

**FINAL REPORT
JUNE 2006**

REPORT NO. 06-07



**45-1/2" x 35" METAL PALLET WITH CARTRIDGE, 40MM,
PACKED 32 PER PA120 METAL BOX, UNITIZED 42 PER PALLET,
FIRST ARTICLE TESTS IN ACCORDANCE WITH MIL-STD-1660,
"DESIGN CRITERIA FOR AMMUNITION UNIT LOADS"**

Prepared for:

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American Ordnance
Iowa Army Ammunition Plant
17575 Hwy 79
Middletown, Iowa 52638-9701



**DEFENSE AMMUNITION CENTER
VALIDATION ENGINEERING DIVISION
MCALESTER, OKLAHOMA 74501-9053**

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**45-1/2" x 35" METAL PALLET WITH CARTRIDGE,
40MM, PACKED 32 PER PA120 METAL BOX,
UNITIZED 42 PER PALLET, FIRST ARTICLE TESTS
IN ACCORDANCE WITH MIL-STD-1660,
"DESIGN CRITERIA FOR AMMUNITION UNIT LOADS"**

ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV) conducted First Article Tests in Accordance with MIL-STD-1660, "Design Criteria for Ammunition Unit Loads" on the 45-1/2" x 35" metal pallet with cartridge, 40MM, packed 32 per metal box, unitized 42 per pallet, manufactured by Flint Cliffs Manufacturing of Middleton, Iowa, for American Ordnance of Burlington, Iowa. Two test units were tested with a load of 1,980 lbs. each. The tests accomplished on the test units were the stacking, vibration, drop, incline-impact, sling compatibility, forklifting, and disassembly tests.

The test units passed all requirements with no significant problems encountered; however, during Incline-Impact tests, it was noted that over an inch of movement of the PA120 Containers occurred within the bottom adapter of the test unit. The bottom adapter was dimensionally checked and found to be within tolerances given on Drawing ACV00126. No further action was taken on the movement of the containers due to the fact that the test unit could safely continue its intended mission and was not a cause for failure. The dimensions and/or tolerances on the pallet fabrication drawings need to be reviewed to determine if a design change should be made.

As a result of the performance of the test units, the 45-1/2" x 35" metal pallet with cartridge, 40MM, packed 32 per metal box, unitized 42 per pallet, manufactured by Flint Cliffs Manufacturing of Burlington, Iowa, for American Ordnance of Middletown, Iowa, is recommended for use by the United States Army.

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U.S. ARMY DEFENSE AMMUNITION CENTER

VALIDATION ENGINEERING DIVISION

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**45-1/2" x 35" METAL PALLET WITH CARTRIDGE,
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UNITIZED 42 PER PALLET, FIRST ARTICLE TESTS
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PART 1 – INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV) conducted First Article Tests in accordance with MIL-STD-1660, "Design Criteria for Ammunition Unit Loads" on the 45-1/2" x 35" metal pallet with cartridge, 40MM, packed 32 per metal box, unitized 42 per pallet, manufactured by Flint Cliffs Manufacturing of Burlington, Iowa, for American Ordnance of Middletown, Iowa. Two test units were tested with a load of 1,980 lbs each. The tests accomplished on the test units were the stacking, vibration, drop, incline-impact, sling compatibility, forklift handling, and disassembly tests. The unitization procedures were provided by DAC, Transportation Engineering Division (SJMAC-DET).

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Joint Munitions Command (JMC), Rock Island, IL. Reference is made to the following:

1. AR 740-1, 15 June 2001, Storage and Supply Activity Operation
2. OSC-R, 10-23, Mission and Major Functions of U.S. Army Defense Ammunition Center (DAC) 21 Nov 2000.

C. OBJECTIVE. The objective of the tests was to determine if the 45-1/2" x 35" metal pallet with cartridge, 40MM, packed 32 per metal box, unitized 42 per pallet, met the MIL-STD-1660 test requirements prior to the acceptance of the unitization procedures by the U.S. Army.

