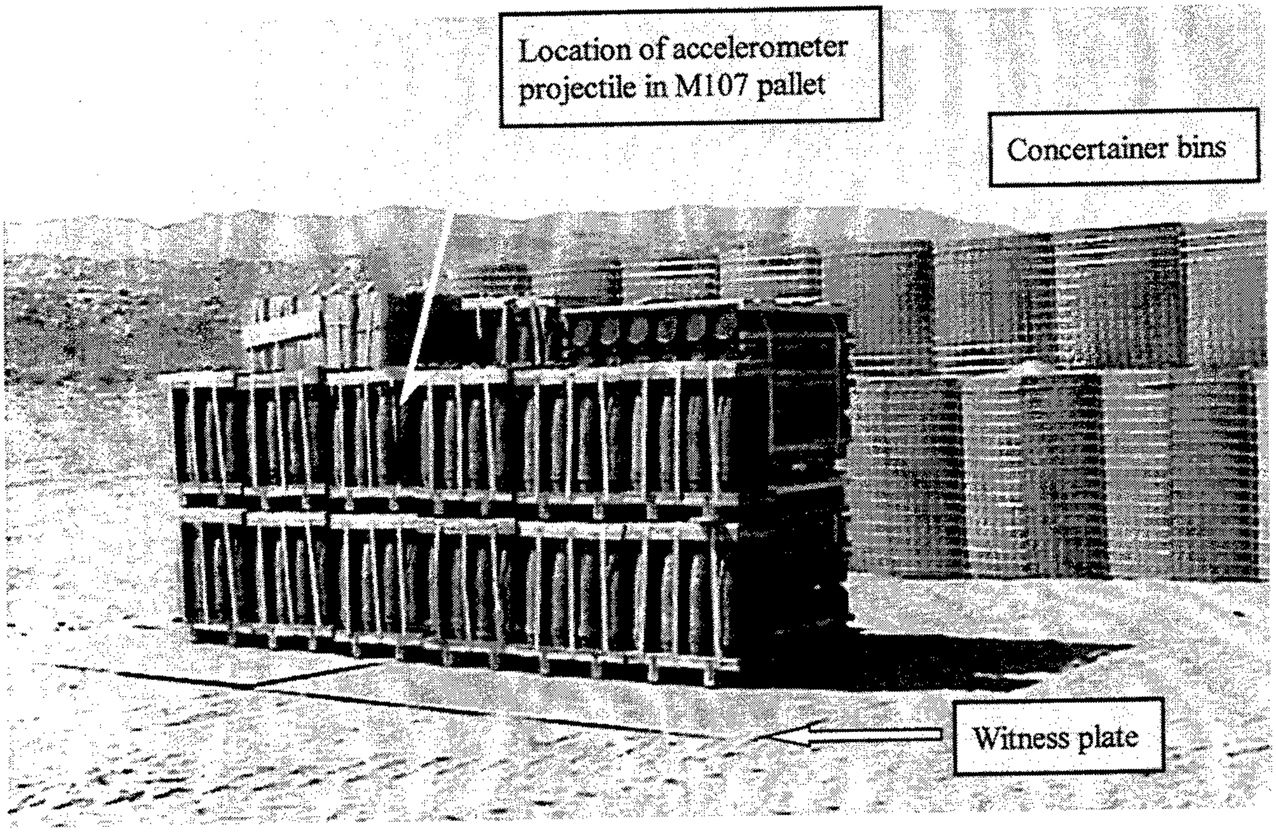
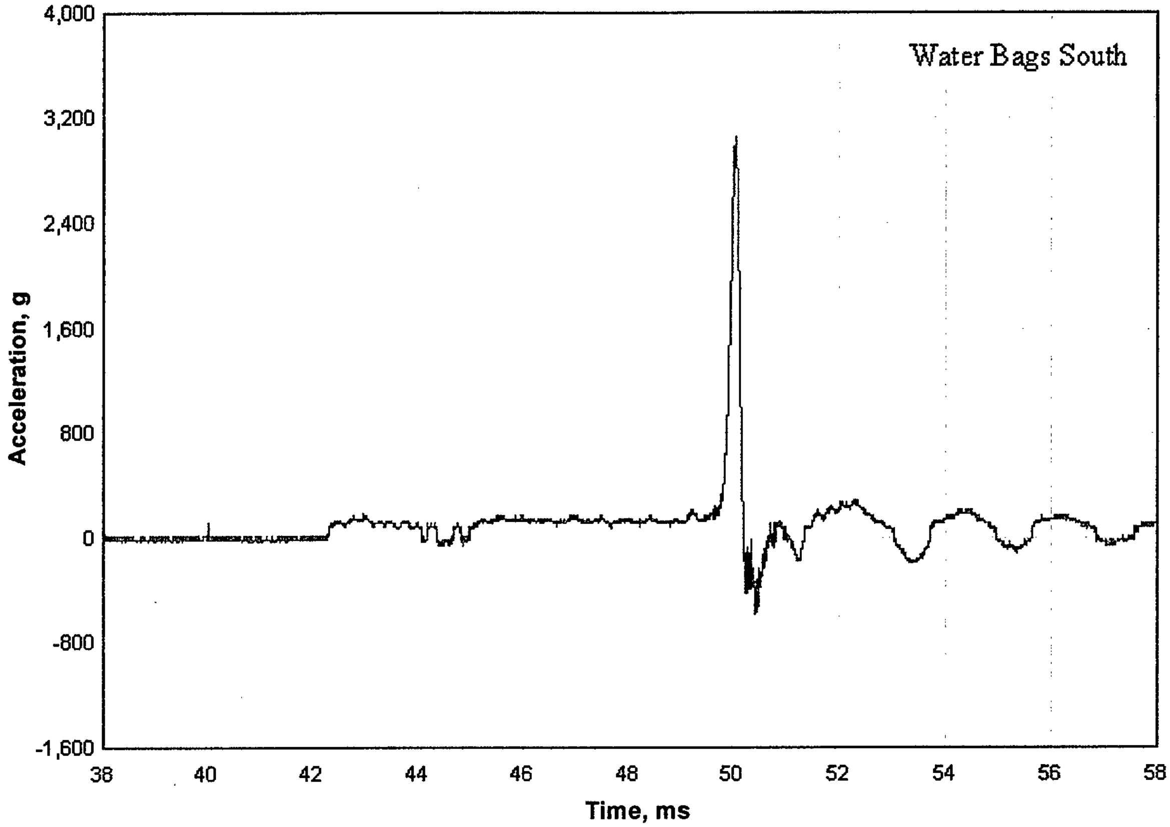


