

FINAL REPORT
JULY 1996

REPORT NO. 96-59

MCALESTER ARMY AMMUNITION
PLANT (MCAAP) WOODEN PALLET
MIL-STD-1660 TESTS

19961021 178

Prepared for:
U.S. Army Armament Research, Development
and Engineering Center
ATTN: AMSTA-AR-ESK
Rock Island, IL 61299-7300

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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NO. 96-59

MCALESTER ARMY AMMUNITION PLANT (MCAAP) WOODEN PALLET
MIL-STD-1660 TESTS

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 tests on 40- by 48-inch oak pallets manufactured by McAlester Army Ammunition Plant (MCAAP).

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

C. OBJECTIVE. The objective of these tests was to determine whether the nails installed in these pallets produce a pallet capable of meeting MIL-STD-1660, Design Criteria for Ammunition Unit Loads, requirements.

D. CONCLUSION. The pallets submitted failed to meet MIL-STD-1660 requirements. Nail failure occurred in each pallet during testing.

E. RECOMMENDATION. Use nails that meet the specifications of MIL-P-15011.

PART 2

25 JUNE - 8 JULY 1996

ATTENDEES

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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 to be considered acceptable. The four tests that were conducted on the test pallets are summarized below.

A. STACKING TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was 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 was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved 1 ± 0.1 Gs. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurred, the total time of vibration was two hours if the specimen was tested in one position and three hours for more than one position.

C. EDGEWISE ROTATIONAL DROP TEST. 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 if 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 conforms 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 - 1000	80 - 95	24	18
1000 - 1500	95 - 114	20	16
1500 - 2000	114 - 144	17	14
2000 - 3000	Above 145 - No limit	15	12
Above - 3000		12	9

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 was 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 are subjected to impacts was at the option of the testing activity and depends upon the objective of the tests. This 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. Pallet A (Test Sample).

- | | |
|----------------------------|-----------------|
| 1. Size: | 40- by 48-inch |
| 2. Pallet Load: | M548 containers |
| 3. Quantity of Containers: | 24 |
| 4. Weight Loaded: | 4,008 pounds |
| 5. Unit Load Height: | 34.5 inches |

B. Pallet B (Test Sample).

- | | |
|----------------------------|-----------------|
| 1. Size: | 40- by 48-inch |
| 2. Pallet Load: | M548 containers |
| 3. Quantity of Containers: | 24 |
| 4. Weight Loaded: | 4,000 pounds |
| 5. Unit Load Height: | 34.5 inches |

C. Compression Tester.

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

D. 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 |

E. Inclined Plane.

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

PART 5

PALLET NAILS

- | | | |
|----|-----------------------|-------------------------|
| A. | 1. Length: | 3-1/4 inches |
| | 2. Diameter: | 10 gauge |
| | 3. Rockwell Hardness: | C41 |
| | 4. Nail Type: | Pallet nail |
| | 5. Supplier: | Insteel Wire Products |
| | 6. Quantity: | 30 per pallet |
| B. | 1. Length: | 2-1/4 inches |
| | 2. Diameter: | 11 gauge |
| | 3. Rockwell Hardness: | C31 |
| | 4. Nail Type: | Drive screw pallet nail |
| | 5. Supplier: | Stiff Stock |
| | 6. Quantity: | 30 per pallet |
| C. | 1. Length: | 1-5/8 inches |
| | 2. Diameter: | 11 gauge |
| | 3. Rockwell Hardness: | C31 |
| | 4. Nail Type: | Drive screw pallet nail |
| | 5. Supplier: | Stiff Stock |
| | 6. Quantity: | 24 per pallet |

Pallet Production.

The type of nail and nailing pattern used by MCAAP in fabricating the test pallets is detailed in the drawing on page 8-2.

Nails described in 5.A. were driven from the deckboard through the stringer and into the post. Three nails were used to fasten the deck to each of the six posts in the two outside deck boards. A total of four nails were used to fasten the deck to each of three posts above the center skid.

Nails described in 5.B. fastened the skids to the posts. A total of three nails were used to fasten the outside skids to each post. The center skid consists of two boards. Each of these boards is fastened by two nails into each post. The pattern of these nails is shown in the drawing on page 8-2.

