AD-A059 055 AIR FORCE PACKAGING EVALUATION AGENCY WRIGHT-PATTERSO--ETC F/G 13/4

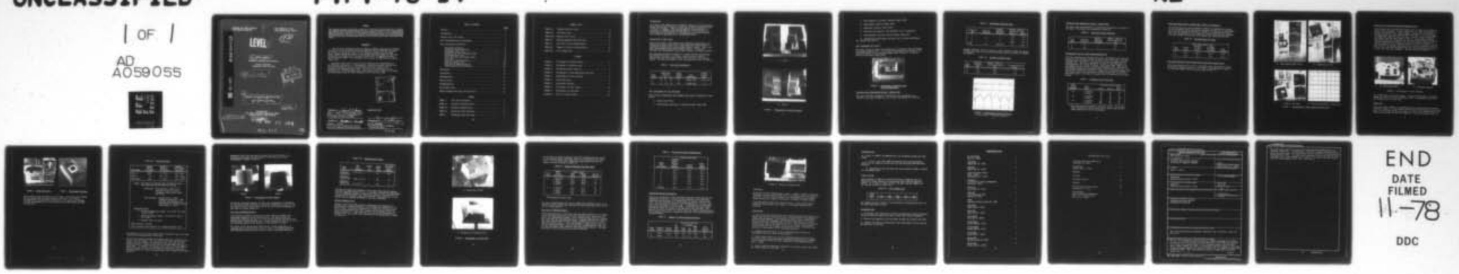
PACKAGING AND SHIPPING ANALYSIS OF THE LN-12 INERTIAL PLATFORM.(U)

JUN 78 F C JARVIS

UNCLASSIFIED PTPT-78-14 NL

1 OF 1

AD A059055



END

DATE FILMED

11-78

DDC

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

PTPT REPORT NO. 78-14
AFPEA PROJECT NO. 78-P7-5

LEVEL II

(12)

(10) FRANK C. JARVIS
Mechanical Engineering Technician

Autovon 787-4519
Commercial (513) 257-4519

(9) Final rept.

(6)

PACKAGING AND SHIPPING ANALYSIS OF THE LN-12 INERTIAL PLATFORM

(12) 25p.

HQ AFALD/PTP
AIR FORCE PACKAGING EVALUATION AGENCY
Wright-Patterson AFB OH 45433

(14) PTPT-78-14

(11) Jun[redacted]78

78 09 15 074

403 519

JOB

ABSTRACT

The Air Force Packaging Evaluation Agency's (AFPEA) packaging and shipping analysis of the LN-12 Inertial Platform (NSN 6605 00 945 8168) was initiated as a result of an urgent request by the Aerospace Guidance and Metrology Center (AGMC), Newark AFS, Ohio, to investigate excessive damage to this unit. During the period August 1977 through 15 March 1978, 51 damaged platforms were received by AGMC. This represented an increase of 388% above the normal repair rate.

The packs being used to ship the LN-12 platforms were manufactured by two different contractors. A comprehensive evaluation program revealed that the packs supplied by one of the contractors did not conform to the Transportation Packaging Order (TPO). The shock level generated on the bottom face of this substandard pack, when dropped from a height of 30 inches, was 300% greater than the rated fragility of 20 G for this item.

PREPARED BY:
FRANK C. JARVIS, Mechanical Engineering Technician, Materials Engineering Div.
AF Packaging Evaluation Agency

PUBLICATION DATE:

REVIEWED BY:
MATTHEW A. VENETOS
Chief, Materials Engineering Division
Air Force Packaging Evaluation Agency

APPROVED BY:
JACK E. THOMPSON
Director, Air Force Packaging Evaluation Agency

15 AUG 1978

TABLE OF CONTENTS

TABLES

TABLES (cont.)

FIGURES

INTRODUCTION

On 15 March 1978, AGMC hosted a meeting to discuss the LN-12 platform damage problem and a "plan of action" was outlined to quickly locate the source of damage. AFPEA was assigned the responsibility of analyzing the packaging and handling aspects of this problem. An accelerated testing program was initiated and the results revealed that inadequate packaging was a contributing factor.

DESCRIPTION OF TEST PACKS

The two test packs, each representing a different manufacturer, are identified as Pack A and Pack B. Both packs were constructed of corrugated fiberboard with polyurethane cushion inserts. Pack A has white polyurethane (ether base) cushion inserts. Pack B has charcoal color polyurethane (ester base) inserts, as shown in Figure 1.

The cushioning material thickness is 4 inches and the load bearing pad surfaces are each 5 x 5 inches. Each test pack included identically constructed inner cartons which nested in the cushion cavity. The size and weights of the test packs are listed in Table I.

TABLE I. Test Pack Information.

