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# U.S. Army Defense Ammunition Center and School

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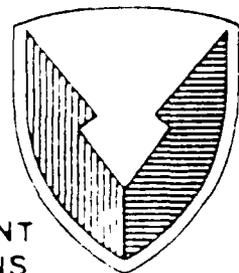
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## MIL-STD-1660 TEST of PA116 120MM TANK AMMUNITION on a STANDARD 40" x 44" METAL PALLET WITH ADAP- TOR ASSEMBLY

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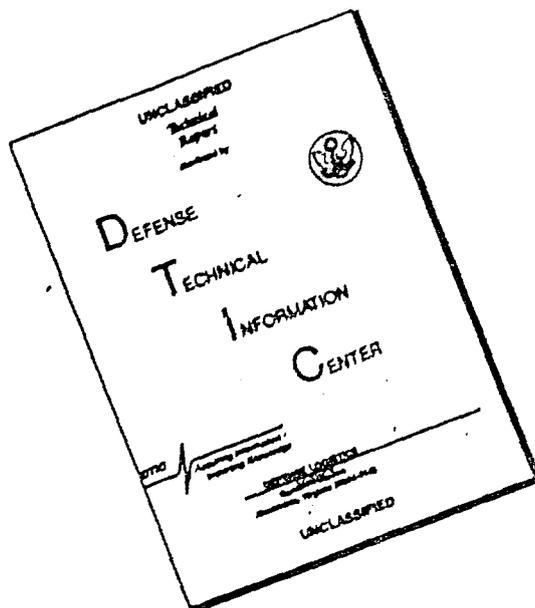


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19. ABSTRACT (Continue on reverse if necessary and identify by block number) The U.S. Army Defense Ammunition Center and School (USADACS) was tasked by Project Manger-Ammunition Logistics (PM-AMMOLOG) to develop an adaptor assembly for the standard 40" by 44" metal pallet for unitization of the 120mm tank ammunition. The objective of this project was to replace the specially designed (single commodity) currently fielded 120mm metal pallet with a less expensive multipurpose standard metal pallet. MIL-STD-1660 tests were conducted on a series of three standard metal pallets with 120mm metal adaptors during the months of July and August, 1988, with all three pallets passing MIL-STD-1660 tests. All pallets had minor metal/weld cracks which was expected. All pallets were serviceable, stackable, and safe to remain in the transportation cycle after testing. The general condition of the standard metal pallets with adaptors was superior to the currently fielded 120mm metal pallet. It is therefore recommended that the standard 40" by 44" metal pallet with adaptors replace the currently fielded pallet.						
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# PART I

## A. INTRODUCTION.

The U.S. Army Defense Ammunition Center and School (USADACS) was tasked by PM-AMMOLOG to develop and test a special adaptor assembly to be used on the standard 40"x44" metal pallet for the purpose of unitizing PA116 containers for 120mm tank ammo. The objective of this program was to reduce cost, while improving the overall quality of the unitized load.

## B. AUTHORITY.

This test was conducted in accordance with mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM) and AR 740-1.

## C. OBJECTIVE.

The test objective was to determine if an adaptor assembly could be placed on a standard 40"x44" pallet for the purpose of unitizing 120mm tank ammunition and pass MIL-STD-1660 design criteria for ammunition unit loads.



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PART 2

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## PART 3

### Test Procedures

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies five steps that a unitized load must undergo if it is considered to be acceptable. These tests are synopsized below:

1. STACKING TESTS. The unit load shall be loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load is simulated by subjecting the unit load to a compression of weight equal to an equivalent 16-foot stacking height. The compression load is calculated in the following manner. The unit load weight is divided by the unit load height in inches and multiplied by 192. The resulting number is the equivalent compressive force of a 16-foot-high load.

2. REPETITIVE SHOCK TEST. The repetitive shock test shall be conducted in accordance with Method 5019, Federal Standard 101. The test procedure is as follows. The test specimen shall be placed on, but not fastened to, the platform. With the specimen in one position, vibrate the platform at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of about 3 cycles per second. Steadily increase the frequency until the package leaves the platform. The resonant frequency is achieved when a 1/16-inch-thick feeler may be momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieves one plus or minus zero point one G. Midway into the testing period the specimen shall be rotated 90 degrees and the test continued for the duration. The total time of vibration shall be two hours if the specimen is tested in one position; and if tested in more than one position, the total time shall be three hours.