Mil-P-15011 states that each deckboard is fastened to each stringer board using 1-5/8-inch nails. Nails described in 5.C. were used to fasten the deckboards to the stringer boards. For these pallets, a total of three nails were used to fasten each deckboard to each stringer board. At the locations that the three nails described in 5.A. are fastening the deck to the post, no nails described in 5.C. are used. Every place two nails described in 5.A. are fastening the deck to the post, one nail described in 5.C. is also used to fasten the deckboard to the post. At the locations where no post is under the stringer board, three nails described in 5.C. are used to fasten the deckboard to the stringer board. The pattern of nails described in 5.C. is shown in the drawing on page 8-2.

PART 6

TEST RESULTS

TEST OBSERVATIONS. Each test pallet was loaded with 24 M548 containers IAW USADACS drawing 19-48-4116/15A. Each container was filled to approximately 160 pounds, creating a 4,000-pound unitized load. During fabrication, one corner post of pallet A was split by a nail fastening the deck to it. This nail protruded out the side of the post. One of the outside deckboards in pallet B contained a loose knot in it. This deckboard also had a crack running with the grain of the wood in each end extending approximately 4-1/2-inches. A maximum separation of 3/8-inch also existed between the end of the pallet B deckboards and the outside edge of the stringer board. The maximum separation between the end of the deckboards and the edge of the stringer boards for pallet A was 1/4-inch.

PALLET A

A. STACKING TEST. The test sample was initially loaded to 22,300 pounds compression. The compression was released after one hour. No damage occurred.

B. REPETITIVE SHOCK TEST. The duration of the test was 90 minutes for each orientation of the pallet. The transportation simulator was operated at 188 rpm for the longitudinal orientation of the pallet. At the completion of 90 minutes, one outside skid was completely free from the pallet. All three of the nails fastening the skid to two of the posts sheared off. The nails fastening the third post to the deck and stringer boards also sheared off. Instead of the three nails used to fasten the deck to the post at the other locations, only two nails were present at this joint. One of these nails entered the top of the post near the edge with its point extending out the side of the post.

C. END OF TEST INSPECTION. The outside skid that is still attached to the pallet appears to have the nails fastening the skid to the center post sheared off.

PALLET B.

A. STACKING TEST. The test sample was initially loaded to 22,300 pounds compression. The compression was released after one hour. No damage occurred.

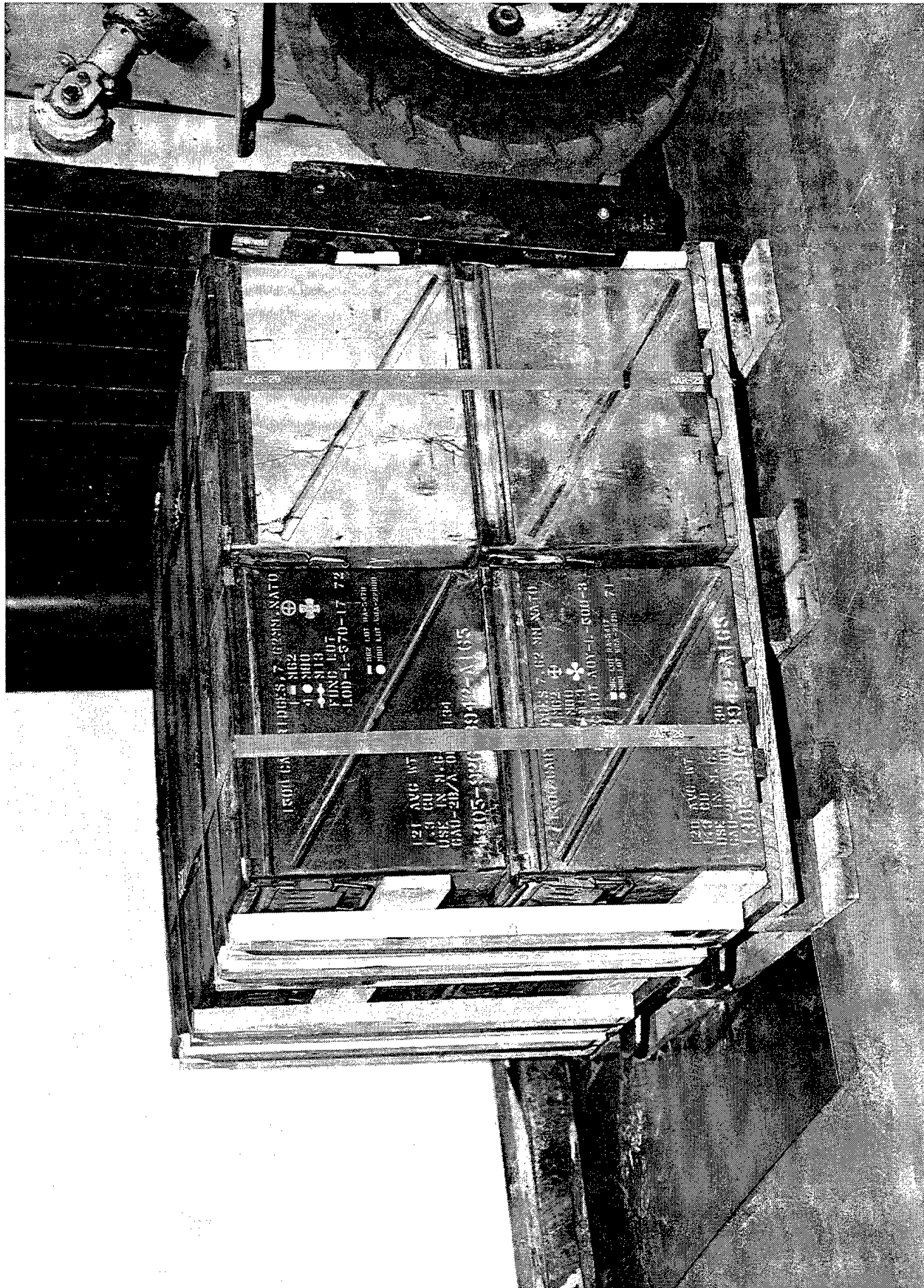
B. REPETITIVE SHOCK TEST. The duration of the test was 90 minutes for each orientation of the pallet. The transportation simulator was operated at 189 rpm while the pallet was in the longitudinal orientation. At the end of this cycle, the skids were warm but still firmly attached to the posts. The lateral orientation of the pallet was performed at 188 rpm. The end of one of the center skids was loose. Two nails are used to fasten the skid to the post. One of these nails sheared and the other pulled out of the post.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet was placed on a beam displacing it 4-1/2 inches above the floor. The opposite end of the pallet was raised to a height of 12 inches, then dropped. No damage occurred.

