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THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.
Modified Enhanced Wood Pallet for 120mm Tank Ammunition MIL-STD-1660 Tests

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 modified enhanced wood pallets for 120mm tank ammunition. Two series of tests were conducted with the second series meeting all MIL-STD-1660, Design Requirements for Ammunition Unit Loads, tests. This report contains details of the tests conducted.
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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 modified enhanced wood pallets for 120mm tank ammunition. The enhanced wood pallets are being evaluated as an alternative to metal pallets which are nuclear, biological, chemical (NBC) decontaminable.

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 these tests was to determine if the enhanced wood pallets could meet MIL-STD-1660 tests.

D. CONCLUSION. Two series of tests were conducted with different methods of restraining the PA116 containers. The first test included eight beveled deck boards nailed to the pallet between the PA116 containers. This design failed during the drop tests with one lateral stringer board failing on the pallet. The second series of tests used a container restraining method similar to what is currently used on the 120mm tank ammunition training round pallets, with substitution of 3/8-inch dimensional lumber for plywood. During this series of tests no problems were encountered with the pallet meeting all MIL-STD-1660 tests.
PART 2
FEBRUARY 1996
ATTENDEES

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DSN 585-8090
815-273-8090

Sanjeev Khanna
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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. 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. 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 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 achieved 1 +/- 0.1 G. 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. **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, 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:

<table>
<thead>
<tr>
<th>GROSS WEIGHT NOT EXCEEDING (Pounds)</th>
<th>DIMENSIONS ON ANY EDGE NOT EXCEEDING (Inches)</th>
<th>HEIGHT OF DROP LEVEL A PROTECTION (Inches)</th>
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<tbody>
<tr>
<td>600</td>
<td>72</td>
<td>36</td>
</tr>
<tr>
<td>3,000</td>
<td>no limit</td>
<td>24</td>
</tr>
<tr>
<td>no limit</td>
<td>no limit</td>
<td>12</td>
</tr>
</tbody>
</table>

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 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. 120MM Tank Ammunition (Palletized).

<p>| | |</p>
<table>
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<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. Width.</td>
<td>40-1/8 inches</td>
</tr>
<tr>
<td>2. Length.</td>
<td>44-1/2 inches</td>
</tr>
<tr>
<td>3. Height.</td>
<td>45-1/4 inches</td>
</tr>
<tr>
<td>4. Weight.</td>
<td>2,550 pounds</td>
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</table>
PART 5

TEST RESULTS

TEST 1

Description: Modified enhanced wood pallet with eight 1- by- 6-inch beveled boards

nailed to the pallet and nested between the container bodies.

A. **COMPRESSION TEST.** The compressive load during this test was 12,000 pounds with no

problems encountered.

B. **VIBRATION TEST.** This test was conducted at 150 rpm for both the lateral and

longitudinal orientations with no problems encountered.

C. **EDGewise ROTATIONAL DROP TEST.** During this test no problems were encountered

during the first three drops; however, on the fourth drop parallel to the skids, one lateral stringer

board failed on the pallet. This failure was due to columnar loading of the PA116 containers

between the pallet posts (see Part 6).

D. **DISASSEMBLY.** At the end of testing, the PA116 containers were removed from the pallet.

One of the eight beveled deck boards was cracked and separated longitudinally the full length of

the board, constituting a major failure (see Part 6).
TEST 2

Description: Modified enhanced wood pallet with 120mm tank ammunition training round pallet design, with 3/8- by 6-inch dimensional lumber substituted for the 3/8-inch plywood.

A. COMPRESSION TEST. The compressive load during this test was 12,500 pounds with no problems encountered.

B. VIBRATION TEST. This test was conducted at 145 to 155 rpm for both the lateral and longitudinal orientations with no problems encountered.

C. EDGEWISE ROTATIONAL DROP TEST. During this test, four drops were completed with no problems encountered.

D. SLINGING TEST. During the three, two, and one sling lifting tests, no damage occurred to the pallet or top pallet adapter assembly.

