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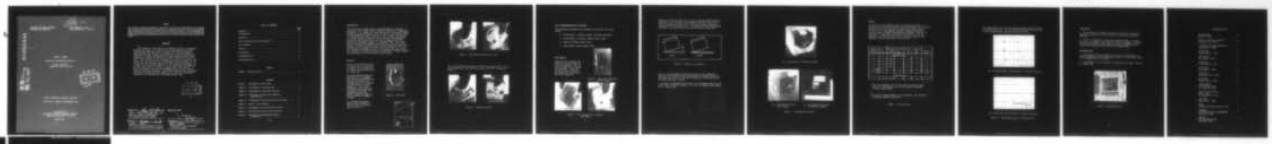

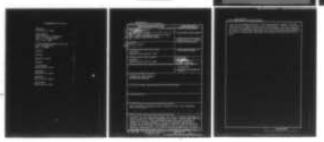

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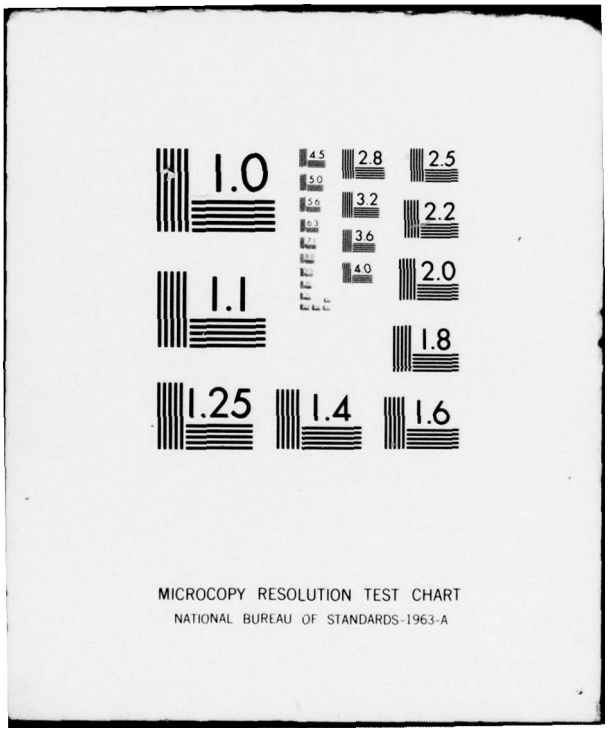
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"OUT OF CONTAINER" HANDLING ANALYSIS OF THE LN-15 INERTIAL MEASUREMENT UNIT

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

March 1978

NOTICE

ABSTRACT

The purpose of this study was to analyze the "out of container" handling procedures of the LN-15 Inertial Measurement Unit (IMU). Unserviceable IMUs were being received by Air Force maintenance organizations which resulted in requests for container evaluation. During the container testing phase, problems were encountered while attempting to remove the IMU from the inner container of the test pack. This container had to be turned on its side to remove the IMU because the top section of the polyethylene insert separated at the bonded joint and the IMU could not be lifted from the container. As a result of this awkward maneuver, it was recognized that damage to the IMU could occur if it came in contact with a hard surface. An "out of container" test plan was implemented and a series of non-standard tests were conducted. The results revealed some significant shock input information which should be of value to all personnel responsible for handling and installing delicate IMUs.

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INTRODUCTION

Since the cause of some types of shipping damage to inertial measurement units (IMUs) cannot always be attributed to inadequate packaging, it is assumed that some IMUs may be accidentally bumped, knocked, dropped or vibrated after the item has been removed from its protective container or carrying case. A small bump against the aircraft frame or vibration from a vehicle transporting an unprotected IMU to and from an aircraft or supply area would normally be overlooked because it is assumed that a very slight bump would have little damage potential to an item of this type. However, "in-house" handling tests revealed that shock levels far exceeded the 15G fragility rating of the LN-15 IMU; i.e., a one-inch edgewise rotational drop on a hard surface generated 100 Gs. This simulated a situation wherein an individual's fingers slipped out from under one end of the IMU during lifting.