D. END OF TEST INSPECTION. No further damage was noted.

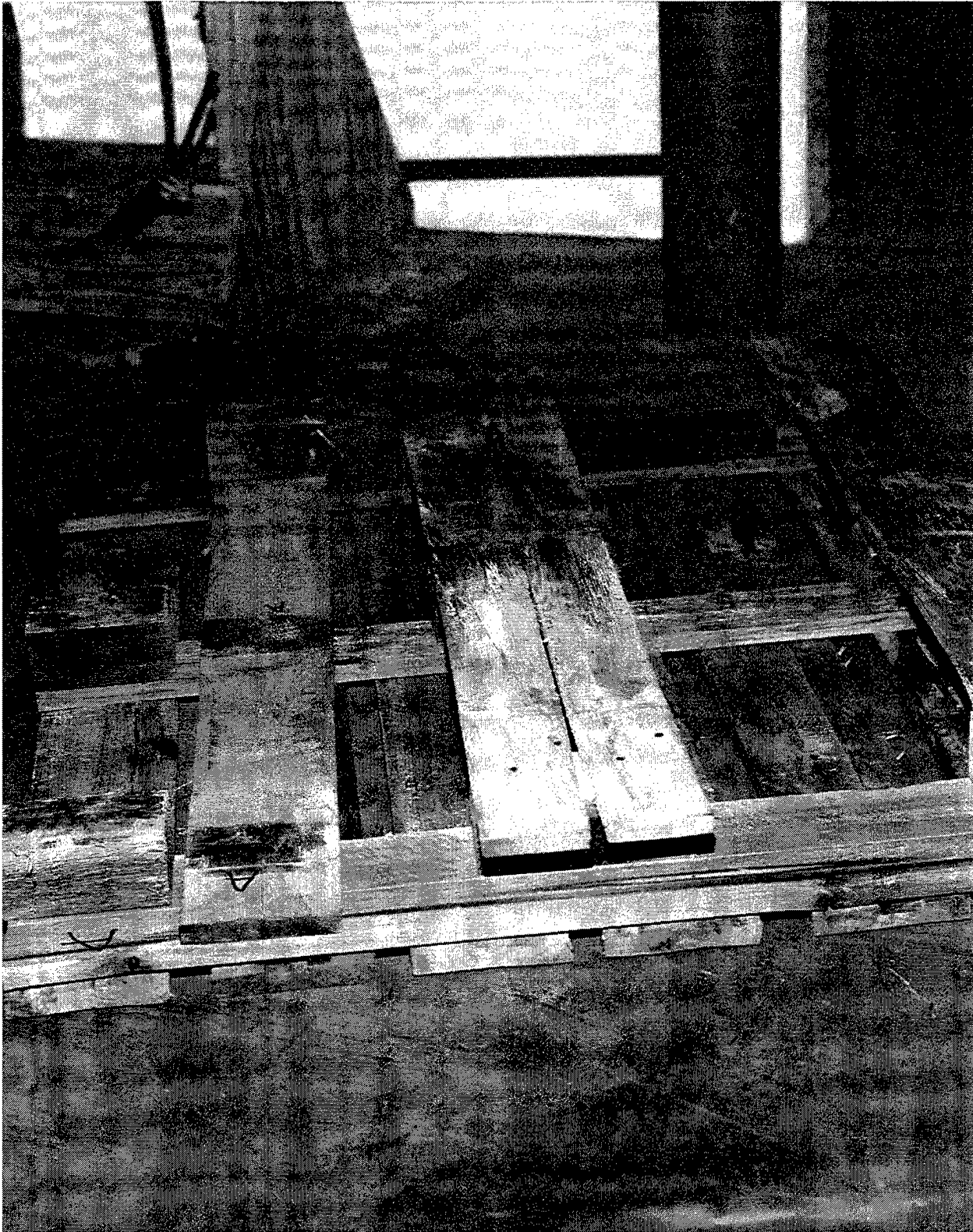
PART 7

PHOTOGRAPHS



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

AO317-SCN-96-163-4103. This photo shows the configuration of the palletized unit load.



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AO317-SCN-96-163-4104. This photo shows the detached skid of pallet A.