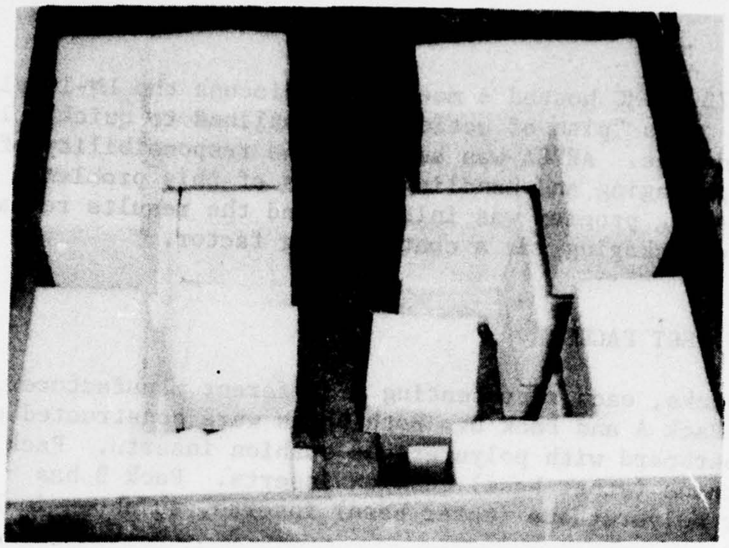
Test Pack	Dimensions (inches) L	W	H	Gross Weight (lbs)	Type Fiberboard	Cushion Density (pcf)
A	23	21	20	46	double wall	1.14-1.45
B	24	21	21	49	triple wall	1.7

TEST INSTRUMENTATION AND EQUIPMENT

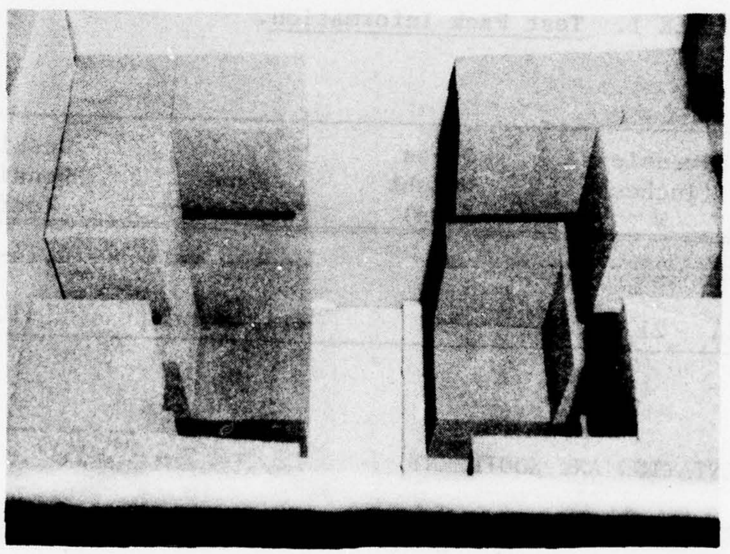
The following instruments and equipment were used to evaluate the test packs:

1. Gaynes Drop Tester

2. Oscilloscope, Tektronic, 4-channel storage, Model 564B



a. Pack A



b. Pack B

FIGURE 1. **<u>Photographs of Cushion Inserts</u>.**

3. Accelerometers, tri-axial, Endevco, Model 2233E

4. Power Supply, Endevco, Model 2622C

5. Amplifiers, Endevco, Model 2614C

6. Vibration Test Machine, Type 5000-96B, L.A.B. Corporation

7. Electrodynamic Vibrator, Unholtz-Dickie, Model 506

8. Transportation Environment Recorder, Bolt, Beranek and Newman, Inc., Models 711A and 714

TEST PROCEDURES AND RESULTS

All tests, except as noted, were conducted in accordance with the Federal Test Method Standard 101B. A tri-axial accelerometer was mounted at the center of gravity of the simulated wooden model (Figure 2) to monitor shock and vibration during tests.

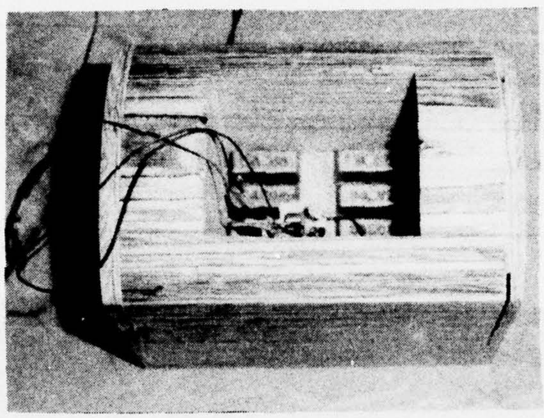


FIGURE 2. Photograph of Simulated Load with Accelerometers.

Vibration Test (Sinusoidal Motion) - Method 5020

The test packs were subjected to vibration at the frequencies and durations, as shown in Table II, for a total time period of two hours.

TABLE II. Sinusoidal Vibration Data.

Frequency Hz	Duration (minutes)	Double Amplitude (inches)	Output: Peak to Peak Accel. (Gs) Pack A	Pack B
2	5	1	0.2	0.4
3	5	1	1.0	1.2
5	5	1	10.9	7.0
5-500	45	.036-.673	7.1	10.4

Resonant frequency data for each test pack is shown in Table III and the oscilloscope trace of the acceleration-time history for Pack A is shown in Figure 3.

