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REPORT NO. EVT 42-87

HEMTT SLING ANGLE FOR THE DOUBLE  
BASKET CHAIN SLING

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>The U.S. Army Defense Ammunition Center and School (USADACS) has been requested by the Department of the Army, HQ 191st Ordnance Battalion, AEROD-P-MA, APO New York, to evaluate a suggestion. The suggestion covers the the use of spreader bars to separate the chain slings, to avoid pallet damage during loading and unloading of the M977 Heavy Expanded Mobility →<br><br>Continued |                       |                                                             |

Tactical Trailer (HEMTT). The initial evaluation of the suggestion concluded that spreader bars were unnecessary in avoiding pallet damage if sling angles between 45 degrees and 60 degrees were maintained during material handling operations. The following tests are being conducted to confirm this initial evaluation. The evaluation of the sling angle versus pallet damage is based on Federal Test Method Standard 101B Method 5011, 15 January 1969, Mechanical Handling Test (undersling handling). The spreader bar stability tests are based on Military Standard 1660, Sling Compatibility Test, 8 April 1977 and U.S. Army Defense Ammunition Center and School Report, EVT 6-78. Tests conducted at USADACS on 26-28 October 1987 confirmed the initial evaluation that spreader bars are not required if the proper rigging procedures of 45 to 60 degree angles are maintained during material handling operations. Minor pallet damage noted at sling angles less than 45 degrees for all pallets tested, is not great enough to warrant repalletization of the damaged boxes. Tests conducted regarding pallet stability with the use of spreader bars indicated that no adverse material handling conditions occurred with their use and spreader bars were safe to use if proper design requirements are followed. It was concluded that spreader bars could be used on a voluntary basis to avoid minor pallet damage if desired.

U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL  
Evaluation Division  
Savanna, IL 61074-9639

REPORT NO. EVT 42-87

HEMTT SLING ANGLE FOR THE DOUBLE  
BASKET CHAIN SLING

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## PART 1

### INTRODUCTION

#### A. BACKGROUND.

A suggestion was received from the Department of the Army, HQ 191st Ordnance Battalion, APO New York, regarding the use of spreader bars to avoid pallet damage. The suggestion indicated that the M977 HEMTT adjustable basket chain sling was causing pallet damage to ammunition during on and off loading operations of the HEMTT truck. The damage to the pallets was caused by angles (pallet to the top of the crane hook) less than 45 degrees that were used while handling pallets. To avoid this damage, spreader bars were constructed (see figure 1) which separated the chain slings, reducing side pressure on the pallets and avoiding damage. The suggestion stated that damage to the pallets included both the container (wood boxes, wire bound boxes and metal cans), as well as the ammunition itself in some cases. The suggestion concluded that this damage resulted in repair and repalletization of ammunition boxes as well as, in some cases, inspection and replacement to the ammunition itself. The double basket chain sling was originally designed by USADACS so that the proper rigging angles (45 to 60 degrees) could be maintained for different size pallets during material handling operations.

#### B. AUTHORITY.

This study was conducted in accordance with AR 740-1 mission responsibilities.

#### C. TEST OBJECTIVES

1. Determine if spreader bars are required to avoid functional damage to the ammunition and or structural damage to the containers at reduced sling

angles.

2. If spreader bars are required, what degree of physical contact is required for safe material handling operations.

3. What general design requirements should be followed.

PART 2

ATTENDEES

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### PART 3

#### TEST PROCEDURES

The test procedures outlined herein were extracted from the general guidelines set forth in MIL-STD-1660, Sling Compatibility Test, 8 April 1977, Federal Test Method Standard 101B, Method 5011, Mechanical Handling Test, 15 January 1969, and U.S. Army Defense Ammunition Center and School Report EVT 6-78.

#### SLING ANGLE VERSUS CONTAINER/CONTENT DAMAGE TEST

The pallets were supported by two slings, one near each end of the pallet, and brought to a common point above the center of balance for attachment to the hoist. The pallets to be tested were wire bound boxes, wood boxes, and metal cans with a pallet weight range between 4000 and 4400 pounds. The vertical lifts were for a minimum of two minutes and began at a 60 degree sling angle and decreased by 5 degree increments until the minimum sling angle was reached. The first 30 seconds of each test, rough material handling conditions were simulated. Pass/fail criteria for this test was based on Standard 101B Method 5011, para 7.1.5, which in part states "when the container or package is subjected to mechanical handling tests the contents (except a dummy load) shall show no functional or physical damage and the container and packing shall show no functional damage. Damage to the exterior shipping container which is the result of improper interior packaging, blocking or bracing, shall be cause for rejection. Structural failure of the exterior shipping container which would result in spilling of the contents, or failure of the container in subsequent handling, is cause for rejection. There shall be no evidence of a substantial amount of shifting of the contents within the exterior shipping container that would create conditions likely to

cause damage during shipping, storage, or reshipment of the container. MINOR CONTAINER DAMAGE SUCH AS CHIPPING OF THE WOOD MEMBERS, NEGLIGIBLE DENTS, OR PAINT CHIPPING IS NOT CAUSE FOR REJECTION.