D. CONCLUSION. The test units passed all requirements with no significant problems encountered; however, during Incline-Impact tests, it was noted that there was over an inch of movement of the PA120 Containers within the bottom adapter of the test unit. The bottom adapter was dimensionally checked and found to be within tolerances given on drawing ACV00126. No further action was

taken on the movement of the containers due the fact that the Test Unit could safely continue its intended mission and was not a cause for failure. The dimensions and/or tolerances on the pallet fabrication drawings need to be reviewed to determine if a design change is required. As a result of the performance of the test units, the 45-1/2" x 35" metal pallet with cartridge, 40MM, packed 32 per metal box, unitized 42 per pallet, manufactured by Flint Cliffs Manufacturing of Burlington, Iowa, for American Ordnance of Middletown, Iowa, is recommended for use by the United States Army.

PART 2 - ATTENDEES

DATE PERFORMED:

Test Unit #1- April 13-14, 2006

Test Unit #2- April 17-18, 2006

ATTENDEE

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PART 3 - TEST PROCEDURES

1. MIL-STD-1660 TEST

The test procedures outlined in this section from were extracted from the MIL-STD-1660. The tests are conducted on ammunition pallet units or unit loads and are summarized as follows:

A. STACKING TEST. The test unit will be tested to simulate a stack of identical items stacked 16 feet high, for a period of one hour. This stacking load will be simulated by subjecting the specimen to a compression weight equal to an equivalent 16-foot stacking height. Photo 1 below shows an example of a unit load in the compression tester.



Photo 1. Example of Stacking Test.

(2.75-inch Hydra 70, PA151 Rocket Pallet in the Stacking Test.)

B. REPETITIVE SHOCK TEST. The repetitive shock test is conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test unit will be placed on (not fastened to) the platform. With the test unit in one

position, the platform will be vibrated at ½-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles-per-second. The frequency will be steadily increased until the specimen leaves the platform. The resonant frequency is achieved when a 1/16-inch-thick feeler gage momentarily slides freely between every point on the specimen in contact with the platform at some instance during the cycle. Midway into the testing period, the specimen will be rotated 90 degrees, and the test continued for the duration. Unless failure occurs, the total time of vibration will be three hours. Photo 2 shows an example of the repetitive shock test.



**Photo 2. Example of the Repetitive Shock Test.
(MSTF Low)**

C. EDGEWISE-ROTATIONAL DROP TEST. This test is conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise-rotational drop test is as follows: The test unit will be placed on its skids with one end of the pallet supported on a beam 6 inches high. The height of the beam will be increased as necessary to ensure that there is no support for the skids between the ends of the specimen when the dropping takes place, but should not be high enough to cause the specimen to slide on the supports when the dropped end is raised for the drop. The unsupported end of the specimen is

then raised and allowed to fall freely to the concrete, pavement, or similar unyielding surface from a prescribed height. Unless otherwise specified, the height of drop for Level A protection will conform to the following tabulation:

GROSS WEIGHT (WITHIN RANGE LIMITS) (Pounds)	DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS) (Inches)	HEIGHT OF DROPS ON EDGES	
		Level A (Inches)	Level B (Inches)
150-250	60-66	36	27
250-400	66-72	32	24
400-600	72-80	28	21
600-1,000	80-95	24	18
1,000-1,500	95-114	20	16
1,500-2,000	114-144	17	14
2,000-3,000	Above 145- No limited	15	12
Above – 3,000		12	9

Figure 1.



Photo 3. Example of Edgewise Rotational Drop Test
(MSTF Low)

D. INCLINE-IMPACT TEST. This test is 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 test unit will be 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 will be brought to a predetermined position on the incline and released. If it were desired to concentrate the impact on any particular position on the container, a 4- x 4-inch timber may be attached to the bumper in the desired position before the test. The carriage will not strike any part of the timber. The position of the specimen 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 dependent upon the objective of the test. When the test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen will be subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at the time of the impact will be 7 feet-per-second. Photo 4 shows an example of this test.



