MIL-STD-1660 TEST OF PA116 CONTAINER ON A STANDARD METAL PALLET WITH FORK TINE PROTECTION.
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The U.S. Army Defense Ammunition Center and School (USADACS) was asked to design a protective system into the Standard Metal Pallet to prevent forklift tines from puncturing the PA116 containers. As a result, a guard plate was added to the PA116 pallet adaptor. The guard plate provides six inches of barrier along the length of the bottom row of the container. In order to verify this modified version of the PA116 metal pallet, it was subjected to the requirements of MIL-STD-1660, Design Criteria for Ammunition Loads. The test specimens, consisting of a standard metal pallet, pallet adaptor with forklift protector, top lift assembly, and inert loaded PA116 containers, weighed 2,423 pounds in a 44 inches W x 40 inches L x 50-1/2 inches high. Tests performed on the specimen were compression, repetitive shock, (vibration), edgewise rotational drop, and inclined impact. As a result of these tests, the test specimen sustained some damage in loosening.
19. Continued

...of the banding straps and lateral load shifting on the pallet. Despite these faults, the pallet is considered acceptable by the criteria of MIL-STD-1660.
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL  
Evaluation Division  
Savanna, IL  61074-9639

REPORT NO. EVT 39-87  
MIL-STD-1660 TEST OF PA116 CONTAINER ON A STANDARD  
METAL PALLET WITH FORK TINE PROTECTION

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USASDACS) was tasked by the Office of the Project Manager for Ammunition (PM-AMMOLOG), AMCPM-AL, to add a protective barrier along the lateral side of the standard metal pallet for reducing the number of accidental container punctures from forklift tines. As a result of this request, USADACS modified the PA116 Container Pallet Adaptor assembly with a six-inch-high formed metal plate along the lateral side of the container.

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

C. OBJECTIVE. The objective of this test is to evaluate the PA116 Standard Metal Pallet with forktine protector in accordance with MIL-STD-1660 design criteria for ammunition unit loads.
PART 2

ATTENDEES

Mr. A. C. McIntosh, Jr.
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Comm (815) 273-8989

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

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 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 load of a 16-foot-high stack.

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. Unless failure occurs, 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 6 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.

<table>
<thead>
<tr>
<th>GROSS WEIGHT NOT EXCEEDING</th>
<th>DIMENSIONS ON ANY EDGE NOT EXCEEDING</th>
<th>HEIGHT OF DROP LEVEL A PROTECTION</th>
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<tr>
<td>600 lbs.</td>
<td>72 inches</td>
<td>36 inches</td>
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<tr>
<td>3,000 lbs.</td>
<td>no limit</td>
<td>24 inches</td>
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<tr>
<td>no limit</td>
<td>no limit</td>
<td>12 inches</td>
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</table>
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 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, and, 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.
PART 4

TEST EQUIPMENT

1. TEST SPECIMEN.
   a. Width: 44 inches
   b. Length: 40 inches
   c. Height: 50-1/2 inches
   d. Weight: 2,423 pounds

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: Gaines Laboratory
   b. Capacity: 5,000 pound pallet
   c. Displacement: 1/2-inch Amplitude
   d. Speed: 50 to 300 cpm
   e. Platform: 5 feet by 8 feet

4. INCLINED RAMP
   a. Manufacturer: Conbur Incline
   b. Type: Impact Tester
   c. Grade: 10 Percent Incline
   d. Length: 12-foot Incline Ramp
PART 5

TEST RESULTS

1. STACKING TEST. Pallet Weight: 2,423 lbs. Pallet Height: 50-1/2 in. Test Load Weight: 9,200 lbs. The PA116 Standard Metal Pallet with the forktine protector was loaded to a test weight of 9,200 pounds in the compression tester. It remained under compression for a period of 60 minutes. Some loosening of the banding straps was noticed. At the end of the test period, the compression load decreased to 8,500 pounds. When the compression load was removed and the test specimen taken out of the compression test fixture, the banding straps returned to the original tension, and no measurable deformation in the load was recordable.

2. REPETITIVE SHOCK TEST. The PA116 Standard Metal Pallet with forktine protector was subjected to two 90 minute periods in the transportation simulator. During the first 90 minute period, the pallet skids were oriented longitudinally to the direction of motion. The Transportation Simulator was operated at 200 rpm in order to achieve a 1/16 inch displacement between the pallet skids and transportation simulator deck. A rotational speed of 200 rpm induces a 1 g shock into the test specimen.

3. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet is placed on a beam displacing it 6 inches above the floor. The opposite side is raised to a height of 24 inches above the floor and then dropped. The pallet skids were oriented longitudinally for the first and third impacts and laterally for the second and fourth
impacts. When the pallet was dropped with the sides oriented in the longitudinal direction, the outside truss members deformed from the impact. As a result of this deformation, the ends of the sides became bowed instead of remaining flat. After the second and fourth impacts, the outer sides were bent outward. Also, the pallet deck became bowed.

4. INCLINED IMPACT TEST. The incline impact test consisted of placing the PA116 Standard Metal Pallet with forktine protector on an inclined impact test with two inches of the pallet projecting over the edge of the sled. The sled was raised approximately eight feet up the inclined ramp and release, allowing the sled to accelerate into a solid wall with an optional 6 inch x 8 inch beam at the base. This test was repeated once on each side of the pallet. To impact on the bell end, the containers were oriented longitudinally to the direction of impact. The PA116 container interlocks did not become disengaged nor was there additional damage to the pallet skids or truss post. With the pallet turned 180 degrees and impacting the closed container end, no additional damage occurred to the unitization. For the remaining two impacts, the PA116 containers and pallet skids were oriented parallel to the direction of impact. When impacted in this orientation, the forktine protectors were deformed from the impacting with the optional beam and the lower row of containers. When this occurred, the top row of containers (5 containers) became disengaged from the second row. Also the bell end flats remained in parallel contact with the impact tester wall. The bells on the third row of containers were in partial wall contact. Dynamically, the top four rows of containers made contact
with the impacting surface while the pallet skid was offset by the amount presented by
the optional beam.
CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS. The PA116 Standard Metal Pallet with forktine protector technically satisfied the requirements of MIL-STD-1660 in that it retained the load after all of the specified tests. However, after testing, the pallet unit was loosened up enough that it would probably fall apart after additional rough handling. This test sequence caused damage to the pallet skid trusses, caused the pallet skids to bend upward, and warped the pallet deck. The pallet adapter with the forktine protector was damaged to a point where the PA116 container had a lateral side slip of two inches. The test specimen was six inches out of square after testing with the first and second rows of container interlocks disengaged.

2. RECOMMENDATIONS. It is recommended that the following design changes be made. The pallet skid should be redesigned to prevent damage to the truss post. The pallet adapter should be modified to reduce the amount of lateral movement. Intermediate dunnage and a better interlocking system of the PA116 container should be developed to eliminate lateral load skewing from bottom to top.
PART 7

PHOTOGRAPHS
DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. 1. This photo shows the PA116 Standard Metal Pallet with fork tine protector in the Transportation Simulator. Operational speed of the simulator was 20C rpm to produce a 1/16-inch clearance between skids and the tester deck.
Photo No. 3. This photo shows the PA116 Standard Metal Pallet with forklift protector positioned for the second edgewise rotational drop test. Note the deformation of the pallet skids on the left. This deformation was caused by the first drop test. Also note that all three outside truss members have been deformed.
DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. 4. This photo shows the PA116 Standard Metal Pallet with the forktine protector positioned for the third edgewise rotational drop test. Note the skid on the left. It is not in contact with the six-inch beam. The center and right skids are in contact with the beam. Photo 2 shows all three skids in contact with the six-inch beam. The first lateral caused the pallet to deform or warp. This warp allows the pallet to rock side to side.
Photo No. 5. This photo shows the PA116 Standard Metal Pallet with forklift protector ready for the last rotational drop test. Note damage to skids and truss posts. This damage was caused by the edgewise rotational drop tests. After this test, the pallet deck sustained additional bending.
Photo No. 6. This photo shows the PA116 Standard Metal Pallet with forklift protector after the first inclined impact test.
DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. 7. This photo shows the PA116 Standard Metal Pallet with forklift protectors after the second inclined impact. Note gap between the bottom row of containers and the pallet adapter. Also note upper pallet skewing as compared to the skid and deformation of the forklift protector on the side of impact.
| Photo No. 8. This photo shows the PA116 Standard Metal Pallet with forklift protector after the third inclined impact. |
Photo No. 9. This photo shows the PA116 Standard Metal Pallet with forklift protector after the fourth and last inclined impact. Note: Disengagement of the two container rows from container interlocks; load skew from top to bottom; damage to the forklift protector on the right; and increased displacement of the bottom row of containers and the left forklift protector.
Photo No. 10. This photo shows the bell end of the PAL6 Standard Metal Pallet with forklift one protector after the fourth impact. Note: Interlock disengagement in the top two container rows; unit load skew; damage to the forklift protector; and disengagement of the end container in the second row.
PART 8

