This is to certify that the

thesis entitled

Handling difference between plywood and corrugated containers with and without fragile labels in overnight shipments

presented by

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has been accepted towards fulfillment of the requirements for

MS degree in Packaging

S. Paul Singh
Major professor

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HANDLING DIFFERENCE BETWEEN PLYWOOD AND CORRUGATED CONTAINERS WITH AND WITHOUT FRAGILE LABELS IN OVERNIGHT SHIPMENTS

By

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A THESIS

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ABSTRACT

HANDLING DIFFERENCES BETWEEN PLYWOOD AND CORRUGATED CONTAINERS WITH AND WITHOUT FRAGILE LABELS IN OVERNIGHT SHIPMENT

By

Timothy Grant Weigel

To measure the shock environment of overnight delivery services a total of forty instrumented shipments were made utilizing two overnight delivery services. The handling differences between corrugated and plywood containers with and without fragile labels was also evaluated.

The type of outer container used appeared to have an effect on the handling the package received during shipment. Shipments made with corrugated containers averaged almost twice as many shock events.

For corrugated containers 95% of the drops or tosses occurred below 23.6 inches, compared to 15.3 inches for plywood containers. Additionally 95% of the impacts that occurred on corrugated container were at less then 151 in/sec compared to 130 in/sec for plywood containers. Labeling with a fragile label did not appear to affect the handling received by either container tested.

To my wife Carol and our family Worm and Henry

ACKNOWLEDGMENTS

I wishes to acknowledge the assistance provided by my major professor Paul Singh, and my graduate committee Drs. Suchsland, Lockhart, and Burgess through out my graduate program. I would like to thank the School of Packaging, and the Consortium for Distribution Packaging for providing funding and support for this research project. I would also like to acknowledge the financial assistance provided by Dr. Potter-Witter and Dr. Stevens, Department of Forestry, during my final year at MSU.

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1.0 INTRODUCTION

One function of packaging is to provide adequate protection to products from damage during distribution. The packaging required to protect the product varies with the products fragility and the severity of the distribution environment. Ostrem and Godshall (1979) listed three major inputs required for the efficient and effective use of packaging materials. These were:

(1) A knowledge of the shipping or operating environment.

(2) A knowledge of the fragility or resistance to damage of the item to be protected or packaged.

(3) A knowledge of the performance or protective characteristics of the packaging materials.

Knowledge of these three factors allows for the design of a package that provides an acceptable level of protection at the least cost.

Standard methods exist for finding the shock fragility of products, such as ASTM D3332-77 for Damage Boundary Curves. These curves display the maximum acceleration and the maximum velocity change that a product can withstand. Most packaging material manufacturers can provide a user with information on the performance and protective characteristic of various materials. If this information is unavailable standard methods are available for determining the various cushioning characteristics of materials (ASTM D1596 and ASTM D4168). As research adds new data to this area, the methods for determining the protective characteristics of packaging materials are continually being improved.

The shipping and operating environment that products are exposed to are not as easily defined. The complexity of the distribution environment makes it difficult to precisely define all the hazards, and their severity in the distribution system. The distribution environment includes physical hazards such as shock, vibrations, and compression, and environmental hazards such as temperature, and humidity. The types and severity of the hazards encountered in a particular distribution system are mainly influenced by the modes of transportation used to move the product, the amount of handling, both mechanical and manual, and the environmental conditions encountered during movement. The vibration content of the physical hazards has been reported in many forms depending on the end use of the data. Most of the recent research in transportation has reported the results in terms of its power-spectral density. Trost (1988, 1989) has suggested using data in this form for setting test levels of vibration simulation programs. The loads imposed on packages during distribution have generally been reported in terms of the drop height (Ostrem and Godshall 1979). A study by Ostrem and Godshall (1979) divided the common carrier shipping environment into components based on the mode of transportation. Included in that study was information on the shock and vibration hazards associated with trucks, railcars, aircraft, ships, and fork lifts. They concluded that although there is a great deal of information on the hazards encountered in the distribution environment, data on transportation shock hazard is sparse or in a form not easily utilized for design purposes. They found that most packages will receive many shocks while passing through the distribution environment, however most will be at a low level. Unitized loads and heavier packages receive fewer and lower drops. Handholds on packages will reduce the likelihood of a package being dropped, and labels such as fragile have at most a minor effect on the handling of packages.

More recently Trost (1988, 1989) divided the air cargo transport environment into two main areas: ground operations using a pallet trailer, and hazards encountered on the aircraft. In this study the shock and vibration acting on a typical cargo pallet was measured and analyzed. Trost found that the stress levels encountered in air transport are generally lower then for other forms of transportation. Additionally, the highest levels of stress encountered occurred during ground transportation to and from the aircraft, and during the short period during landing of the aircraft. The highest levels of stress measured during ground transport was a vertical acceleration of 5.8 g at the pallet corner and could be traced directly to uneven pavement surface and careless driving during ground transportation. The highest level measured during the air portion of the study was a vertical acceleration of 0.42 g recorded during landing.

In their investigation of the small parcel environment Singh and Voss (1992) collected data on shocks encountered during handling by United Parcel Service between East Lansing, MI and Monterey, CA. To detect the effect of package size and weight on the handling of UPS shipments they shipped Drop Height Data recorders made by Dallas Instrument in packages of varying size and weight. Through lab simulation of common material handling processes they were able to classify package impacts into categories of drops, tosses, and kicks. The various events were classified in to categories based on a "unit ratio". This is the ratio between the drop height measured by the drop height recorders zero-G channel and the calculated equivalent drop height based on the velocity change as measured by the drop height recorders accelerometers. If the unit ratio was less then 0.5 the container was not in free fall long enough to produce the level of shock recorded and the event was classified as a "kick". If the unit ratio was between 0.5 and 2.0 the shock was approximately equal to that produced by a free fall drop and the event was classified as a "drop". If the unit ratio was larger then 2.0 the shock recorded was much smaller than the shock that would have been produced by a

free fall drop from the zero-g drop height and the event was classified as a "toss".

The packages shipped ranged in size from approximately a 12-inch cube to a 26" x 20" x 19" container, and the weight ranged from 20 lb. to 45 lb. The data was reported by type of drops, kicks, and tosses. They concluded that for the containers tested, package size did not significantly affect the drop height, and except for the small packages the weight did not significantly affect the drop heights of the packages. The highest recorded flat drop was 42.1 inches for a small / light package (12 x 12 x 12 inches weighing 20 lb.).

Singh et. al (1992) monitored the impacts packages received while passing through the overnight air delivery system. They made 150 one way shipments of instrumented packages to five different locations in the United States, using three delivery services. During this study the highest drop encountered was 77.8 inches. They found that of the drops made during shipments using either Federal Express or United Parcel Service 99.5% were below 27.5 inches, and 99.5 % of the drops in United States Postal Service shipments were below 50 inches. The highest lateral impact they found was measured to have

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a velocity change of 250 in. / sec. In shipments made using either Federal Express or United Parcel Service 99.5% of the lateral impacts measured had a velocity change of less then 165 in. / sec., and 99.5% of the lateral impacts in United States Postal Service shipments had a velocity change of less than 225 in. sec.

2.0 OBJECTIVES

This study had the following objectives:

1. Measure the shock environment of overnight package delivery services (Federal Express and US Postal Service) for corrugated and plywood containers.

2. To determine if handling differences exist between corrugated and plywood containers with and without 'fragile' labels for overnight delivery shipments.

3.0 EXPERIMENTAL DESIGN

To measure the shock environment of the overnight delivery service distribution system, a total of forty round trip shipments were made. Past research has shown that a container's size and weight can have an effect on its handling in a distribution system (Ostrem and Godshall 1979). Little research has been done in the past on the effect of the type of outer container within a particular size and weight class. The effect of fragile labeling in a highly automated distribution system, such as the over night delivery environment, has not been thoroughly explored. In their study of the overnight delivery system Singh et. al. (1992) found differences in the handling of small corrugated packages between the various delivery services, but in general regardless of the delivery service used, most of the drops and impacts encountered were at low levels. Similar drop and impact levels are expected in this study. It is hoped that by spreading the shipments equally between delivery services the differences between them will be reduced and any handling differences found will be the result of the outer container used or the labeling of the package.

The effect of the type of container used was analyzed by making twenty shipments in corrugated containers and twenty in plywood containers. The effect of labeling was also studied by placing fragile labels on half of all the shipments made.

To obtain a general view of the overnight shipping environment rather than a single distribution route, shipments were made to two locations. The locations needed to be far enough from East Lansing to allow the packages to pass through a major distribution hub and far enough from each other to allow the packages to pass through different distribution routes. Shipments were made from the School of Packaging (zip code 48824) to two locations, Trabuco Canyon, California (zip code 92679), and Cedar Park, Texas (zip code 78613). The containers were then return shipped to the School of Packaging in East Lansing, Michigan. In addition two different overnight services were used. Half the shipments were made via United States Post Office Express Mail Service, and the remaining shipments were made through Federal Express. It was assumed that any effect caused by the service used, or, the location of the shipment would be small. The experimental design is shown in Table 1.

Table 1. Experimental Design.

Container	Corrugated								Vikex Plywood							
Labeling	None				Fragile				None				Fragile			
Service	US		FD		US		FD		US		FD		US		FD	
Destination	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T

Service

US = United State Postal Service Express Mail

FD = Federal Express

Designation

T = Cedar Park, Texas (zip code 78613)

C = Trabuco Canyon, California (zip code 92679)

The destination of the initial shipment, the service used, and the number of plywood or corrugated containers in the first shipment was randomly selected. All other shipments were designed to allow for equal distribution of containers, labeling, and service to a given location.

3.1 PACKAGE TYPES

Two types of containers were tested in this project. The wooden container tested was a Vikex collapsible plywood container manufactured by Nefab Corporation Chicago, Illinois. The Vikex container was made of 5 mm thick, five ply Russian birch plywood walls connected with galvanized steel corner pieces. The containers were custom made with interior dimensions of 10.875" x 10.875" x 10.875". The Vikex container with a 2" Ethafoam 220 cushioning weighed approximately 7.5 pounds. The corrugated container tested was a 600-LB. triple wall regular slotted container (RSC) manufactured by Arvco container of Kalamazoo, Michigan. The corrugated containers were also custom made with the same interior dimensions as the plywood containers. The corrugated containers with the same cushions weighed approximately 5.25 pounds. Fragile labels used during testing were 4" x 6" American Labelmark model L76 labels (Figure 1). The recording module used was a Drop Height Recorder model DHR-1 made by Dallas Instruments. The unit is a 6.5 inch cube that weighs 9.5 pounds. It is an electronic shock recorder designed to determine free-fall drop heights. The unit is battery powered and able to record shocks over a two week period. The recorder can measure accelerations up to 125 g. In the recording mode used the DHR-1 can record up to 137 separate shock events. The DHR-1 unit is a four-channel recorder which uses a piezoelectric triaxial accelerometer to record shock events on three channels. This information is processed through a high-gain amplifier to sense a change to a zero-g state.

Figure 1. Fragile label.

Besides recording the shock event wave form, the unit also records the time and date of the event in its random access memory. Since the time of the event is recorded along with the acceleration data the free fall distance (zero-g drop height) can be determined using equation 2-1.

$$h_z = g\, t.^2 / 2 \qquad (2\text{-}1)$$

Where:

g = acceleration due to gravity (386.4 in./s^2)

t = measured time of freefall (seconds)

h_z = zero-g drop height.

The height the unit has fallen can also be determined from the area under the acceleration-time curve recorded by each of the units accelerometers using equation 2-2.

$$h = (V / (1 + e))^2 * (1 / 2\, g) \qquad (2\text{-}2)$$

Where:

V = velocity change for each channel

e = coefficient of restitution

h = equivalent drop height for each channel.

The free fall drop height is then be calculated by summing the component drop heights of each accelerometer.

The number of shock events and the severity of each event was measured in this study. Differences in the type, number, and severity of events between plywood and corrugated containers, and labeled and unlabeled containers was evaluated. The severity of the event was based on the following criteria developed by Singh and Voss (1992):

1. The velocity change for shock events with a unit ratio of less than 0.5 were classified as "kicks" or "impacts".
2. The zero-G drop height was used for shock events with a unit ratio between 0.5 and 2.0 to determine "drops".
3. The equivalent drop height was used for shock events with a unit ratio above 2.0 to determine "tosses".
4. The drop height data for drops and tosses was combined for the analysis.

3.2 INSTRUMENTED PACKAGE CALIBRATION

The equivalent drop height calculation was made for each event based on the integration of the area under the acceleration traces. The individual channel values are then multiplied by a user input correction factor to allow for the coefficients of restitution of the package cushion for the three orientations. When the DHR-1 is shipped in a user supplied, package these factors need to be modified by the user to make the calculated equivalent drop heights equal to the zero-g drop height of a simulated flat drop (DHR manual 1988). Due to possible differences in the coefficient of restitution in the six directions measured by the DHR it is necessary to do calibration drops on all six faces of the container.

For each type of container (plywood and triple wall corrugated) known height drop tests were done in the lab. Drop tests were done from 24 inches and from 18 inches. For each series of tests the DHR-1 units were packaged as they would have been for shipment. During each drop test the packaged unit was randomly dropped 10 time on each side from the indicted height in accordance with ASTM D775 using a Lansmont model PDT 56E precision drop tester. At least one minute between drops was allowed for the cushion to recover (Graesser, et-al, 1990). The data was broken down into sets based on the type of container used and side on which the container was dropped. To eliminate secondary impacts or drops with excessive rotation from the data set used to calculate the calibration coefficients, the data from any drop whose zero-G drop height deviated more then 2% from the known drop height was eliminated from the data set. Each data set was initially analyzed with the correction factors for the shipping containers provided with the DHR-1. The data was analyzed to find the deviation between the known (zero-G) and the calculated drop height was calculated for each side separately. The correction factors were modified as instructed by the DHR-1 manual and the original data sets were run through the analysis procedure using the modified correction factors. This was repeated until the resulting equivalent drop height average varied less than 1% from the known drop height for each side.

The resulting calibration coefficients use to analyze the data from shipments made in the plywood Vikex boxes and corrugated boxes are described in Table 2.

Table 2. Correction coefficients.

Plywood Container

Recording Channels

X+	X-	Y+	Y-	Z+	Z-
1.810	2.130	1.800	1.950	2.070	2.075

Corrugated containers

Recording Channels

X+	X-	Y+	Y-	Z+	Z-
1.075	1.690	1.375	0.975	1.750	2.050

X, Y = Lateral / Longitudinal channels

Z = Vertical channels

3.3 SHIPPING TEST

All containers were received from the manufactures in a collapsed condition with only the manufacture's joint formed. The plywood containers from Nefab were erected and the bottoms attached to the container sides in accordance with the manufacture's instructions. The corrugated containers were erected and the bottom H-sealed with a semi-automatic case sealer using a plastic tape. Six complete sets of cushion were formed from a single sheet of material, cushions were used interchangeable through out the study. Three types of cushions were formed using Ethafoam 220 (Figure 2). The cushion placement in the containers is shown in Figure 3. Before shipment the battery of each DHR-1 unit was recharged for a minimum of 24 hours. The cushions were then placed in the containers as described earlier. The unit was then placed in its container. To help monitor any physical damage that might occur to an individual container each container was numbered for identification. For corrugated containers the DHR unit was placed in the container so that the units front was opposite the manufactures joint on the box.

Figure 2. Cushion types.