**Photo 4. Example of the Incline-Impact Test.
(2.75-Inch, Hydra 70, PA151 Rocket Pallet on incline-impact tester.)**

E. SLING COMPATIBILITY TEST. The test unit utilizing special design or non-standard pallets will be lifted, swung, lowered and otherwise handled as necessary, using slings of the types normally used for handling the unit loads under consideration. Slings will be easily attached and removed. Danger of slippage or disengagement when load is suspended will be cause for rejection of the specimen.

F. FORKLIFTING TESTS. The test unit will be lifted clear of the ground by a forklift from the end of the test unit and transported on the forks in the level or back-tilt position. The forklift will pass over the Optional Rough Handling Course For Forklift Trucks as outlined in MIL-STD-1660. The course will consist of parallel pairs of 1-inch boards spaced 54 inches apart and will be laid flat wise on the pavement across the path of the forklift. One pair will be laid at an angle of approximately 60 degrees to the path so that the left wheel strikes first. Another pair will be laid securely across the path of the forklift so that the wheels strike simultaneously. Another pair will be laid at an angle of approximately 75 degrees to the path so that the right wheel strikes first. The test unit will be transported over the Optional Rough Handling Course. The test unit shall be observed for deflection and damage. The test unit will be rotated 90 degrees and the test unit lifted from the side and the above steps repeated.

G. DISASSEMBLY TEST. Following all rough handling tests the test unit may be squared up within 2 inches of its original shape and on a flat level surface. The strapping will then be cut and removed from the palletized load. Assembly of the test unit will be such that it retains its unity upon removal of the strapping.

PART 4 - TEST EQUIPMENT

A. COMPRESSION TESTER.

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

B. TRANSPORTATION SIMULATOR.

- | | |
|------------------|---------------------|
| 1. Manufacturer: | Gaynes Laboratory |
| 2. Capacity: | 6,000-pound payload |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed: | 50 to 400 RPM |
| 5. Platform: | 5- x 8-foot |

C. INCLINED PLANE.

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

PART 5 - TEST RESULTS

5.1. TEST UNIT DATA. The test unit was inertly loaded to the specified design weight using inert materials. The test unit was prepared using the unitization procedures specified in Part 6 – Drawings. Special care was taken to ensure that each PA120 metal box had the proper amount of weight in order to achieve a realistic pallet center of gravity (CG). Once properly prepared, Test Units #1 and #2 were tested using MIL-STD-1660 requirements.

TEST UNIT #1

45-1/2" x 35" Metal Pallet with Cartridge, 40MM

Test Date:	14 –15 April 2006 (MIL-STD-1660)
Gross Weight:	1,980 pounds
Length:	45-1/2 inches
Width:	35 inches
Height:	38 inches
Mfgr:	Flint Cliffs Manufacturing of Burlington, Iowa for American Ordnance, Middletown, Iowa

TEST UNIT #2

45-1/2" x 35" Metal Pallet with Cartridge, 40MM

Test Date:	17 –18 April 2006 (MIL-STD-1660)
Gross Weight:	1,980 pounds
Length:	45-1/2 inches
Width:	35 inches
Height:	38 inches
Mfgr:	Flint Cliffs Manufacturing of Burlington, Iowa for American Ordnance, Middletown, Iowa

A. MIL-STD-1660 TEST RESULTS TEST UNIT #1:

1. STACKING TEST. The test unit was compressed with a load force of **7,920** pounds for 60 minutes on 14 April 2006. No damage was noted as a result of this test. See Photo 5 of the test unit in the compression unit.



Photo 5. Test Unit in the Stacking Test.

2. REPETITIVE SHOCK TEST. The test unit was vibrated 90 minutes at **220** RPM in the longitudinal orientation and 90 minutes at **195** RPM in the lateral orientation on 14 April 2006. No damage was noted as a result of this test. Photo 6 shows the test unit on the vibration platform.



Photo 6. Test Unit During Repetitive Shock Testing.

3. EDGEWISE-ROTATIONAL DROP TEST. The test unit was edgewise rotationally dropped from a height of 17 inches on both longitudinal sides and both lateral sides. No significant damage was noted as a result of this test, however the test unit sustained minor damage to the welds on the pallet post to the bottom of the deck during drop testing. The damage was deemed minor because it would not interfere with the container safely continuing on with its intended mission. The minor damage that occurred is common to this type of pallet with this load capacity. Photo 7 shows the test unit during the edgewise drop test.



