Plastic Tote Drop Impact Study

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Abstract: Pre-shipment tests are well established for packages distributed from manufacturers to distribution centers. Healthcare products are often distributed in plastic totes from distribution centers to retail stores. Often products are damaged due to impact during transit. This study shows the impact acceleration can be reduced significantly by using bubble wrap at the bottom of the tote. The study also indicates that providing air pillows at the top of the tote to limit the product bouncing reduces maximum impact acceleration and impact accelerations after the initial impact.

Keywords: Packaging, plastic totes, healthcare product distribution, drop impact, bubble wraps, air pillow

Introduction

The Healthcare Packaging Consortium was established at Christian Brothers University (Memphis, Tennessee) on June 1, 2010, with seven founding members: Evergreen Packaging, FedEx, Medtronic, Merck Consumer Care, Plastic Ingenuity, Smith & Nephew, and Wright Medical [1]. Its mission is to advance healthcare packaging knowledge through education and research. This plastic tote study is one of the consortium‟s current R&D projects.

Healthcare products are typically shipped from manufacturers to distribution centers of "big box" retailers or large drug chains. At this distribution phase, products are well organized and shipped in large quantities. Pre-shipment tests, such as ISTA test procedures, are well established. At a distribution center, various products are often placed randomly in partially-filled plastic totes as shown in Figure 1. Damage to products often occurs during this distribution phase. There is no pre-shipment test established, nor good practices recommended. This missing link (Figure 2) is the motivation for this study.

Figure 1. Partially filled plastic tote

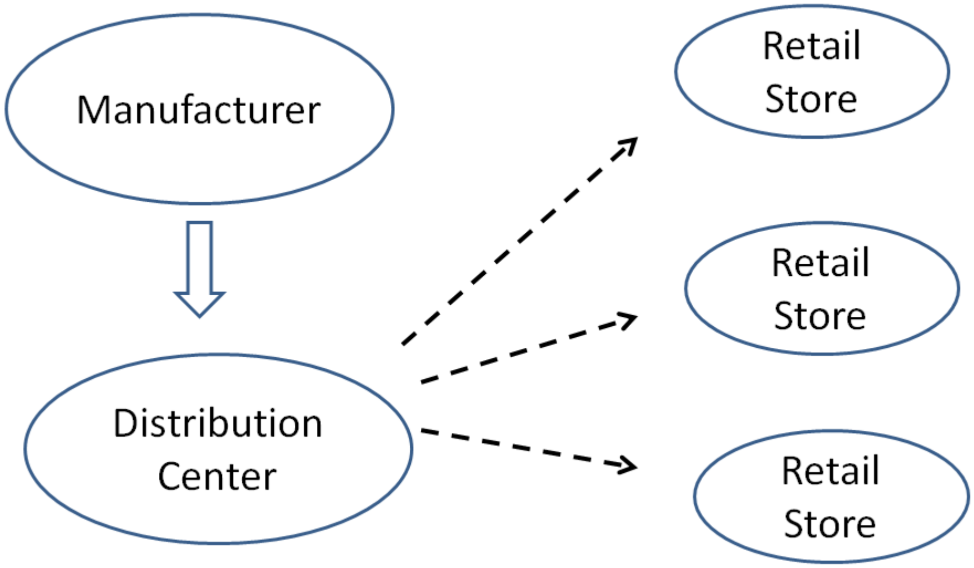


Figure 2. The missing link of healthcare product distribution

Rutledge, Malasri, and Lawrence [2] experimented with shipments of two comparable plastic totes, one with organized tote contents and another with unorganized contents. A wide range of damage occurred to products in the randomly loaded tote, including crushing of folding cartons, scuffing and abrasion of printed cartons, and tears in the shrink wrap film around banded aerosol cans, as shown in Figure 3. Thus, proper organization of tote contents was recommended over random placement in this previous study.

Figure 3. Damage found in the randomly loaded tote

In another controlled experiment [3], two common cushioning materials available in office supplies stores – thin cushioning foam (often used as sheet dividers for dishes) and 3/16" bubble wrap – were inserted separately underneath a Claritin box and secured at the bottom of the tote. The foam reduced drop impact acceleration by an average of only 5%, while the bubble wrap resulted in a 23% average reduction in drop impact acceleration. This preliminary study demonstrated the potential of using bubble wrap as a cushioning material at the bottom of a plastic tote to reduce impact acceleration and thus damage.

The current study extends the previous study [3] by considering two additional cushioning materials at the bottom of a plastic tote: thicker bubble wrap and thicker/better foam. In addition a study of the effectiveness of an air pillow, placed at the top of the tote, was performed. Air pillows can be used to fill in the empty space on the top part of a partially filled plastic tote; this helps to reduce the bouncing of products during transit.

Effectiveness of Cushioning at the Bottom of Plastic Tote

Cushioning Materials

Three cushioning materials are included in this study:

(1) 3/16" bubble wrap: As mentioned before, this was used in a previous study [3] and is included in this study for comparison with the other two new materials listed below.
(2) 5/16" bubble wrap: This was chosen because of the significant drop acceleration reduction obtained from the thinner 3/16" bubble wrap in the previous study.
(3) 1/2" 1.3 lb/ft^3 viscoelastic foam: This was selected to see the effectiveness of thicker and better quality foam, since the previous study showed that thin foam produced minimal impact reduction.

Design of Experiment

A Claritin box was used as a representative healthcare product. A sheet of cushioning material (3/16" bubble wrap, 5/16" bubble wrap, or viscoelastic foam) was inserted between the tote bottom and Claritin box (Figure 4). The box and cushion were taped to the bottom of the tote so the experiment could be repeated consistently. A no-cushion case was also considered to provide a control point. A 500g single-axis accelerometer was attached on the top of the Claritin box. The total setup (Figure 5A) weighed 5.78 lbs, which consisted mostly of the tote weight. The accelerometer was connected to a data acquisition system (Figure 5B).

