AD NUMBER
AD849498
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies only; Administrative/Operational Use; FEB 1969. Other requests shall be referred to Military Traffic Management and Terminal Service, Washington, DC 20315.**
AUTHORITY
MTMC D/A ltr, 12 May 1981

AD

AD849498

USATEA REPORT 69-3

ENGINEERING REPORT

TRANPORTABILITY STUDY

HOUSEHOLD GOODS SHIPPING CONTAINERS

By

DAVID R. PHELPS, 1LT, TC

February 1969

U. S. ARMY

TRANSPORTATION ENGINEERING AGENCY

FORT EUSTIS, VIRGINIA

DISCLAIMER NOTICE

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

* * *

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

* * *

Trade names cited in this report do not constitute an official indorsement or approval of the use of such commercial hardware or software.

AD

USATEA REPORT 69-3

ENGINEERING REPORT

TRANSPORTABILITY STUDY

HOUSEHOLD GOODS SHIPPING CONTAINERS

FEBRUARY 1969

Prepared by

David R. Phelps, 1LT, TC

Engineering Research Division
U.S. ARMY TRANSPORTATION ENGINEERING AGENCY
MILITARY TRAFFIC MANAGEMENT AND TERMINAL SERVICE
Fort Eustis, Virginia

ABSTRACT

A transportability study of household goods shipping containers was performed by the U.S. Army Transportation Engineering Agency, Military Traffic Management and Terminal Service, Fort Eustis, Virginia, covering four representative types of commercial and military design containers. Containers were subjected to highway transport over roads ranging from marginal gravel roads to interstate highways, to drop tests from a height of 24 inches to simulate adverse terminal-handling conditions, and to rail coupling impact tests at speeds up to 9.5 miles per hour.

Although testing was limited to land transport modes and terminal handling, results were compared with previous findings for air and water.

Wooden containers with bolted or lag screw construction were found to be superior to those with nailed construction. A prototype metal container was found to be uneconomical and structurally deficient. Internal moisture from condensation was found to be a widespread problem area.

A proposed container configuration, intermodal in nature, and a test procedure are presented, along with suggestions for implementing their use. The new container configuration is proposed to replace the present U.S. Army Type II container, while the test procedure will provide a uniform means of evaluating containers built within the proposed configuration.

CONTENTS

CONTENTS - contd

ILLUSTRATIONS

ILLUSTRATIONS - contd

ILLUSTRATIONS - contd

ILLUSTRATIONS - contd

TABLES

I. INTRODUCTION

Damage-free movement of household goods and personal property of military personnel and dependents remains a continuing objective of Military Traffic Management and Terminal Service (MTMTS). However, current shipping experience is that loss and damage in the movement of household goods are at an unacceptably high level. At the request of the Directorate of Personal Property, MTMTS, the U. S. Army Transportation Engineering Agency (USATEA), Fort Eustis, Virginia, initiated a project for the determination of the performance of existing and prototype household goods shipping containers when subjected to worldwide physical and climatic environments encountered in transport and storage. This project was designed to result in the development of criteria for specifications or physical requirements by which qualitative materiel requests can be issued, and present or proposed containers can be evaluated or designed.

In the conduct of the project, highway, rail, and ocean modes of transport have been considered, as well as terminal-handling conditions common to all modes. Containers of military and representative commercial design were used, most of which were of wood box construction. In later phases of the tests, a prototype metal container was also included. This report summarizes the findings for surface modes and terminal handling and includes recommendations designed to alleviate present problem areas.

II. OBJECTIVES

1. To develop criteria for the design and evaluation of present and proposed military and commercial household goods containers.

2. To determine shock and vibration environments experienced by household goods containers in surface transport and terminal handling.

III. CONCLUSIONS

1. Even in the least severe mode of transport, the potential for damage exists if container contents are not securely packed. Typical internal household goods cushioning material by itself does not have sufficient cushioning effect to protect loosely packed goods. Under conditions of loosely packed cargo, acceleration values will rise significantly from the container input to the cargo itself.

2. The highway transport mode does not present a severe operational environment. No damage to containers or contents occurred during this

portion of the tests. Shocks generated by road features, such as potholes and grade crossings, constitute the major source of high-level accelerations. The continuous vibration is not severe except for movement over very poor roads (a continual series of potholes). A literature search[1/, 2/] revealed that dynamic forces induced in ocean transport were considerably less than those expected in land surface transport. The ocean transport environment is relegated, therefore, to a study of static loads. Since static loading lends itself more easily to theoretical analysis, it was not pursued in this test series.

3. Based on available data,[1/] the continuous vibrations in rail movements and those found in air movements are comparable, although the frequencies in air movements are higher. Rail coupling and severe terminal-handling shocks represent the highest transient inputs to containers. The amplitudes are sufficient to cause severe damage unless containers are designed specifically to withstand these environments. Table I lists maximum input shock values for all modes.

TABLE I
MAXIMUM INPUT SHOCKS - ALL MODES*

Direction	Amplitude (g)	Time Base	Mode
Vertical	63.0	8 ms	End Drop Test
Longitudinal**	54.8	12 cps 110 cps***	Rail Impact Test
Lateral	16.1	8 ms	Side Drop Test

*At the container base; measured on the conveyance or container, as appropriate.
**With respect to the longer horizontal dimension of the container.
***Superimposed; peak given.

1/ General American Transportation Corporation, Shock and Vibration Transportation Environmental Criteria (prepared for NASA, Huntsville, Alabama), MR1262, September 1965, and MR1262-2, April 1967 (two reports).

2/ Lessells and Associates, Acquisition and Analysis of Acceleration Data, Technical Report 787/i16, June 1963.

4. Wooden household goods shipping containers of nailed or similar construction are more vulnerable to shipping and handling damage than those using through bolts, lag screws, or equivalent. Existing containers of the U.S. Army Type II design are more than adequate for household goods service. Structurally equivalent containers should also provide satisfactory service.

5. Although containers of other than plywood construction can be designed to give satisfactory service, care in design must be exercised to insure that their weight and initial cost are not prohibitive. If not carefully designed, such containers may be uneconomical because of poor cube utilization. Any design for Government or preferred commercial containers which is inconvenient to use as a result of its built-in features will not be readily accepted by the moving industry. The prototype container tested in some phases of this investigation suffered from just such faults; it was too heavy, too costly, too inefficient in cube utilization, and too inconvenient to use both in packing and handling. In addition, the prototype container was structurally inadequate without major redesign; the skid fastenings were not suited to rail impact shocks.

6. The major environmental problem other than physical shock and vibration is moisture (Figure 1). Although structural integrity will prevent direct moisture impingement, container construction to prevent rain damage may actually contribute to internal condensation with destructive consequences. It appears impractical to insulate sufficiently any economically feasible container to prevent condensation completely; other methods must be used. As an example, the prototype metal container, while insulated and weathertight, had sufficient conducting heat flow paths in its basic design that considerable condensation in damaging levels formed inside after relatively few natural heating-cooling cycles. Further testing is required to identify the problem completely.

Figure 1. Moisture-Damaged Test Load.

7. The dimensional characteristics of household goods containers are not presently compatible with intermodal shipments. The

increased emphasis on air movement makes containers with a high tare weight/cube ratio (for example, U.S. Army Type II) increasingly unattractive. The great disparity in container sizes now used, while a natural outgrowth of the competitive situation, is inconvenient to all concerned, whether Government, shipper, or carrier. It is possible, however, to design a container which will accommodate long couches, oversize mattresses, and other large furniture; fit inside United States of America Standards Institute (USASI) standard (8-foot by 8-foot family) demountable containers; and be compatible with both the 463L pallet sizes and International Air Transport Association (IATA) air container requirements.

IV. RECOMMENDATIONS

1. Appropriate commercial organizations and Government agencies should be invited to design a household goods shipping container or family of containers embodying the dimensional characteristics and design features as outlined in Appendix I. Such a container design should completely replace the U.S. Army Type II and be the subject of a new Federal Specification to replace PPP-B-580a. It is expected that, initially, two dimensionally compatible but structurally dissimilar containers may result, depending upon whether it is intended for air and truck use only or all modes. Preferential business distribution should be given to carriers using the recommended container design and dimensions.

2. Standard test procedures should be evolved for household goods shipping containers. Certified conformance to such a test standard should be a requirement for preferential business distribution. No attempt should be made to dictate construction material used so long as the container meets the dimensional and test requirements. An outline of a suggested test procedure is given in Appendix II.

3. The Government should avoid being placed in the position of having to test and/or approve container designs. The drafting of a suitable test specification as mentioned in paragraph 2 above and carrier certification through impartial test laboratories of conformance to the test specification should be sufficient when combined with presently used safeguards.

4. As sufficient containerships become available, household goods containers should be stuffed into seavan-type containers (Figure 2) (8-foot by 8-foot family) for all oversea surface moves. Where household goods move by rail in CONUS on either a Government Bill of Lading (GBL) or a Commercial Bill of Lading to be converted to GBL at destination, routing stipulations should include the requirements for the use of cushioned cars in Container on Flat Car (COFC) Service, Trailer on Flat Car (TOFC) Service, or cushioned Damage Free (DF) equipped boxcars by either

Figure 2. Seavan Container, 8-Foot by 8-Foot by 20-Foot.

Freight Forwarders or rail carriers. By increased use of double-stuffing into seavan-type containers, it should be possible eventually to use only the lighter constructed containers as initially intended for air usage.

5. The detailed investigation of the internal moisture problem should be continued to the extent necessary to verify the causes and recommend an optimum solution.

V. FIELD EVALUATION

1. HIGHWAY TESTS

Table II shows the maximum acceleration values recorded at three locations, for longitudinal and vertical directions.

Figures 3 and 4 are graphs presenting the average truck-bed vibration frequency in the vertical and longitudinal directions in terms of vehicle speed and road surface.

Figures 5 through 12 show the probability distribution of acceleration amplitudes (g's) for vertical and longitudinal directions in relation to roadway type and vehicle speed.

TABLE II
MAXIMUM ACCELERATION VALUES RECORDED

Instrumentation Channel	Location	Direction	g Value (± Pk.)	Average Frequency (Hz.)	Series*	Run*
2	In Box	Vert.	3.40	10.5	A	8
4	Truck Bed	Vert.	2.07	15.7	B	9
6	Top of Box	Vert.	2.60	11.5	A	8
8	In Box	Long.	3.28	9.9	A	8
10	Truck Bed	Long.	0.92	23.9	B	9
12	Top of Box	Long.	2.95	10.9	A	7

*See Tables III and IV.

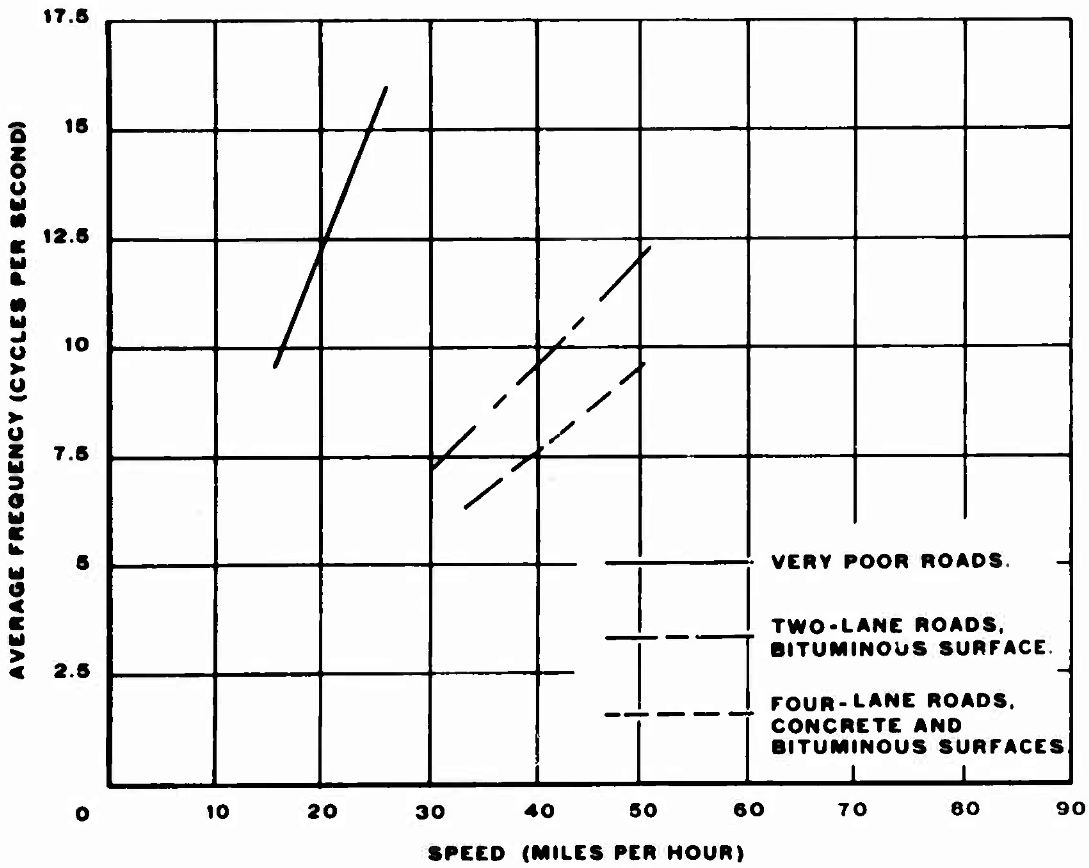


Figure 3. Household Goods Container Vertical Vibration Frequency in Terms of Vehicle Speed and Road Surface.

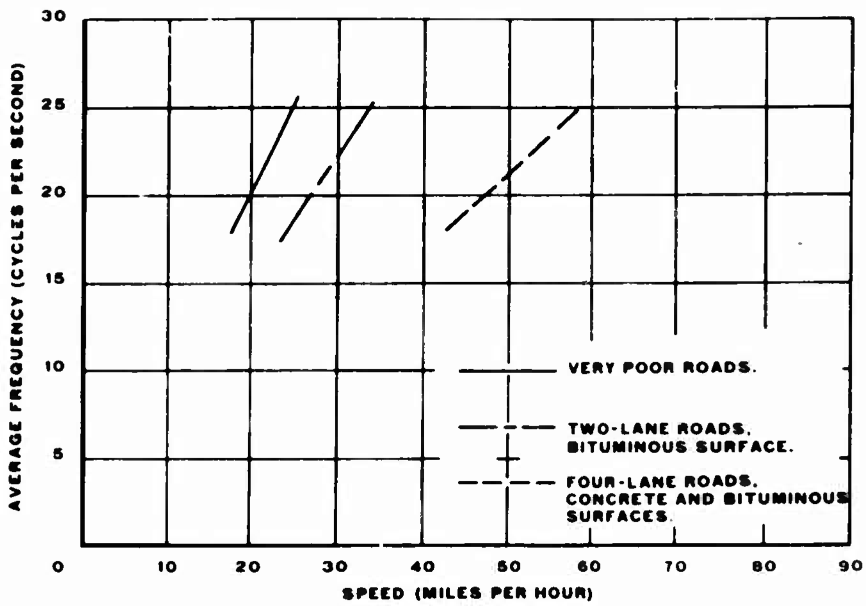


Figure 4. Household Goods Container Longitudinal Vibration Frequency in Terms of Vehicle Speed and Road Surface.

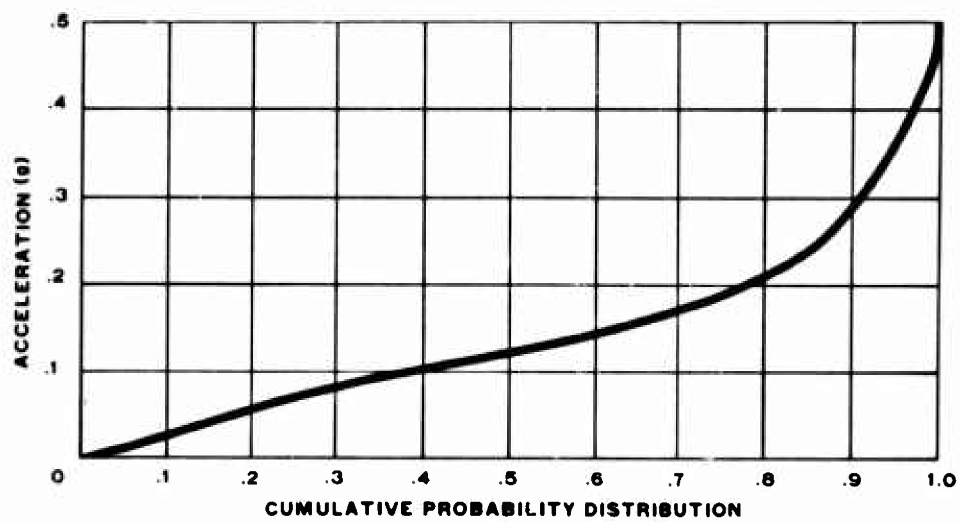


Figure 5. Probability Distribution for Vertical Acceleration on a Two-Lane Local Street (Maximum Speed 35 Miles per Hour).

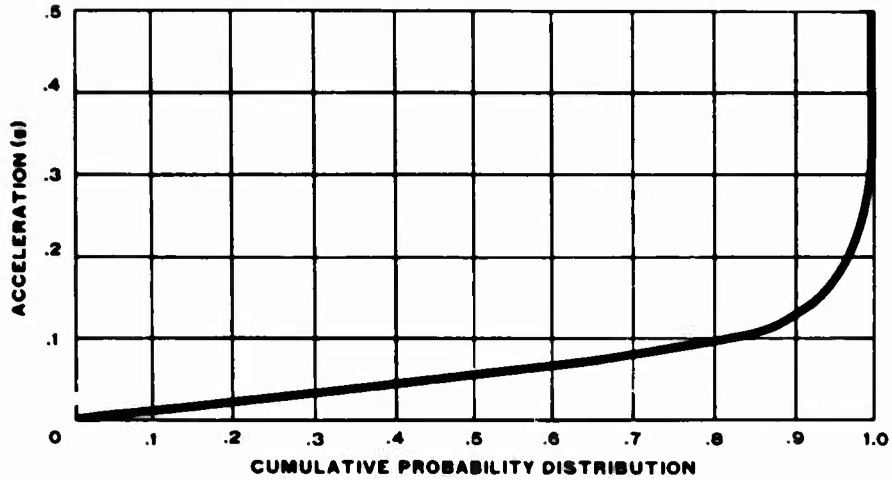


Figure 6. Probability Distribution for Longitudinal Acceleration on a Two-Lane Local Street (Maximum Speed 35 Miles per Hour).