3. EDGEWISE DROP TEST. This test shall be conducted by using the procedures of Method 5008, Federal Standard 101. The procedure for the Edgewise Drop (Rotational) Test is as follows. The specimen shall be placed on its bottom with one end of the base of the container supported on a sill nominally six inches high. The height of the sill shall be increased

if necessary to ensure that there will be no support for the base between the ends of the container when dropping takes place, but should not be high enough to cause the container to slide on the supports when the dropped end is raised for the drops. The unsupported end of the container shall then be raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection shall conform to the following tabulation.

GROSS WT.	DIMENSIONS ON	HEIGHT OF DROP
NOT EXCEEDING	ANY EDGE	LEVEL A PROTECTION
POUNDS	INCHES	INCHES
600	72	36
3,000	No Limit	24
No Limit	No Limit	12

4. IMPACT TEST. This test shall be conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the Incline-Impact Test is as follows. The specimen shall be placed on the carriage with the surface or edge which is to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage shall be brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4x4-inch optional timber may be attached to the bumper in the desired position before the test. No part of the timber shall be struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are subjected to impacts may be at the option of the testing activity and will depend upon the objective of the tests. When the test is to determine satisfactory requirements for a container or pack, unless otherwise specified, the specimen shall be subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact shall be 7 feet per second.

5. MECHANICAL HANDLING WITH ATTACHMENTS. This test shall be conducted in accordance with Method 5011, Federal Standard 101 Sub-Part 6.3, Hoisting With Slings. Attach slings to the four hoisting arrangements. The length of the slings shall be such that, when lifting, they form angles between 20 and 25 degrees with a horizontal plane. Lift the specimen clear of the floor and hold it suspended for not less than two minutes. Observe for any indications of inadequacies in this specimen. Record observations and let the specimen down. Repeat the previous procedure using three, two, alternate two, and one sling

## PART 4

### TEST EQUIPMENT

#### 1. TEST SPECIMEN.

- a. Pallet Weight: 103 lbs.
- b. Lower Adaptor: 40 lbs.
- c. Top Adaptor: 39 lbs.
- d. Total Pallet Weight: 2,690

#### 2. COMPRESSION TESTER.

- a. Manufacturer: Ormond Scientific
- b. Platform: 60 inches by 60 inches
- c. Compression Limit: 50,000 pounds
- d. Tension Limit: 50,000 pounds

#### 3. TRANSPORTATION SIMULATOR.

- a. Manufacturer: Gaynes Laboratory
- b. Capacity: 6,000 pound pallet
- c. 1/2-inch Amplitude
- d. Speed: 50 to 3000 cpm
- e. Platform: 5 foot by 8 foot

#### 4. INCLINED RAMP.

- a. Manufacturer: Conbur Incline
- b. Impact Tester
- c. 10 Percent Incline
- d. 12 Foot Incline

## Part 5

### Test Results

#### Pallet I Test Results.

Pallet I was compressed to a test weight of 10,440 pounds for a period of 1 hour simulating a unitized stack of 16 feet. The center band during compression was noted to be somewhat loose but returned to a taut configuration after this test.

During the 180 minutes of low frequency vibration testing the vibration table was set at 180rpm.

At the end of 90 minutes, several minor metal/weld cracks were noted at the bell end of the pallet on the skid supports as well as the center runner itself.

At the end of an additional 90 minutes, several additional metal/weld stress cracks were also noted.

During the four 24" edgewise rotational drops, less than 1/2" deck warping perpendicular to the skids was noted, with no changes noted to the pallet during slinging and incline plane impact tests.

At the conclusion of MIL-STD-1660 tests the bottom row of projectiles was removed with no container or projectile damage observed.

End of test pallet examination indicated metal and weld stress cracks ranging from .42" to 1.10" on the pallet deck, with the average length of each weld estimated to be 5.5".

Therefore, the worst cracks noted in this area were approximately 20 percent of the total weld with no structural failures occurring.