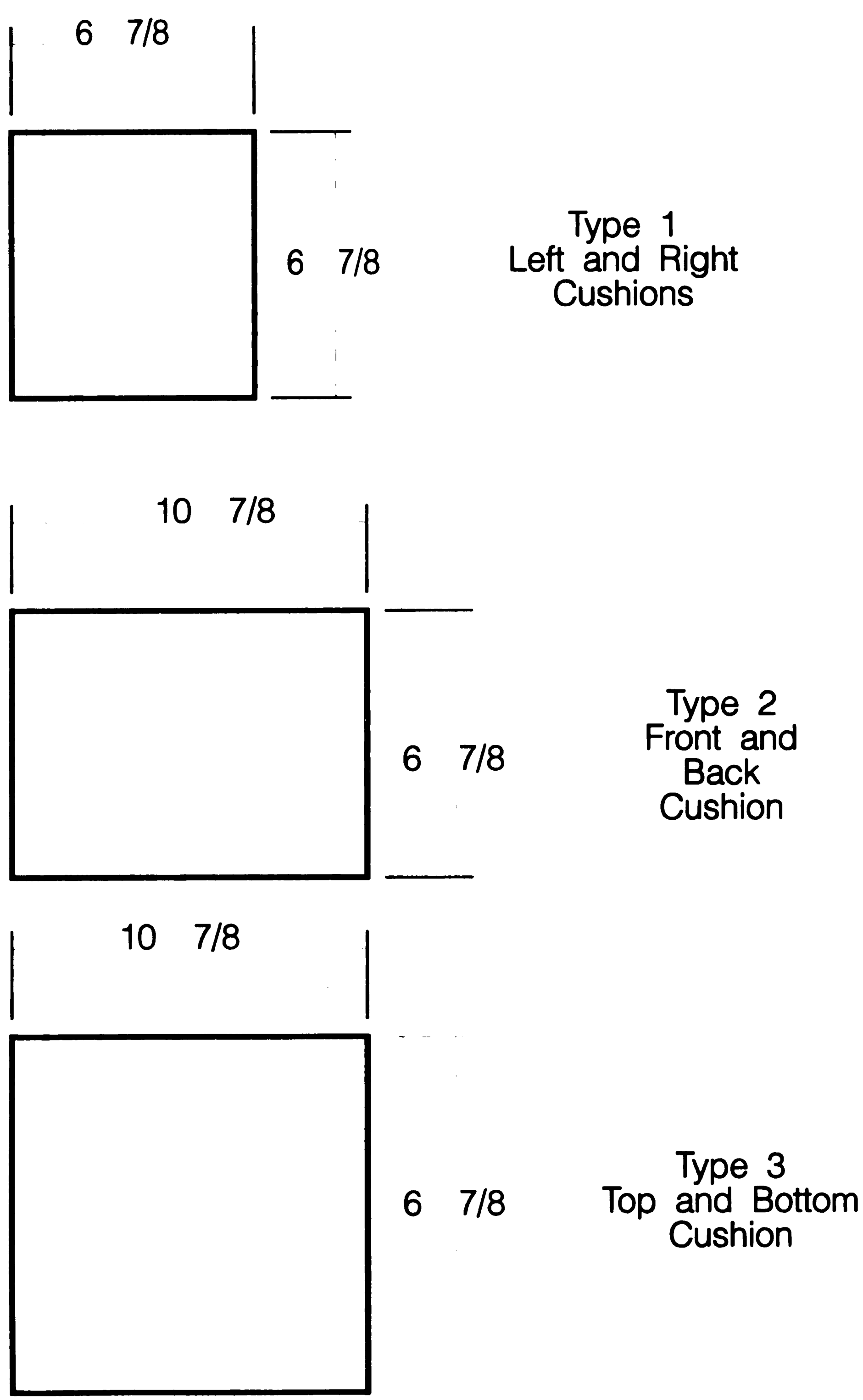
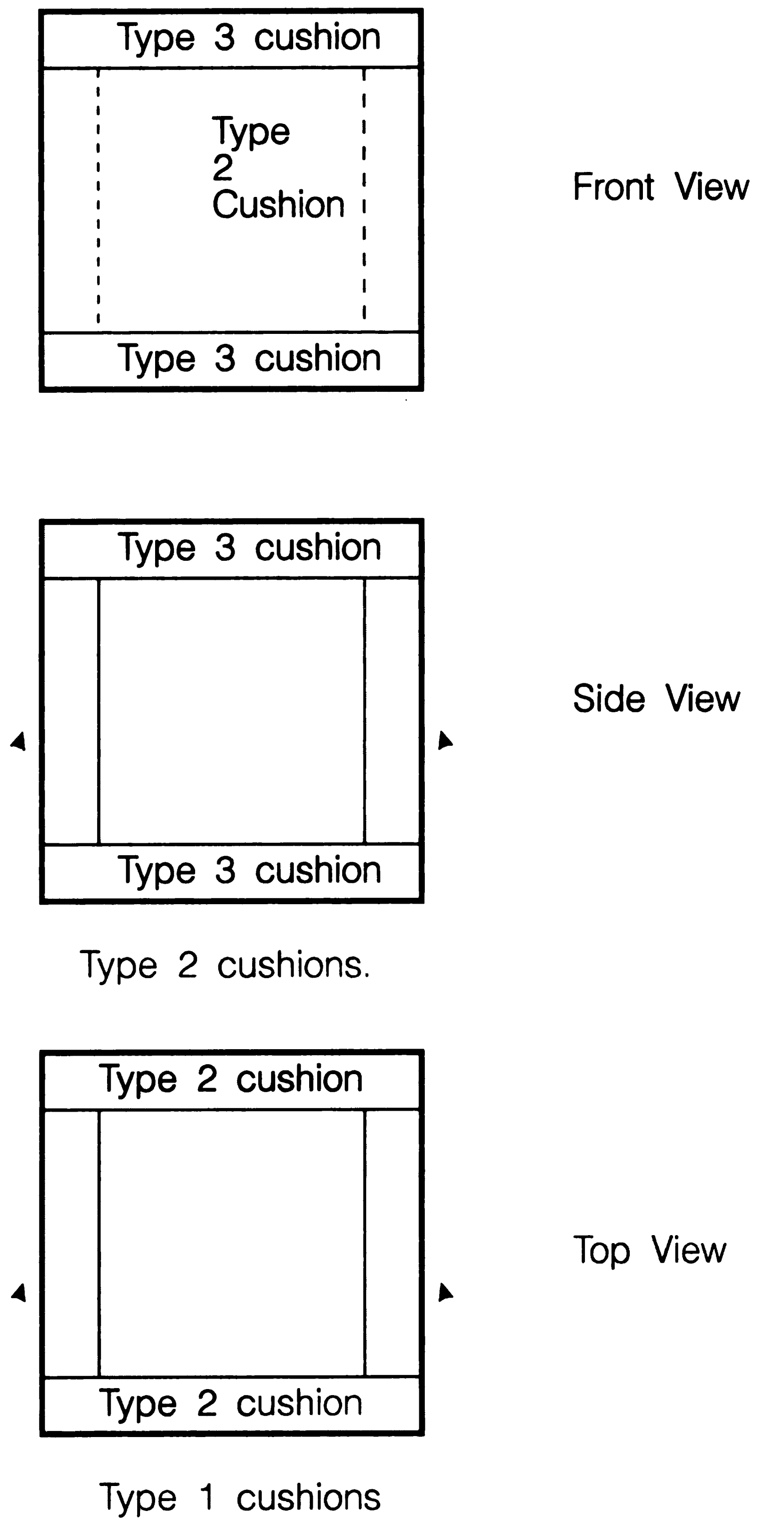


Figure 3. Cushion placement.

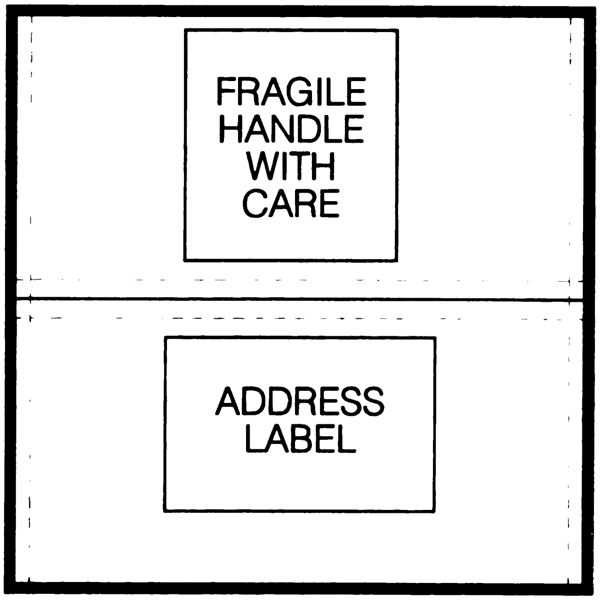


The plywood containers were marked with an arbitrary front that was then used on subsequent shipments. After placing the unit in the container a configuration file containing trip information, triggering levels, and memory modes was downloaded to the unit. The trigger level was set at the default level of 10% full scale. The memory mode used was full stop, which recorded the first 137 events and then stopped recording. Downloading the configuration file to the DHR-1 unit cleared previous data from the units RAM memory and prepared the unit for triggering. The current date and time were also downloaded to the unit. This was done so that upon return of the unit to MSU any events recorded before the unit leaving MSU would be eliminated from the data set prior to analysis. Such events included accidental impacts while sealing corrugated containers, and applying the lid to the plywood containers.

Address labels were applied to the center top of the container facing as to be read from the designated front of the shipping container. On container labeled **Fragile Handle with Care** the labels were placed above the address label on the top of the container and on the center of the four sides of the container. No labeling was applied to the bottom of the container (Figure 4). New labeling was applied to the containers as necessary to maintain legibility of all labels.

Federal Express shipments were picked up at the School of Packaging by Federal Express. Postal Service shipments were delivered to the main post office on Collins Road in Lansing, Michigan. The time of delivery to the post office was recorded for use in eliminating any events that might have occurred before delivery to the post office. When the containers were returned to the School of Packaging each container was inspected for physical damage and any damage was recorded. To reduce damage to the Vikex container when opening, the manufacture supplied tools and instructions were used to remove the top of the Vikex container.

Figure 4. Label placement.



Box Top

Box Side

The DHR-1 unit was then unpacked and removed from the shipping container. The DHR-1 unit was inspected for any physical damage to the unit that may have occurred during shipment. No physical damage was recorded during the shipment test. The DHR-1 unit was then connected to a computer in the lab and the units configuration information and shock event information was downloaded for further analysis. The DHR-1 unit was then recharged.

The shock event data was then processed through the software supplied with the units and the zero-g, equivalent drop height, and change in velocity for each shock event was calculated. These results were then uploaded into a spreadsheet for further processing.

3.4 DATA ANALYSIS

Immediately upon arrival back at MSU the outer containers were inspected for physical damage. Any damage found was recorded by container type and number. The damage was also marked on the container itself so it would not be recorded more than once.

Using the unit ratio developed by Singh and Voss (1992), the number of impacts, toss, drops, and the total number of events per shipment was calculated. The average, and standard deviation of the number shock event per shipment was calculated for each type of container used and for each labeling type.

To analyze the severity of the drops and impacts encountered during shipment the data was broken into two sets, one combining events classified as drops and tosses (this group will be called drops through out the rest of this thesis), the other containing only events classified as impacts. The drop data was then used to analyze the height of the drops encountered measured in inches, and the impact's data for analyzing the size of the impacts measured in in./sec. The minimum, maximum, average, and standard deviation of the drop heights for the two types of containers was calculated. The minimum, maximum, average, and standard deviation of the drop heights for the two labeling configurations was also calculated. In determining package test specification the drop height frequency is often used in place of average drop height. Depending on the relative costs of packaging and the value of the product an acceptable level of damage can be decided. A common practice is to test the package at a height below which 95% of the expected drops will occur (Singh, Voss 1992). The cumulative percent of drops occurring at a given drop height was calculated for corrugated and plywood containers, and labeled and unlabeled containers.

Using the impact's data the minimum, maximum, average, and standard deviation of the velocity changes for the two types of containers, and two labeling configurations was calculated. The cumulative percent of impacts occurring at a given velocity change was calculated for corrugated and plywood containers, and labeled and unlabeled containers.

4.0 RESULTS

4.1 PHYSICAL DAMAGE

The container used for each shipment was randomly selected. During this study multiple shipments were made with each outer container type. A total of five corrugated containers were used and they ranged from three shipments to five shipments per container. Four plywood Vikex containers were used and they ranged from three shipments to seven shipments per container. After each shipment the containers and DHR units were inspected for physical damage that may have occurred during that shipment. No physical damage was observed on any of the DHR units during this study. Physical damage to the outer containers was recorded upon their return to the School of Packaging at MSU, and a record for each outer container maintained. Most of the instances of damage recorded (Table 3) were punctures to the corrugated containers.

Table 3. Summary of physical damage during handling.

CORRUGATED	PLYWOOD
Container #	Container #
1 Puncture front Tear right side Puncture right side	1 No visible damage
2 Tear front Puncture left side Puncture front Puncture back	2 Dent back right top corner Dent bottom right edge
3 Tear right side Puncture bottom	3 Bent locking tab top left Loose top
4 Puncture front	4 Bent locking tab bottom front
5 Puncture bottom Puncture bottom Puncture front	

Most of the punctures were limited to the first wall of the corrugated material. Several tears were also recorded on the corrugated container and again they were generally limited to the outer layer of liner board. The plywood material used for the walls of the Vikex containers is resistant to damage and no damage was recorded to the plywood walls during this study. The damage to the plywood boxes was limited to a few dents to the metal connectors on the edges and corners of the boxes. In two cases a metal locking tab on the top or the bottom of the container had been bent from its locked position. In both cases the other locking tabs were not damaged and the cover remained tight. In a single instance a plywood container was returned with the cover noticeably loosened, however the locking tabs remained in place and the cover could not be removed manually.

4.2 SHIPPING TEST RESULTS

A total of 1527 shock events were recorded during the 40 shipments. This included 644 classified as impacts, 465 events classified as drops, and 418 classified as tosses. The number of each type of shock event for each shipment is shown in Table 4. Most of the events recorded (42%) were impacts, drops accounted for about 32%, and the remaining 26% were tosses (Figure 5) The number of shock events recorded ranged from 1 event to 65 events per shipment. There was an average of 16 impacts, 12 drops, and 10 tosses for a total of 38 shock events per shipment (Table 5). The distribution of impacts, drops, and tosses for corrugated and plywood container is shown in Figure 6 and for labeled and unlabeled containers in Figure 7.

Table 4. Number of impacts, drops, and tosses per shipment.

SHIPMENT	IMPACTS	DROPS	TOSSES	TOTAL
CUFC1	18	17	16	51
CUFC2	23	13	10	46
CUFC3	14	19	7	40
CUFT1	22	16	18	56
CUFT2	29	22	14	65
CUFT3	21	16	16	53
CUPC1	12	13	5	30
CUPC2	29	22	13	64
CUPC3	24	20	14	58
CUPT1	21	22	11	54
CUPT2	8	12	12	32
CLFC4	21	16	11	48
CLFC5	25	12	25	62
CLFT4	18	13	17	48
CLFT5	20	11	6	37
CLPC4	37	20	8	65
CLPC5	26	12	12	50
CLPT3	22	14	8	44
CLPT4	27	12	9	48
CLPT5	18	8	13	39

The shipment code is made up of five units

1. Container = C or W for **C**orrugated or ply**W**ood
2. Labeling = L or U for **L**abeled fragile or **U**nlabeled
3. Shipper = F or P for **F**ederal Express or **P**ostal Service
4. Destination = C or T for **C**alifornia or **T**exas
5. Repetition = 1-5 for the repetition of a container type shipped by a service to a location.

Table 4. (cont'd).

WUFC1	5	2	3	9
WUFC2	4	4	2	10
WUFT1	10	6	14	30
WUFT2	12	3	15	30
WUPC1	2	3	2	7
WUPC2	14	14	11	39
WUPT1	13	18	18	49
WUPT2	12	7	15	34
WUPT3	14	15	21	50
WLFC3	4	11	10	25
WLFC4	10	11	8	29
WLFC5	0	1	0	1
WLFT3	5	5	3	13
WLFT4	14	7	6	27
WLFT5	7	11	8	26
WLPC3	5	5	4	14
WLPC4	31	9	5	45
WLPC5	20	10	8	38
WLPT4	10	5	10	25
WLPT5	18	8	10	36
AVERAGE	16	12	10	38
STD. DEV.	9	6	5	17

The shipment code is made up of five units

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5. Repetition = 1-5 for the repetition of a container type shipped by a service to a location.

Figure 5. Percentage of shock events by type.