Flat bottom drops were made at drop heights from 12" to 24", in 3" increments. For each case (no-cushion, viscoelastic foam, bubble wraps), thirty drops (Figure 5C) were made from each height to obtain a statistically sufficient number of data points. The resulting impact accelerations were measured as shown in Figure 5D, with an enlarged view in Figure 5E.

Figure 4. Claritin box with a bubble wrap sheet (left) and viscoelastic foam (right) underneath

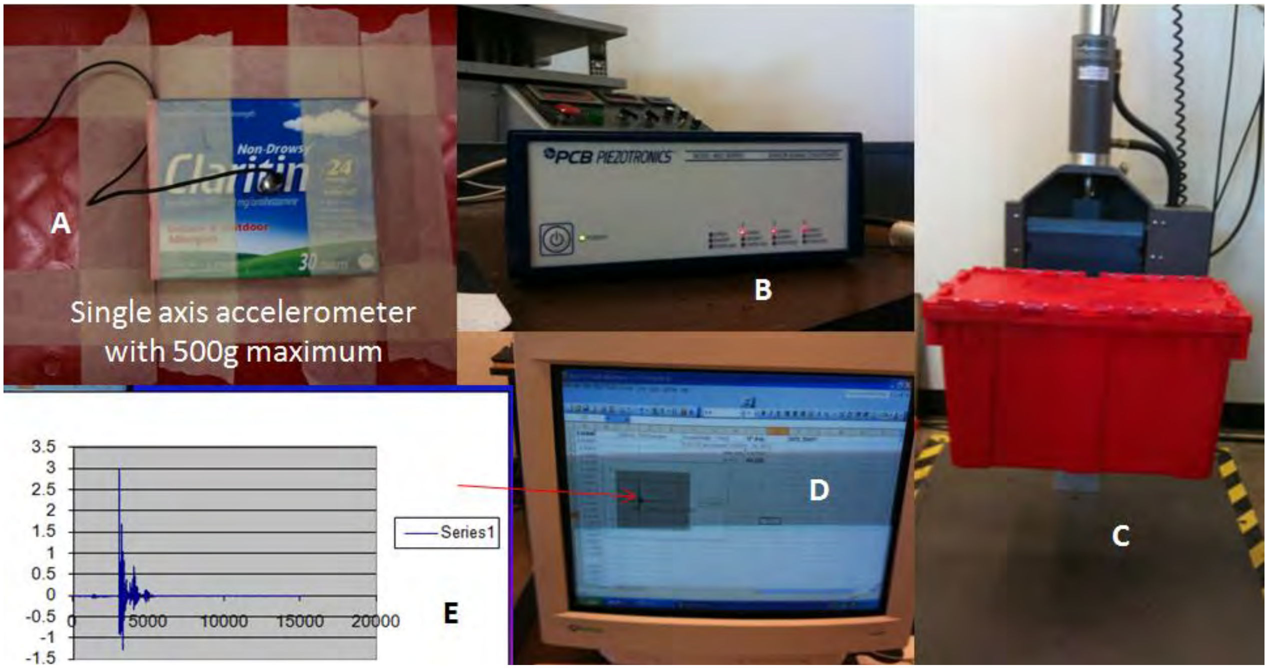


Figure 5. Controlled experiment setting for drop tests with various cushioning types underneath a Claritin box

Results

The drop test data is given in Appendix A and summarized in Table 1.

Table 1. Summary of tote bottom cushioning drop tests

Drop Height (in)	No Cushion	3/16" Bubble Wrap		5/16" Bubble Wrap		1/2" 1.3 lb/ft^3 Viscoelastic Foam	
	Impact Acceleration	Impact Acceleration	% Change from No Cushion	Impact Acceleration	% Change from No Cushion	Impact Acceleration	% Change from No Cushion
12	146.93g	120.09g	-18	110.03g	-25	134.45g	-8
15	200.09g	154.33g	-23	136.14g	-32	180.65g	-10
18	229.76g	179.94g	-22	151.38g	-34	209.75g	-9
21	264.25g	194.23g	-26	159.24g	-40	246.63g	-7
24	293.68g	219.18g	-25	183.65g	-37	257.99g	-12
			Avg = -23		***Avg = -34***		***Avg = -9***

The drop heights and maximum impact accelerations are plotted in Figures 6 and 7. After performing linear regressions, the equations obtained from the two plots are:

No Cushion:	$H = 0.0827A - 0.7649$	and	$A = 10.435H + 18.066$
1/2" 1.3 lb/ft^3 Viscoelastic Foam:	$H = 0.0927A - 1.0904$	and	$A = 7.9363H + 30.7$
3/16" Bubble Wrap:	$H = 0.1236A - 3.453$	and	$A = 11.922H + 12.35$
5/16" Bubble Wrap:	$H = 0.1708A - 7.2988$	and	$A = 5.6784H + 45.878$

where H = drop height (inches) and A = impact acceleration (g).