TABLE III. Resonant Frequency Data.

Test Pack	Resonant Frequency (Hz)	Output: Peak to Peak Acceleration (Gs)	Transmissibility Factor
A	5.25	15.4	5.4
B	5.10	8.8	3.3

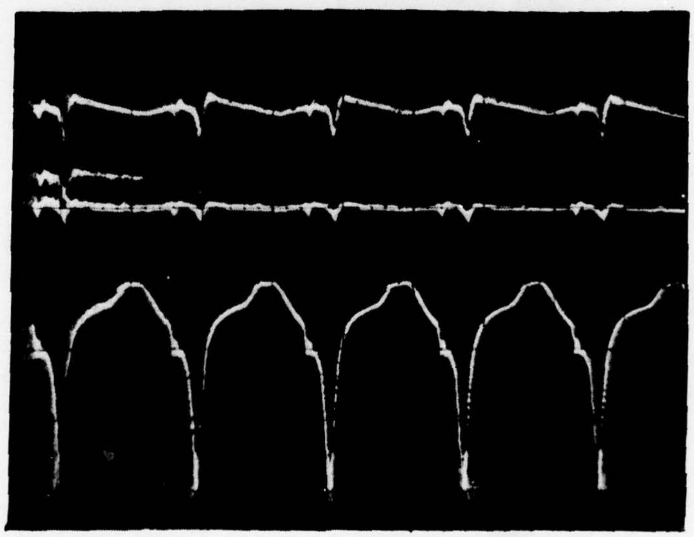


FIGURE 3. Oscilloscope Trace for Pack A,
(5 G/cm (vert.), 0.1 sec/cm (horiz.))

Vibration Test (Repetitive Shock) - Method 5019

The test packs were subjected to repetitive vibration for a period of two hours. The results are presented in Table IV.

TABLE IV. Repetitive Shock Vibration.

Test Pack	Frequency (c.p.s.)	Double Amplitude (inches)	Output: Peak to Peak Acceleration (Gs)
A	4.5	1	3.8
B	4.2	1	3.5

Preliminary Drop Test Data (Non-standard test)

Prior to conducting the standard drop test, preliminary test data were obtained on the bottom face and one side of the test packs to provide reference data for AGMC to take corrective action regarding the substandard pack. This data, presented in Table V, were generated for drop heights of 21, 30 and 48 inches. The 30-inch drop height is in accordance with the Federal Test Method Standard 101B. The 48-inch drop height simulates an accidental drop from a three-high stack. The 21-inch drop height was included to compare the relative performance of these packs with a new pack design currently being used by the Navy. The final report on the Navy's container will be published in the near future.

TABLE V. Preliminary Drop Test Data.

Drop Height (inches)	Impact Face	Peak Acceleration (Gs) Pack A	Pack B	Navy's Pack
21	3 (bottom)	51	14	14
	5 (side)	28	14	12
30	3 (bottom)	74	16	17
	5 (side)	48	20	26*
48	3 (bottom)	122	34	43
	5 (side)	107	38	39

*Test load was not centered on container platen. Off-center loads will generate shock levels two to three times the 20 G rated fragility of the LN-12 platform.

Drop Test (Free Fall) - Method 5007, Level A, Procedure A

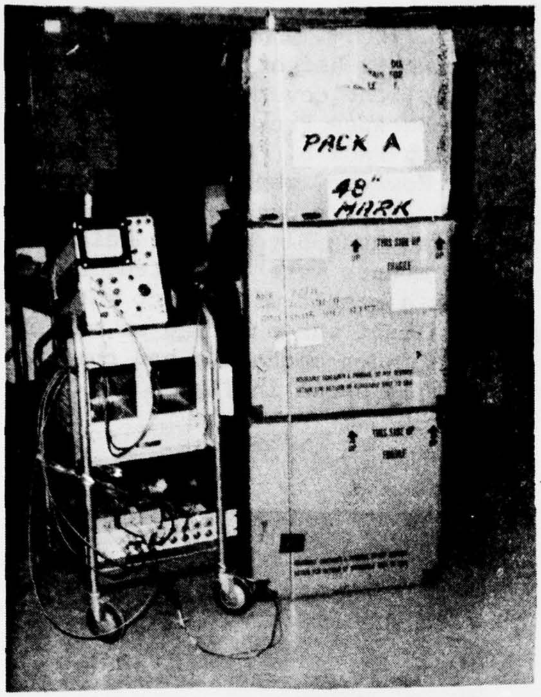
The 30-inch drop test data presented in Table VI confirmed the results of the preliminary tests and clearly revealed that Pack A was substandard. Note that the average shock level for Pack A is relatively low because 20 of the 26 drops were on the edges and corners which normally generate low level shocks for this type of container and cushioning material.

TABLE VI. Standard Drop Test Data.

