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TOW MISSILE PALLET MIL-STD-1660 TESTS

Prepared for:
U.S. Army Armament Research, Development
and Engineering Center
ATTN: SMCAR-AEP
Picatinny Arsenal, NJ 07806-5000

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The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to test the TOW missile pallet. This report contains the procedures, results, and recommendations from the MIL-STD-1660 tests conducted. As tested, the metal pallet passed MIL-STD-1660, Design Criteria for Ammunition Unit Loads, tests..

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to test the TOW missile pallet.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of this series of tests was to ascertain the TOW missile pallet and container would not be damaged during transportation (see part 6, pages 6-2 through 6-4).

D. CONCLUSION. There were excessive gaps between the containers of the initial pallet tested due to the containers being out of tolerance (see part 6, pages 6-5 and 6-6). The excess gaps, along with weld and material problems with the stacking lugs, contributed to several stacking lug failures on the bottom adapters. The stacking lug design was changed to a button lug which allows for more weld area and does not have a decreased diameter. The button lug provides stability when it is seated in the hole. Also, cracking and bending occurred on the pallet deck due to the overhang (see part 6, pages 6-7 and 6-8). The problem was alleviated by centering the front and rear cross members of the bottom adapter longitudinally on the pallet deck. The most important aspect of the centered cross members is that both cross members hang over the end of the pallet slightly (see part 6, pages 6-9 through 6-11). This puts the load bearing of the containers closer to the pallet posts and adds flexibility to the pallet. This design passed MIL-STD-1660, Design Criteria for Ammunition Unit Loads, testing.

PART 2

ATTENDEES

Jason B. Solberg General Engineer DSN 585-8079 815-273-8079	Director U.S. Army Defense Ammunition Center and School ATTN: SMCAC-DEV Savanna, IL 61074-9639
Sandra Schültz Industrial Engineer DSN 585-8086 815-273-8086	Director U.S. Army Defense Ammunition Center and School ATTN: SMCAC-DES Savanna, IL 61074-9639
Betty Kundert Engineering Draftsman DSN 585-8095 815-273-8095	Director U.S. Army Defense Ammunition Center and School ATTN: SMCAC-DES Savanna, IL 61074-9639

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 nine steps that a unitized load must undergo if it is considered to be acceptable. The five tests that were conducted on the test pallet are synopsized below:

A. SUPERIMPOSED LOAD TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high for a period of one hour, as specified in Method 5016, Federal Standard 101. This stacking load was 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 multiplied by 192 minus the unit height in inches, then divided by the unit height in inches, then multiplied by a safety factor of two. The resulting number is the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency is achieved when a 1/16-inch-thick feeler gage can 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 $1 \pm 0.1G$. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurs, the total time of vibration is two hours when the specimen is tested in one position. When the specimen is tested in more than one position, the total time is three hours.

C. <u>EDGEWISE ROTATIONAL DROP TEST</u>. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the Edgewise Rotational Drop Test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased, when necessary, to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then 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 WEIGHT NOT EXCEEDING (Pounds)	DIMENSIONS ON ANY EDGE NOT EXCEEDING (Inches)	HEIGHT OF DROP LEVEL A PROTECTION (Inches)
600	72	36
3,000	no limit	24
no limit	no limit	12

D. <u>INCLINE-IMPACT TEST</u>. This test was conducted 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 was placed on the carriage with the surface or edge to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was 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 4- by 4-inch timber may be attached to the bumper in the desired position before the test. No part of the timber was struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges were subjected to impacts was at the option of the testing activity and depended upon the objective of the tests. When the test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was 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 was 7 feet-per-second.

PART 4

TEST EQUIPMENT

A. TEST PALLET.

1. Height:	38.43 inches (97.61cm)
2. Width:	45.50 inches (115.57cm)
3. Length:	58.92 inches (149.66cm)
4. Weight:	1,532 pounds (696.36kg)

B. COMPRESSION TESTER.

1. Manufacturer:	Ormond Manufacturing
2. Platform:	60 inches by 60 inches
3. Compression Limit:	50,000 pounds
4. Tension Limit:	50,000 pounds

C. TRANSPORTATION SIMULATOR.

1. Manufacturer:	Gaynes Laboratory
2. Capacity:	6,000-pound pallet
3. Displacement:	1/2-inch Amplitude
4. Speed:	50 to 400 rpm
5. Platform:	5- by 8-foot

D. INCLINED RAMP.

1. Manufacturer: Conbur Incline
2. Type: Impact Tester
3. Grade: 10 percent Incline
4. Length: 12-foot Incline

PART 5

TEST RESULTS

TEST OBSERVATION. Four pallet loads were tested before the design successfully passed. The first three pallet loads had stacking lug failures. The first two pallet loads had excess gaps between the containers due to their widths being under tolerance. The gap problem was corrected by welding shims to the bells to bring the containers up to tolerance. The stacking lugs continued to fail so the lug was changed to a button lug to allow for more weld area and no decrease in lug diameter. The button lug provides stability when it is seated in the hole.