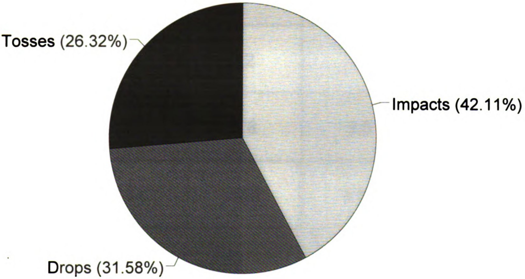


Table 5. Summary of the number of events per shipment.

	IMPACTS	DROPS	TOSSES	TOTAL
Minimum	0	1	0	1
Maximum	37	22	25	65
Average	16	12	10	38
Std. Dev.	8.9	5.8	5.5	16.8
Number	644	465	418	1527

Figure 6. Percentage of shock events by type for corrugated and plywood containers.

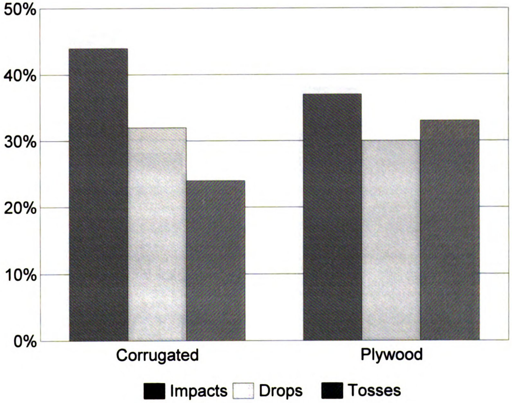
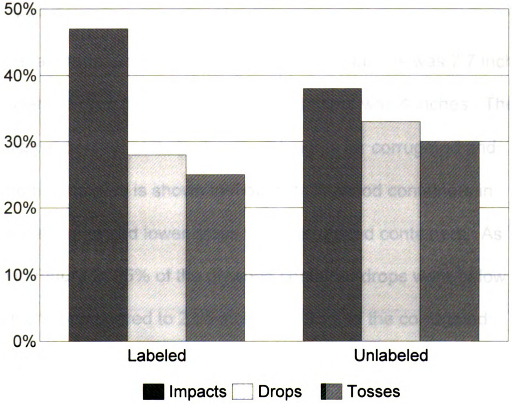


Figure 7. Percentage of shock events by type for labeled and unlabeled containers.



The 883 drops and tosses encountered ranged in drop height from the threshold of the DHR-1 unit, 0.1 inches, to a high of 83.1 inches. The average drop height was 6.3 inches with a standard deviation of 8.2 inches. The cumulative percent of drops occurring at a given height is shown in Figure 8. Of the 883 events 95% occurred below 21.5 inches and 99.5% below 48.3 inches.

The average drop height of corrugated containers was 7.7 inches. The average drop height of plywood containers was 4 inches. The cumulative percent of drop at various heights for corrugated and plywood containers is shown in Figure 9. Plywood containers in general experienced lower drops then corrugated containers. As seen in Figure 9, 95% of the plywood container drops were below 15.3 inches compared to 23.6 inches for 95% of the corrugated containers. This trend also holds at higher levels with 99.5% of the plywood containers were dropped from below 31.7 inches, 99.5% of the corrugated container drops were from below 54.8 inches. Drops and tosses are generally related more to manual handling then automated handling so the difference most likely reflects real handling difference between the two types of containers.

Figure 8 Cumulative percent of drops vs. drop height

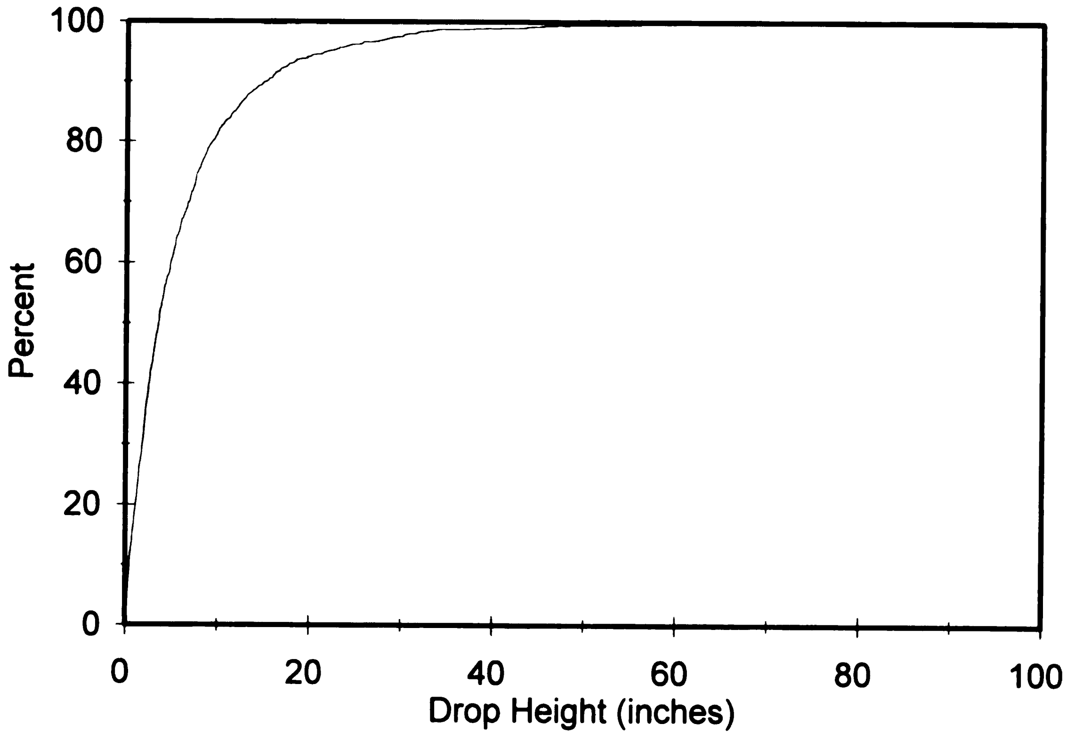
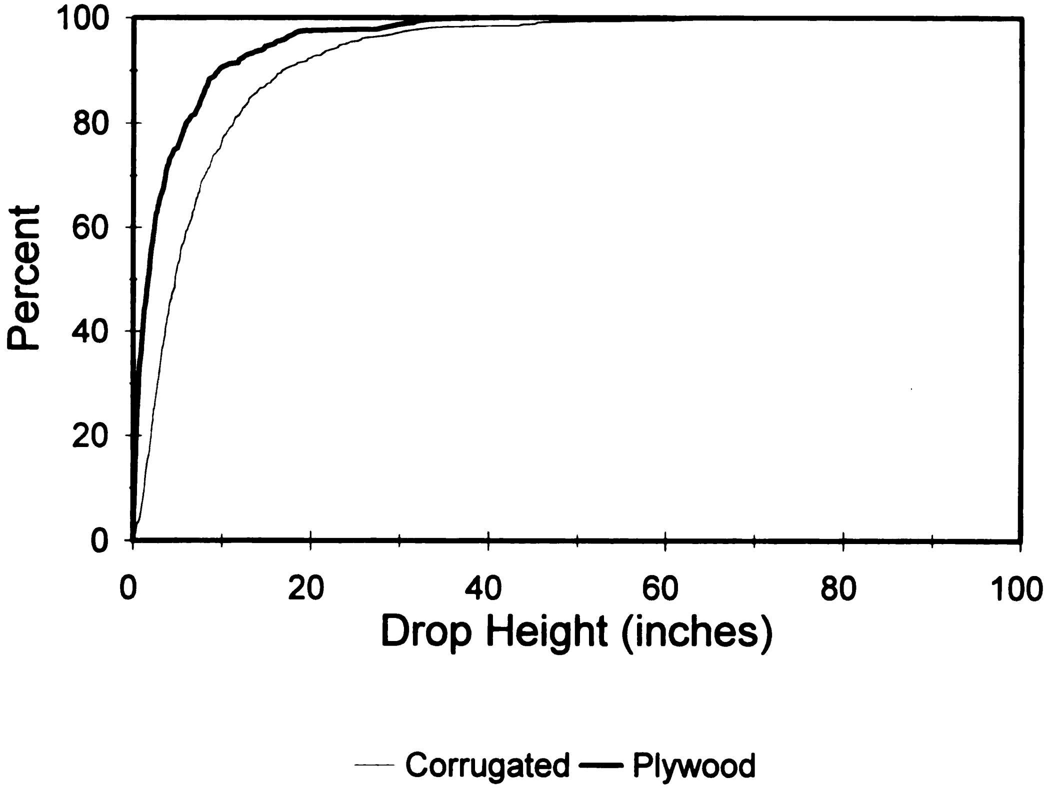


Figure 9. Cumulative percent of drops vs. drop height for Corrugated and Plywood containers.



The average drop height of labeled containers, 6.5 inches, did not differ greatly from that of unlabeled containers, 6.2 inches. This shows little if any difference in handling due to the labeling used. The cumulative percent of drops occurring at a given height for labeled and unlabeled containers is shown in Figure 10. Both types of labeling showed approximately the same distribution in drop heights, 95% of the drops in both types of containers were from below 22 inches and 99.5% from below 48.3 inches. The automated nature of this distribution system may account for this lack of difference. Any real manual handling difference appeared to be small.

The 644 impacts recorded ranged from a velocity change of 22 in/sec to a high of 392 in. / sec. The average velocity change was 78 in/sec with a standard deviation of 43.6 in. / sec. The cumulative percent of impacts at a given velocity change is shown in Figure 11. Of the 644 impacts 95% of them occurred at less than 149 in. / sec. and 99.5% of them at less then 307 in. / sec.

Figure 10. Cumulative percent of drops vs. drop height for labeled and unlabeled containers.

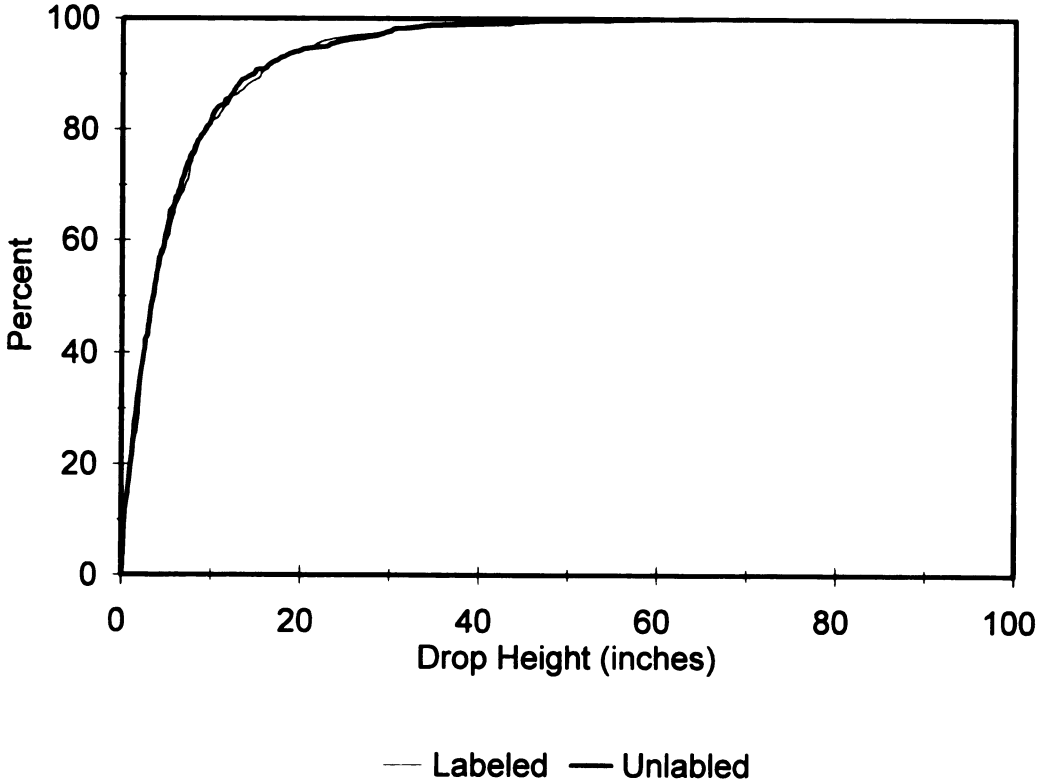
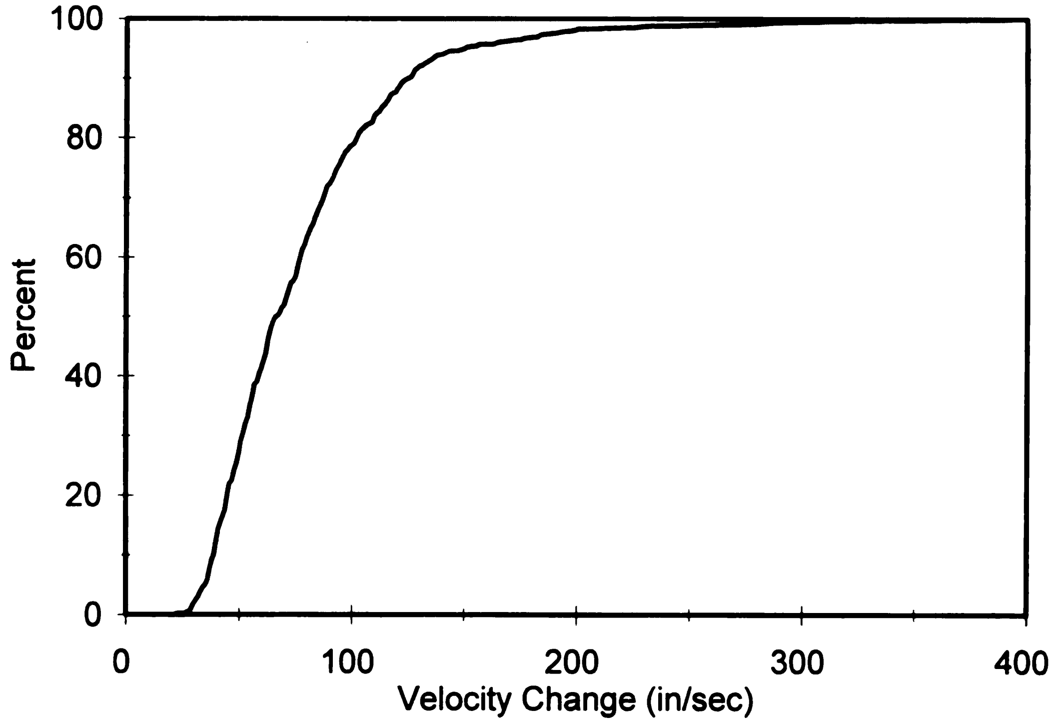
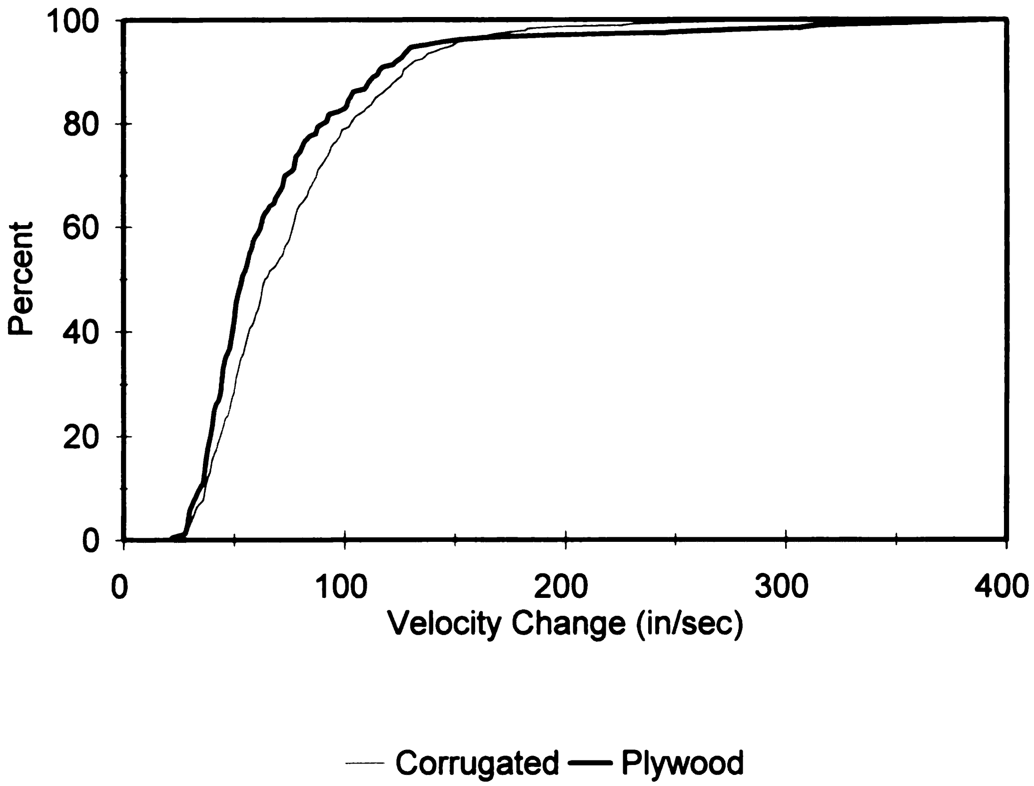


Figure 11. Cumulative percent of impacts vs. velocity change.