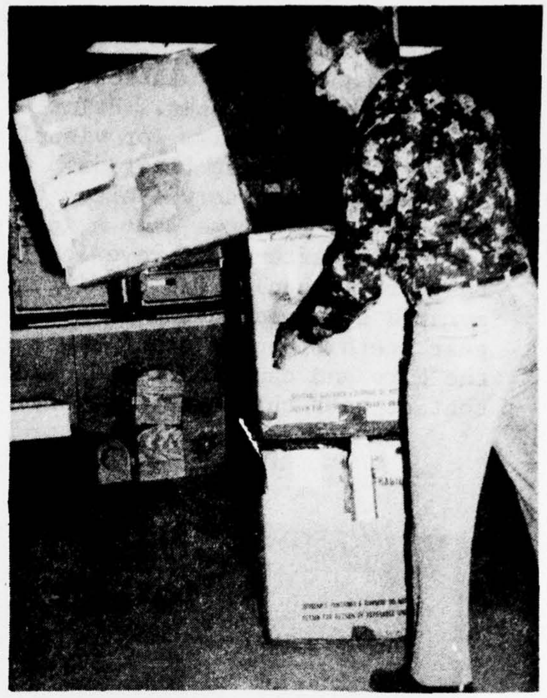
Test Pack	Peak Acceleration (Gs) Bottom Face	Average For Flat Drops	Average For Edges & Corners	Pack Average
A	83.7	40.5	15.0	20.9
B	17.5	16.2	14.0	14.6

Free Fall Drop Test from a Three-High Stack (Non-standard test)

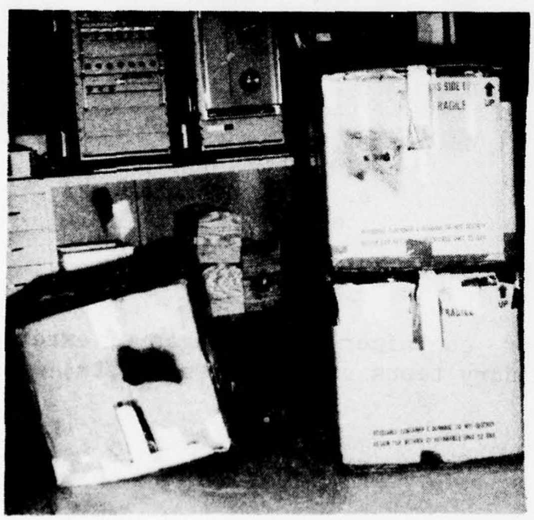
Pack A was placed on the top of a three-high stack and manually tipped to simulate toppling as shown in the series of photographs in Figure 4. The resultant impact force on the top edge was 38.7 G.



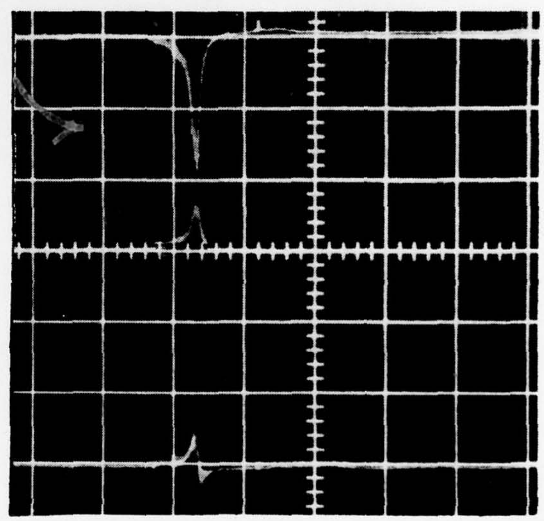
a. Instrumented Pack on Top



b. Beginning of Drop



c. Drops on Top Edge

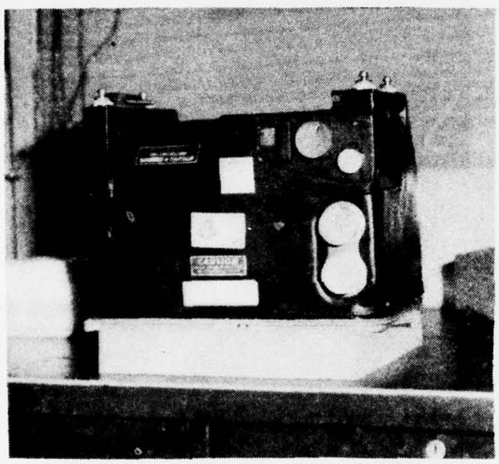


d. Oscilloscope Trace of Actual Drop

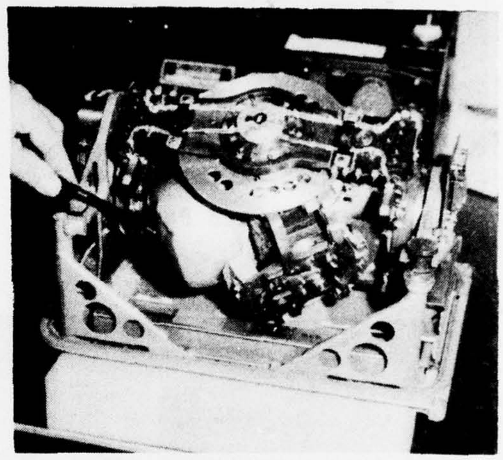
FIGURE 4. Photographs of Three-High Stack Drop Test.