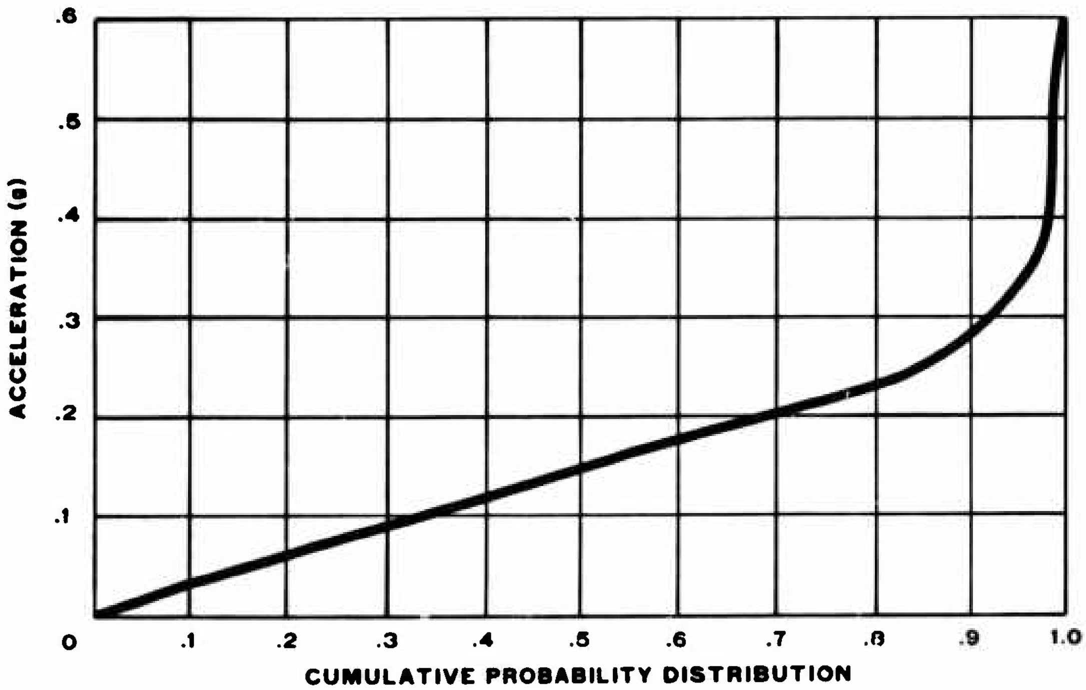


Figure 7. Probability Distribution for Vertical Acceleration on an Intercity Highway (Maximum Speed 45 Miles per Hour).

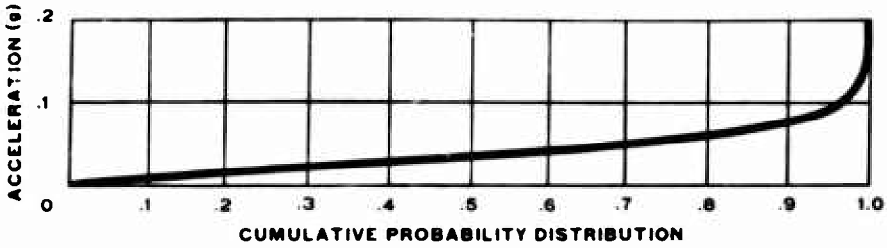


Figure 8. Probability Distribution for Longitudinal Acceleration on an Intercity Highway (Maximum Speed 45 Miles per Hour).

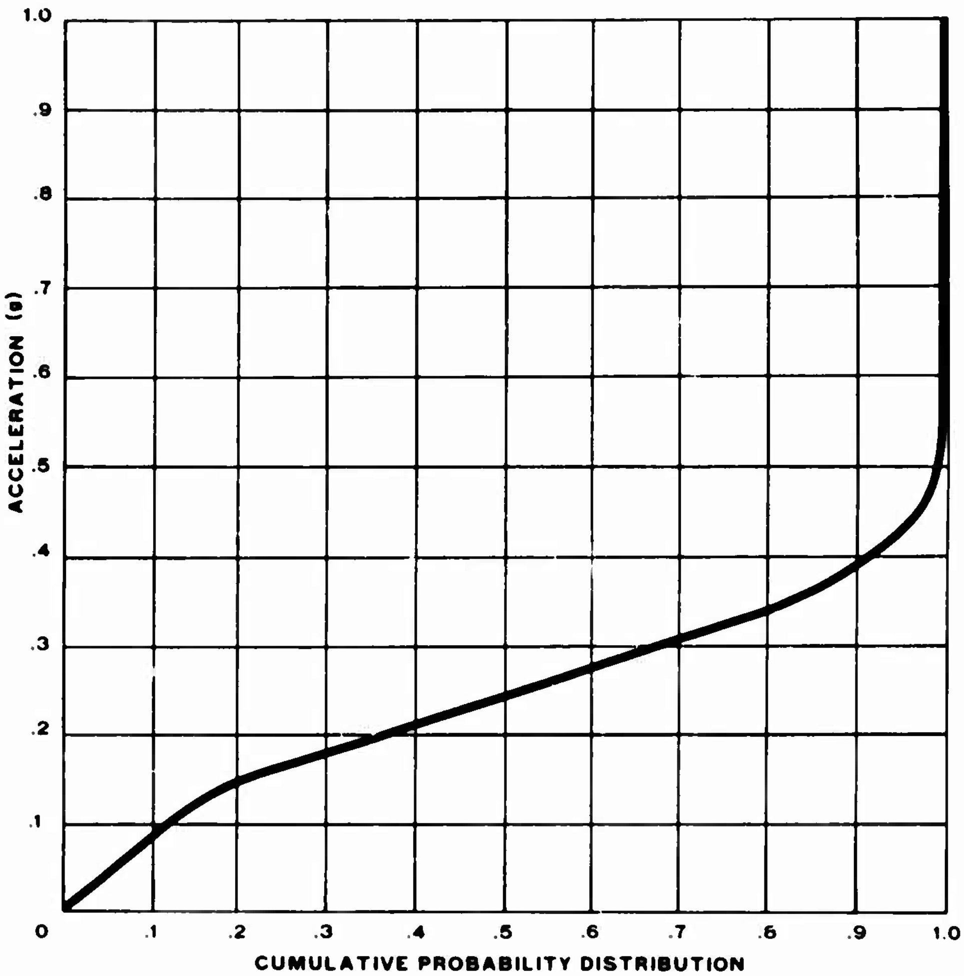


Figure 9. Probability Distribution for Vertical Acceleration on a Four-Lane Intercity Highway (Maximum Speed 50 Miles per Hour).

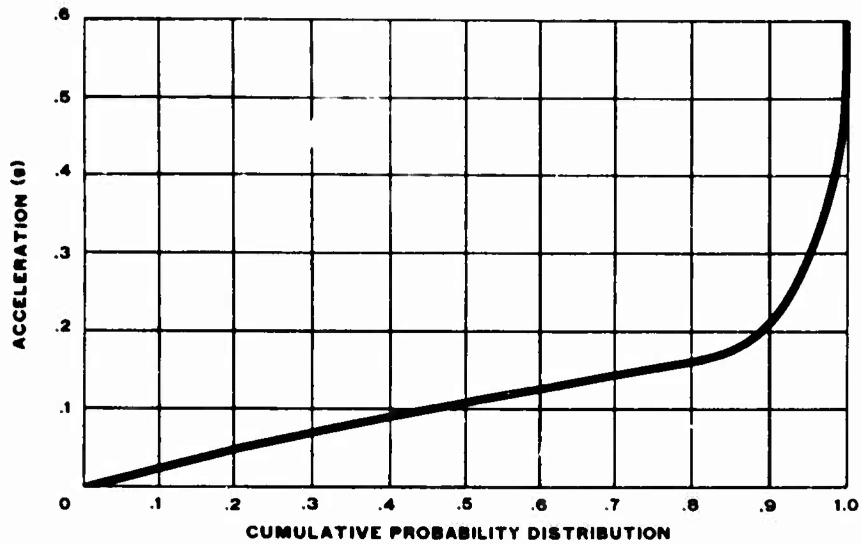


Figure 10. Probability Distribution for Longitudinal Acceleration on a Four-Lane Intercity Highway (Maximum Speed 50 Miles per Hour).

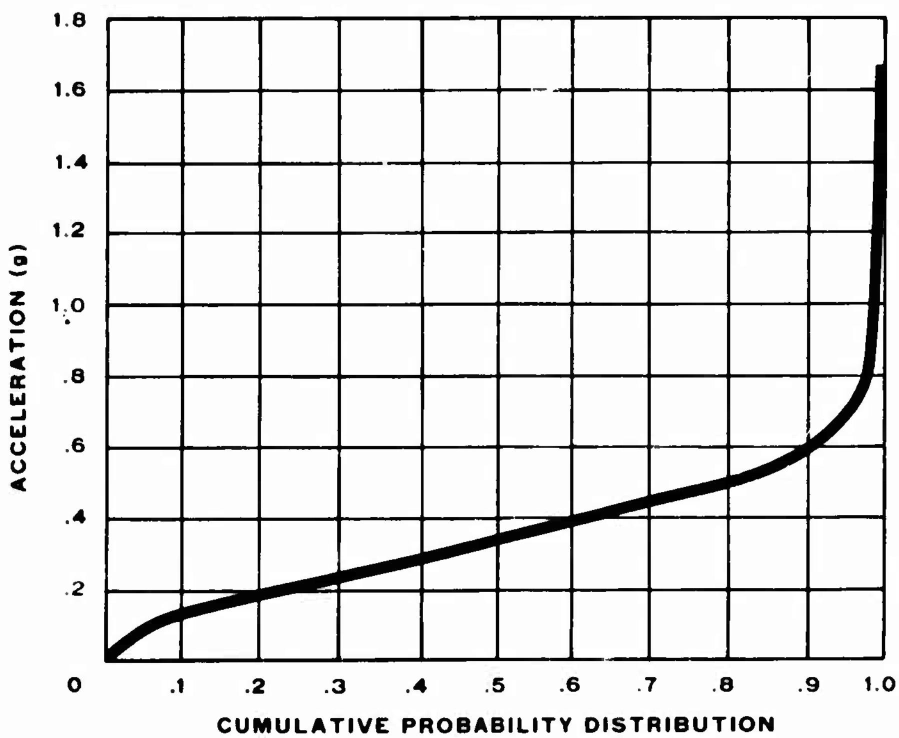


Figure 11. Probability Distribution for Vertical Acceleration on a Marginal Road (Maximum Speed 25 Miles per Hour).

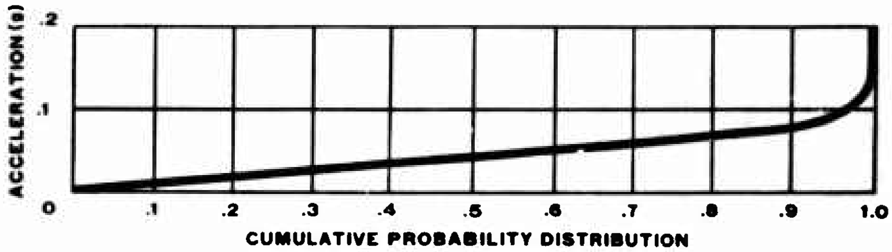


Figure 12. Probability Distribution for Longitudinal Acceleration on a Marginal Road (Maximum Speed 25 Miles per Hour).

Testing

For the purposes of the tests, five representative wooden containers were employed. The U.S. Army Type II design, detailed by Federal Specification PPP-B-580a (or subsequent revisions), was used for three containers. One each of two commercial designs (Van Pac and Jet Forwarding) were selected.

All containers were loaded with typical household goods such as beds, chairs, desks, chest-of-drawers, appliances, etc., in accordance with procedures prescribed by MIL-STD-212C, Preparation of Household Goods for Shipment and Storage. The loading was accomplished by U.S. Army personnel under USATEA supervision. If the load did not reach the 1,500-pound capacity of the containers when the container was full, 50-pound sandbags were placed in each container to bring its calculated load to 1,500 plus or minus 50 pounds. Figures 13 and 14 show interior views of the U.S. Army Type II and Jet Forwarding containers respectively. The Van Pac and Jet Forwarding containers were each transversely banded with two 3/4-inch bands, after loading was completed.

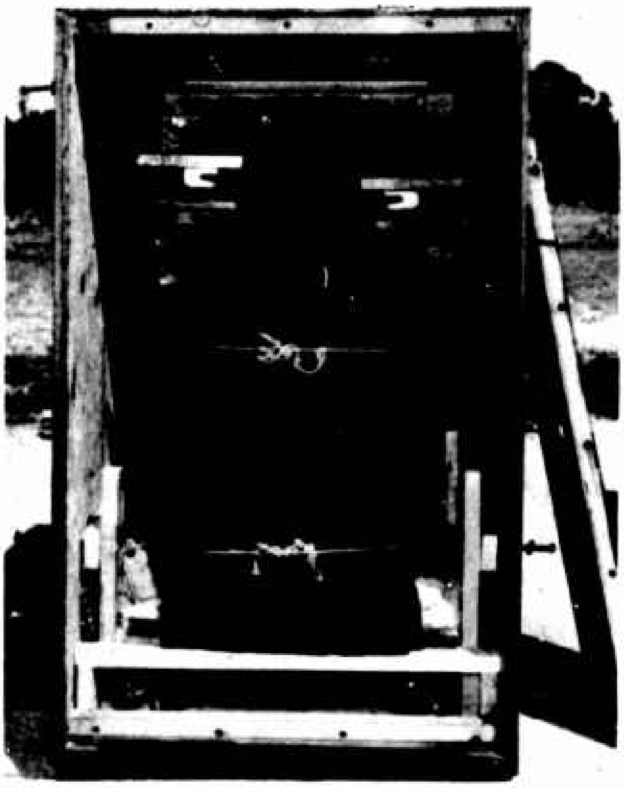


Figure 13. Interior of U.S. Army Type II Container Showing Household Goods Load.

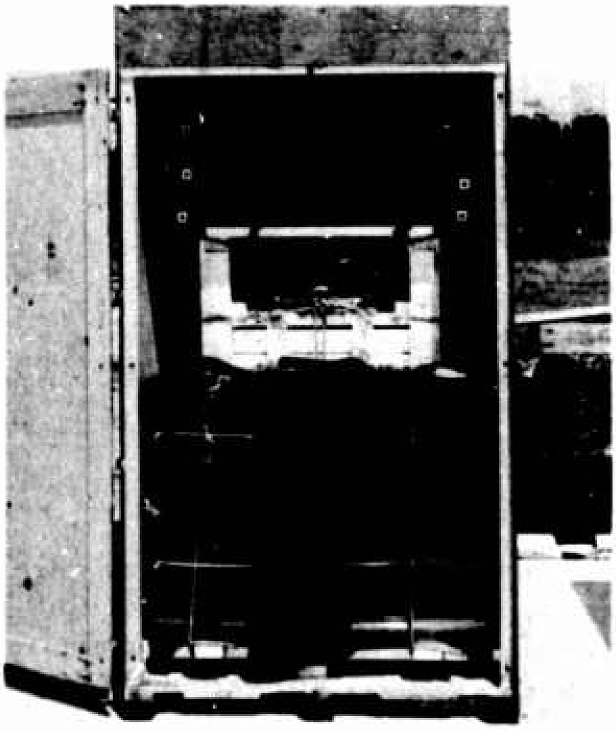


Figure 14. Interior of Jet Forwarding Container Showing Household Goods Load.

The five containers were placed on an M127A1 semitrailer by a forklift. Each container was blocked in place with 2- by 6-inch boards two-high, transverse to the bed, and tied down with a single 3/8-inch cable looped over the top of the container and secured to the stake pockets of the trailer (Figure 15).

Figure 16 is a map of the route over which the tests were conducted. Road surfaces traversed included poorly-maintained gravel, two-lane and four-lane blacktop, and concrete divided highways. Several special runs over railroad grade crossings were also included in the testing.

Figure 15. Semitrailer Loaded With Five Test Containers and USATEA Instrument Box.

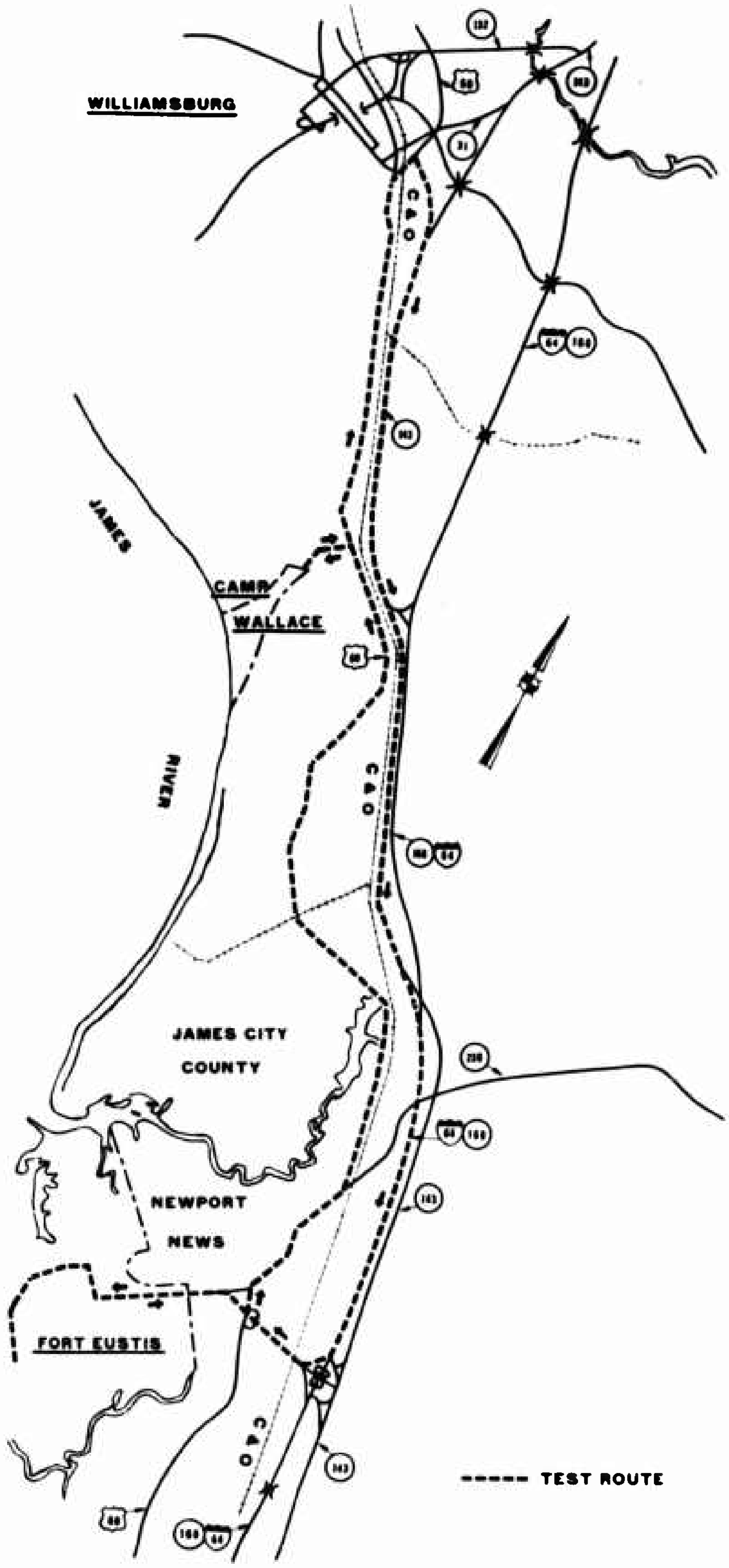


Figure 16. Map of Route of Highway Tests.