E. DISASSEMBLY. At the end of testing, the PA116 containers were removed from the pallet with minor chipping of the 3/8- by 6-inch dimensional lumber noted.
PART 6

PHOTOGRAPHS
AO317-SCN96-81-1525. This photo shows the design of the first pallet with beveled PA116 restraint boards. This design failed.
AO317-SCN96-81-1527. This photo shows failure of the pallet during the first series of tests.
AO317-SCN96-81-1528. This photo shows the pallet design for the second series of tests. This pallet passed all MIL-STD-1660 criteria.
PART 7

DRAWINGS
SPECIAL 40"x44" PALLET

NOTE:
1. NAIL THROW DECK BOARDS
   WITH 5-6d NAILS.

---

DECK DUNNAGE DETAILS

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<tr>
<th>LENGTH</th>
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<td>17.75</td>
<td>4</td>
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<td>18.75</td>
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---

DECK DUNNAGE

$1 \times 6$ DECK DUNNAGE

LENGTH

$3 \frac{1}{2}$

$5 \frac{1}{2}$

---

TOP VIEW

$40" \times 44"$ Pallet

DECK DUNNAGE

$21 \frac{1}{2}$

$18 \frac{1}{2}$

$17 \frac{1}{2}$

$2 \frac{1}{2}$

---

SIDE VIEW

$40" \times 44"$ Pallet
SPECIAL 40" x 44" PALLEET
ENHANCED WOOD.

NOTES
1. NAIL THROW DECK BOARDS
WITH 6-6d NAILS.
2. VARIFY DIMENSIONS.

NOTE 1

1x6" NOM. DECK BOARDS
PLAINED TO 3/8" x 5-1/2".

TOP VIEW

40 x 44 ENHANCED
WOOD PALLEET

SIDE VIEW

3/8"x 5-1/2"
DECK DUNNGAGE
(4 REQD.)
APPENDIX 7C

UNITIZING PROCEDURES FOR COMPLETE ROUNDS PACKED IN CYLINDRICAL METAL CONTAINERS ON 4-WAY ENTRY PALLETS

PA116 SERIES CONTAINER

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<th>PAGE(S)</th>
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<td>GENERAL NOTES</td>
<td>3</td>
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<tr>
<td>UNIT A (HA METAL LIFTING FRAME)</td>
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<td>DUNNAGE DETAILS</td>
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<tr>
<td>FILLERS AND INSTALLATION PROCEDURES FOR OMITTED CONTAINERS</td>
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*These procedures delineated within this appendix for the items specified in the “Pallet Unit Data” chart are for Marine Corps use only and are not intended to be used by any other service without appropriate command approval.

*See general note "H" on page 3.

Notice: This appendix cannot stand alone but must be used in conjunction with the basic unitization procedures drawing 19-48-4079-20PM1002.

U.S. ARMY MATIERIEL COMMAND DRAWING

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<th>S. KINNAN</th>
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<tr>
<td>Approved by Order of Commanding General, U.S. Army Materiel Command</td>
<td>Logistics Engineering Office</td>
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<td>48</td>
<td>4079/7C</td>
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Revision No. 19

See the Revision Listing on Page 2

Project FSA 63/7C-86

Do not Scale
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<td>E</td>
<td>1.968</td>
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* 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).
GENERAL NOTES

A. THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19-49-0709-20MPD02. 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, CURT AND WEIGHT OF A PALLETT UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE CONTAINER AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.


D. IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUE, THE CONTAINERS NEED NOT BE UNITIZED SOLELY TO CONFORM TO THIS APPENDIX.