Figure B-1. Rear View of Acceptor Stack Showing Location of Accelerometer Shell.

In the water bag test, one of the acceptor stacks went high order, and its HDAS round was not found. Figure B-2 shows the one water bag record. For the Concertainer test, both rounds were recovered, and the data are shown in Figure B-3. The acceleration measured in both tests was between 3 and 5 kg, much below a full-scale record. Even so, because of the wide dynamic range of the HDAS, clean data were extracted.

Ground shock probably triggered the HDAS. That short delay time from donor stack detonation until ground shock arrival is not included on the records. Neglecting it for the nearly identical size tests, the motion of the water bag acceptor stack begins 50 ms after time zero and after 70 ms for the Concertainer acceptor stacks.

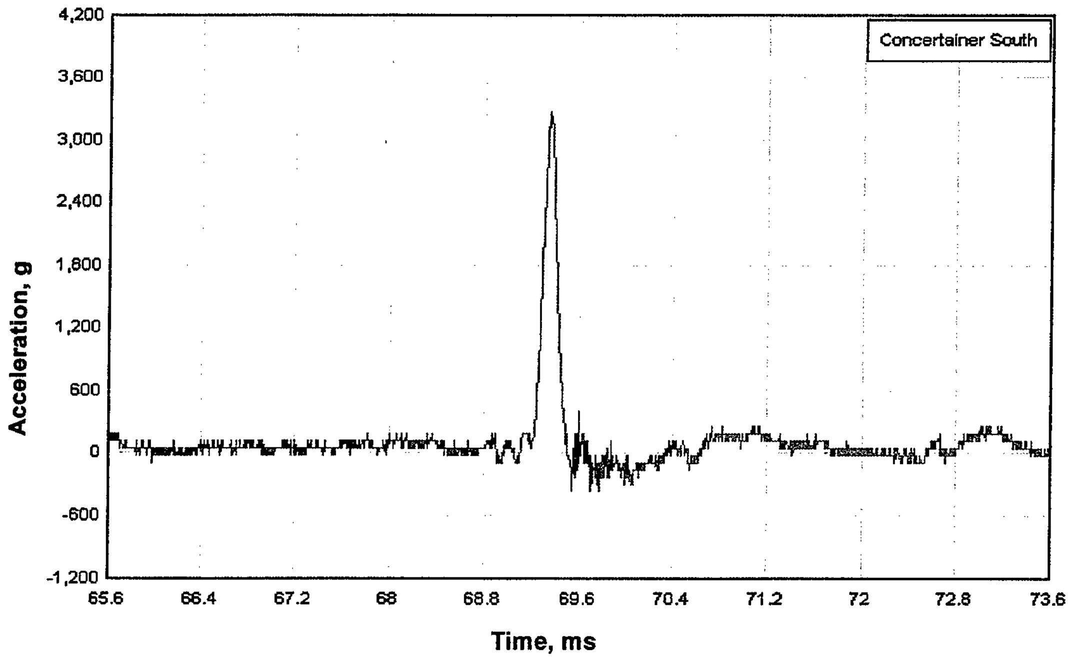


a. Accelerometer Position: Rear Middle of South Acceptor Stack.