Instrumentation

Two series of runs were made (Tables III and IV), the difference between the two being the relative positions of the containers on the semitrailer. Table V summarizes the data channels.

TABLE III
SERIES A HIGHWAY TESTS

Container Arrangement		
Position on Semitrailer	Type	Container Identification No.
1 (front)	U.S. Army Type II	1
2	U.S. Army Type II	2
3	Van Pac	4
4	Jet Forwarding	3
5 (rear)	U.S. Army Type II	5

Run	Route*	Max. Speed (m.p.h.)
0	Impact Area to Wilson Ave.	20
1	Wilson Ave. Eastbound (Over Grade Crossings)	20
2	Wilson Ave. Westbound (Over Grade Crossings)	20
3	Wilson Ave. Eastbound (Over Grade Crossings)	30
4	Wilson Ave. Westbound (Over Grade Crossings)	35
5	Wilson Ave. Eastbound (Over Grade Crossings)	35
6	Wilson Ave. Westbound (Over Grade Crossings)	35
7	Wilson Ave. to Impact Area	35
8	U.S. 60 From Va. 105 to Gate, Camp Wallace	45
9	Gate, Camp Wallace to U.S. 60	25
10	Va. 143 at Va. 162 to I-64	45
11	I-64 at Va. 143 to Va. 105	50

*See Map Route, Figure 16.

TABLE IV
SERIES B HIGHWAY TESTS

Container Arrangement		
Position on Semitrailer	Type	Container Identification No.
1 (front)	U.S. Army Type II	1
2	U.S. Army Type II	2
3	Van Pac	4
4	U.S. Army Type II	5
5 (rear)	Jet Forwarding	3

Run	Route*	Max. Speed (m.p.h.)
0	Impact Area to Wilson Ave.	30
1	Wilson Ave. Eastbound (Over Grade Crossings)	20
2	Wilson Ave. Westbound (Over Grade Crossings)	20
3	Wilson Ave. Eastbound (Over Grade Crossings)	30
4	Wilson Ave. Westbound (Over Grade Crossings)	35
5	Wilson Ave. Eastbound (Over Grade Crossings)	35
6	Wilson Ave. to Impact Area	35
7	U.S. 60 From Va. 105 to Gate, Camp Wallace	45
8	U.S. 60 From Va. 105 to Gate, Camp Wallace (second run)	45
9	Gate, Camp Wallace to U.S. 60	25
10	Va. 143 at Va. 162 to I-64	45
11	I-64 at Va. 143 to Va. 105	50

*See Map Route, Figure 16.

TABLE V
DATA CHANNEL SUMMARY OF HIGHWAY TESTS

Tape Channel	Location	Type Measurement	Type Calibration
2	Inside of Box*	Vert. Acceleration	± 5g
4	Truck Bed	Vert. Acceleration	± 5g
6	Top of Box*	Vert. Acceleration	± 5g
8	Inside of Box*	Long. Acceleration	± 3g
10	Truck Bed	Long. Acceleration	± 3g
12	Top of Box*	Long. Acceleration	± 3g
14	Fifth Wheel	Speed	21.5 m.p.h. and 56.5 m.p.h.

*Rear container location was monitored in both Series A and B.

Bridge-type strain-gage accelerometers were used for the tests (Figure 17 shows the relative location), with Consolidated Electrodynamics Corporation (CEC) Type 1-113B carrier amplifiers (one per channel) feeding into a Genisco Model 10-126C portable instrumentation tape recorder operating at 7-1/2 inches per second. In the laboratory the data tapes were played back on a Honeywell LAR 7400 instrumentation tape system into a Sierra Research PA102 probability analyzer. The analyzer output and concurrent data channel output were recorded on a Brush RD 2341-00 oscillograph. A fifth wheel provided speed information (Figure 18).

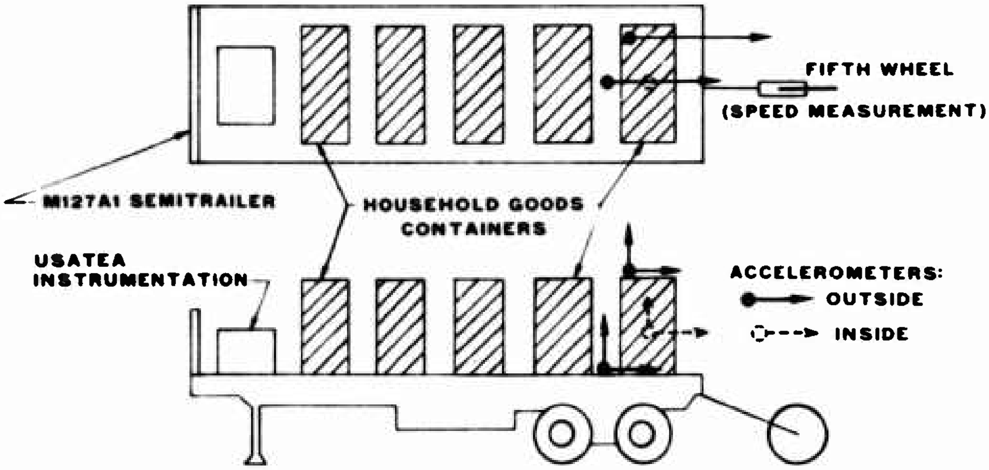


Figure 17. Accelerometer Locations, Highway Tests.

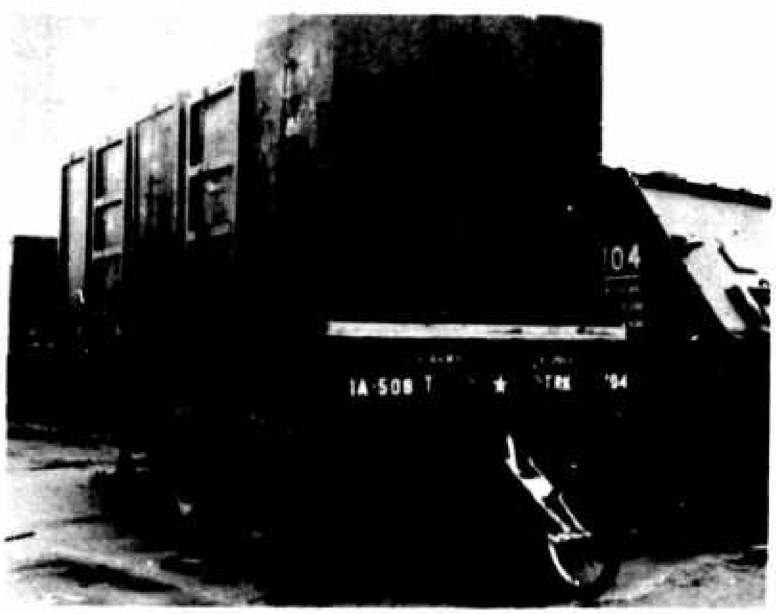


Figure 18. Rear View of Semitrailer Showing Fifth Wheel.

The probability analyzer provided semiautomatic data reduction with graphical output. It gave the maximum and second greatest values, a histogram of the number of counts falling into each 1/16 of full scale, the total number of interval counts, and the first and second statistical moments of the data sample. A digital computer program on a time-sharing system was then used to convert the graphical deflections to tabulated numerical values. Appendix III shows typical probability analyzer and computer outputs.

High Cargo Accelerations

As mentioned in the conclusions, acceleration values on the cargo were significantly higher than the inputs. This is caused by relative motion between the truck bed, the container, and the contents. Figure 19 shows one aspect. At the point designated by the arrow, the slight relative motion allowed by packing and structural flexibility caused the motion of the load to be out of phase with the bed after the latter received a sudden shock input. Since the shock input was out of phase with the quasi-steady-state motion, the load was apparently slammed into the container, causing the load to experience a very high acceleration value.

.05g/line; 25 cm/sec
Top: Channel 2 - Inside Container
Bottom: Channel 4 - Trailer Bed
Footage Counter Reading: About 2950, Series A

Figure 19. Vertical Accelerations, Data Trace, Semi-trailer Bed and Inside Container.

Cushioning used in packing the containers would normally be expected to reduce the amplitude of shocks at the cargo. However, the implication in this case is that the packing was so loose and the cushioning so minimal that there was no significant attenuation of the slamming motion imparted to the container contents.

Method of Packing

Inexperienced loaders attempting to adhere to military standards not rigidly observed by industry packed a load which was not representative of typical commercial household goods loads. This was recognized at the time the tests were run. The resultant extremely loose cargo pack (a condition present only during the highway tests) accounted for the high on-cargo accelerations previously discussed. Since, however, the primary concern was to determine the environmental inputs to the containers, and the mass of the load was low compared to the total system mass, the specific internal packing did not affect the validity of the tests.

Containers Used

Shortly after the tests were completed, MTMTS instituted regulations which gave preferential business distribution to carriers using containers either of the U.S. Army Type II design or commercial design equivalents. Since other commercial containers are still used and since similar results were obtained both on the U.S. Army Type II and the commercial design, additional tests were considered unnecessary.

2. DROP TESTS

Table VI summarizes the maximum shock values recorded. Note that with only two exceptions, all maximum values occurred during end drop tests.

TABLE VI
MAXIMUM VALUES OF DROP TESTS

Location	Test	Container	Amplitude (g)	Time Base (ms)
Vert. End	End	Jet Forwarding	60.3	10
Long. End	End	Van Pac	30.9	4
Lat. End	Side	Van Pac	16.1	8
Vert. Side	End	Jet Forwarding	45.6	8
Long. Side	End	Jet Forwarding	13.3	5
Lat. Side	End	Van Pac	13.7	11
Vert. Corner	End	Jet Forwarding	63.0	8
Long. Corner	Corner	Van Pac	14.1	10
Lat. Corner	End	Van Pac	14.8	9

TABLE VI - contd

Location	Test	Container	Amplitude (g)	Time Base (ms)
Vert. Inside	End	U.S. Army Type II*	22.7**	20
Long. Inside	End	U.S. Army Type II*	9.6**	26
Lat. Inside	End	U.S. Army Type II*	21.1**	10
Weights:	Van Pac		2,200 lb	
	Jet Forwarding		2,300 lb	
	U.S. Army Type II		1,300 lb	

*Only the U.S. Army Type II was instrumented inside.
**Corresponding vertical end accelerations: 48.1g @ 12 ms and 46.8g @ 11 ms.

Testing

The same types of containers used in the highway tests were employed for this series of tests.

The containers had been previously loaded with representative household goods by a commercial mover in accordance with his best practice.

Figures 20, 21, and 22 show the arrangement of the containers for the end, side, and corner drops respectively.

The containers were lifted from the ground with a forklift truck, then lowered gently onto the blocks. The 24-inch block was then knocked out with a spike maul and the containers allowed to drop to the concrete surface.

Instrumentation

Table VII summarizes the data channels. Bridge-type strain-gage accelerometers were utilized, fed from regulated direct-current power supplies. Figure 23 shows the accelerometer locations on a Jet Forwarding container. A Brown and Forman Model 18-200A automatic bridge-balance and calibrating unit provided control and calibration of the individual channels. The data were recorded on two Honeywell Model 906 Visicorders

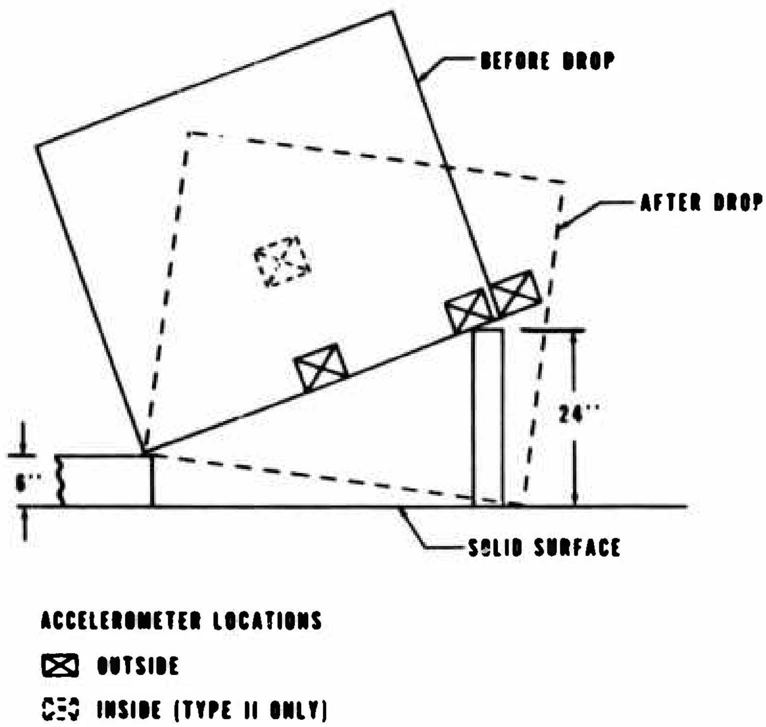


Figure 20. End Drop Test.

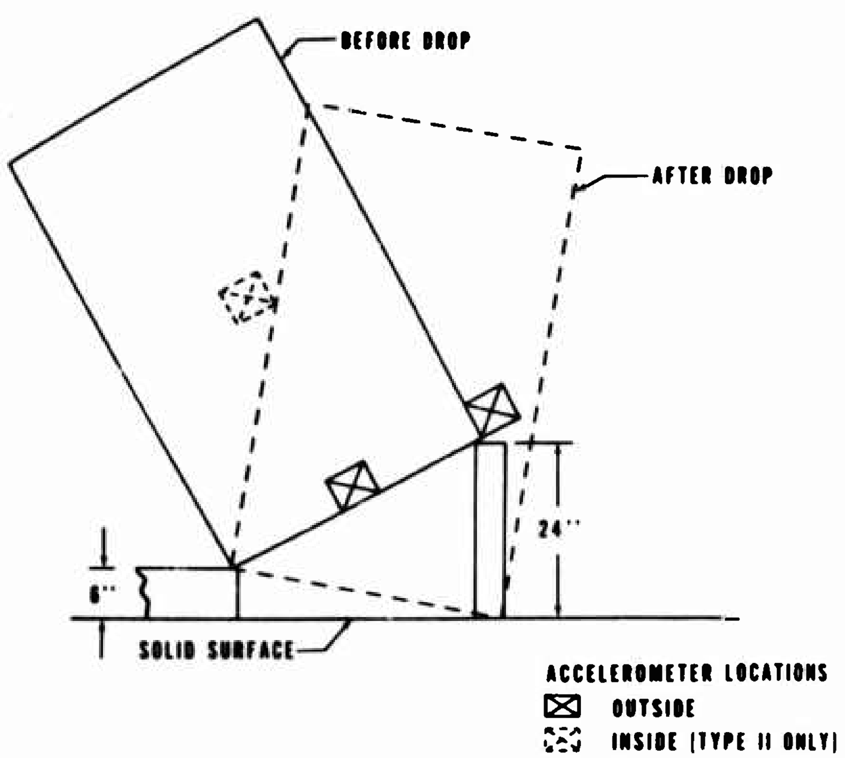


Figure 21. Side Drop Test.

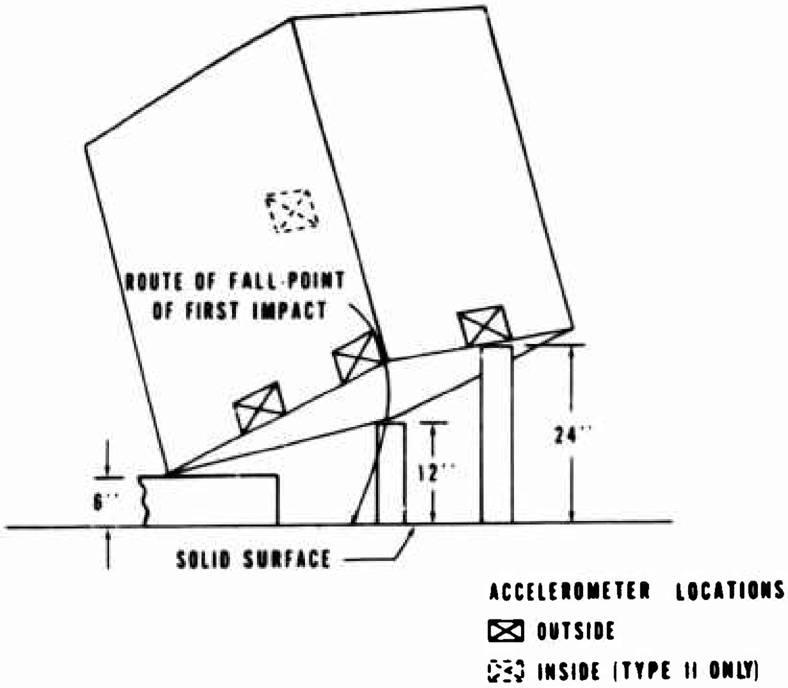


Figure 22. Corner Drop Test.

