

Measurement and Analysis of shocks to packages and pails in single parcel ground shipping environment

Koushik Saha and S.Paul Singh (Ph.d)

School of Packaging, MSU

Agenda

- **Introduction**
- **Objectives**
- **Materials and Methods**
- **Results and Discussions**
- **Conclusion**
- **Test Protocol**

Introduction

- **Plastic pail**

- Introduced to the packaging industry in 1967¹
- Expected to replace existing bulk consumer packaging systems such as glass jars, metal pails, tins, steel drums, and bulk boxes
- Products such as paints, food products, and adhesives were initially packaged in plastic pails
- Plastic pails became more widely used than metal pails, since plastic pails were more durable and cost-effective



Introduction

• Plastic pail



- Made from high density polyethylene (HDPE), and range in size and thickness
- Five-gallon capacity is the most common and widely used
- Lube oils, vegetable oils, building products, paints, pet food, adhesives, sealants, and hazardous materials (HazMat) such as paints, food and flavoring, janitorial supply, chemical powders and solvents
- Shipped via ground (truck and rail) in palletized quantities

Introduction

- **Plastic pail**

- In the past, test methods to determine the performance of plastic-pail packaging were conducted by the Department of Transportation (DOT) at the request of the Food and Drug Administration (FDA).
- The single-parcel shipments have increased with a demand of direct delivery of individual packages to the customer by carriers such as FedEx, UPS and DHL.
- However, currently there are no test methods with validation to test the performance of individual pails that are exposed to the handling and transportation environment of single-parcel ground shipment.

Introduction

- **Previous studies**

Singh and Voss (1992)² studied the drop height of different sizes and weights of packages ranging from small, medium, and large and weighing 20 to 45 lbs, in a small-parcel environment via UPS Ground service .

The package sizes had no significant effect on the drop heights. The package weights also had no significant effect on drop heights for medium and large size packages. However, lighter weight packages of smaller sizes experienced higher drop heights.

Introduction

- **Previous studies**

Hays (1999)³ measured the dynamic events of large and heavy packages ranging from 40-150 lbs in UPS Ground shipping environment.

The result showed slightly effect of size and weight on average drop height levels. Results also showed that 50% of all drops occurred on an edge of packages followed by a face and a corner.

Introduction

- **Previous studies**

Singh *et al.*, (2004)⁴ measured the dynamics of air shipments of light weight packages (weighing less than 5.5 lbs) of various sizes, with and without warning labels via FedEx second-day air shipments.

The results were similar to some of the previous studies. Package size and weight had no effect on measured drop heights for packages classified as small and light-weight. Warning labels reading “Fragile-Handle with Care” had also no significant effect on the handling of packages.

Introduction

- **Previous studies**

Singh *et al.*, (2007)⁶ studied the effect of pictorial markings and warning labels on handling of packages in the DHL single-parcel environment (next-day and 2nd day services).

The study showed similar drop height levels in DHL next-day and 2nd day shipments.

Pictorial markings and warning labels reading “Fragile” and “Handle with Care” had no effect on drop height levels or better handling of packages in DHL’s single parcel environment.

Introduction

- **Code of Federal Regulations (Title 49 CFR) for HazMat Packages⁷**
 - Published by the US Department of Transportation (DOT).
 - National Motor Freight Classification (NMFC); Item 258
 - Uniform Freight Classification (UFC) ; Rule 40

Introduction

- **FedEx Hazardous Material Shipping Guide⁸**
 - All hazardous materials must be packaged in the United Nations Performance Oriented Packaging (UN POP) except when non-specification packaging is authorized by title 49 CFR.
 - All packaging must meet the requirements set out in title 49 CFR 173.24 and 173.24a. Packaging that is not in new or “like new” condition will not be accepted.
 - Hazardous materials cannot be shipped in any FedEx packaging.

Introduction

- **FedEx Hazardous Material Shipping Guide**

- Hazardous materials cannot be banded, strapped or taped to form a bundle.
- FedEx Ground does not accept pails or drums over eight gallons (32 liters). All pails or drums must be UN POP.
- FedEx will accept authorized pails or drums as single packaging, however an incompatible fee may apply to these shipments.

Objectives

- To measure the dynamics of the ground shipping environment in FedEx for five-gallon pails shipped with and without secondary outer corrugated packaging.
- To study the effect of warning labels “Handle with Care” on the severity of drops of pails observe when shipped by FedEx Ground.
- To develop a test protocol to test pails for the FedEx Ground shipping environment.