Photo 7. Edgewise Drop Test on the Test Unit.

4. INCLINE-IMPACT TEST. The test unit was impact tested on both longitudinal sides and both lateral sides. No significant damage was noted as a result of this test; however, it was noted that there was over an inch of movement of the PA120 Containers within the bottom adapter of the test unit. The bottom adapter was dimensionally checked and found to be within tolerances given in Drawing ACV00126. No further action was taken on the movement of the containers due to the fact that the test unit could safely continue its intended mission and was not a cause for failure. The dimensions and/or tolerances on the pallet fabrication drawings need to be reviewed to determine if a design change is required. See Photo 8 shows movement of the PA120 Containers. See Photo 9 for the specimen during the lateral incline-impact test.



Photo 8. Test Unit Movement During Incline-Impact Testing



Photo 9. Incline-Impact Testing of the Test Unit.

5. SLING COMPATIBILITY TEST. Test Unit #1 was sling compatibility tested by slinging the container with lifting cables through the lifting rings on the top assembly by four, three, and two points. No problems were encountered during the lifts. See photo 9 for the test setup during the sling compatibility test.



Photo 10. Two-Point Sling Compatibility Testing of the Test Unit.

6. **FORKLIFTING TEST.** The test unit was lifted clear of the ground by a forklift from both longitudinal sides and both lateral sides and transported on the forks. No damage was noted as a result of this test.

7. **DISASSEMBLY TEST.** Inspection revealed no damage.

8. **CONCLUSION.** No major problems were encountered during the completion of the required testing. The test unit passed the requirements of the MIL-STD-1660.

B. MIL-STD-1660 TEST RESULTS TEST UNIT#2:

1. **STACKING TEST.** The test unit was compressed with a load force of **7,920** pounds for 60 minutes on 17 April 2006. No damage was noted as a result of this test.

2. **REPETITIVE SHOCK TEST.** The test unit was vibrated 90 minutes at 220 RPM in the longitudinal orientation and 90 minutes at 195 RPM in the lateral orientation on 17 April 2006. No damage was noted as a result of this test.

3. **EDGEWISE- ROTATIONAL DROP TEST.** The test unit was edgewise rotationally dropped from a height of 17 inches on both longitudinal sides and both lateral sides. No significant damage was noted as a result of this test, however the test unit sustained minor damage to the welds on the pallet post to the bottom of the deck during drop testing. The damage was the same as seen in test unit #1 and was deemed minor because it would not interfere with the container safely continuing on with its intended mission. The minor damage that occurred is common to this type of pallet with this load capacity.

4. **INCLINE-IMPACT TEST.** The test unit was impact tested on both longitudinal sides and both lateral sides. No significant damage was noted as a result of this test, however there was over an inch of movement of the PA120 Containers as noted in the first Test Unit.

5. **SLING COMPATIBILITY TEST.** Test Unit #2 was sling compatibility tested by slinging the container with lifting cables through the lifting rings on the top assembly by four, three, and two points. No problems were encountered during the lifts.

6. **FORKLIFTING TEST.** The test unit was lifted clear of the ground by a forklift from both longitudinal sides and both lateral sides and transported on the forks. No damage was noted as a result of this test.

7. **DISASSEMBLY TEST.** Inspection revealed no damage.

8. **CONCLUSION.** No major problems were encountered during the

completion of the required testing. The test unit passed the requirements of the MIL-STD-1660.

PART 6– DRAWINGS

The following test sketches represent the load configuration that was subjected to the test criteria.

APPENDIX 21

UNITIZATION PROCEDURES FOR AMMUNITION AND COMPONENTS PACKED IN METAL OR PLASTIC BOXES ON 4-WAY ENTRY PALLETS

CARTRIDGE, 40MM, PACKED 32 PER PA120
METAL BOX, UNITIZED 42 PER 45-1/2" X 35"
PALLET; APPROX CONTAINER SIZE 18-3/4"
L X 6-3/8" W X 10-3/8" H

NOTICE: THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH
THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4232-20PM1007.