Note the sheared nails in the skid.



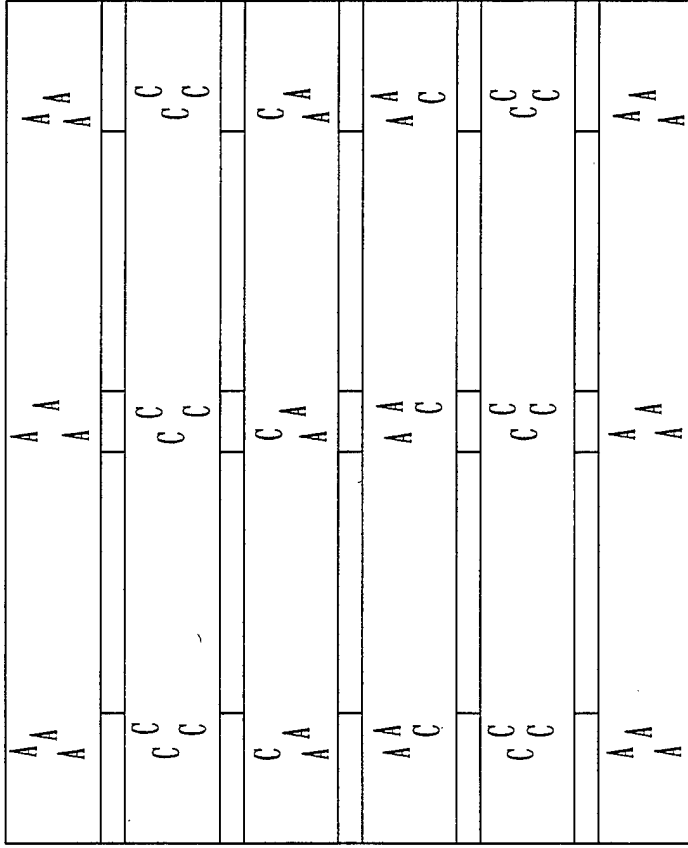
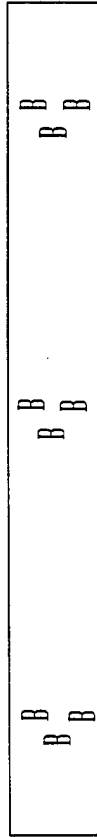
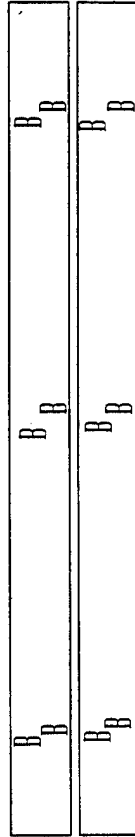
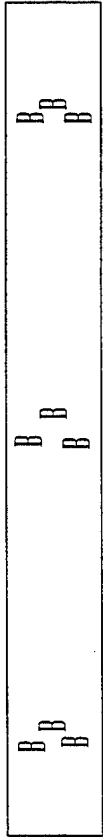
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL -
SAVANNA, IL

AO317-SCN-96-163-4102. This photo shows the end of the skid board detached from the post of pallet B.

