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FINAL REPORT
JULY 1991

REPORT NO. EVT 24-90-1

MIL-STD-398 TEST OF
BARRICADE FOR M82 PRIMER,
DRAWING NO. EC-11686

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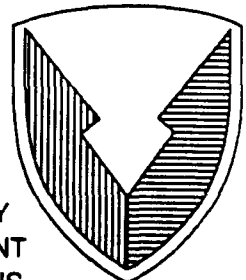
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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
 VALIDATION ENGINEERING DIVISION
 SAVANNA, IL 61074-9639

REPORT NUMBER EVT 24-90-1
 MIL-STD-398 TEST OF BARRICADE FOR M82 PRIMER, DRAWING NUMBER EC-11686

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PART 1

INTRODUCTION

A. **BACKGROUND**. The U.S. Army Defense Ammunition Center and School (USADACS) was tasked by Lone Star Army Ammunition Plant (LSAAP), Texarkana, TX to provide MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, instrumentation services for measuring blast overpressure and thermal flux produced by several charges of Class 3 black powder constrained to function high order. Two amounts of powder were used, 1.25 and 1.875 pounds. Blast overpressure and thermal flux gages were placed at the operator's position and at a possible transient position around the barricade. All test charges resulted in blast overpressure in excess of 5.0 psi reflected, shrapnel production. Thermal flux was at a minimum. As a result, the barricade for the M82 primer did not satisfy the requirements of MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, or the requirements of AMCR 385-100 for energetic materiel.

B. **AUTHORITY**. This test was conducted in accordance with mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL 61299-6000. Reference is made to Change 4, 4 October 1974, to AR 740-1, 23 April 1971, Storage and Supply operations; AMCCOMR 10-17, 13 January 1986, Mission and Major Functions of U.S. Army Defense Ammunition Center and School.

C. **OBJECTIVE**. The objective of this test is to determine if the barricade for the M82 primer, Drawing No. EC-11686, meets the requirements of MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance; Methods 101, Blast Overpressure; 201, Fragment Retention; and 301, Heat Flux Measurement.

D. CONCLUSIONS:

1. Blast overpressure at the operator's position was 5.9 and 6.31 psi for charge weights of 1.25 pounds and 9.35 psi for the charge weight of 1.875 pounds. All recorded pressures were reflected. All recorded pressures were greater than the 5.0 psi limit.

2. The barricade for the M82 primer generated shrapnel. An external aluminum vent stack cover was disengaged from the top of the barricade as a result of functioning the black powder charge. Due to the weight of the cover and the distance it moved from the centerline of the barricade, its energetic content varied from 330 ft.-lbs. to 734 ft.-lbs. Two shots, using a powder canister, yielded the lid and canister respectively, with energetic value ranging from 12.5 ft.-lbs. to 220 ft.-lbs. These energetic values exceed the limits of AMCR 385-100.

3. Thermal flux radiation recorded at the operator's position was 0.10 Btu/sq. ft.-sec. for all three tests.

4. Blast overpressure and heat flux measurements indicated that the barricade for the M82 primer, Drawing Number EC-11686, did not meet the requirements of MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, in terms of blast overpressure and fragment retention. It did meet the requirements of MIL-STD-398 in terms of thermal flux.

PART 2

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PART 3

TEST PROCEDURES

DETAILED REQUIREMENTS

100 Class - Blast Attenuation Tests

200 Class - Fragmentation Tests

300 Class - Thermal Effects Attenuation Tests

CLASS-100 BLAST ATTENUATION TESTS

METHOD 101 BLAST OVERPRESSURE MEASUREMENT

A. PURPOSE:

1. Measurement of blast overpressure is conducted to ensure that personnel are not exposed to peak positive incident overpressure greater than 2.3 psi when the operational shield is subjected to a maximum credible incident (MCI).

2. An acceptable alternate to measuring peak positive incident overpressure is to measure peak positive normal reflected overpressure. Personnel shall not be exposed to a maximum positive normal reflected overpressure greater than 5.0 psi when the operational shield is subjected to an MCI.