E. FOR DETAILS OF THE PA118 SERIES CONTAINER, SEE U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER DRAWING NO. 9396931.
   CONTAINER DIMENSIONS: 44-1/2" LONG X 7-3/4" WIDE X 7-3/4" HIGH.
   CONTAINER CUBE: 1.5 CUBIC FEET (APPROX).
   CONTAINER WEIGHT (WITH ROUND): 64, 73 OR 75 POUNDS (APPROX).

F. THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING COMPLETE ROUNDS WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN THOSE SHOWN ON PAGE 2. PROVIDED THE ITEM IS PACKED IN THE SAME CONTAINER. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.

G. DIMENSIONS GIVEN FOR DAMAGE PIECES WILL BE FIELD CHECKED PRIOR TO THEIR ASSEMBLY TO THE PALLETT UNIT. CONTAINERS MUST FIT SNUGLY IN THE DAMAGE ASSEMBLY. ALSO, DUE TO THE VARIATION OF CONTAINER DIMENSIONS, ADJUSTMENTS MAY BE REQUIRED AS TO THE LOCATION OF CERTAIN PIECES OF DAMAGE IN A DAMAGE ASSEMBLY.

H. THE SPECIAL PALLETS WILL BE CONSTRUCTED AND ASSEMBLED IN ACCORDANCE WITH A MILITARY SPECIFICATION MIL-P-15011. STYLE I, TYPE I. CLASS I PALLETT WITH THE EXCEPTION THAT THE TOP AND BOTTOM DECK BOARDS WILL BE 44" LONG INSTEAD OF 48" ALL OTHER REQUIREMENTS SPECIFIED WITHIN MIL-P-15011 FOR A STYLE I, TYPE I. CLASS I PALLETT WILL APPLY TO THE PALLETT SPECIFIED WITHIN THIS DRAWING.

I. THE SPECIAL PALLETT DETAILED IN THE DETAIL ON PAGE 4 NEED NOT HAVE CHAMBERS OR STRAP SLOTS AS SPECIFIED WITHIN MILITARY SPECIFICATION MIL-P-15011 WHEN USED FOR THE UNITIZATION OF THE ITEMS COVERED BY THIS APPENDIX.

J. FULL IDENTIFICATION MARKINGS IN ACCORDANCE WITH MIL-STD-129-1. TO INCLUDE NSN AND CUDIC, QUANTITY AND NOMENCLATURE, LOT NUMBER, AND GROSS WEIGHT OF THE LOAD. SHALL BE MARKED ON TAGS LOCATED ON OPPOSITE UPPER CORNERS OF THE LOAD.


L. THE THICKNESS OF THE SIDE BUFFER PIECES DEPICTED ON PAGE 6 MAY BE ADJUSTED. AS REQUIRED, TO COMPLY WITH THE DIMENSIONAL VARIANCE OF THE PA118 CONTAINERS, SO AS TO COMPLETELY FILL OUT THE PALLETT. THE LENGTH DIMENSION OF THE PALLETT UNIT AT THE SIDE ASSEMBLIES MUST BE EQUAL TO OR GREATER THAN 40-1/2".

(GENERAL NOTES CONTINUED AT RIGHT)
DRAFT

SEAL FOR 1/4" STRAPPING (3 REQD. 1 PER STRAP), CRIMP EACH SEAL WITH TWO PAIR OF NOTCHES.

SEAL FOR 3/4" STRAPPING (5 REQD. 1 PER STRAP), CRIMP EACH SEAL WITH TWO PAIR OF NOTCHES.

SIDE BUFFER PIECE (2 REQD). SEE THE "SIDE BUFFER DETAIL ON PAGE 6 AND GENERAL NOTES "H" AND "O" ON PAGE 3.

STAPLE, 1-1/32" WIDE BY 3/4" LEG LENGTH (12 REQD. 4 PER TIEDOWN STRAP).

PALLETS DUNNAGE: SEE "PALLETS DUNNAGE LOCATION" DETAIL ON PAGE 6 AND GENERAL NOTE "P" ON PAGE 3.

