FINAL REPORT
December 2004

REPORT NO. 04-22

PA171 CONTAINERS ON A WOOD PALLET WITH METAL TOP ADAPTER, AIR PRESSURE TESTS DURING MIL-STD-1660 TESTS

Prepared for:

Distribution Unlimited

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MCALESTER, OKLAHOMA 74501-9053

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REPORT NO. 04-22 **DECEMBER 2004**

PA171 CONTAINERS ON A WOOD PALLET WITH METAL TOP ADAPTER, AIR PRESSURE TESTS DURING MIL-STD-1660 TESTS

ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV) was requested by Project Manager – Maneuver Ammunition Systems (PM-MAS) to conduct Air Pressure Tests during MIL-STD-1660, "Design Criteria for Ammunition Unit Loads" testing on the PA171 containers on a wood pallet with metal top adapter as manufactured by Alliant Tech Ordnance and Ground Systems LLC, Plymouth, Maine. Two separate test units were tested with total weights of 2,470 lbs each. Pressure sensors were placed on five PA171 containers during the MIL-STD-1660 Testing. On Test Unit #1 the five sensors were placed on the top, middle, and bottom rows of the PA171 containers. On Test Unit #2 the five sensors were all placed on the bottom row of PA171 containers. The pressure in the PA171 containers was constantly monitored during the MIL-STD-1660 Tests. The MIL-STD-1660 tests accomplished on the test units were the stacking, repetitive shock, edgewise-rotational drop, and incline-impact. The test units passed all required tests of MIL-STD-1660 and the Pressure Air Test in accordance with the U.S. Army Armament Research, Development and Engineering Center Drawing Number 9386831, Note 4.

As a result of the performance of the test units, the PA71 containers on a wood pallet with metal top adapter manufactured by Alliant Tech Ordnance and Ground Systems LLC, Plymouth, Maine, is recommended for use by the United States Army.

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Reviewed by:

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REPORT NO. 04-22

PA171 CONTAINERS ON A WOOD PALLET
WITH METAL TOP ADAPTER, AIR PRESSURE TESTS
DURING MIL-STD-1660 TESTS

TABLE OF CONTENTS

PART 1 – INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV) was requested Project Manager – Maneuver Ammunition Systems (PM-MAS) to conduct Air Pressure Tests during MIL-STD-1660, "Design Criteria for Ammunition Unit Loads" testing on the PA171 containers on a wood pallet with metal top adapter as manufactured by Alliant Tech Ordnance and Ground Systems LLC, Plymouth, Maine. 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 PA171 containers on a wood pallet with metal top adapter met the Pressure Air Test requirements in accordance with the U.S. Army Armament Research, Development and Engineering Center Drawing Number 9386831, Note 4 during the MIL-STD-1660 tests prior to the acceptance of the unitization procedures by the U.S. Army.

D. CONCLUSION. The test units passed all required tests of MIL-STD-1660 and the Pressure Air Test in accordance with the U.S. Army Armament Research, Development and Engineering Center Drawing Number 9386831, Note 4.
As a result of the performance of the test units, the PA171 containers on a wood pallet with metal top adapter manufactured by Alliant Tech Ordnance and Ground Systems LLC, Plymouth, Maine, is recommended for use by the United States Army.

PART 2 - ATTENDEES

DATE PERFORMED:	Test Unit #1- 3 November 2004 Test Unit #2- 4 November 2004

ATTENDEES	**MAILING ADDRESS**
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PART 3 - TEST PROCEDURES

The test procedures outlined in this section were extracted from the MIL-STD-1660, "Design Criteria for Ammunition Unit Loads," 8 April 1977. This standard identifies steps that a unitized load must undergo if it is to be considered acceptable. The Air Pressure Tests are conducted by placing five sensors on the PA171 Containers in various places and monitoring the pressure continuously during the MIL-STD-1660 testing. The pressure data was collected using a National Instrument Data Acquisition System running Labview Software. The MIL-STD-1660 tests are conducted on ammunition pallet units or unit loads and are summarized as follows:

A. STACKING TEST. The specimen 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 unit load 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.

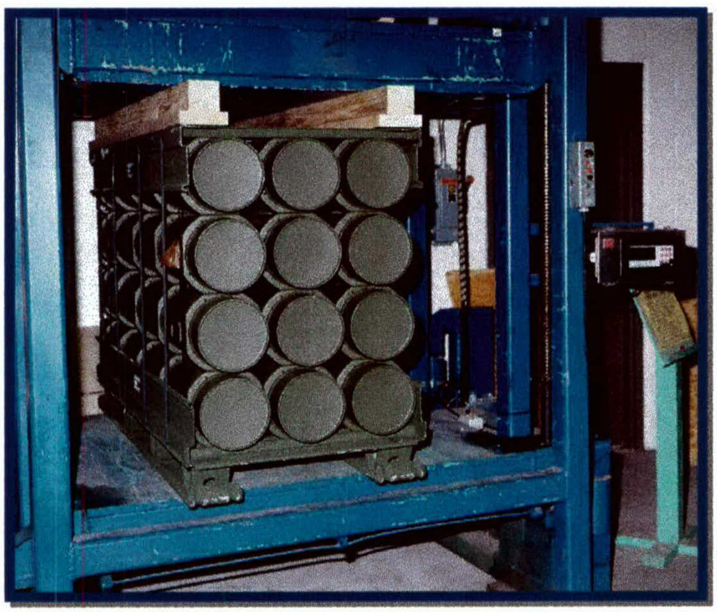

Photo 1. Example of Compression Tester.
(2.75-inch Hydra 70, PA151 Rocket Pallet in the Stacking tester.)

