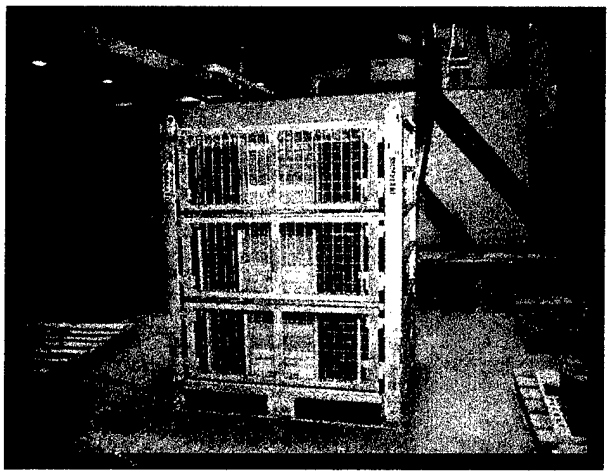
FINAL REPORT
MARCH 2004

REPORT NO. 04-08



INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF), MIL-STD-1660, "DESIGN CRITERIA FOR AMMUNITION UNIT LOADS" TESTING

Prepared for: Distribution Unlimited

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

U.S. Army Defense Ammunition Center
ATTN: SJMAC-DET
1 C Tree Road
McAlester, OK 74501-5900

VALIDATION ENGINEERING DIVISION
MCALESTER, OKLAHOMA 74501-9053

AVAILABILTY NOTICE

A copy of this report will be furnished each attendee on automatic distribution. Additional copies or authority for reprinting may be obtained by written request from:

Director
U.S. Army Defense Ammunition Center
ATTN: SJMAC-DEV
1 C Tree Road, Bldg. 35
McAlester, OK 74501-9053

DISTRIBUTION INSTRUCTIONS

Destroy this report when no longer needed. Do not return.

***

Citation of trade names in this report does not constitute an official endorsement.

***

The information contained herein will not be used for advertising purposes.

REPORT NO. 04-08 **MARCH 2004**

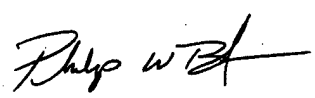
INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF)
MIL-STD-1660, "DESIGN CRITERIA FOR AMMUNITION UNIT LOADS" TESTING

ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV) was tasked by the Transportation Engineering Division, (SJMAC-DET) to conduct testing on the Intermodal Storage and Transport Frame (ISTF), manufactured by Mobile Shelter Systems, Inc. The ISTF was evaluated by the testing procedures set forth in MIL-STD-1660. Stacking, vibration, edgewise rotational drop, incline impact, sling compatibility, forklifting, and disassembly testing were conducted on the ISTF units.

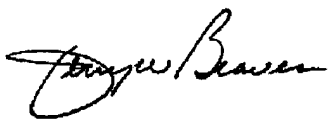
Each unit sustained weld cracks that occurred at the base of the corner posts. These weld cracks are an area of concern and should be evaluated by the manufacturer and design improvements identified. Each unit had cracked welds along the base. Inspection also revealed that each unit had bent wire mesh. The bent wire mesh was located in the frame end walls and was not significant. The damage was caused by impact of the wooden and metal containers against the mesh. The ISTF units remained intact and were capable of safely handling ammunition after completion of testing. The ISTF units successfully completed the test requirements of MIL-STD-1660 and are approved for the transport of ammunition. Also, instructions should be provided with each ISTF to ensure proper assembly/disassembly.

Prepared by:



PHILIP W. BARICKMAN
Validation Engineer

Reviewed by:



JERRY W. BEAVER
Chief, Validation Engineering Division

U.S. ARMY DEFENSE AMMUNITION CENTER

VALIDATION ENGINEERING DIVISION
MCALESTER, OK 74501-9053

REPORT NO. 04-08

INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF), MIL-STD-1660, "DESIGN CRITERIA FOR AMMUNITION UNIT LOADS" TESTS

TABLE OF CONTENTS

PART 1 – INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV), was tasked by the Transportation Engineering Division (SJMAC-DEV) to conduct testing on the Intermodal Storage and Transport Frame (ISTF), manufactured by Mobile Shelter Systems, Inc. The ISTF was evaluated by the testing procedures set forth in MIL-STD-1660. Stacking, vibration, edgewise rotational drop, incline impact, sling compatibility, forklifting, and disassembly testing were conducted on the ISTF units. The unitization procedures were provided by the DAC, Transportation Engineering Division (SJMAC-DET) (See Part 6).

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 testing was to determine if the ISTF was adequate for unitization and transportation of ammunition in wooden and metal containers and if it could successfully pass the MIL-STD-1660 test requirements.

D. CONCLUSION. Each unit sustained weld cracks that occurred at the base of the corner posts. These weld cracks are an area of concern and should be evaluated by the manufacturer and design improvements identified. Each unit had cracked welds along the base. Inspection also revealed that each unit had bent wire mesh. The bent wire mesh was located in the frame end walls and was not significant. The damage was caused by impact of the wooden and metal containers against the mesh. The ISTF units remained intact and were capable of safely handling ammunition after completion of testing. The ISTF units successfully completed the test requirements of

MIL-STD-1660. Also, instructions should be provided with each ISTF to ensure proper assembly/disassembly.

PART 2 - ATTENDEES

ATTENDEE	MAILING ADDRESS
Philip W. Barickman General Engineer DSN 956-8992 (918) 420-8992	Director U.S. Army Defense Ammunition Center ATTN: SJMAC-DEV 1 C Tree Road, Bldg. 35 McAlester, OK 74501-9053
Michael S. Bartosiak Mechanical Engineer DSN 956-8083 (918) 420-8083	Director U.S. Army Defense Ammunition Center ATTN: SJMAC-DET 1 C Tree Road, Bldg. 35 McAlester, OK 74501-9053
Frank Chan (973) 724-4783	U.S. Army Armament Research Development and Engineering Center LRED, Packaging Group Picatinny, NJ 07806
Rob Kim (973) 724-7235	U.S. Army Armament Research Development and Engineering Center LRED, Packaging Group Picatinny, NJ 07806
Bob Forrester (973) 724-2042	U.S. Army Armament Research Development and Engineering Center LRED, Packaging Group Picatinny, NJ 07806
James F. Mitchell (757) 229-9482	Mobile Shelter Systems Inc. 4039 Ironbound Road Williamsburg, VA 23188

PART 3 - TEST PROCEDURES

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

A. MIL-STD-1660:

1. 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 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.