Two of the first three pallet loads had excessive bending of the bottom adapter and cracked welds due to the load protruding off the pallet producing a cantilever effect. The fourth test load was shifted 1-1/2 inches to the rear of the pallet to correct this problem. Also, on the fourth test load, the front cross member damaged the front of the pallet. The cause of this failure was a slight cantilever introduced by putting the front bell of the container ahead of the pallet posts. To alleviate the cantilever from damaging the pallet, the container load was shifted forward another 7/8-inch so the front overhang of the cross member of the bottom adapter increased and only the inside edge of the cross member contacted the pallet. The rear portion of the front cross member then contacted the pallet closer to the pallet posts, thus, decreasing the cantilever.

Slight cracking of the pallet deck occurred on the fifth and sixth pallet loads; however, the damage was minimized with the design changes made in the preceding tests. The final design had the front and rear cross members of the bottom adapter centered on the pallet, thus, the load bearing surfaces of the containers were centered on the pallet. This minimizes damage to each end of the pallet by avoiding excess cantilevering.

PALLET NO. 1

A. SUPERIMPOSED LOAD TEST. The test pallet was initially loaded to 13,770-pounds compression. No damage was noted during this test.

B. REPETITIVE SHOCK TEST. Duration of the test was 90 minutes for each orientation of the pallet. In order to achieve the clearance between the pallet and the transportation simulator bed, the equipment was operated at 175 rpm for the lateral orientation and 238 rpm for the longitudinal orientation. During the lateral vibration, the containers rolled slightly and two lid cables frayed from impact of the bell end of the containers against the wall of the vibration table. During the longitudinal vibration, one cotter key on one container lid detached.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet base was placed on a beam displacing it 4-1/2 inches above the floor. The ends of the pallet were raised to a height of 24 inches. The process was repeated in a clockwise direction until all four sides of the pallet had been tested. No damage was noted during this test.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage was noted from the tests.

E. END OF TEST INSPECTION. During final inspection, one stacking lug on the bottom adapter detached due to an insufficient weld. One stacking lug on one container also was removed.

PALLET NO. 2

A. SUPERIMPOSED LOAD TEST. The test pallet was initially loaded to 13,564-pounds compression. No damage was noted during this test.

B. REPETITIVE SHOCK TEST. Duration of the test was 90 minutes for each orientation of the pallet. In order to achieve the clearance between the pallet and the transportation simulator bed, the equipment was operated at 172 rpm for the lateral orientation and 240 rpm for the longitudinal orientation. No damage was noted during this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet base was placed on a beam displacing it 4-1/2 inches above the floor. The ends of the pallet were raised to a height of 24 inches. The process was repeated in a clockwise direction until all four sides of the pallet had been tested. No damage was noted during this test.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage was noted from the tests; however, a 3/4-inch gap between the containers at the rear and a 1/4-inch gap at the front of the pallet were evident.

E. END OF TEST INSPECTION. During final inspection, two stacking lugs on the bottom adapter were missing. One stacking lug failed due to an insufficient weld and another was due to material failure. The remaining lugs were damaged due to excessive friction from the pallet. Excess movement allowed by the containers was also a contributing factor to the failure. It was determined that the container bells were out of tolerance so shims were welded to bring them up to tolerance, thus, limiting the movement of the containers within the pallet adapters.

PALLET NO. 3

A. SUPERIMPOSED LOAD TEST. The test pallet was initially loaded to 13,592-pounds compression. No damage was noted during this test.

B. REPETITIVE SHOCK TEST. Duration of the test was 90 minutes for each orientation of the pallet. In order to achieve the clearance between the pallet and the transportation simulator bed, the equipment was operated at 178 rpm for the lateral orientation and 231 rpm for the longitudinal orientation. No damage was noted during this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet base was placed on a beam displacing it 4-1/2 inches above the floor. The ends of the pallet were raised to a height of 24 inches. The process was repeated in a clockwise direction until all four sides of the pallet had been tested. Two lugs detached during this test. The amout of space in the bottom adapter was 1/2-inch in front and 1/4-inch at the rear of the pallet.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. One stacking lug on the bottom adapter detached on the first impact and another detached on the third impact.

E. END OF TEST INSPECTION. Overhang on front of pallet caused excessive bending of bottom adapter and cracked welds. The fourth pallet bottom adapter was shifted 1-1/2 inches to the rear to alleviate the bending movement.

PALLET NO. 4

A. SUPERIMPOSED LOAD TEST. The test pallet was initially loaded to 13,800-pounds compression. No damage was noted during this test.

B. REPETITIVE SHOCK TEST. Duration of the test was 90 minutes for each orientation of the pallet. In order to achieve the clearance between the pallet and the transportation simulator bed, the equipment was operated at 179 rpm for the lateral orientation and 278 rpm for the longitudinal orientation. No damage was noted during this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet base was placed on a beam displacing it 4-1/2 inches above the floor. The ends of the pallet were raised to a height of 24 inches. The process was repeated in a clockwise direction until all four sides of the pallet had been tested. No damage was noted during this test.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage was noted during this test.