Weld/metal cracks were also noted of the skid supports, and ranged from .17" to .88" with no structural or weld failures occurring.

Deck flatness perpendicular to the skids was .37" at the base end of the pallet and .42" at the bell end of the pallet. Therefore only slight side to side rocking of the pallet occurred to the pallet at the end of the test.

### Pallet II Test Results

Pallet II was compressed to 10,480 pounds, with minor adjustments required to compensate for pallet compaction during the test.

Low frequency vibration for the first 90 minutes was at 180 rpm, and the load being applied parallel to the skids. Again, several minor weld/metal cracks were noted at the end of 90 minutes.

At the conclusion of the second 90 minutes at 188rpm, no additional cracks were noted.

At the conclusion of four 24" edgewise rotational drops, incline, tilt, and slinging tests, no major changes were noted to the pallet or metal filled containers. The projectiles were again removed with no damage observed.

End of test pallet examination indicated deck weld/metal cracks ranging from 0.37" to 1.41" with skid support cracks ranging from 0.09" to 1.15" with no failures noted.

The deck flatness at the end of all tests was 0.30" at the base end of the pallet and 0.16" at the bell end of the pallet.

### Pallet III Test Results

Pallet III was compressed to 10,500 pounds, with no damage occurring.

The first 90 minutes on the low frequency vibration was at 195 rpm, and at 50 minutes into this cycle lower adaptor pin failure was noted where attachment to the metal pallet takes place. This pin failure was the result of quality control problems by the manufacturer due to incomplete and improper welding of the pin.

The second 90 minutes of low frequency vibration perpendicular to the skids was at 215 rpm with no weld cracks noted at test conclusion.

The four 24" edgewise rotational drops were conducted without incident, as well as incline plane and slinging tests.

At the conclusion of testing, the bottom row of rounds was removed with no container or round damage observed.

End of test pallet examination indicated several minor pallet deck metal/weld cracks of 0.52" to 0.96" with skid support cracks ranging from 0.11" to 0.59", with this pallet showing the least amount of damage of the three pallets tested.

Pallet deck flatness at test conclusion was 0.21" at the base end and 0.25" at the bell end of the pallet.

## PART 6

### Conclusions

Both the currently fielded and the standard pallet meet or exceed MIL-STD-1660 requirements, but based on the superior mechanical strength and durability of the standard pallet it is highly recommended that the standard pallet replace the currently fielded metal pallet for the 120mm tank ammunition.

Other advantages of the standard pallet include:

- Cost savings on a per pallet basis.
- Simpler design with less welds.
- Curved (rounded) skids for sliding across unimproved surfaces.
- Elevated lower support structure for the containers, providing greater protection to the containers during rough material handling conditions
- Multi-reusable pallets for other commodities.
- Additional skid strength in the lateral and longitudinal directions providing increased durability during rough terrain material handling operations.

During MIL-STD-1660 testing, each pallet reacted differently, on the low frequency vibration table with speed changes and adjustments required to maintain the required 1/16" clearance; this is due in part to the following variables:

- Strap tension and uniform tension between straps.
- Deck flatness in the longitudinal and lateral directions.
- Workmanship, including clearance between mating parts, and weld quality.
- Skid warping in the longitudinal and lateral direction.
- Skid and deck damage during material handling before testing.

A disadvantage of the standard metal pallet over the current fielded metal pallet is the increased weight due to the addition of the lower adaptor assembly on the standard pallet.

All pallets tested showed minor metal/stress cracking at points of contact with the skids and top deck assembly, from extremely small almost non detectable to the more obvious metal/stress cracks. These cracks and the degree vary from pallet to pallet depending on the geometry of the pallet being tested and how well critical points are being uniformly loaded, and is common to all pallets tested to date, regardless of the design configuration. Minor metal cracking is acceptable during MIL-STD-1660 testing as long as structural failure does not occur and the pallet, after testing, is still serviceable, stackable, and safe to remain in the transportation cycle.

### RECOMMENDATIONS

The following changes are recommended on production pallets to further enhance the quality and durability of the standard pallet.