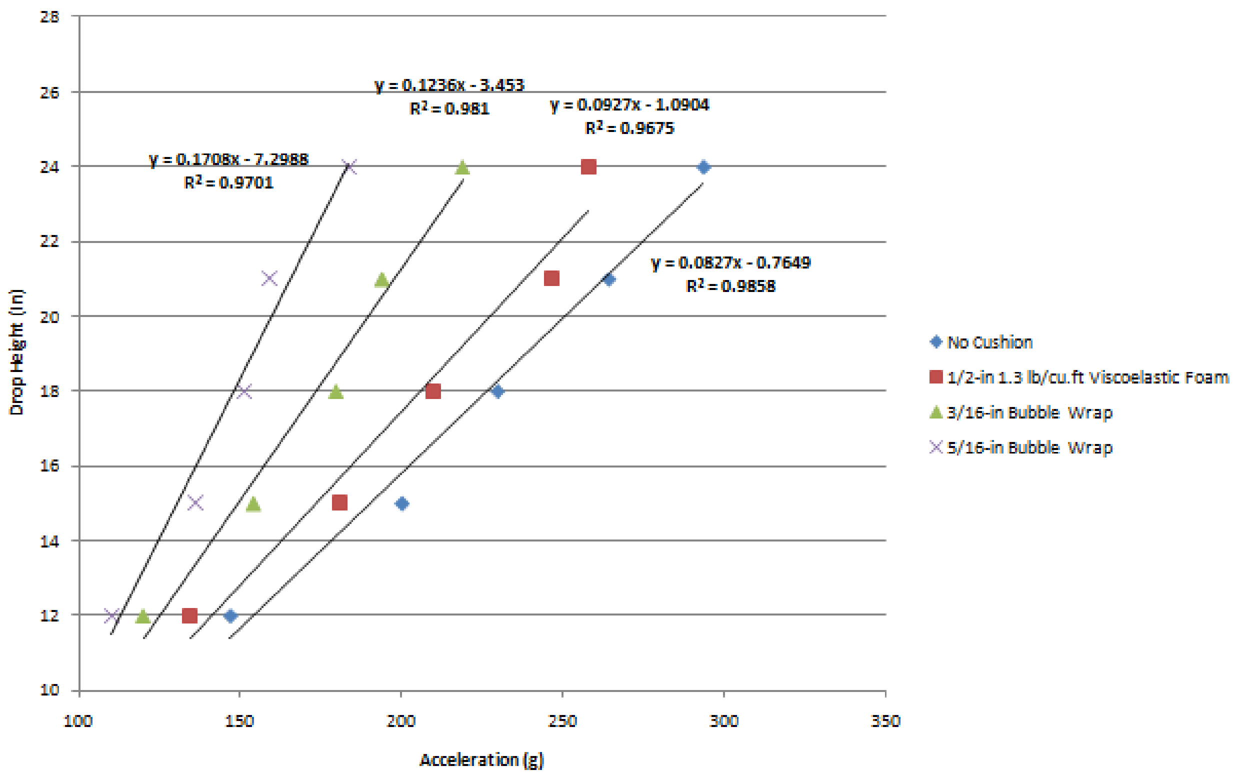


Figure 6. Drop acceleration (*x*-axis) versus drop height (*y*-axis)

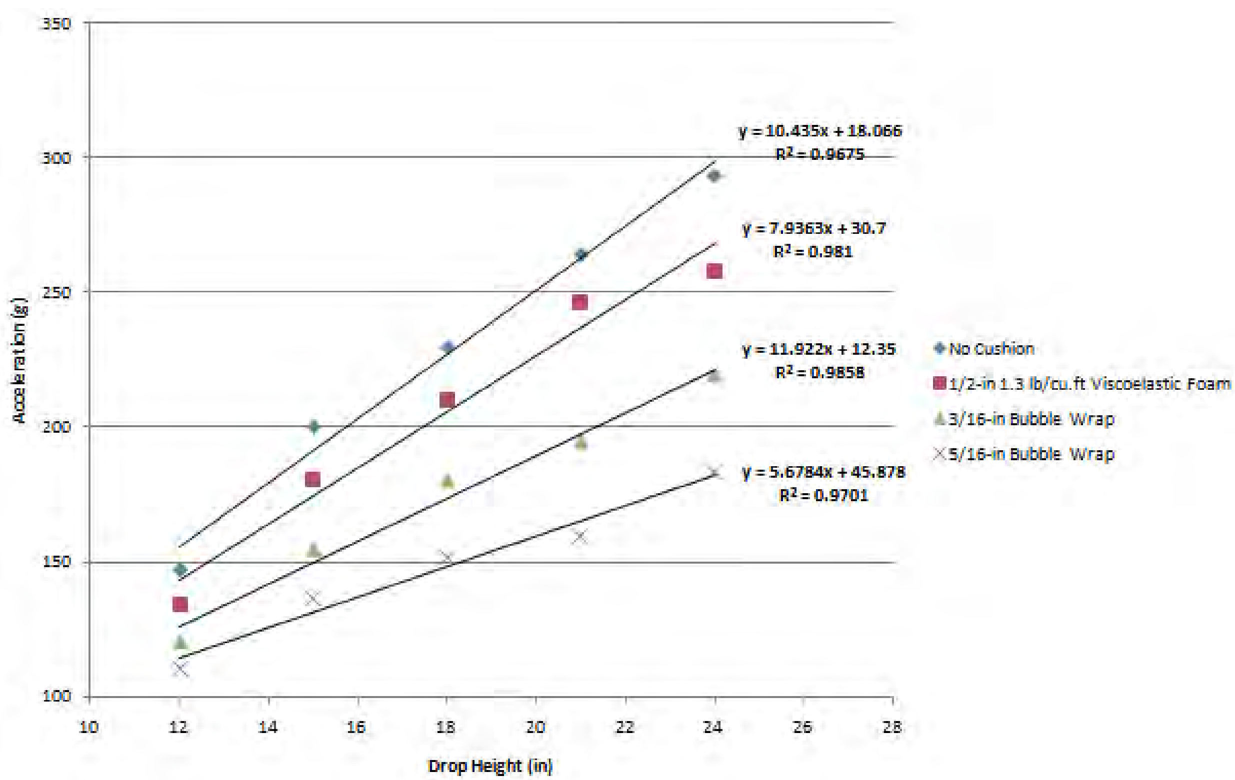


Figure 7. Drop height (*x*-axis) versus drop acceleration (*y*-axis)

Effectiveness of Cushioning at the Top of a Plastic Tote

An additional experiment was performed to investigate the effectiveness of adding cushioning at the top of the plastic tote, as opposed to at the bottom.

Cushioning Material

- Air pillows

Design of Experiment

A fixture was designed to simulate the effects of air pillows placed on the top of a partially filled plastic tote as shown in Figure 8. When there is no air pillow, the ball-bearing sleeve (B) can slide freely up to 1.5 inches along the aluminum guide pole (A) from the bottom flexible plastic platform (D). A single-axis accelerometer (C) was attached to the ball-bearing sleeve. The position of the bottom plastic platform was controlled by a PVC pipe (E). To measure the effect of air pillows, a top plastic platform was placed above the sleeve. A layer of air pillows was placed between the top plastic disc and the top aluminum frame. The sleeve could move only very little into the pillows, thus significantly reducing the bouncing ability. The total weight was 6.94 lbs. Thirty drops per drop height were performed with and without the air pillows in place.