E. END OF TEST INSPECTION. The overhang on the front of the pallet was alleviated; however, the extra weight over the front posts caused one front post to break through the pallet deck. To alleviate the problem, the bottom adapter was shifted 7/8-inch forward.

PALLET NO. 5

A. SUPERIMPOSED LOAD TEST. The test pallet was initially loaded to 13,800-pounds compression. No damage was noted during this test.

B. REPETITIVE SHOCK TEST. Duration of the test was 90 minutes for each orientation of the pallet. In order to achieve the clearance between the pallet and the transportation simulator bed, the equipment was operated at 175 rpm for the lateral orientation and 240 rpm for the longitudinal orientation. No damage was noted during this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet base was placed on a beam displacing it 4-1/2 inches above the floor. The ends of the pallet were raised to a height of

24 inches. The process was repeated in a clockwise direction until all four sides of the pallet had been tested. No damage was noted during this test.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage was noted during this test.

E. END OF TEST INSPECTION. During final inspection, only slight cracking on the pallet deck from the pallet posts was evident.

PALLET NO. 6

A. SUPERIMPOSED LOAD TEST. The test pallet was initially loaded to 13,800-pounds compression. No damage was noted during this test.

B. REPETITIVE SHOCK TEST. Duration of the test was 90 minutes for each orientation of the pallet. In order to achieve the clearance between the pallet and the transportation simulator bed, the equipment was operated at 178 rpm for the lateral orientation and 217 rpm for the longitudinal orientation. No damage was noted during this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet base was placed on a beam displacing it 4-1/2 inches above the floor. The ends of the pallet were raised to a height of 24 inches. The process was repeated in a clockwise direction until all four sides of the pallet had been tested. No damage was noted during this test.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage was noted during this test.

E. <u>END OF TEST INSPECTION</u>. During final inspection, only slight cracking on the pallet deck from the pallet posts was evident.

PART 6

PHOTOGRAPHS

U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

PHOTO NO. SPN 93-250-4570: This photo shows an overall view of the TOW missile pallet.

