FINAL REPORT

MARCH 1992

REPORT NO. 92-13

MIL-STD-1660 TESTS OF PLASTIC BOX PALLET

Prepared for:
U.S. Army Defense Ammunition
Center and School
ATTN: SMCAC-DES
Savanna, IL 61074-9639

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b. RESTRICTIVE MARKINGS:

2a. SECURITY CLASSIFICATION AUTHORITY:

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE:

3. DISTRIBUTION / AVAILABILITY OF REPORT: UNLIMITED

4. PERFORMING ORGANIZATION REPORT NUMBER(S): 92-13

5. MONITORING ORGANIZATION REPORT NUMBER(S):

6a. NAME OF PERFORMING ORGANIZATION: U.S. Army Defense Ammunition Center and School

6b. OFFICE SYMBOL *(if applicable)***:** SMCAC-DEV

6c. ADDRESS *(City, State, and ZIP Code)***:** ATTN: SMCAC-DEV, Savanna, IL 61074-9639

7a. NAME OF MONITORING ORGANIZATION:

7b. ADDRESS *(City, State, and ZIP Code)***:**

8a. NAME OF FUNDING / SPONSORING ORGANIZATION: U.S. Army Defense Ammunition Center and School

8b. OFFICE SYMBOL *(if applicable)***:** SMCAC-DES

8c. ADDRESS *(City, State, and ZIP Code)***:** ATTN: SMCAC-DES, Savanna, IL 61074-9639

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)***:** MIL-STD-1660 Tests of Plastic Box Pallet

12. PERSONAL AUTHOR(S): Jason Solberg

13a. TYPE OF REPORT: Final

13b. TIME COVERED: FROM ———— TO ————

14. DATE OF REPORT *(Year, Month, Day)***:** 1992 March

15. PAGE COUNT:

16. SUPPLEMENTARY NOTATION:

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Supply Engineering Division (SMCAC-DES), to test the 2,500-pound-capacity plastic box pallet. This report contains the procedures, results, and recommendations from the MIL-STD-1660 tests conducted. As tested, the plastic box pallet failed MIL-STD-1660, Design Criteria for Ammunition Unit Loads.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: XX UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL: JEROME H. KROHN

22b. TELEPHONE *(Include Area Code)***:** 815-273-8929

22c. OFFICE SYMBOL: SMCAC-DEV

DD Form 1473, Jun 86 — *Previous editions are obsolete*

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

DTIC QUALITY INSPECTED 4

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Justification	
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Dist	Avail and / or Special
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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
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MIL-STD-1660 TESTS OF PLASTIC BOX PALLET

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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 USADACS, Supply Engineering Division (SMCAC-DES), to test the 2,500-pound-capacity plastic box 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 assess the ability of the plastic box pallet (see photos 1 and 2) to prevent it from being damaged during transportation.

D. CONCLUSION. The plastic box pallet performed unsatisfactorily in three of the four tests, therefore, failing MIL-STD-1660 tests. The superimposed load test showed that the pallet was resilient, although deformation was substantial while the load was being applied so the load had to be decreased from the test specifications to prevent further damage. The repetitive shock test showed that the plastic skids and posts are susceptible to wear during vibration. Edgewise drops caused the hinges to become damaged. The recommendations given below should improve the performance of the pallet.

E. RECOMMENDATIONS.

1. Place wooden 4- by 4-inch posts vertically at each corner extending to approximately 1/2-inch below the top of the pallet walls to improve the performance of the plastic box pallet for stacking purposes. This configuration would take the force from the load stacked above while still allowing the above pallet to nest.

2. The addition of wooden or metal inserts under the pallet skids and posts would give the pallet more resistance to friction during repetitive shocks.

3. Increase the lateral strength of the pallet by increasing the amount of material at the hinge areas of the front and rear of the pallet to prevent lateral flexing.

PART 2

11-13 MARCH 1992

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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 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 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 $1 \pm 0.1G$. 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 shall be two hours when the specimen is tested in one position. When the specimen is tested in more than one position, the total time shall be three hours.