PART 8

DRAWINGS

MCAAP 40- BY 48-INCH PALLET



SKIDS

DECK

- NOTES:
- A = 3-1/4-inch nail
 - B = 2-1/4-inch nail
 - C = 1-5/8-inch nail

APPENDIX 15A

UNITIZATION PROCEDURES FOR BOXED AMMUNITION AND COMPONENTS ON 4-WAY ENTRY PALLETS

CARTRIDGE, 20MM, PACKED 100 PER M548 METAL
BOX, UNITIZED 24 BOXES PER 40" X 48" PALLET;
APPROX BOX SIZE 18-19/32" L X 8-19/64" W X
14-19/32" H

NOTICE: THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH
THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4116-20PA1002.

THIS APPENDIX SUPERSEDES THE TWO-LAYER UNITIZATION PROCEDURES OF INTERIM DRAWING
19-48-4141-20PA1003, DATED FEBRUARY 1977.

U. S. ARMY MATERIEL COMMAND DRAWING			
APPROVED, U. S. ARMY ARMAMENT, MUNITIONS AND CHEMICAL COMMAND <i>NAH</i> <i>David M. Paddock</i> <i>Justin J. Fox</i> SMCAR-ESK AMSMC-TMJ/T	DRAFTSMAN	BETTY J. KUNDEBT	
	ENGINEER	SANDRA M. SCHULTZ	
	SUPPLY ENGINEERING DIVISION	TRANSPORTATION ENGINEERING DIVISION	VALIDATION ENGINEERING DIVISION
	<i>J. J. Muehl</i>	<i>W. Ernst</i>	<i>S. Schultz</i>
APPROVED BY ORDER OF COMMANDING GENERAL, U. S. ARMY MATERIEL COMMAND <i>William F. Ernst</i> U. S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL	LOGISTICS ENGINEERING OFFICE <i>William F. Ernst</i>		
	SEPTEMBER 1989		
	CLASS	DIVISION	DRAWING
	19	48	4116/ 15A
REVISION NO. 8	OCTOBER 1993		FILE
			20PA 1002
SEE THE REVISION LISTING ON PAGE 2			

DO NOT SCALE

REVISIONS

REVISION NO. 1, DATED SEPTEMBER 1980, CONSISTS OF:

1. REMOVING FILLER ASSEMBLY AND ADDING TWO ADDITIONAL CONTAINERS IN LIEU THEREOF.

REVISION NO. 2, DATED APRIL 1981, CONSISTS OF:

1. ADDING NEW NATIONAL STOCK NUMBERS.

REVISION NO. 3, DATED MARCH 1983, CONSISTS OF:

1. ADDING NATIONAL STOCK NUMBERS TO "PALLET UNIT DATA" CHART.
2. REDESIGNING FILLER ASSEMBLY.

REVISION NO. 4, DATED DECEMBER 1983, CONSISTS OF:

1. CHANGING BOX DIMENSIONS.

REVISION NO. 5, DATED JULY 1984, CONSISTS OF:

1. DELETING ITEMS BY NATIONAL STOCK NUMBER FROM THE "PALLET UNIT DATA" CHART.

REVISION NO. 6, DATED MAY 1986, CONSISTS OF:

1. ADDING ITEMS BY NATIONAL STOCK NUMBER TO "PALLET UNIT DATA" CHART.

REVISION NO. 7, DATED SEPTEMBER 1989, CONSISTS OF:

1. ADDING ITEM BY NATIONAL STOCK NUMBER TO "PALLET UNIT DATA" CHART.

REVISION NO. 8, DATED OCTOBER 1993, CONSISTS OF:

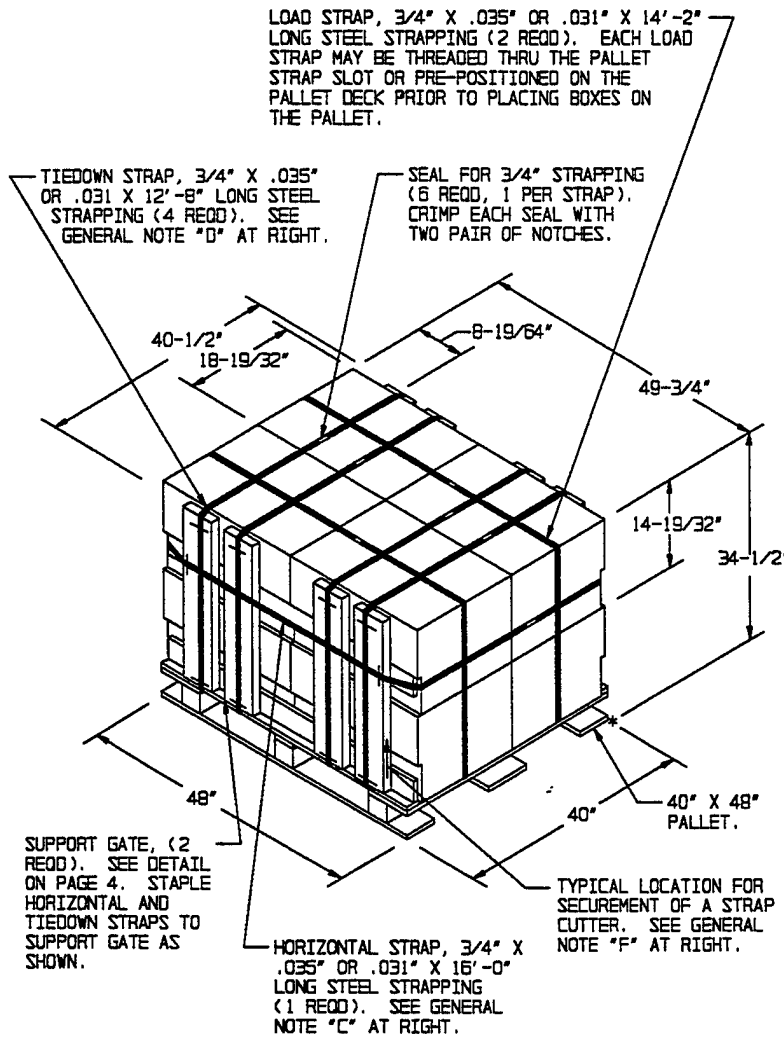
1. ADDING ITEMS BY NATIONAL STOCK NUMBER TO "PALLET UNIT DATA" CHART.
2. DELETING ONE HORIZONTAL STRAP AND ADDING TWO LOAD STRAPS TO THE PALLET UNIT.

PALLET UNIT DATA				
ITEMS INCLUDED		HAZARD CLASS AND DIVISION ●		APPROX WEIGHT LBS
NSN	DODIC	OD CLASS	COMP GROUP	
1305-				
00-157-4886	A652	1.4	C	2,344
00-522-3701	A652	1.4	C	2,344
00-785-2848	A652	1.4	C	2,344
00-143-7034	A653	(04)1.2	E	2,344
00-935-6188	A653	(04)1.2	E	2,344
01-135-2582	A653	(04)1.2	E	2,344
00-078-8220	A654	1.4	C	2,344
00-926-4058	A655	(04)1.2	E	2,344
01-116-3932	A655	(04)1.2	E	2,224
00-152-3662	A658	(04)1.2	E	2,344
00-783-5482	A658	(04)1.2	E	2,344
01-116-3928	A658	---	-	2,224
00-169-1880	A660	(04)1.2	E	2,344
01-116-3926	A660	---	-	2,224
00-182-3157	A663	(04)1.2	E	2,344
01-116-3934	A663	(04)1.2	E	2,224
00-182-3158	A664	1.4	C	2,344
00-182-3250	A665	(04)1.2	E	2,344
01-116-9529	A665	(04)1.2	E	2,344
01-116-3927	A666	(04)1.2	E	2,224
01-010-0258	A700	1.4	C	2,344
01-011-6324	A701	(04)1.2	E	2,224
01-116-3935	A701	(04)1.2	E	2,224
01-283-2134	A710	(04)1.2	E	2,296
01-116-3929	A751	(04)1.2	E	2,224
01-330-9494	A762	(04)1.2	E	2,224
01-323-1525	A763	1.4	C	2,224
00-157-4616	A781	---INERT	---	2,344
00-935-1964	A781	---INERT	---	2,344
01-328-5877	A781	---INERT	---	2,344
00-926-3943	A786	(04)1.2	G	2,344
00-152-3659	A792	(04)1.2	E	2,344
00-401-1536	A792	(04)1.2	E	2,344
00-926-9279	A792	(04)1.2	E	2,344
01-116-3924	A792	---	-	2,368
01-116-3925	A792	---	-	2,368
00-143-6922	A796	(04)1.2	E	2,344
01-119-7862	A818	(04)1.2	E	2,224
00-144-5527	A852	(04)1.2	E	2,344
01-116-3933	A852	(04)1.2	E	2,224
00-169-8805	A875	1.4	G	2,344
00-301-1589	A884	1.4	G	2,344
00-850-3986	A884	1.4	G	2,344
00-144-5545	A894	1.4	C	2,344
00-892-2161	A894	1.4	C	2,344
00-935-6060	A894	1.4	C	2,344
00-169-1784	A896	1.4	C	2,344
00-849-4535	A918	1.4	G	2,344
00-182-3081	A919	(04)1.2	E	2,344
00-850-3676	A919	(04)1.2	E	2,344
00-892-4321	A919	(04)1.2	E	2,344
00-965-0560	A919	(04)1.2	E	2,344
01-119-6068	A919	(04)1.2	E	2,344
00-965-0794	A924	---INERT	---	2,344
00-180-9268	A926	1.4	C	2,344
00-892-2162	A953	(04)1.2	E	2,344
01-116-3936	A953	(04)1.2	E	2,224