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U.S. ARMY MATERIEL COMMAND DRAWING

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U.S. ARMY DEFENSE AMMUNITION CENTER		ENGINEER OR TECHNICIAN	BASIC REV.	SANDRA SCHULTZ	REVISION NO. 3
		TRANSPORTATION ENGINEERING DIVISION	TESTED	PATRICK DOUGHERTY	DECEMBER 2004
		VALIDATION ENGINEERING DIVISION	TESTED	SEE THE REVISION LISTING ON PAGE 2	
		ENGINEERING DIRECTORATE	TESTED	CLASS	DIVISION
				19	48
				4232/ 21	20PM1007

PALLET UNIT DATA				
ITEMS INCLUDED		HAZARD CLASS AND DIVISION		APPROX WEIGHT LBS
NSN	DODIC	QD CLASS	COMP GROUP	
1310-				
01-315-1636	B472	—— INERT ——		1,975
01-369-1902	B472	—— INERT ——		1,975
01-319-1541	B542	1.1	E	1,975
01-354-8745	B542	1.1	E	1,975
01-419-8203	B542	1.1	E	1,975
01-316-9973	B576	1.4	C	1,975
01-317-5948	B584	1.4	C	1,975
01-464-4117	BAI 1			1,975
01-472-9916	BAI 2	1.4	C	1,975

- HAZARD CLASSIFICATION DATA CONTAINED IN THE ABOVE CHART IS FOR GUIDANCE AND INFORMATIONAL PURPOSES ONLY. VERIFICATION OF THE SPECIFIED DATA SHOULD BE MADE BY CONSULTING THE MOST RECENT JOINT HAZARD CLASSIFICATION SYSTEM LISTING OR OTHER APPROVED LISTING(S).

REVISIONS

REVISION NO. 1, DATED MARCH 1996, CONSISTS OF:

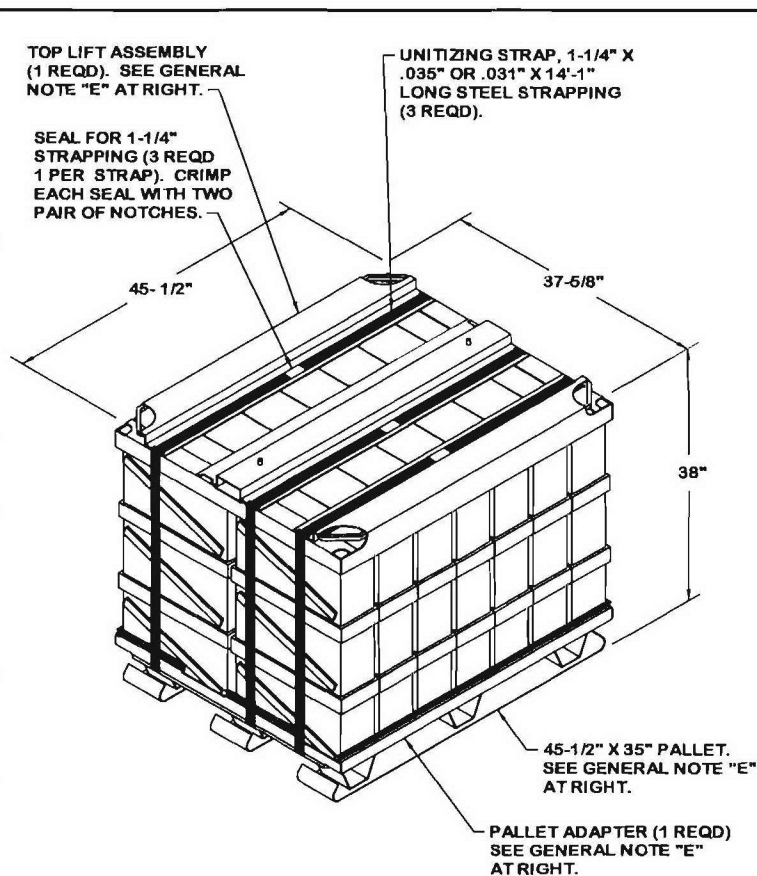
1. ADDING ITEM TO PALLET UNIT DATA CHART.
2. DELETING GENERAL NOTE RELATING TO STRAP CUTTER AND RE-LETTERING OTHER GENERAL NOTES.
3. CHANGING WEIGHT OF ITEM.
4. CHANGES PER ECP M6S3042.