Drop Test of Actual Platform (Non-standard test)

A serviceable LN-12 platform was dropped from a height of 48 inches in each of the test packs. Prior to each drop, the cover was removed to inspect the mechanism for visual damage. Because Pack A was found to be substandard, the first drop was made with Pack B. No visual signs of damage were observed after this drop. However, when the platform was dropped from the same height in Pack A, severe damage resulted. Inspection after test revealed that the gyro assembly was not balanced, the gyro mechanism was binding, the shock mounts were distorted, a scratch appeared on the large gear face as a result of contact with the gear teeth of an adjacent small gear and a dent was observed on one of the gyro end caps which indicated that the inner mechanism had come in contact with the outer assembly. The dent is shown in Figure 5.



a. LN-12 with Cover



b. Mechanism Exposed

FIGURE 5. Photographs of LN-12 Platform

It is important to note that neither container showed signs of external damage as a result of these preliminary tests or subsequent tests, with the exception of the field test.

Field Test

Three test packs (Figure 6), instrumented with transportation environment recorders (Figure 7), were shipped simultaneously from Wright-Patterson AFB, Ohio, to Nellis AFB, Nevada, via Logair, to monitor the transportation and handling environment of the LN-12 platform. The route included stops at

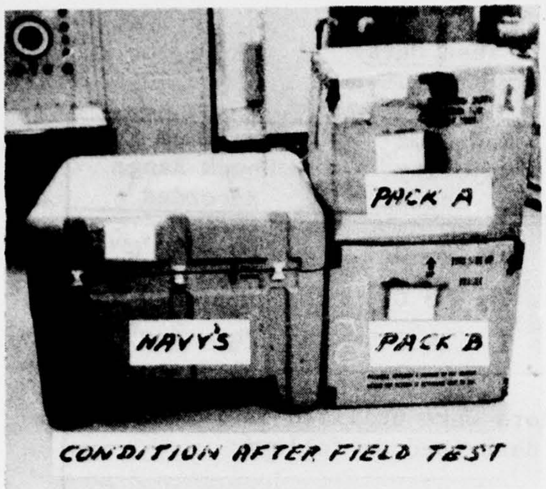


FIGURE 6. Field Test Packs.

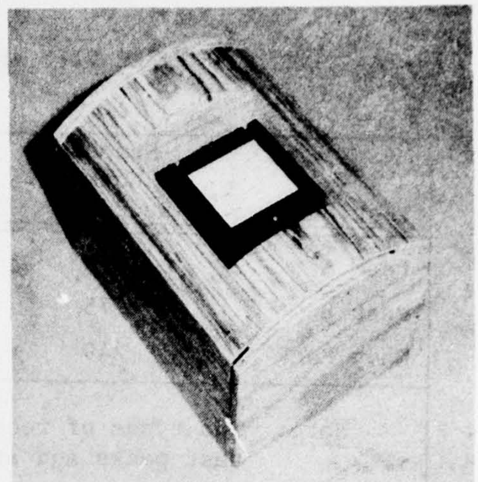


FIGURE 7. Environment Recorder.

Dover, Robins, Kelly and Hill Air Force bases. Data were also recorded for the return trip to Wright-Patterson AFB, Ohio. The results correlated with in-house tests conducted by this Agency and revealed that the substandard Pack A received high level shock inputs as shown in Table VII.

TABLE VII. Field Test Data.

Test Pack	Number Shocks Recorded	Range of Majority of Shocks	Maximum Shock Range Recorded
Pack A	1638	5 - 7½ G	60 - 70 G
Pack B	75	2½ - 5 G	17½ - 20 G
Navy Pack*	249	1 - 2½ G	2½ - 5 G**

Note: Two types of recorders were utilized in these test packs and are described as follows:

Resultant: Electronically computes the resultant of the x, y and z components (shock level range: 2½ - 90 G).

Non-resultant: Records the x, y and z components separately. This recorder also monitors the temperature and humidity (shock level range: 1 - 80 G).