B. DESCRIPTION OF TEST. An MCI is created with the operational shield. Blast pressure gages are used to measure blast overpressure.

C. CRITERIA FOR PASSING TEST. The operational shield shall be considered adequate if it can be determined from a pressure-distance plot of the data that personnel will not be exposed to a peak positive incident overpressure above 2.3 psi or a peak positive normal reflected overpressure above 5.0 psi.

D. INSTRUMENTATION. Blast Pressure Gages and Electronic Recording System. Based on the equivalent test charge, weight of explosives, and anticipated peak overpressure, the instrumentation system shall have the necessary response time and bandwidth to acquire data. Instrumentation shall be calibrated in accordance with current procedures of TB 43-180, Calibration Requirements for the Maintenance of Army Materiel.

E. TEST PROCEDURES:

1. When the shield is tested in a simulated operational bay environment, overpressure readings shall be taken at the following locations:

(a) At the center of probable head locations of each operator. For standing locations, the gages shall be positioned 65 inches above the floor; for sitting locations, it shall be 31.5 inches above the seat.

(b) At representative positions where transient personnel may be located.

2. When testing is conducted in open air, position blast pressure gages around the shield in two or three concentric circles at distances where it is expected that overpressures of interest will be found. Stagger the gages so shock waves reaching the outer circles are not distorted by gages in the inner circle. The gages shall be placed at a height of 65 inches.

3. All instrumentation shall be within calibration at time of test.

4. If the shield is designed for use with more than one model or type of ammunition, select the item that would produce the maximum overpressure.

5. Apply an overload equal to 25 percent or more of the filler weight of the ammunition selected for the test, unless otherwise directed in an approved test plan.

6. All major explosive components should be fuzed separately to ensure simultaneous detonation or deflagration in order to simulate the MCI, unless otherwise directed in an approved test plan.

7. Function explosives and record overpressure readings.

8. Prepare pressure-distance plots from overpressure recordings.

CLASS - 200 FRAGMENT RETENTION TESTS

METHOD 201 FRAGMENT RETENTION TEST

A. PURPOSE. Fragment testing is conducted to verify that a prototype operational shield will:

1. Contain all fragmentation or direct fragmentation away from areas requiring protection.
2. Prevent generation of secondary fragmentation within areas requiring protection.
3. Prevent movement, overturning, or structural deflections which could result in personal injury.

B. DESCRIPTION OF TEST. An MCI is created to test the operational shield.

C. CRITERIA FOR PASSING TEST:

1. Contain all fragmentation or direct fragmentation away from areas requiring protection.
2. Prevent generation of secondary fragmentation within areas requiring protection.
3. Prevent movement, overturning, or structural deflections which could result in personal injury.

D. TEST EQUIPMENT. Still picture camera equipment.

E. TEST PROCEDURES:

1. Fragment Retention Test.

(a) If the shield is designed for use with more than one mode or type of ammunition, select that item which will have the greatest potential fragmentation or shape charge effect.

Equipment, or reasonable simulation thereof, which shall perform the intended function on the ammunition, shall be positioned to generate secondary fragments.

(b) Apply an overload equal to 25 percent or more of the filler weight of the ammunition selected for the test, unless otherwise directed in an approved test plan.

(c) All major explosive components should be fused separately to ensure simultaneous detonation or deflagration in order to simulate the MCI, unless otherwise directed in the approved test plan.

(d) Function explosives.

2. Post-Test Procedures:

(a) Examine the interior and exterior for evidence of fragments. Photograph the shield to document the results.

(b) Examine the shield for movement, overturning, or structural deflections which could result in personal injury.

(c) Shields designed for intentional detonation shall be examined for damage and an estimate made as to the ability of the shield to remain operational as specified in the design criteria.

CLASS - 300 THERMAL EFFECTS MEASUREMENT

METHOD 301 HEAT FLUX MEASUREMENT

A. PURPOSE. Heat flux measurement is a condition of measure that personnel are not exposed to a maximum radiant heat flux determined in the equation given in criteria for passing test of this standard.