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted by 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 s ds 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 ould be 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)	ANY EDGE DIMENSIONS ON NOT EXCEEDING (Inches)	HEIGHT OF DROP LEVEL A PROTECTION (Inches)
600	72	36
3,000	no limit	24
no limit	no limit	12

D. INCLINE-IMPACT TEST. This test was 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 was 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 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 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, 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:	33.75 inches (85.73cm)
2. Width:	47.5 inches (120.65cm)
3. Length:	44.75 inches (113.67cm)
4. Weight:	2,500 pounds (1136.36kg)

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 foot 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

A. SUPERIMPOSED LOAD TEST. The test pallet was loaded to 28,672 pounds compression initially. The load was decreased to 18,480 pounds due to excessive deformation. The right side hinge bowed out approximately 1/2-inch and the left side hinge bowed out approximately 1-inch. After the pallet was loaded for a total of one hour, the load was removed and within 10 minutes the deformation decreased 25 percent. After an hour, the pallet was back to its original shape (see part 1, E.1. for a method to improve the strength of this pallet).

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 263 rpm for the longitudinal orientation and 272 rpm for the lateral orientation. During the longitudinal vibration, the skids showed substantial wear with the middle posts on each side receiving most of the wear and a 1/2-inch crack began next to the front center post (see photo 3). Two more smaller cracks began during the lateral vibration at the rear of the pallet (see photo 4) and more wear was evident to the skids (see photos 5 and 6). This wear caused the center post to collapse (see part 1, E.2. for a possible solution to this problem).

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. The first drop, to the right side, caused several hinges to break on the front and rear and a crack was evident through the pallet structure at the location of one of the hinges on the rear of the pallet. The third drop caused more hinges to break on the front and rear of the pallet. After the test was completed, 14 of the 16 hinges on the front and 10 of the 16 hinges on the rear of the pallet were damaged; therefore, 8 out of 32 (or 25 percent) of the hinges were undamaged on the front and rear pallet walls. All of the hinges on the left and right sides remained intact. Therefore, only 40 of the 64 (or 62.5 percent) of the total number of hinges remained effective. The failure of such a large portion of the hinges was due to insufficient lateral strength of the pallet, allowing it to flex while the wall remained rigid; thus, the hinges yielded due to the excessive displacement of the wall of the pallet (see figure 1 below).

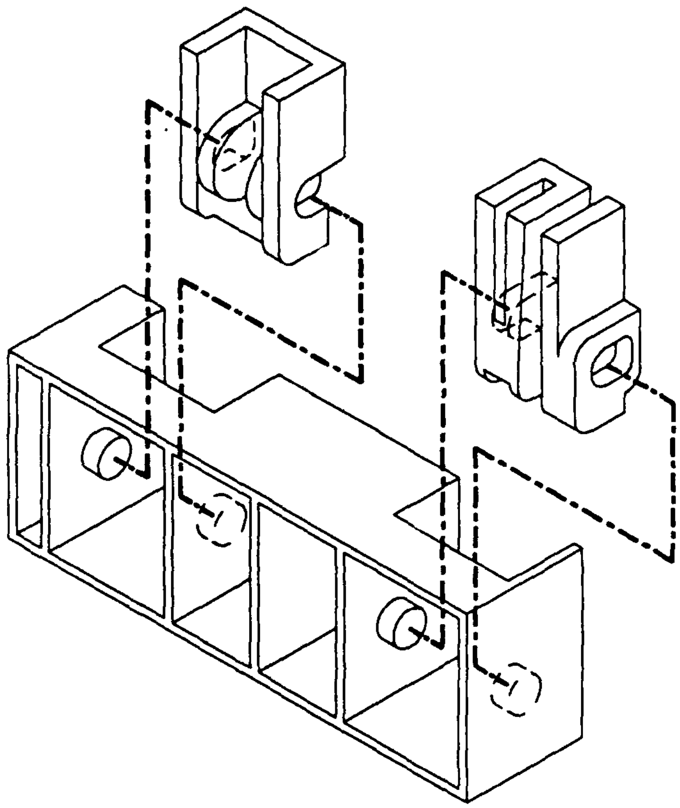

Figure 1. Hinge Detail

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, no damage was noted to the inside of the pallet; however, the structural deficiencies were substantial.