Materials & Methods

- Test instrumentation and recording parameters
- Drop height calculation
- Test package shipments

Materials & Methods

- **Test instrumentation and recording parameters**

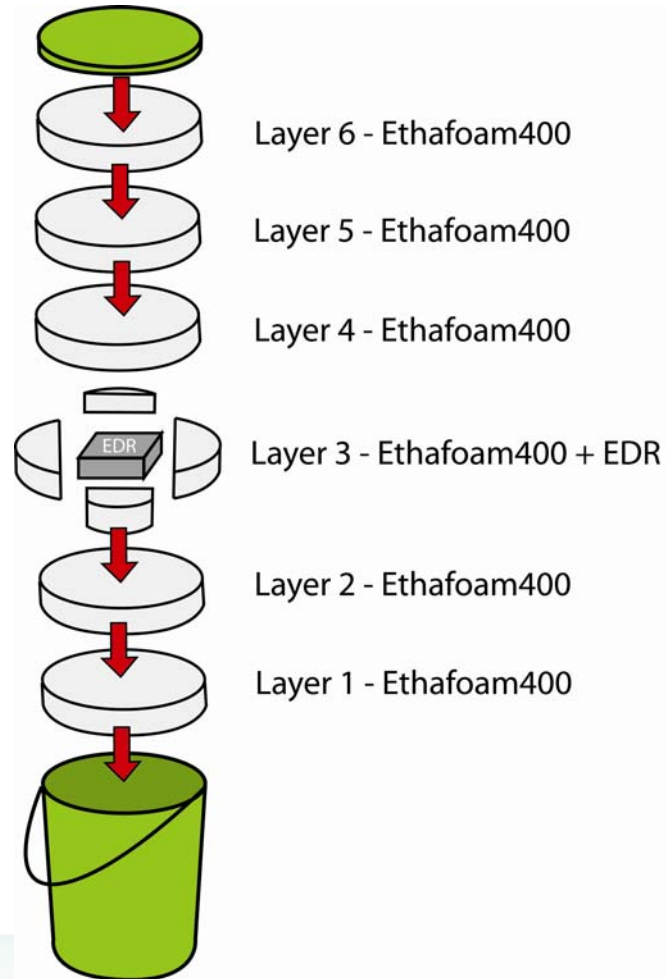


The Environment Data Recorder (EDR) model EDR-3C manufactured by Instrumented Sensor Technology (IST)

- Pre-trigger time- 50 ms
- Post trigger time- 250 ms.
- Sampling rate- 1,000 Hz.
- Trigger level -2 G
- Dead time after each event -140 ms.
- Test duration 60 days (fill-and-stop)

Materials & Methods

- Test package shipments



Materials & Methods

- Test package shipments

Manufacturer	Pail model	Lid type/model	Dimension (Diameter x Height) (in)	Thickness (mil)	Weight (lb)
Nampac (UN pail)	05UUN pail	20UN liquid	11.25 x 14.25	90	8
Letica	90 mil pail	cut-tab cover	11.00 x 14.00	90	8
Plastican	40B pail	40CRT tear strip	11.25 x 14.13	90	8
Encore	#50640	5 gal teat strip gasket	11.25 x 13.75	70	8
Pail with over-pack Box	-	-	12.50 x 12.50 x 17.25	-	8

Materials & Methods

- **Test package shipments**
 - Shipment 1. Plastic pails without warning labels
 - Shipment 2. Plastic pails with warning labels
 - Shipment 3. Plastic pails with secondary over-pack corrugated boxes