B. DESCRIPTION OF TEST. An MCI is created. Heat flux transducers are used to measure radiant heat flux.

C. CRITERIA FOR PASSING TEST. The operational shield shall be considered acceptable if it can be determined from heat flux-distance and heat flux-time plots to the test data that personnel will not be exposed to a radiant heat flux rating exceeding the formula:

$F=1.0/[(0.62t)^{0.7423}]$ cal/cm²-sec, where F is the thermal flux, T is the time in seconds.

D. INSTRUMENTATION. Heat Flux Transducers and Electronic Recording System. Based on the thermal flux expected at the location of the transducers, the instrumentation system shall have the necessary response time and bandwidth to acquire data. Instrumentation shall be calibrated in accordance with current procedures of TB 43-180, Calibration Requirements for the Maintenance of Army Materiel.

E. TEST PROCEDURES:

1. When the shield is tested in a simulated operational bay environment, heat flux readings shall be taken at the following locations:

(a) At the center of probable head locations of each operator. For standing locations the transducers shall be positioned 65 inches above the floor; for sitting locations it shall be 31.5 inches above the seat.

(b) At representative positions where transient personnel may be located.

2. In a free field test, flux values at various distances from the point of detonation can be estimated by the relationship: $O_1 \times d_1^2 = O_2 \times d_2^2$, where o =heat flux in Btu/in²-sec, and d =distance from point of detonation.

3. All instrumentation shall be within calibration at time of test.

4. If the shield is designed for use with more than one model or type of ammunition, select the item for the greatest heat flux.

5. Apply an overload equal to 25 percent or more of the filler weight of ammunition selected for the test, unless otherwise directed in an approved test plan.

6. All major explosive components should be fuzed separately to ensure simultaneous detonation or deflagration in order to simulate the MCI, unless otherwise directed in an approved test plan.

7. Function explosives and record radiant flux readings.

8. Prepare heat flux-distance and heat flux-time plots from radiant flux recordings.

PART 4

LONE STAR ARMY AMMUNITION PLANT

TEST PROCEDURE

EM-8500/QAT/DK
MAY 16, 1991

TECHNICAL PROGRAM NUMBER LS-325

SUBJECT: TESTING OF PROPOSED BARRICADE FOR M82 PRIMER, DRAWING NUMBER EC-11686.

PURPOSE: TO DETERMINE IF THE PROPOSED BARRICADE WILL ADEQUATELY CONTAIN THE EXPLOSION OF 1.875 POUNDS OF BLACK POWDER, CLASS 3. THIS AMOUNT IS EQUIVALENT TO A NORMAL CHARGE WEIGHT PLUS A 25% SAFETY FACTOR.