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

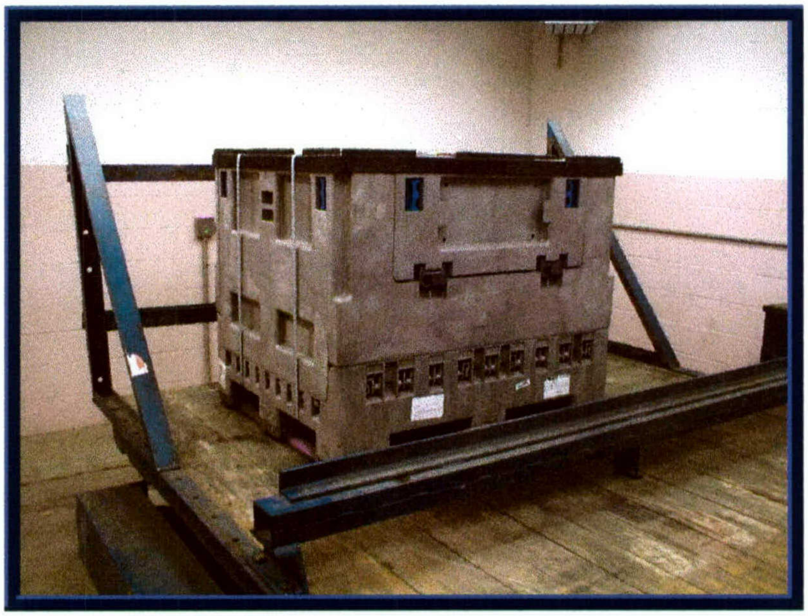

Photo 2. Example of the Repetitive Shock Test. (Plastic Gemini Pallet Box)

C. <u>EDGEWISE ROTATIONAL DROP TEST</u>. 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 specimen 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 dropping takes place, but was not 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 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
600-1,000	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

Photo 3. Example of Edgewise Rotational Drop Test
(Plastic XYTEC 4845 Pallet Box)

D. <u>INCLINE-IMPACT TEST</u>. 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 specimen is 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 struck no part of the timber. 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 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 was 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 specimen 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 specimen will be lifted clear of the ground by a forklift from the end of the specimen 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 specimen will be transported over the Optional Rough Handling Course. The forklift will be brought to a stop prior to traversing the course. The specimen shall be observed for deflection and damage. The specimen will be rotated 90 degrees and the specimen lifted from the side and the above steps repeated.

G. <u>DISASSEMBLY TEST.</u> Following all rough handling tests the specimen 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 load will be such that it retains its unity upon removal of the strapping.

PART 4 - TEST EQUIPMENT

A. COMPRESSION TESTER.

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

B. TRANSPORTATION (REPETITIVE SHOCK) SIMULATOR.

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

C. INCLINED PLANE.

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

D. DATA ACQUISITION SYSTEM.

1. Nomenclature	Data Acquisition System
2. Manufacturer:	National Instruments Inc.
3. Model:	PXI-1011

PART 5 - TEST RESULTS

A. CONTAINER DATA. The test units were inertly loaded to the specified design weight. The test specimen was prepared using the unitization procedures specified in Part 6 – Drawings. Special care was taken to ensure that each individual interior ammunition container had the proper amount of weight in order to achieve a realistic pallet center of gravity (CG). Once properly prepared, the test unit was tested using MIL-STD-1660, "Design Criteria for Ammunition Unit Loads," requirements.

TEST UNIT #1:

Test Date: 3 November 2004		Container Inertly loaded with:
Weight:	2,470 pounds	30 PA171 Containers each at 76 lbs
Length:	44-1/2 inches	loaded with inert round
Width:	40-1/8 inches	
Height:	52-5/8 inches	

TEST UNIT #2:

Test Date: 4 November 2004		Container Inertly loaded with:
Weight:	2,470 pounds	30 PA171 Containers each at 76 lbs
Length:	44-1/2 inches	loaded with inert round
Width:	40-1/8 inches	
Height:	52-5/8 inches	

B. TEST RESULTS - TEST UNIT #1:

1. STACKING TEST. Test Unit #1 was compressed with a load force of 7,410 pounds for 60 minutes on 3 November 2004. There was no damage noted to the test unit as a result of this test. Chart 1 below depicts the time versus pressure data for all five pressure sensors on the test unit during the Stacking Test. See Photo 5 below for a typical picture of the test unit in the stacking tester and each pressure sensor location.

Pressure Sensor 5 experienced the largest drop in pressure. The leak rate can be calculated as follows:

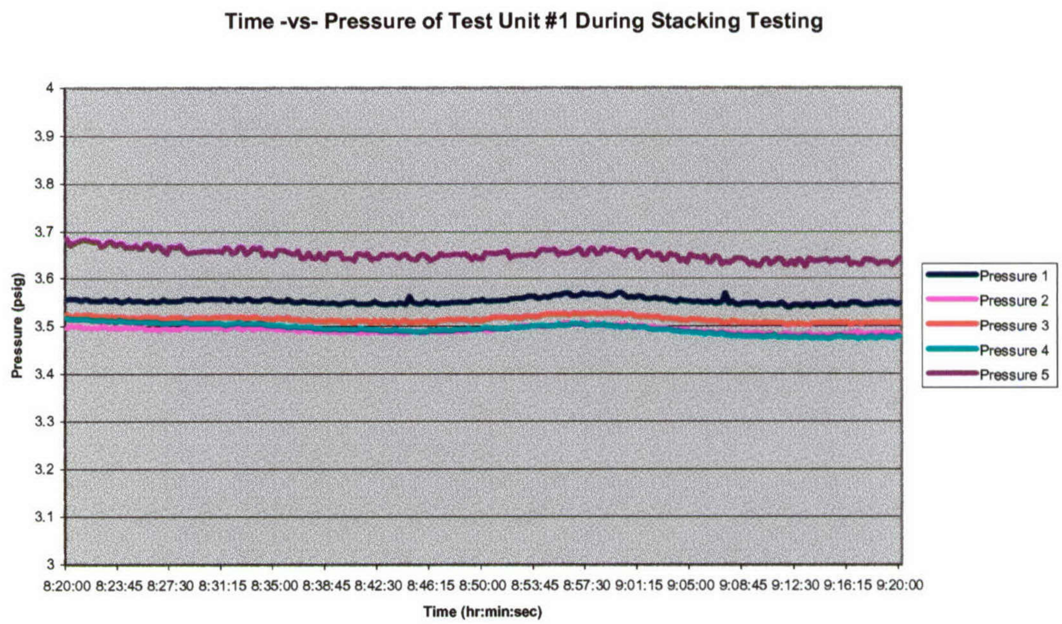

Chart 1. Time -vs- Pressure Data from Stacking Test on Test Unit #1.

$$\text{Leak Rate (ccm)} = \frac{\text{Pressure Drop (psi)} \times 1.12 \times \text{Volume (in}^3\text{)}}{\text{Test Time (sec)}}$$

$$\text{Leak Rate (ccm)} = \frac{((3.682-3.625) \times 1.12 \times 554.65)}{3600}$$

Leak Rate (ccm) = .01

- 1.12 converts inches^3 to ccm and adds standard atmospheric pressure

The calculated leak rate is .01 ccm. The allowable leak rate shall not exceed 5 ccm; therefore, all five PA171 containers pass the Air Pressure Test during the Stacking Test.