TABLE VII
DATA CHANNELS OF DROP TESTS

Visicorder	Channel	Location	Direction*
1	1	End	Vert.
	2	End	Long.
	3	End	Lat.
	4	Inside	Vert.
	5	Inside	Long.
	6	Inside	Lat.
2	1	Side	Vert.
	2	Side	Long.
	3	Side	Lat.
	4	Corner	Vert.
	5	Corner	Long.
	6	Corner	Lat.

*With respect to the container.

Figure 23. Jet Forwarding Container Showing Accelerometer Locations.

Discussion

As can be seen in Table VI, the shocks sustained by the containers in the drop tests were rather severe. It was not surprising, therefore, that physical damage occurred to some of the containers. The U.S. Army Type II container, being of heavier construction, sustained no physical damage. The other two containers, however, showed the various effects of the testing. The Jet Forwarding container showed damage around the door (Figures 24 and 25) where the impact shifted the load with sufficient force to break the framing member and splinter the plywood around the bolt hole. The Van Pac, which is primarily a nailed construction container, showed extensive separation of nailed joints (Figure 26) as well as punctures of the side sheet. The Jet Forwarding container, it should be noted, experienced the same magnitude of shocks as the Van Pac, but sustained no damage to its bolted interconnections, except at the door.

Throughout the drop tests, no damage was found to container contents, although the particular loads involved contained no extremely fragile items (such as dishes). However, none of the wooden furniture sustained damage, either. In the case of the U.S. Army Type II, which was instrumented inside and out, the attenuation by the packing was in the ratio of approximately 2 to 1.

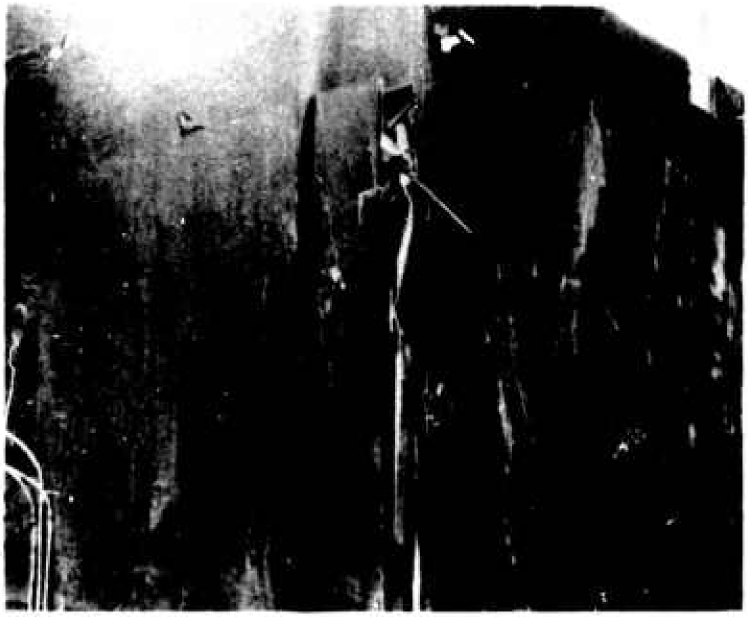


Figure 24. Exterior View of Jet Forwarding Container Showing Door Damage.

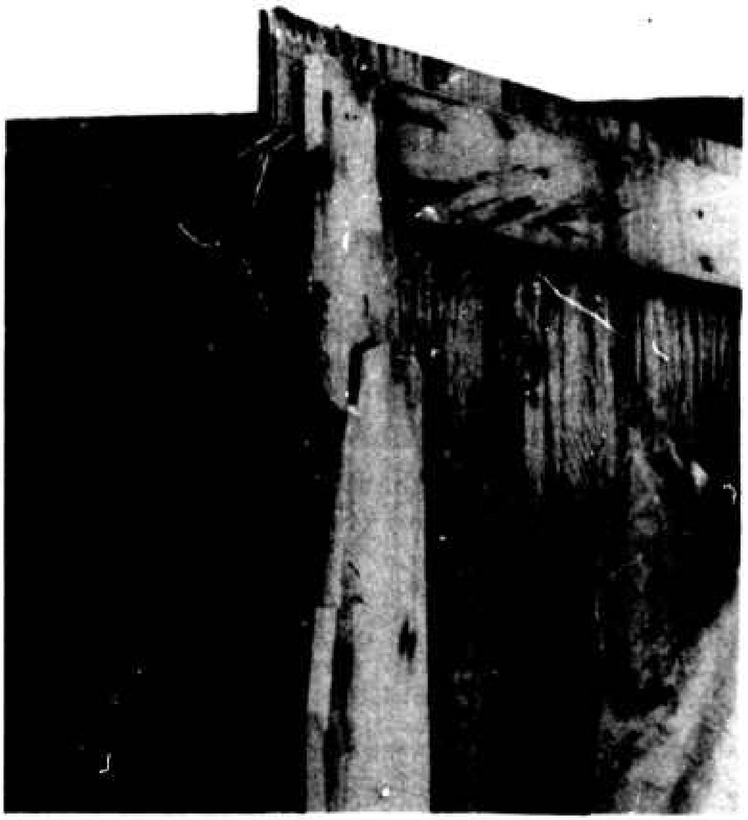


Figure 25. Interior View of Jet Forwarding Container Showing Door Damage.

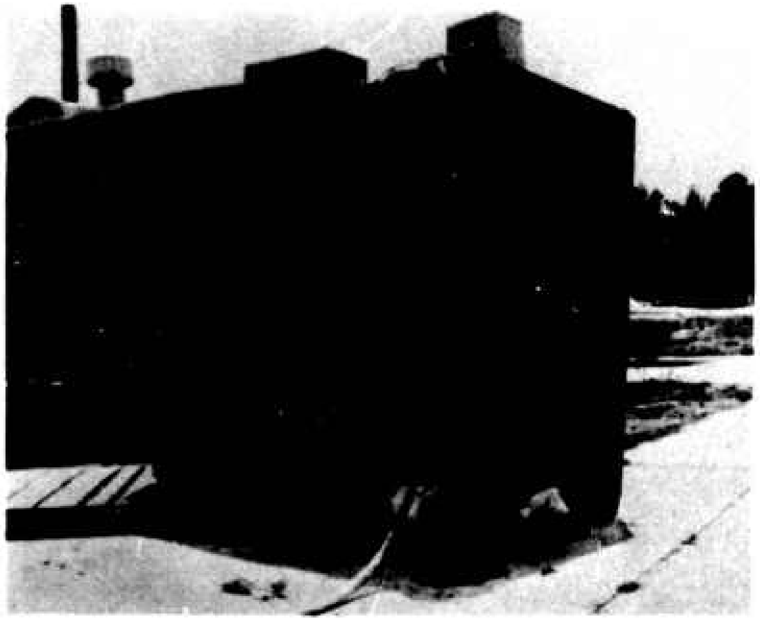


Figure 26. Van Pac Container Showing Post-Test Damage.

3. RAIL IMPACT TESTS

Tables VIII and IX show the maximum acceleration values recorded at various locations in and on the containers and railcars for the two series of runs.

Figures 27 through 30 show the longitudinal and vertical shocks on the railcar floors. These represent the inputs to the containers, measured at the center of the railcar, as a function of coupling impact speeds.

Testing

Rail impact tests were run in two phases, using two different railcars. Wooden containers were used in both phases; in Phase II, a prototype metal container was included. Table X lists the containers tested. The wooden containers are the same as those described for the highway tests; the prototype metal container was an experimental design built to Government specifications (Figure 31).

In both phases all containers used were loaded by commercial movers in accordance with their best practice (Figure 32). Loads were composed of typical household goods, as outlined previously.

TABLE VIII
INSTRUMENTATION CHANNELS
MAXIMUM SHOCKS RECORDED - RUNS 1 THROUGH 45 (BOXCAR)

Location	Direction	Amplitude (g)	Time (cps)	Impact Speed (m.p.h.)
Car Floor	Long.	54.8	90	9.35
Car Floor	Vert.	34.1	110	9.10
Car Floor	Lat.	11.6	40	8.32
Top Corner of of End Container*	Long.	42.1	75	8.40
	Vert.	20.6	55	NA
Top Corner of Center Container**	Long.	36.1	55	8.40
	Vert.	32.8	60	8.32
Inside Container***	Long.	13.2	50	5.83
	Vert.	11.6	45	6.15
	Lat.	5.3	30	5.83

*Car end.
**Car center.
***Container No. 1 (U.S. Army Type II).

TABLE IX
INSTRUMENTATION CHANNELS
MAXIMUM SHOCKS RECORDED - RUNS 46 THROUGH 60 (GONDOLA)

Location	Direction	Amplitude (g)	Time (cps)	Impact Speed (m.p.h.)
Car Floor	Long.	34.3	12	9.2
Car Floor	Vert.	16.6	100	9.5
End of Container*	Long.**	16.8/14.4***	10/90	7.1/7.4
	Vert.	23.1/14.4	50/30	6.3/7.3
Top of Container	Lat.	3.7/4.2	10/90	6.6/7.3
	Long.	15.1	11	7.3
Top of Container*	Vert.	13.8/11.0	20/25	7.5/6.3
Inside Container+	Long.	12.4	10	7.1
	Lat.	4.6	80	7.4

*Car end.
**Higher values caused by shifting load were noted - 51.4g.
***Opposite impacted end/impacted end.
+Vertical accelerometer inoperative.

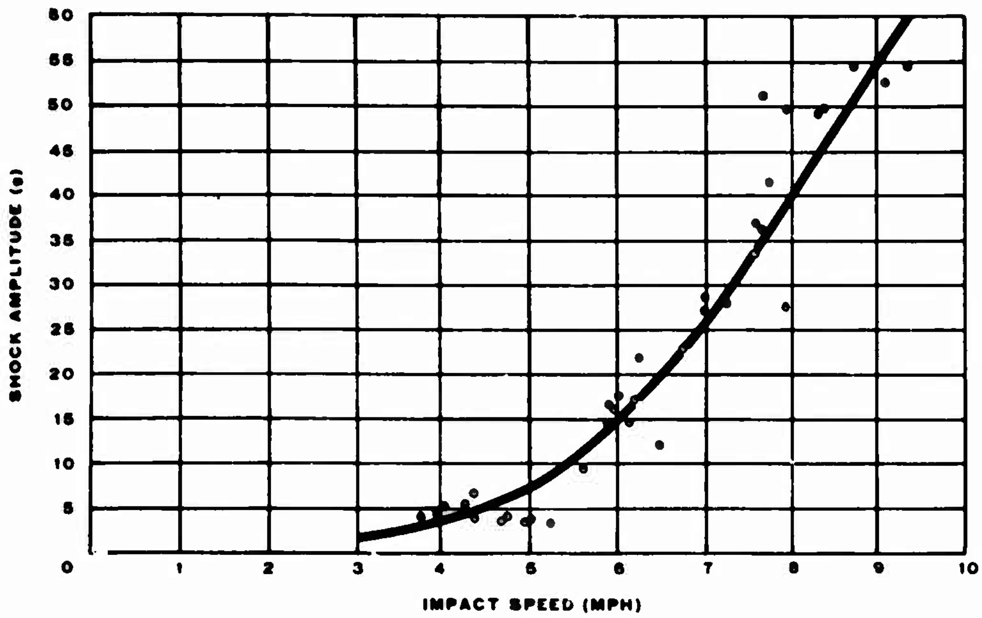


Figure 27. Longitudinal Shocks on Boxcar Floor, Runs 1 Through 45.

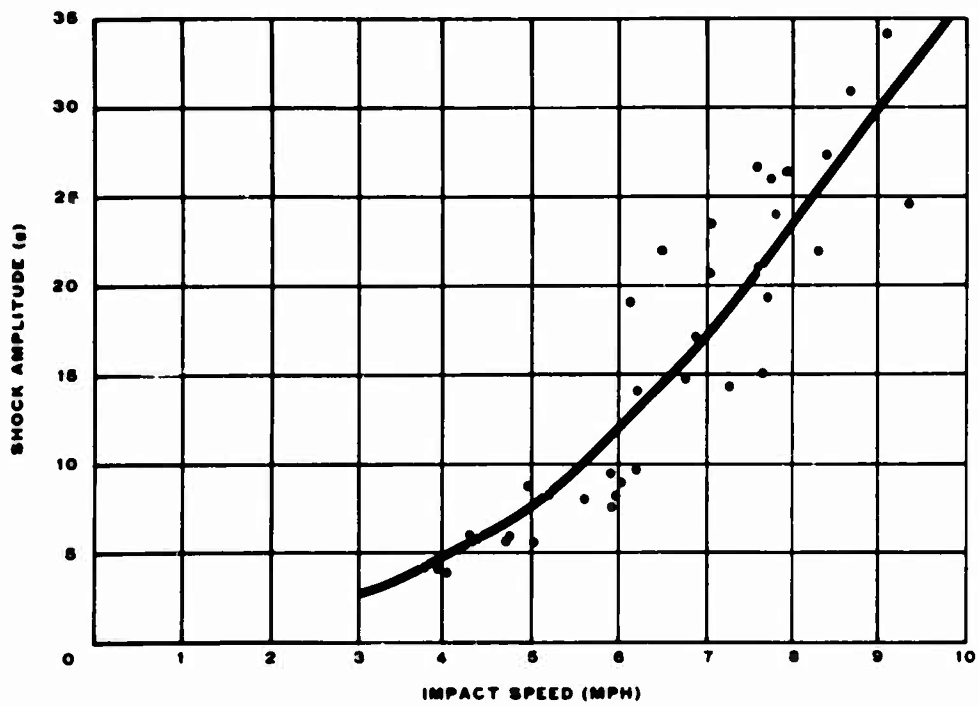


Figure 28. Vertical Shocks on Boxcar Floor, Runs 1 Through 45.

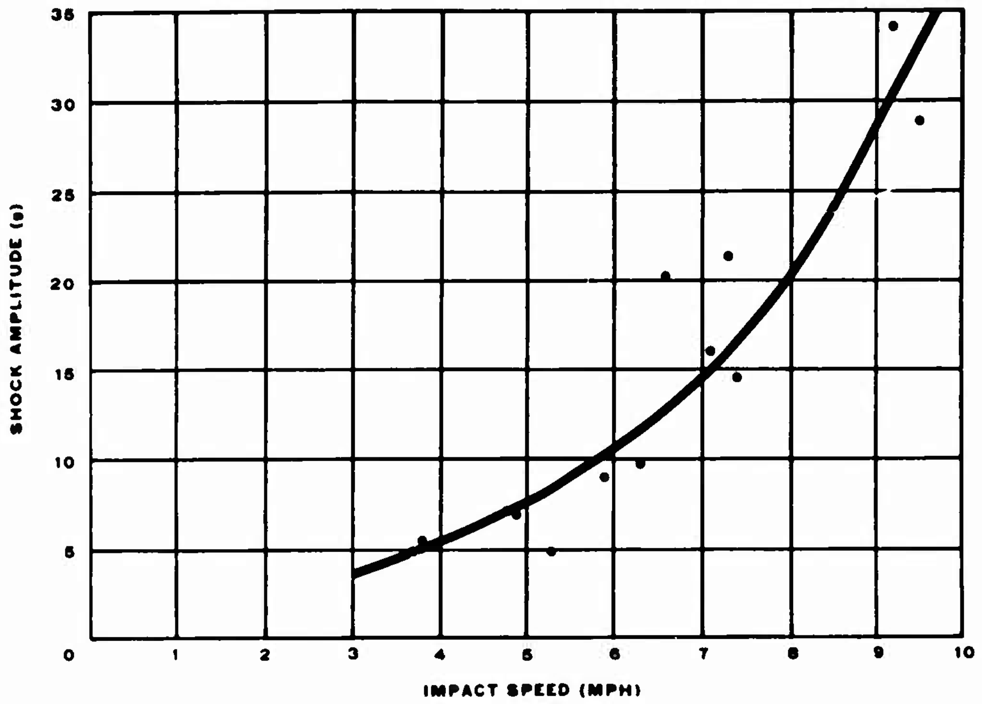


Figure 29. Longitudinal Shocks on Gondola Car Floor, Runs 46 Through 60.

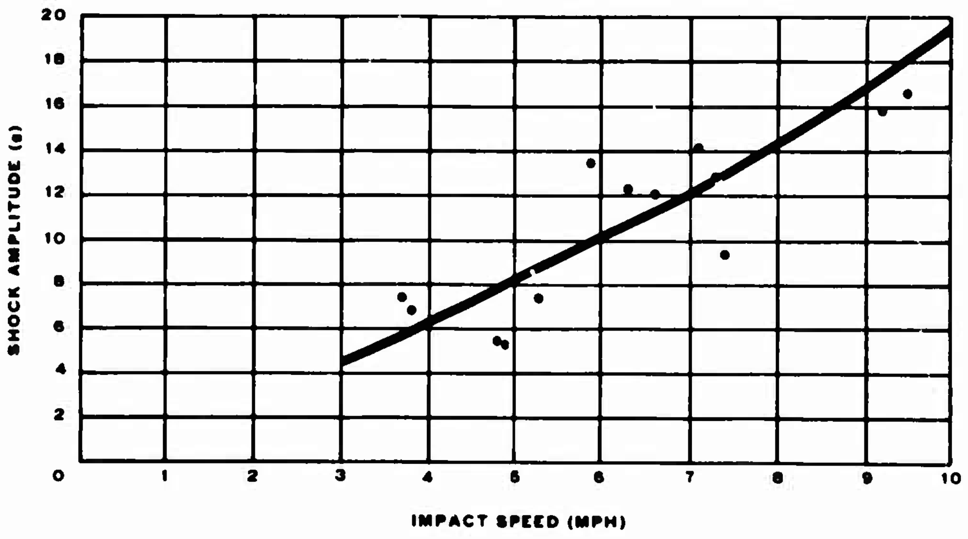


Figure 30. Vertical Shocks on Gondola Car Floor, Runs 46 Through 60.