DISCUSSION: THE PROPOSED BARRICADE WILL BE UTILIZED TO ENCLOSE DISPENSE MECHANISMS FOR BLACK POWDER, CLASS 3, REQUIRED IN PRODUCING THE M82 PRIMER. WHEN IN PRODUCTION, THE BARRICADE WILL BE MOUNTED ON A SWANSON ERIE INDEXING BASE OF THE TYPE UTILIZED IN DETONATOR PRODUCTION ON THE WHEATON LOADER THROUGHOUT MUCH OF THE AMMUNITION INDUSTRY. THIS DESIGN INCORPORATES LEXAN DOORS AROUND THE PERIMETER OF THE MACHINE FOR ADDITIONAL OPERATOR PROTECTION. IN ORDER TO DUPLICATE ACTUAL PRODUCTION MACHINE CONDITIONS, A METAL FRAME WILL BE COVERED WITH 1/4 INCH METAL WHICH WILL DUPLICATE THE LOWER TOOLING PLATE OF THE WHEATON LOADER. THE BARRICADE WILL BE POSITIONED ON TOP OF THE 1/4 INCH METAL TABLE AND PARTIALLY ENCLOSED WITH 3/8 INCH LEXAN DOORS AROUND THE PERIMETER OF THE SIMULATED WHEATON LOADER. THE LEXAN DOORS ARE AFFORD OPERATOR PROTECTION. ONE OF THE LEXAN DOORS, ADJACENT TO THE TEST BARRICADE, WILL BE THREE FEET IN WIDTH TO ENSURE ADEQUATE ACCESS FOR THE TEST TECHNICIAN. EXTENSIVE PHOTOGRAPHIC DOCUMENTATION WILL BE PROVIDED BEFORE AND AFTER THE TEST, AS WELL AS FASTEX FILMING OF THE ACTUAL DETONATION. THE BARRICADE WILL ALSO BE EQUIPPED WITH SIMULATED POWDER DISPENSE MECHANISMS TO ASSIST IN DETERMINING FRAGMENT RETENTION CAPABILITIES. ELECTRONIC EQUIPMENT WILL BE PROVIDED BY USADACS PERSONNEL TO DETERMINE BLAST OVERPRESSURE AND THERMAL FLUX. SENSORS FOR THESE DEVICES WILL BE LOCATED SOME 14 INCHES FROM THE FRONT OF THE SERVICE ENTRANCE, IN THE AREA THAT WILL BE OCCUPIED BY A PRODUCTION WORKER WHEN IN ACTUAL USE. USADACS PERSONNEL MAY ALSO DESIRE SENSORS TO THE SIDE, OR OTHER LOCATIONS, TO GATHER ADDITIONAL DATA. THE SERVICE PORT LOCATION WILL BE THE MAIN AREA OF CONCERN FOR POSSIBLE BODILY INJURY WHEN IN PRODUCTION. NOISE ATTENUATION, DUE TO THE INFREQUENCY OF ANTICIPATED DETONATION, WILL NOT BE ADDRESSED IN THIS TEST.

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MAY 16, 1991

TECHNICAL PROGRAM LS-325 (CONTINUED)

PROCEDURE: THE BARRICADE WILL BE POSITIONED FOR TESTING AT A SUITABLE LOCATION IN XX76. A #6 IRECO ELECTRIC BLASTING CAP WILL BE PLACED INSIDE THE BARRICADE WITH THE LEAD WIRES RUN TO THE OUTSIDE. IF NECESSARY, A PAIR OF SUPPLEMENTAL LEAD WIRES WILL BE ATTACHED TO THE WIRES OF THE BLASTING CAP AND SHUNTED. AN EXACT WEIGHT OF 1.875 POUNDS OF CLASS 3 BLACK POWDER WILL BE FITTED INTO A CANISTER, THE #6 IRECO BLASTING CAP WILL BE POSITIONED INTO THE MATERIAL AND THE LEAD WIRES RUN THROUGH A HOLE IN THE TOP OF THE CONTAINER. THE CANISTER WILL THEN BE SEALED BY ACTIVATING THE SPRING TENSION TOP. THIS CONTAINMENT WILL PROVIDE THE CLASS 3 BLACK POWDER THE GREATEST OPPORTUNITY TO BURN AT A SUPERSONIC RATE AND CONSEQUENTLY PRODUCE THE MAXIMUM CREDIBLE INCIDENT.

THE FIELD LINES WILL BE SHUNTED AT THE CONNECTOR BOX AND CHECKED AT THE BARRICADE END FOR CONTINUITY AND EXTRANEOUS ELECTRICITY. IF THE CIRCUIT IS COMPLETE, AND NO EXTRANEOUS ELECTRICITY IS DETECTED, THE LEAD WIRES AND FIELD LINE WILL BE CONNECTED.

THE CIRCUIT WILL BE CHECKED AT THE CONNECTOR BOX. IF NO DEFICIENCIES EXIST IN THE CIRCUIT, THE TECHNICAL SUPERVISOR WILL ASCERTAIN THAT ALL PERSONS ARE IN THEIR PROPER LOCATIONS. THE BLASTING MACHINE WILL THEN BE INTRODUCED TO THE CIRCUIT AND ACTIVATED.

SAFETY REQUIREMENTS: ALL ELECTRICAL CONNECTIONS WILL BE TAPED TO THE CIRCUIT. ALL ELECTRICAL CONNECTIONS WILL BE TAPED AND WILL BE LOCKED AT ALL TIMES EXCEPT WHEN FIRING. THE KEY WILL BE IN THE POSSESSION OF THE TECHNICAL SUPERVISOR.