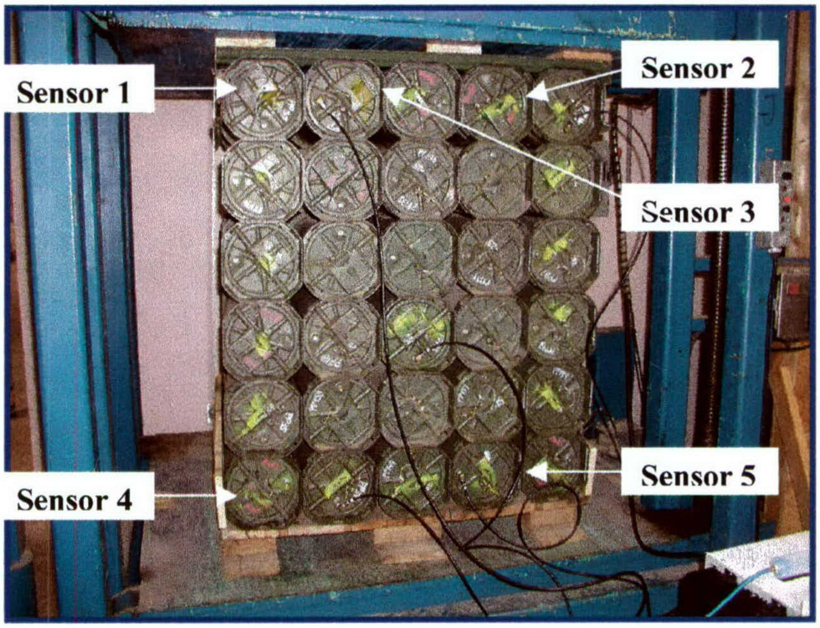

Photo 5. Test Setup w/Pressure Sensor Locations for Stacking Testing of Test Unit #1.

2. <u>REPETITIVE SHOCK TEST</u>. Test Unit #1 was vibrated 90 minutes at 165 RPM in the longitudinal orientation and 90 minutes at 160 RPM in the lateral orientation on 3 November 2004. There was no damage noted to the test unit during testing. Chart 2 below shows the time versus pressure data for the five pressure sensors on the test unit during the Repetitive Shock Test in the lateral direction. See Photo 6 below for the test unit on the Repetitive Shock Test Table.

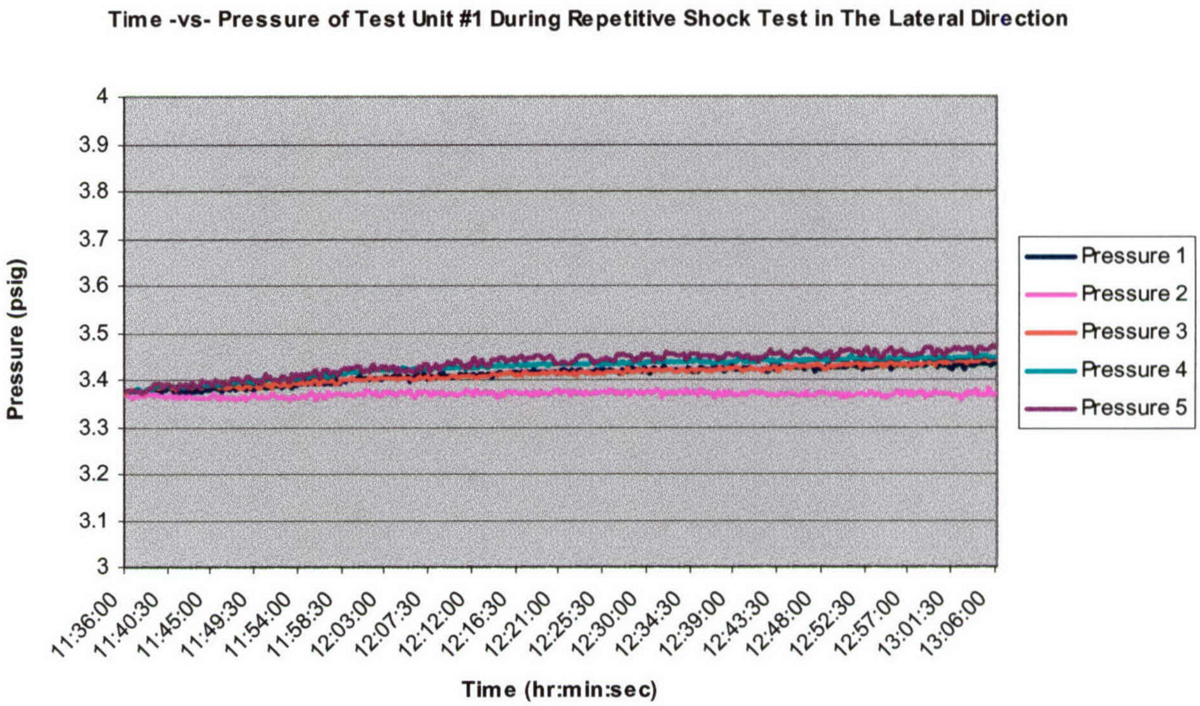

Chart 2. Time -vs- Pressure Data from Repetitive Shock Test on Test Unit #1.

The pressure during the vibration tests actually increased slightly during the Repetitive Shock Tests. This rise in pressure can be explained by the rise in temperature in the containers caused by the friction from the round moving in the container and the test unit rubbing on the deck of the test table. Since any minor leak rate was overcome by the pressure rise due to the temperature rise in the container, the leak rate did not exceed the maximum allowable rate of 5 ccm during the lateral Repetitive Shock Test. The longitudinal test data shows that the round was moving in the container causing spikes in the pressure data. The data also shows a slight rise in pressure in all five sensored containers; and, therefore, the leak rate did not exceed the maximum allowable rate of 5 ccm during the longitudinal Repetitive Shock Test.

Photo 6. Test Setup for Repetitive Shock Tests.

3. <u>EDGEWISE ROTATIONAL DROP TEST</u>. Test Unit #1 was edgewise rotationally dropped from a height of 15 inches on both longitudinal sides and both lateral sides. No damage was noted from this test. Chart 3 below shows the time versus pressure data for the five pressure sensors on the test unit during the Drop Tests. See Photo 7 below for the test setup for the Drop Tests.