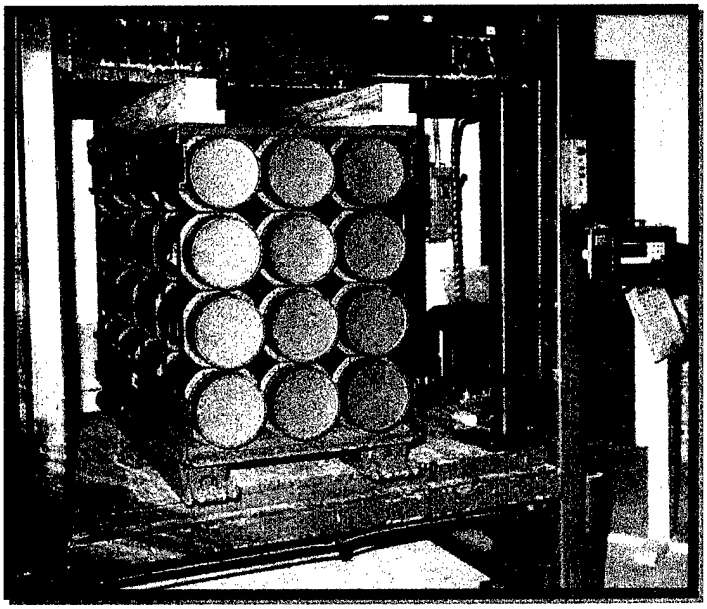


Photo 1. Example of Stacking Test.
(2.75-inch Hydra 70, PA151 Rocket Pallet in the Stacking Test.)

2. **REPETITIVE SHOCK TEST.** 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.

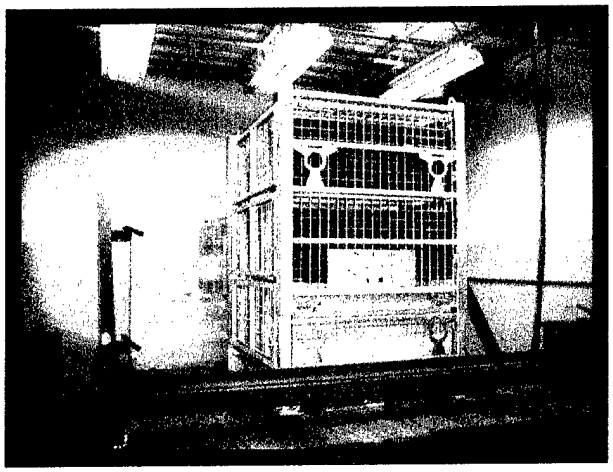


Photo 2. Example of the Repetitive Shock Test.
(ISTF)

3. **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 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 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.

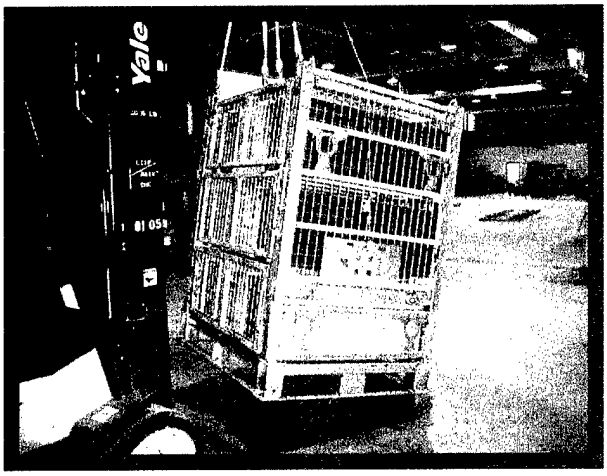


Photo 3. Example of Edgewise Rotational Drop Test (ISTF)

4. <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 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.

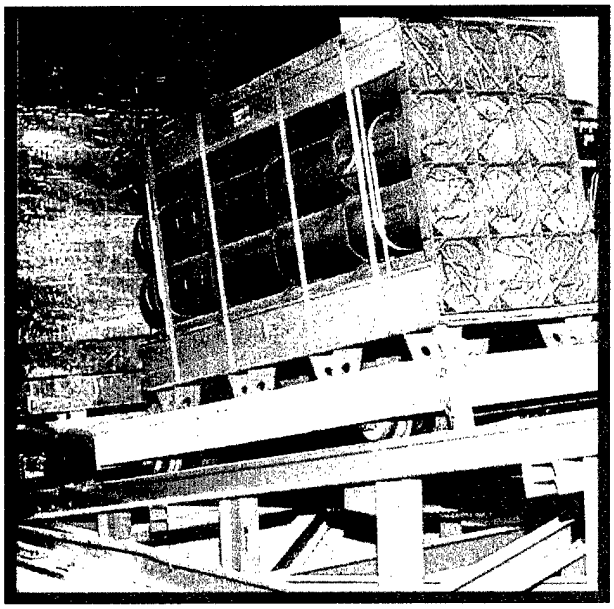


Photo 4. Example of the Incline-Impact Test.
(2.75-Inch, Hydra 70, PA151 Rocket Pallet on incline-impact tester.)

5. 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.

6. 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

down and back the Optional Rough Handling Course one time. The forklift will be brought to a stop prior to transversing 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.

7. **DISASSEMBLY TEST.** 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 specimen will be such that it retains its unity upon removal of the strapping.