#### SPREADER BAR STABILITY TEST

This test was conducted with a 53-inch-high pallet with a mass of 2300 pounds. The spreader bars were constructed so as to allow no lateral pressure to be applied to the top of the pallet by the chains which created an unstable material handling condition. The pallet was lifted, swung, and lowered by a crane to determine if safe handling of the pallet could be maintained while using spreader bars. Pass/Fail criteria for this test was based on MIL-STD-1660, Sling Compatibility Test, which in part states "when danger of slippage or disengagement (of the sling) when the load is suspended shall be cause for rejection of the load unit" (which would create an unsafe material handling situation). This test was lieu of the hoisting test outlined in USADACS Report EVT 6-78 (hoisting test).

#### RAISED DROP/CATCH TEST

The pallet was lifted approximately ten feet into the air, the cable brake on the crane was released, allowing the load to drop to the ground, with the brake being reset prior to the pallet impacting the ground. The abrupt stop (catch) was as severe as the equipment could generate. The pallet, upon test completion, was inspected for signs of damage and deformation caused by the chain and/or the spreader bars.

#### SLEWING TEST

The pallet was lowered to within two feet of the ground with a minimum of eight feet of cable between the tip of the boom and the crane hook. The crane was transversed through an arc of 90 degrees and brought to an abrupt

stop. Attention was given to the side slip of the pallet as well as slipping of the chain and spreader bars. If the chains and spreader bars did not require readjustment prior to further material handling, the test was considered successful with no hazardous material handling conditions present.

#### SLEW IMPACT WITH THE GROUND TEST

The pallet was lowered to within one foot of the ground and having at least eight feet of cable between the tip of the boom and the crane hook. The boom was traversed through an arc of 90 degree, traveling at maximum speed with the hook intentionally being lowered, causing the pallet to impact the ground as the boom continued to swing through its intended arc of travel. The ability of the chain sling with spreader bar to pick up the pallet after impact without readjustment or causing unsafe material handling conditions was considered passing for this test.

#### SLEW IMPACT WITH THE WALL TEST

The pallet was lowered to within two feet of the ground with a cable length of at least eight feet from the tip of the boom to the pallet. The pallet was transversed through an arc of 90 degrees prior to impacting the wall at a velocity of about seven feet per second. Pass/fail criteria for this test was the ability of the lifting sling with spreader bars to maintain pallet stability after impact as well as lifting the pallet again without readjustment of the chain sling and/or spreader bar prior to further material handling.

PART 4  
TEST EQUIPMENT

1. TEST PALLETS

A. Pallet with Wood Boxes (105mm Howitzer Wood Boxes)

width 36 inches

height 41.5 inches

length 37 inches

weight 4,180 pounds

B. Pallet with Wirebound Boxes (5.56mm Small Arms)

width 43 inches

height 50 inches

length 50 inches

weight 4,220 pounds

C. Pallet with Metal Cans [548 Metal Cans (20mm Electric Primer Cans)]

width 40 inches (approx)

height 24 inches (approx)

length 44 inches (approx)

weight 4,315 pounds

D. Pallet with Wood Boxes (105mm Howitzer Wood Boxes)

width 36 inches

height 53 inches

length 37 inches

weight 2,302 pounds

2. TEST EQUIPMENT

A. Hemtt Truck with crane

B. Mobil Crane

C. 1- Spreader Bar see figure 1 page 7-1

D. 1- double basket sling Fed. Stock No. 3940-01-209-6008

## PART 5

### TEST RESULTS

#### 1. Sling Angle Versus Container/Content Damage Test.

A. Test Pallet Containing Wood Boxes. Tests started at a 60 degree angle with the pallet being lifted approximately two feet off the ground. The first 30 seconds of each lift, the crane was oscillated, causing a jerking motion on the chain which increased the pressure exerted to the top of the pallet at points of contact with the chain. Following this procedure, the pallet was suspended in mid-air for a period of an additional 90 seconds, allowing the chains to dig into the sides of the containers. This procedure was followed for all lifts to simulate rough material handling of the pallets by the crane operator. Lifts from 60 down to 45 degrees showed no container damage with the exception of 1/4 inch imbedment of the chain at contact points. The tests continued down to 30 degrees with the boxes being inspected after each lift to determine serviceability of the containers. Each lift after 45 degrees showed minor increases in the container damage. The test was stopped after the 30 degree lift with the boxes still serviceable. The side walls supporting the hinges were extended inward approximately 3/8 inch with the hinges and wooden lid still operable and serviceable. The contents within the boxes (inert fill) showed no signs of spillage. Photo 1 page 8-1 shows damage to the wooden box after the final lift. A second series of tests were conducted with the pallet rotated 90 degrees. With the chains contacting the ends of the wooden boxes, embedment of the chains into the end grain of the wood was noted, as well as chipping of the wood at points of contact, photo 2 page 8-2.