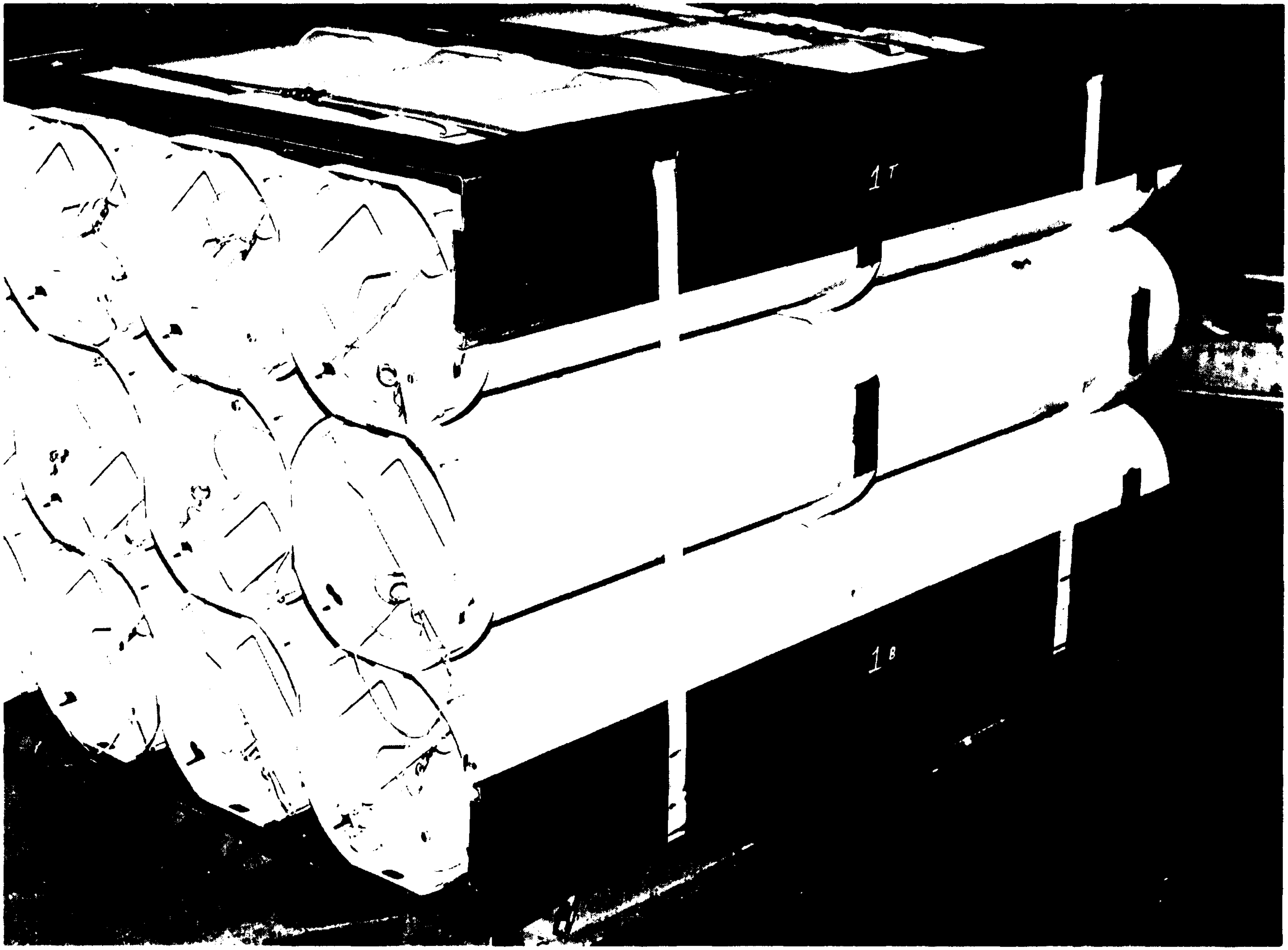

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PHOTO NO. SCN 93-250-4502: This photo shows an overall view of the TOW missile pallet.

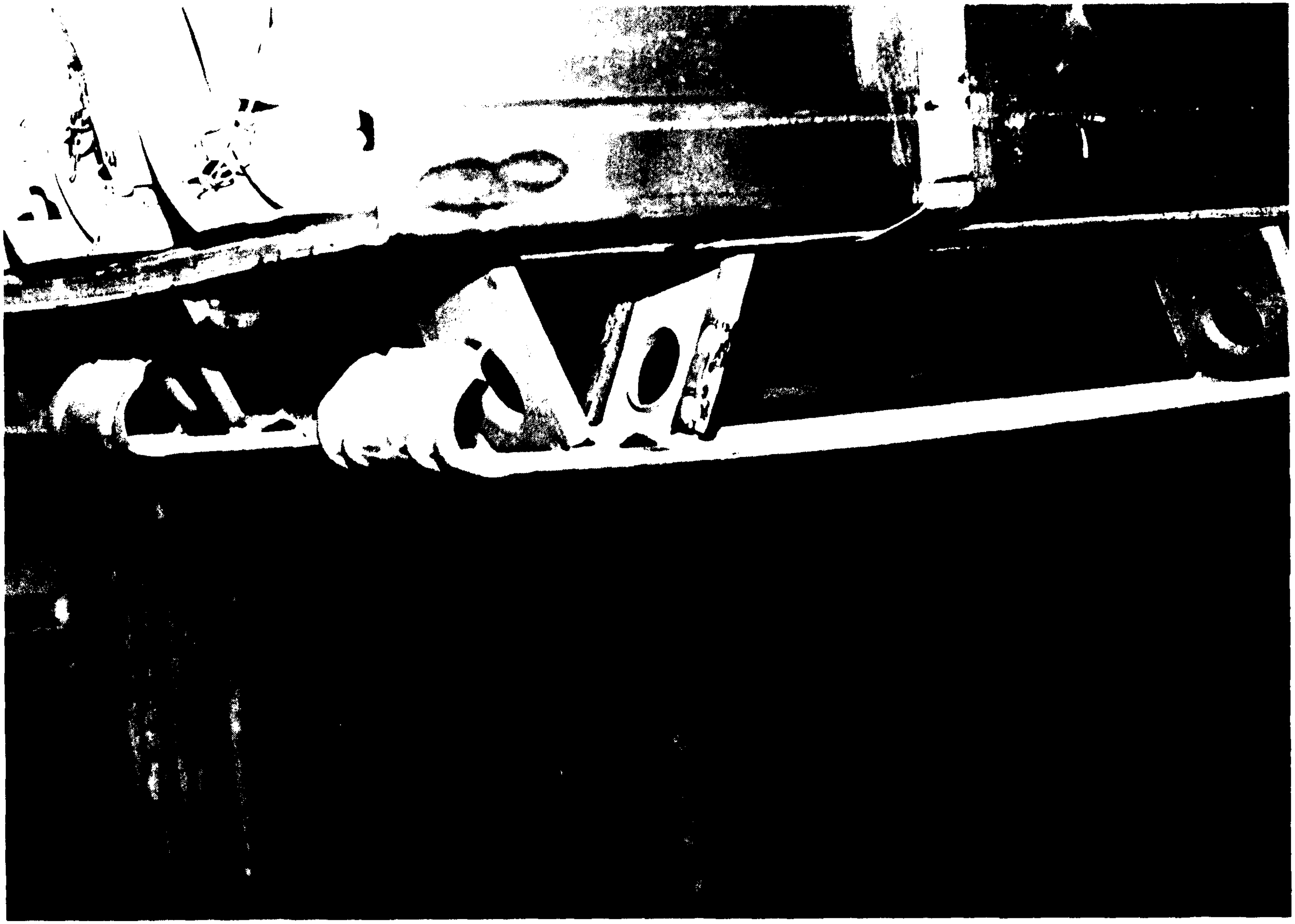

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PHOTO NO. SCN 93-250-4507: This photo shows the bar stock inserted per MICOM specifications.