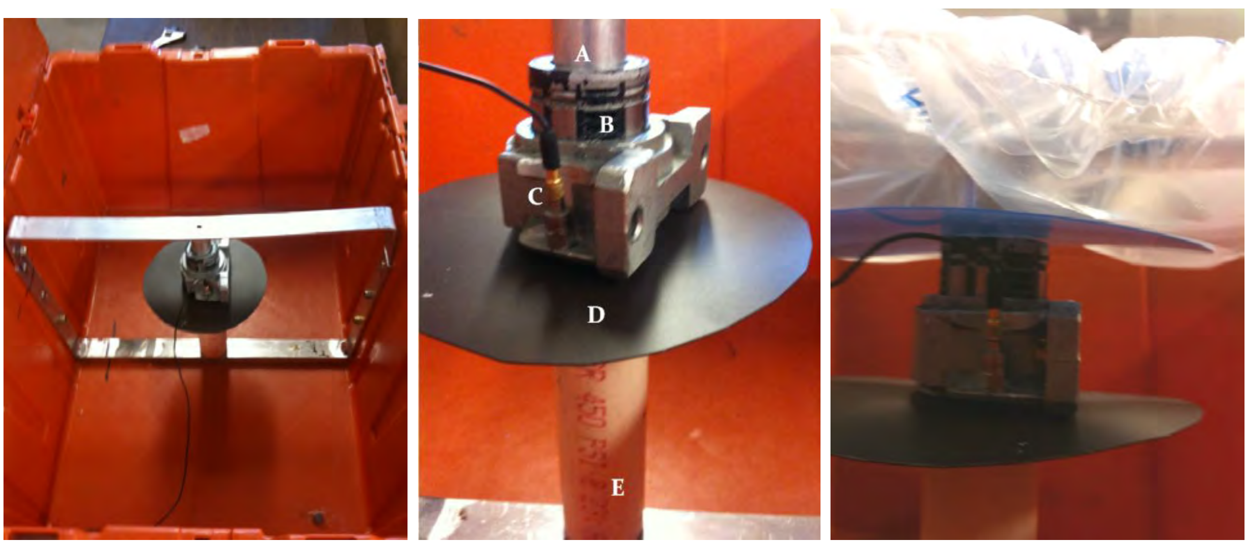


Figure 8. Air pillow simulation fixture

Results

The results from this study are given in Appendix B and summarized in Table 2 and Figure 9. Detailed plots of raw accelerometer readings (*y*-axis) against time (*x*-axis) are shown in Figure 10 for two comparable impact accelerations obtained from drops without air pillows (245g – drop no. 3 at 15-inch drop height in Appendix B) and with air pillows (242g – drop no. 11 at 15-inch drop height in Appendix B). It should be noted that the two graphs shown in Figure 10 do not start from the same time step due to the difference in time between starting the data acquisition software and dropping the tote. However, both graphs are based on the same data sampling time interval on the *x*-axis.

Table 2. Average impact accelerations

Drop Height	No Air Pillows	With Air Pillows	% Change by Adding Air Pillows
12 inches	220g (SD = 50g)	203g (SD = 59g)	-7.73%
15 inches	252g (SD = 66g)	242g (SD = 69g)	-3.97%
18 inches	326g (SD = 98g)	248g (SD = 77g)	-23.93%
21 inches	347g (SD = 83g)	252g (SD = 78g)	-27.38%
24 inches	315g (SD = 130g)	272g (SD = 58g)	-13.65%
		Average	*-15.33%*