STABILIZING STRAP, 3/4" X 0.35" OR .031" X 9'-0" LONG STEEL STRAPPING (1 REQD). SEE SPECIAL NOTE 2 BELOW.

BINDING STRAP, 3/4" X 0.35" OR .031" X 11'-1" LONG STEEL STRAPPING (4 REQD). SEE SPECIAL NOTE 2 BELOW.

ISOMETRIC VIEW

PARTIAL VIEW

(SIDE BUFFER PIECE HAS BEEN OMITTED FOR CLARITY.)

BILL OF MATERIAL (UNIT A)

<table>
<thead>
<tr>
<th>NAILS</th>
<th>NO. REQD</th>
<th>POUNDS</th>
</tr>
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<tbody>
<tr>
<td>6d (2&quot;)</td>
<td>12</td>
<td>0.07</td>
</tr>
<tr>
<td>SPECIAL PALLET 40&quot; X 44&quot;</td>
<td>1</td>
<td>77 lbs</td>
</tr>
<tr>
<td>STEEL STRAPPING, 3/4&quot;</td>
<td>26</td>
<td>0.08</td>
</tr>
<tr>
<td>SEAL FOR 3/4&quot; STRAPPING</td>
<td>2</td>
<td>6.58</td>
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<tr>
<td>STEEL STRAPPING, 1-1/4&quot;</td>
<td>43</td>
<td>0.26</td>
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<tr>
<td>SEAL FOR 1-1/4&quot; STRAPPING</td>
<td>3</td>
<td>NIL</td>
</tr>
<tr>
<td>SIDE BUFFER</td>
<td>3</td>
<td>3.67</td>
</tr>
<tr>
<td>STRAP STAPLE, 1-1/32&quot; X 3/4&quot;</td>
<td>1</td>
<td>5.30</td>
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<tr>
<td>METAL LIFTING FRAME</td>
<td>1</td>
<td>57 lbs</td>
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UNIT DATA

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<th>SHOP</th>
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<tr>
<td>CUBE</td>
<td>48.8 CUBIC FEET (APPROX)</td>
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<tr>
<td>CONTAINER, PA116 SERIES</td>
<td>28.64 AT 75 LBS</td>
</tr>
<tr>
<td>PALLETS</td>
<td>77 LBS</td>
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</table>

TOTAL WEIGHT: 2,028 LBS (APPROX)

PAGE 4

PROJECT FSA 63/7C-56
DECK BOARDS DUNNAGE,
3/8" X 5-1/2" X 40" (4 REDD). NAIL THRU BOARDS W/1-6D NAILS AND CLINCH. SEE GENERAL NOTE "3" ON PAGE 3.

SPECIAL 40" X 44" PALLETS. SEE GENERAL NOTES "J" & "D" ON PAGE 3.

PALLET DUNNAGE LOCATION

SIDE BUFFER PIECE, 3/4" X 5-1/2" X 44".

SIDE BUFFER
A LEFT HAND PIECE IS DEPICTED.
A RIGHT HAND PIECE IS ALSO REQUIRED.
SEE GENERAL NOTES "M" AND "G" ON PAGE 3.
**DETAIL A**

This detail depicts procedures to be used when a standard pallet unit minus one container is to be utilized. The filler assembly depicted must be installed in the middle of the top layer of the pallet unit.

**SPECIAL NOTES:**

1. When five containers are to be omitted from a pallet unit, a complete layer of containers must be omitted. When four containers are to be omitted from a pallet unit, a combination of filler assemblies depicted on page B must be used. When three or less containers are to be omitted from a pallet unit, a combination or one of the filler assemblies depicted on page B may be used. All filler assemblies must be installed in the middle of the top layer or layers of a pallet unit.

2. When two "filler A" assemblies are used in place of two omitted containers, the filler assemblies will be separated by at least one container to insure proper filler assembly retention and to preclude assembly interferences.