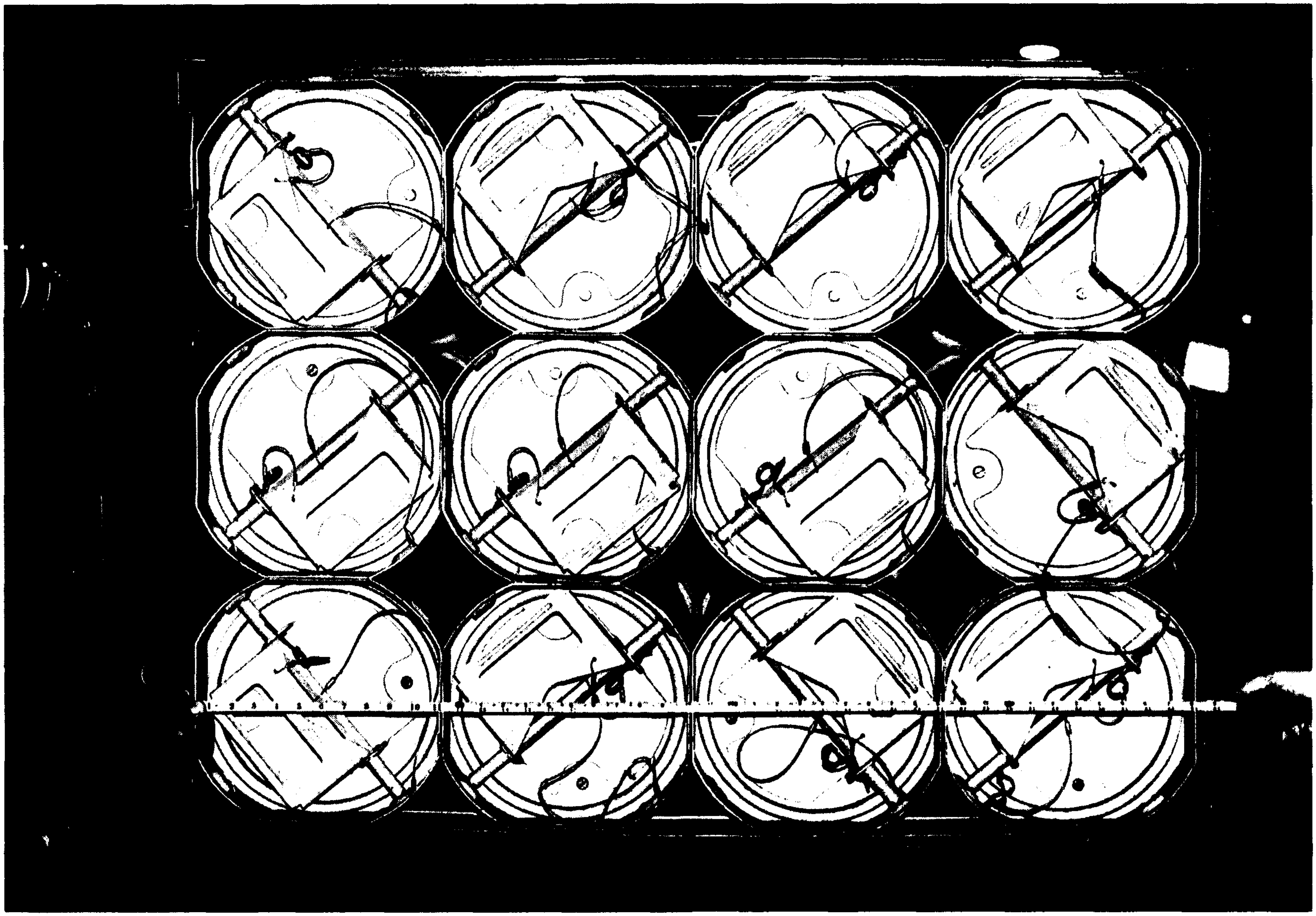

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PHOTO NO. SCN 93-250-4508: This photo shows the width of the bottom adapter being sufficient for the bell end.