PERSONNEL LIMITS: ONLY THE TECHNICIAN IN CHARGE AND TWO DESIGNATED ASSISTANTS WILL BE ALLOWED IN THE VICINITY OF THE BARRICADE WHEN EXPLOSIVES ARE BEING INTRODUCED OR ELECTRICAL CONNECTIONS ARE BEING MADE. THE TECHNICIANS WILL BE LOCATED A SAFE DISTANCE FROM THE TEST SITE AND IN A PROTECTED ENVIRONMENT DURING THE ACTUAL DETONATION OF THE BLACK POWDER. OTHER PERSONNEL WILL BE LOCATED AT THE XX OFFICE BUILDING.

PAGE 3

MAY 16, 1991

TECHNICAL PROGRAM LS-325 (CONTINUED)

NOTE: DAY AND ZIMMERMANN AND ACO SAFETY OFFICES WILL BE NOTIFIED PRIOR TO THE TEST. THE BEFORE AND AFTER STILL PHOTOGRAPHS, AS WELL AS THE FASTEX FILM, WILL BE REVIEWED TO

STANDING ORDER #63 WILL BE FOLLOWED IN THE EVENT OF ANY UNUSUAL OCCURRENCE.

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PART 5

TEST RESULTS

A. Blast Overpressure, Method 101, at Operator's Position:

1. 1.25 pounds black powder - 5.9 psi reflected.
2. 1.875 pounds black powder - 9.35 psi reflected.
3. 1.25 pounds black powder - 6.31 psi reflected.

B. Fragment Retention Test, Method 201:

1. 1.25 pounds black powder - The barricade lid, fabricated from aluminum, weighed approximately 7.34 pounds. It was displaced 62 feet from the center line of the barricade. The energetic value was 455 ft.-lbs. The powder container lid was found 50 feet from the barricade. It weighed approximately 1/4-pound and had an energetic value of 12.5 ft.-lbs.

2. 1.875 pounds black powder - The barricade lid, fabricated from aluminum, weighed approximately 7.34 pounds. It was displaced 100 feet from the center line of the barricade. The energetic value was 734 ft.-lbs. The powder container was found 110 feet from the barricade. It weighed approximately 2 pounds and had an energetic value of 220 ft.-lbs.

3. 1.25 pounds black powder - The barricade lid, fabricated from aluminum, weighed approximately 7.34 pounds. It was displaced 45 feet from the center line of the barricade. The energetic value was 330 ft.-lbs.

C. Heat Flux Measurements, Method 301:

1. 1.25 pounds black powder - less than 0.1 Btu/sq. ft.-sec.
2. 1.875 pounds black powder - less than 0.1 Btu/sq. ft.-sec.
3. 1.25 pounds black powder - less than 0.1 Btu/sq. ft.-sec.