APPROACH

Since the LN-15 does not have a carrying case or handles on the shell, the test plan was to simulate the handling without these aids.

The LN-15 IMU Shop Guide (1-B52-2-39JG-1-8) recommends that the item be handled with the 1½ inch diameter hose fittings located in the front and back faces of the IMU (Figure 1). Since these fittings are not located at the center of gravity, this handling method could produce accidental bumps or drops resulting in damage to the IMU.

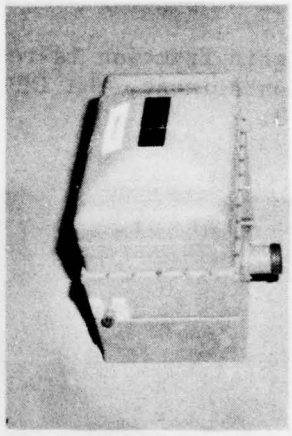


Figure 1. LN-15 IMU

If a strong grip is not applied when lifting, the IMU can start to rotate as shown in Figure 2.

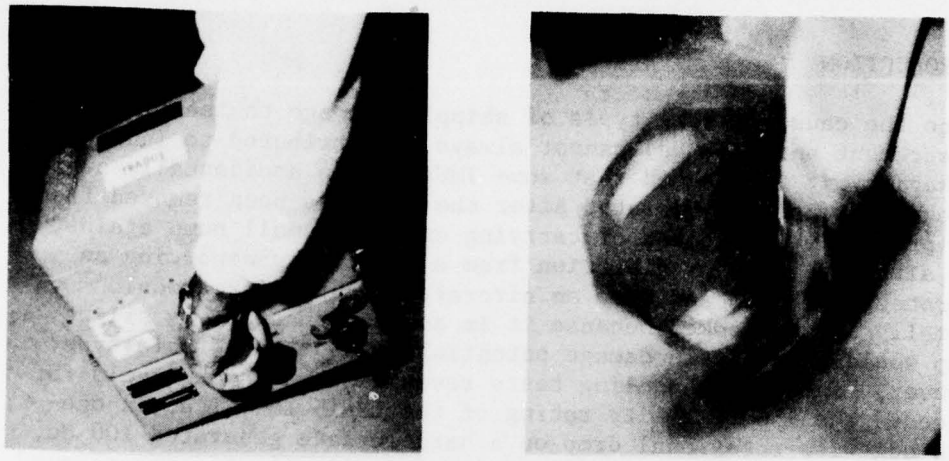


Figure 2. IMU Begins Rotating After Lift

If the grip friction is reduced by water from perspiration, oil or other contaminant, the IMU could rotate a full 180 as shown in Figure 3.

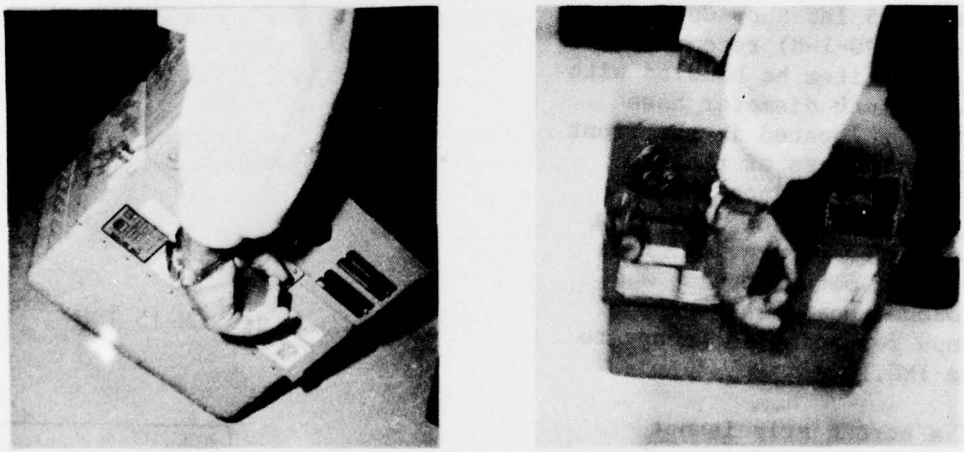


Figure 3. Complete Rotation

TEST INSTRUMENTATION AND EQUIPMENT

The following instruments and equipment were used for this test series:

1. Oscilloscope, 4 channel storage, Tektronix Type 564B.
2. Accelerometer, tri-axial, Endevco Model 2233E.
3. Amplifier, Endevco Model 2614C.
4. Power supply, Endevco Model 2622C.