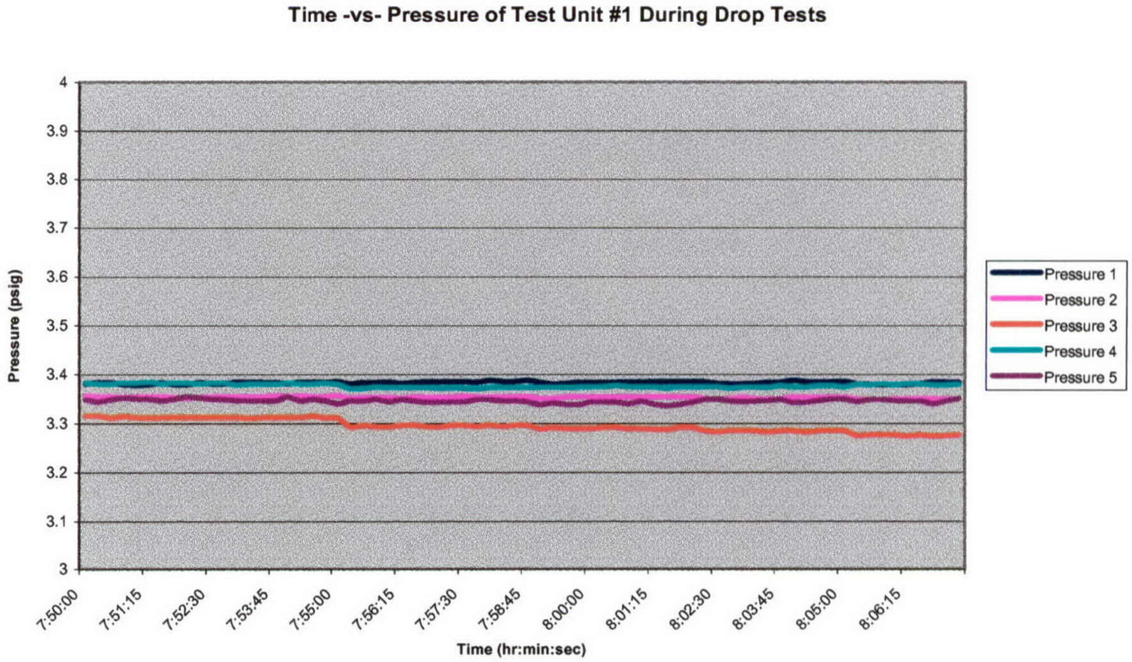

Chart 3. Time -vs- Pressure Data from Drop Test on Test Unit #1.

Pressure Sensor 3 experienced the largest drop in pressure. The leak rate can be calculated as follows:

$$\text{Leak Rate (ccm)} = \frac{\text{Pressure Drop (psi)} \times 1.12 \times \text{Volume(in}^3\text{)}}{\text{Test Time (sec)}}$$

$$\text{Leak Rate (ccm)} = \frac{((3.316-3.277) \times 1.12 \times 554.65)}{1050}$$

Leak Rate (ccm) = .023

- 1.12 converts inches^3 to ccm and adds standard atmospheric pressure

The calculated leak rate is .023 ccm. The allowable leak rate shall not exceed 5 ccm; therefore, all five PA171 containers pass the Air Pressure Test during the Drop Tests.

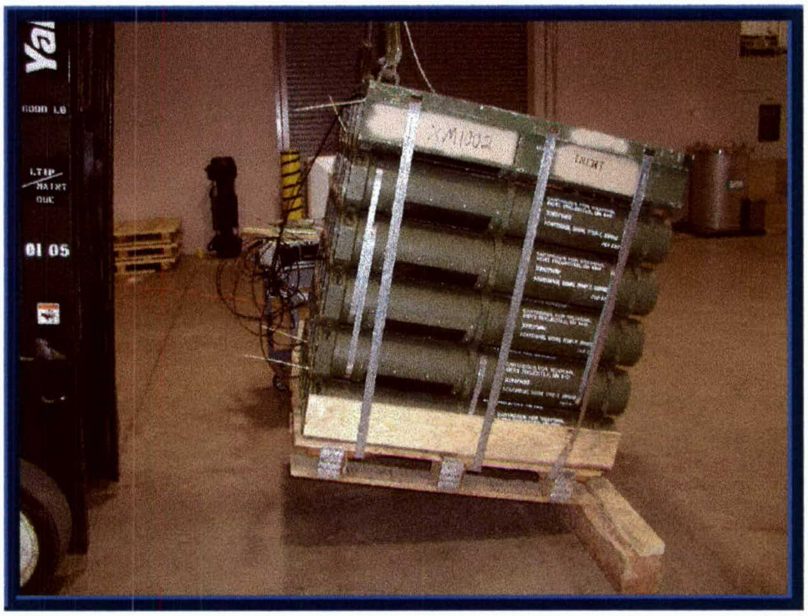

Photo 7. Test Setup for Edgewise Rotational Drop Testing.

4. <u>INCLINE-IMPACT TEST</u>. Test Unit #1 was incline-impacted on all four sides with the pallet impacting the stationary wall from a distance of 8 feet. No additional problems were encountered. Chart 4 shows the time versus pressure data for the five pressure sensors on the test unit during the Incline-Impact Tests. See Photo 8 for test setup for Incline-Impact Testing.