PART 6

PHOTOGRAPHS

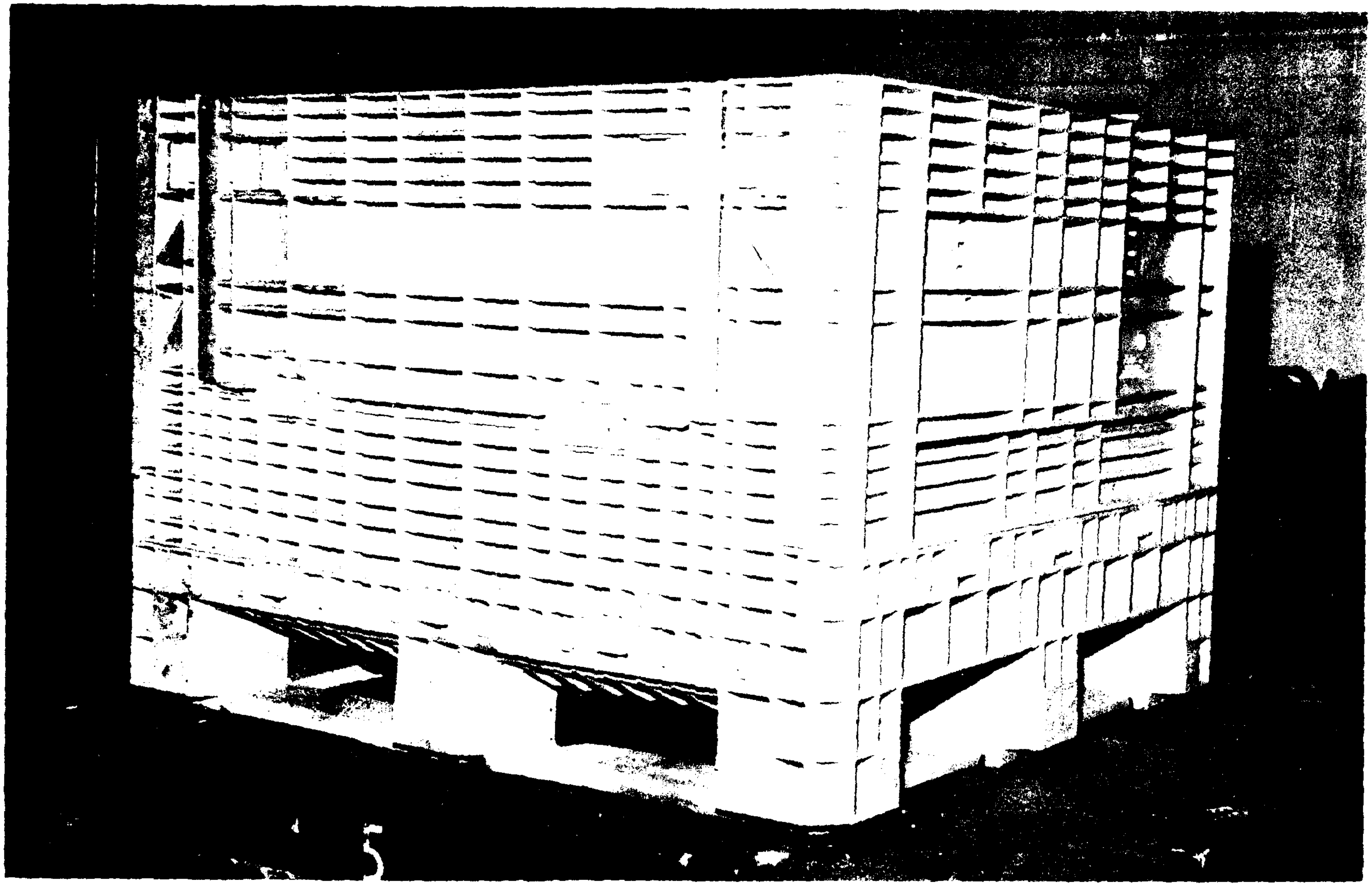

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Photo No. AO317-SCN91-177-1531. This photo shows an overall view of the 2,500-pound capacity plastic box pallet.