B. Test Pallet Containing Wire Bound Boxes. The same test procedure was followed as described above with the following damage noted. For lifts from

60 degrees to 45 degrees, no physical damage was noted. At 30 degrees, photo 3 shows the boxes misaligned where contact with the chains was being made, as well as digging into the edge of the wire bound boxes. The chains were also digging into and collapsing the fiberboard pallet used for this test (Photograph 4), which caused functional damage to the pallet as well as wire bound boxes directly above points of failure of the pallet. Inspection after the final lift (25 degrees) indicated that all wire bound boxes at the top of the pallet (area of interest for this test) were still serviceable having minor wood chipping, with the contents not damaged and repalletization not necessary prior to future handling.

C. Test Pallet Containing Metal Cans. The pallet was tested from 60 degrees down to 25 degrees with inspections taking place after each lift with minor paint chipping, scratches, and small dents noted at points of contact with the chains (Photo 5, page 8-5). All metal cans were still serviceable with the contents not damaged after each lift.

## 2. Stability Tests.

The purpose of the five tests conducted (spreader bar stability test, raised drop/catch test, slewing test, slew impact with the wall and ground tests) was to determine what, if any, detrimental effects in material handling safety would be encountered with the use of spreader bars and the basket chain sling. This series of tests were also conducted to determine the proper spreader bar design to be used in avoiding minor container damage, noted in the sling angle versus container/content damage test above. The spreader bars used during this series of tests were notched the width of the pallet, with a sling angle from the spreader bar to crane hook being 30 degrees. This simulated conditions under which the spreader bar would normally be used.

A. Spreader Bar Stability Test. During this test, no adverse material handling conditions were noted, with the spreader bars passing this test.

B. Raised Drop/Catch Test. During this test, the pallet was observed to flex approximately two inches as the crane lock was engaged prior to pallet impacting the ground. The speed at which the pallet falls after release of the crane brake was slower than desired due to the operating limitations of the crane being used and was estimated to be at two feet per second. The test indicated that the spreader bars with basket sling were stable and no adverse material handling conditions or pallet damage was noted.

C. Slewing Test. The pallet was transversed through an arc of 90 degrees at the maximum speed of the crane with the pallet two feet above the ground prior to an abrupt stop. After stopping the pallet, basket sling and spreader bars showed no signs of shifting, with the spreader bars passing this test.

D. Slew Impact With the Ground Test. The pallet was transversed through an arc of 90 degrees at maximum speed prior to impacting the ground. The pallet on impact tilted 20 to 30 degrees to one side prior to being retrieved by the crane boom. The spreader bars showed no signs of shifting and did not require readjustment prior to further testing.

E. Slew Impact With the Wall Test. This test was conducted three times. In the first test, the chain slings were perpendicular to the impact surface (figure 2, page 7-2) with the pallet one foot off the ground prior to impacting the wall. In the second test, the chains were parallel to the wall (figure 3, page 7-3). In the final test, the chains were again perpendicular to the impact surface, with the impact at skid height simulating a pallet hitting a curb or the top of a second pallet.

After each test, the spreader bars and chains were inspected and did not shift to a point where readjustment of the rigging was required prior to future material handling. Also, no unsafe material handling conditions were observed during these five tests. Photograph 6, page 8-6, was taken after the last impact with functional damage to the pallet skids and wooden box clearly evident, which was to be expected based on the severity of the last impact. The primary concern of this test was the pallet stability with respect to the spreader bars and not pallet or container damage at points of contact with the wall.

## PART 6

### CONCLUSIONS AND RECOMMENDATIONS

#### 1. CONCLUSIONS.

A. The amount of minor container damage increases as the chain sling angle decreases, with minor damage occurring to all pallets tested at sling angles less than 45 degrees.

B. Tests conducted indicated the sole use of a double basket sling will not cause structural damage to the container or functional damage to the contents with sling angles between 60 degrees and 25 degrees (the smallest sling angle available).

C. The use of spreader bars to reduce chain pressure at the top of the pallet will not create unsafe material handling conditions as long as the spreader bars are properly designed (see Figure 1).

D. Spreader bars will reduce the amount of minor pallet damage that occurs to the top containers on the pallet at rigging angles less than 45 degrees, but their use is not required.

E. Structural and functional damage was noted to containers during two tests: 1) wire bound boxes with a fiberboard pallet during sling angle tests, and 2) wooden boxes with a wooden pallet during wall impact tests. In both cases, container damage was caused by pallet failure and/or excessive impact forces, not the chain sling angle or spreader bars, which was of interest during the tests.

#### 2. RECOMMENDATION

A. The use of normal rigging procedures with sling angles between 45 to 60 degrees should be practiced whenever possible.

B. If spreader bars are used on a voluntary basis, the maximum space between notches in the spreader bar should be pallet width or less, and limited in use to situations where proper rigging procedures cannot be followed and minor container damage is to be avoided. The use of spreader bars that have notches wider than the width of the pallet could result in unsafe material handling conditions.