PART 4 - TEST EQUIPMENT

A. 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

B. 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. FRAME DATA. The ISTF units were inertly loaded to the specified design weight using inert simulation in metal cans, wooden boxes and wood dunnage. The test specimen was prepared using the unitization procedures specified in Part 6 – Drawings. Special care was taken to ensure that each metal can and wooden box had the proper amount of weight in order to achieve a realistic pallet center of gravity (CG). Once properly prepared, the ISTF unit was tested utilizing the MIL-STD-1660 requirements.

INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF) UNIT #1

Testing Date:	3 – 17 February 2004
Gross Weight:	3515 pounds
Length:	51.75 inches
Width:	41.875 inches
Height:	65.5 inches
Mfg:	Mobile Shelter Systems, Inc.

A. INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF) - TEST RESULTS:

1. COMPRESSION TEST. The Test Unit #1 was compressed with a load force of 3,530 pounds for 60 minutes on 3 February 2004. Test Unit #2 was used as the load force for the test. No damage was noted as a result of this test. See Photo 5 of the test specimen in the compression unit.

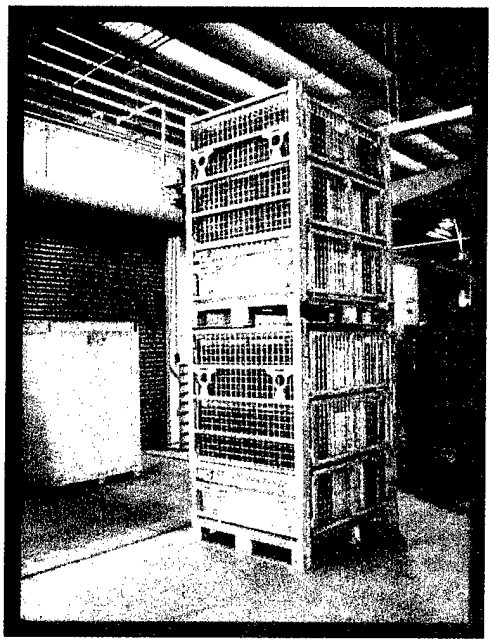


Photo 5. ISTF Unit #1 During Compression Testing.

2. **REPETITIVE SHOCK TEST.** The specimen was vibrated 90 minutes at 227 RPM in the lateral orientation and 90 minutes at 212 RPM in the longitudinal orientation. A cracked weld occurred along the base support. Cracks also occurred in some of the welds at the base of the corner post. Photo 6 shows the specimen on the vibration platform. Photo 7 shows the cracked base weld and Photo 8 shows an example of the cracked weld along the ISTF corner post.

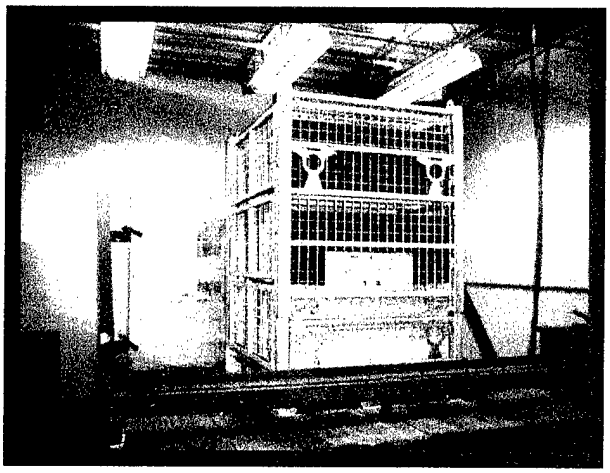


Photo 6. ISTF Unit #1 During Repetitive Shock Testing.

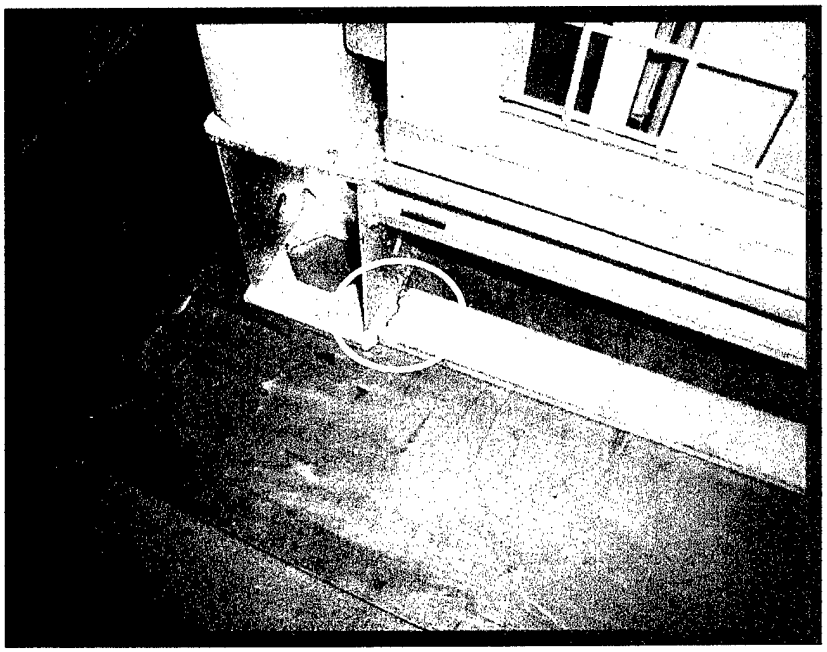


Photo 7. ISTF Unit #1 Cracked Weld on the Base Structure.