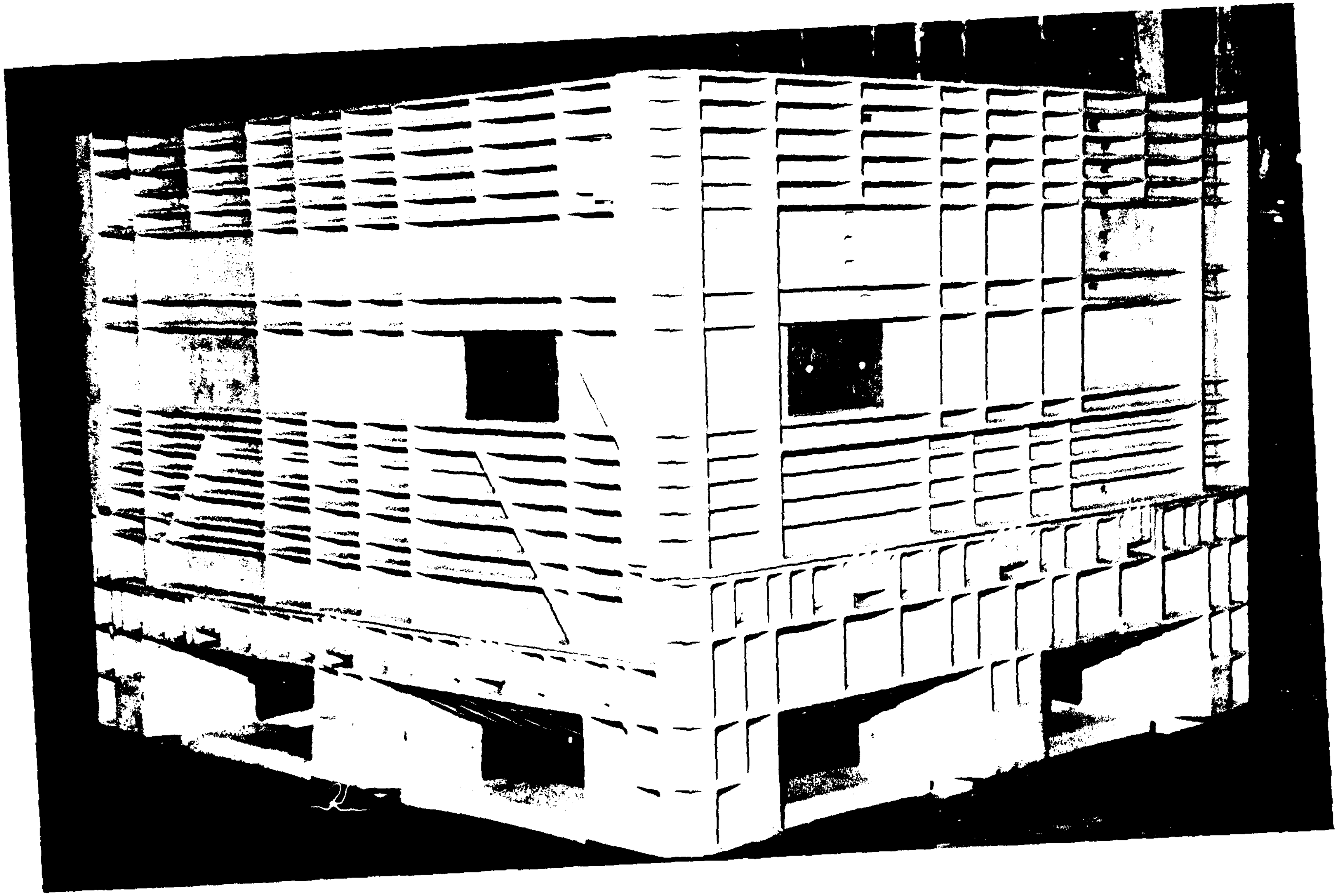

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Photo No. AO317-SCN92-177-1524. This photo shows an overall view of the 2,500-pound capacity plastic box pallet.