TABLE X
HOUSEHOLD GOODS CONTAINERS

Container No.	Type	Gross Weight (lb)
Rail Impact Tested		
	Phase I - Boxcar	
1	U.S. Army Type II	1,300
2	U.S. Army Type II	3,000
3	Jet Forwarding	2,300
4	Van Pac	2,200
5	U.S. Army Type II	1,400
	Phase II - Gondola	
1	U.S. Army Type II	1,450
9	Prototype Metal	1,870
11	Prototype Metal	2,180
12	Van Pac	1,550
Not Impact Tested		
Container No.	**Type**	**Disposition**
6, 7	Prototype Metal	Not Utilized
8	Prototype Metal	Display
10	Prototype Metal	To U.S. Army Natick Laboratories*
13	Van Pac	To U.S. Army Natick Laboratories*

*For environmental tests.

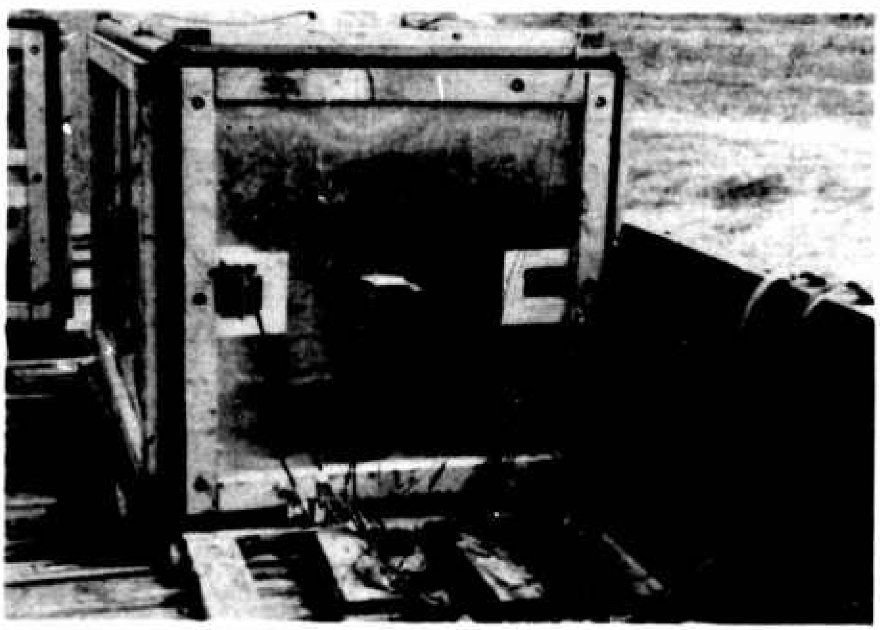


Figure 31. Prototype Metal Container, Instrumented for Phase II Rail Impact Tests.

Figure 32. Typical Commercially Packed Load (Van Pac Container Loaded for Phase II Rail Impact Tests).

Phase I tests (runs 1 through 45) were run using a 40-foot boxcar. Containers were placed in the boxcar with a forklift and manually placed in final position. Blocking and bracing was accomplished with 2- by 6-inch lumber as shown in Figure 33. Concrete blocks were used to balance the car. Figure 34 shows the arrangement of the containers and ballasting in the boxcar for the three series of runs in Phase I.

Figure 33. Blocking and Bracing of U.S. Army Type II Container, Phase I Rail Impact Tests.

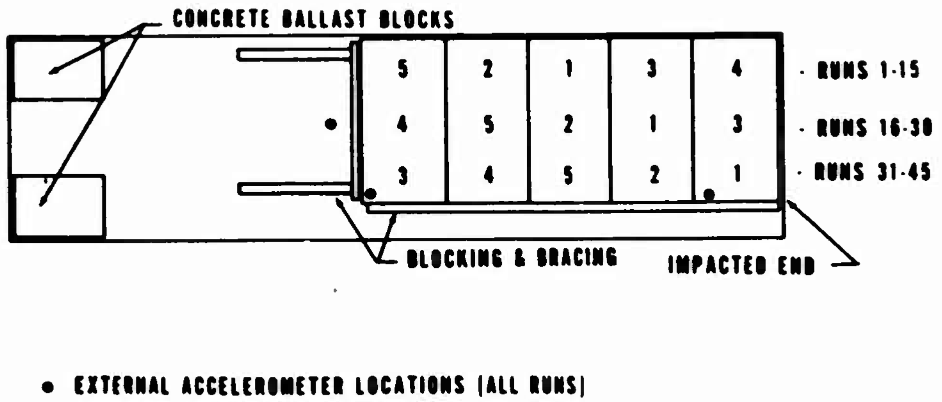


Figure 34. Arrangement of Containers and Ballasting in Boxcar (Runs 1 Through 45).

Phase II tests (runs 46 through 60) were run using a 45-foot gondola. Containers were loaded using a mobile crane and slinging cables (Figure 35). Within the limitations of the test facilities, the containers were loaded in accordance with Association of American Railroads (AAR) loading rules for containers of less than 4,000 pounds in open-top cars (Figure 36).

All impact tests were run in accordance with the method recommended by U.S. Army Technical Bulletin 55-100. Although the method in TB 55-100 gives less severe impacts for the same test speed than the AAR method, it is considerably easier to perform when the test car is highly instrumented. In the TB 55-100 method, a hammer car is accelerated to

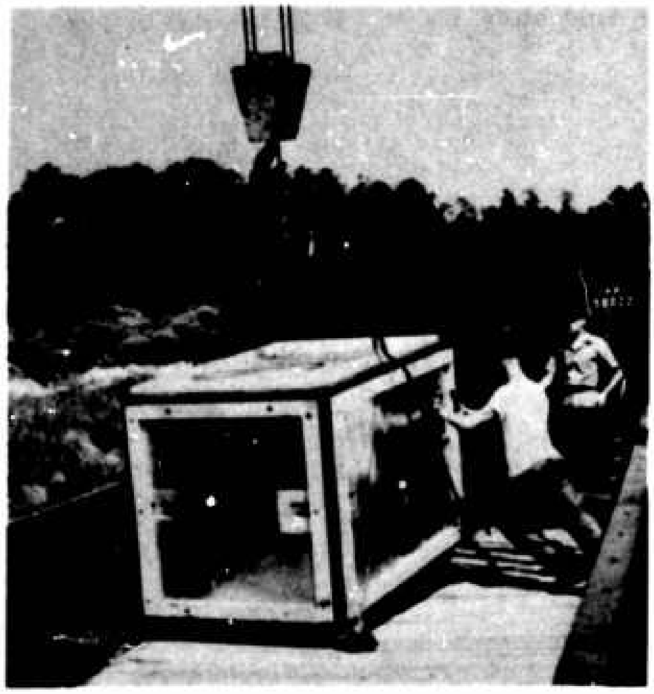


Figure 35. Mobile Crane Placement of Prototype Metal Container in Gondola Car for Phase II Rail Impact Tests.

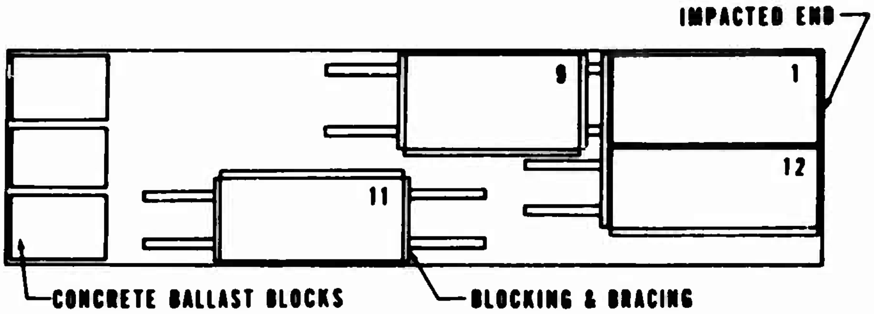


Figure 36. Arrangement of Containers and Ballasting in Gondola Car (Runs 46 Through 60).

the test speed, then uncoupled from the locomotive and allowed to roll into the test car. The two together then run the 20 feet (approximately) into the anvil cars which provide a backup. Unless the hammer and test cars fail to couple, the initial impact is the most severe. Flange-activated track switches connected to a time clock provided an accurate measure of the actual impact speed. Figure 37 shows a typical run at the instant of impact. Note that the closest container, with a gross weight of about 2,300 pounds, has jumped several inches into the air at one end.

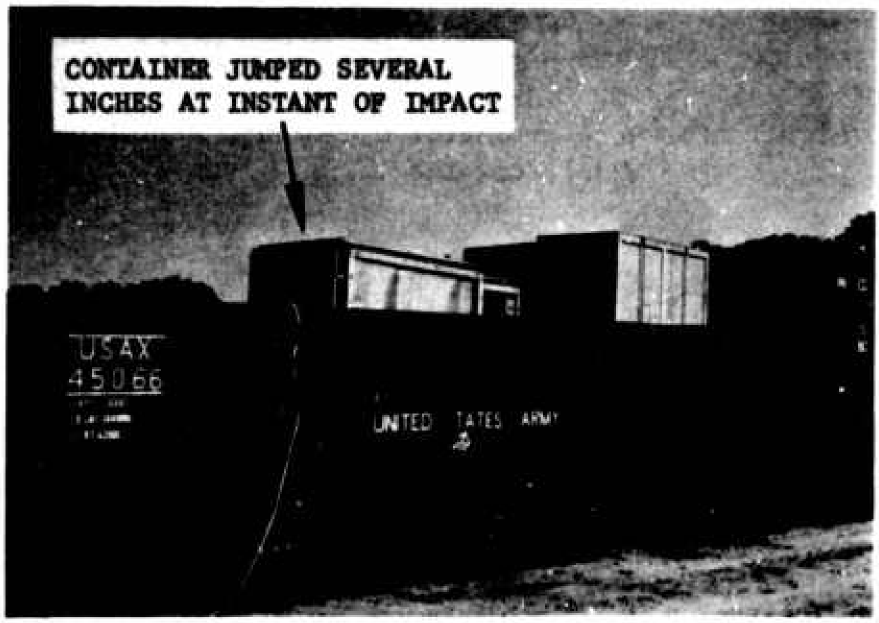


Figure 37. Test Car (Gondola) at Instant of Initial Impact.

Instrumentation

Bridge-type strain-gage accelerometers were used for both phases of the tests. The instrumentation system was the same as used in the drop tests except in Phase II, where some strain gages supplemented the accelerometers used on the metal container. Although it was hoped that the strain-gage data would provide a basis for validation of force values derived from the accelerometers, only the information obtained from the accelerometers is given since it is the direct source of the desired criteria. A CEC oscillograph was added to the two Visicorders mentioned earlier, in order to accommodate the additional data channels. Figure 38 shows accelerometer locations on the metal container.

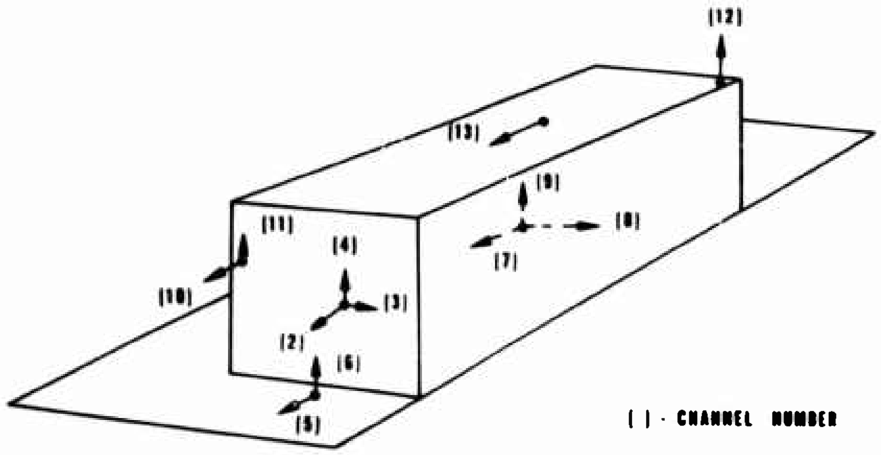


Figure 38. Accelerometer Locations, Prototype Metal Container.

Railcars

Although both railcars had approximately the same tare weight (boxcar - 45,020 pounds; gondola - 42,100 pounds) and both were loaded to approximatelv the same gross weight (boxcar - 60,220 pounds; gondola - 56,650 pounds), Figures 27 to 30 and Table VIII showed that the peak accelerations were higher on the boxcar for the same impact speed. However, as shown in Figure 39, the peak coupler forces were lower in the boxcar. This latter fact can be explained by the cushioned draft gear on the boxcar. Ironically, this very feature (the gondola had standard draft gear) may have contributed to the higher accelerations. The boxcar used was equipped with one of the earliest forms of cushioned draft gear. As such, it consisted of a floating center sill positioned by springs.

No damping beyond the friction damping inherent in the design was present. Also, the amount of travel was limited to about plus or minus 8 inches.

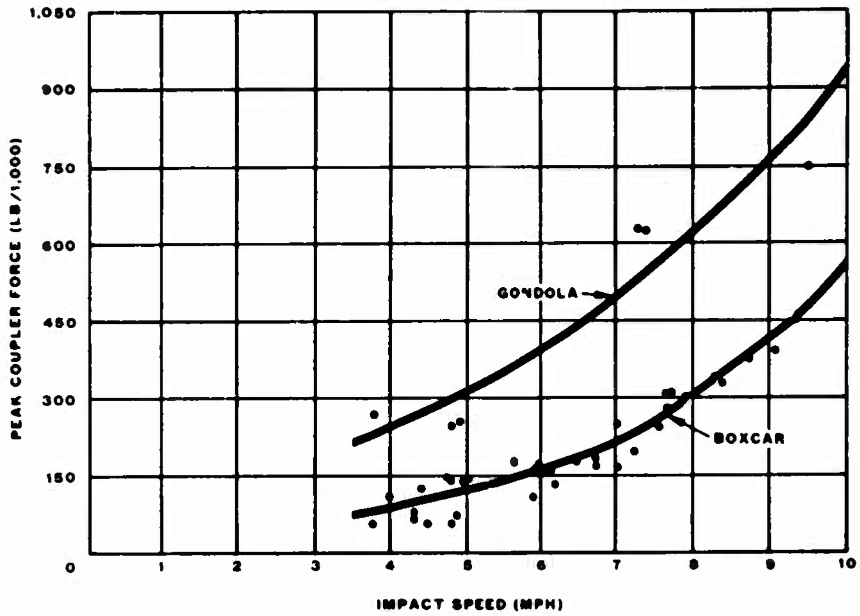


Figure 39. Peak Coupler Impact Forces.

Therefore, the cushioning springs tended to go solid at the end of the stroke, the car body oscillated longitudinally with respect to the center sill, and the higher frequency natural resonances of the structure were excited.

Performance of Wooden Containers

As was true in the drop test, there was considerable variation in the relative performance of the different types of wooden containers. Figure 40, taken at the local office of a nationwide carrier, illustrates the source of this problem. This particular container is very similar to the Van Pac used in these tests. Time and again, the superiority of bolted construction as used in the U.S. Army Type II container and, to a certain extent, in the Jet Forwarding, was demonstrated. Neither of these two containers sustained structural damage in either phase of the rail impact tests. However, containers using nailed construction did not fare as well. Figure 41 shows a close-up of the Van Pac container at the conclusion of the Phase I rail impact tests. Note the separation of the joint and the partially backed-out nail. Figure 42 shows a view of the side of the same container after removal from the boxcar. Note that the relatively thin side panels have been punctured in at least three places. As a test of possible individual variations, brand-new Van Pac style containers were built for the Phase II tests. Figure 43 shows the condition of the container at the conclusion of the Phase II tests. The same loosening of nailed joints seen in Phase I has once again appeared. It is readily apparent that the

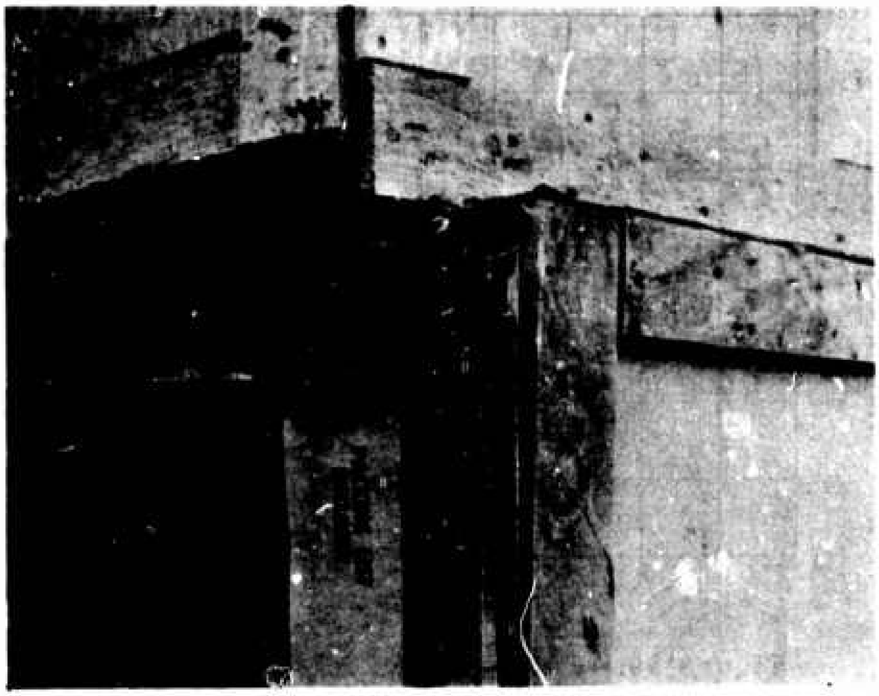


Figure 40. In-Service Damage, Commercial Container.