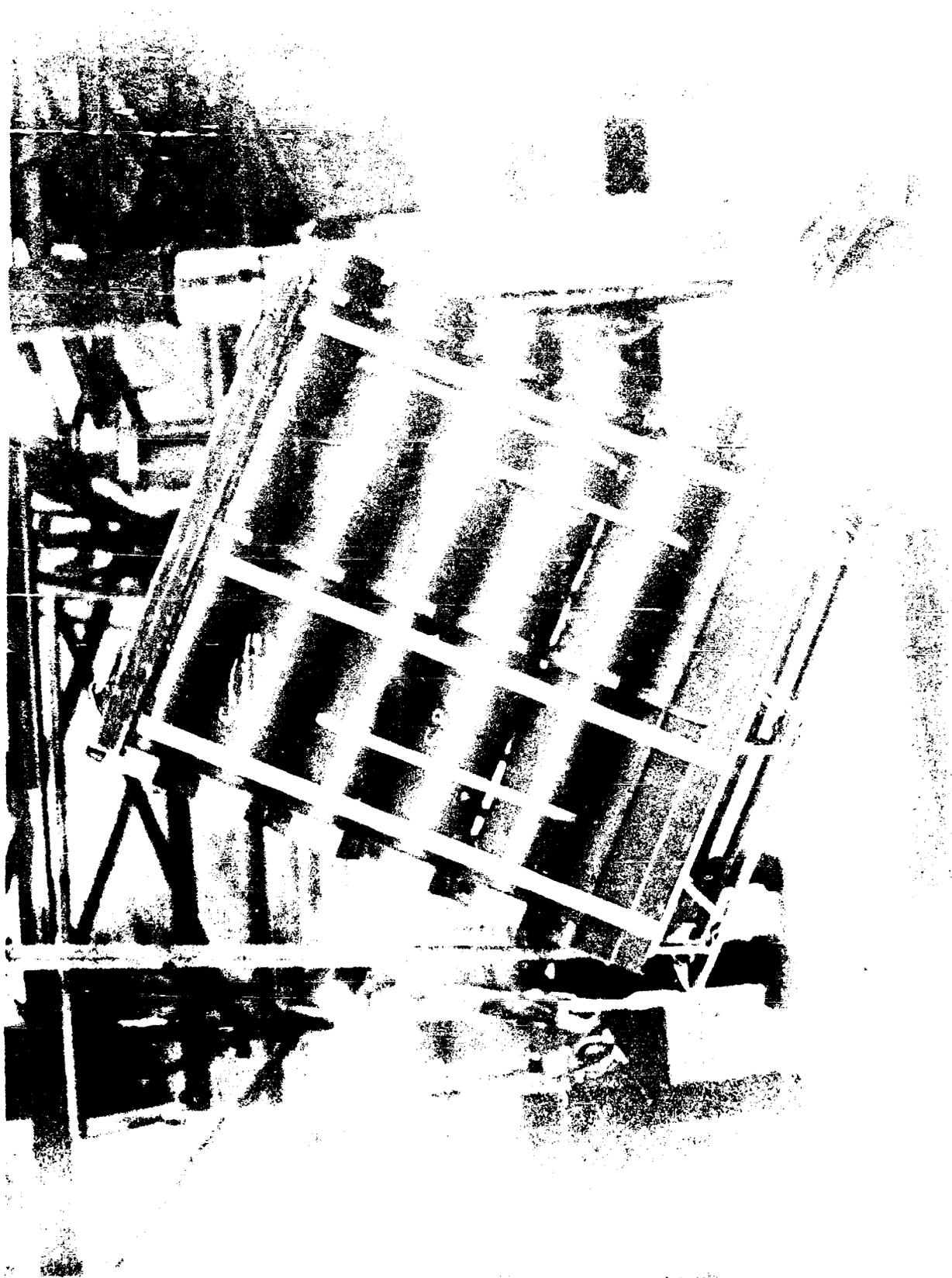
- Full welds the entire length of all mating parts on production pallets.
- The reinforcing dimple on the skid support shifted inward to remove metal stress at the leading edge of the support.
- Tighter quality control measures be taken during the assembly of mating parts to avoid high spots in the pallet deck.
- Deck flatness tolerances be included in the production drawings for both the longitudinal and lateral directions.
- Increased diameter of the lower support pins which mate with the pallet deck.