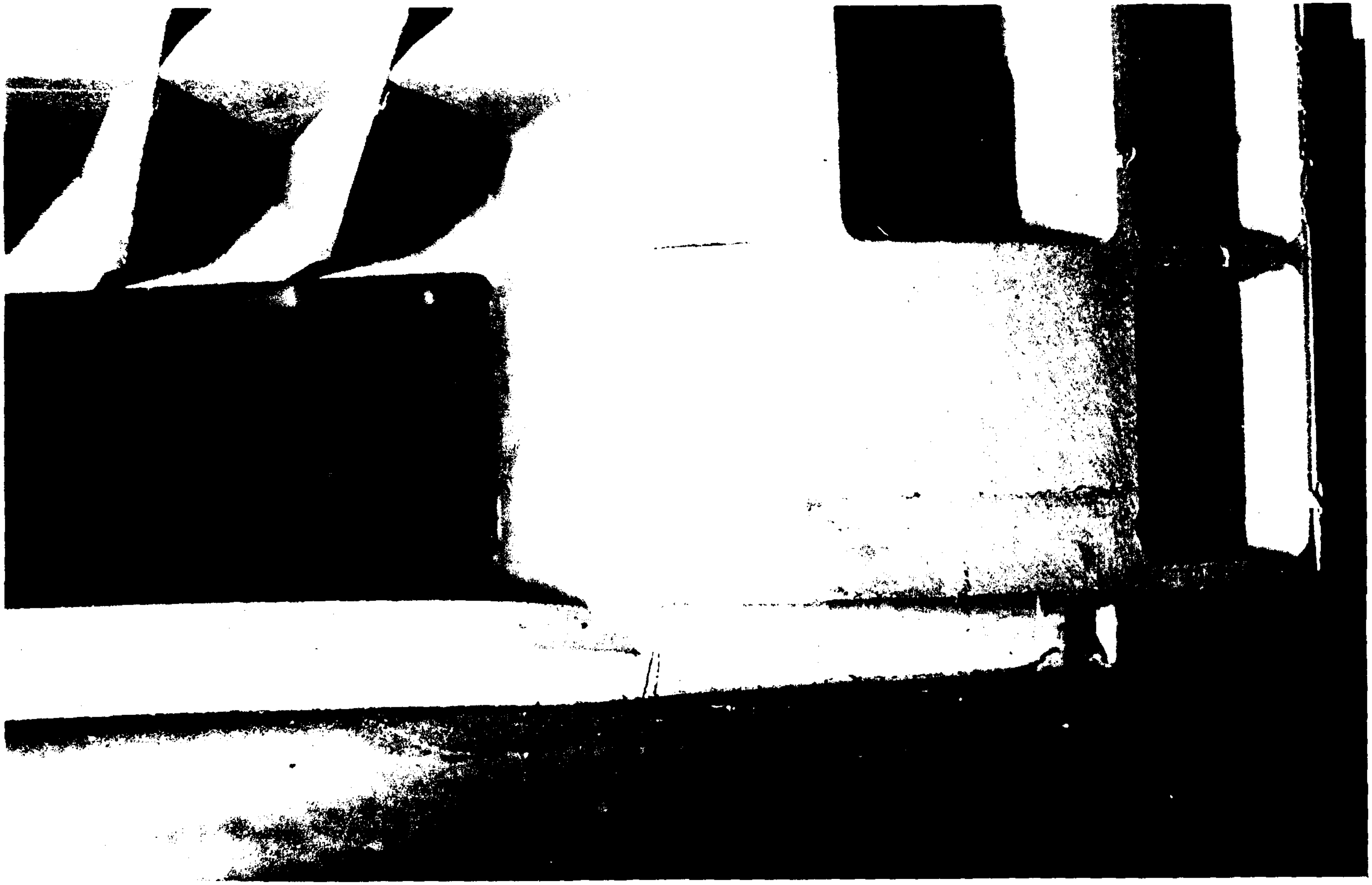

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Photo No. AO317-SCN92-177-1543. This photo shows some cracking that occurred during the first 1 1/2-hour cycle of the vibration test.