Time -vs- Pressure of Test Unit # 1 During Incline Impact Tests

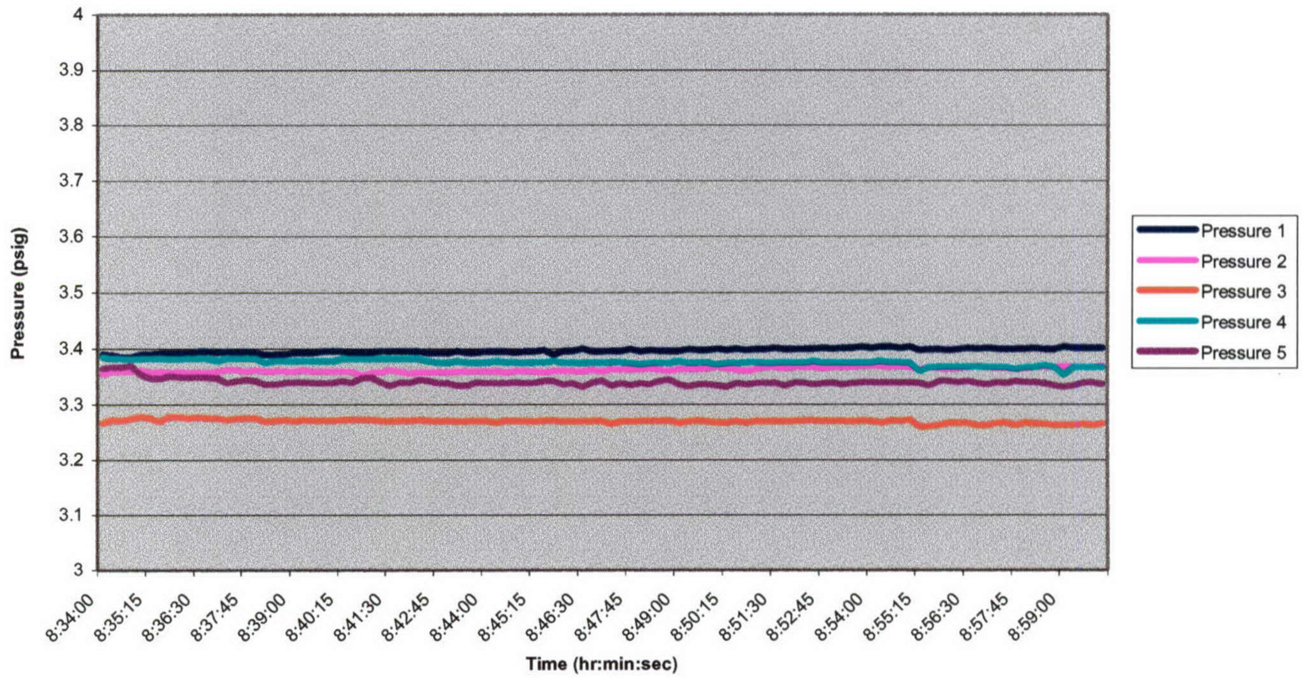

Chart 4.Time-vs-Pressure Data for Incline Impact Test on Test Unit 1.

Pressure Sensor 5 experienced the largest drop in pressure. The leak rate can be calculated as follows:

$$\text{Leak Rate (ccm)} = \frac{\text{Pressure Drop (psi)} \times 1.12 \times \text{Volume (in}^3)}{\text{Test Time (sec)}}$$

$$\text{Leak Rate (ccm)} = \frac{(3.365-3.336) \times 1.12 \times 554.65)}{1575}$$

Leak Rate (ccm) = .015

- 1.12 converts inches3 to ccm and adds standard atmospheric pressure

The calculated leak rate is .015 ccm. The allowable leak rate shall not exceed 5 ccm; therefore, all five PA171 containers pass the Air Pressure Test during the Incline-Impact Tests.

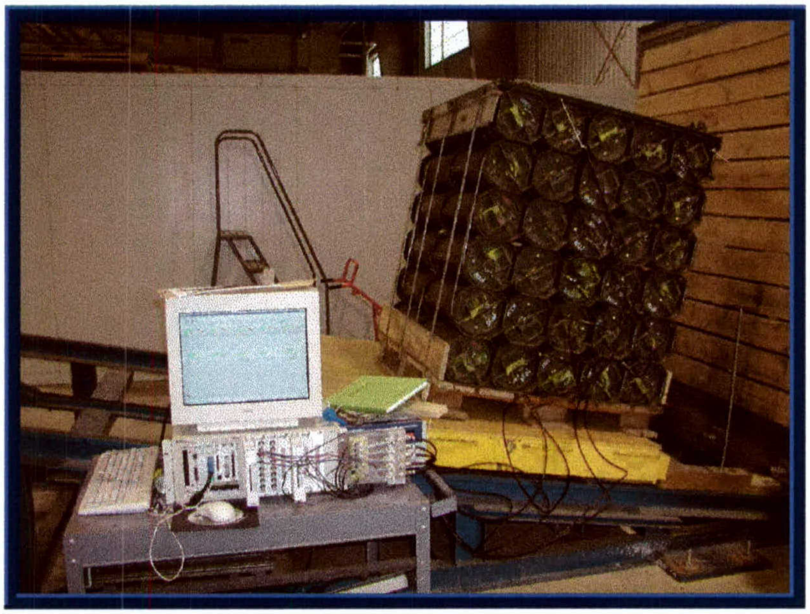

Photo 8. Test Setup for Incline-Impact Testing.

5. **SLING COMPATIBILITY TEST.** Not applicable.

6. **FORKLIFTING TEST**. Not applicable.

7. **DISASSEMBLY TEST**. During the disassembly of Test Unit #1 no additional damage was noted.

8. **CONCLUSION**. Test Unit #1 passed all required tests.

C. TEST RESULTS - TEST UNIT #2:

1. **STACKING TEST**. Test Unit #2 was compressed with a load force of 7,410 pounds for 60 minutes on 4 November 2004. No damage was noted as a result of this test. Chart 5 below shows the time versus pressure data for all five pressure sensors on the test unit during the Stacking Test. See Photo 9 below for a typical picture of the test unit in the Stacking Tester and each pressure sensor location. The data indicates that the pressure drop was well within the allowable leak rate.