Figure 1  
Spreader Bar

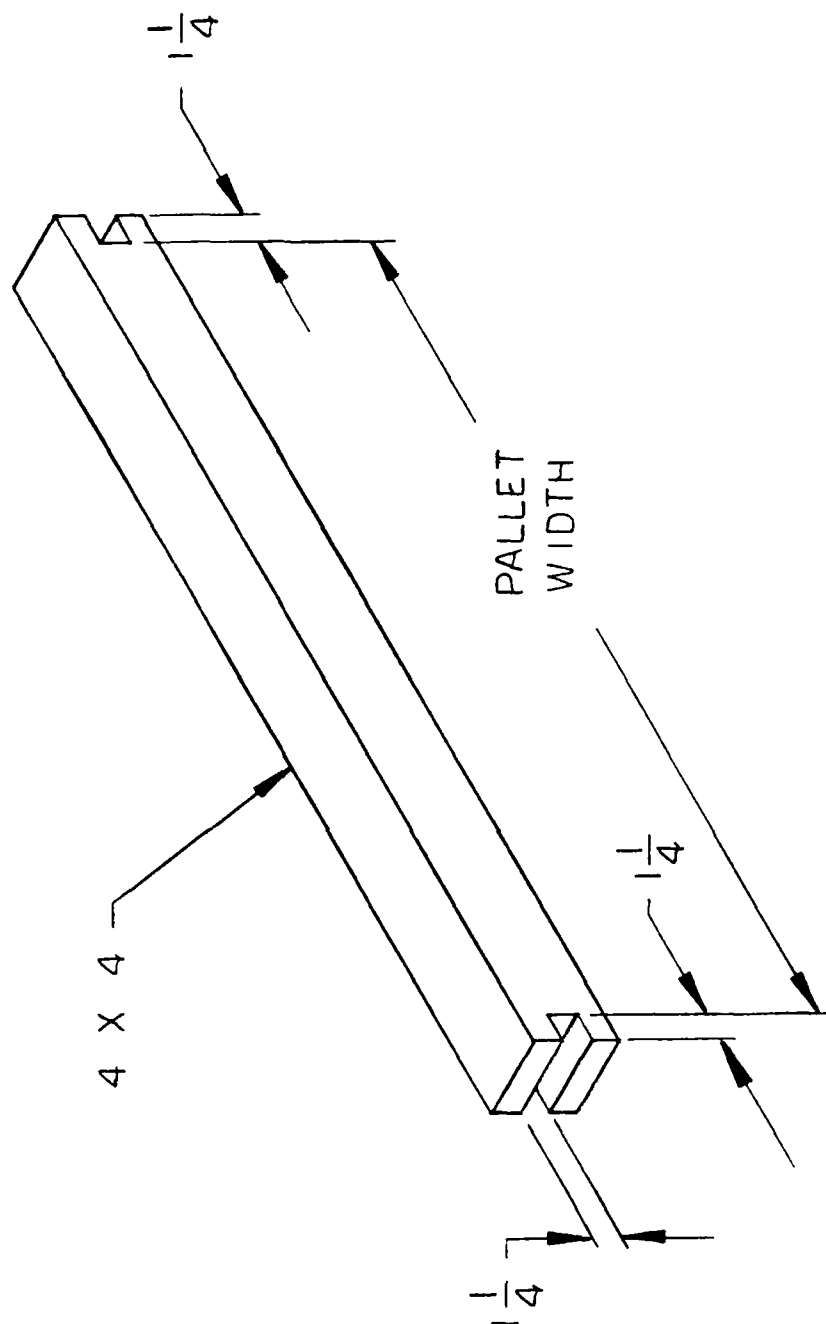