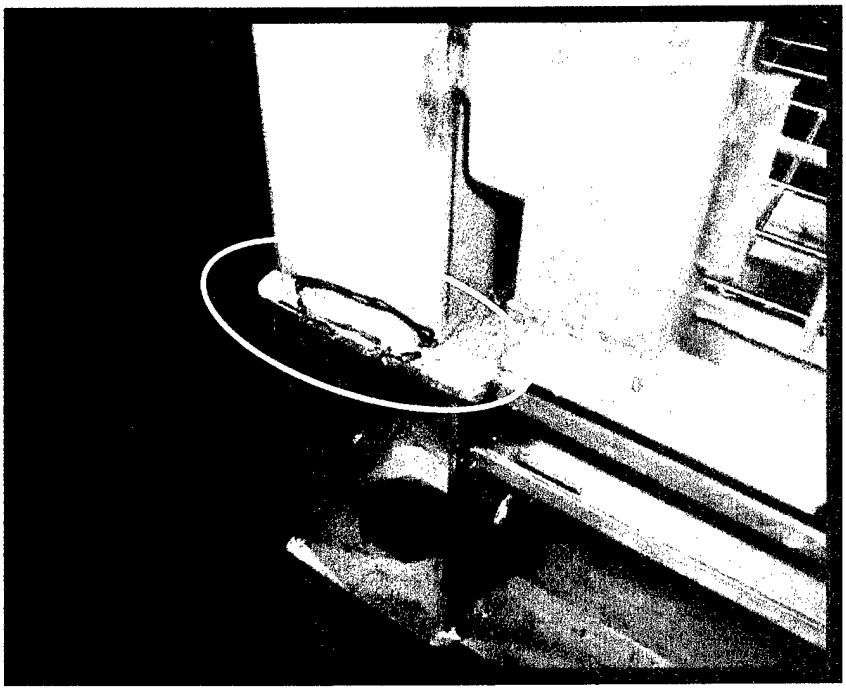


Photo 8. ISTF Unit #1 Cracked Weld Along the Corner Post.

3. **EDGEWISE ROTATIONAL DROP TEST**. The specimen was edgewise rotationally dropped from a height of 12 inches on both longitudinal sides and both lateral sides. Photo 9 shows the specimen during the drop test.

Photo 9. Edgewise Rotational Drop Test on the ISTF Unit #1.

4. **INCLINE-IMPACT TEST**. The specimen was impact tested on both longitudinal sides and both lateral sides. No significant damage was noted as a result of this test to the ISTF Unit #1. See Photo 10 for the specimen during the lateral incline-impact test.

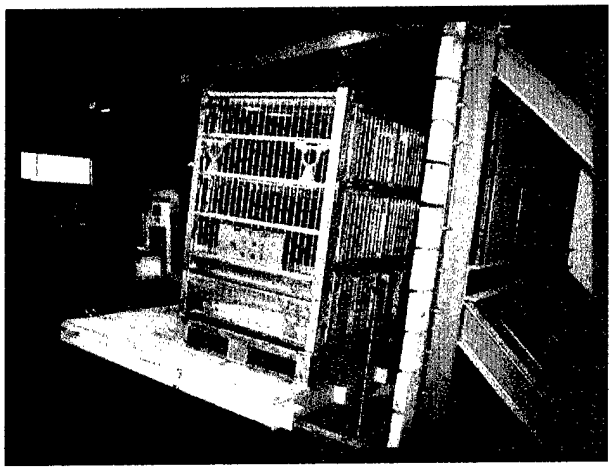


Photo 10. Incline-Impact Testing of the ISTF Unit #1.

5. SLING COMPATIBILITY TEST. During testing the specimen was lifted, swung, lowered and handled as necessary using slings of the types normally used for handling the unit loads. The sling compatibility testing was conducted using a two-point lift, a three-point lift and a four-point lift. Photo 11 shows the specimen during the sling compatibility test. No damage was noted as a result of this test. The slings were easily attached and removed. The markings on the ISTF are unclear on the sling attachment locations. The markings need to be modified to better identify the slinging locations.

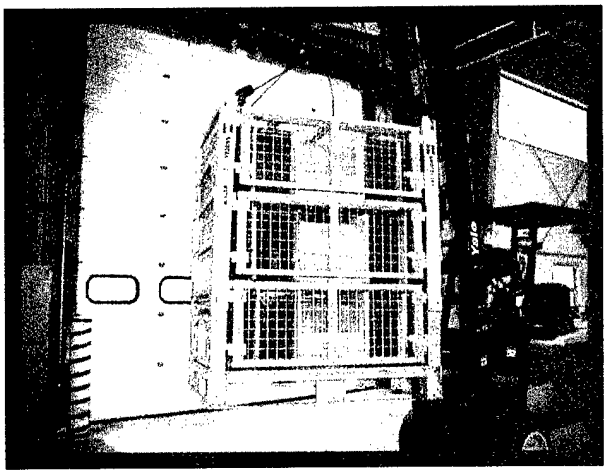


Photo 11. ISTF Unit 1 During the Sling Compatibility Test

6. FORKLIFTING TEST. The specimen was lifted clear of the ground by a forklift from the longitudinal and lateral sides and transported on the forks. Photo 12 shows the specimen during the Forklift Test. No damage was noted as a result of this test.

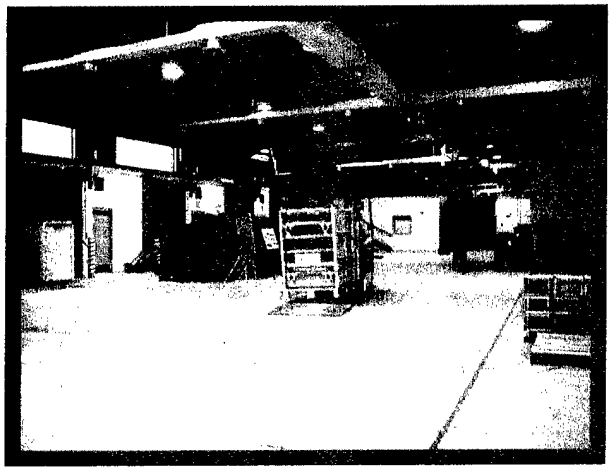


Photo 12. ISTF Unit 1 During the Forklifting Test

7. **DISASSEMBLY TEST**. Inspection revealed bent wire mesh. The bent wire mesh was located in the frame end walls and was not significant. The damage was caused by impact of the wooden and metal containers against the mesh. The test specimen had some cracked welds at the base of the corner posts. One corner post also had a small fatigue crack in the bend profile. Photo 13 shows the bend profile fatigue crack. The specimen maintained adequate integrity and was still considered safe to handle.