PART 6

PHOTOGRAPHS



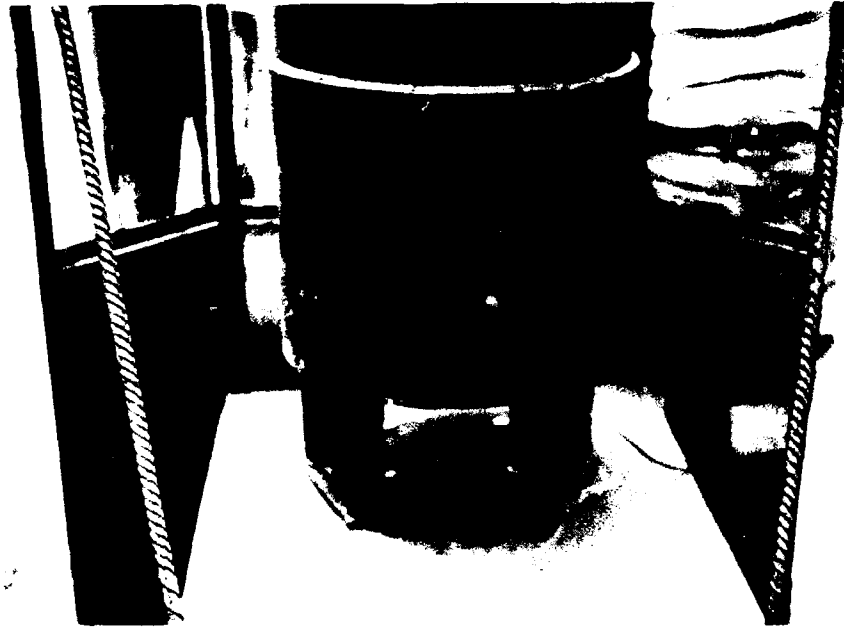
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Photo No. EVT-90-24-1-01. This is an overview of the test site with the barricade for the M82 primer in position. The test cell was open on one side and had no roof. In normal operation, the barricade would be used in a cell that has a roof. In order to simulate the actual roof, wooden scaffolding was built around the barricade and covered with translucent sheets. This roof did not simulate the real operating environment. One transducer stand was in front of the barricade, and the second at the edge of the roof line on the left. The doors on the plastic shield and the barricade were open.



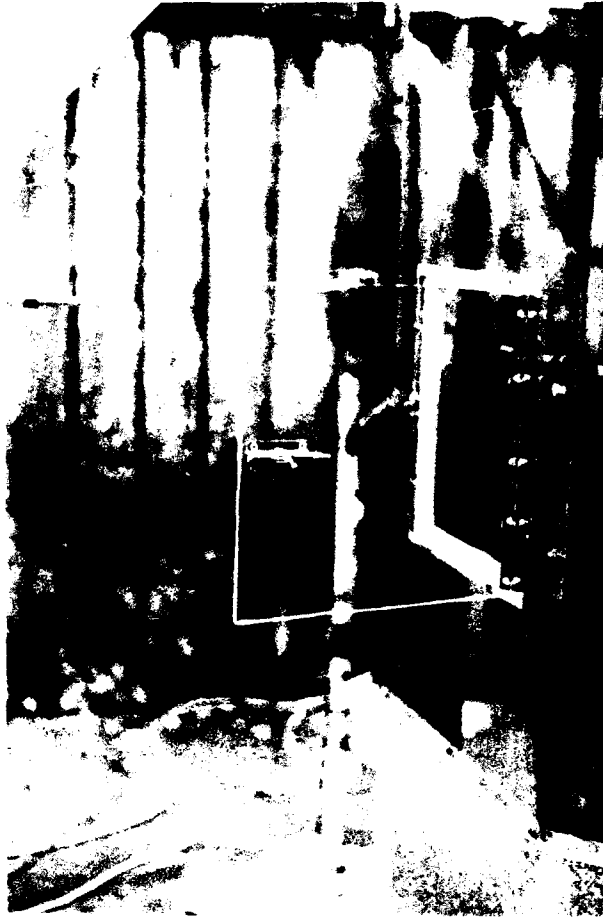
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Photo No. EVT-90-24-1-03. This is an overview of the test site with the barricade for the M82 primer in position. The test cell was open on one side and had no roof. In normal operation, the barricade would be used in a cell that has a roof. In order to simulate the actual roof, wooden scaffolding was built around the barricade and covered with translucent sheets. This roof did not simulate the real operating environment. One transducer stand was in front of the barricade, and the second at the edge of the roof line on the left.



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Photo No. EVT-90-24-1-05. This photo shows a rearview of the barricade and shield. As can be seen, the lower part of the shield was fabricated from aluminum and the upper portion from lucite. The frame was made from angle-iron and attached to the barricade base with 1/2-inch rebar welded in place.



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Photo No. EVT-90-24-1-06. This photo shows the secondary shield access door and method of attachment and closure lock. A blast overpressure gage is at the left.



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Photo No. EVT-90-24-1-08. This photo shows the M82 barricade loaded with black powder constrained by the aluminum can. The firing wire can be seen in front of the sealed can.