3. When a "filler A" assembly is used in conjunction with a "filler B" or "filler C" assembly, the "filler A" assembly must be positioned in the second layer of containers from the top of the pallet unit and must have its overall height reduced from 7-3/4" to 6-7/8" for pallet unit B, and from 7-1/4" to 7" for pallet unit A. Note: 2" x 8" material will be substituted for the 2" x 6" material ripped to 5-3/4" pieces used when the filler assembly is constructed with a height of 7" (for pallet unit A only).

4. A four layer unit will have two bundling straps omitted that were around the third, fourth and fifth layers. The remaining bundling straps will surround the second through fourth layers. A unit with three or less layers, does not require bundling straps. There will be no changes in the stabilizing strap requirements.

**DETAIL B**

This detail depicts procedures to be used when a standard pallet unit minus two containers is to be utilized. The filler assembly depicted must be installed in the middle of the top layer of the pallet unit.

**DETAIL C**

This detail depicts procedures to be used when a standard pallet unit minus four containers is to be utilized. The filler assemblies depicted must be installed in the middle of the top layers of the pallet unit.

**FILLERS AND INSTALLATION PROCEDURES FOR OMITTED CONTAINERS**

**PAGE 7**

**PROJECT FSA 63/7C-65**
END BEARING PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 7-1/8" (2 REDD). NAIL TO THE TIE PIECES W/3-10D NAILS AT EACH END.

FILLER A

END BEARING PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 7-3/4" (6 REDD). NAIL TO A TIE PIECE W/2-5D NAILS AND TO THE STRUTS W/2-8D NAILS AT EACH JOINT.

TIE PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 41-1/2" (2 REDD).

4" 44-1/2" 10-1/2" 3" 8-5/8"

 Bell End of Filler Assembly.

STRUT, 1" x 4" x 7-1/8" (6 REDD). NAIL TO THE TIE PIECES W/2-6D NAILS AT EACH Joint.

This assembly is to be used when one or two containers are to be omitted from a pallet unit or in combination with other filler assemblies. See special note 2 on page 8.

**NOTE:** The 7-3/4" dimension is for filler assemblies constructed for pallet unit A (4" metal lifting frame). This dimension must be decreased to 7-1/4" for filler assemblies constructed for use in pallet unit B (3" metal lifting frame). Other dimensions must be adjusted as necessary to allow for the 1/2" decrease in height.

FILLER B

END BEARING PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 22-5/8" (2 REDD). NAIL TO THE TIE PIECES W/2-8D NAILS AT EACH JOINT.

STRUT, 1" x 4" x 22-5/8" (6 REDD). NAIL TO THE TIE PIECES W/2-6D NAILS AT EACH JOINT.

FILL PIECE, 1" x 4" x 7-3/4" (6 REDD). NAIL TO THE TIE PIECES W/2-8D NAILS AND TO THE STRUTS W/2-6D NAILS AT EACH JOINT.

TIE PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 41-1/2" (4 REDD).

4" 44-1/2" 10-1/2" 3" 26-1/8"

Bell End of Filler Assembly.

FILLER C

END BEARING PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 7-3/4" (2 REDD). NAIL TO THE TIE PIECES W/3-10D NAILS AT EACH END.

FILL PIECE, 1" x 4" x 7-3/4" (6 REDD). NAIL TO THE TIE PIECES W/2-5D NAILS AND TO THE STRUTS W/2-8D NAILS AT EACH JOINT.

TIE PIECE, 2" x 8" (RIPPED-TO-6-1/4") X 41-1/2" (4 REDD).

4" 44-1/2" 10-1/2" 3" 7-3/4"

Bell End of Filler Assembly.

This filler assembly is to be used when three containers are to be omitted from a pallet unit, or in combination with other filler assemblies.

FILLERS AND INSTALLATION PROCEDURES FOR OMITTED CONTAINERS

PROJECT PSA 63/7C-66