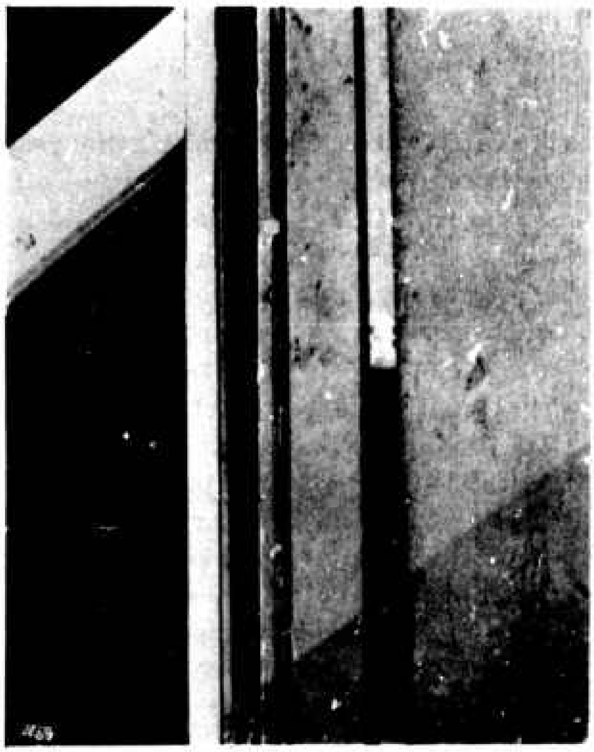


Figure 41. Joint Separation, Van Pac Container, After Phase I Rail Impact Tests.

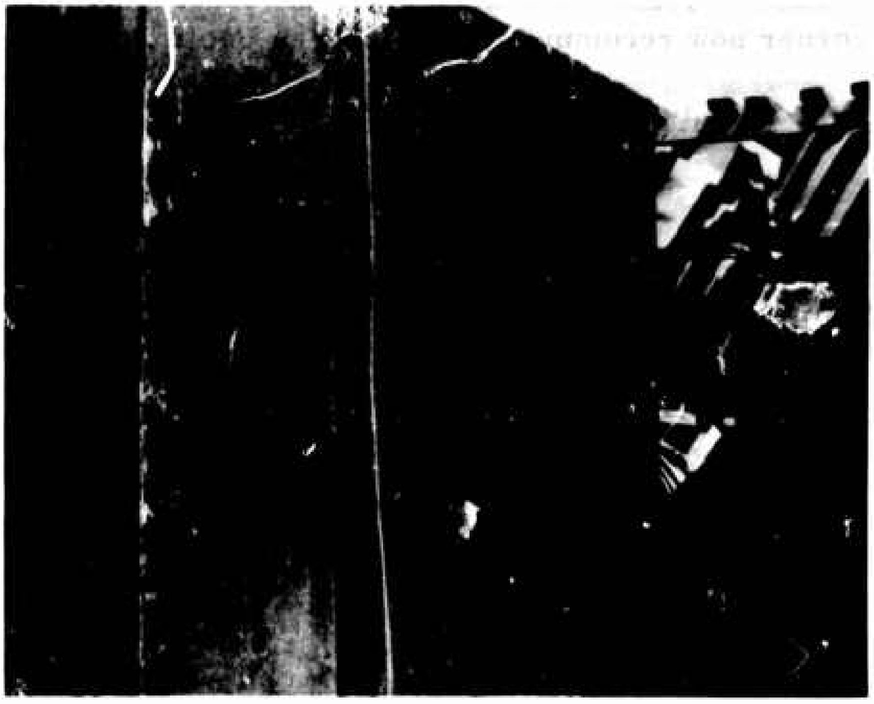


Figure 42. Side Panel Punctures, Van Pac Container, After Phase I Rail Impact Tests.

Figure 43. Damage to Commercial-Design Van Pac Container, After Phase II Rail Impact Tests.

nailed joints must be reinforced, such as by the short lengths of strapping around the corner now recommended by the Van Pac's designers.

Performance of Prototype Metal Container

Considerable advance interest had been generated in the possibility of using an all-metal, insulated panel container in household goods movements. Unfortunately, the prototype container examined as a part of the Phase II tests proved to have several shortcomings which, in total, ruled against further consideration of the design in question.

The ratio of usable inside cube to outside cube in the prototype was extremely poor. The nominal outside dimensions were 54 inches by 54 inches by 84 inches, or 142 cubic feet. However, the actual outside dimensions were increased by the skids and rub boards to 58-7/8 inches by 57-1/4 inches by 87-1/4 inches, or 170 cubic feet. Further, the usable interior dimensions were approximately 47-1/8 inches by 46-3/4 inches by 76-3/4 inches, or 98 cubic feet.

Figure 44 illustrates the problem; the panels (1-5/8 inches thick) were not designed to be load-bearing; thus the 2-inch loading bars and a 1-5/8-inch false floor were needed. The resulting load (Figure 45) was a very inefficient fraction of the total volume available. The metal container

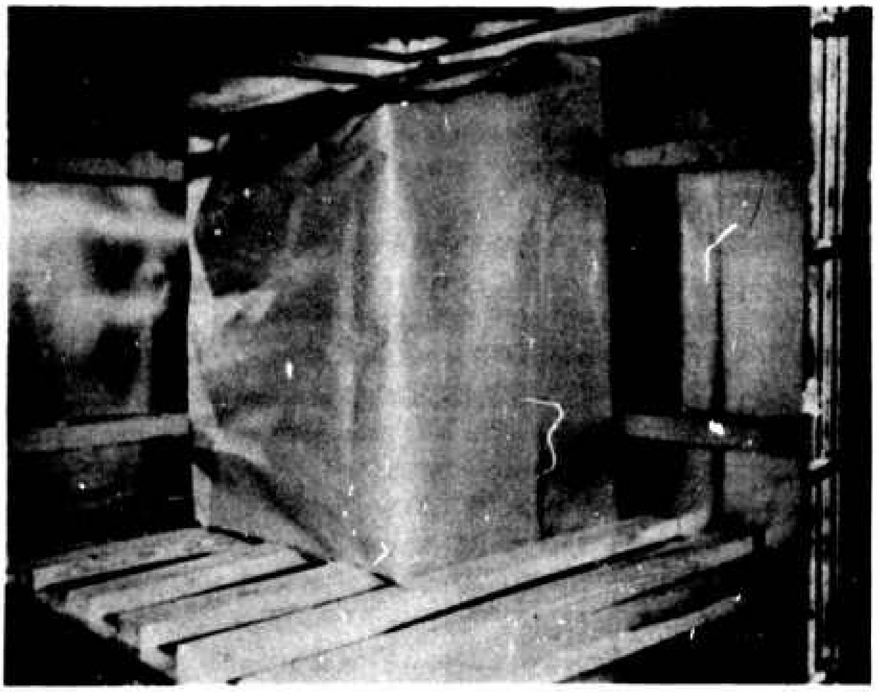


Figure 44. Interior of Prototype Metal Container.

Figure 45. Partially Loaded Prototype Metal Container.

also was very heavy, with a tare weight of 950 pounds versus a design load of 1,500 pounds of household goods. Thus, no matter how the billing might be accomplished, whether on a weight or volume basis, the prototype was prohibitively uneconomical, especially in view of its high first cost.

During the course of testing, the containers were opened after having been loaded only 10 days. Extremely high levels of moisture condensation, sufficient to cause damage to contents, were found. The design of the panels and studs provides heat flow paths that negate the thermal insulation in the panels, while at the same time the gasket provides a nearly air-tight seal. This creates an ideal situation for the formation of internal condensation. The containers were loaded in an ambient temperature of 75 degrees Fahrenheit dry bulb, 55 percent relative humidity, and were lowered to a minimum dry bulb temperature of 50 degrees Fahrenheit. While 50 degrees Fahrenheit is below the dew point of 75 degrees Fahrenheit, 55 percent relative humidity, this is not a particularly severe temperature swing at all, except where the wetter air is trapped, as it was here.

A further deficiency was revealed during the Phase II impact tests. At coupling impact speeds as low as 6.6 miles per hour, the container tore loose from its skid (Figure 46). Investigation revealed that the aluminum

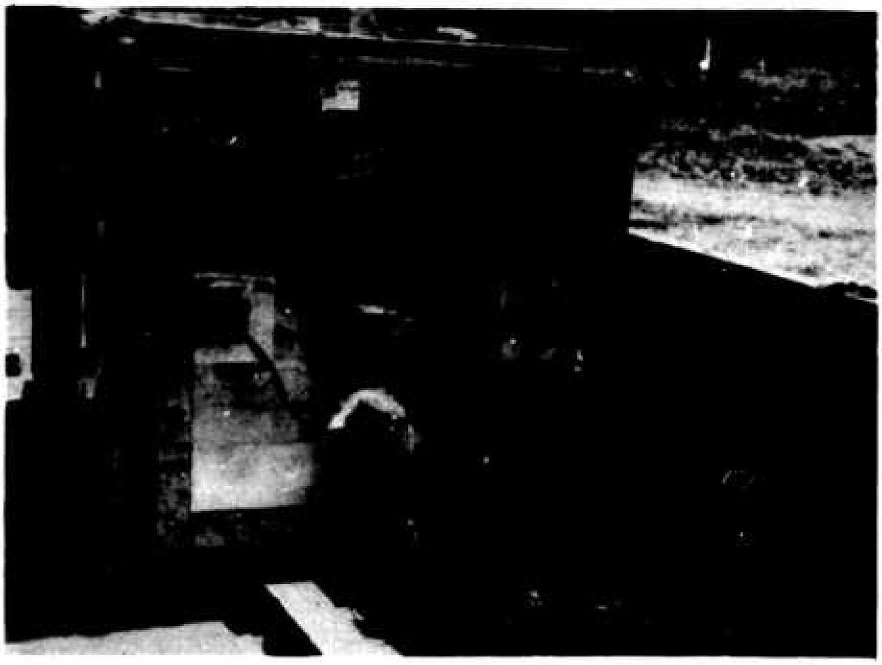


Figure 46. Metal Container Broken Loose From Skid.

bolts holding the skid on had sheared off flush with the bottom panel (Figure 47). When the container was removed from the gondola, the skid, undamaged to any great extent, stayed behind as a unit. Failure could have been predicted by a structural analysis of the skid fastenings under impact conditions. Further investigation revealed that, indeed, the container had not been designed to be restrained by the skid, despite the inference in the Purchase Description (Appendix IV) that such was the primary alternate. In any case, USATEA was not informed of this limitation until after the failures occurred. Besides the skid failures, several panel fastening studs broke off, and the panel securing nut assemblies (on either side of the skid bolt in Figure 47) showed several cracked and broken welds.

The prototype container was also inherently inconvenient to use. The great number of stud fasteners for each panel, combined with the tight fit into the rubber sealing gaskets, made removal and replacement of access panels extremely time-consuming. Total times of 45 minutes to remove and replace panels were not uncommon even for personnel practiced in working with the container.

The operational and economic shortcomings noted and physical deficiencies found in testing ended further consideration of the prototype metal container as a solution to the household goods container problem.

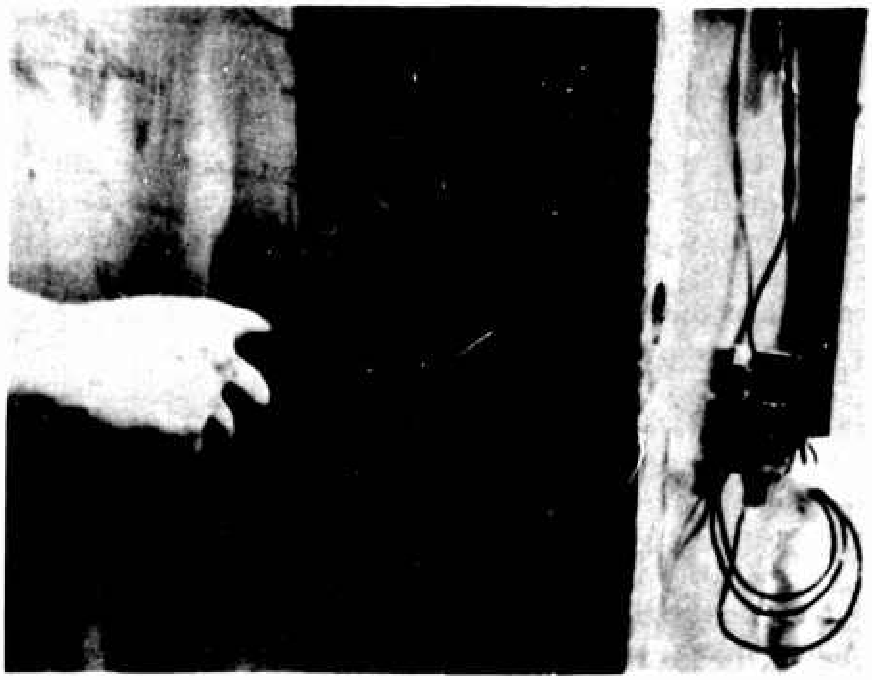


Figure 47. Sheared Bolt Remnant After Rail Impact Test Skid Failure.

VI. SELECTED BIBLIOGRAPHY

1. Association of American Railroads, Rules Governing the Loading of Commodities on Open Top Cars, February 1960.

2. Butler, C. O., Impact Testing of Long Travel Shock Mount for Transportability Rail Instrumentation, TEA Report 65-5, U.S. Army Transportation Engineering Agency, Fort Eustis, Virginia, April 1965.

3. Butler, C. O., Impact Testing of Long Travel Shock Mounts, Models 230 and 570, for Transportability Rail Instrumentation, USATEA Report 65-7, U.S. Army Transportation Engineering Agency, Fort Eustis, Virginia, August 1965, AD 468 868.

4. Butler, C. O., Rail Impact Testing on Long Travel Shock Mounts, USATEA Report 67-4, U.S. Army Transportation Engineering Agency, Fort Eustis, Virginia, July 1967, AD 656 600.

5. Department of the Army Technical Bulletin 55-100, Transportability Criteria - Shock and Vibration, Washington, D.C., April 1964.

6. Federal Specification NN-P-530c, Plywood, Flat Panel, April 1967.

7. Federal Specification PPP-B-580a, Boxes, Wooden, Household Goods, April 1963.

8. Federal Specification PPP-B-601c, Boxes, Wooden, Cleated - Plywood, February 1967.

9. General Electric Company, Information Service Department, Basic Language Reference Manual, 1968.

10. General Electric Company, Information Service Department, Regression Analysis Program User's Guide, 1968.

11. Holman, Harlan K., Optimum Size Household Goods Container, Staff Study, U.S. Army Transportation Engineering Agency, Fort Eustis, Virginia, December 1968.

12. International Air Transport Association, Container Program; Register of Containers and Pallets.

13. International Organization for Standardization, Dimensions and Ratings of Freight Containers, June 1967.

14. International Organization for Standardization, Specifications and Testing of Series 1 Freight Containers, June 1967.

15. Military Standard MIL-STD-212C, Preparation of Household Goods for Shipment and Storage, October 1965.

16. Military Standard MIL-STD-731, Quality of Wood Members for Containers and Pallets, December 1959.

17. Military Standard MIL-STD-810B, Environmental Test Methods, June 1967.

18. Military Traffic Management and Terminal Service, Guidelines for Stuffing Containers, MTMTS Pamphlet 55-2, August 1968.

19. Regular Common Carrier Conference, Containerization in International and Domestic Commerce.

20. U.S. Air Force Systems Command, Aeronautical Systems Division, 463L Materials Handling Equipment, April 1967.

21. U.S. Navy Supply Research and Development Facility, Evaluation of Storage and Shipping Containers, Report No. 2.505911, May 1960.

22. United States of America Standards Institute, Specifications for Cargo Containers, USASI MH 5.1-1965.

APPENDIX I

RECOMMENDED DESIGN FOR HOUSEHOLD GOODS SHIPPING CONTAINERS

1. General.

This recommendation is not intended to fix specific materials, techniques, or construction, but should be considered a guide incorporating those design features considered desirable. It covers dimensions, limiting characteristics, and other design features needed in an expendable, stowable, intermodal household goods shipping container.

2. Dimensions, weights, and capacity.

a. Nominal capacity shall be 1, 500 pounds.

b. Containers shall have the following overall dimensions (Figure 48): (Values are plus O, minus 1 inch.)

(1) Length - 104 inches.

(2) Width - 42 inches.

(3) Height - 82 inches.

(4) Forklift entry height - 2-1/2 inches minimum.

c. Inside volume shall be at least 185 cubic feet.

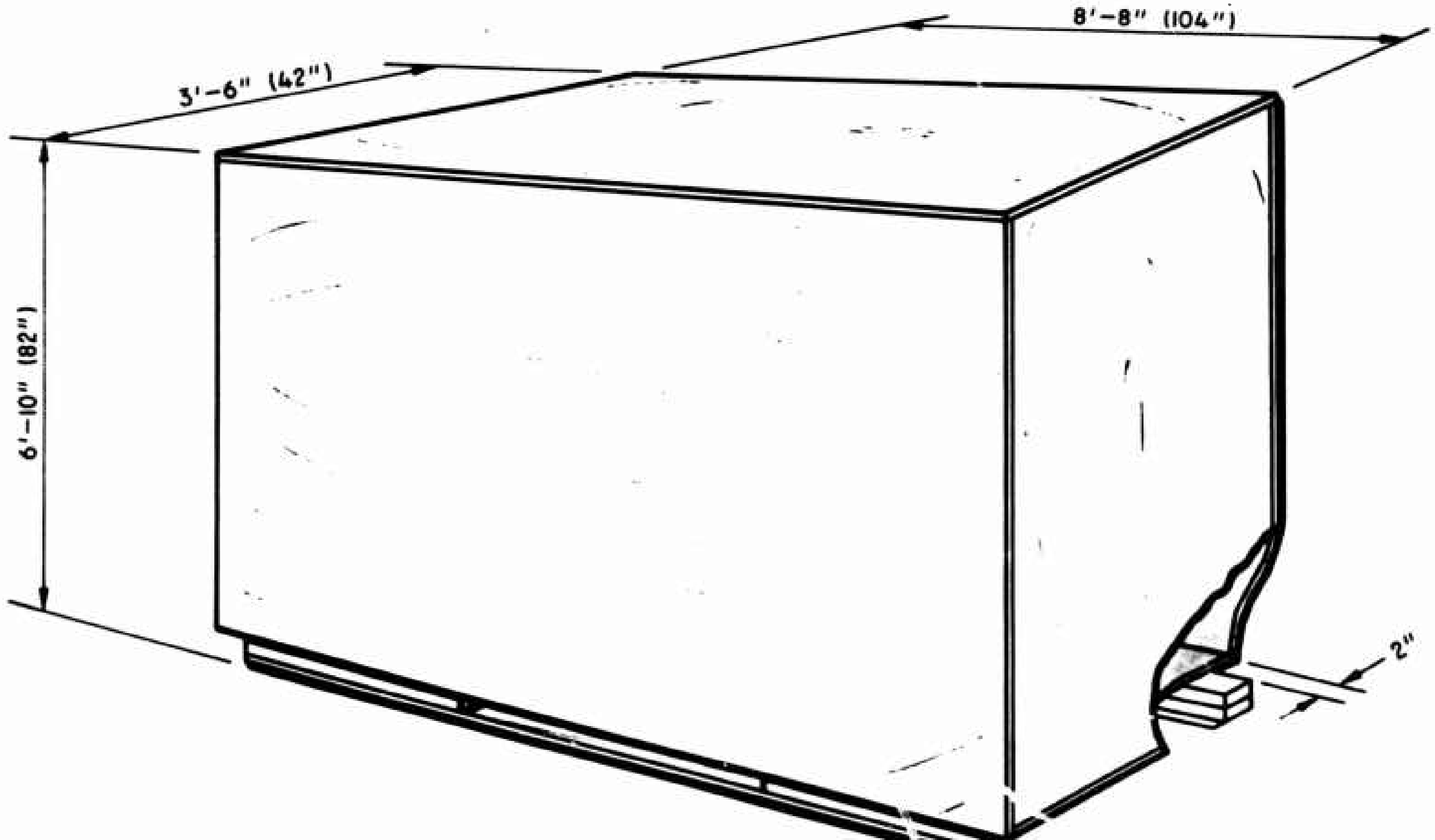
d. Tare weight should not exceed 400 pounds.

e. Four containers of the above size will fit inside an 8-foot by 8-foot by 20-foot container. Two will fit on usable surface (84 inches by 104 inches) of a 463L pallet (88 inches by 108 inches).