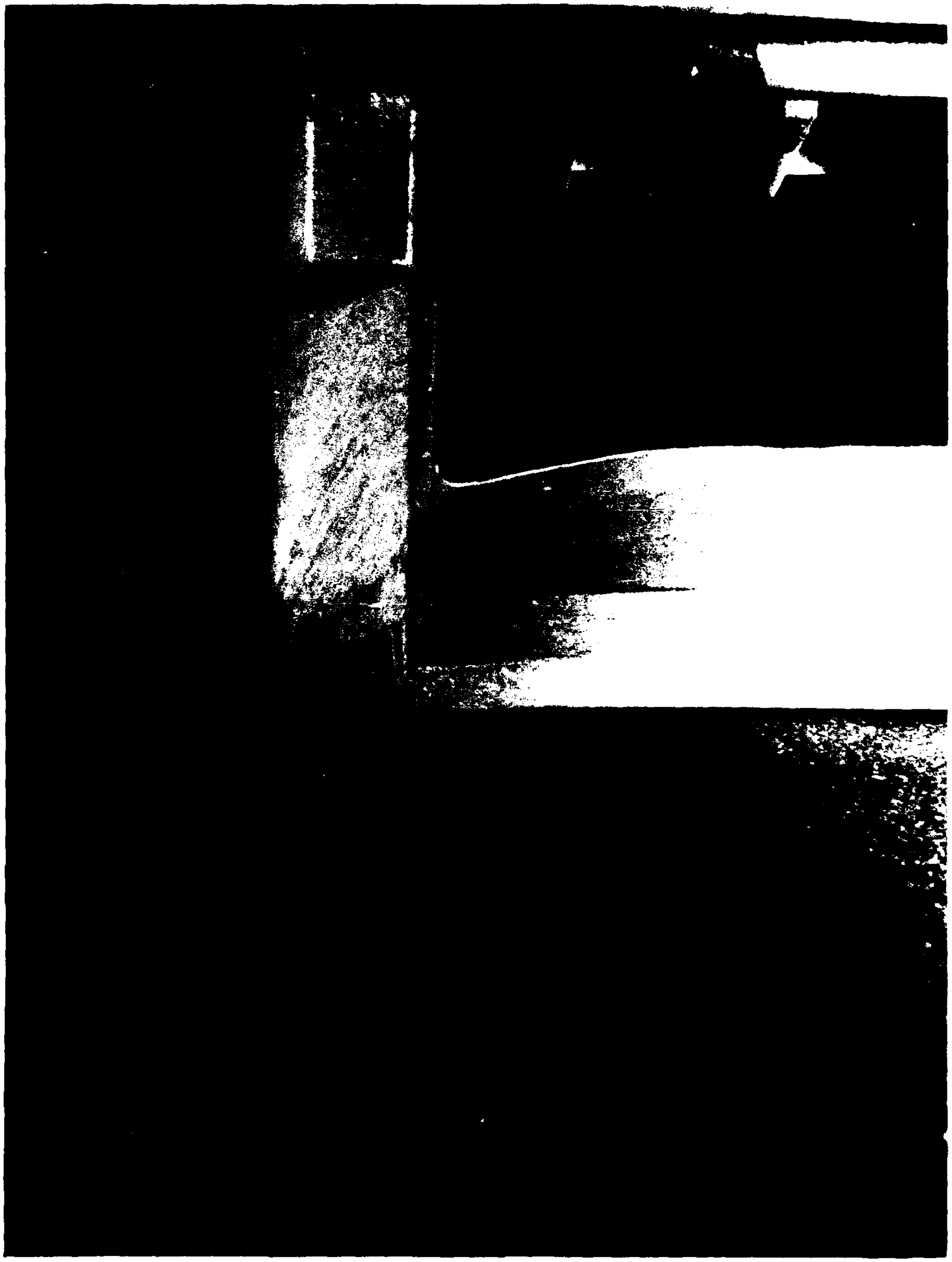

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Photo No. AO317-SCN92-177-1533. This photo shows some cracking that occurred during the second 1 1/2-hour cycle of the vibration test.