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GENERAL NOTES

- A. THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4116-20PA1002. 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. INSTALL THE HORIZONTAL STRAP TO ENCIRCLE THE TOP LAYER OF BOXES ON THE PALLET AND TO BE ALIGNED WITH THE HORIZONTAL PIECE OF THE "SUPPORT GATE" AS SHOWN. THE HORIZONTAL STRAP MUST BE TENSIONED AND SEALED PRIOR TO THE APPLICATION OF TIEDOWN AND LOAD STRAPS.
- D. INSTALL EACH TIEDOWN STRAP TO PASS UNDER THE TOP DECK BOARDS OF THE PALLET AND TO BE ALIGNED WITH THE VERTICAL PIECES OF THE "SUPPORT GATE" AS SHOWN. TIEDOWN STRAPS WILL NOT BE APPLIED UNTIL THE HORIZONTAL AND LOAD STRAPS HAVE BEEN TENSIONED AND SEALED.
- E. THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS APPENDIX.
 - CARLOADING - - - - 19-48-4115-SPA1002
 - TRUCKLOADING - - - - 19-48-4117-11PA1003
 - STORAGE - - - - - 19-48-4118-1-2-3-4-14-22PA1002
 - COMMERCIAL CONTAINER - - - - 19-48-4153-15PA1002
 - MILVAN - - - - - 19-48-4166-15PA1003
- F. FOR METHOD OF SECURING A STRAP CUTTER TO THE PALLET UNIT, SEE AMC DRAWING 19-48-4127-20P1000.
- G. IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS APPENDIX, THE BOXES NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS APPENDIX.
- H. THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING 20MM CARTRIDGES WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN WHAT IS SHOWN ON PAGE 2, PROVIDED THE BOX PACK DOES NOT VARY FROM WHAT IS DELINEATED HEREIN. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.