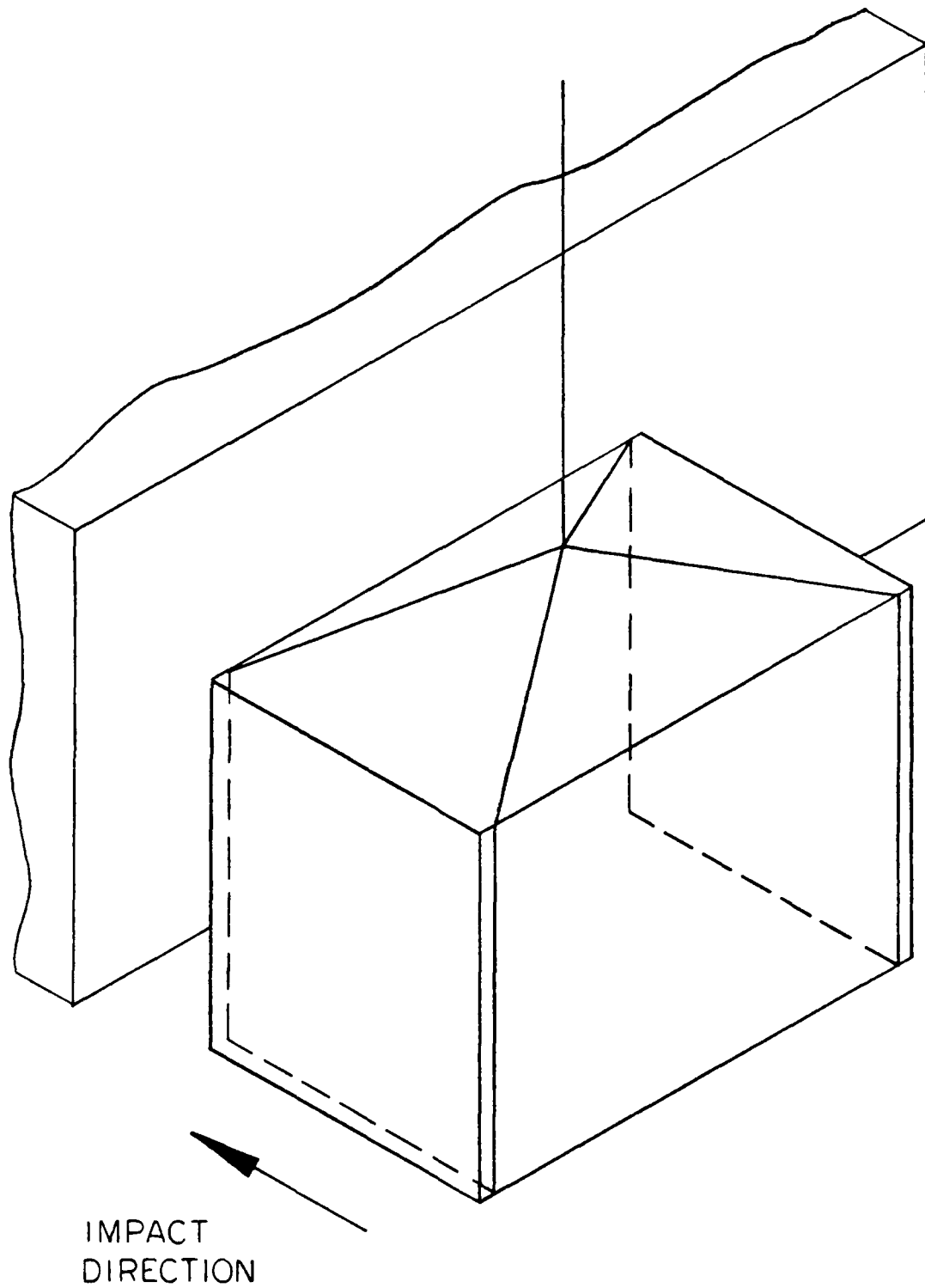
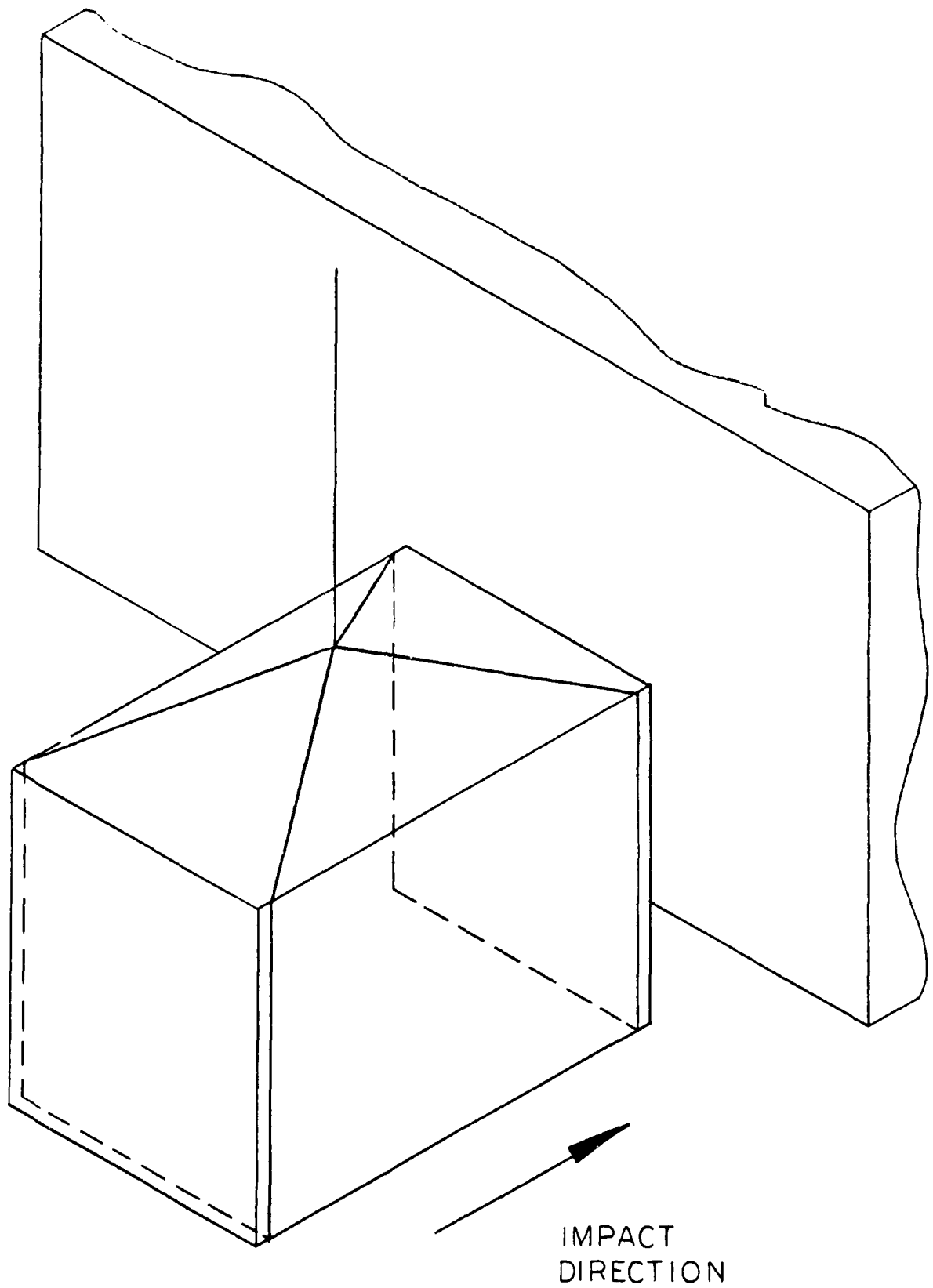