Additional Data:

1. Recorded temperature range: 40 to 80°F (3.8 days @ 60 to 70°F)
2. Recorded humidity range: 0 to 60% (4.3 days @ 30 to 40%)
3. Elapsed time: 8.1 days

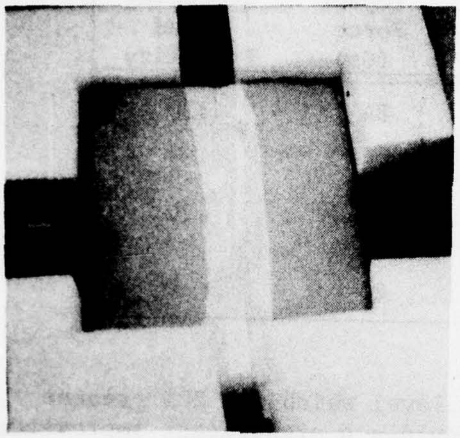
*Non-resultant recorder

**The resultant force would be at a slightly higher level

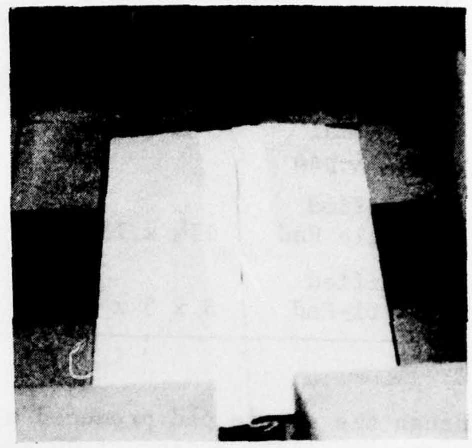
The majority of the low level shock inputs recorded in each test pack resulted from transportation vibrations.

The low level shocks recorded in the Navy's pack are a result of its design, size and weight. The size (36" x 30" x 29") and the gross weight (104 lbs.) reduces the possibility that this pack will be handled severely or placed at the top of the stack when the cargo is palletized. In contrast, the smaller (23" x 21" x 21") and lighter fiberboard packs (46-49 lbs.) can easily be dropped or placed at greater heights in a stack and subsequently have a higher drop height potential.

Immediately after the test packs returned from the field test, the containers were opened and the position of the inner carton was photographed as shown in Figure 8.



Pack A



Pack B

FIGURE 8. Photographs of Inner Carton.

The bottom cushioning material of Pack A was compressed to a thickness of less than 2 inches compared to negligible compression in Pack B. The top corner of Pack A was crushed, as can be seen from the photograph of the three test packs (Figure 6).

Drop Test of Modified Pack A

As an interim corrective action, Pack A was modified to improve the cushioning capability of the bottom surface. The modification was achieved by replacing the four 5 x 5 inch bottom cushion sections of the bottom corner cushion assembly with a single cushion pad (15½" x 13" x 4"). The cushioning material was identical to the material in Pack B.

The result of the 30-inch drop (Table VIII), on the bottom face, is compared with the shock levels of Pack A prior to the modification and with individual pads fabricated from the correct cushioning material.

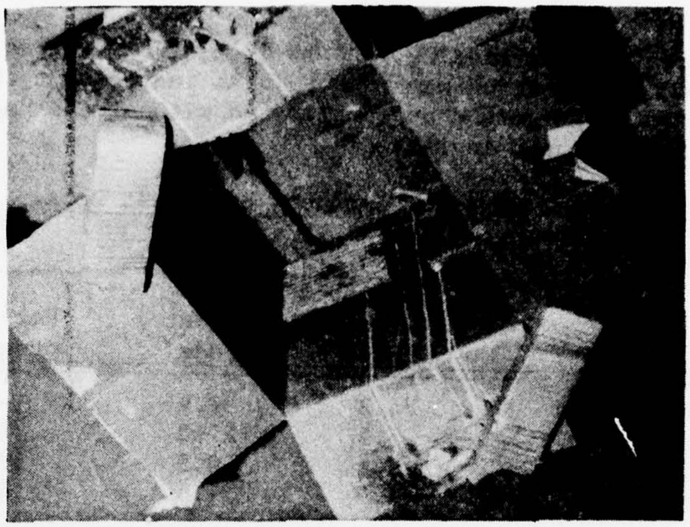
TABLE VIII. Modified Pack A Data.

Type Pad	Pad Size (inches)	Number of Pads	Impact Force (Gs)	Percentage Exceeding Rated Fragility
Original Multi-pad	5 x 5 x 4	4	84	320
Modified Single Pad	15½ x 13 x 4	1	24	20
Modified Multi-Pad	5 x 5 x 4	4	20	0

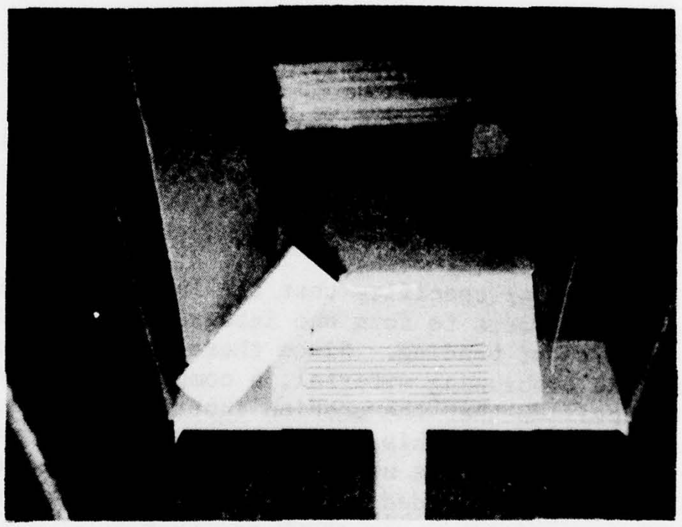
Although the single pad produced a shock level which was 20% greater than the fragility rating of 20 G, it provides a significant improvement. It was recommended because no bonding was required, less man-hours for fabrication was required, and, most important, the possibility of the smaller pieces becoming dislodged or lost was eliminated.