Materials & Methods

- Test package shipments



Shipment 1 : Instrumented pail without warning labels

Materials & Methods

- Test package shipments



Shipment 2 : Instrumented pail with warning labels

Materials & Methods

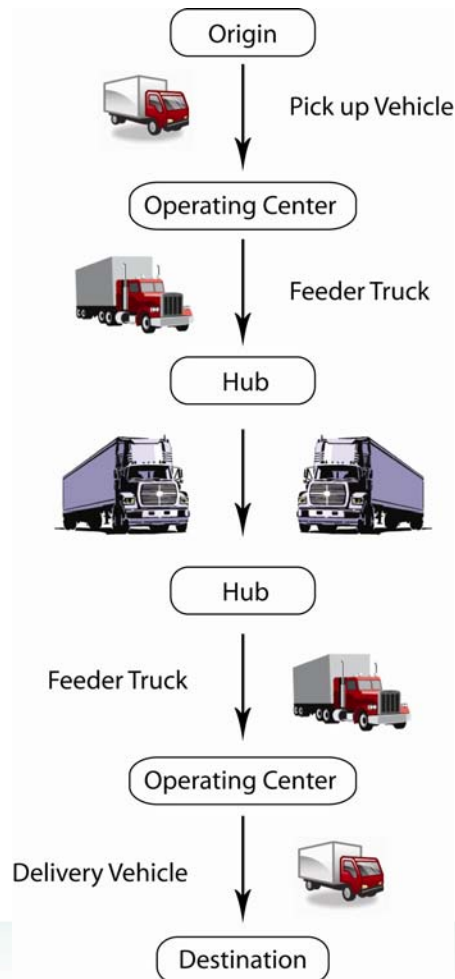
- Test package shipments



Shipment 3 : Instrumented package with secondary over- pack corrugated box

Materials & Methods

- Test package shipments



- Shipment from MI to CA

Distance : ~ 2,500 mi

Hubs : Toledo, OH

Champaign, IL

Lenexa, KS

Bloomington, CA

- Shipment from MI to NY

Distance : ~ 490 mi

Hubs : Toledo, OH

Syracuse, NY

Materials & Methods

- Test package shipments

Results & Discussions

- Pails condition after shipment



Pail without warning label after shipping

Results & Discussions

- Pails condition after shipment



Pail with warning label after shipping

Results & Discussions

- Pails condition after shipment



Pail with outer corrugated box after shipping

Results & Discussions

Average drop height data measured above 3 inches of pails with labels, without labels, and with over-pack corrugated boxes for one-way trip

Drop data	Without Label	With Label	With Corrugated Box
Average number of drops	10	10	18
Maximum drop height (in)	40.31	75.72	47.28
Drop height at 99% occurrence (in)	37.93	60.12	45.49
Drop height at 95% occurrence (in)	26.23	33.87	32.14
Drop height at 90% occurrence (in)	19.07	18.60	24.98
Average drop height (in)	8.44	9.75	11.25

Results & Discussions

Average highest drop height levels of pails with labels, without labels, and with over-pack corrugated boxes

Drop height (in)	Without Label	With Label	With Corrugated Box
Highest	23.90	30.27	34.13
2nd highest	12.33	14.87	27.42
3rd highest	9.77	10.28	21.92
4th highest	7.43	8.20	18.50
5th highest	5.93	7.69	14.88
6th highest	5.27	5.87	11.44
7th highest	5.06	4.83	10.03
8th highest	4.80	5.17	8.74
9th highest	4.92	5.16	7.82
10th highest	4.47	4.68	6.84