Note: 30 drops per drop height

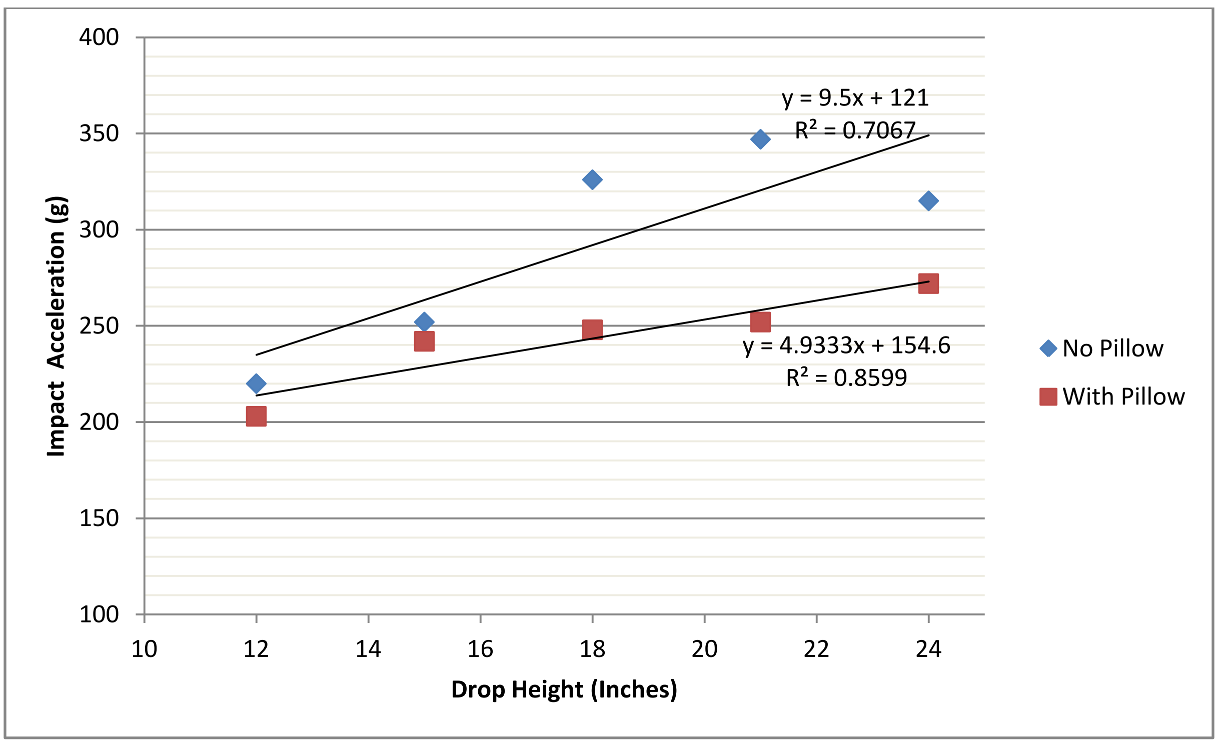
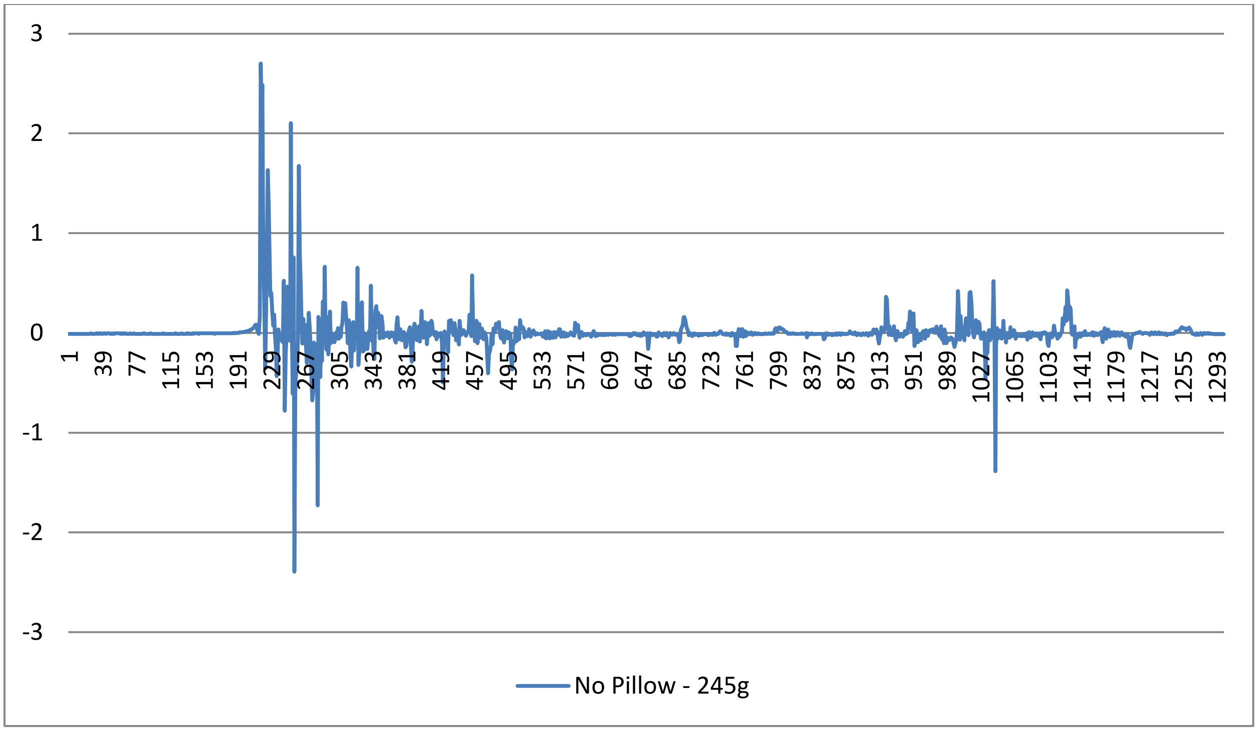


Figure 9. Drop height (*x*-axis) versus impact acceleration (*y*-axis)



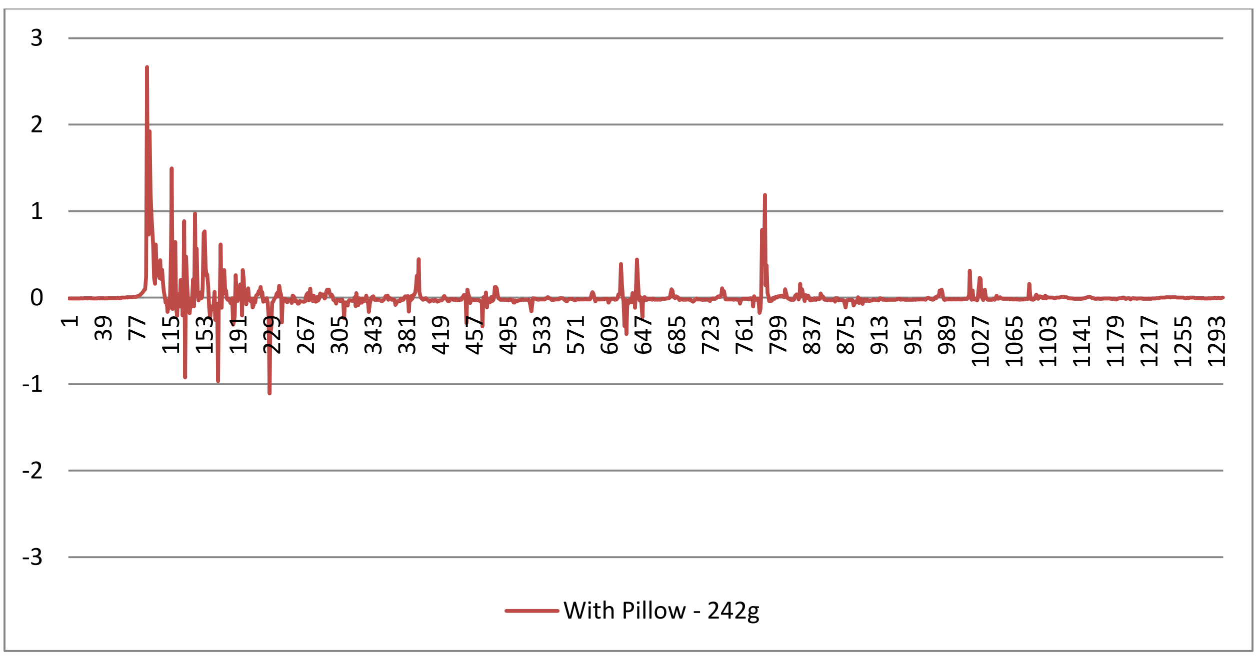


Figure 10. Comparison of measured impact acceleration with and without air pillows

Validation

Two validation tests were performed to simulate real situations: vibration and drop tests.