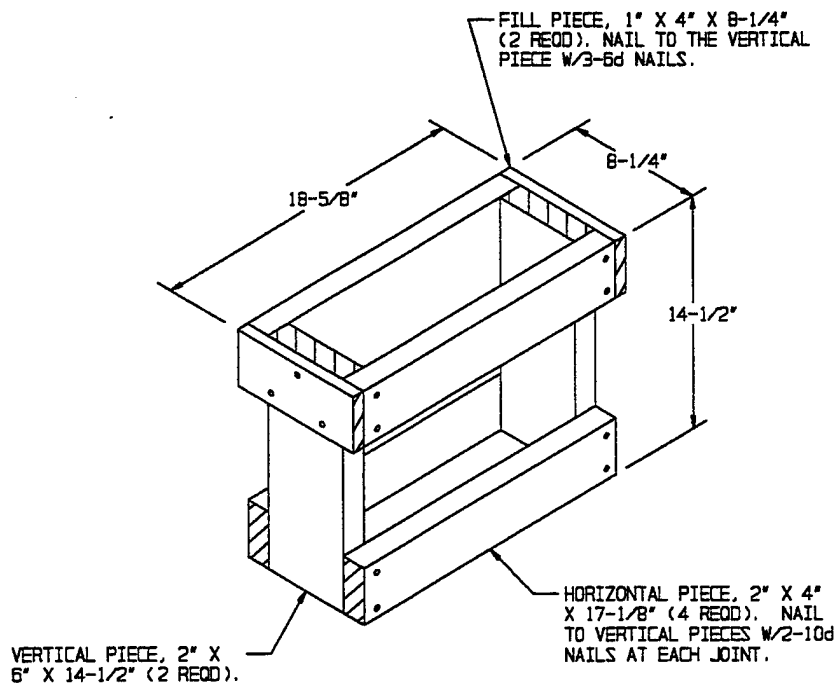


PALLET UNIT

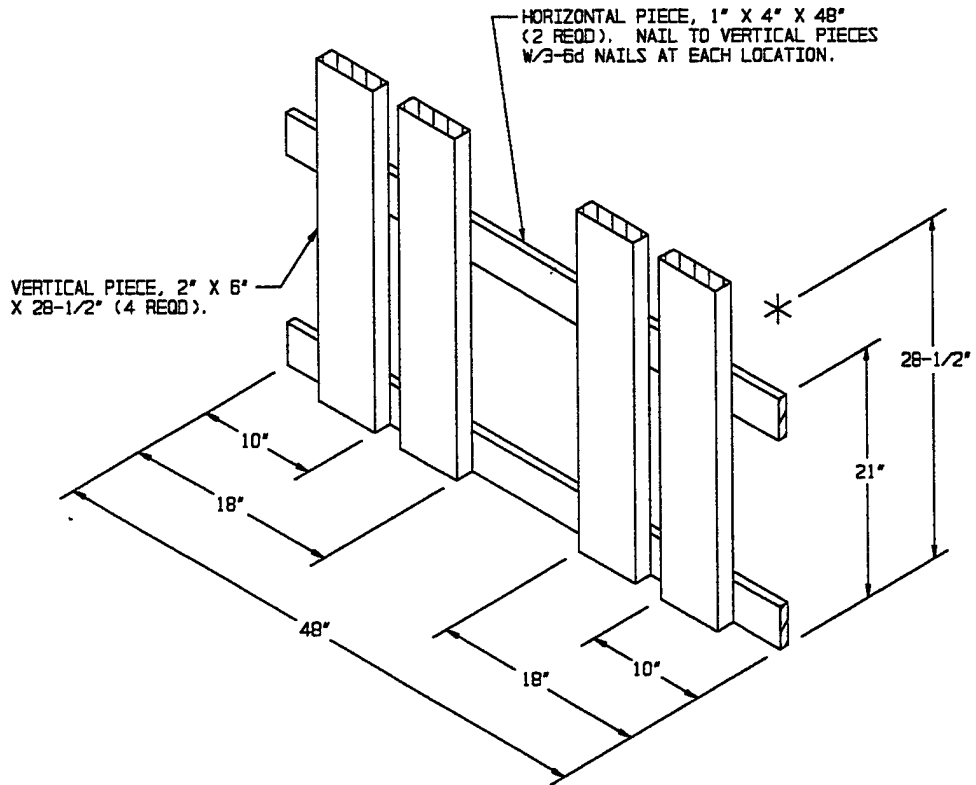
SEE GENERAL NOTE "B" AT RIGHT.

24 BOXES OF 20MM CARTRIDGE (100 PER BOX) AT 92 LBS	- - - -	2,208 LBS (APPROX)
DUNNAGE	- - - -	56 LBS
PALLET	- - - -	80 LBS
TOTAL WEIGHT	- - - -	2,344 LBS (APPROX)
CUBE	- - - -	40.0 CU FT (APPROX)

BILL OF MATERIAL		
LUMBER	LINEAR FEET	BOARD FEET
1' X 4'	16.00	5.33
2' X 6'	19.00	19.00
NAILS	NO. REQD	POUNDS
6d(2")	48	0.28
PALLET, 40" X 48"	1 REQD	80 LBS
STEEL STRAPPING, 3/4"	95.00' REQD	6.79 LBS
SEAL FOR 3/4" STRAPPING	6 REQD	NIL
STAPLE	20 REQD	NIL



FILLER ASSEMBLY
(FOR MINUS ONE BOX)



SUPPORT GATE
(2 REQD)