Figure 2

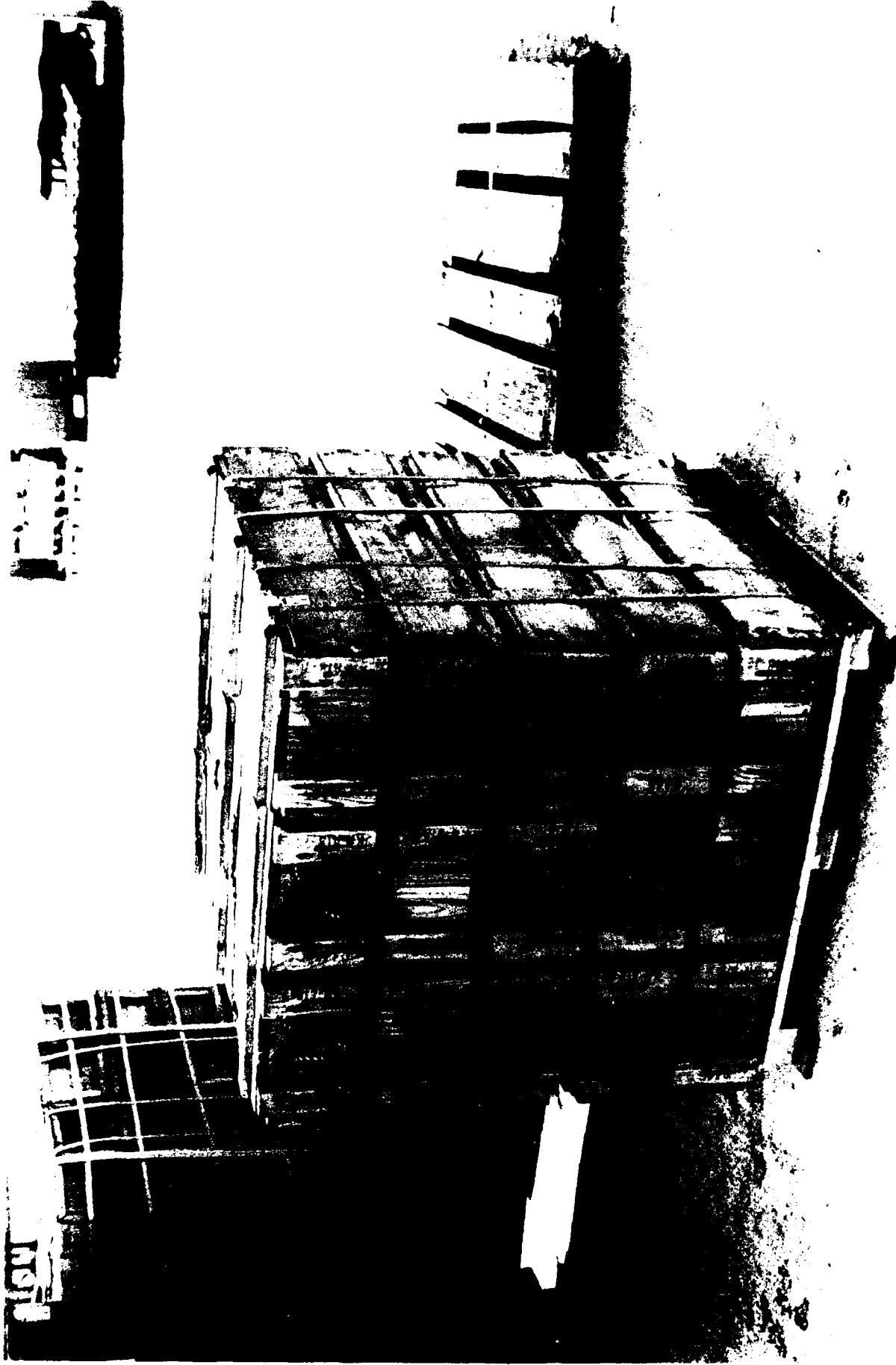


INDICATES CHAINS PERPENDICULAR TO IMPACT SURFACE

Figure 3



INDICATES CHAINS PARALLEL TO IMPACT SURFACE



|  |                                                           |
|--|-----------------------------------------------------------|
|  | <b>DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL</b> |
|--|-----------------------------------------------------------|