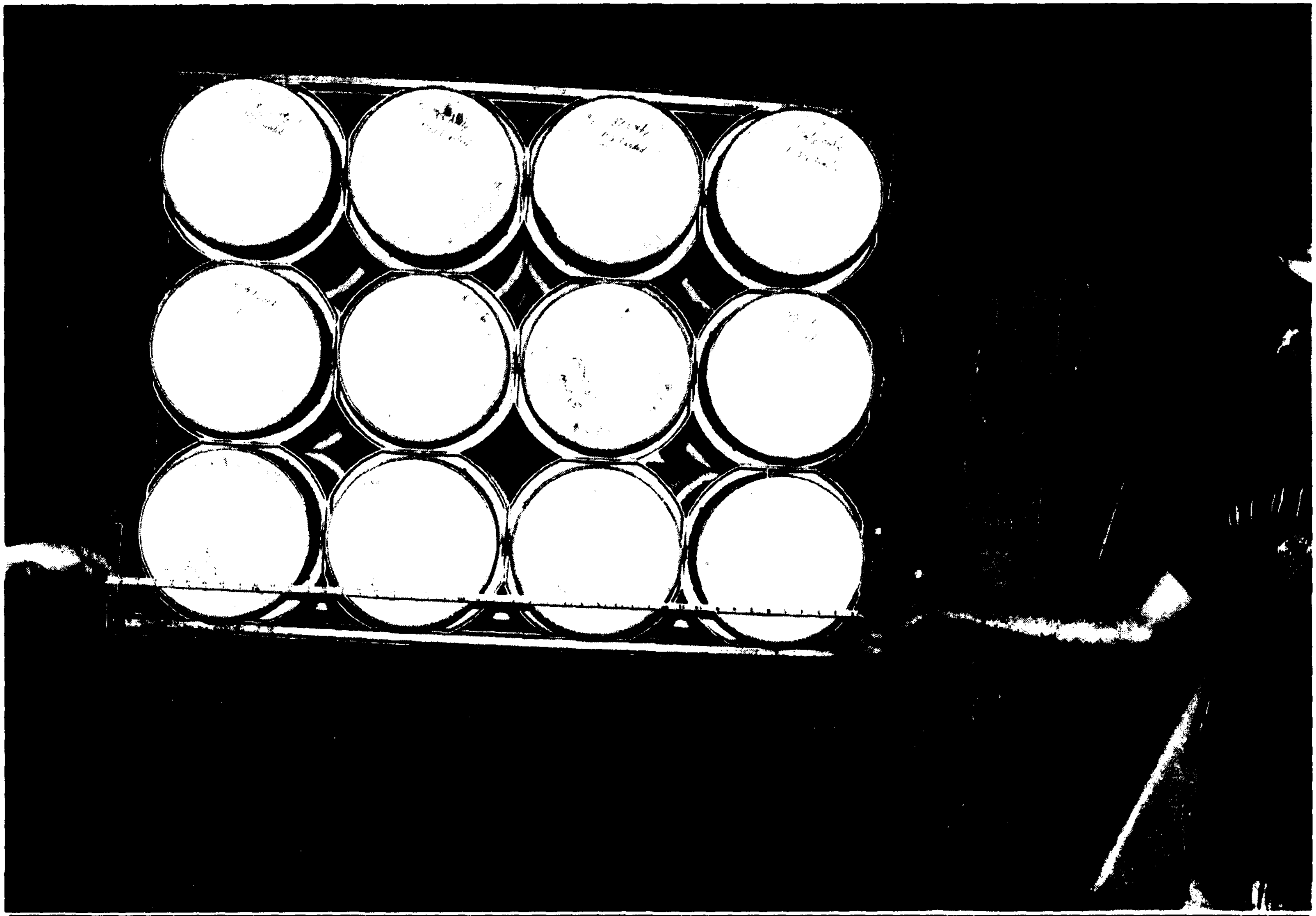

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PHOTO NO. SCN 93-250-4505: This photo shows the gap made sufficiently small between containers after shims were welded to each container to bring each up to tolerance.