Missing Component Test

During a tour of the AGMC facility, examination of incoming LN-12 platform packs revealed missing or loose fiberboard components in the inner carton. Pieces most susceptible to being lost or coming loose are the top fiberboard pads which separate at the bonded surface as shown in Figure 9a. Loose pads may also result from fiberboard ply separation as can be seen in the photograph of an unused pack as shown in Figure 9b.



a. Separation of Bond



b. Separation of Fiberboard Ply

FIGURE 9. Photographs of Loose Pads.

If the pads are loose or missing, the LN-12 platform can move within the fiberboard carton, which may result in an increase in the shock level. The test packs were dropped with and without the pads and produced results as shown in Table IX.

TABLE IX. Missing Component Drop Test Data.

Test Pack	Impact Face (30" Drop)	Impact Force With Pads	Impact Force Without Pads	Percent Increase
A	3 (bottom)	74.3	57.9*	---
	1 (top)	25.5	27.8	7
	2 (front)	22.1	30.8	39
	5 (side)	47.9	51.6	8
B	3 (bottom)	16.4	21.0	28
	1 (top)	15.7	15.7	0
	2 (front)	12.0	17.1	43
	5 (side)	19.5	20.2	4

*Misaligned drop (not flat)

The front and back faces will receive higher level shocks because of the greater distance between the item and the inner carton wall which allows for a "rolling effect".

Drop Test of Modified Pack B

TPO 00-987-6167 (note 4) specifies that the inner carton is to be bonded on all cushioning surfaces to form one integral unit. Tests were conducted with and without bonding. Since there was some clearance between the carton and the cushioning material, a complete bond was not possible. Also, the TPO specifies that the cushion inserts are to be cut to the depth indicated in note 1. This cut provides a shear stress relief for all the bearing surfaces. The new pack (B), as received from AGMC, did not have the inner carton bonded or the shear stress reliefs. The drop test data of these variations are shown in Table X.

TABLE X. Test Data on Pack B Modification.

Impact Face (30" Drop)	Impact Force (Gs) Unbonded Carton Without Shear Reliefs	Bonded Carton	With Shear Relief
3	17.5	17.5	19.0
1	15.7	14.4	14.1
2	12.0	16.2	14.0
4	16.0	19.1	16.1
5	17.1	16.1	16.1
6	19.1	19.0	19.0
average	16.2	17.0	16.4

Cushioning Material Evaluation

Data on the properties of the cushioning materials from each pack are summarized in Table XI. Details on the evaluation of the material properties are presented in an AFPEA "Memo for Record", dated 10 May 1978. The TPO specifies that the cushioning material is to be 2 pcf ester base polyurethane flexible foam. To demonstrate the difference between the materials in the two packs, a load with the same weights and surface areas was placed on the materials from each pack. The material from Pack A would not support the load without toppling unless it was manually balanced, as shown in Figure 10. The load on material B remained upright.

TABLE XI. Summary of Cushion Characteristics.

Test Pack	Material Base	Density (pcf)	% Dev. From TPO	Stress At 0.66 psi Loading: Creep (%)	Set (%)	Max. Def. (%)	ILD 25% Def. (lbs.)
A	ether	1.1-1.4	30-45	21.0	2.3	53.8	25
B	ester	1.7	15	2.3	1.1	6.5	48

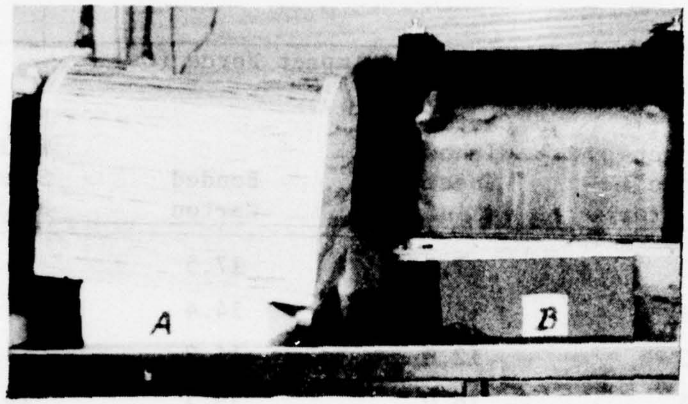


FIGURE 10. Photo of Loaded Cushion

DISCUSSION

During the 15 March 1978 meeting at AGMC, a committee member recommended including stacking height instructions in the TPO to limit the stack to two high. Our test results support this recommendation and stacking height instructions should be included in all TPOs of fragile items.