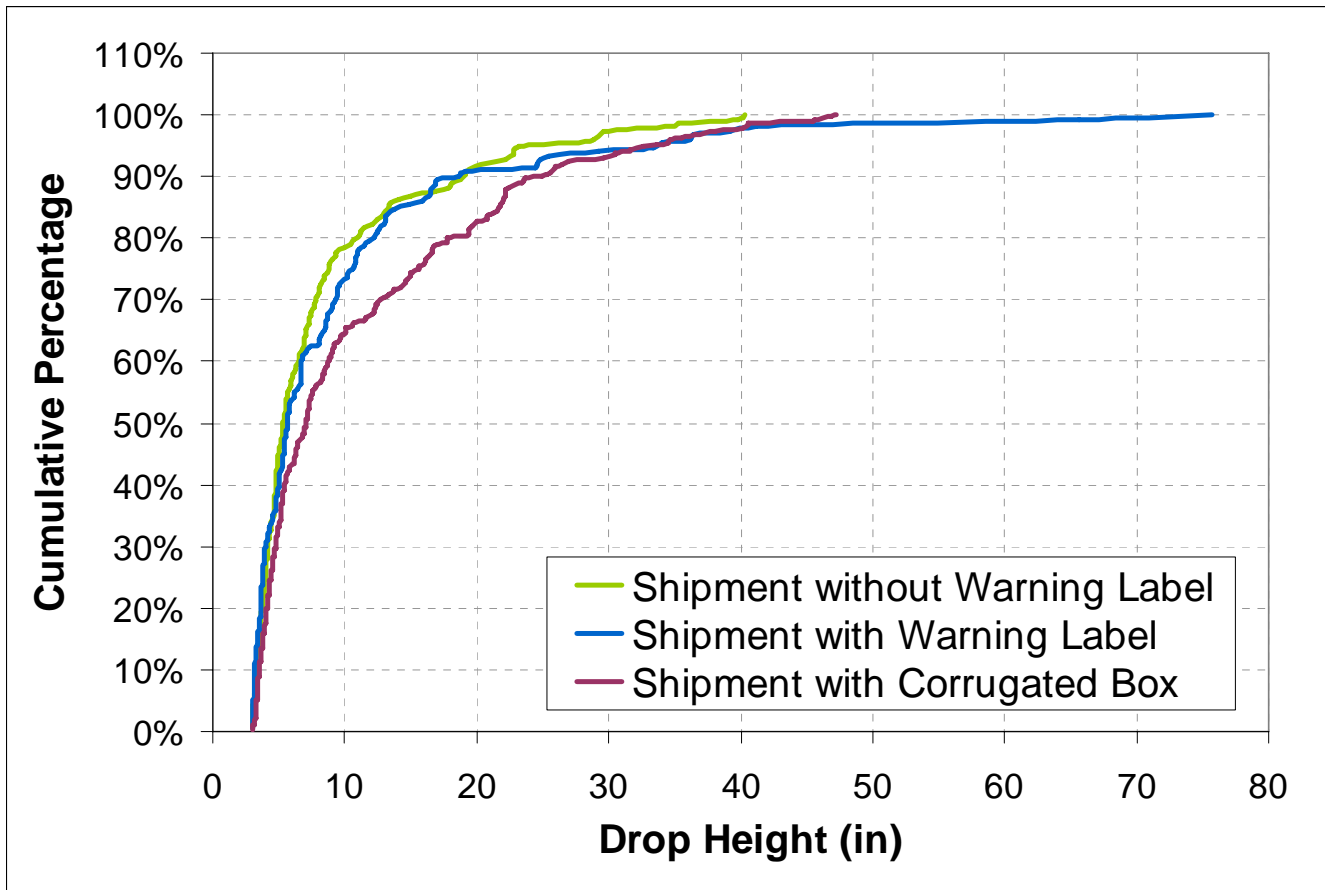
Results & Discussions

Percent impact orientations of pails with labels, without labels, and with over-pack corrugated boxes

Orientation of Drop (%)	Without Label	With Label	With Corrugated Box
Face (Bottom)	37.25	41.72	21.72
Face (Side)	62.75	58.28	34.48
Edge	-	-	27.59
Corner	-	-	16.21

Results & Discussions

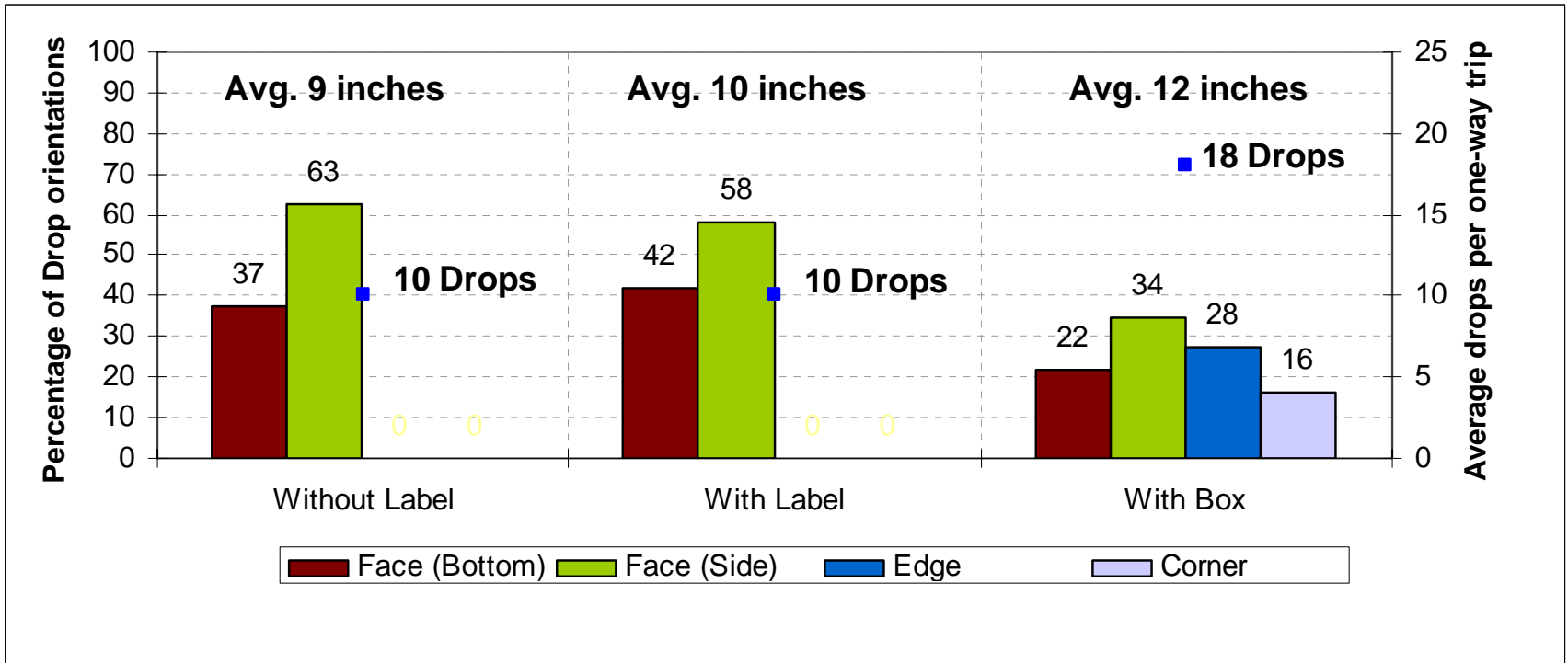
Cumulative Percentage versus Drop Height for packages with label, without label, and with over-pack corrugated box