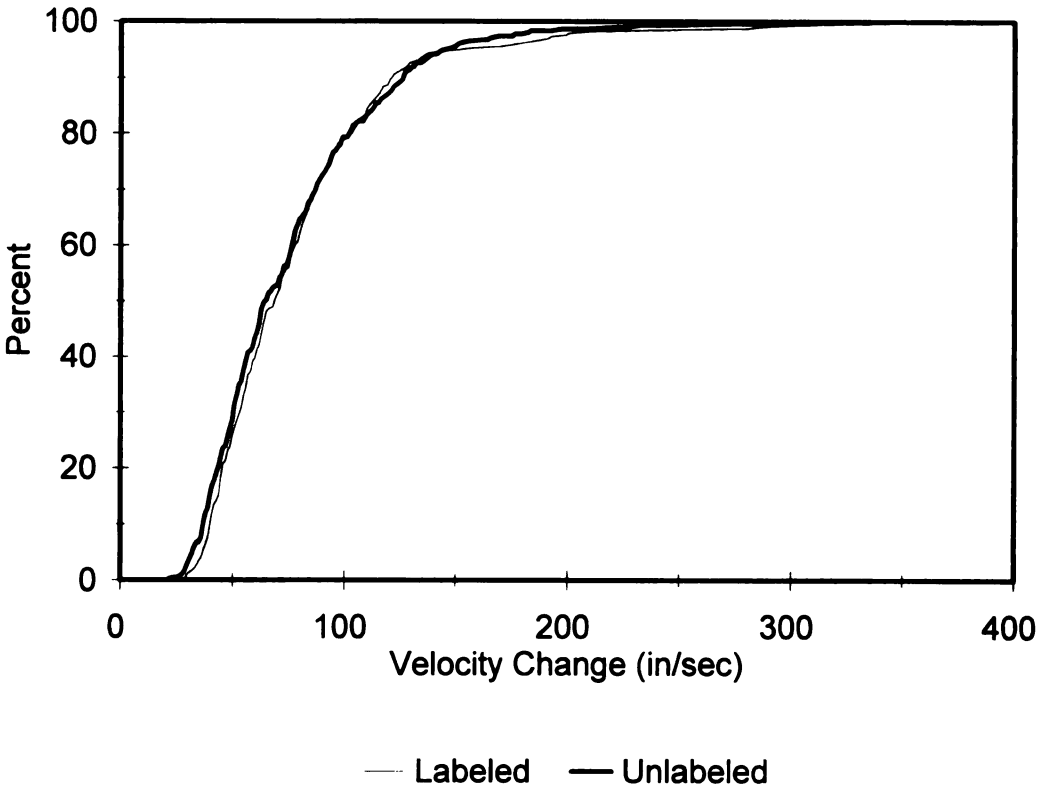
The average velocity change for impacts on the corrugated container was 81.4 in/sec, and for plywood containers 70.8 in./sec. The cumulative percent of impacts at the observed impact levels for corrugated and plywood containers is shown in Figure 12. As with the drop data there was a real difference in impact level between the two types of containers. With corrugated containers receiving higher levels of acceleration changes then plywood containers. However unlike drop heights where the distribution of drops for corrugated containers was consistently higher, the distributions of velocity changes for corrugated and plywood containers switch position at the higher levels. If we compare the cumulative distribution of velocity changes for corrugated and plywood containers we see that at the 95% level of the velocity changes for corrugated container are higher then the plywood containers. But the trends change if we look at the 99.5 % cut off point. For plywood containers 99.5% of the velocity changes are below 355 in./sec. compared with 232 in./sec. for corrugated containers.

Figure 12. Cumulative percent of impacts vs. velocity change for corrugated and plywood containers.



The average velocity change for impacts on containers labeled fragile was 79.4 in. /sec. and for unlabeled containers 76.4 in./sec. While there is a slight difference between the type of labeling it is minor and opposite of what would be expected. The cumulative percent of impacts at various levels for labeled and unlabeled containers is shown in Figure 13. As with the drop data the distribution of velocity changes for labeled and unlabeled containers are virtually identical.

Figure 13. Cumulative percent of impacts vs. velocity change for labeled and unlabeled containers.



5.0 SUMMARY AND CONCLUSIONS

To measure the shock environment of overnight delivery services a total of forty instrumented shipments were made utilizing two overnight delivery services. The handling differences between corrugated and plywood containers with and without fragile labels was also evaluated. To measure the shock environment the shipments were instrumented with a drop height recorder and shipped from East Lansing, Michigan to Cedar Park, Texas and Trabaco Canyon, California. Half the shipments were made in a plywood Vikex container manufactured by Nefab, and the remaining shipments made in a 600 # burst test triple wall corrugated container. Half the containers used were labeled **Fragile Handle With Care**. The data from the drop height recorders was evaluated to determine the drop height and velocity change of each shock event measured during shipment. The shock environment was evaluated in terms of the number of shocks received and the level of shock as measured by the drop height for shock events classified as drops or tosses, and velocity changes for the events classified as impacts.

The average shipment received approximately 38 shock events including 12 drops, 16 impacts, and 10 tosses. The drop heights, of the drops and tosses, ranged from 0.1 inches (the threshold level of the recording device) to 83.1 inches. Of these 95% occurred below 21.5 inches and 99.5% were below 48.3 inches. The velocity changes of the impacts measured ranged from 22 in/sec to 392 in/sec. Of the impacts measured 95% occurred at less then 149 in/sec and 99.5% at less then 307 in/sec.

The type of package used had an affect on the handling of the container. Corrugated containers averaged almost twice as many shock events, 50 events, as plywood containers, 29 events. In general the shock events corrugated containers received were also more severe then those of plywood containers. The drop height of 95% of the drops in corrugated containers were below 23.6 inches, and below 15.3 inches for plywood containers. Additionally the drop height of 99.5% of the drops were below 54.8 inches and 31.7 inches for corrugated and plywood containers respectively. The average impact velocity measured in corrugated container was 81.4 in/sec and for the plywood Vikex container 70.8 in/sec. The impact velocity of

95% of the impacts measured in corrugated containers were below 151 in/sec, for plywood containers 95% of the impacts were below 130 in/sec. The impact velocity of 99.5% of the impacts were below 232 in/sec and 355 in/sec for corrugated and plywood containers respectively. While the very highest levels of impact were received by plywood containers these represent a very few large impacts and in general plywood containers received lower levels of impact then corrugated containers.

Labeling with a fragile label used did not appear to affect the handling received by the containers tested. The packages used averaged roughly the same number of shock events per trip, 36 events for packages labeled fragile and 40 events for unlabeled packages. Similarly the average drop height of unlabeled packages, 6.2 inches, was nearly the same packages labeled fragile, 6.5 inches. Likewise the average impact velocity for containers labeled fragile, 79.4 in/sec, was only slightly higher then that of unlabeled containers, 76.4 in/sec.

In conclusion despite the highly automated nature of the overnight delivery environment it would appear that the type of outer container does affect the handling received. Packages with plywood outer containers received fewer and less severe shocks during shipment than packages with corrugated outer containers. The fragile labeling used, however, did not appear to have any real effect on either the number of shock events, or the severity of these events, that the packages received during shipment through the overnight delivery environment.

In this particular environment it would appear that the fragile labeling used was not effective means for altering the handling a package received. However, the type of outer container did appear to alter the handling that the package received. This may indicate that labeling by itself may not be sufficient to separate a package out from the surrounding packages for special handling. Further testing with containers in a variety of shapes and sizes, along with different types of labeling should be used to confirm these results. Given the DHR-1 modules ability to record not only shock information but also date and time information, it also might be possible to monitor the shipping environment and match handling practices to the shock events recorded. From this type of information it might be possible to determine if the handling difference were the result of structural differences, which the calibration process could not detect, or the result of human interaction.

Appendix

Appendix A

Shock event data

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	C	4	1	87	1.1	6.2	0.2
C	L	F	C	4	2	54	4.8	2.2	2.2
C	L	F	C	4	3	89	0.0	10.5	0.0
C	L	F	C	4	4	49	73.7	2.8	26.3
C	L	F	C	4	5	65	14.1	3.7	3.8
C	L	F	C	4	6	46	3.6	1.8	2.0
C	L	F	C	4	7	55	0.3	2.3	0.1
C	L	F	C	4	8	46	0.9	2.6	0.3
C	L	F	C	4	9	35	2.3	1.3	1.8
C	L	F	C	4	10	77	4.8	5.0	1.0
C	L	F	C	4	11	71	2.4	5.5	0.4
C	L	F	C	4	12	41	2.0	1.4	1.4
C	L	F	C	4	13	95	1.1	7.8	0.1
C	L	F	C	4	14	101	1.7	8.8	0.2
C	L	F	C	4	15	46	0.2	1.9	0.1
C	L	F	C	4	16	68	0.0	3.8	0.0
C	L	F	C	4	17	110	0.8	9.3	0.1
C	L	F	C	4	18	61	2.5	3.4	0.7
C	L	F	C	4	19	86	8.2	6.2	1.3
C	L	F	C	4	20	76	102.0	4.4	23.2
C	L	F	C	4	22	18	23.6	0.2	118.0
C	L	F	C	4	23	106	12.0	11.6	1.0
C	L	F	C	4	24	60	1.4	3.3	0.4
C	L	F	C	4	25	63	1.3	3.3	0.4
C	L	F	C	4	26	40	0.1	1.2	0.1
C	L	F	C	4	27	53	0.2	2.6	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	C	4	28	43	0.1	1.6	0.1
C	L	F	C	4	29	45	2.3	1.9	1.2
C	L	F	C	4	30	85	16.7	6.5	2.6
C	L	F	C	4	31	52	4.3	2.3	1.9
C	L	F	C	4	32	97	0.2	8.1	0.0
C	L	F	C	4	33	66	4.6	4.0	1.2
C	L	F	C	4	35	66	12.5	3.3	3.8
C	L	F	C	4	36	103	0.0	8.2	0.0
C	L	F	C	4	37	73	0.0	6.2	0.0
C	L	F	C	4	38	72	0.0	3.4	0.0
C	L	F	C	4	39	48	3.0	1.8	1.7
C	L	F	C	4	40	86	0.0	7.5	0.0
C	L	F	C	4	41	66	2.9	3.5	0.8
C	L	F	C	4	42	49	4.9	1.8	2.7
C	L	F	C	4	43	48	24.5	2.5	9.8
C	L	F	C	4	44	69	0.4	4.0	0.1
C	L	F	C	4	45	68	2.1	3.6	0.6
C	L	F	C	4	46	151	11.9	17.9	0.7
C	L	F	C	4	47	73	31.7	5.4	5.9
C	L	F	C	4	48	98	40.7	8.5	4.8
C	L	F	C	4	49	126	12.8	13.2	1.0
C	L	F	C	4	50	79	5.4	4.7	1.1
C	L	F	C	5	1	72	0.2	3.9	0.1
C	L	F	C	5	2	44	0.5	1.6	0.3
C	L	F	C	5	3	40	0.3	1.4	0.2
C	L	F	C	5	4	97	0.2	7.9	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	C	5	5	56	4.7	2.3	2.0
C	L	F	C	5	6	87	4.1	5.3	0.8
C	L	F	C	5	7	59	7.3	2.4	3.0
C	L	F	C	5	8	56	6.1	2.2	2.8
C	L	F	C	5	9	75	8.8	4.2	2.1
C	L	F	C	5	10	60	10.9	4.2	2.6
C	L	F	C	5	11	80	22.8	7.6	3.0
C	L	F	C	5	12	72	56.5	6.3	9.0
C	L	F	C	5	13	43	5.9	2.2	2.7
C	L	F	C	5	14	55	0.2	3.5	0.1
C	L	F	C	5	15	102	5.9	10.5	0.6
C	L	F	C	5	16	84	3.2	6.3	0.5
C	L	F	C	5	17	59	0.0	3.9	0.0
C	L	F	C	5	18	45	0.0	2.4	0.0
C	L	F	C	5	19	33	0.5	1.4	0.4
C	L	F	C	5	20	46	84.1	1.4	60.1
C	L	F	C	5	21	55	0.2	4.0	0.1
C	L	F	C	5	22	45	0.0	2.7	0.0
C	L	F	C	5	23	110	4.9	14.0	0.4
C	L	F	C	5	24	109	10.9	15.8	0.7
C	L	F	C	5	25	131	37.5	13.0	2.9
C	L	F	C	5	26	61	0.0	2.7	0.0
C	L	F	C	5	27	55	0.2	2.4	0.1
C	L	F	C	5	28	53	10.8	2.1	5.1
C	L	F	C	5	29	90	99.5	6.2	16.0
C	L	F	C	5	30	121	68.6	11.3	6.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	C	5	31	72	47.5	5.9	8.1
C	L	F	C	5	32	50	40.7	2.0	20.4
C	L	F	C	5	33	47	0.0	1.8	0.0
C	L	F	C	5	34	67	5.3	3.9	1.4
C	L	F	C	5	35	122	0.0	14.1	0.0
C	L	F	C	5	36	52	34.5	2.3	15.0
C	L	F	C	5	37	92	39.1	6.9	5.7
C	L	F	C	5	38	78	69.0	4.8	14.4
C	L	F	C	5	39	72	8.8	3.9	2.3
C	L	F	C	5	40	69	0.2	3.7	0.1
C	L	F	C	5	41	96	0.0	8.4	0.0
C	L	F	C	5	42	83	9.9	5.1	1.9
C	L	F	C	5	43	36	0.3	1.6	0.2
C	L	F	C	5	44	35	0.2	1.5	0.1
C	L	F	C	5	45	39	1.9	1.1	1.7
C	L	F	C	5	46	82	0.3	5.1	0.1
C	L	F	C	5	47	52	0.3	2.1	0.1
C	L	F	C	5	48	67	9.8	3.5	2.8
C	L	F	C	5	49	108	2.3	8.9	0.3
C	L	F	C	5	50	35	70.2	1.1	63.8
C	L	F	C	5	51	61	9.7	4.9	2.0
C	L	F	C	5	52	102	97.3	9.0	10.8
C	L	F	C	5	53	135	4.4	16.5	0.3
C	L	F	C	5	55	76	2.2	4.0	0.6
C	L	F	C	5	56	21	0.5	0.5	1.0
C	L	F	C	5	57	67	4.4	3.9	1.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	C	5	58	134	12.2	20.4	0.6
C	L	F	C	5	59	100	40.8	7.6	5.4
C	L	F	C	5	60	136	3.1	15.8	0.2
C	L	F	C	5	61	95	53.6	6.9	7.8
C	L	F	C	5	62	61	0.5	2.9	0.2
C	L	F	C	5	63	88	12.6	5.8	2.2
C	L	F	T	4	1	94	20.3	11.4	1.8
C	L	F	T	4	2	99	7.0	7.6	0.9
C	L	F	T	4	3	84	0.6	5.2	0.1
C	L	F	T	4	4	42	4.0	1.4	2.9
C	L	F	T	4	5	45	0.6	1.6	0.4
C	L	F	T	4	6	78	0.7	5.0	0.1
C	L	F	T	4	7	25	60.1	0.4	150.3
C	L	F	T	4	8	143	106.0	17.6	6.0
C	L	F	T	4	9	44	1.3	1.7	0.8
C	L	F	T	4	10	120	0.7	18.9	0.0
C	L	F	T	4	11	54	1.2	2.2	0.5
C	L	F	T	4	12	46	0.0	1.7	0.0
C	L	F	T	4	13	80	0.6	4.9	0.1
C	L	F	T	4	14	44	0.8	1.6	0.5
C	L	F	T	4	15	51	2.7	2.0	1.4
C	L	F	T	4	16	48	0.4	1.8	0.2
C	L	F	T	4	17	170	6.3	34.5	0.2
C	L	F	T	4	19	49	6.7	2.8	2.4
C	L	F	T	4	20	72	0.0	6.2	0.0
C	L	F	T	4	21	60	7.6	3.9	1.9