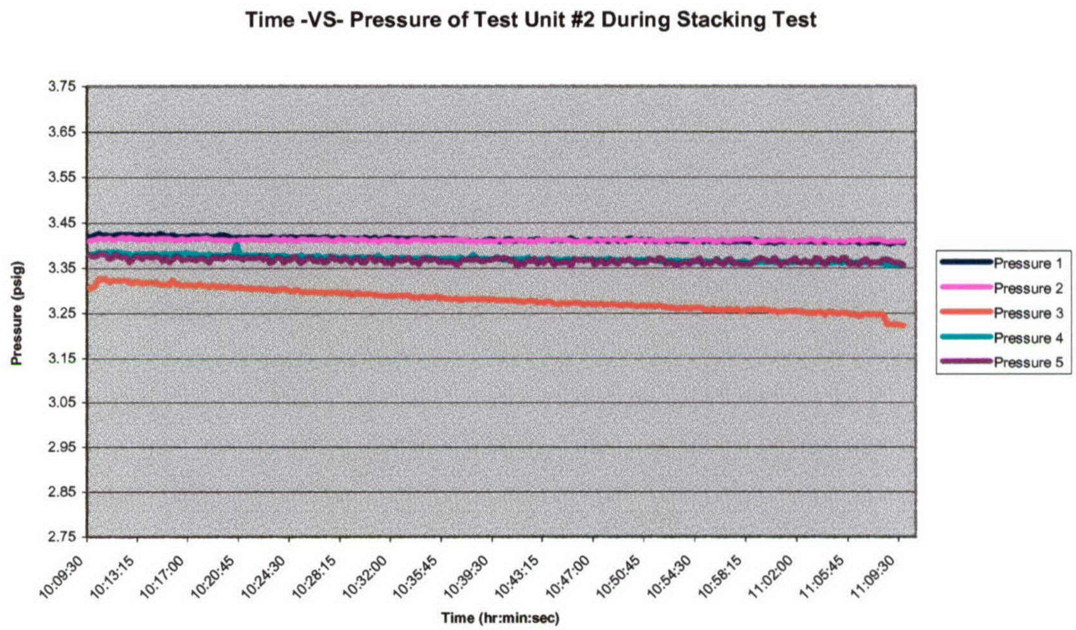

Chart 5. Time -vs- Pressure Data for Stacking Test on Test Unit #2

Photo 9. Test Setup for Stacking Testing of Test Unit #2.

2. <u>REPETITIVE SHOCK TEST</u>. Test Unit #2 was vibrated 90 minutes at 165 RPM in the longitudinal orientation and 160 RPM in the lateral orientation. No damage was noted as a result of this test. Chart 6 below shows the time versus pressure data for all five pressure sensors on the test unit during the Repetitive Shock Tests in the lateral direction and Chart 7 below shows the time versus pressure data for all five pressure sensors on the test unit during the Repetitive Shock Tests in the longitudinal direction. The repetitive vibration created friction heat resulting in increased temperature and pressure in both directions within the containers.

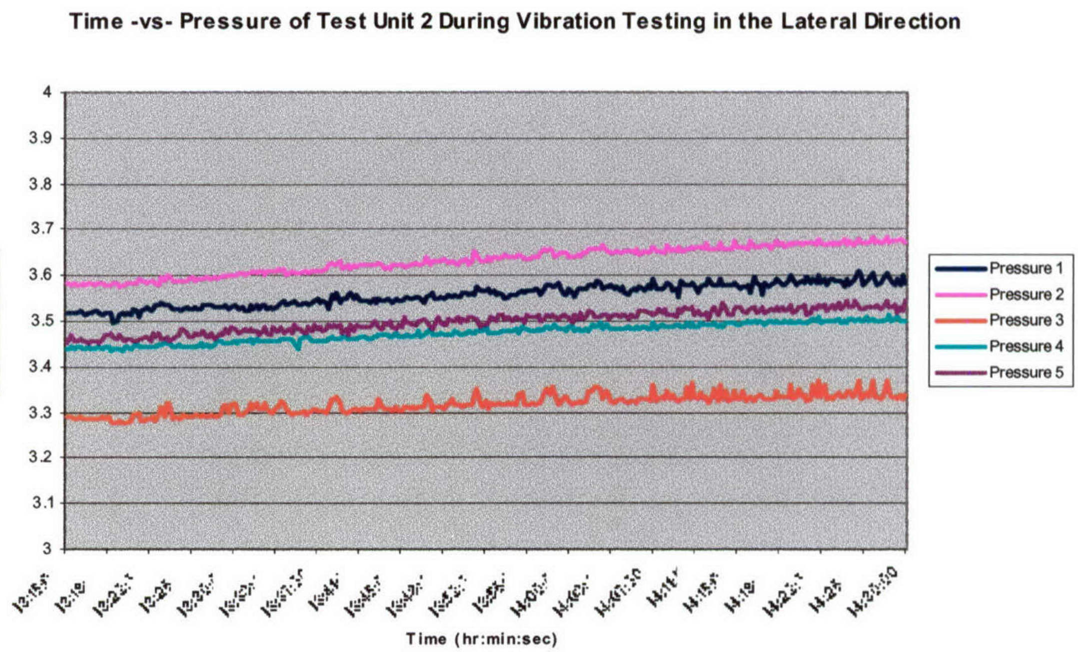

Chart 6. Time -vs- Pressure Data for Lateral Repetitive Shock Test on Test Unit #2

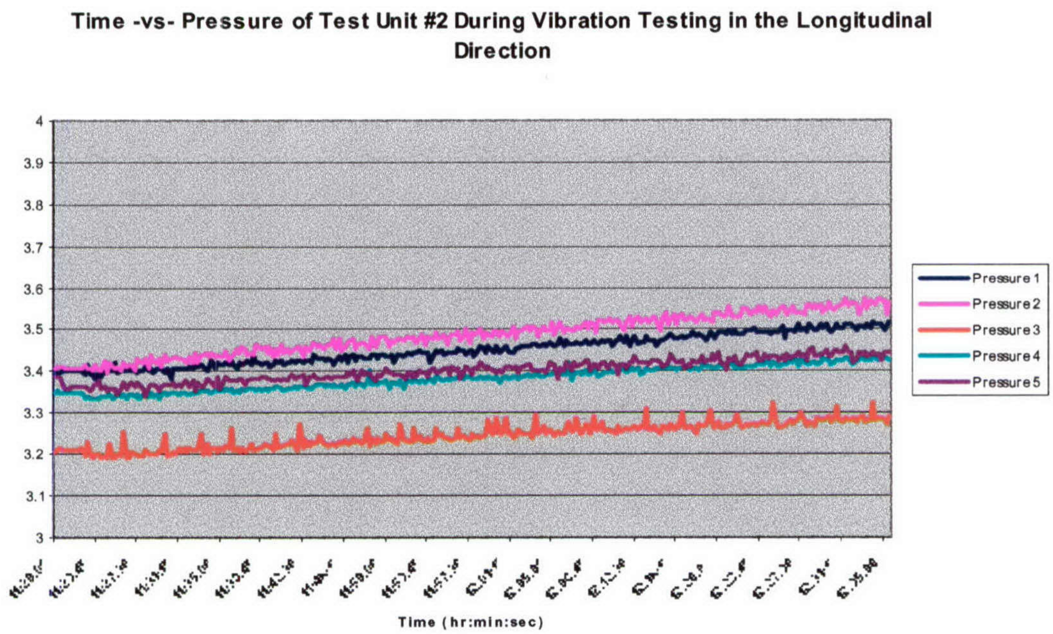

Chart 7. Time -vs- Pressure Data for Longitudinal Repetitive Shock Test on Test Unit #2