Loose and broken staples were found in Pack A. This could produce a potential safety hazard (cut fingers) for personnel handling this container.

CONCLUSIONS

1. Pack A provides significantly less shock protection than Pack B, to the extent that the LN-12 Platform could be severly damaged if accidentally dropped during shipment. This inadequate protection is attributed to both the appreciable permanent set and deflection under static load experienced by the cushioning material used. This reduced the thickness of the bottom cushion pad from 4 inches to 1½ inches. This problem could be prevented if an Indent Load Deflection (ILD) requirement was specified in procurement of the cushioning material.

2. Bonding the inner carton to the cushioning material does not appreciably affect the pack characteristics.

3. Shear stress relief cuts, in the cushioning material, do not significantly change the pack dynamic cushioning characteristics; however, the cut cushion sections are more susceptible to dislodging than the uncut design.

4. Loose or missing fiberboard components of the inner carton can reduce the effectiveness of this pack.

IMPLEMENTATION

As a result of AFPEA's recommendations, the following actions have been taken:

1. As of 1 June 1978, AGMC has removed 120 of the substandard packs from the logistics system and 50 of the existing packs have been modified.

2. Approximately 600 new packs have been ordered by AGMC to replace the substandard pack.

FUTURE ACTIONS

AGMC responded to AFPEA's 23 March 1978 verbal recommendations and immediately began removing the substandard packs from the logistics system. As a result of their actions, the April and May damage rate was reduced as shown in Table XII.

TALBE XII. LN-12 Damage Rate.

1978 Damage Rate	Jan	Feb	Mar	Apr	May
	7	15	12	5	3

The damage rate will continue to be monitored to determine the effect of the pack replacement actions.

RECOMMENDATIONS

1. Investigate the possibility of using a multipurpose reusable container similar to the pack used by the Navy to ship their avionic equipment.

2. Monitor the progress of the new packs through the calendar year 1978.

3. Include the Indent Load Deflection (ILD) requirement for the cushioning material, in the TPO.

DISTRIBUTION LIST

HQ USAF/LEXTN Wash DC 20330	1
AGMC/MABE Newark AFS OH 43055	2
AGMC/SNA Newark AFS OH 43055	1
Aviation Supply Office ATTN: TEP-A Philadelphia PA 19111	1
Commander US Army Natick R&D Ctr/DRXNM-EPS Natick MA 01760	1
NWC-Earle Colts Neck NJ 07722	1
DESC/LQP 1507 Wilmington Pike Dayton OH 45444	1
JMPTC Aberdeen Proving Ground MD 21005	2
ADTC/SD3E Eglin AFB FL 32542	1
ADTC/SD3P Eglin AFB FL 32542	1
OO-ALC/DSTC Hill AFB UT 84406	1
OC-ALC/DSPA Tinker AFB OK 73145	1
OC-ALC/MMIMI Tinker AFB OK 73145	1
SA-ALC/DSP Kelly AFB TX 78241	1
SM-ALC/DSP McClellan AFB CA 95652	1
WR-ALC/DSP Robins AFB GA 31098	1

DISTRIBUTION LIST (cont.)

Tobyhanna Army Depot/DRXTO-TP-S Tobyhanna PA 18466	1
HQ AFSC/LGT Andrews AFB DC 20334	1
AFALD/PT	1
AFLC/LOT	1
AFALD/PTP Library	10
ASD/AEGT	1
DDC-TC (Accessions Division) Alexandria VA 22314	12
DLSIE/DRXMC-D US Army Logistics Management ATTN: Mr. Malcolm Alley Fort Lee VA 23801	2

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: PTPT Report No. 78-14	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): PACKAGING AND SHIPPING ANALYSIS OF THE LN-12 INERTIAL PLATFORM	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER: AFPEA Project No. 78-P7-5
7. AUTHOR(s): Frank C. Jarvis	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: AFALD/PTPT Wright-Patterson AFB OH 45433	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: AFALD/PTP Wright-Patterson AFB OH 45433	12. REPORT DATE: June 1978
	13. NUMBER OF PAGES: 26
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

LN-12 Inertial Platform; packaging; laboratory test; vibration, field test, drop test.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Air Force Packaging Evaluation Agency's (AFPEA) packaging and shipping analysis of the LN-12 Inertial Platform (NSS 6605 00 945 8168) was initiated as a result of an urgent request by the Aerospace Guidance and Metrology Center (AGMC), Newark AFS, Ohio, to investigate excessive damage to this unit. During the period August 1977 through 15 March 1978, 51 damaged platforms were received by AGMC. This represented an increase of 388% above the normal repair rate. → over

(cont.)

The packs being used to ship the LN-12 platforms were manufactured by two different contractors. A comprehensive evaluation program revealed that the packs supplied by one of the contractors did not confom to the Transportation Packaging Order (TPO). The shock level generated on the bottom face of this substandard pack, when dropped from a height of 30 inches, was 300% greater than the rated fragility of 20 G for this item.