REVISION NO. 2, DATED DECEMBER 1999, CONSISTS OF:

1. ADDING ITEM TO PALLET UNIT DATA CHART.
2. CHANGE TO NEW DRAWING FORMAT.
3. ADDING GENERAL NOTE "H" RELATING TO PA120 CONTAINER.

REVISION NO. 3, DATED DECEMBER 2004, CONSISTS OF:

ADDING A NATIONAL STOCK NUMBER AND ASSOCIATED DATA TO PALLET UNIT DATA BLOCK ON PAGE 2.



PALLET UNIT

SEE GENERAL NOTE "B" AT RIGHT.

42 BOXES OF 40MM CTG (32 PER BOX) AT 42 LBS - - - 1,764 LBS (APPROX)
 DUNNAGE - - - - - 112 LBS
 PALLET - - - - - 99 LBS

TOTAL WEIGHT - - - - - 1,975 LBS (APPROX)
 CUBE - - - - - 37.6 CU FT (APPROX)

BILL OF MATERIAL

METAL PALLET, 45-1/2" X 35"	- 1 REQD	- - - -	99 LBS
PALLET ADAPTER	- 1 REQD	- - - -	35 LBS
TOP LIFT ASSEMBLY	- 1 REQD	- - - -	70 LBS
STEEL STRAPPING, 1-1/4"	42.25' REQD	- - - -	6.41 LBS
SEAL FOR 1-1/4" STRAPPING	- 3 REQD	- - - -	NIL

GENERAL NOTES

- A. THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4232-20PM1007. TO PRODUCE AN APPROVED UNIT LOAD, ALL PERTINENT PROCEDURES, SPECIFICATIONS AND CRITERIA SET FORTH WITHIN THE BASIC DRAWING WILL APPLY TO THE PROCEDURES DELINEATED IN THIS APPENDIX. ANY EXCEPTIONS TO THE BASIC PROCEDURES ARE SPECIFIED IN THIS APPENDIX.
- B. DIMENSIONS, CUBE AND WEIGHT OF A PALLET UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE BOXES AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.
- C. THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS APPENDIX.

CARLOADING - - - -	19-48-4246/21-5PM1005
TRUCKLOADING - - -	19-48-4247/21-11PM1005
STORAGE - - - - -	19-48-4251/21-1-2-3-4-14-22PM1005
END OPENING ISO CONTAINER - - - -	19-48-4249/21-15PM1011
MIL VAN - - - - -	19-48-4248/21-15PM1010
SIDE OPENING ISO CONTAINER - - - -	19-48-4271/21-15PM1015
- D. IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS REVISION TO THIS APPENDIX, THE BOXES NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS REVISION.
- E. FOR DETAILS OF THE PALLET, PALLET ADAPTER AND TOP LIFT ASSEMBLY SEE MILITARY SPECIFICATIONS MIL-A-70786, MIL-A-70788 AND DAC DRAWING ACV00124.
- F. THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING OTHER AMMUNITION ITEMS WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN WHAT IS SHOWN ON PAGE 2, PROVIDED THE ITEM IS PACKED IN THE PA120 METAL BOX. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.
- G. EMPTY OR REJECT PA120 METAL BOXES WILL BE USED AS FILLER BOXES AS NECESSARY. IF 14 FULL BOXES ARE TO BE OMITTED, ONE FULL LAYER OF BOXES WILL BE OMITTED. WHEN (EMPTY) FILLER BOXES ARE USED IN PLACE OF OMITTED BOXES TO COMPLETELY FILL OUT A LAYER ON A PALLET, THEY WILL BE MARKED AS SPECIFIED IN ARDEC DRAWING 12982865.
- H. FOR DETAILS OF THE PA120 CONTAINER REFER TO ARDEC DRAWING NO. 12564414.