Conclusion

- **This study showed that the dynamic data from UN pail and non-UN pail shipment were not significantly different.**
- **The pictorial marking or warning label had no effect in improving handling or reducing drop height level of pail in single parcel shipment.**

Conclusion



ISTA 3A Requires

Pails without over-pack corrugated box

Test sequence;

- 1 ea. 36 in. drop bottom
- 1 ea. 18 in. drop bottom
- 1 ea. 18 in. drop, bottom on hazard
- 13 ea. 36 in. drops, rim
- 1 ea 36 in., critical orientation

FedEx Requires

Test sequence;

- 10 ea. 30 in. drops
 - 6 ea. Top/bottom/sides, 4 on rims

Test protocol

Pails without over-pack corrugated box

The test protocol will perform drop tests from 28, 14, and 10 inches.

A total of 10 drops (4 drops on bottom and 6 drops on side of the pails) are to be performed.

Test sequence;

- At drop height of 28 inches perform 2 drops
(1 on bottom and 1 on side of the pails)
- At drop height of 14 inches perform 2 drops
(1 on bottom and 1 on side of the pails)
- At drop height of 10 inches perform 6 drops
(2 on bottom and 4 on side of the pails)

Test protocol

Drop test will be performed on the Drop Tester machine

Bottom drop

Side drop

References

- 1] Baker, D. H. (2008a). History of Plastic Pail Industry (Publication. Retrieved March 16, 2008, from Plastic Shipping Container Institute: <http://www.pscionline.org/history.html>
- 2] Singh, S. P., & Voss, T. (1992). Drop Heights Encountered in the United Parcel Service Small Parcel Environment in the United States. *Journal of Testing and Evaluation*, 20(5), 382-387.
- 3] Hays, Z. G. (1999). *Measurement of the United Parcel Service Ground Shipping Environment for Large and Heavy Packages (Up to 150 pounds)*. Michigan State University, East Lansing.
- 4] Singh, S. P., Burgess, G., & Singh, J. (2004). Measurement and analysis of the second-day air small and light-weight package shipping environment within Federal Express. *Packaging Technology and Science*, 17(3), 119-127.
- 5] Garcia-Romeu-Martinez, M.-A., Singh, S. P., Cloquell-Ballester, V.-A., & Saha, K. (2007). Measurement and analysis of international air parcel shipping environment for DHL and FedEx between Europe and United States. *Packaging Technology and Science*, 20(6), 421-429.
- 6] Singh, J., Singh, S. P., Voss, T., & Saha, K. (2007). A Study of the Effect of Pictorial Markings and Warning Labels on Handling of Packages in the DHL Single-Parcel Environment [Electronic Version]. *Packaging Technology and Science*, DOI: 10.1002/pts.800, 8. Retrieved March 16, 2008 from <http://www3.interscience.wiley.com/cgi-bin/fulltext/116837594/PDFSTART>
- 7] Code of Federal Regulations: Title 49, § 178.603 (2008).
- 8] FedEx. (2005). Hazardous Materials Shipping Guide (Publication no. OP-896). Retrieved March 26, 2008, from FedEx <http://images.fedex.com/us/services/pdf/HazmatShippingGuide.pdf>