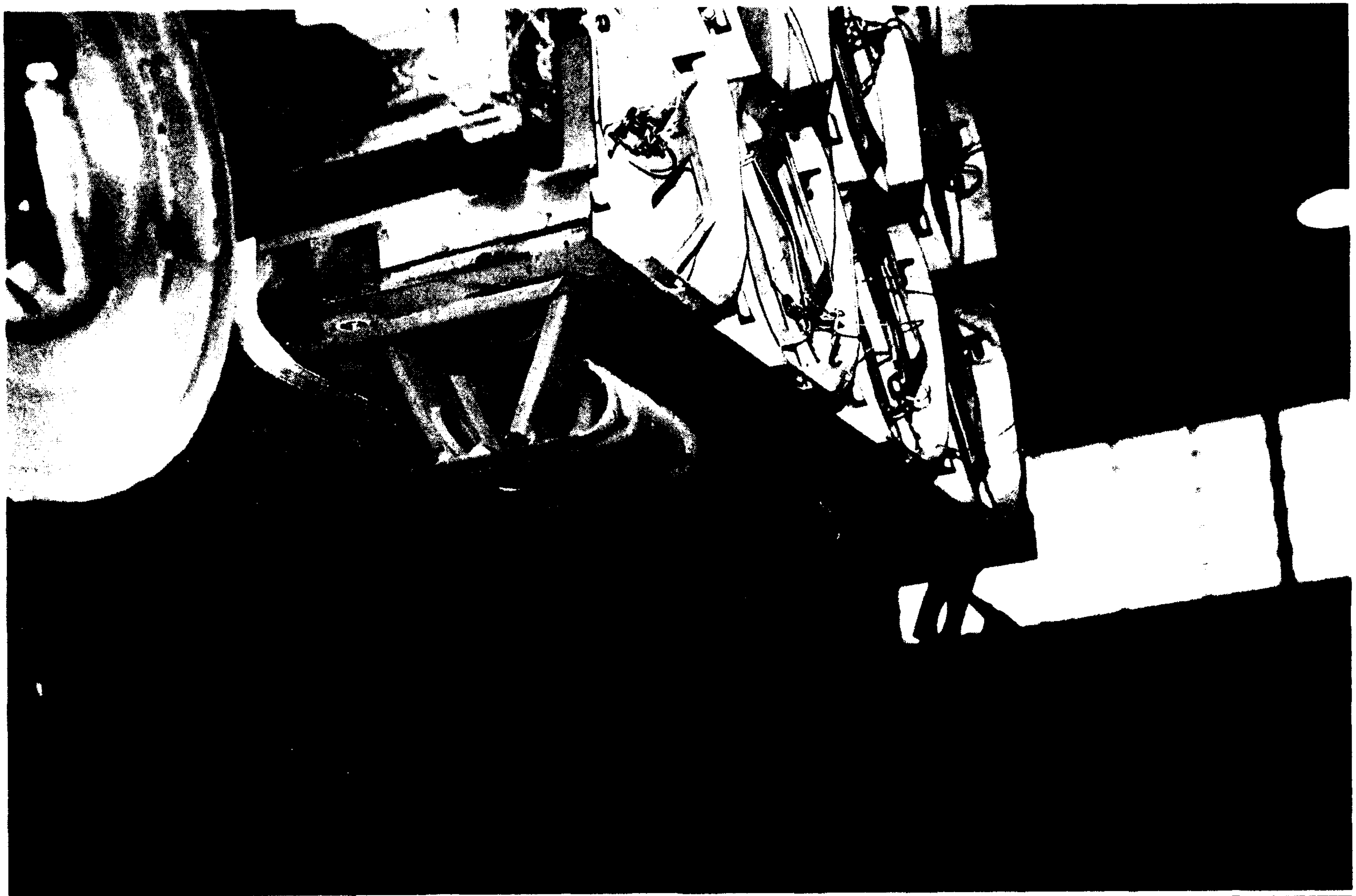

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PHOTO NO. SPN 93-250-4567: This photo shows the location of the bottom adapter relative to the pallet as an example of what to avoid. This orientation caused excess cracking of the pallet deck.

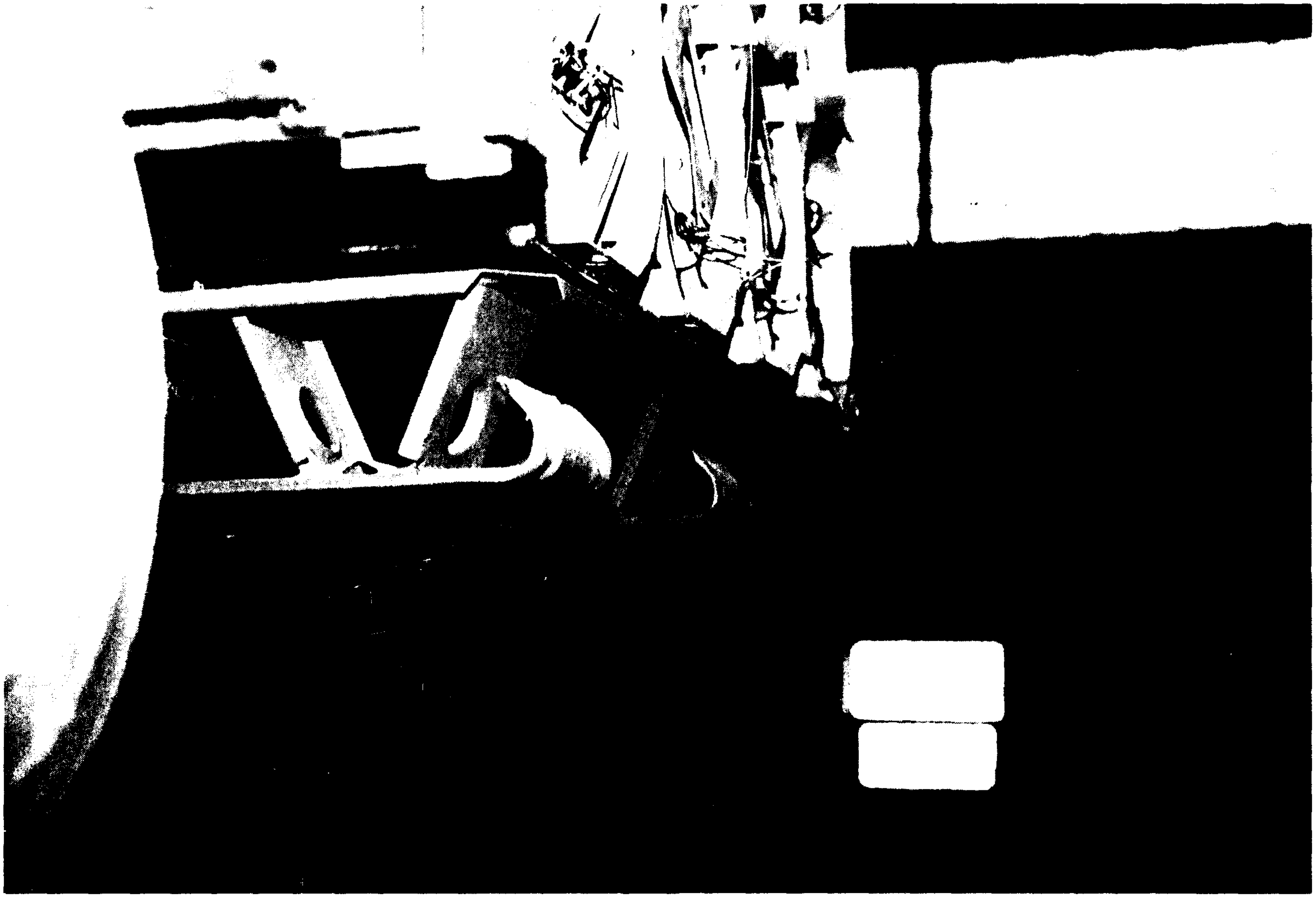

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PHOTO NO. SPN 93-250-4568: This photo shows the location of the bottom adapter relative to the pallet as an example of what to avoid. This orientation caused excess cracking of the pallet deck.