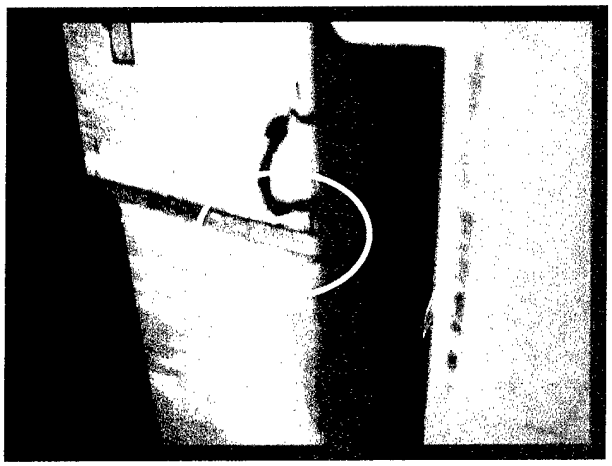


Photo 13. Bend Profile Fatigue Crack

8. CONCLUSION. As tested, the Intermodal Storage and Transport Frame (ISTF) Unit #1, manufactured by Mobile Shelter Systems, successfully completed the MIL-STD-1660 test requirements. Also, instructions should be provided with each ISTF to ensure proper assembly/disassembly.

5.2. FRAME DATA. The ISTF Unit #2, was inertly loaded to the specified design weight using inert simulation in metal cans, wooden boxes and wood dunnage. The test specimen was prepared using the unitization procedures specified in Part 6 – Drawings. Special care was taken to ensure that each metal can and wooden box had the proper amount of weight in order to achieve a realistic center of gravity (CG). Once properly prepared, the ISTF unit was tested using the MIL-STD-1660 requirements.

INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF) UNIT #2

Testing Date: 3 - 17 February 2004
Gross Weight: 3530 pounds
Length: 51.75 inches
Width: 41.875 inches
Height: 65.5 inches
Mfg: Mobile Shelter Systems, Inc.

A. INTERMODAL STORAGE AND TRANSPORT FRAME (ISTF) UNIT 2 WITH WOOD DUNNAGE- TEST RESULTS:

1. COMPRESSION TEST. The Test Unit #2 was compressed with a load force of 3515 pounds for 60 minutes on 3 February 2004. Test Unit #1 was used as the load force for the test. No damage was noted as a result of this test. See Photo 14 of the test specimen in the compression unit.

Photo 14. ISTF Unit #2 in the Compression Tester.

2. **REPETITIVE SHOCK TEST.** The specimen was vibrated 90 minutes at 218 RPM in the lateral orientation and 90 minutes at 210 RPM in the longitudinal orientation. A crack occurred along the base support. No significant damage was noted to the ISTF as a result of this test. Photo 15 shows the specimen on the vibration platform.

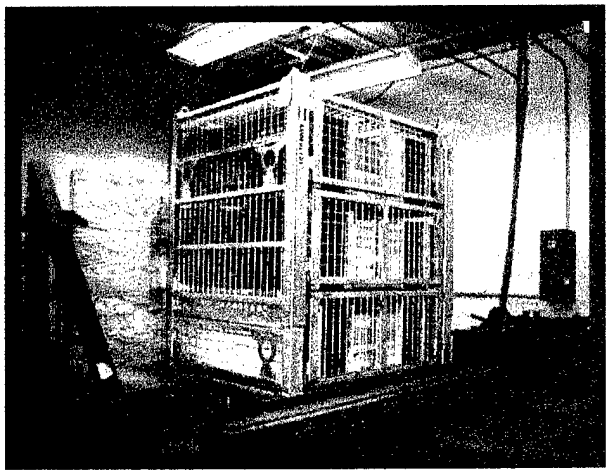


Photo 15. ISTF Unit #2 During the Repetitive Shock Testing.

3. **EDGEWISE ROTATIONAL DROP TEST**. The specimen was edgewise rotationally dropped from a height of 12 inches on both longitudinal sides and both lateral sides. Cracks occurred in some of the welds at the base of the corner post. No significant damage was noted as a result of this test. Photo 16 shows the specimen during the drop test and Photo 17 shows the corner post weld crack.

Photo 16. Edgewise Rotational Drop Test on the ISTF Unit #2.

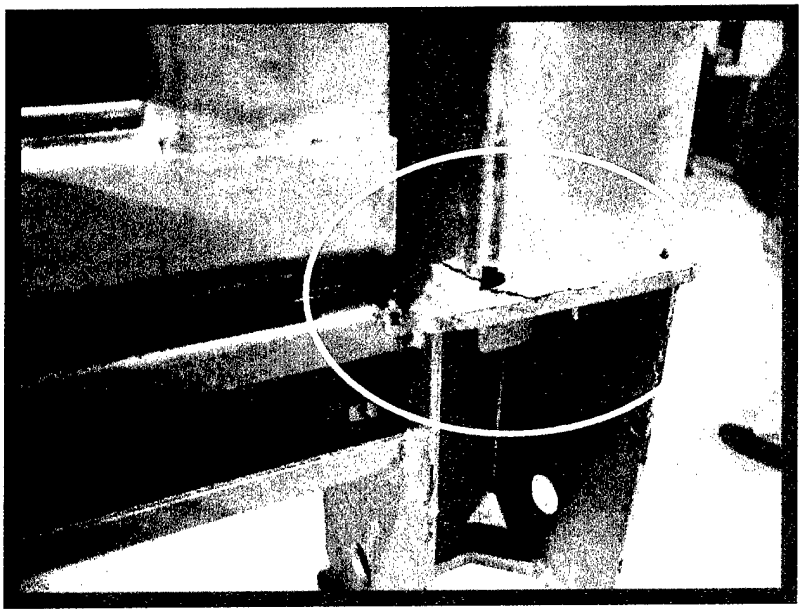


Photo 17. Corner Post Weld Crack on ISTF Unit #2.