Photo 1 Page 8-1 - Shows pallet containing wooden boxes after the final 25 degree vertical lift, with the chains positioned along the longitudinal side of the boxes. Minor damage can be noted at chain contact points on the top layer outside edge, with wood chipping, chain embedment and hinge slightly deformed. The box was still structurally sound and serviceable.



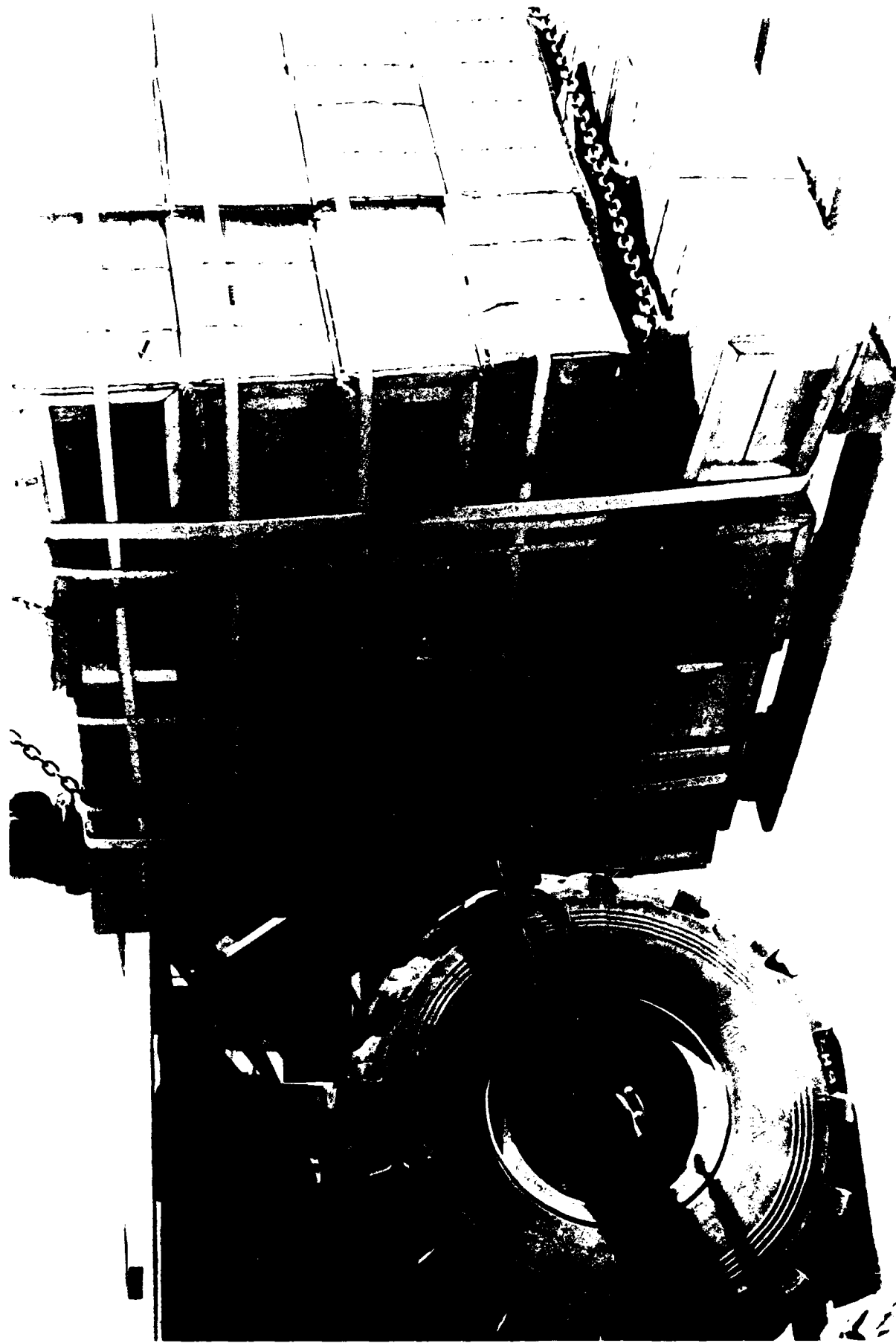
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Photo 2 Page 8-2 - Shows the same pallet seen in Photo 1 after the chains were rotated 90 degrees so chain contact points were on the ends of the wooden boxes. Minor damage can clearly be seen where embedment of the chains took place.