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Photo No. EVT-90-24-1-09. This photo shows the M82 barricade with the barricade door and shield door closed. The barricade was loaded with the constrained black powder ready for functioning.



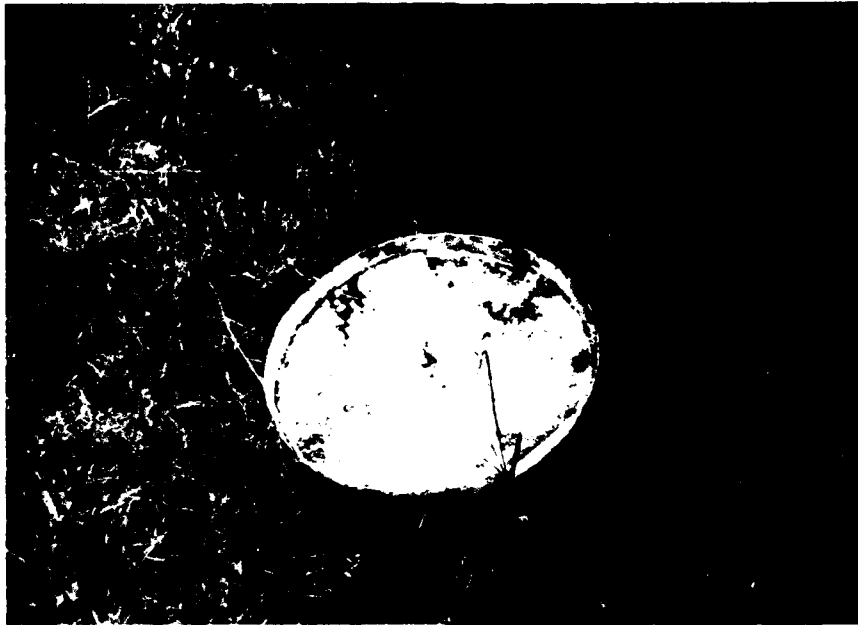
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Photo No. EVT-90-24-1-12. This photo shows the inside of the M82 primer barricade, as seen through the loading door after detonating 1.25 pounds of black powder. The powder canister cover was blown out of the barricade. The barricade retained all other schrapnel.



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Photo No. EVT-90-24-1-16. This photo shows the M82 primer barricade, secondary lucite shield, and transducer stands. Each transducer stand had a blast overpressure gage and thermal flux gage mounted at operator's head height. The wooden structure supported a simulated roof over a portion of the test cell. In actual operation, the barricade would be operated in a building with the exhaust stack vented through the roof. With the roof configuration used in testing, recorded pressures were in excess of the 5.0 psi limit.



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<p>Photo No. EVT-90-24-1-19. This photo shows the M82 primer barricade exhaust stack cover where it was found after detonating 1.25 pounds of M10 propellant. The cover was found 62 feet from the centerline of the barricade. The energetic level required to move the lid this distance exceeded the limit imposed by AMCR-385-100.</p>
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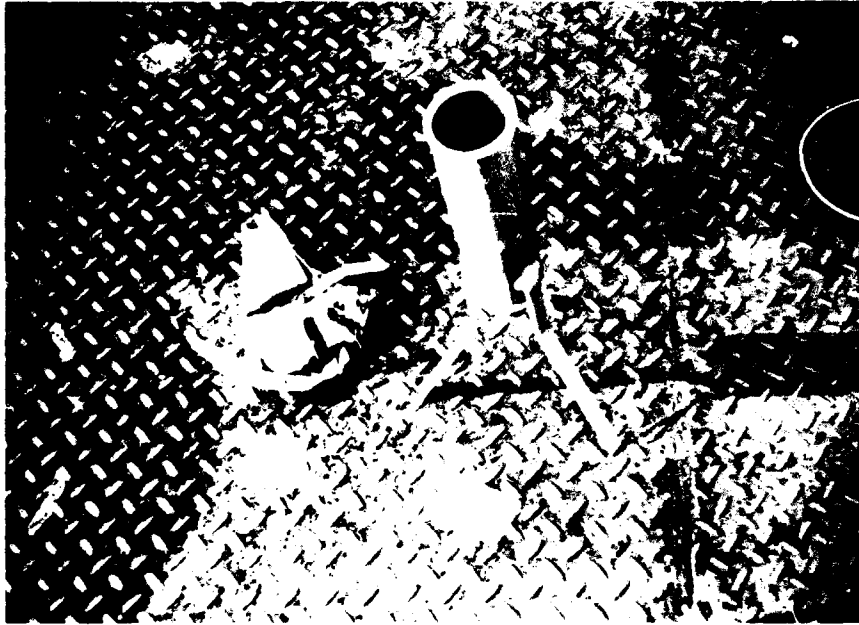
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<p>Photo No. EVT-90-24-1-20. This photo shows, in the foreground, the M82 primer barricade cover after detonating 1.6 pounds of M10 propellant. The cover was found 100 feet from the barricade. The energetic level required to move the lid this distance was in excess of the limit imposed by AMCR-385-100.</p>