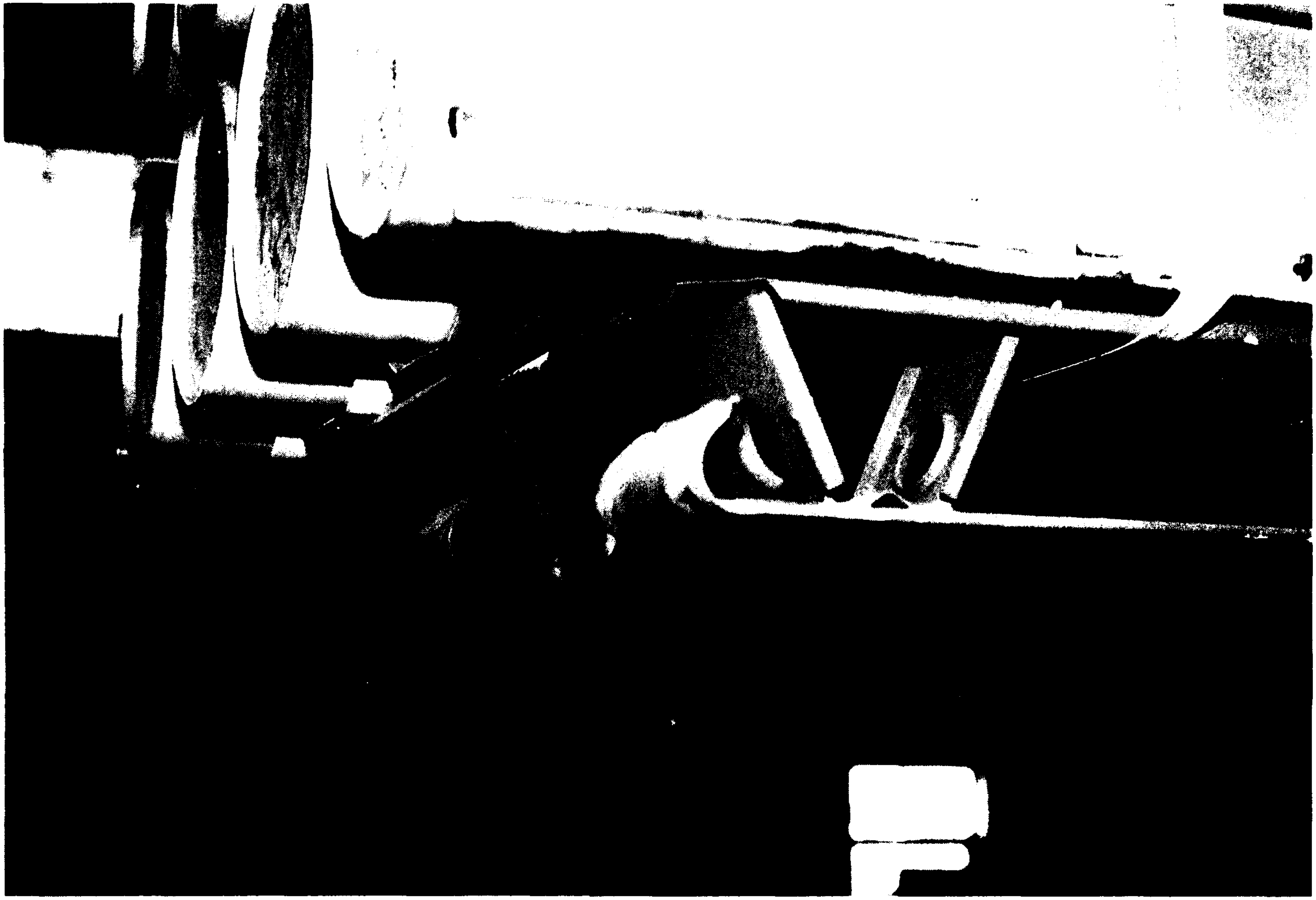

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PHOTO NO. SPN 93-250-4565: This photo shows the location of the bottom adapter relative to the pallet as an example of the correct orientation.

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PHOTO NO. SPN 93-250-4566: This photo shows the location of the bottom adapter relative to the pallet as an example of the correct orientation.

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PHOTO NO. SPN 93-250-4564: This photo shows the location of the bottom adapter relative to the pallet as an example of the correct orientation. Note the flexibility introduced by the bottom adapter.