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	T	4	22	159	21.5	19.4	1.1
C	L	F	T	4	23	56	105.7	2.8	37.8
C	L	F	T	4	24	36	0.0	1.1	0.0
C	L	F	T	4	25	44	11.0	1.5	7.3
C	L	F	T	4	26	57	8.3	2.5	3.3
C	L	F	T	4	27	43	1.7	1.5	1.1
C	L	F	T	4	28	89	1.8	6.0	0.3
C	L	F	T	4	29	76	4.5	4.1	1.1
C	L	F	T	4	30	50	14.2	3.1	4.6
C	L	F	T	4	31	75	4.0	7.4	0.5
C	L	F	T	4	32	91	2.6	6.6	0.4
C	L	F	T	4	33	67	5.9	3.4	1.7
C	L	F	T	4	34	58	25.7	3.5	7.3
C	L	F	T	4	35	48	5.4	1.5	3.6
C	L	F	T	4	36	38	41.2	1.3	31.7
C	L	F	T	4	37	83	0.0	4.4	0.0
C	L	F	T	4	38	45	7.3	1.8	4.1
C	L	F	T	4	39	133	2.4	17.0	0.1
C	L	F	T	4	40	61	2.1	4.6	0.5
C	L	F	T	4	41	52	9.3	2.1	4.4
C	L	F	T	4	42	42	6.5	1.9	3.4
C	L	F	T	4	43	60	21.7	2.8	7.8
C	L	F	T	4	44	105	56.1	13.8	4.1
C	L	F	T	4	45	50	25.3	2.1	12.0
C	L	F	T	4	46	76	0.0	4.4	0.0
C	L	F	T	4	47	85	0.0	5.4	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	T	4	48	57	0.1	2.5	0.0
C	L	F	T	4	49	83	3.6	5.2	0.7
C	L	F	T	5	1	33	22.8	0.9	25.3
C	L	F	T	5	2	65	1.5	5.6	0.3
C	L	F	T	5	3	87	8.9	9.8	0.9
C	L	F	T	5	4	45	4.9	2.6	1.9
C	L	F	T	5	5	46	0.3	1.7	0.2
C	L	F	T	5	6	79	91.4	7.7	11.9
C	L	F	T	5	7	70	2.9	5.5	0.5
C	L	F	T	5	8	46	0.5	1.5	0.3
C	L	F	T	5	9	48	2.2	2.7	0.8
C	L	F	T	5	10	41	0.2	1.8	0.1
C	L	F	T	5	11	56	0.5	3.3	0.2
C	L	F	T	5	12	129	3.8	14.2	0.3
C	L	F	T	5	13	91	0.0	7.5	0.0
C	L	F	T	5	15	76	0.0	6.1	0.0
C	L	F	T	5	16	60	3.7	2.7	1.4
C	L	F	T	5	17	98	0.4	8.1	0.0
C	L	F	T	5	18	88	31.5	6.2	5.1
C	L	F	T	5	19	71	5.4	6.5	0.8
C	L	F	T	5	20	34	0.2	1.5	0.1
C	L	F	T	5	21	107	0.7	8.9	0.1
C	L	F	T	5	22	31	0.4	1.3	0.3
C	L	F	T	5	23	76	0.3	5.4	0.1
C	L	F	T	5	24	42	0.3	1.3	0.2
C	L	F	T	5	25	65	1.0	5.3	0.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	F	T	5	26	57	0.0	3.0	0.0
C	L	F	T	5	27	86	2.3	7.5	0.3
C	L	F	T	5	28	51	0.6	2.7	0.2
C	L	F	T	5	29	50	2.0	2.3	0.9
C	L	F	T	5	30	76	3.0	4.5	0.7
C	L	F	T	5	31	77	31.0	4.3	7.2
C	L	F	T	5	32	88	0.0	7.3	0.0
C	L	F	T	5	33	76	16.8	4.4	3.8
C	L	F	T	5	34	117	5.4	11.0	0.5
C	L	F	T	5	36	64	5.6	3.3	1.7
C	L	F	T	5	37	121	12.3	11.1	1.1
C	L	F	T	5	38	41	15.0	1.4	10.7
C	L	F	T	5	39	74	4.9	4.1	1.2
C	L	P	C	4	2	33	0.0	1.4	0.0
C	L	P	C	4	3	125	7.2	11.7	0.6
C	L	P	C	4	4	92	1.1	6.7	0.2
C	L	P	C	4	5	137	87.2	14.2	6.1
C	L	P	C	4	6	40	0.0	1.2	0.0
C	L	P	C	4	7	68	85.6	5.5	15.6
C	L	P	C	4	8	42	0.0	2.1	0.0
C	L	P	C	4	9	190	65.1	43.6	1.5
C	L	P	C	4	10	62	2.5	3.8	0.7
C	L	P	C	4	11	134	0.1	18.7	0.0
C	L	P	C	4	12	77	5.1	5.4	0.9
C	L	P	C	4	13	87	4.1	5.5	0.7
C	L	P	C	4	14	83	0.0	6.6	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	C	4	15	87	10.0	6.1	1.6
C	L	P	C	4	16	132	25.6	21.2	1.2
C	L	P	C	4	17	67	92.4	2.9	31.9
C	L	P	C	4	18	109	0.6	11.1	0.1
C	L	P	C	4	19	30	0.5	0.7	0.7
C	L	P	C	4	20	55	6.5	4.0	1.6
C	L	P	C	4	21	43	2.6	2.5	1.0
C	L	P	C	4	22	93	0.0	5.8	0.0
C	L	P	C	4	23	64	0.0	3.4	0.0
C	L	P	C	4	24	24	0.2	0.4	0.5
C	L	P	C	4	25	119	4.8	10.9	0.4
C	L	P	C	4	26	289	40.3	89.2	0.5
C	L	P	C	4	27	89	78.6	6.1	12.9
C	L	P	C	4	28	110	0.4	9.1	0.0
C	L	P	C	4	29	82	0.6	5.2	0.1
C	L	P	C	4	30	81	0.0	8.1	0.0
C	L	P	C	4	31	77	0.4	4.6	0.1
C	L	P	C	4	32	85	0.5	5.6	0.1
C	L	P	C	4	33	63	0.2	4.6	0.0
C	L	P	C	4	34	49	0.6	2.9	0.2
C	L	P	C	4	35	103	0.2	12.9	0.0
C	L	P	C	4	36	113	3.0	15.5	0.2
C	L	P	C	4	37	96	0.2	11.2	0.0
C	L	P	C	4	38	56	0.5	3.7	0.1
C	L	P	C	4	39	55	0.6	3.7	0.2
C	L	P	C	4	40	74	0.7	6.7	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	C	4	41	69	0.3	3.6	0.1
C	L	P	C	4	42	92	0.2	10.3	0.0
C	L	P	C	4	43	64	0.2	5.0	0.0
C	L	P	C	4	44	61	1.8	2.9	0.6
C	L	P	C	4	45	61	0.2	4.6	0.0
C	L	P	C	4	46	77	2.8	4.5	0.6
C	L	P	C	4	47	63	10.6	3.1	3.4
C	L	P	C	4	48	134	10.6	13.7	0.8
C	L	P	C	4	49	103	15.9	10.1	1.6
C	L	P	C	4	50	199	21.0	44.1	0.5
C	L	P	C	4	51	74	4.8	5.6	0.9
C	L	P	C	4	52	177	22.0	30.5	0.7
C	L	P	C	4	53	88	4.1	7.6	0.5
C	L	P	C	4	54	131	41.9	18.4	2.3
C	L	P	C	4	55	72	4.9	6.4	0.8
C	L	P	C	4	56	188	0.0	29.3	0.0
C	L	P	C	4	57	124	1.8	14.6	0.1
C	L	P	C	4	58	50	0.0	1.8	0.0
C	L	P	C	4	59	65	0.0	4.1	0.0
C	L	P	C	4	60	68	8.9	3.7	2.4
C	L	P	C	4	61	110	4.3	11.6	0.4
C	L	P	C	4	62	75	2.5	4.3	0.6
C	L	P	C	4	63	75	0.2	4.4	0.0
C	L	P	C	4	64	145	36.2	17.2	2.1
C	L	P	C	4	65	63	0.2	2.9	0.1
C	L	P	C	4	66	53	0.0	2.4	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	C	5	1	77	0.0	4.4	0.0
C	L	P	C	5	2	98	8.7	7.1	1.2
C	L	P	C	5	3	106	0.4	8.0	0.1
C	L	P	C	5	4	64	0.2	3.8	0.1
C	L	P	C	5	5	47	0.2	2.7	0.1
C	L	P	C	5	6	20	58.8	0.3	196.0
C	L	P	C	5	7	116	1.4	14.6	0.1
C	L	P	C	5	8	175	0.0	34.4	0.0
C	L	P	C	5	9	84	0.0	7.2	0.0
C	L	P	C	5	10	156	8.3	25.6	0.3
C	L	P	C	5	11	209	0.5	38.5	0.0
C	L	P	C	5	12	81	20.8	5.1	4.1
C	L	P	C	5	13	111	15.7	9.8	1.6
C	L	P	C	5	14	144	32.3	15.4	2.1
C	L	P	C	5	15	123	16.5	16.1	1.0
C	L	P	C	5	16	40	3.4	2.0	1.7
C	L	P	C	5	17	63	0.9	4.4	0.2
C	L	P	C	5	18	151	0.0	23.4	0.0
C	L	P	C	5	19	90	24.5	6.0	4.1
C	L	P	C	5	20	128	0.0	13.2	0.0
C	L	P	C	5	21	98	24.2	8.6	2.8
C	L	P	C	5	22	184	1.2	29.0	0.0
C	L	P	C	5	23	101	1.9	6.5	0.3
C	L	P	C	5	24	95	0.0	5.8	0.0
C	L	P	C	5	25	115	0.2	16.0	0.0
C	L	P	C	5	26	89	0.2	9.5	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	C	5	27	111	18.8	7.9	2.4
C	L	P	C	5	28	71	5.5	3.2	1.7
C	L	P	C	5	29	137	0.4	12.1	0.0
C	L	P	C	5	30	93	0.0	6.5	0.0
C	L	P	C	5	33	221	45.2	37.8	1.2
C	L	P	C	5	34	269	83.1	60.3	1.4
C	L	P	C	5	35	72	0.0	3.7	0.0
C	L	P	C	5	36	110	14.2	11.4	1.2
C	L	P	C	5	37	144	37.5	15.5	2.4
C	L	P	C	5	38	94	28.8	11.1	2.6
C	L	P	C	5	39	76	0.0	5.0	0.0
C	L	P	C	5	40	120	0.0	11.0	0.0
C	L	P	C	5	41	149	11.4	16.7	0.7
C	L	P	C	5	42	61	0.0	4.0	0.0
C	L	P	C	5	43	205	32.6	46.3	0.7
C	L	P	C	5	44	49	9.6	2.2	4.4
C	L	P	C	5	45	76	16.2	5.5	2.9
C	L	P	C	5	47	50	39.6	1.9	20.8
C	L	P	C	5	48	76	48.1	4.4	10.9
C	L	P	C	5	49	103	3.0	9.7	0.3
C	L	P	C	5	50	88	0.0	7.0	0.0
C	L	P	C	5	51	69	3.5	3.6	1.0
C	L	P	C	5	52	80	2.5	5.6	0.4
C	L	P	C	5	53	61	1.6	2.8	0.6
C	L	P	T	3	1	90	3.7	6.1	0.6
C	L	P	T	3	2	85	1.5	6.4	0.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	T	3	3	89	0.2	6.0	0.0
C	L	P	T	3	5	161	23.9	19.6	1.2
C	L	P	T	3	7	175	48.3	38.2	1.3
C	L	P	T	3	8	99	20.3	7.5	2.7
C	L	P	T	3	9	79	1.2	8.4	0.1
C	L	P	T	3	10	54	6.6	2.2	3.0
C	L	P	T	3	11	62	0.8	3.5	0.2
C	L	P	T	3	12	55	0.3	2.4	0.1
C	L	P	T	3	13	75	22.6	6.0	3.8
C	L	P	T	3	14	83	0.0	7.3	0.0
C	L	P	T	3	15	96	2.0	7.5	0.3
C	L	P	T	3	16	77	11.8	4.8	2.5
C	L	P	T	3	17	175	18.3	23.6	0.8
C	L	P	T	3	18	200	14.0	47.8	0.3
C	L	P	T	3	19	122	65.6	11.1	5.9
C	L	P	T	3	20	97	0.0	7.2	0.0
C	L	P	T	3	21	65	0.4	5.0	0.1
C	L	P	T	3	23	59	11.3	2.6	4.3
C	L	P	T	3	24	54	0.0	2.7	0.0
C	L	P	T	3	25	77	0.0	4.5	0.0
C	L	P	T	3	26	43	0.0	1.5	0.0
C	L	P	T	3	27	73	8.6	7.0	1.2
C	L	P	T	3	28	48	0.0	2.7	0.0
C	L	P	T	3	29	56	0.0	2.3	0.0
C	L	P	T	3	30	81	0.0	4.9	0.0
C	L	P	T	3	31	87	0.3	5.7	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	T	3	32	131	15.5	20.0	0.8
C	L	P	T	3	33	89	1.1	7.0	0.2
C	L	P	T	3	34	144	15.1	15.9	0.9
C	L	P	T	3	35	85	4.7	6.4	0.7
C	L	P	T	3	36	112	52.4	10.6	4.9
C	L	P	T	3	37	51	1.4	2.1	0.7
C	L	P	T	3	38	57	0.0	3.2	0.0
C	L	P	T	3	39	78	9.6	5.6	1.7
C	L	P	T	3	40	42	0.0	1.4	0.0
C	L	P	T	3	41	51	6.7	2.0	3.4
C	L	P	T	3	42	128	0.0	14.5	0.0
C	L	P	T	3	44	36	1.0	1.0	1.0
C	L	P	T	3	45	117	16.0	10.2	1.6
C	L	P	T	3	46	81	7.5	5.1	1.5
C	L	P	T	3	48	70	7.4	6.3	1.2
C	L	P	T	3	49	71	0.4	3.8	0.1
C	L	P	T	4	1	35	1.9	0.9	2.1
C	L	P	T	4	2	82	0.2	5.9	0.0
C	L	P	T	4	3	39	0.0	1.1	0.0
C	L	P	T	4	4	50	4.9	2.0	2.5
C	L	P	T	4	5	71	0.0	4.4	0.0
C	L	P	T	4	7	82	13.5	8.2	1.6
C	L	P	T	4	8	132	25.3	14.9	1.7
C	L	P	T	4	9	70	0.4	3.9	0.1
C	L	P	T	4	10	158	63.6	19.5	3.3
C	L	P	T	4	11	110	22.7	8.1	2.8