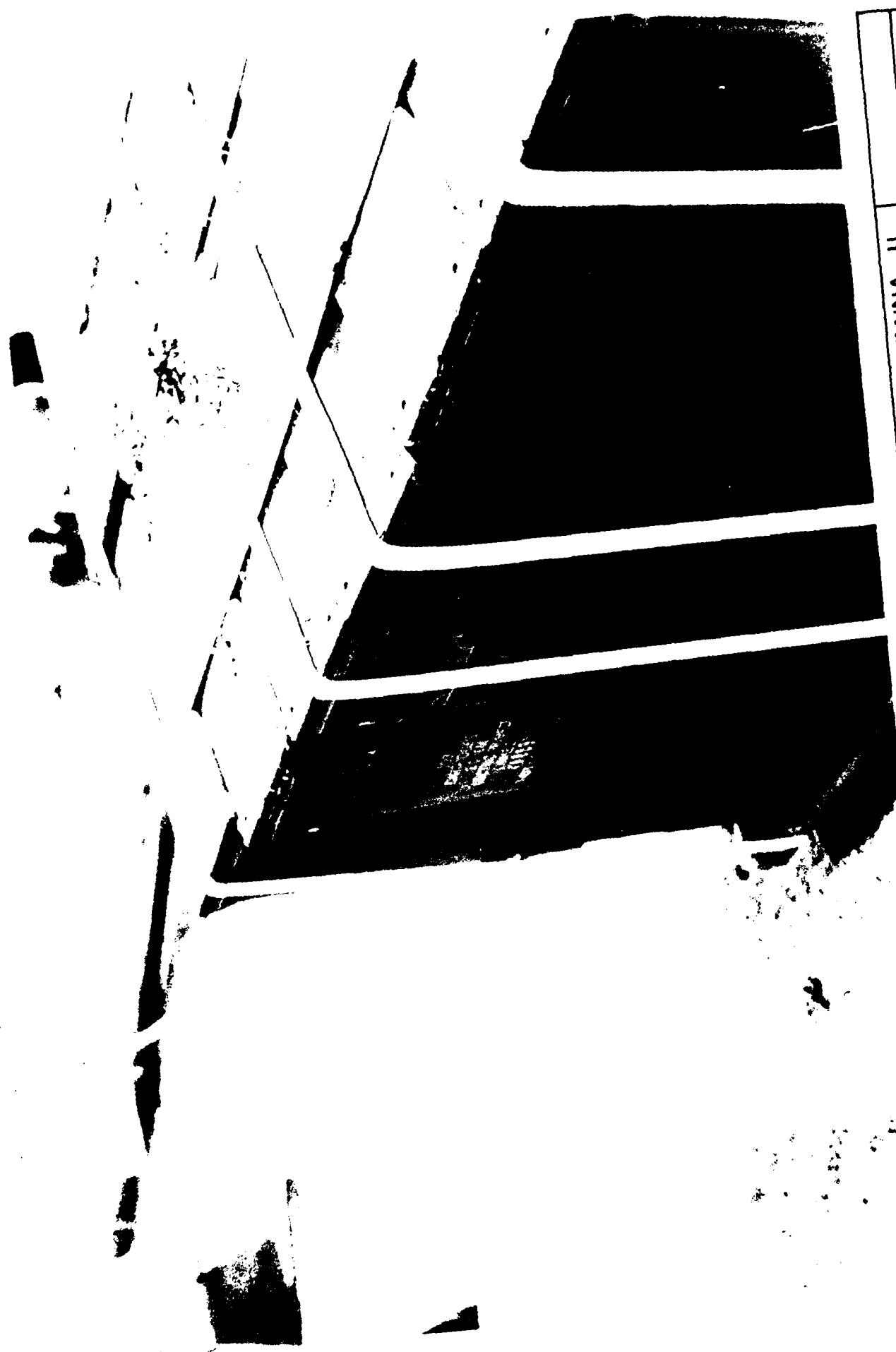
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Photo 3 Page B-3 - Shows the pallet containing winch and boxes to be lifted. Measurements of the boxes and minor chipping of the winch can be noted at pressure points with the chain.



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Photo 4 Page 8-4 - Same pallet seen in Photo 3 from the side, showing the structural damage to the pallet at lift points of the basket sling. Also note the cover slightly raised at the top of the pallet caused the lid being caught on a chain link as the pallet was vertically lifted, with no structural or functional damage occurring to the top of the pallet. A single layer pallet was added to the base of the test pallet to achieve the proper test weight.



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Photo 5 Page 8-5 - Shows the pallet containing the metal cans after vertical lifts were completed (25 degrees). Minor damage occurred to the cans at chain contact points, which included paint scratches and cold flow of metal at pressure points.



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Photo 6 Page 8-6 - Shows severe functional and structural damage to the lower wooden box and pallet skid after the final slew impact with a curb, indicating the severe force that was applied to the pallet by the slewing action of the chain. The spreader bars after this test did not require repositioning prior to the final lift.