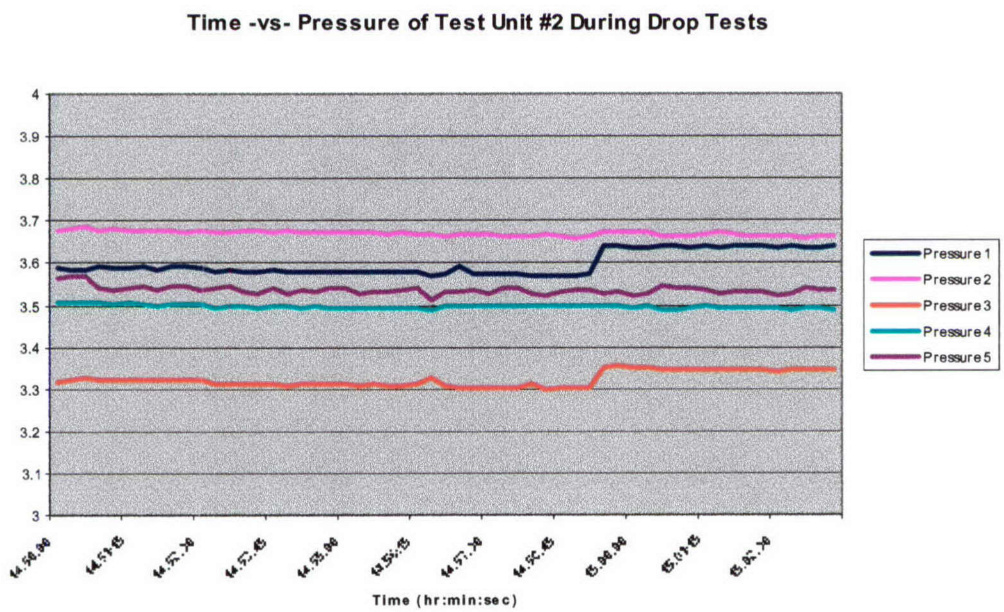

Chart 8. Time -vs- Pressure Data for Drop Tests on Test Unit #2

3. **EDGEWISE ROTATIONAL DROP TEST**. Test Unit #2 was edgewise rotationally dropped from a height of 15 inches on both longitudinal sides and both lateral sides. No damage was noted from this test. Chart 8 below depicts the pressure loss over time. The leak rate is within the allowable leak rate.

4. **INCLINE-IMPACT TEST**. Test Unit #2 was incline-impacted on all four sides with the pallet impacting the stationary wall from a distance of 8 feet. No additional problems were encountered. Chart 9 shows the pressure loss over time during the Drop Tests. The leak rate is within the allowable leak rate.

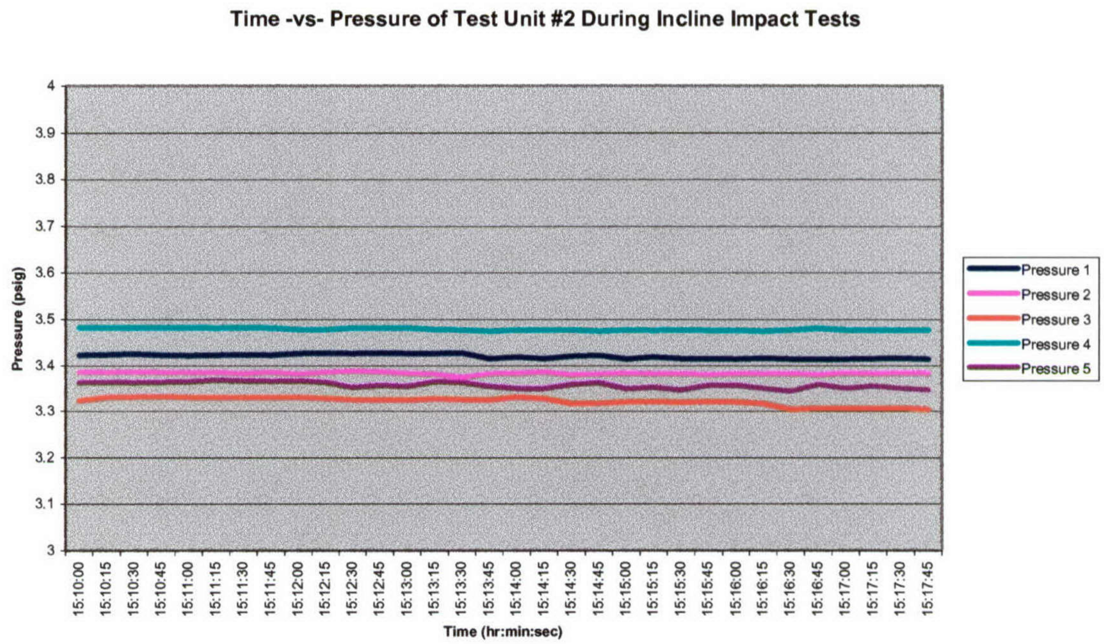

Chart 9. Time -vs- Pressure Data for Incline Impact Tests on Test Unit #2

5. **SLING COMPATIBILITY TEST**. Not applicable.

6. **FORKLIFTING TEST**. Not applicable.

7. **DISASSEMBLY TEST**. During the disassembly of Test Unit #2 no additional problems were noted, other than the same minor damage noted during

testing of Test Unit #1. The leak rates were all well below the allowable leak rates.

8. **CONCLUSION**. Test Unit #2 passed all required tests.

PART 6– DRAWINGS

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

MIL-STD-1660 TESTING OF THE UNITIZATION OF PA116/PA171 CONTAINERS ON A WOOD PALLET WITH METAL TOP ADAPTER SKETCH

THIS THREE PAGE DOCUMENT DEPICTS PROCEDURES FOR UNITIZING PA116/PA171 CONTAINERS FOR MIL-STD 1660 TESTING.