DRAWINGS
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- ANSI Y14.5-82
- ASTM A58
- ASTM A588
- ASTM A586
- ASTM A587
- ANSI A2.4-86
- FED-STD-595
- MIL-A-2550
- MIL-C-46168
- MIL-C-53039
- MIL-STD-171
- MIL-STD-1261
- MIL-T-704
- MIL-F-52192

DIMENSIONING AND TOLERANCING
SPECIFICATIONS FOR STRUCTURAL STEEL
STEEL, SHEET, CARBON, COLD ROLLED,
COMMERCIAL QUALITY
STEEL, SHEET, CARBON, AND HIGH STRENGTH, LOW ALLOY
HOT ROLLED, AND COLD ROLLED
STEEL, CARBON (0.15 MAXIMUM, PERCENT) HOT ROLLED,
SHEET AND STRIP, COMMERCIAL QUALITY
STANDARD SYMBOLS FOR WELDING, BRAZING AND
NONDESTRUCTIVE EXAMINATION
COLORS
AMMUNITION, GENERAL SPECIFICATIONS FOR
COATING, ALIPHATIC POLYURETHANE, CHEMICAL
AGENT RESISTANT
COATING, ALIPHATIC POLYURETHANE, SINGLE COMPONENT
CHEMICAL AGENT RESISTANT
FINISHING OF METAL AND WOOD SURFACES
ARC WELDING PROCEDURES FOR CONSTRUCTIONAL STEELS
TREATMENT AND PAINTING OF MATERIAL
PRIMER COATING, EPOXY
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1. DETAIL REQUIREMENTS FOR SURFACE PREPARATION (CLEANING AND PREPARATION) TO BARE METAL PRIOR TO PRIMING AND PAINTING.

1.1 ALL SURFACES SHALL BE THOROUGHLY CLEANED SUCH THAT THE BARE METAL SURFACES ARE FREE FROM OIL, GREASE, DIRT, SCALE, RUST, FOREIGN MATTER AND WELD SPATTER. THE CLEANING METHOD SHALL BE IN ACCORDANCE WITH ANY METHODS IN TABLE IV OF MIL-S-1471 OR AS SPECIFIED IN PARAGRAPH 3.1 OF MIL-I-1200. PARTICULAR CARE MUST BE TAKEN TO REMOVE WELD BEAD AND WELD SPATTER FROM WELDS AND ADJACENT AREAS.

1.2 IMMEDIATELY AFTER CLEANING, ANY SOLVENTS OR MOISTURE SHALL BE COMPLETELY REMOVED. THESE CLEAN, DRY SURFACES SHALL THEN HAVE A PREPAREMENT APPLIED IN ACCORDANCE WITH MIL-S-1471, MIL-I-6471, OR MIL-I-1200 PER THE PREPARATION TO USE A ZINC PHOSPHATE, FINISH NO. 8,0,1,1 OR BRONZE PHOSPHATE, FINISH NO. 18,12,1 OR WASH PRIMER, FINISH NO. 5,3.

1.3 IMMEDIATELY AFTER PRIMING, ALL SURFACES WHICH HAVE BEEN CLEANED AND PREPARED IN ACCORDANCE WITH PARAGRAPH 1.1 AND 1.2 SHALL BE CHECKED FOR THOROUGH CLEANLINESS, ANY ACCUMULATION OF OIL, GREASE, DUST, RESIDUES FROM THE CLEANING PROCESS OR ANY FOREIGN MATERIAL SHALL BE COMPLETELY REMOVED. THE USE OF SOLVENTS MEETING THE REQUIREMENTS OF TABLE IV, FINISH NO. 4,3 OF MIL-S-1471 IS ACCEPTABLE. THE COMPLETE DRYING OF ANY SOLVENTS OR MOISTURE IS ESSENTIAL.