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	T	4	12	36	15.3	1.0	15.3
C	L	P	T	4	13	80	0.0	6.0	0.0
C	L	P	T	4	14	224	28.0	40.9	0.7
C	L	P	T	4	15	64	0.9	5.4	0.2
C	L	P	T	4	16	281	21.7	60.2	0.4
C	L	P	T	4	18	121	0.7	15.8	0.0
C	L	P	T	4	19	78	0.1	6.1	0.0
C	L	P	T	4	20	117	12.2	10.9	1.1
C	L	P	T	4	21	148	11.2	16.5	0.7
C	L	P	T	4	22	65	0.0	3.6	0.0
C	L	P	T	4	23	42	8.8	1.4	6.3
C	L	P	T	4	25	115	1.0	10.5	0.1
C	L	P	T	4	26	89	8.3	6.6	1.3
C	L	P	T	4	27	117	0.0	10.2	0.0
C	L	P	T	4	28	56	0.3	2.3	0.1
C	L	P	T	4	29	64	0.9	3.1	0.3
C	L	P	T	4	30	50	0.0	1.9	0.0
C	L	P	T	4	31	113	0.2	12.1	0.0
C	L	P	T	4	32	87	0.0	5.0	0.0
C	L	P	T	4	33	179	0.0	24.3	0.0
C	L	P	T	4	34	80	3.4	7.6	0.4
C	L	P	T	4	35	81	8.9	7.5	1.2
C	L	P	T	4	36	131	0.0	15.1	0.0
C	L	P	T	4	37	48	0.8	2.8	0.3
C	L	P	T	4	38	98	7.1	11.0	0.6
C	L	P	T	4	39	59	0.0	4.5	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	T	4	40	169	21.5	31.6	0.7
C	L	P	T	4	41	40	0.0	1.2	0.0
C	L	P	T	4	42	85	0.9	6.4	0.1
C	L	P	T	4	43	83	6.7	5.4	1.2
C	L	P	T	4	44	57	0.0	2.5	0.0
C	L	P	T	4	45	138	69.9	13.0	5.4
C	L	P	T	4	48	95	34.7	7.1	4.9
C	L	P	T	4	49	57	4.9	2.1	2.3
C	L	P	T	4	50	191	0.3	28.1	0.0
C	L	P	T	4	51	53	1.3	2.6	0.5
C	L	P	T	4	52	89	2.3	6.4	0.4
C	L	P	T	4	53	52	3.1	2.1	1.5
C	L	P	T	5	1	141	0.4	14.9	0.0
C	L	P	T	5	2	44	0.0	1.5	0.0
C	L	P	T	5	3	73	6.8	4.3	1.6
C	L	P	T	5	4	99	9.0	8.0	1.1
C	L	P	T	5	5	151	93.0	18.0	5.2
C	L	P	T	5	6	178	66.3	21.2	3.1
C	L	P	T	5	7	186	31.5	37.2	0.8
C	L	P	T	5	8	112	98.4	9.9	9.9
C	L	P	T	5	9	85	0.0	8.0	0.0
C	L	P	T	5	10	219	29.1	33.1	0.9
C	L	P	T	5	11	95	0.0	8.8	0.0
C	L	P	T	5	12	76	0.0	3.9	0.0
C	L	P	T	5	13	157	89.8	21.6	4.2
C	L	P	T	5	14	162	95.4	19.6	4.9

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	L	P	T	5	15	62	0.0	3.1	0.0
C	L	P	T	5	16	38	0.2	1.0	0.2
C	L	P	T	5	17	55	10.3	2.3	4.5
C	L	P	T	5	18	102	0.0	7.8	0.0
C	L	P	T	5	19	59	0.0	3.8	0.0
C	L	P	T	5	20	48	6.4	2.1	3.0
C	L	P	T	5	21	105	0.0	8.3	0.0
C	L	P	T	5	22	148	23.1	26.9	0.9
C	L	P	T	5	23	85	6.6	6.7	1.0
C	L	P	T	5	24	120	0.2	14.9	0.0
C	L	P	T	5	25	109	10.9	11.5	0.9
C	L	P	T	5	26	166	22.4	23.4	1.0
C	L	P	T	5	27	59	0.0	4.0	0.0
C	L	P	T	5	28	74	0.0	4.7	0.0
C	L	P	T	5	29	66	0.0	3.9	0.0
C	L	P	T	5	30	57	12.6	2.5	5.0
C	L	P	T	5	31	84	0.0	5.4	0.0
C	L	P	T	5	32	56	9.3	3.3	2.8
C	L	P	T	5	33	45	6.5	1.5	4.3
C	L	P	T	5	34	92	0.5	6.9	0.1
C	L	P	T	5	35	90	93.5	7.8	12.0
C	L	P	T	5	36	64	0.0	3.3	0.0
C	L	P	T	5	37	69	11.5	3.8	3.0
C	L	P	T	5	38	60	54.6	3.1	17.6
C	L	P	T	5	39	93	0.0	7.7	0.0
C	U	F	C	1	1	79	48.6	5.3	9.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	C	1	2	97	5.8	7.3	0.8
C	U	F	C	1	3	61	0.0	2.9	0.0
C	U	F	C	1	4	96	27.7	8.4	3.3
C	U	F	C	1	5	29	0.8	0.8	1.0
C	U	F	C	1	6	37	0.2	1.1	0.2
C	U	F	C	1	7	37	2.3	1.1	2.1
C	U	F	C	1	8	70	10.6	3.8	2.8
C	U	F	C	1	9	109	82.0	7.6	10.8
C	U	F	C	1	10	74	3.7	4.2	0.9
C	U	F	C	1	11	40	2.9	1.4	2.1
C	U	F	C	1	12	50	0.4	3.3	0.1
C	U	F	C	1	13	34	2.1	1.5	1.4
C	U	F	C	1	14	95	0.7	7.0	0.1
C	U	F	C	1	15	53	24.9	2.1	11.9
C	U	F	C	1	16	39	2.3	1.2	1.9
C	U	F	C	1	17	24	3.7	0.4	9.3
C	U	F	C	1	18	39	0.0	1.4	0.0
C	U	F	C	1	19	132	10.6	12.9	0.8
C	U	F	C	1	20	218	43.7	36.8	1.2
C	U	F	C	1	21	24	3.7	0.4	9.3
C	U	F	C	1	22	48	0.6	1.8	0.3
C	U	F	C	1	23	63	10.7	3.1	3.5
C	U	F	C	1	24	60	0.6	3.0	0.2
C	U	F	C	1	26	127	0.0	15.2	0.0
C	U	F	C	1	27	79	98.1	4.8	20.4
C	U	F	C	1	28	236	45.4	39.3	1.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	C	1	29	45	0.0	1.3	0.0
C	U	F	C	1	30	133	14.2	21.2	0.7
C	U	F	C	1	31	45	1.6	2.3	0.7
C	U	F	C	1	32	27	40.1	0.9	44.6
C	U	F	C	1	33	37	1.7	1.7	1.0
C	U	F	C	1	34	38	0.8	1.8	0.4
C	U	F	C	1	35	73	4.1	5.6	0.7
C	U	F	C	1	36	53	12.1	3.7	3.3
C	U	F	C	1	37	75	0.6	3.8	0.2
C	U	F	C	1	38	88	4.4	9.3	0.5
C	U	F	C	1	39	35	5.2	1.5	3.5
C	U	F	C	1	40	33	0.0	1.5	0.0
C	U	F	C	1	41	102	33.2	12.0	2.8
C	U	F	C	1	42	49	0.9	2.6	0.3
C	U	F	C	1	43	37	0.8	1.2	0.7
C	U	F	C	1	44	81	1.5	4.8	0.3
C	U	F	C	1	45	43	1.5	2.1	0.7
C	U	F	C	1	46	36	0.0	1.7	0.0
C	U	F	C	1	47	72	39.1	4.9	8.0
C	U	F	C	1	48	73	7.6	4.2	1.8
C	U	F	C	1	49	46	1.5	1.7	0.9
C	U	F	C	1	50	53	3.0	2.7	1.1
C	U	F	C	1	51	89	1.0	6.0	0.2
C	U	F	C	1	52	121	0.5	11.2	0.0
C	U	F	C	2	1	33	63.8	0.9	70.9
C	U	F	C	2	2	64	0.3	5.3	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	C	2	3	127	0.0	12.4	0.0
C	U	F	C	2	4	62	0.3	2.5	0.1
C	U	F	C	2	5	86	45.8	7.3	6.3
C	U	F	C	2	6	74	32.1	4.8	6.7
C	U	F	C	2	7	40	0.3	2.0	0.2
C	U	F	C	2	8	89	10.7	10.0	1.1
C	U	F	C	2	9	55	3.9	3.6	1.1
C	U	F	C	2	10	63	1.1	2.9	0.4
C	U	F	C	2	11	52	4.8	3.4	1.4
C	U	F	C	2	12	67	3.9	5.6	0.7
C	U	F	C	2	13	95	2.0	6.5	0.3
C	U	F	C	2	14	182	2.5	25.1	0.1
C	U	F	C	2	15	93	41.7	6.7	6.2
C	U	F	C	2	16	46	0.0	1.6	0.0
C	U	F	C	2	17	36	47.3	1.0	47.3
C	U	F	C	2	18	110	0.0	9.0	0.0
C	U	F	C	2	19	177	54.8	33.1	1.7
C	U	F	C	2	20	51	1.1	2.4	0.5
C	U	F	C	2	21	87	46.2	6.9	6.7
C	U	F	C	2	22	81	7.3	5.1	1.4
C	U	F	C	2	23	74	73.2	4.1	17.9
C	U	F	C	2	24	67	0.0	3.3	0.0
C	U	F	C	2	25	94	0.0	6.6	0.0
C	U	F	C	2	26	114	0.0	10.6	0.0
C	U	F	C	2	27	88	85.3	5.8	14.7
C	U	F	C	2	28	79	0.0	7.6	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	C	2	29	49	1.8	1.7	1.1
C	U	F	C	2	30	84	5.4	4.7	1.1
C	U	F	C	2	31	81	3.6	4.7	0.8
C	U	F	C	2	32	69	4.9	3.8	1.3
C	U	F	C	2	33	99	0.3	8.3	0.0
C	U	F	C	2	34	45	0.0	2.2	0.0
C	U	F	C	2	35	53	95.9	2.5	38.4
C	U	F	C	2	36	76	1.5	7.3	0.2
C	U	F	C	2	37	48	7.1	1.8	3.9
C	U	F	C	2	38	58	1.5	2.8	0.5
C	U	F	C	2	39	57	0.0	2.7	0.0
C	U	F	C	2	40	103	0.0	12.1	0.0
C	U	F	C	2	41	86	11.5	6.1	1.9
C	U	F	C	2	42	116	10.0	11.1	0.9
C	U	F	C	2	43	62	0.0	3.0	0.0
C	U	F	C	2	44	75	0.0	4.2	0.0
C	U	F	C	2	45	124	0.0	12.0	0.0
C	U	F	C	2	46	53	0.0	2.2	0.0
C	U	F	C	3	1	116	77.6	10.2	7.6
C	U	F	C	3	2	54	0.0	3.8	0.0
C	U	F	C	3	3	90	8.4	6.2	1.4
C	U	F	C	3	4	78	43.4	6.7	6.5
C	U	F	C	3	5	43	0.6	2.3	0.3
C	U	F	C	3	6	53	0.1	2.2	0.0
C	U	F	C	3	7	49	1.3	1.9	0.7
C	U	F	C	3	8	103	9.0	8.4	1.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	C	3	9	31	0.4	1.2	0.3
C	U	F	C	3	10	64	0.0	3.3	0.0
C	U	F	C	3	11	109	2.1	10.5	0.2
C	U	F	C	3	12	40	1.0	1.5	0.7
C	U	F	C	3	13	76	4.1	4.3	1.0
C	U	F	C	3	14	54	2.7	3.0	0.9
C	U	F	C	3	15	226	14.2	66.7	0.2
C	U	F	C	3	16	49	9.8	2.1	4.7
C	U	F	C	3	17	58	13.5	3.0	4.5
C	U	F	C	3	18	122	16.2	11.9	1.4
C	U	F	C	3	19	182	43.4	29.7	1.5
C	U	F	C	3	20	100	17.0	10.1	1.7
C	U	F	C	3	21	49	0.9	1.7	0.5
C	U	F	C	3	22	107	10.1	8.7	1.2
C	U	F	C	3	23	39	69.9	1.2	58.2
C	U	F	C	3	24	86	9.4	5.6	1.7
C	U	F	C	3	25	61	5.1	3.3	1.5
C	U	F	C	3	26	36	14.8	1.1	13.5
C	U	F	C	3	27	151	0.1	16.9	0.0
C	U	F	C	3	28	41	0.3	1.5	0.2
C	U	F	C	3	29	58	2.7	4.2	0.6
C	U	F	C	3	30	51	1.2	3.5	0.3
C	U	F	C	3	31	73	5.4	6.4	0.8
C	U	F	C	3	32	71	0.3	6.4	0.0
C	U	F	C	3	33	76	6.0	7.5	0.8
C	U	F	C	3	34	68	5.3	6.0	0.9

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	C	3	35	84	0.2	5.4	0.0
C	U	F	C	3	36	40	0.5	1.2	0.4
C	U	F	C	3	37	54	6.6	2.4	2.8
C	U	F	C	3	38	66	3.0	3.5	0.9
C	U	F	C	3	39	100	13.2	7.5	1.8
C	U	F	C	3	40	63	0.3	3.3	0.1
C	U	F	T	1	1	83	4.5	5.2	0.9
C	U	F	T	1	2	102	13.3	8.5	1.6
C	U	F	T	1	3	115	54.4	11.5	4.7
C	U	F	T	1	4	34	5.4	0.9	6.0
C	U	F	T	1	5	32	0.3	0.8	0.4
C	U	F	T	1	6	29	1.4	0.7	2.0
C	U	F	T	1	7	81	11.2	5.2	2.2
C	U	F	T	1	8	39	3.0	1.2	2.5
C	U	F	T	1	9	67	3.1	3.4	0.9
C	U	F	T	1	10	36	7.7	1.0	7.7
C	U	F	T	1	11	70	9.9	4.1	2.4
C	U	F	T	1	12	113	12.5	9.6	1.3
C	U	F	T	1	13	52	1.0	2.5	0.4
C	U	F	T	1	14	64	0.4	3.4	0.1
C	U	F	T	1	15	56	14.6	2.7	5.4
C	U	F	T	1	16	51	1.4	2.5	0.6
C	U	F	T	1	17	71	59.2	5.1	11.6
C	U	F	T	1	18	47	1.5	1.8	0.8
C	U	F	T	1	19	54	2.7	2.5	1.1
C	U	F	T	1	20	42	0.3	1.6	0.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	T	1	21	61	1.1	3.2	0.3
C	U	F	T	1	22	48	0.6	2.1	0.3
C	U	F	T	1	23	43	0.1	1.7	0.1
C	U	F	T	1	24	183	8.4	23.8	0.4
C	U	F	T	1	25	106	8.2	9.2	0.9
C	U	F	T	1	26	76	1.1	5.3	0.2
C	U	F	T	1	27	91	0.4	6.3	0.1
C	U	F	T	1	28	90	0.0	6.0	0.0
C	U	F	T	1	29	122	4.2	11.4	0.4
C	U	F	T	1	30	92	0.0	6.6	0.0
C	U	F	T	1	31	68	1.3	3.7	0.4
C	U	F	T	1	32	97	16.1	9.8	1.6
C	U	F	T	1	33	135	6.7	14.1	0.5
C	U	F	T	1	34	45	92.7	1.9	48.8
C	U	F	T	1	35	142	62.7	25.7	2.4
C	U	F	T	1	36	63	3.1	2.7	1.1
C	U	F	T	1	37	44	0.2	1.4	0.1
C	U	F	T	1	38	39	1.6	1.7	0.9
C	U	F	T	1	39	48	6.8	2.8	2.4
C	U	F	T	1	40	37	0.3	1.6	0.2
C	U	F	T	1	41	71	9.0	3.3	2.7
C	U	F	T	1	42	42	2.6	1.2	2.2
C	U	F	T	1	43	76	0.6	4.5	0.1
C	U	F	T	1	44	58	11.1	2.3	4.8
C	U	F	T	1	45	92	7.0	6.4	1.1
C	U	F	T	1	46	77	3.8	4.7	0.8