TEST METHODS

Simulated hose fittings were added to the wooden model of the LN-15 (Figure 4) and the "hose fitting" lift technique was performed. During the lifting process, the model was allowed to rotate and hit the floor (Figure 5).

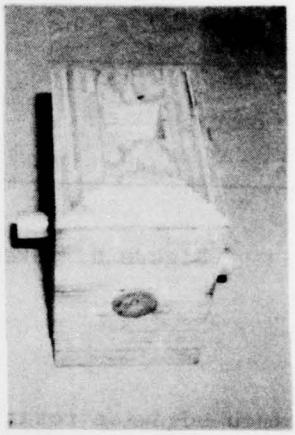


Figure 4. Model with Simulated Hose Fittings

Figure 5. Hose Fitting Lift Technique with Model

Since this method was difficult to control and the results were not repeatable, a two and four inch edgewise rotational drop test was used to simulate the impact force an IMU may receive during this rotational lift and drop process. The method is shown schematically in Figure 6 with and without a protective cushion on the floor.

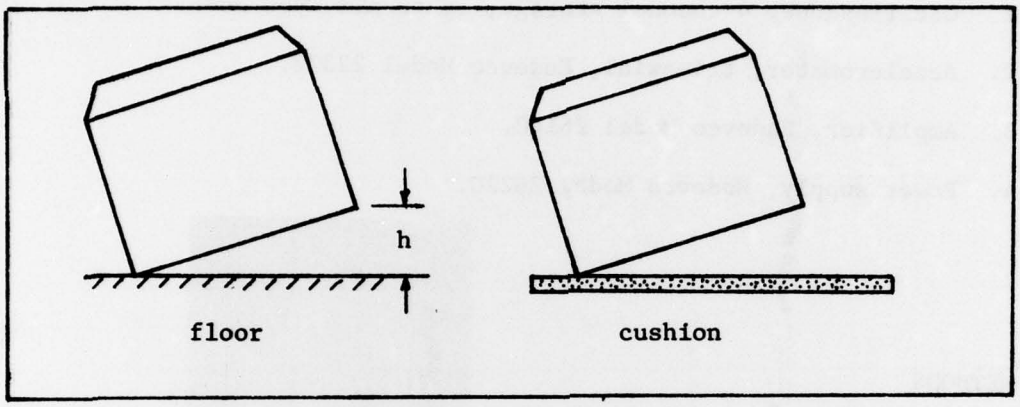
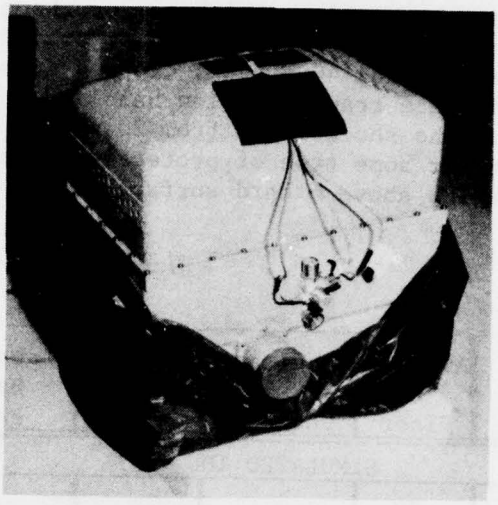