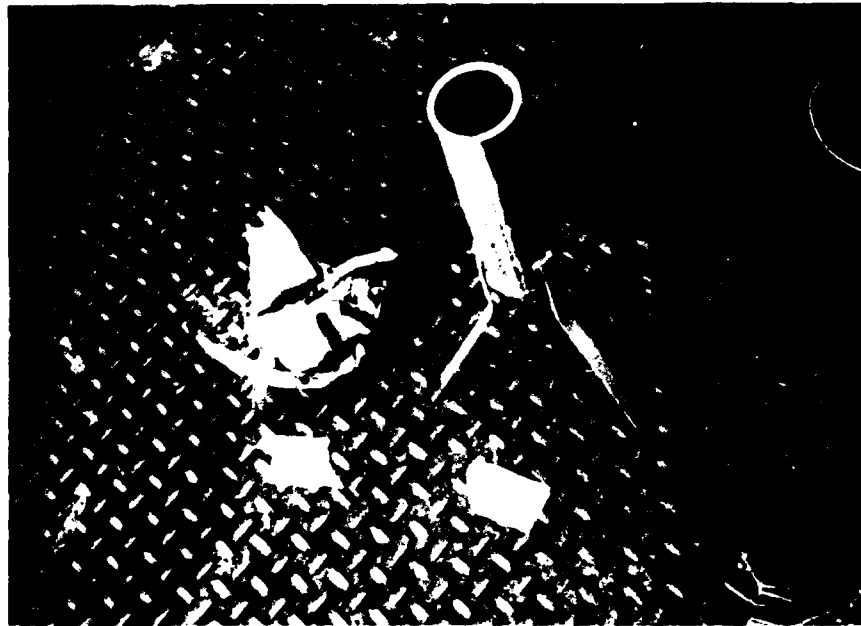
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Photo No. EVT-90-24-1-21. This photo shows, in the foreground, the top of the powder container used to hold the detonated M10 propellant. It illustrates the distance the cover moved as shrapnel from inside the M82 primer barricade to 110 feet from the barricade, as a result of the detonation.



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Photo No. EVT-90-24-1-22. This is a model of the M10 propellant hopper that will be in actual use for loading the M82 primers. The electric match was placed at the bottom of the hopper, 1.6 pounds of propellant were loaded, then the match was functioned. The powder in the hopper detonated. All that remained was the twisted metal at the left. An unused model is at the right. During actual production operation, the mass is required to get the propellant to flow at the required feed rate. As a result, there is a potential for the filler hopper to detonate based on the "critical mass" of the M10 propellant fill.



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Photo No. EVT-90-24-1-26. This is a model of the M10 propellant hopper that will be in actual use for loading the M82 primers. The electric match was placed at the bottom of the hopper, 1.6 pounds of propellant were loaded, then the match was functioned. The powder in the hopper detonated. All that remained was the twisted metal at the left. An unused model is at the right. During actual production operation, the mass is required to get the propellant to flow at the required feed rate. As a result, there is a potential for the filler hopper to detonate based on the "critical mass" of the M10 propellant fill.