Vibration Test

A vibration test was used to simulate vibration during transit. In a real application, results will vary due to road conditions, tote contents, and content arrangement. For this validation four totes were used: (1) no cushion, (2) 5/16-inch bubble wrap at tote bottom, (3) air pillows at tote top, and (4) 5/16-inch bubble wrap and air pillows at bottom and top of tote, respectively. The four partially-filled totes contained the same contents. Each tote weighed 19.98 pounds. Products were arranged randomly. However, the randomness was kept consistent among the four totes. The four totes went through a commonly used one-hour vibration test as specified in ISTA 1C, 1D, 1E, 1F, 1G, 1H, 2A, 2B, and 3G. Figure 11 shows how a bubble wrap sheet and air pillows were placed in these totes. Observations of damage after the vibration test are summarized in Table 3.

Figure 11. Bubble wrap sheet (left) and air pillows (right)

Table 3. Vibration validation test results

Case	Damaged Items	Damage Type
No cushion	**5** out of 18 items	Abrasion (1 item) Dent (1 item) Corner crushing (2 items) Bending (1 item)
Bubble wrap sheet at bottom	**4** out of 18 items	Edge crushing (1 item) Bending (1 item) Scratch (1 item) Corner crushing (1 item)
Air pillows at top	**3** out of 18 items	Abrasion (2 items)
Bubble wrap sheet at top and air pillows at bottom	**0** out of 18 items	None

Drop Test

A drop test was used to simulate a drop that could happen while a tote was carried manually. Four partially-filled totes were used, similar to the vibration test above. They contained same products, with the total weight of each tote being 20.80 pounds. The products were arranged randomly, but the randomness was kept consistent among the four totes. Each tote was flat-bottom dropped from a 24-inch drop height. Observations of damage after the drop test are summarized in Table 4. As in the vibration test validation, damage in a real-world situation may vary depending on the contents, arrangement, and how the tote hits the ground (flat bottom drop, edge drop, corner drop, etc.).

Table 4. Drop validation test results

Case	Damaged Items	Damage Type
No cushion	**6** out of 18 items	Edge crushing (3 items) Bending (2 items) Dent (1 tiem)
Bubble wrap sheet at bottom	**3** out of 18 items	Edge crushing (3 items)
Air pillows at top	**2** out of 18 items	Edge crushing (2 items)
Bubble wrap sheet at top and air pillows at bottom	**1** out of 18 items	Edge crushing (1 item)

Conclusions

Our study shows that bubble wrap is very effective in reducing impact acceleration, producing a 23% and 34% reduction (vs. no cushioning at all) for 3/16" and 5/16" bubble wrap, respectively. Even more reduction could be obtained by using a thicker wrap or by using multiple sheets at the bottom of a plastic tote. To determine the thickness and number of layers of bubble wrap to be used, the total tote weight (with contents) and product fragility need to be considered. The values obtained in our study may not be applicable directly, but they demonstrate the benefit of using bubble wrap cushioning – a practical and inexpensive solution. For certain types of healthcare products, these bubble sheets could be reused for several times. It should be noted that despite its poor performance in this study, foam cushioning has its place. Foam insulates better and is more durable than bubble wrap. However, as far as impact is concerned, bubble wrap seems to be a better choice.

The air pillow study indicates that air pillows reduce impact acceleration about 15% and reduce the subsequent impact accelerations due to bouncing. In this study the air pillows used allowed movement of the ball bearing somewhat. With a tighter cushioning of air pillows on the top, impact accelerations could be halted completely in a shorter time duration.

The two validation tests support the findings of this comprehensive tote study, even though damage in real-world situations will vary significantly due to different road conditions, driving behavior, product types, content arrangement, etc. It is apparent that using both bubble wrap at the tote bottom and air pillows at the tote top is very effective in damage reduction/prevention.

References

[1] Siripong Malasri, Asit Ray, and Larry Rutledge, "Healthcare Packaging Consortium," *Proceedings of the MAESC 2011 Conference*, Memphis, Tennessee, May 3, 2011.

[2] Larry Rutledge, Siripong Malasri, and Anthony Lawrence, "Distribution Tote Testing," *Proceedings of the International Transport Packaging Forum*, Orlando, Florida, April 18-21, 2011.

[3] Siripong Malasri, Paul Shiue, Anthony Lawrence, Larry Rutledge, and Robert Moats, "Preliminary Study of Plastic Tote Drop Impact," *Proceedings of the MAESC 2011 Conference*, Memphis, Tennessee, May 3, 2011.

Credit

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Authors

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Larry Rutledge is the Manager of CBU"s ISTA-certified Packaging Lab. A former packaging manager at FedEx for 18 years, his experience covers every aspect of distribution packaging. He was on the Board of Directors of ISTA and currently is a member of IoPP.