4. INCLINE-IMPACT TEST. The specimen was impact tested on both longitudinal sides and both lateral sides. No damage was noted as a result of this test. See Photo 18 for the specimen during the lateral incline-impact test.

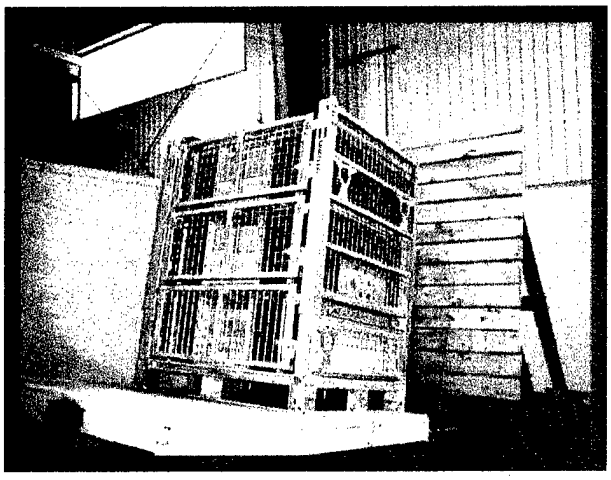


Photo 18. Incline-Impact Testing of the ISTF Unit #2.

5. SLING COMPATIBILITY TEST. During testing the specimen was lifted, swung, lowered and handled as necessary using slings of the types normally used for handling the unit loads. The sling compatibility testing was conducted using a two-point lift, a three-point lift and a four-point lift. No damage was noted as a result of this test. The slings were easily attached and removed. The markings on the ISTF are unclear on the sling attachment locations. The markings need to be modified to better identify the slinging locations. Photo 19 shows the specimen during the sling compatibility test.

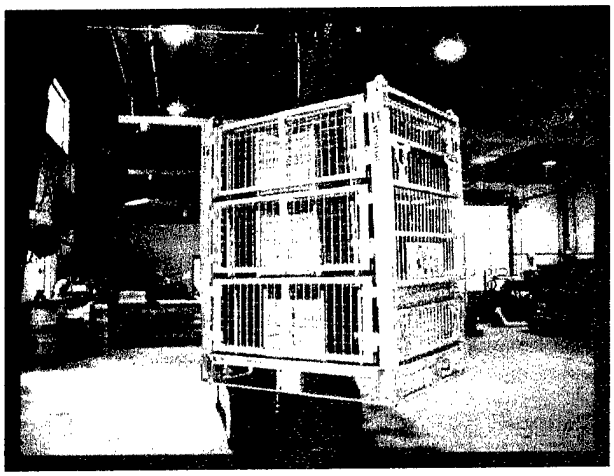


Photo 19. ISTF Unit #2 Sling Compatibility Testing.

6. **FORKLIFTING TEST**. The specimen 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. Photo 20 shows the specimen during the Forklift Test.

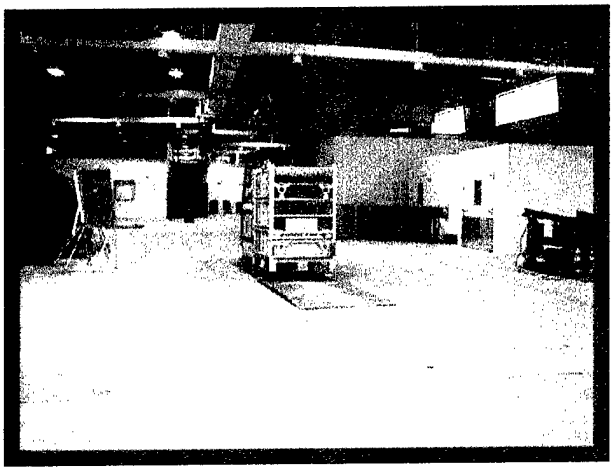


Photo 20. ISTF Unit #2 During the Forklifting Test.

7. **DISASSEMBLY TEST**. Inspection revealed bent wire mesh. The bent wire mesh was located in the frame end walls and was not significant. The damage was caused by impact of the wooden and metal containers against the mesh. The test specimen had cracked welds at the base of the corner post. A crack

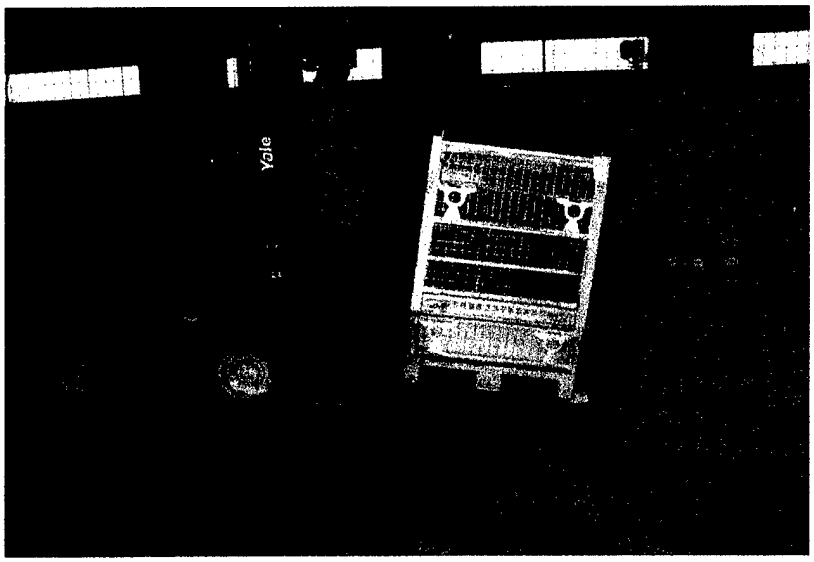
occurred along the base support. The specimen maintained adequate integrity and was still considered safe to handle.