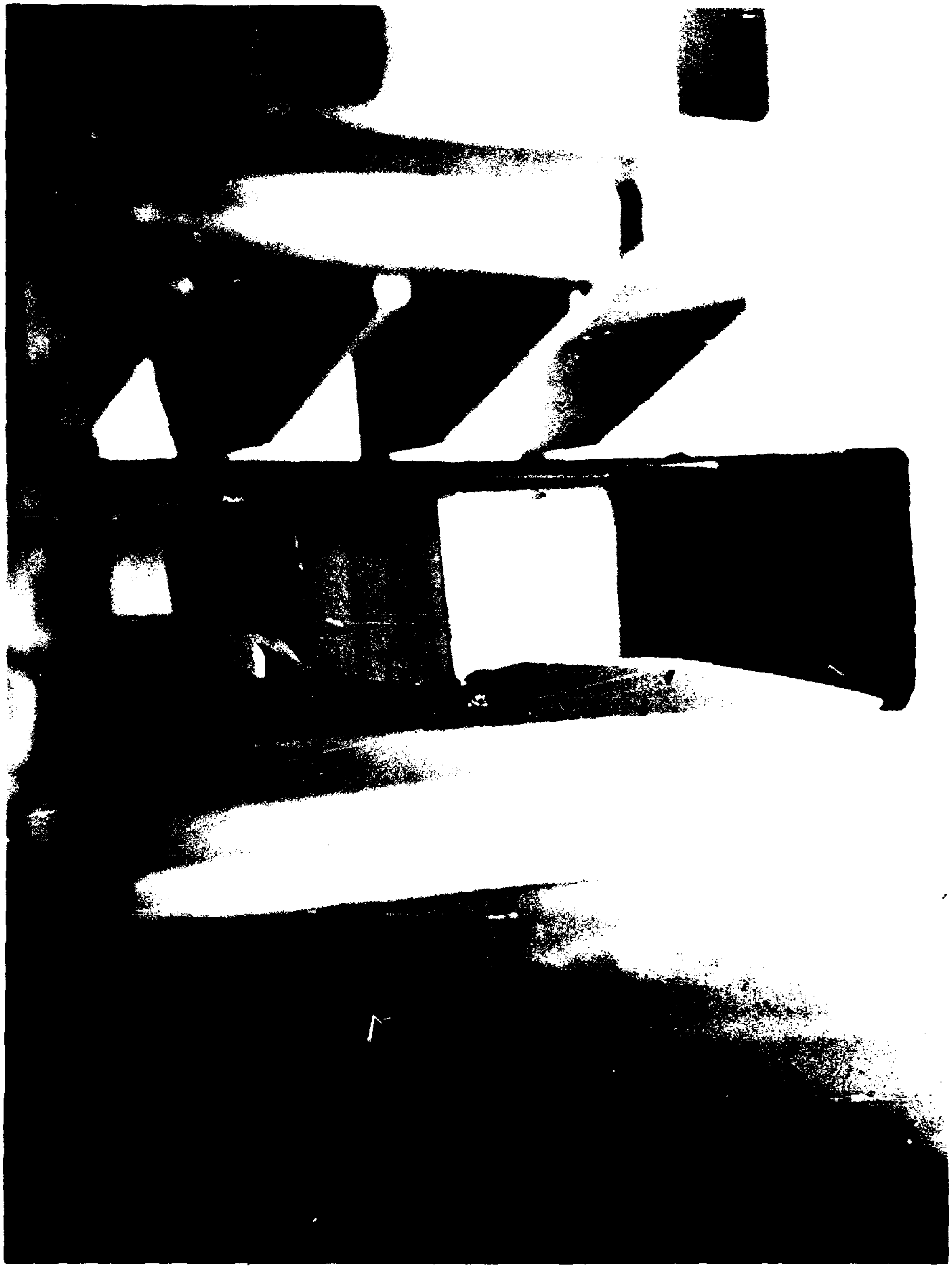

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Photo No. AO317-SCN92-177-1534. This photo shows the resulting collapsing due to wear from the vibration testing.		