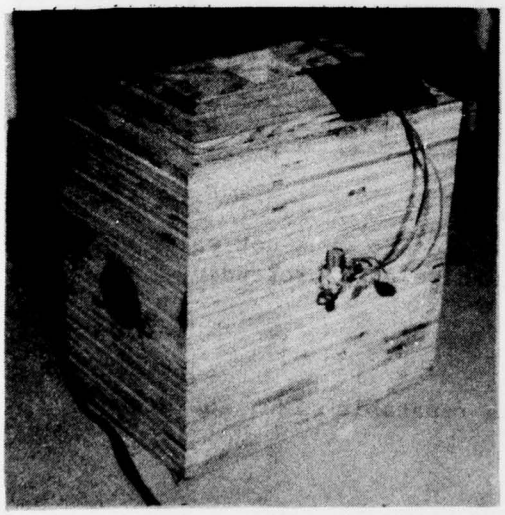
Figure 6. Sketch of Test Method

Also, a one inch edgewise rotational drop test was conducted to simulate the situation wherein an individual's fingers slipped out from under one end of the IMU when lifting with the bottom surface instead of the hose fittings.

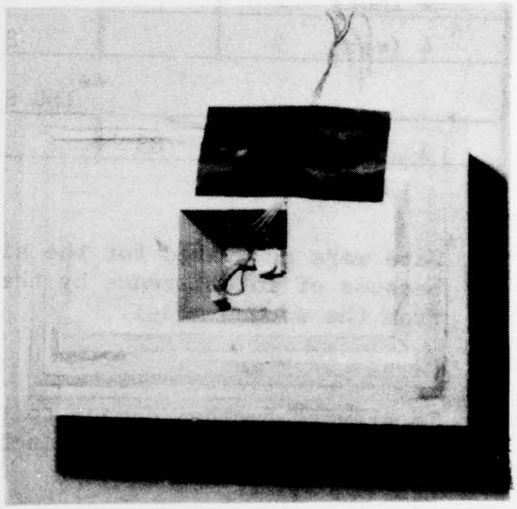
A tri-axial accelerometer was secured to the simulated model and the actual IMU, as shown in Figure 7, to record the impact forces along the x, y and z axes.



(a) Accelerometer on Back Face of IMU



(b) Accelerometer on Back Face of Model



(b) Accelerometer at Center of Gravity of Model

Figure 7. Accelerometer Location

RESULTS

The results of the handling tests are presented in Table I. It should be noted that the one inch thick polyurethane (1½ pcf) foam cushion used for the four inch drop would not provide much protection for an item weighing 40 pounds, dropped from heights normally used to simulate transportation handling. However, in this case it reduced the shock level from 200 Gs to 5 Gs and emphasizes the need for some type of protective covering when handling a delicate IMU above a hard surface.

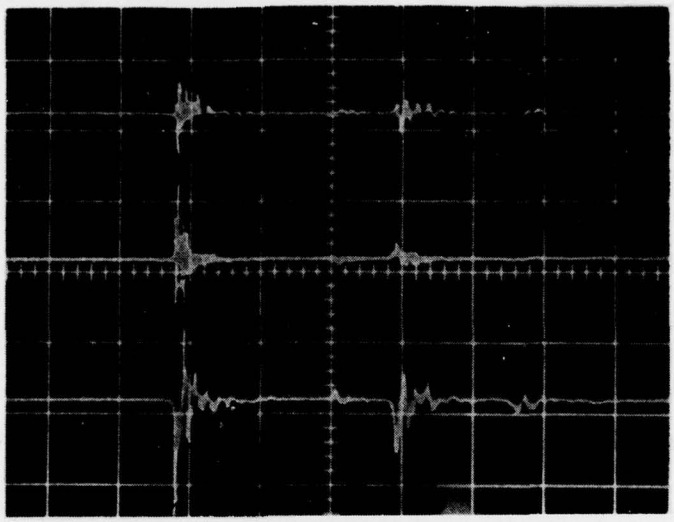
Edgewise Drop Ht. h(inches)	No. of Drops	Average Resultant Force - Gs		Accel. at C.G.	Location Back Face	Duration msec.
		Floor	Cushion			
SIMULATED IMU						
1	1	99			X	3
2	4	138		X		6
2	1	136			X	5
4	8	211		X		2
4 (hor)	2		5		X	15
* 4 (ver)	2		8		X	15
** IMU S/N 193						
1	3	83			X	2

*Data were generated for the side face but were not valid because of interference by the lead weights protruding from the wooden model.