3. Construction.

a. Containers shall be constructed to meet the physical requirements of paragraph 4 below.

b. Containers shall be constructed in the most economical manner consistent with protection of contents and conformance with other requirements given herein.



SUGGESTED FASTENING HARDWARE:
$\frac{3}{8}$"×3" LAG BOLTS (PANELS AND FRAME)
$\frac{1}{4}$"×1$\frac{1}{2}$" LAG SCREWS (PANELS AND FRAME)
$\frac{3}{8}$"–16NC×4$\frac{1}{2}$". THROUGH BOLTS W/NUTS (SKID FASTENINGS)

NOTE: EXACT ARRANGEMENT DEPENDENT ON WHETHER SIDE OR END IS THE REMOVABLE ACCESS PANEL

Figure 48. Proposed Container Configuration.

c. To the maximum extent possible, any necessary framing, other than skids, shall be inside to increase the ratio of inside to outside cube (Figure 49).

d. All necessary fastening shall be by lag screw, through bolts, or equivalent. Nails, staples, and similar friction fastening shall be avoided.

e. Containers shall be so designed as to allow either the side or the end to be removed for access to contents. The manufacturer may, at his option, designate at time of manufacture that a given container is designed for either side or end access. Forklift entry should be provided from both sides and ends.

f. Containers shall be waterproof. If plywood sheathing is used, this shall include use of exterior glue, fully waterproof bond, and water repellent wood preservative, as applicable. (Federal Specification PPP-B-601c, with references, gives additional information in this area.) Seams shall be caulked or sealed with waterproof glue. Containers shall further include means to prevent interior condensation, such as (but not limited to) weatherproof breather vents or renewable dessicant pouches, or shall demonstrate absolute freedom from such condensation.

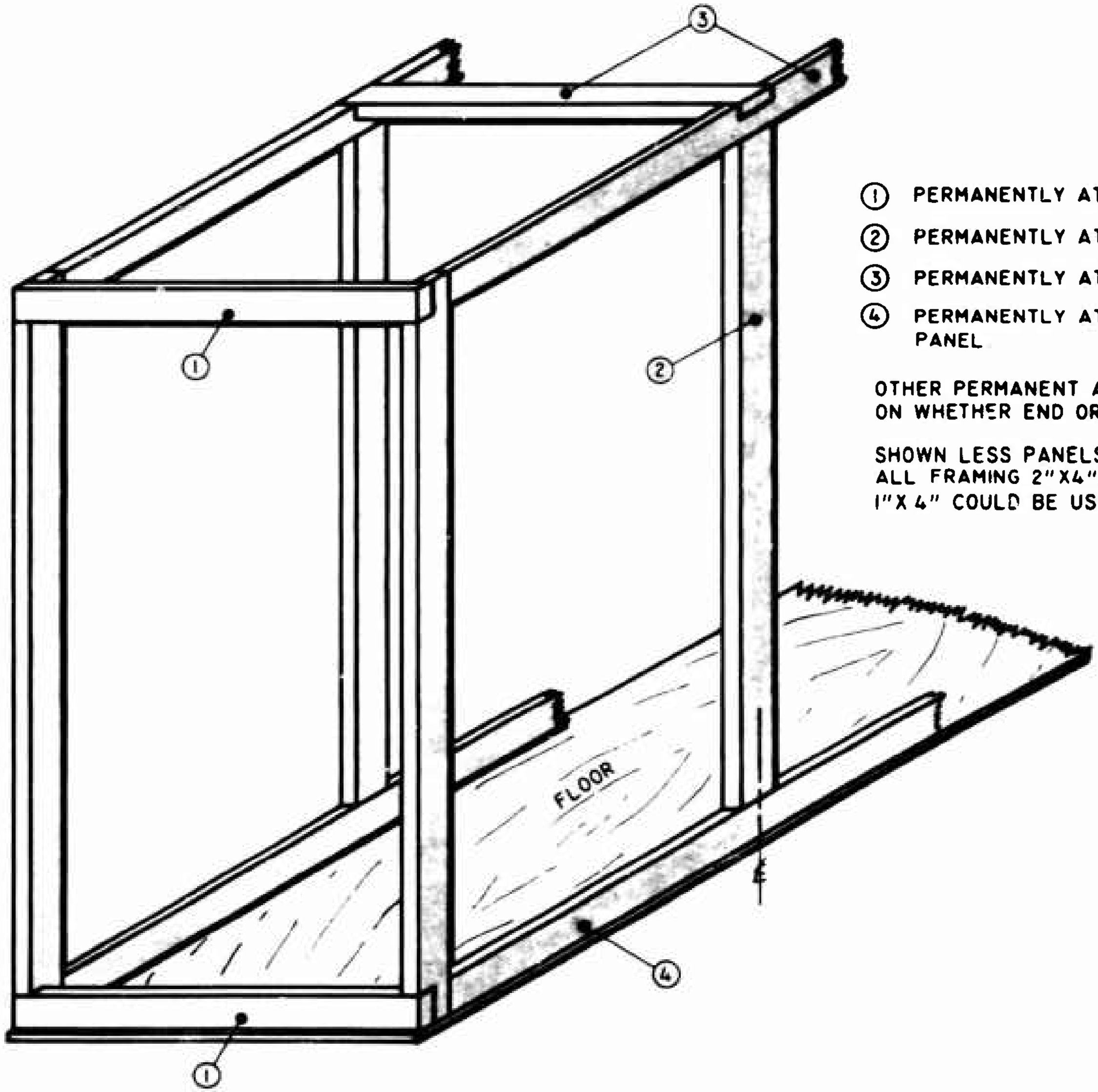
g. Skids shall be inset 2 inches from all edges, in order to meet IATA requirements. Full length stringers shall be used on the skids.

h. Unit cost at point of destination in carload lots shall not exceed $15 per design trip; for example, a container designed to have a service life of four trips (as is the U.S. Army Type II) should not cost over $60. It is suggested that cost be under $100 so that containers may be inventoried as expendable items.

4. Physical requirements.

a. All containers shall meet the IATA test requirements, except that the compression test shall be performed with a load of 4,200 pounds.

b. Containers designed for intermodal use independent of a demountable consolidation container (e.g., 8-foot by 8-foot family) shall, further, meet the test requirements of Appendix II.



(1) PERMANENTLY ATTACHED TO END PANEL
(2) PERMANENTLY ATTACHED TO SIDE PANEL
(3) PERMANENTLY ATTACHED TO TOP PANEL
(4) PERMANENTLY ATTACHED TO BOTTOM PANEL

OTHER PERMANENT ATTACHMENTS DEPEND ON WHETHER END OR SIDE ACCESS IS USED

SHOWN LESS PANELS AND SKIDS
ALL FRAMING 2"X4" FOR AIR-ONLY VERSION, 1"X 4" COULD BE USED FOR SOME MEMBERS

Figure 49. Suggested Framing, All-Wood, Proposed Container.

5. **Where applicable, containers shall meet the requirements of the following Military Standards and Federal Specifications:**

a. **MIL-STD-731.**

b. **PPP-B-601c.**

c. **NN-P-530c.**

APPENDIX II

SUGGESTED TEST PROCEDURE, INTERMODAL HOUSEHOLD GOODS SHIPPING CONTAINERS

1. General.

a. Containers designed only for air use and associated local trucking, or for stuffing into a demountable consolidation container (e.g., 8-foot by 8-foot family), shall meet IATA test requirements, except that the compression test shall be performed with a load of 4,200 pounds (containers stacked three-high, with a 10 percent overload).

b. Containers designed for intermodal use independent of a consolidation container (seavan) shall, in addition, meet the requirements of paragraphs 2 through 4 below.

c. Where not specifically spelled out, tests shall be performed in accordance with:

(1) International Organization for Standardization (ISO), Specifications and Testing of Freight Containers.

(2) MIL-STD-810B, Environmental Test Methods.

2. Static loading - The loads shall be uniformly distributed by mechanical means such as jacks, or by utilizing homogeneous load of the total value specified.

a. Stacking - see paragraph 1a above.

b. Horizontal.

(1) A load of 1,000 pounds shall be uniformly applied from the inside to sides and ends. Load may be applied to each side and end independently by use of a homogeneous load or to sides simultaneously and ends simultaneously by use of jacks. If a homogeneous load is used, it shall be applied by lifting the loaded container with slinging cables applied under the loaded panel at the extreme dimension.

(2) A load of 1,000 pounds shall be uniformly applied to the outside of the sides by one of the methods of paragraph 2b(1) above.

(3) A load of 675 pounds shall be uniformly applied to the outside of the ends by one of the methods of paragraph 2b(1) above.

c. Floor - With the container loaded to rated capacity plus 10 percent, it shall be lifted by slinging cables applied under the floor at the ends and held suspended off the ground for 1 minute.

d. Roof - A concentrated load of 400 pounds shall be uniformly distributed over an area of 24 inches by 12 inches, located at the weakest area of the roof.

e. Requirement - The container shall, at the conclusion of each test, show no deformity or permanent damage which would render it unsuitable for continued use.

3. Dynamic loading - To the maximum extent possible, loads shall be applied as given; however, alternate methods may be used if they result in the same input to the container.

a. Puncture - see paragraph 1a above.

b. Side and end loading - With the container loaded to rated capacity plus 10 percent, it shall be impacted on a Conbur inclined ramp at a speed equivalent to a rail coupling speed with standard draft gear of 8 miles per hour. Alternatively, rail impact tests using the AAR recommended test procedure may be employed. If rail impact tests are employed, the container shall be restrained in accordance with applicable AAR loading rules. The container shall be impacted once on a side and once on an end, or the railcar impacted once with the container transverse and once with it longitudinal.

c. Floor loading - With the container loaded to rated capacity plus 10 percent, it shall be drop-tested onto the end edge. With one end raised 6 inches (a common industrial pallet is useful here), the other end shall be raised 24 inches and held in place by a piece of lumber, or similar restraint. The restraint shall be removed suddenly, allowing the container to drop. The surface onto which it drops shall be rigid and on a firm foundation. (A concrete slab floor will generally be suitable.)

d. Vibration* - With the container loaded to rated capacity plus 10 percent, it shall be placed on a shaker table, or on four shakers at the corners, and vibrated for 1 hour, either -

(1) At an amplitude of 5g's logarithmically sweeping the frequency range of 10 to 500 cycles per second in accordance with the rate specified in MIL-STD-810B, or,

---

* To be performed when equipment is available.

(2) According to the following schedule:

Amplitude (g)	Frequency (Hz.)	Duration (min)
1	10	3.0
5	50	3.0
5	100	0.5

and repeat to conclusion.

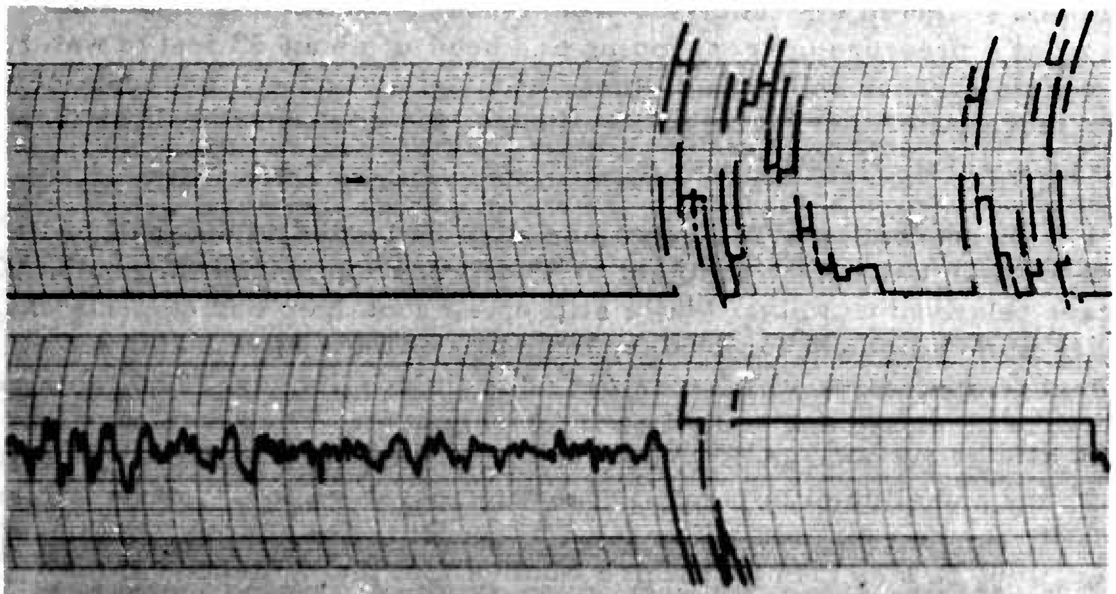
4. Weatherproofness.

a. Direct rain - A stream of water shall be applied on all exterior joints and seams of the container from a nozzle of 0.5 inch inside diameter, at a pressure corresponding to a head of about 33 feet of water. The nozzle shall be held at a distance of 5 feet away from the container under test. After a duration of 15 minutes, the container shall be free from penetration of water.

b. Condensation - The container shall be loaded to one-half of its inside volume while in an ambient of 95 degrees Fahrenheit dry bulb, 90 percent relative humidity. While still open, container and contents shall remain in this ambient for 1 hour, or until all items have stabilized at ambient temperature, whichever period of time is longer. The container shall then be closed and sealed as if for shipment. The container ambient shall next be reduced to 70 degrees Fahrenheit dry bulb over a period of 3 hours and allowed to remain at that temperature for 3 hours, after which it may be reopened. The level of condensation, if any, in the container shall be less than that which would affect the contents. If the probable effects of any condensation found cannot be determined, the container shall be retested as above, except that it shall be cycled through the conditions and time periods given three times before being reopened.

APPENDIX III

TYPICAL PROBABILITY ANALYZER AND COMPUTER OUTPUTS



Top: Probability Analyzer Readout
Bottom: End of Data Sample Being Analysed
(Taken from Series A, Channel 6, ending
at footage 3238)
1 -- Time Base: 25mm/sec
1 -- Amplitude Calibration: .1 g/line (bottom)
Full Scale: 10V (top)

PACOMP 15:57 W1 FRI 03/08/68

ANALYSIS IS FOR +/- PK VALUES

FOOTAGE COVERED BY THIS ANALYSIS 828 TO 845

FILTER CUTOFF FREQUENCY SETTING 17.5 HZ

FULL SCALE [10 V] VALUE = 5.6 UNITS
MAXIMUM VALUE = 1.106
SECOND LARGEST VALUE = 1.008
THRESHOLD VALUE .04368

VARIANCE = .623041
RMS = .78933
MEAN = .663478

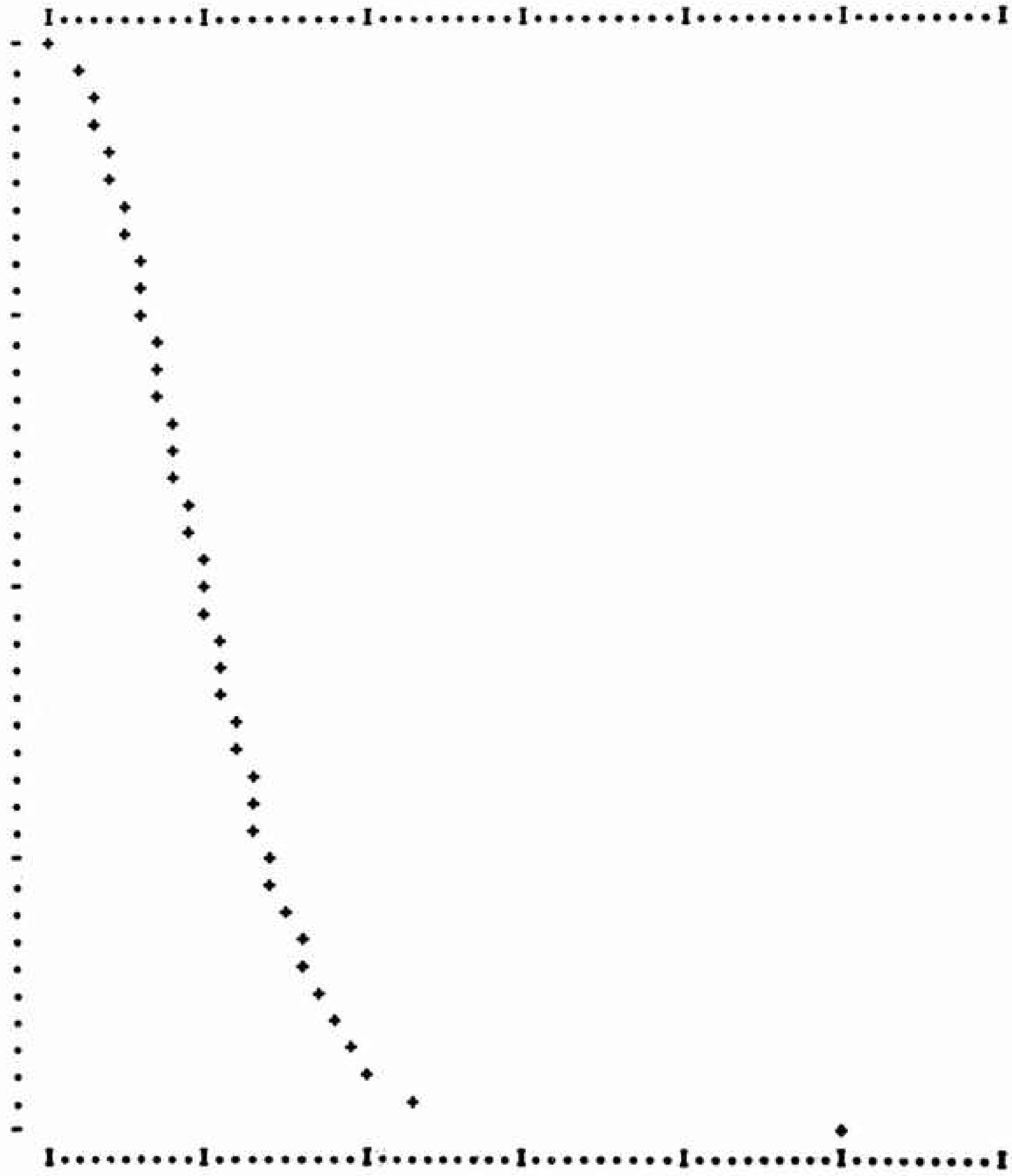
COUNTER NO.	COUNTS	CUMULATIVE COUNTS
1	69	69
2	78	147
3	92	239
4	54	293
5	35	328
6	16	344
7	8	352
8	6	358
9	6	364
10	6	370
11	1	371
12	0	371
13	0	371
14	0	371
15	0	371
16	0	371