8. CONCLUSION. As tested, the Intermodal Storage and Transport Frame (ISTF) Unit #2, manufactured by Mobile Shelter Systems, successfully completed the MIL-STD-1660 test requirements. Also, instructions should be provided with each ISTF to ensure proper assembly/disassembly.

PART 6– DRAWINGS

The following test sketches represent the load configurations that were subjected to the test criteria.

MIL-STD-1660 TESTING OF THE INTERMODAL - STORAGE AND TRANSPORT FRAME (ISTF) LOAD SKETCH

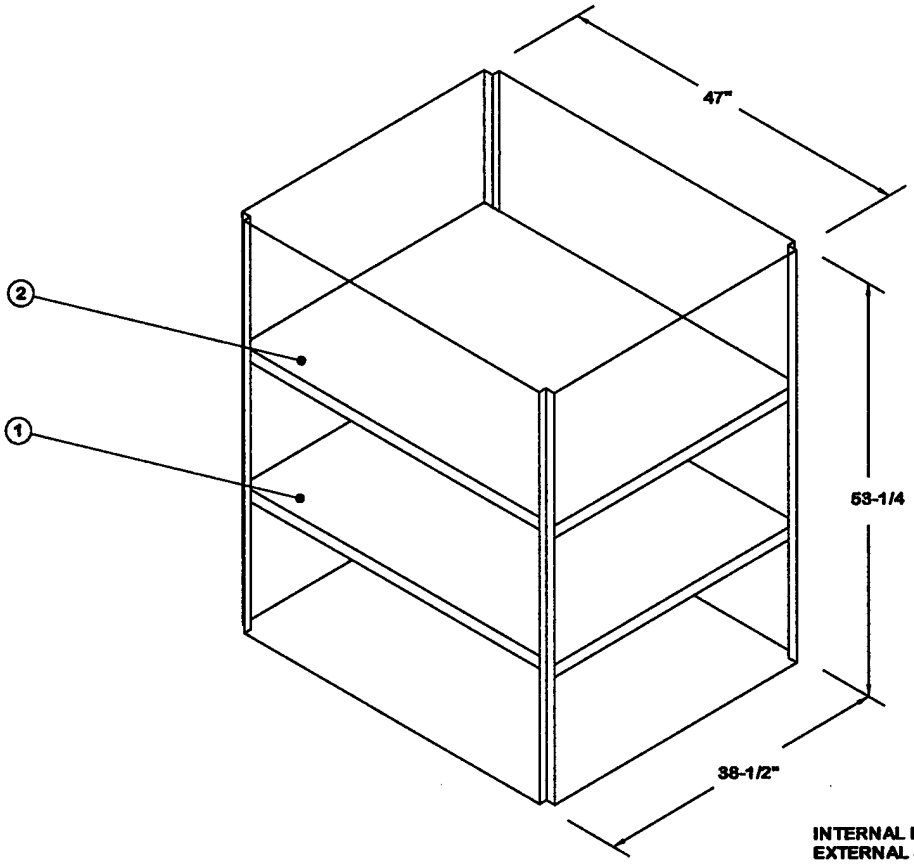


THIS FOUR PAGE DOCUMENT DEPICTS PROCEDURES FOR UNITIZING THE TEST LOAD FOR THE ISTF MIL-STD 1660 TESTING.

OVERALL DIMENSIONS OF THE ISTF:
51-7/8"L X 41-7/8"W X 66-15/16"H

Prepared during February 2004 by:
U.S. Army Defense Ammunition Center
ATTN: SJMAC-DET
McAlester, OK 74501
POC: Mike Bartosiak
DSN 956-8083
Comm (918) 420-8083
Fax 956-8811
E-mail: michael.bartosiak@dac.army.mil

Gregory L. Willis
Chief, Transportation Engineering Division



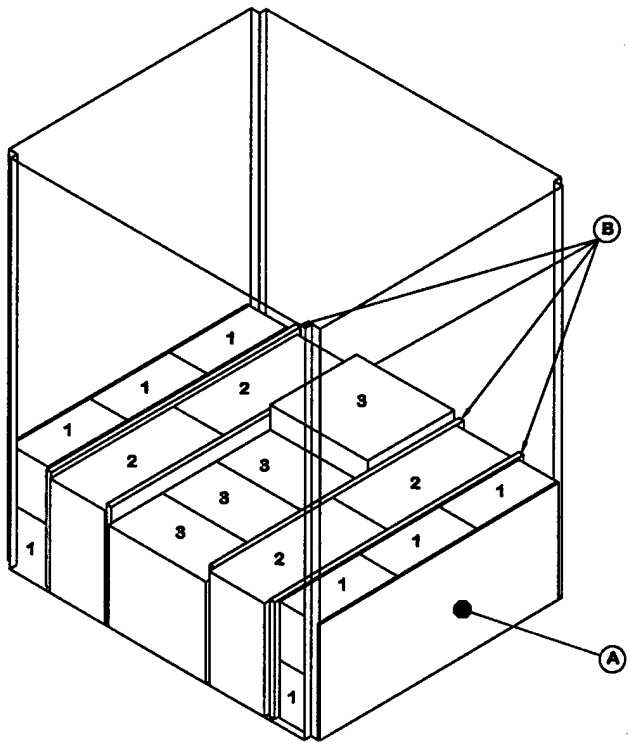
INTERNAL EXTENTS OF THE ISTF SHOWN.
EXTERNAL SIDE PANELS, END WALLS,
AND BOTTOM FRAME NOT SHOWN.

ISTF INTERNAL SETUP

(1) PLACE FIRST SHELF IN THE FIRST SLOT FROM THE BOTTOM.

(2) PLACE SECOND SHELF IN THE FIFTH SLOT FROM THE BOTTOM.