Appendix A

Experiment Data: Cushioning Materials at the Bottom of Plastic Tote

Values shown in the table are impact accelerations in „g‟

	No Cushion					3/16" Bubble Wrap				
Drop Heights (in)	12	15	18	21	24	12	15	18	21	24
Drop Number										
1	143.82	185.55	244.14	233.04	305.84	117.63	167.79	169.12	184.22	233.49
2	148.70	206.41	218.39	243.25	292.08	125.62	153.59	166.90	194.87	236.59
3	155.36	197.98	231.27	239.70	309.84	146.04	137.61	173.12	186.43	230.38
4	150.48	187.32	234.82	270.33	266.78	115.86	148.26	177.11	200.64	255.68
5	146.48	210.85	207.74	283.20	321.38	116.74	122.51	174.45	196.64	217.06
6	146.93	217.06	229.94	272.55	285.42	130.50	136.72	189.10	209.52	206.85
7	145.60	194.42	230.38	284.98	295.63	117.19	158.47	178.44	205.97	217.95
8	140.27	199.75	233.93	235.26	274.77	147.37	153.14	184.66	186.43	224.61
9	157.14	200.64	227.72	264.12	300.96	147.82	158.47	187.32	183.33	215.73
10	143.82	207.74	230.38	275.68	278.76	116.30	148.70	174.89	179.78	209.96
11	190.87	216.62	234.38	263.67	258.79	117.19	160.25	186.43	174.89	183.77
12	167.35	218.39	222.83	287.64	311.17	127.84	150.04	174.01	185.10	203.75
13	130.06	202.41	260.12	280.54	296.52	123.40	143.82	161.58	204.19	207.30
14	135.39	217.95	212.62	251.24	298.74	117.63	141.16	190.43	194.87	197.53
15	131.39	192.21	204.19	237.48	270.33	113.64	144.26	170.45	187.32	226.83
16	138.05	179.78	216.18	264.56	315.16	118.52	153.14	187.32	196.64	229.94
17	134.94	194.87	211.74	278.76	275.21	119.85	158.47	167.35	193.98	229.05
18	150.04	201.08	225.05	276.10	324.49	118.08	165.57	179.33	192.65	236.15
19	146.48	193.09	223.72	261.01	305.84	112.75	177.56	176.67	197.53	192.21
20	189.54	203.30	245.03	263.67	280.10	122.96	148.70	186.88	204.19	218.39
21	145.60	196.64	234.82	277.88	275.54	114.08	125.18	180.22	194.42	220.61
22	135.39	194.87	235.71	287.76	337.80	106.53	170.90	175.34	198.42	227.72
23	138.49	212.62	245.47	249.30	317.38	114.08	179.78	183.33	186.43	222.39
24	151.81	203.75	241.03	270.77	262.34	110.97	163.80	193.09	220.17	221.06
25	132.28	224.61	217.95	262.34	293.41	112.75	154.03	174.45	210.85	227.72
26	131.39	182.88	246.36	264.56	294.30	109.20	185.55	189.54	209.96	209.07
27	147.37	187.32	225.05	274.33	266.34	116.30	140.27	178.89	196.64	248.58
28	146.93	200.64	237.48	265.89	336.91	113.64	162.91	176.23	182.44	213.96
29	129.17	176.23	229.49	264.12	288.53	112.75	147.37	182.44	186.43	211.74
30	156.69	195.76	234.82	243.70	269.89	119.41	171.79	209.07	182.00	199.31
Xavg -->	**146.93**	**200.09**	**229.76**	**264.25**	**293.68**	**120.09**	**154.33**	**179.94**	**194.23**	**219.18**
SD -->	**14.87**	**12.13**	**12.55**	**16.06**	**21.83**	**10.51**	**14.97**	**9.55**	**10.70**	**15.81**
Min -->	**129.17**	**176.23**	**204.19**	**233.04**	**258.79**	**106.53**	**122.51**	**161.58**	**174.89**	**183.77**
Max -->	**190.87**	**224.61**	**260.12**	**287.76**	**337.80**	**147.82**	**185.55**	**209.07**	**220.17**	**255.68**
Range -->	**61.70**	**48.38**	**55.93**	**54.71**	**79.01**	**41.28**	**63.03**	**47.50**	**45.28**	**71.91**

	5/16" Bubble Wrap					1/2” 1.3 lb/ft^3 Viscoelastic Foam				
Drop Heights (in)	12	15	18	21	24	12	15	18	21	24
Drop Number										
1	118.52	115.41	150.92	139.38	183.33	120.29	189.99	215.29	268.55	255.68
2	110.53	139.83	163.35	170.01	184.22	128.28	184.22	221.95	249.47	270.33
3	129.62	154.92	137.61	164.68	159.80	143.38	216.62	197.98	227.72	251.24
4	108.75	162.91	135.83	144.71	170.90	145.60	201.08	194.87	267.67	245.92
5	120.74	125.18	167.35	168.68	176.23	126.51	184.66	206.85	277.43	264.12
6	108.75	148.70	171.34	164.24	194.87	130.50	178.89	208.19	259.68	261.90
7	108.31	154.03	137.61	167.35	192.21	138.05	219.73	209.07	282.76	247.69
8	92.77	130.50	172.67	158.03	205.52	146.48	169.12	223.28	289.42	284.09
9	108.75	149.59	150.04	146.93	165.13	146.04	184.22	211.29	250.36	241.92
10	105.65	129.17	153.14	138.05	179.33	145.15	189.10	212.18	264.56	272.99
11	100.32	143.38	138.05	191.76	161.58	134.50	174.89	217.95	264.12	252.57
12	112.30	118.96	156.69	173.56	171.34	126.51	176.23	199.75	268.55	230.82
13	118.52	150.48	178.00	156.69	180.66	130.06	180.22	212.62	214.84	256.57
14	108.75	121.63	159.36	158.47	178.44	135.83	164.68	209.52	218.84	269.00
15	110.09	137.16	132.72	150.92	167.35	126.95	189.10	229.94	245.47	221.06
16	110.09	134.94	166.02	165.57	192.65	126.51	171.34	226.83	262.34	252.57
17	93.66	149.59	166.02	140.27	172.67	127.40	165.13	187.77	228.16	268.11
18	113.64	116.74	184.22	160.25	182.88	123.40	185.10	219.28	245.03	266.78
19	101.21	125.62	154.03	149.15	178.89	140.71	163.35	197.98	221.95	269.89
20	115.86	123.85	160.69	163.80	190.43	139.38	189.10	228.60	213.07	225.94
21	102.98	138.49	130.95	173.12	197.53	125.18	166.02	172.23	235.26	265.45
22	110.53	136.72	131.39	143.82	173.56	140.71	177.56	208.63	238.37	258.79
23	118.52	130.95	148.70	185.55	195.76	140.27	163.35	197.09	230.38	252.57
24	102.10	129.17	134.06	140.27	202.86	128.28	160.25	217.51	253.02	244.14
25	118.08	146.93	144.71	149.15	195.31	139.38	179.33	243.25	204.63	246.80
26	122.96	126.07	136.72	154.92	185.10	134.94	164.68	201.08	265.00	259.68
27	104.76	144.26	128.28	173.56	189.10	137.61	191.76	217.51	236.59	275.66
28	107.42	126.95	165.13	147.82	210.40	133.61	188.65	193.54	237.04	267.67
29	99.88	138.05	138.49	195.76	189.99	135.39	178.44	195.76	244.58	261.01
30	116.74	134.06	147.37	140.71	181.55	136.72	172.67	214.84	233.93	298.74
Xavg -->	**110.03**	**136.14**	**151.38**	**159.24**	**183.65**	**134.45**	**180.65**	**209.75**	**246.63**	**257.99**
SD -->	**8.43**	**12.34**	**15.64**	**15.55**	**12.83**	**7.44**	**14.53**	**14.45**	**21.77**	**16.38**
Min -->	**92.77**	**115.41**	**128.28**	**138.05**	**159.80**	**120.29**	**160.25**	**172.23**	**204.63**	**221.06**
Max -->	**129.62**	**162.91**	**184.22**	**195.76**	**210.40**	**146.48**	**219.73**	**243.25**	**289.42**	**298.74**
Range -->	**36.84**	**47.50**	**55.93**	**57.71**	**50.60**	**26.19**	**59.48**	**71.02**	**84.78**	**77.68**