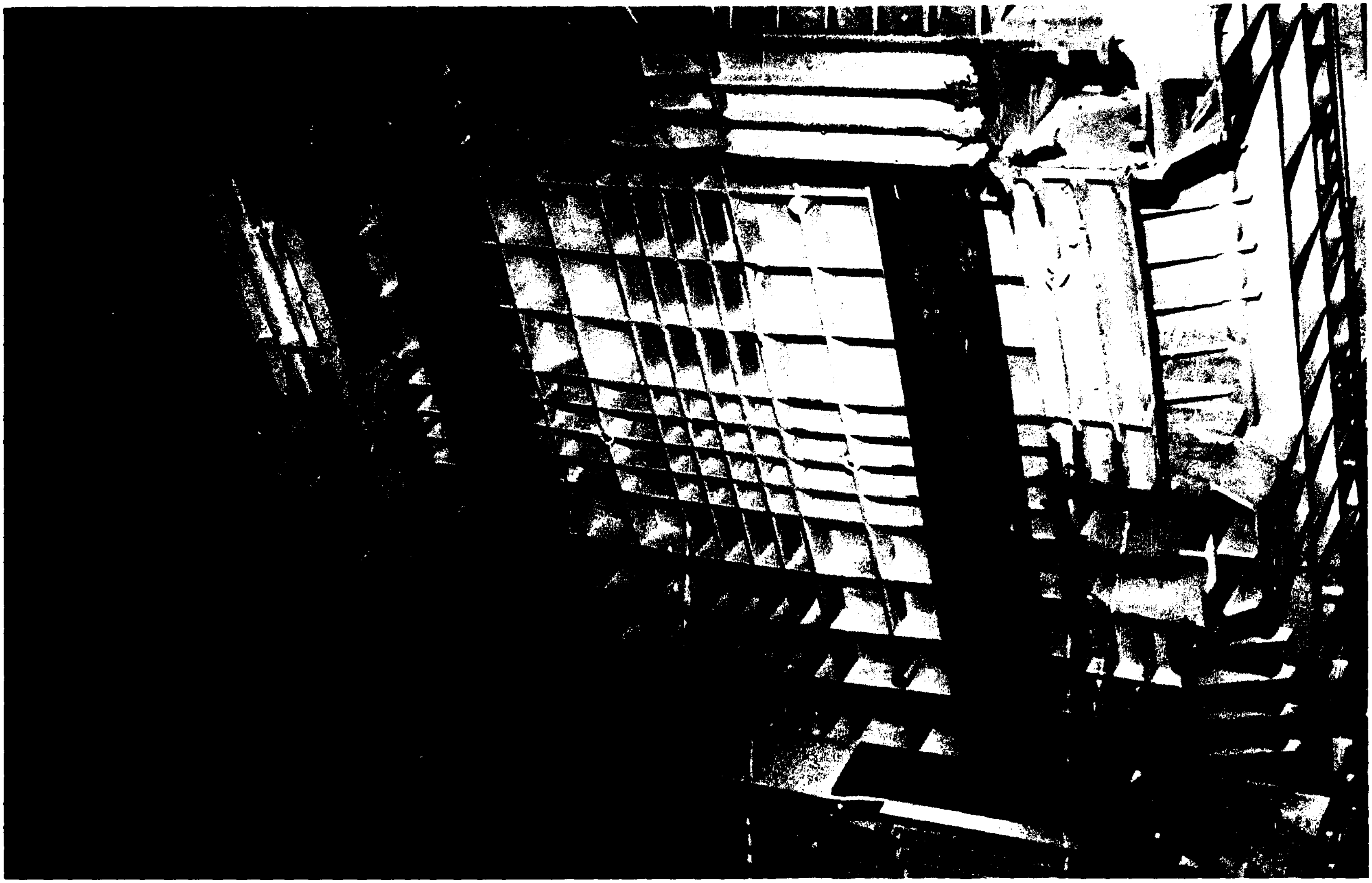

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Photo No. AO317-SCN92-177-1538. This photo shows the wear on the bottom from vibration testing.