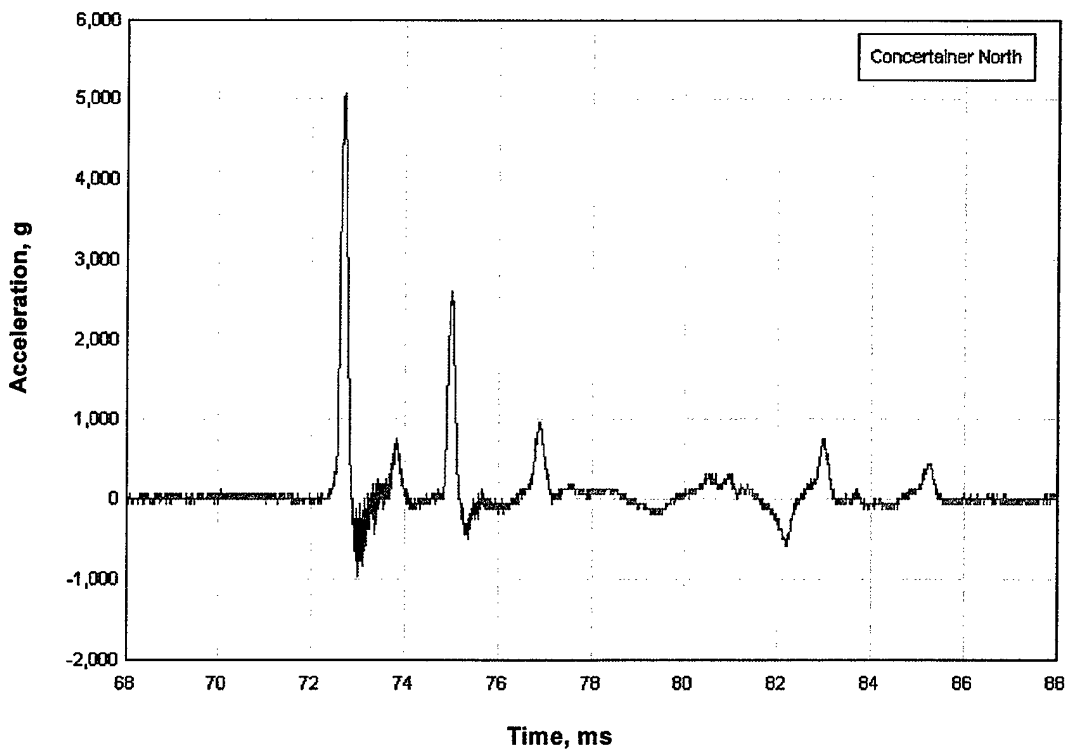
North Acceptor Stack Detonated in Water Bag Test, Destroying the Accelerometer.

b. Accelerometer Position: Rear Middle of North Acceptor Stack.

Figure B-2. Accelerometer Record in Water Bag Test.



a. Accelerometer Position: Rear Middle of South Acceptor Stack.



b. Accelerometer Position: Rear Middle of North Acceptor Stack.

Figure B-3. Accelerometer Record in Concertainer Test.

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The Munitions Survivability Technology (MST) program was initiated by the Defense Ammunition Logistics Activity to develop a rapidly deployable system of fragment barricades combined with lightweight fire-inhibiting blankets; the guidelines for their use include preventing or reducing the propagation of explosions and fire between stacks of Army munitions.

Two types of expedient barricades were tested in a large-scale, donor-acceptor ammunition setup (Hazard Class 1.1 mass detonation). The setup placed a barricade-acceptor pair symmetrically on either side of the central donor stack. One shot was fired on each type of barricade. One type of barricade contained large tubular bags of water stacked in a three-bag linear pyramid; the other type contained sand bins (Concertainer) stacked one bin on two. The sand bins were easier to set up than the water bags. The donor was a stack of palleted 155-mm HE projectiles, centrally detonated on two layers. An acceptor stack faced the barricade with a mixture of four kinds of storage compatible munitions; the most sensitive were the 15-lb demolition shaped charges. The stack was backed with weighty pallets of the 155-mm projectiles, and one housed a self-recording accelerometer. The test resulted in one water bag's acceptor stack detonating, while the other acceptor's munitions survived. High speed film shows that the initiation time was late and behind the stack, which makes shock wave, fragment, or water spray impact initiation doubtful.

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