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	T	1	47	75	1.5	5.5	0.3
C	U	F	T	1	48	52	0.2	3.5	0.1
C	U	F	T	1	49	60	94.0	2.3	40.9
C	U	F	T	1	50	122	0.2	11.3	0.0
C	U	F	T	1	51	51	4.6	2.0	2.3
C	U	F	T	1	52	132	0.5	13.3	0.0
C	U	F	T	1	55	69	6.7	4.0	1.7
C	U	F	T	1	56	22	22.3	0.6	37.2
C	U	F	T	1	57	92	7.8	6.6	1.2
C	U	F	T	1	58	67	11.7	3.4	3.4
C	U	F	T	2	1	197	0.0	27.5	0.0
C	U	F	T	2	2	127	4.5	14.1	0.3
C	U	F	T	2	3	44	0.5	1.3	0.4
C	U	F	T	2	4	33	0.5	0.8	0.6
C	U	F	T	2	5	73	0.2	3.4	0.1
C	U	F	T	2	6	47	3.2	2.6	1.2
C	U	F	T	2	7	86	0.2	8.9	0.0
C	U	F	T	2	8	75	3.5	6.4	0.5
C	U	F	T	2	9	66	3.9	5.2	0.8
C	U	F	T	2	10	89	11.4	9.4	1.2
C	U	F	T	2	11	71	13.0	5.8	2.2
C	U	F	T	2	12	50	0.0	2.9	0.0
C	U	F	T	2	13	71	0.2	5.2	0.0
C	U	F	T	2	14	37	3.2	1.7	1.9
C	U	F	T	2	15	40	5.6	1.9	2.9
C	U	F	T	2	16	40	0.4	1.3	0.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	T	2	17	71	6.0	3.8	1.6
C	U	F	T	2	18	52	22.0	3.3	6.7
C	U	F	T	2	19	59	0.2	2.7	0.1
C	U	F	T	2	20	71	0.9	4.2	0.2
C	U	F	T	2	21	63	1.1	3.2	0.3
C	U	F	T	2	22	94	1.6	6.4	0.3
C	U	F	T	2	23	51	0.1	2.7	0.0
C	U	F	T	2	24	40	0.9	1.5	0.6
C	U	F	T	2	25	57	0.4	2.5	0.2
C	U	F	T	2	26	95	12.6	6.6	1.9
C	U	F	T	2	27	169	5.4	24.3	0.2
C	U	F	T	2	28	57	5.8	2.6	2.2
C	U	F	T	2	29	50	0.0	2.0	0.0
C	U	F	T	2	30	109	8.7	9.1	1.0
C	U	F	T	2	31	117	3.9	16.5	0.2
C	U	F	T	2	32	47	34.9	1.7	20.5
C	U	F	T	2	33	56	0.0	2.5	0.0
C	U	F	T	2	34	42	3.6	1.3	2.8
C	U	F	T	2	35	137	12.7	17.4	0.7
C	U	F	T	2	36	134	44.1	13.6	3.2
C	U	F	T	2	37	119	16.7	11.3	1.5
C	U	F	T	2	38	64	98.4	3.1	31.7
C	U	F	T	2	39	119	1.0	18.7	0.1
C	U	F	T	2	40	69	0.0	4.1	0.0
C	U	F	T	2	41	98	61.8	10.6	5.8
C	U	F	T	2	42	48	5.0	2.6	1.9

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	T	2	43	57	6.5	3.5	1.9
C	U	F	T	2	44	77	3.4	7.0	0.5
C	U	F	T	2	45	51	0.3	2.2	0.1
C	U	F	T	2	46	39	7.4	1.5	4.9
C	U	F	T	2	47	83	5.3	4.8	1.1
C	U	F	T	2	48	76	22.0	5.8	3.8
C	U	F	T	2	49	30	0.7	1.1	0.6
C	U	F	T	2	50	58	0.0	2.5	0.0
C	U	F	T	2	51	130	3.6	13.0	0.3
C	U	F	T	2	52	46	0.0	2.8	0.0
C	U	F	T	2	53	38	10.9	1.3	8.4
C	U	F	T	2	54	67	6.4	4.4	1.5
C	U	F	T	2	55	97	8.1	8.1	1.0
C	U	F	T	2	56	113	6.1	12.8	0.5
C	U	F	T	2	57	76	1.1	6.6	0.2
C	U	F	T	2	58	55	1.2	2.3	0.5
C	U	F	T	2	59	120	19.2	10.5	1.8
C	U	F	T	2	60	51	0.0	2.0	0.0
C	U	F	T	2	61	72	29.1	4.3	6.8
C	U	F	T	2	62	75	5.3	7.3	0.7
C	U	F	T	2	63	45	3.6	1.9	1.9
C	U	F	T	2	64	93	1.5	6.6	0.2
C	U	F	T	2	65	76	31.3	4.4	7.1
C	U	F	T	3	1	82	45.0	5.9	7.6
C	U	F	T	3	2	164	0.0	20.3	0.0
C	U	F	T	3	3	55	0.3	2.3	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	T	3	4	58	1.6	2.7	0.6
C	U	F	T	3	5	69	4.3	3.7	1.2
C	U	F	T	3	6	82	0.1	5.4	0.0
C	U	F	T	3	7	63	1.7	3.3	0.5
C	U	F	T	3	8	90	3.7	6.9	0.5
C	U	F	T	3	9	60	0.0	2.8	0.0
C	U	F	T	3	10	94	0.2	7.3	0.0
C	U	F	T	3	11	34	2.0	1.4	1.4
C	U	F	T	3	12	68	11.3	5.7	2.0
C	U	F	T	3	13	95	16.9	7.0	2.4
C	U	F	T	3	14	56	0.0	2.2	0.0
C	U	F	T	3	15	97	80.0	10.3	7.8
C	U	F	T	3	16	41	0.0	1.8	0.0
C	U	F	T	3	17	54	3.6	3.0	1.2
C	U	F	T	3	18	33	0.0	1.4	0.0
C	U	F	T	3	19	55	0.7	3.9	0.2
C	U	F	T	3	20	50	12.2	2.0	6.1
C	U	F	T	3	21	56	0.2	2.4	0.1
C	U	F	T	3	22	58	10.7	3.9	2.7
C	U	F	T	3	23	65	1.4	4.2	0.3
C	U	F	T	3	24	105	4.8	8.7	0.6
C	U	F	T	3	25	40	0.0	1.3	0.0
C	U	F	T	3	26	129	23.0	13.0	1.8
C	U	F	T	3	27	120	24.5	12.7	1.9
C	U	F	T	3	28	21	0.3	0.6	0.5
C	U	F	T	3	29	57	5.4	2.6	2.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	F	T	3	30	26	24.2	0.5	48.4
C	U	F	T	3	31	66	7.9	3.3	2.4
C	U	F	T	3	32	59	98.1	2.6	37.7
C	U	F	T	3	33	147	0.6	16.5	0.0
C	U	F	T	3	34	99	0.0	11.2	0.0
C	U	F	T	3	35	120	10.1	17.3	0.6
C	U	F	T	3	36	53	3.3	3.3	1.0
C	U	F	T	3	37	40	3.5	1.8	1.9
C	U	F	T	3	38	84	0.5	5.3	0.1
C	U	F	T	3	39	75	35.2	7.5	4.7
C	U	F	T	3	40	71	92.2	6.7	13.8
C	U	F	T	3	41	62	25.6	3.7	6.9
C	U	F	T	3	42	53	0.3	2.2	0.1
C	U	F	T	3	43	63	33.2	3.2	10.4
C	U	F	T	3	44	85	0.1	8.9	0.0
C	U	F	T	3	45	75	1.9	5.2	0.4
C	U	F	T	3	46	34	0.5	1.2	0.4
C	U	F	T	3	47	105	2.1	11.2	0.2
C	U	F	T	3	48	106	27.9	11.4	2.4
C	U	F	T	3	49	42	3.1	1.5	2.1
C	U	F	T	3	50	63	7.3	5.1	1.4
C	U	F	T	3	51	106	28.2	9.4	3.0
C	U	F	T	3	52	67	3.2	3.3	1.0
C	U	F	T	3	53	48	0.0	2.2	0.0
C	U	P	C	1	1	86	0.0	5.8	0.0
C	U	P	C	1	2	106	0.2	8.7	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	C	1	3	72	0.3	3.9	0.1
C	U	P	C	1	4	43	0.0	1.4	0.0
C	U	P	C	1	5	106	30.0	9.8	3.1
C	U	P	C	1	6	111	2.8	12.5	0.2
C	U	P	C	1	7	78	0.4	7.0	0.1
C	U	P	C	1	8	126	22.7	18.2	1.2
C	U	P	C	1	9	62	5.9	3.7	1.6
C	U	P	C	1	10	79	9.9	6.4	1.5
C	U	P	C	1	11	176	13.9	29.6	0.5
C	U	P	C	1	12	89	4.1	7.3	0.6
C	U	P	C	1	13	94	12.1	7.3	1.7
C	U	P	C	1	14	173	37.2	19.5	1.9
C	U	P	C	1	15	94	0.2	6.8	0.0
C	U	P	C	1	16	119	14.9	16.0	0.9
C	U	P	C	1	17	73	0.4	5.0	0.1
C	U	P	C	1	18	35	4.6	1.1	4.2
C	U	P	C	1	19	48	3.3	1.7	1.9
C	U	P	C	1	20	50	7.7	1.8	4.3
C	U	P	C	1	21	124	7.0	11.5	0.6
C	U	P	C	1	22	62	4.9	3.0	1.6
C	U	P	C	1	23	137	35.4	14.2	2.5
C	U	P	C	1	24	55	0.0	2.3	0.0
C	U	P	C	1	25	55	0.2	4.0	0.1
C	U	P	C	1	26	49	0.2	1.8	0.1
C	U	P	C	1	27	100	66.5	7.5	8.9
C	U	P	C	1	28	67	4.8	3.6	1.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	C	1	29	68	5.9	3.4	1.7
C	U	P	C	1	30	103	7.3	8.1	0.9
C	U	P	C	2	1	140	0.6	14.2	0.0
C	U	P	C	2	2	13	0.2	0.1	2.0
C	U	P	C	2	3	96	2.3	6.1	0.4
C	U	P	C	2	5	97	0.2	6.0	0.0
C	U	P	C	2	6	143	14.6	23.9	0.6
C	U	P	C	2	7	89	3.2	7.3	0.4
C	U	P	C	2	8	71	12.7	3.7	3.4
C	U	P	C	2	9	99	1.2	8.5	0.1
C	U	P	C	2	10	73	0.4	6.6	0.1
C	U	P	C	2	11	136	0.2	20.3	0.0
C	U	P	C	2	12	61	5.9	2.9	2.0
C	U	P	C	2	13	113	13.2	10.1	1.3
C	U	P	C	2	14	158	16.7	17.1	1.0
C	U	P	C	2	15	80	0.0	5.9	0.0
C	U	P	C	2	16	115	8.8	12.1	0.7
C	U	P	C	2	17	104	27.7	8.0	3.5
C	U	P	C	2	18	104	0.2	7.3	0.0
C	U	P	C	2	19	71	0.2	4.2	0.0
C	U	P	C	2	21	94	22.8	10.0	2.3
C	U	P	C	2	22	126	14.8	14.5	1.0
C	U	P	C	2	23	163	5.6	17.0	0.3
C	U	P	C	2	24	128	9.3	11.1	0.8
C	U	P	C	2	25	63	0.0	2.7	0.0
C	U	P	C	2	26	44	14.6	1.5	9.7

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	C	2	27	70	5.4	3.2	1.7
C	U	P	C	2	28	102	0.3	6.8	0.0
C	U	P	C	2	29	40	0.0	1.0	0.0
C	U	P	C	2	30	85	4.9	4.5	1.1
C	U	P	C	2	31	120	2.0	9.4	0.2
C	U	P	C	2	32	52	0.2	2.1	0.1
C	U	P	C	2	33	61	6.6	3.1	2.1
C	U	P	C	2	34	70	13.3	5.0	2.7
C	U	P	C	2	35	40	0.1	1.0	0.1
C	U	P	C	2	36	104	12.3	6.9	1.8
C	U	P	C	2	37	46	0.0	1.6	0.0
C	U	P	C	2	38	86	0.7	5.7	0.1
C	U	P	C	2	39	138	0.5	12.4	0.0
C	U	P	C	2	40	17	15.9	0.3	53.0
C	U	P	C	2	41	50	1.9	3.1	0.6
C	U	P	C	2	42	119	3.3	14.9	0.2
C	U	P	C	2	43	94	12.9	7.9	1.6
C	U	P	C	2	44	76	4.7	4.7	1.0
C	U	P	C	2	45	88	29.8	6.5	4.6
C	U	P	C	2	46	66	0.0	3.6	0.0
C	U	P	C	2	47	112	8.0	10.8	0.7
C	U	P	C	2	48	66	10.0	3.4	2.9
C	U	P	C	2	49	206	19.6	33.7	0.6
C	U	P	C	2	50	53	0.0	2.0	0.0
C	U	P	C	2	51	63	0.0	3.0	0.0
C	U	P	C	2	52	232	0.3	57.8	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	C	2	53	103	98.1	7.1	13.8
C	U	P	C	2	55	74	20.1	4.8	4.2
C	U	P	C	2	56	100	8.8	7.4	1.2
C	U	P	C	2	57	39	0.0	1.0	0.0
C	U	P	C	2	58	106	7.1	7.2	1.0
C	U	P	C	2	59	87	5.4	5.0	1.1
C	U	P	C	2	60	64	39.6	3.1	12.8
C	U	P	C	2	61	66	0.0	2.8	0.0
C	U	P	C	2	62	109	6.3	7.6	0.8
C	U	P	C	2	63	95	9.9	7.6	1.3
C	U	P	C	2	64	68	5.3	3.2	1.7
C	U	P	C	2	65	62	1.9	3.0	0.6
C	U	P	C	2	66	98	0.4	6.1	0.1
C	U	P	C	2	67	76	0.0	4.0	0.0
C	U	P	C	3	1	85	0.0	5.2	0.0
C	U	P	C	3	2	116	1.4	10.6	0.1
C	U	P	C	3	3	57	0.1	2.4	0.0
C	U	P	C	3	4	152	49.4	19.9	2.5
C	U	P	C	3	5	66	0.0	5.2	0.0
C	U	P	C	3	6	187	29.1	29.2	1.0
C	U	P	C	3	7	76	2.7	4.4	0.6
C	U	P	C	3	8	83	15.0	5.2	2.9
C	U	P	C	3	9	149	6.6	15.6	0.4
C	U	P	C	3	10	77	1.6	7.1	0.2
C	U	P	C	3	11	116	26.9	15.9	1.7
C	U	P	C	3	12	31	0.9	1.1	0.8

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	C	3	13	34	12.5	1.4	8.9
C	U	P	C	3	14	56	8.7	4.2	2.1
C	U	P	C	3	15	123	3.9	11.5	0.3
C	U	P	C	3	16	126	13.0	12.5	1.0
C	U	P	C	3	17	40	0.0	1.2	0.0
C	U	P	C	3	18	27	0.3	0.6	0.5
C	U	P	C	3	19	96	11.8	7.3	1.6
C	U	P	C	3	20	74	9.2	4.6	2.0
C	U	P	C	3	21	29	5.2	0.7	7.4
C	U	P	C	3	22	23	63.1	0.4	157.8
C	U	P	C	3	23	115	42.6	9.9	4.3
C	U	P	C	3	24	47	1.3	1.7	0.8
C	U	P	C	3	25	121	5.4	10.9	0.5
C	U	P	C	3	27	95	7.7	7.1	1.1
C	U	P	C	3	28	145	16.2	15.8	1.0
C	U	P	C	3	29	79	0.8	4.8	0.2
C	U	P	C	3	30	38	94.6	1.1	86.0
C	U	P	C	3	31	32	0.4	0.7	0.6
C	U	P	C	3	32	54	9.4	2.1	4.5
C	U	P	C	3	33	57	0.4	4.3	0.1
C	U	P	C	3	34	103	9.6	7.5	1.3
C	U	P	C	3	35	107	33.1	8.7	3.8
C	U	P	C	3	36	174	24.5	31.1	0.8
C	U	P	C	3	37	97	3.5	10.1	0.3
C	U	P	C	3	38	113	28.6	10.4	2.8
C	U	P	C	3	39	109	8.3	10.3	0.8