2. DETAIL REQUIREMENTS FOR APPLICATION OF ANTI-CORROSIVE PRIMER PAINT.

2.1 PRIMER SHALL BE APPLIED ON ALL SURFACES IN ACCORDANCE WITH MANUFACTURERS INSTRUCTIONS AND PARAGRAPH 5.2.1 OF MIL-S-1471, EXCEPT THAT WHEN ACCELERATED DRYING IS EMPLOYED, OVEN TEMPERATURE IS NOT TO EXCEED 200°C. THE PREFERRED PRIMER FOR PEERIOUS SURFACES IS MIL-F-22234; HOWEVER, MIL-F-30522 AND MIL-F-33032 MAY BE USED AS A SUBSTITUTE FOR MIL-F-33175.

2.2 ONE COAT OF PRIMER SHALL BE APPLIED AS PROMPTLY AS POSSIBLE AFTER THE SURFACES HAVE BEEN PREPARED AND CLEANED BY THE FOREMENTIONED PROCEDURES. ALL FROZEN PRIMERS SHALL BE PROMPTLY DRIED BEFORE TOPCOATING. PRIMER DRY FILM THICKNESS SHALL BE .0008 TO .0010 INCHES (0.2 TO .25MM).

3. DETAIL REQUIREMENTS FOR APPLICATION OF POLYURETHANE TOPCOAT PAINT.

3.1 TOPCOAT SHALL BE APPLIED ON EXTERIOR SURFACES ONLY IN ACCORDANCE WITH MANUFACTURERS INSTRUCTIONS OR PARAGRAPH 5.2.1 OF MIL-S-1471, UNLESS OTHERWISE SPECIFIED, THE TOPCOAT COLOR SHALL BE GREEN NO. 383 IN ACCORDANCE WITH MIL-C-44148 OR MIL-C-33091.

3.2 TOPCOAT DRY FILM THICKNESS OF MIL-C-44148 AND MIL-C-33091 SHALL BE .0018 TO .0020 INCHES (.0046 TO .0051MM) TOTAL APPLIED IN TWO COATS. THE SECOND COAT MAY BE APPLIED AFTER 15 MINUTES OF THE FIRST AT 75°F, OR ANY TIME THEREAFTER. THERE IS NO MINIMUM TIME PERIOD LIMIT BETWEEN APPLICATION OF THE FIRST AND SECOND COATS AND NO SURFACE PREPARATION, EXCEPT FOR CLEANING, IS NECESSARY EVEN IF THE SECOND COAT IS NOT APPLIED DIRECTLY AFTER THE FIRST.

4. DETAIL REQUIREMENTS FOR APPLICATION TO PREVIOUSLY PAINTED SUBSTRATES.

4.1 ALL PREVIOUSLY PAINTED SURFACES MUST BE CLEAN AND FREE FROM RUST, WHERE RUST EXISTS, MECHANICAL CLEANING IN ACCORDANCE WITH FINISH NO. 4.1 OF MIL-S-1471 (WETBRUSH IS ACCEPTABLE) SHALL BE PERFORMED UNTIL BRILLIANT METAL IS EXPOSED. ONE COAT OF POLYURETHANE PAINT PER MIL-C-44148 OR MIL-C-33091 CAN BE APPLIED DIRECTLY OVER EXISTING ENAMEL OR POLYURETHANE COATINGS WITHOUT ANY ADDITIONAL SURFACE PREPARATION EXCEPT CLEANING, IF THE SURFACE IS BLOWN DOWN TO THE SUBSTRATE, THAT AREA MUST BE CLEANED, PREPARED, PRIMED AND TOPCOATED PER PARAGRAPHS 1 THROUGH 3. THE POLYURETHANE COATING SHALL NOT, HOWEVER, BE DIRECTLY APPLIED OVER LACQUER. THE LACQUER MUST BE REMOVED DOWN TO THE BARE METAL BEFORE POLYURETHANE COATING IS APPLIED PER PARAGRAPHS 1 THROUGH 3.

(Continued at right)
NOTES
1. SPEC. ANSI Y14.5M-82 APPLY.
2. MATERIAL: STEEL, MEDIUM CARBON, HOT ROLL, PER ASTM A36
3. ALL DIMENSIONS ARE IN INCHES.