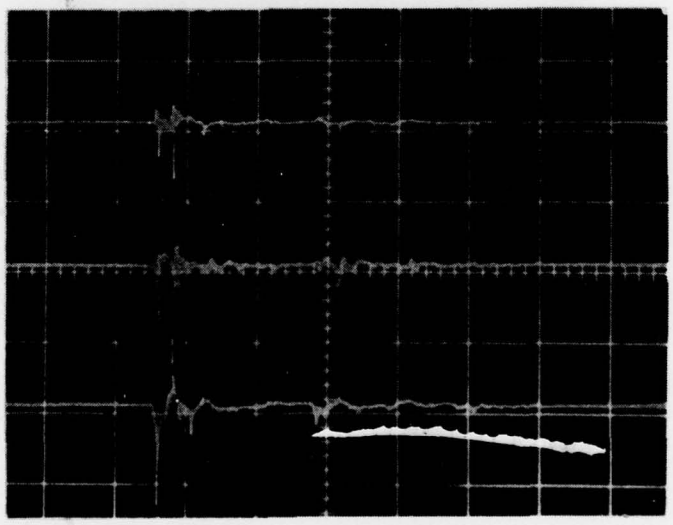
**To prevent further damage to this reparable IMU, the drop height was limited to one inch.

TABLE 1. Drop Test Data

The oscilloscope traces of the one-inch edgewise rotational drop are shown in Figure 8. Note the similarity between the wave form of the simulated model (a) and the actual item (b).



(a) Simulated Model - 50 G/cm (vert.) 20 msec/cm (horiz.)



(b) Actual IMU - 50 G/cm (vert.) 20 msec/cm (horiz.)

Figure 8. Oscilloscope Traces of One-Inch Drop

CONCLUSIONS

1. The probability of damage occurring to the LN-15 is relatively high during removal from the protective container and subsequent handling.

2. Since it is difficult to prevent accidental shocks, a handling aid, such as a handle, could reduce the amount of damage. A special handling device which can be removed, is not recommended because studies have shown that these aids are not always used.

RECOMMENDATIONS

1. Incorporate a fold-type handle in the top of the IMU shell as shown superimposed on the photograph in Figure 9. This handle should be an integral part of the shell.

2. Re-emphasize, to all personnel, the importance of proper handling of fragile IMUs.

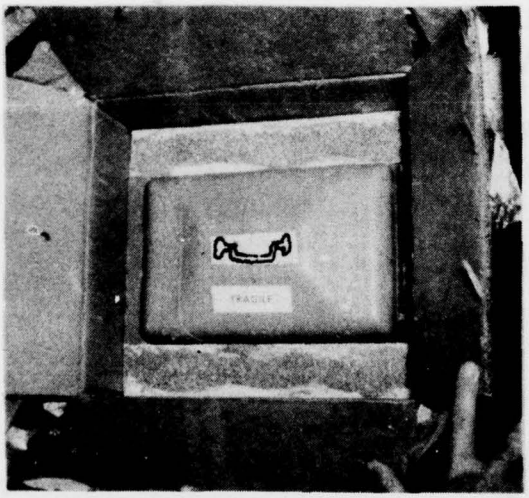


Figure 9. Handle Location

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*
The purpose of this study was to analyze the "out of container" handling procedures of the LN-15 Inertial Measurement Unit (IMU). Unserviceable IMUs were being received by Air Force maintenance organizations which resulted in requests for container evaluation. During the container testing phase, problems were encountered while attempting to remove the IMU from the inner container of the test pack. This container had to be turned on its side to remove the IMU because the top section of the polyethylene insert separated at the bonded joint and the IMU could not be lifted from the container. As a

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result of this awkward maneuver, it was recognized that damage to the IMU could occur if it came in contact with a hard surface. An "out of container" test plan was implemented and a series of non-standard tests were conducted. The results revealed some significant shock input information which should be of value to all personnel responsible for handling and installing delicate IMUs.