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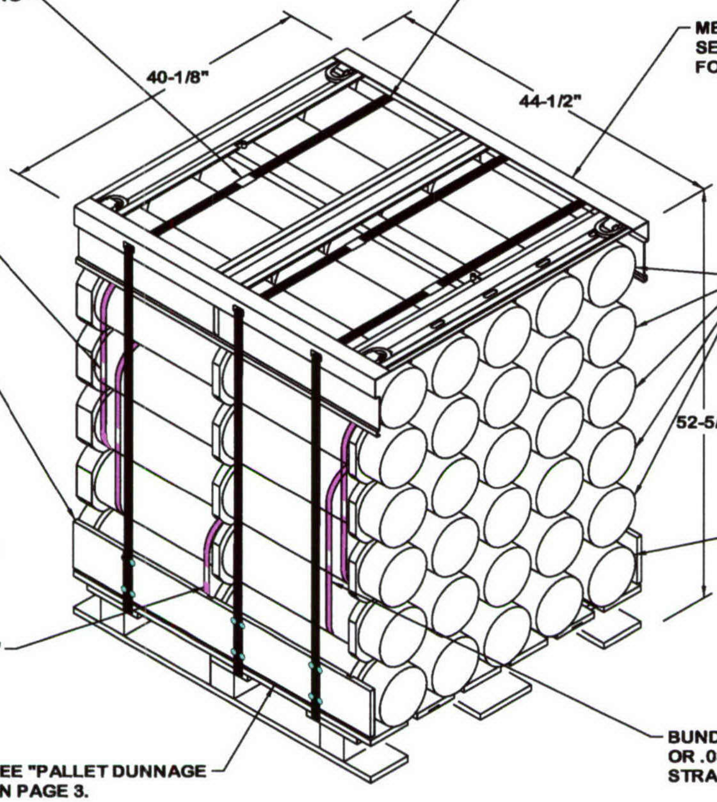


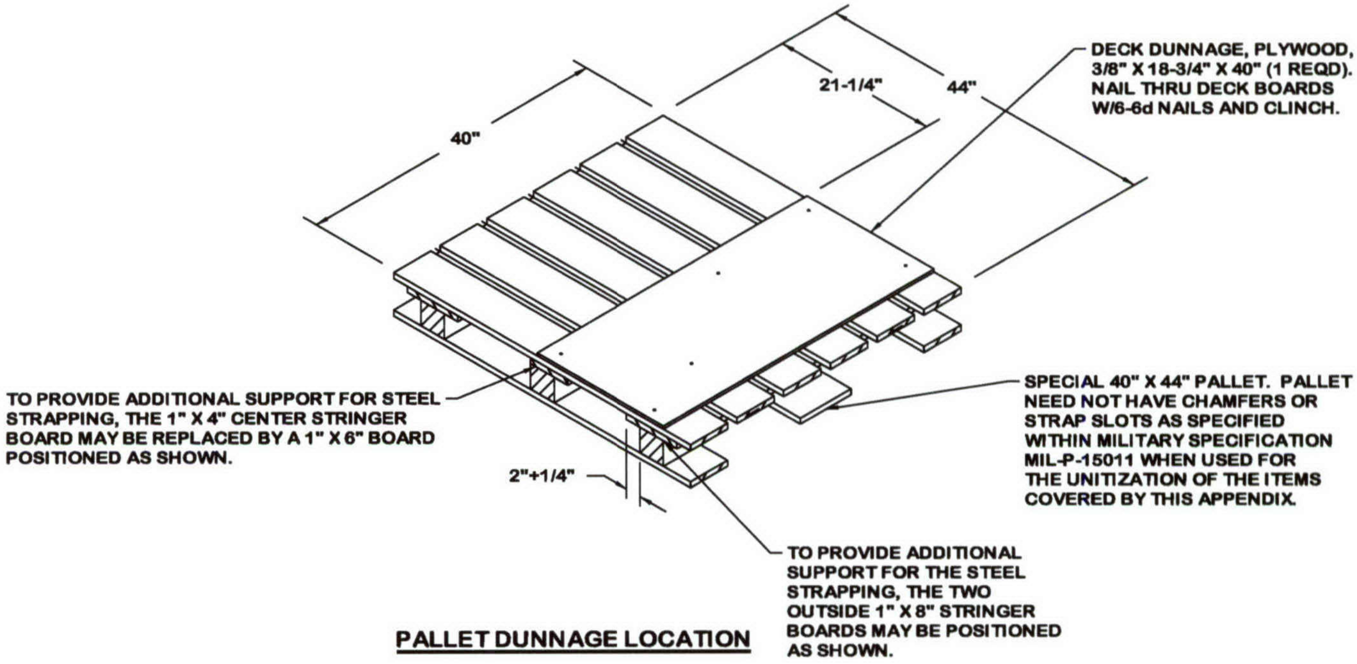
PA116/PA171 TEST LOAD

BILL OF MATERIAL		
NAILS	NO. REQD	POUNDS
NLRFR-02Z	24	0.14
6d (2")	6	0.04

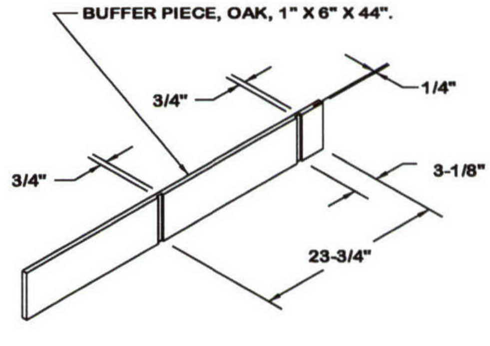
SPECIAL PALLET, 40" X 44"	1 REQD	77 LBS
STEEL STRAPPING, 3/4"	54.08' REQD	4.83 LBS
SEAL FOR 3/4" STRAPPING	5 REQD	NIL
STEEL STRAPPING, 1-1/4"	43.25' REQD	6.55 LBS
SEAL FOR 1-1/4" STRAPPING	3 REQD	NIL
PLYWOOD, 3/8"	5.21 SQ FT REQD	5.37 LBS
OAK, 3/4"	3.67 SQ FT REQD	7.37 LBS
METAL TOP ADAPTER	1 REQD	57 LBS

LOAD AS SHOWN

ITEM	WEIGHT (APPROX)
25 PA 116 CONTAINERS AT 76 LBS	1,900 LBS
5 PA 171 CONTAINERS AT 76 LBS	380 LBS
DUNNAGE	82 LBS
PALLET	77 LBS
TOTAL WEIGHT	2,439 LBS (APPROX)
CUBE	54.4 CU FT (APPROX)



PALLET DUNNAGE LOCATION



SIDE BUFFER

2 REQD.

DUNNAGE DETAILS