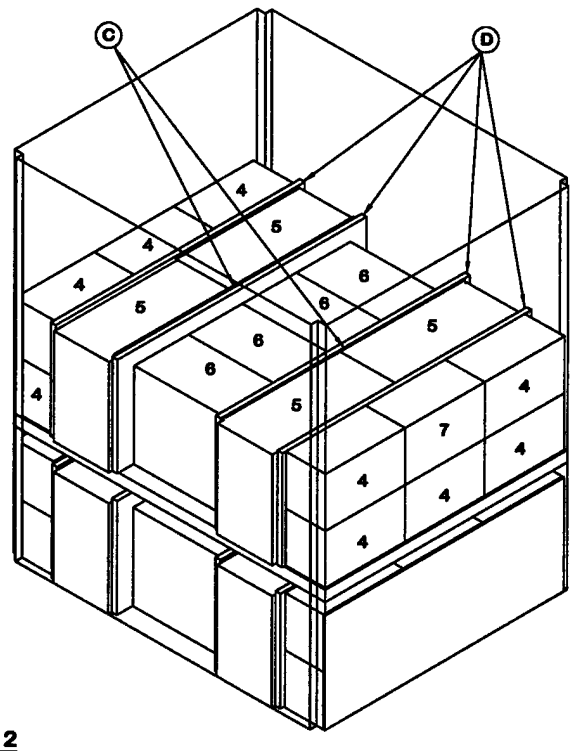
INTERMODAL STORAGE AND TRANSPORT FRAME		
COMPONENTS	WEIGHT	NO. REQD
BOTTOM FRAME	207 LBS	1 REQD
END WALL	62 LBS	2 REQD
SHELF	42 LBS	2 REQD
SIDE PANEL	20 LBS	6 REQD
DIVIDER	7 LBS	N/A
TOTAL WEIGHT WITHOUT DIVIDERS ..... 535 LBS		



ISTF BOTTOM FRAME COMPOSITION CHART			
ITEM	PKG TYPE	NO. REQD	WEIGHT EA (LBS)
1	M2A1 / METAL CAN	12	35
2	M548 / METAL CAN	4	90
3	WIREBOUND	4	46
ITEM	MATERIAL	NO. REQD	WEIGHT (LBS)
A	PLYWOOD 36" X 15" x 1/4"	2	5.2
B	PLYWOOD 38" X 15" x 3/4"	4	32.7
TOTAL WEIGHT - - - - - - - - - 1,002 LBS (APPROX)			

STEP 1

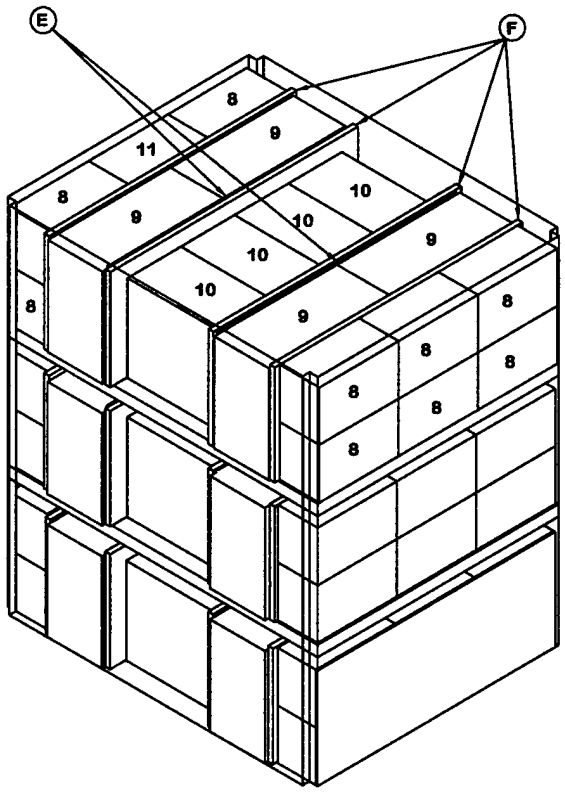
LOAD BOTTOM FRAME.



ISTF SHELF 1 COMPOSITION CHART			
ITEM	PKG TYPE	NO. REQD	WEIGHT EA (LBS)
4	M2A1 / METAL CAN	11	35
5	M548 / METAL CAN	4	90
6	WIREBOUND	4	46
7	EMPTY M2A1	1	5
ITEM	MATERIAL	NO. REQD	WEIGHT (LBS)
C	PLYWOOD 36" X 15" x 1/4"	2	5.2
D	PLYWOOD 38" X 15" x 3/4"	4	32.7
TOTAL WEIGHT - - - - - - - - - 972 LBS (APPROX)			

STEP 2

LOAD SHELF 1.



ISTF SHELF 2 COMPOSITION CHART			
ITEM	PKG TYPE	NO. REQD	WEIGHT EA (LBS)
8	M2A1 / METAL CAN	11	35
9	M548 / METAL CAN	4	90
10	WIREBOUND	5	46
11	M2A1 EMPTY	1	5
ITEM	MATERIAL	NO. REQD	WEIGHT (LBS)
E	PLYWOOD 36" X 15" x 1/4"	2	5.2
F	PLYWOOD 38" X 15" x 3/4"	4	32.7
TOTAL WEIGHT - - - - - - - - - -			972 LBS (APPROX)

STEP 3

LOAD SHELF 3.

I-STF UNIT LOAD

ITEM	QUANTITY	WEIGHT (APPROX)
M2A1 BOX	34	1,190 LBS
M2A1 EMPTY	2	10 LBS
M548 BOX	12	1,080 LBS
WIREBOUND	12	552 LBS
DUNNAGE		112 LBS
ISTF		535 LBS
TOTAL WEIGHT		3,479 LBS (APPROX)

BILL OF MATERIAL		
I-STF	1 REQD	535 LBS
1/4 PLYWOOD	22.5 SQ FT	15.47 LBS
3/4 PLYWOOD	47.5 SQ FT	96.19 LBS