Appendix B

Experiment Data: Cushioning Materials at the Top of Plastic Tote

Values shown in the table are impact accelerations in „g"

	No air pillows					With air pillows				
Drop Height (in) -->	12	15	18	21	24	12	15	18	21	24
1	128.73	210.40	503.37	407.94	521.13	254.35	310.72	142.93	332.92	242.81
2	123.85	323.60	227.27	516.69	836.29	173.56	260.12	244.58	152.25	224.61
3	170.45	245.47	468.31	337.80	304.51	238.81	288.09	359.55	193.98	309.84
4	142.49	221.95	541.10	449.22	515.80	217.51	366.21	200.64	374.20	253.91
5	202.86	235.26	196.20	385.74	234.38	325.82	238.37	287.64	189.10	324.49
6	201.97	160.69	428.36	328.04	263.23	140.27	227.72	191.76	216.62	300.51
7	206.85	297.41	431.46	353.78	204.63	308.50	182.44	241.92	295.19	298.30
8	241.92	325.82	403.50	378.20	195.76	304.95	334.25	207.30	185.99	288.97
9	299.18	191.32	242.81	285.87	191.32	158.91	221.06	166.46	375.98	233.93
10	229.94	175.78	213.07	279.65	337.36	194.42	197.53	213.96	374.64	210.40
11	180.66	385.74	325.82	409.71	288.53	305.84	242.37	223.28	185.55	225.05
12	240.15	233.93	239.70	287.20	304.51	221.95	320.05	400.39	204.19	318.27
13	221.50	163.35	375.53	488.73	239.26	177.11	324.04	358.66	188.21	238.37
14	240.15	316.05	450.11	282.76	266.78	191.32	352.45	374.64	145.60	327.15
15	296.08	376.42	409.27	304.07	179.33	225.05	136.72	240.59	177.11	357.33
16	234.38	263.67	265.89	403.50	277.88	172.23	280.54	299.63	201.08	224.61
17	207.74	296.08	349.34	371.98	316.05	169.57	136.27	241.03	251.69	216.18
18	276.99	205.97	299.63	454.10	361.33	120.74	224.61	387.07	399.95	342.68
19	178.44	209.07	313.83	229.49	366.21	315.61	182.00	220.17	273.88	209.52
20	170.45	267.22	306.73	349.79	390.18	200.64	199.31	139.83	178.89	342.24
21	231.71	203.30	264.12	389.29	205.52	170.45	143.38	198.42	213.96	270.77
22	299.63	210.85	245.92	270.33	296.08	136.72	326.70	176.23	240.59	272.99
23	227.27	310.28	271.22	303.62	292.52	163.80	264.56	182.88	301.40	233.49
24	180.22	193.09	209.96	230.38	215.73	193.09	133.61	174.01	440.78	241.03
25	221.95	281.87	331.14	482.51	289.42	134.06	309.39	226.38	275.66	214.40
26	212.62	191.76	233.93	344.90	310.72	157.14	250.36	341.35	274.77	228.60
27	297.85	277.88	437.23	184.22	322.71	217.95	162.02	206.41	209.07	238.81
28	311.17	397.73	293.41	331.14	279.21	147.37	242.37	251.69	265.00	466.53
29	194.87	191.76	188.65	221.50	211.29	149.59	161.58	181.55	221.50	283.65
30	218.39	206.85	329.81	360.44	421.70	196.64	226.83	361.33	225.94	237.93
Xavg -->	**219.68**	**252.35**	**326.56**	**347.42**	**314.65**	**202.80**	**241.52**	**248.08**	**252.19**	**272.58**
SD -->	**50.10**	**66.53**	**97.73**	**83.26**	**130.25**	**59.15**	**69.14**	**77.06**	**78.56**	**57.99**
Min -->	**123.85**	**160.69**	**188.65**	**184.22**	**179.33**	**120.74**	**133.61**	**139.83**	**145.60**	**209.52**
Max -->	**311.17**	**397.73**	**541.10**	**516.69**	**836.29**	**325.82**	**366.21**	**400.39**	**440.78**	**466.53**
Range -->	**187.32**	**237.04**	**352.45**	**332.48**	**656.96**	**205.08**	**232.60**	**260.56**	**295.19**	**257.01**