TOTAL COUNTS = 345

AVERAGE FREQUENCY = 14.375

```
IS STATISTICAL ANALYSIS DESIRED [YES=1,NO=0]? 1


TABLE OF CUMULATIVE PROBABILITIES:

EXPERIMENTAL P[X]              VALUE OF X
 .185984                        .13125
 .396226                        .2625
 .644205                        .39375
 .789757                        .525
 .884097                        .65625
 .927224                        .7875
 .948787                        .91875
 .96496                         1.05
 .981132                        1.18125
 .997305                        1.3125
 1.                             1.44375


VALUE OF T= 1.01632

IF ABS[T]<=ABOUT .25, THE IDEAL DISTRIBUTION [RAYLEIGH] IS PROBABLY
A GOOD FIT TO THE EXPERIMENTAL DATA.

IS A PLOT OF THE IDEAL DEISTRIBUTION DESIRED [YES=1,NO=0]? 1

VALUE OF T= 1.01632

IF ABS[T]<=ABOUT .25, THE IDEAL DISTRIBUTION [RAYLEIGH] IS PROBABLY
A GOOD FIT TO THE EXPERIMENTAL DATA.

IS A PLOT OF THE IDEAL DISTRIBUTION DESIRED [YES=1,NO=0]? 1
```

FOR P[X]: TOP = 0 BOTTOM = 1 INCREMENT = .025
FOR X: LEFT = 0 RIGHT = 2 INCREMENT = 3.33333 E-2



TIME: 21 SECS.

APPENDIX IV

PURCHASE DESCRIPTION MTMTS
RSE 150
CONTAINER, SPECIAL, HOUSEHOLD GOODS 23 May 1967

1. SCOPE

1.1 This purchase description covers research, and development, of a container, special, household goods, having a built-in capability that shall facilitate packing and stowage of household goods.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this purchase description.

SPECIFICATIONS

FEDERAL

FF-B-571	Bolts, Nuts, Studs, and Top Rivets (and Material for same)

2.2 Other publications -- The following documents form a part of this purchase description. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

NATIONAL BUREAU OF STANDARDS

Handbook H28	Screw-Thread Standards for Federal Services

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, 25, D. C.)

AMERICAN WELDING SOCIETY

Welding Handbook

(Application for copies should be addressed to American Welding Society, 33 West 39th Street, New York 18, N. Y.)

COPY

AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM)
Material specifications as applicable to the container design and construction

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.)

3. REQUIREMENTS

3.1 Design. The container shall have a nominal load carrying capacity amounting to 8,000 pounds with a maximum load capacity to tare weight ratio consistent with the container structural integrity to withstand static and superimposed dynamic loads. The container shall have a built-in capability that shall facilitate the packing and stowage of household goods.

3.1.1 Construction. The container structure shall be constructed in a manner that shall be suitable for quantitative production. Structural members and components shall have load-carrying capacity to resist the static design loads and superimposed dynamic loads, as specified in 3.1.2, without exceeding the allowable stress limits of the material. Structural members shall be free of notch-sensitive areas and discontinuations that could result in high localized stress concentrations.

3.1.2 Static and dynamic loads. Static and dynamic loads shall be based as follows.

3.1.2.1 Static load.

(1) The nominal load carrying capacity, 8000 pounds, distributed over the design load carrying members.

(2) Household goods static load, 1500 pounds, distributed over the design load carrying members.

(3) The container when loaded in conformance with 3.1.2.1(2) shall be capable of sustaining a superimposed vertical static load amounting to nine times the container's gross weight (1500 pounds plus the tare weight of the container).

3.1.2.2 Dynamic load. The container when loaded in conformance with 3.1.2.1(2) shall be capable of sustaining, within the stress limits specified in 3.1.1, the following dynamic loads:

(1) Nine times the container gross weight, 1500 pounds plus the container tare weight, and when subjected to an acceleration

having an amplitude of 1.5G's and a 40 milli-seconds duration applied normal to the container shipping orientation.

(2) Nine times the container gross weight, 1500 pounds plus the container tare weight, and when subjected to an acceleration having an amplitude of 1.5G's and a 40 milli-seconds duration applied parallel to the container shipping orientation.

(3) Two times the container gross weight, 1500 pounds plus the container tare weight and when subjected to an acceleration having an amplitude of 15G's and a 20 milli-seconds duration applied parallel to the container shipping orientation.

(4) An acceleration having an amplitude of 8G's and a 10 milli-seconds duration applied to the container bottom end sill, each end independently, and when the container is loaded in conformance with 3.1.2.1(3).

(5) An acceleration having an amplitude of 8G's and a 10 milli-seconds duration applied to the container bottom side sill, each side independently, and when the container is loaded in conformance with 3.1.2.1(2).

(6) An acceleration having an amplitude of 8G's and a 10 milli-seconds duration applied to the container bottom corner, each corner independently, and when the container is loaded in conformance with 3.1.2.1(2).

3.2 Materials. Unless otherwise specified, materials and components shall be of a quality used for the purpose in standard commercial light fabrication practice and shall have high strength characteristics with minimum weight.

3.3 Interchangeability of parts. Components and sub-assemblies shall be interchangeable without requiring modification for replacement with similar components furnished under the same contract or order.

3.4 Threaded parts. Threaded parts shall conform to Handbook H28. The American National fine thread series shall be used for threaded parts less than 1/4-inch diameter. The Unified or American National coarse thread series shall be used for threaded parts 1/4-inch diameter and larger; however, the American National fine thread series may be employed for these sizes when applicable.

3.5 Welding. The surface of all parts to be welded shall be free from rust, scale, paint, grease, and other foreign matter. Unless otherwise specified, welds shall develop the strength as required for the parts connected. All welding shall be in accordance with the latest applicable codes of the American Welding Society as contained in the Welding Handbook.

3.6 Fabrication. Material used in the fabrication of parts shall be free from laminations, and bends, kinks, and any other defects that may result from handling and shipment. Forming and bending operations shall be performed in a manner as to provide uniformity of parts. Cold formed sections shall have an adequate bend radius to avoid fracture or crimping of the material. Templates or other gaging methods shall be used to insure that parts conform to the design size, shape, and tolerance.

3.7 Bolted connections. All bolt holes shall be accurately located to insure interchangeability of parts and the bolted connections shall provide an absolute water tight connection.

3.8 Tolerances and fits. Tolerances and fits shall conform to all limitations specified herein, and when not specified, shall conform to standard commercial practice.

3.9 Dimensions. Nominal dimensions of the container shall be as follows:

Length over ends	84 in.
Height less skids	54 in.
Width.	54 in.
Cube inside, minimum	123 $ft.^3$
Load opening height (minimum)	45 in.
Load opening length (minimum)	75 in.

3.10 Structure.

3.10.1 Side. Side shall be constructed with light weight high strength material where applicable and as consistent with the combined structure design. Side top and bottom sills shall be constructed integral with the side and shall be of a geometry as to provide for a water tight connection between the container top and bottom structure; however, the top and bottom sills may be designed integral with the container top and bottom structure. Side shall be capable of sustaining the static and dynamic loads specified in 3.1.2.1 and 3.1.2.2. Side bottom sill shall be capable of resisting dynamic loads specified in 3.1.2.2(5).

3.10.2 Ends. Ends construction and material shall be similar to that used in the sides. Ends shall be provided with top and bottom sills and corner posts having a geometry that shall insure a water tight connection between the container top, bottom, and sides; however, the top and bottom sills may be designed integral with the container top and bottom structure. Ends shall be capable of sustaining the static and dynamic loads specified in 3. 1. 2. 1 and 3. 1. 2. 2. Ends bottom sill shall be capable of resisting dynamic loads specified in 3. 1. 2. 2(5).

3. 10. 3 Top. Top construction and material shall be similar to that used in the ends and sides. When top sills are not provided on the sides, they shall be constructed integral with the top structure. Connection between the top, ends, and sides shall be water tight. Top shall be capable of sustaining the applicable static and dynamic loads specified in 3. 1. 2. 1 and 3. 1. 2. 2.

3. 10. 4 Bottom. Bottom construction and material shall be, as far as practicable, similar to that used in the sides. When bottom sills are not provided on the ends they shall be constructed integral with the bottom structure. Connection between bottom, ends and sides shall be water tight. Bottom, when designed as the principal load carrying member, shall be capable of supporting static loads specified in 3. 1. 2. 1(1) and 3. 1. 2. 1(2); however, the bottom may be designed to transmit these loads to the sides and top. Bottom shall have adequate structural integrity to resist applicable dynamic loads specified in 3. 1. 2. 2.

3. 10. 5 Corner Supports. Corner supports shall be provided as necessary to reinforce all corners of the container in resisting the static and dynamic loads, and to distribute, as necessary, static loads to the applicable structural members. Each corner of the container shall be capable of resisting the dynamic load specified in 3. 1. 2. 2(6).

3. 10. 6 Lifting sling fitting. Lifting sling fitting shall be located near each end of the bottom sill and shall be provided with sufficient structural integrity to resist a static load amounting to 5000 pounds. Lifting sling fitting shall be compatible with standard ship gear.

3. 10. 7 Tie-downs. Two tiedowns shall be located near the ends of each side and end of the container. When the container skids are intended to restrain the container during shipment, tie-downs shall be capable of resisting a static load amounting to 2000 pounds; however, when tie-downs are intended to restrain the container during shipment, they shall be capable of resisting a 5000 pound load.

3. 10. 8 Skids. Skids shall be provided on the bottom of the container and shall be located in a manner as to transmit the static load specified in 3. 1. 2. 1(3) to the applicable structural members. Skids shall be arranged to provide easy stacking of containers. When skids are

designed to restrain the container during shipment, their connection to the container structure shall be designed to withstand the dynamic load specified in 3.1.2.2(3).

3.10.9 Rub boards. Rub boards shall be applied to the container sides and ends when the top and bottom sills are designed flush with the outside panels.

3.10.10 Loading opening. Loading opening shall be of a maximum height and length consistent with the container structure. Minimum dimensions shall be 45 inches high, and 75 inches long. Loading opening shall be provided with a sealing arrangement that shall provide an absolute water tight connection.

3.10.11 Water resistance attachments. Loading opening and all components and parts of the container structure that cause a direct inside to outside contact shall be designed, as far as practicable, in a manner that will provide an absolute water resistant connection. The government shall subject the delivered container to driving rain, drip-proof, and complete immersion tests to evaluate the effectiveness and reliability of the water resistant connections.

3.10.12 Pilferage protection. The container structure, fastenings, and locking arrangements shall provide maximum protection against pilferage. Hinged or removable parts shall be provided with attachments suitable for applying standard door seals.

3.10.13 Thermal conductivity. Container structure, sides, ends, top and bottom shall be designed in a manner that will provide a heat transmission coefficient not greater than 0.09 Btu/hr/sq ft/ ^{o}F. Direct metal to metal contact between outside and inside shall be avoided as far as practicable.

3.10.14 Pressure differential. Container structure, sides, ends, top and bottom shall have sufficient structural integrity to sustain an external pressure differential of not less than 8.0 pounds per square inch.

3.11 Interior.

3.11.1 Interior walls. Interior walls shall be smooth and free from pointed obstructions that could have an injurious effect on the household goods that will be transported in the container.

3.11.2 Stowing and bracing devices. Stowing and bracing devices, having a plurality of adjustments, longitudinally and vertically, shall be provided in sufficient quantity as to sectionalize the container into three independent sections. Stowing and bracing devices shall be arranged to minimize packing, crating, and wrapping, as well as providing adequate strength to restrain the stowed household goods during transport.

3.11.3 Adjustable strapping. Cotton webbing adjustable strapping, of sufficient length to extend from end to end and from side to side, shall be applied to one longitudinal and transverse stowing and bracing device. Strapping shall have adequate strength to restrain stowed household goods in the vertical plane.

3.12 Painting and marking.

3.12.1 Container interior. Container interior shall be cleaned to remove all by-products of fabrication and assembly, but shall not otherwise require surface preparation, and shall remain unpainted.

3.12.2 Container exterior. Procuring documents shall specify the exterior surface preparation. However, the intended use of items procured under this specification is for the purpose of conducting engineering and service evaluations which require the exterior surface remain unpainted. Container exterior surface shall be cleaned to remove all by-products of fabrication and assembly, and shall be free from all protective coatings and calking.

3.12.3 Drawings and technical data. The supplier, during the submission of his proposal, to conduct the research and development required by this specification, shall include engineering drawings and technical data, in sufficient detail, that an engineering evaluation can be made on the proposed container design.

3.14 Workmanship.

3.14.1 Fabricated parts and components. Fabricated parts shall be free from discontinuities, notches, die-marks, cracks, welding-arc burns, and any other injurious defects. Start and finish of hand and automatic welds, where applied, shall be done in a manner to provide uniform welds compatible with the physical strength requirements.

3.14.2 Subassemblies. Subassemblies shall be within manufacturing tolerances to permit interchangeability and proper fitting during assembly. Shims, spacers and calking compounds shall not be used to make allowances for poor fitting assemblies.

3.14.3 Finished container. The finished container shall be free from any defects that will bring about premature failure during the series of tests that will be conducted on the container. Construction and appearance shall be compatible with standard quality workmanship for light fabricated items.

4. QUALITY ASSURANCE PROVISIONS.

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Components and material inspection. The supplier is responsible for insuring that components and materials used are manufactured, examined, and tested in accordance with the applicable specifications and standards.

4.2 Inspection. Each container shall be inspected at the place of manufacture to determine conformance with the requirements of this specification.

4.3 Tests.

4.3.1 Supplier. It is not mandatory that the supplier conduct tests on the finished container; however, the supplier at his discretion may conduct tests considered necessary to provide reasonable assurance that the container shall withstand the physical and environmental requirements specified herein. When such tests are conducted by the supplier, the Government representative shall be notified.

4.3.2 Government. The Government, at its own facilities, shall conduct the following tests on the finished container:

Highway physical environments
Railway physical environments
Terminal handling
Humidity and spray tests
Water immersion
Pressure tests
Ocean and stacking tests

4.3.3 Method of rating. The container shall be loaded to 1500 pounds. During the physical tests, loads may simulate household goods; however, during environmental tests the load shall be representative of household goods. The tests shall be conducted in conformance with the test specification.

4.3.4 Materials. It is not mandatory that all materials be tested in conformance with the applicable specifications in each individual case. However, the Government will require appropriate tests whenever it is judged necessary to ascertain that the quality of the materials used conforms to the applicable specifications.

5. PREPARATION FOR DELIVERY.

5.1 Preservation, level C. The finished container shall be prepared for delivery in accordance with good commercial practice.

6. NOTES.

6.1 Intended use. The container constructed under this purchase description is intended to transport household goods and will be used to conduct engineering and service evaluations to determine its feasibility and any modification thereto.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number, and date of this purchase description.

(b) The applicable Government serial numbers and reporting marks.

(c) The weight, cube, and lifting point stencilling, instructions.

Notice. -- When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way relate thereto.

Custodian: Army - MTMTS-RSE

Preparing activity: Army - MTMTS-RSE

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U.S. Army Transportation Engineering Agency Military Traffic Management and Terminal Service Fort Eustis, Virginia 23604	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRANSPORTABILITY STUDY - HOUSEHOLD GOODS SHIPPING CONTAINERS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

David R. Phelps, 1LT, TC

6. REPORT DATE February 1969	7a. TOTAL NO. OF PAGES 64	7b. NO. OF REFS 24
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) USATEA Report 69-3 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT

Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of Headquarters, Military Traffic Management and Terminal Service, Washington, D.C. 20315.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

A transportability study of household goods shipping containers was performed, covering four representative types of commercial and military design containers. Containers were subjected to highway transport over roads ranging from marginal gravel roads to interstate highways, to drop tests from a height of 24 inches to simulate adverse terminal-handling conditions, and to rail coupling impact tests at speeds up to 9.5 miles per hour. Although testing was limited to land transport modes and terminal handling, results were compared with previous findings for air and water.

Wooden containers with bolted or lag screw construction were found to be superior to those with nailed construction. A prototype metal container was found to be uneconomical and structurally deficient. Internal moisture from condensation was found to be a widespread problem area.

A proposed container configuration, intermodal in nature, and a test procedure are presented, along with suggestions for implementing their use. The new container configuration is proposed to replace the present U.S. Army Type II container, while the test procedure will provide a uniform means of evaluating containers built within the proposed configuration.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Shock and Vibration						
Household Goods Containers						
Rail Impact Tests						
Highway Roughness						
Drop Tests						