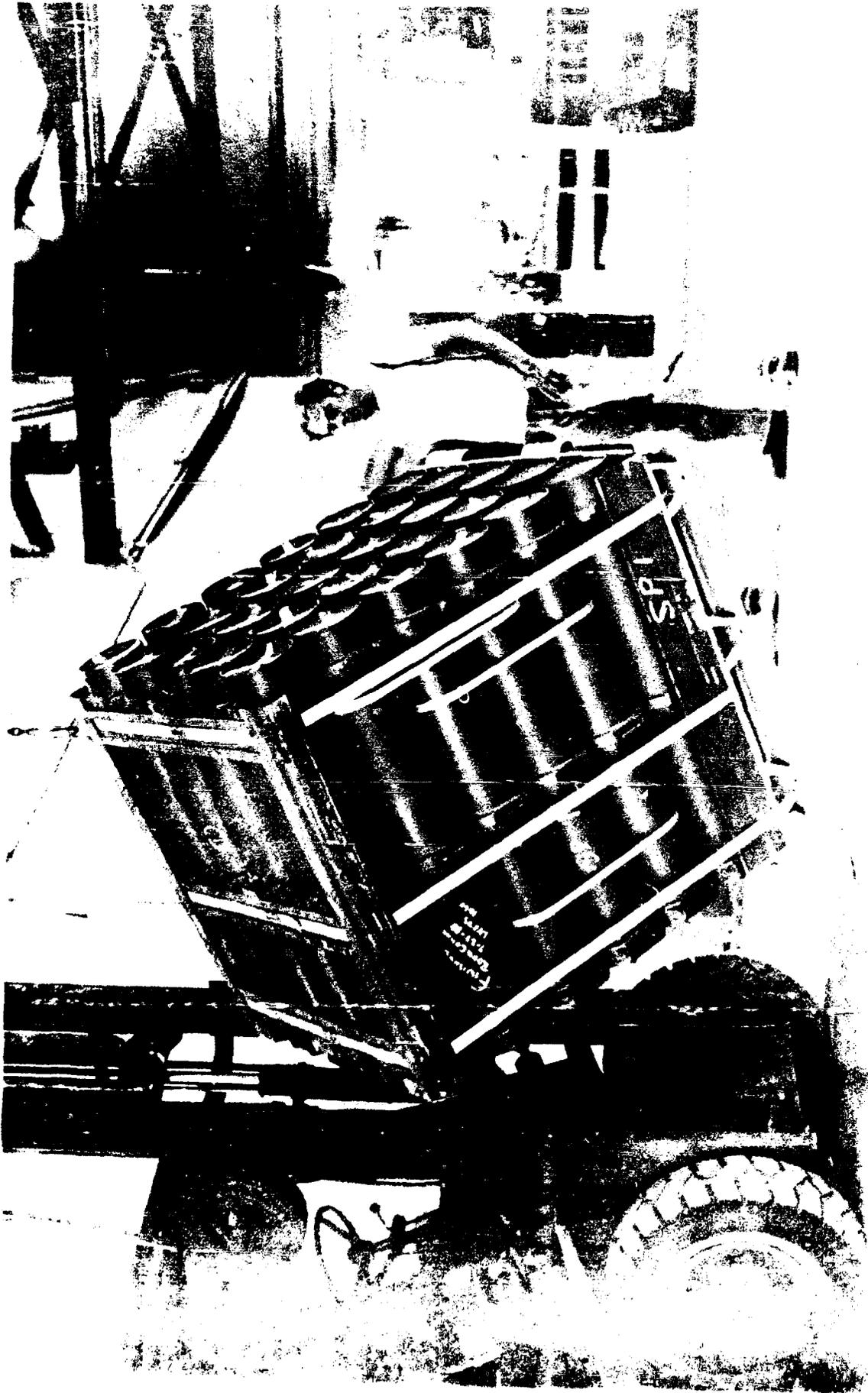
PART 7  
PHOTOGRAPHS



DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

... of pallet orientation for the 37th ...





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Stacks of the 300 of the standard bullet of 1000 rounds.



DEFENSE AWARDS



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