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	C	3	40	207	29.4	41.8	0.7
C	U	P	C	3	41	80	0.0	4.1	0.0
C	U	P	C	3	42	56	3.4	3.2	1.1
C	U	P	C	3	43	77	3.3	6.9	0.5
C	U	P	C	3	44	55	0.3	2.9	0.1
C	U	P	C	3	45	118	31.0	11.3	2.7
C	U	P	C	3	46	119	6.3	11.3	0.6
C	U	P	C	3	48	78	0.3	6.2	0.0
C	U	P	C	3	49	142	0.2	18.5	0.0
C	U	P	C	3	50	52	0.0	2.0	0.0
C	U	P	C	3	51	53	0.0	2.2	0.0
C	U	P	C	3	52	79	0.2	4.7	0.0
C	U	P	C	3	53	63	0.0	3.0	0.0
C	U	P	C	3	54	22	3.6	0.4	9.0
C	U	P	C	3	55	35	3.7	1.0	3.7
C	U	P	C	3	56	38	0.2	1.1	0.2
C	U	P	C	3	57	84	0.6	5.4	0.1
C	U	P	C	3	58	41	0.3	1.5	0.2
C	U	P	C	3	59	58	2.7	2.5	1.1
C	U	P	C	3	60	36	0.0	1.0	0.0
C	U	P	T	1	1	132	0.7	11.2	0.1
C	U	P	T	1	2	132	15.8	11.8	1.3
C	U	P	T	1	3	78	6.7	4.5	1.5
C	U	P	T	1	4	63	0.0	2.9	0.0
C	U	P	T	1	5	128	0.0	11.6	0.0
C	U	P	T	1	6	133	6.7	12.6	0.5

Appendix A Shock event data

File #	Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
CUPT1 7	64	2.3	3.8	0.6
CUPT1 8	218	30.1	46.7	0.6
CUPT1 9	26	0.2	0.9	0.2
CUPT1 10	111	14.2	15.7	0.9
CUPT1 11	99	0.0	12.3	0.0
CUPT1 12	57	12.8	3.9	3.3
CUPT1 13	121	30.3	18.9	1.6
CUPT1 14	94	48.1	6.2	7.8
CUPT1 15	74	4.0	7.1	0.6
CUPT1 16	105	3.5	7.3	0.5
CUPT1 17	91	0.4	10.2	0.0
CUPT1 18	60	0.5	2.7	0.2
CUPT1 19	45	0.0	1.5	0.0
CUPT1 20	77	0.2	4.1	0.0
CUPT1 21	88	2.7	10.1	0.3
CUPT1 22	113	2.0	11.9	0.2
CUPT1 23	56	2.2	2.4	0.9
CUPT1 24	57	0.0	2.4	0.0
CUPT1 25	89	8.9	6.4	1.4
CUPT1 26	60	0.4	2.7	0.1
CUPT1 27	87	0.0	8.8	0.0
CUPT1 28	197	34.0	36.6	0.9
CUPT1 29	170	17.6	20.4	0.9
CUPT1 30	70	9.2	3.9	2.4
CUPT1 31	66	11.1	3.7	3.0
CUPT1 32	118	23.6	14.3	1.7

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	T	1	33	71	1.5	4.6	0.3
C	U	P	T	1	34	83	0.0	6.5	0.0
C	U	P	T	1	35	62	9.7	3.3	2.9
C	U	P	T	1	36	135	27.0	12.5	2.2
C	U	P	T	1	37	37	0.0	1.0	0.0
C	U	P	T	1	38	37	52.2	1.4	37.3
C	U	P	T	1	39	50	2.7	2.7	1.0
C	U	P	T	1	40	85	4.5	7.4	0.6
C	U	P	T	1	41	120	8.7	14.8	0.6
C	U	P	T	1	42	74	7.6	6.7	1.1
C	U	P	T	1	43	171	61.0	32.6	1.9
C	U	P	T	1	44	77	0.0	5.1	0.0
C	U	P	T	1	45	71	5.0	3.8	1.3
C	U	P	T	1	46	46	3.9	1.5	2.6
C	U	P	T	1	47	79	52.0	6.7	7.8
C	U	P	T	1	48	37	0.0	1.0	0.0
C	U	P	T	1	49	127	16.7	19.7	0.8
C	U	P	T	1	50	123	25.7	13.0	2.0
C	U	P	T	1	51	62	6.0	2.5	2.4
C	U	P	T	1	52	82	10.1	5.3	1.9
C	U	P	T	1	53	56	42.6	2.1	20.3
C	U	P	T	1	54	46	0.2	1.4	0.1
C	U	P	T	2	1	210	18.4	35.8	0.5
C	U	P	T	2	2	62	0.4	3.3	0.1
C	U	P	T	2	3	114	0.3	10.1	0.0
C	U	P	T	2	4	72	10.3	4.2	2.5

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	T	2	5	144	12.9	15.9	0.8
C	U	P	T	2	6	59	2.6	2.6	1.0
C	U	P	T	2	7	66	2.3	3.6	0.6
C	U	P	T	2	8	56	9.2	3.0	3.1
C	U	P	T	2	9	84	14.9	4.7	3.2
C	U	P	T	2	10	43	32.1	1.6	20.1
C	U	P	T	2	11	47	0.2	1.7	0.1
C	U	P	T	2	12	137	55.4	21.1	2.6
C	U	P	T	2	13	144	58.8	23.1	2.5
C	U	P	T	2	14	169	20.1	18.2	1.1
C	U	P	T	2	15	57	7.0	3.0	2.3
C	U	P	T	2	16	47	20.9	1.7	12.3
C	U	P	T	2	17	62	0.4	3.2	0.1
C	U	P	T	2	18	87	7.6	6.9	1.1
C	U	P	T	2	19	88	14.9	7.6	2.0
C	U	P	T	2	20	24	9.9	0.5	19.8
C	U	P	T	2	21	149	31.7	20.9	1.5
C	U	P	T	2	22	55	4.1	3.3	1.2
C	U	P	T	2	23	40	80.5	1.2	67.1
C	U	P	T	2	24	42	0.0	1.6	0.0
C	U	P	T	2	25	91	16.8	6.9	2.4
C	U	P	T	2	26	60	3.2	2.8	1.1
C	U	P	T	2	27	52	2.2	2.0	1.1
C	U	P	T	2	28	155	6.8	18.1	0.4
C	U	P	T	2	29	76	4.0	4.7	0.9
C	U	P	T	2	30	78	53.8	5.1	10.5

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
C	U	P	T	2	34	48	0.0	1.8	0.0
C	U	P	T	2	35	87	0.0	6.0	0.0
W	L	F	C	3	1	181	16.5	20.1	0.8
W	L	F	C	3	2	108	20.8	7.5	2.8
W	L	F	C	3	4	34	3.3	0.7	4.7
W	L	F	C	3	5	40	0.0	1.0	0.0
W	L	F	C	3	6	120	34.2	9.5	3.6
W	L	F	C	3	7	46	0.2	1.3	0.2
W	L	F	C	3	9	91	8.5	5.6	1.5
W	L	F	C	3	10	92	7.3	5.4	1.4
W	L	F	C	3	11	49	5.8	1.6	3.6
W	L	F	C	3	12	138	34.2	11.8	2.9
W	L	F	C	3	13	57	1.6	2.4	0.7
W	L	F	C	3	14	58	0.7	2.1	0.3
W	L	F	C	3	15	57	0.3	2.0	0.2
W	L	F	C	3	16	39	0.5	1.0	0.5
W	L	F	C	3	17	68	2.0	3.0	0.7
W	L	F	C	3	18	34	0.6	0.7	0.9
W	L	F	C	3	19	125	10.7	10.3	1.0
W	L	F	C	3	20	142	15.9	12.6	1.3
W	L	F	C	3	22	35	5.4	0.8	6.8
W	L	F	C	3	23	17	0.3	0.2	1.5
W	L	F	C	3	24	76	7.9	3.6	2.2
W	L	F	C	3	25	39	4.0	0.9	4.4
W	L	F	C	3	26	31	6.2	0.6	10.3
W	L	F	C	3	27	75	26.4	3.6	7.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	F	C	3	28	39	1.1	1.0	1.1
W	L	F	C	4	1	140	35.7	13.4	2.7
W	L	F	C	4	2	45	0.5	1.3	0.4
W	L	F	C	4	3	54	9.3	1.9	4.9
W	L	F	C	4	4	74	10.6	3.4	3.1
W	L	F	C	4	5	63	0.1	2.5	0.0
W	L	F	C	4	6	66	71.8	2.8	25.6
W	L	F	C	4	7	17	0.2	0.2	1.0
W	L	F	C	4	8	34	0.1	0.7	0.1
W	L	F	C	4	9	52	0.5	1.7	0.3
W	L	F	C	4	10	39	1.0	1.0	1.0
W	L	F	C	4	11	84	8.3	4.5	1.8
W	L	F	C	4	12	33	6.1	0.7	8.7
W	L	F	C	4	13	57	10.2	2.2	4.6
W	L	F	C	4	14	21	0.2	0.3	0.7
W	L	F	C	4	15	392	12.3	110.7	0.1
W	L	F	C	4	16	111	17.0	8.5	2.0
W	L	F	C	4	17	42	4.1	1.1	3.7
W	L	F	C	4	18	48	1.6	1.5	1.1
W	L	F	C	4	19	109	5.1	7.7	0.7
W	L	F	C	4	20	100	9.6	6.3	1.5
W	L	F	C	4	21	59	2.8	2.4	1.2
W	L	F	C	4	22	307	0.0	67.4	0.0
W	L	F	C	4	23	117	0.5	9.6	0.1
W	L	F	C	4	24	355	2.9	89.9	0.0
W	L	F	C	4	25	246	2.3	43.7	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	F	C	4	26	135	5.7	11.5	0.5
W	L	F	C	4	27	140	7.8	12.5	0.6
W	L	F	C	4	28	65	0.0	3.0	0.0
W	L	F	C	4	30	146	42.1	14.8	2.8
W	L	F	C	5	1	23	0.2	0.3	0.7
W	L	F	T	3	2	45	0.0	1.3	0.0
W	L	F	T	3	3	179	15.3	20.3	0.8
W	L	F	T	3	4	30	0.2	0.6	0.3
W	L	F	T	3	5	53	0.0	1.9	0.0
W	L	F	T	3	6	13	0.2	0.1	2.0
W	L	F	T	3	7	39	34.2	1.0	34.2
W	L	F	T	3	8	60	0.6	2.3	0.3
W	L	F	T	3	9	48	4.3	1.5	2.9
W	L	F	T	3	10	104	0.3	7.6	0.0
W	L	F	T	3	11	75	7.7	3.5	2.2
W	L	F	T	3	12	127	7.4	10.2	0.7
W	L	F	T	3	13	59	2.0	2.2	0.9
W	L	F	T	3	14	63	2.1	2.5	0.8
W	L	F	T	4	1	64	8.3	2.6	3.2
W	L	F	T	4	2	27	0.6	0.5	1.2
W	L	F	T	4	3	114	14.4	8.6	1.7
W	L	F	T	4	4	94	43.7	5.6	7.8
W	L	F	T	4	5	50	0.5	1.7	0.3
W	L	F	T	4	6	46	21.1	1.3	16.2
W	L	F	T	4	7	55	6.9	2.0	3.5
W	L	F	T	4	8	24	0.2	0.4	0.5

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	F	T	4	9	37	0.4	0.9	0.4
W	L	F	T	4	10	75	37.5	3.6	10.4
W	L	F	T	4	11	34	10.7	0.7	15.3
W	L	F	T	4	12	70	0.2	3.0	0.1
W	L	F	T	4	13	45	0.0	1.4	0.0
W	L	F	T	4	14	57	0.0	2.1	0.0
W	L	F	T	4	15	30	0.1	0.6	0.2
W	L	F	T	4	16	31	0.5	0.6	0.8
W	L	F	T	4	17	50	0.2	1.6	0.1
W	L	F	T	4	18	130	11.9	10.7	1.1
W	L	F	T	4	19	50	0.3	1.6	0.2
W	L	F	T	4	20	41	0.8	1.0	0.8
W	L	F	T	4	21	81	0.0	4.2	0.0
W	L	F	T	4	22	64	0.6	2.7	0.2
W	L	F	T	4	23	68	5.3	2.9	1.8
W	L	F	T	4	24	51	0.0	1.6	0.0
W	L	F	T	4	25	41	0.0	1.1	0.0
W	L	F	T	4	26	72	0.3	3.5	0.1
W	L	F	T	4	28	48	0.0	1.5	0.0
W	L	F	T	5	1	111	3.9	7.9	0.5
W	L	F	T	5	2	43	2.2	1.2	1.8
W	L	F	T	5	3	41	0.0	1.2	0.0
W	L	F	T	5	4	129	1.1	10.5	0.1
W	L	F	T	5	5	33	0.6	0.7	0.9
W	L	F	T	5	6	44	1.1	1.2	0.9
W	L	F	T	5	7	79	5.6	4.4	1.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	F	T	5	8	40	0.6	1.0	0.6
W	L	F	T	5	9	80	7.0	4.0	1.8
W	L	F	T	5	11	25	0.2	0.4	0.5
W	L	F	T	5	12	66	12.5	2.8	4.5
W	L	F	T	5	13	40	0.3	1.0	0.3
W	L	F	T	5	14	28	0.3	0.5	0.6
W	L	F	T	5	15	35	45.8	0.8	57.3
W	L	F	T	5	16	34	29.4	0.7	42.0
W	L	F	T	5	17	54	40.0	1.8	22.2
W	L	F	T	5	18	18	0.1	0.2	0.5
W	L	F	T	5	19	29	103.7	0.5	207.4
W	L	F	T	5	20	67	8.4	2.9	2.9
W	L	F	T	5	21	46	2.6	1.3	2.0
W	L	F	T	5	22	41	0.0	1.1	0.0
W	L	F	T	5	23	111	0.3	8.6	0.0
W	L	F	T	5	24	39	0.3	1.1	0.3
W	L	F	T	5	26	29	3.3	0.5	6.6
W	L	F	T	5	27	89	5.6	5.0	1.1
W	L	F	T	5	28	79	10.7	3.9	2.7
W	L	P	C	3	1	42	1.6	1.3	1.2
W	L	P	C	3	3	38	0.3	0.9	0.3
W	L	P	C	3	4	43	2.9	1.2	2.4
W	L	P	C	3	5	53	2.4	1.7	1.4
W	L	P	C	3	6	29	14.5	0.5	29.0
W	L	P	C	3	8	64	4.5	2.6	1.7
W	L	P	C	3	9	38	10.1	1.0	10.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	P	C	3	10	128	0.6	10.5	0.1
W	L	P	C	3	11	39	0.2	1.0	0.2
W	L	P	C	3	12	38	5.3	0.9	5.9
W	L	P	C	3	13	59	1.0	2.4	0.4
W	L	P	C	3	14	29	0.1	0.5	0.2
W	L	P	C	3	15	74	3.3	3.5	0.9
W	L	P	C	3	16	86	2.6	5.1	0.5
W	L	P	C	4	2	78	1.9	3.8	0.5
W	L	P	C	4	3	38	1.9	0.9	2.1
W	L	P	C	4	4	23	0.2	0.3	0.7
W	L	P	C	4	5	106	6.5	7.2	0.9
W	L	P	C	4	6	51	0.2	1.7	0.1
W	L	P	C	4	7	38	21.5	1.0	21.5
W	L	P	C	4	8	51	0.3	1.6	0.2
W	L	P	C	4	9	34	0.4	0.7	0.6
W	L	P	C	4	10	64	10.7	2.6	4.1
W	L	P	C	4	11	35	0.3	0.8	0.4
W	L	P	C	4	12	38	2.3	0.9	2.6
W	L	P	C	4	13	73	0.0	3.8	0.0
W	L	P	C	4	14	102	0.5	6.4	0.1
W	L	P	C	4	15	122	3.8	9.0	0.4
W	L	P	C	4	16	59	0.4	2.5	0.2
W	L	P	C	4	17	76	0.2	4.1	0.0
W	L	P	C	4	18	57	0.4	2.0	0.2
W	L	P	C	4	19	101	0.2	7.3	0.0
W	L	P	C	4	20	113	0.2	9.1	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	P	C	4	21	53	0.4	2.0	0.2
W	L	P	C	4	22	54	0.2	2.1	0.1
W	L	P	C	4	23	69	0.3	3.4	0.1
W	L	P	C	4	24	57	1.3	2.3	0.6
W	L	P	C	4	25	72	0.8	3.2	0.3
W	L	P	C	4	26	52	0.2	2.0	0.1
W	L	P	C	4	27	76	0.1	4.1	0.0
W	L	P	C	4	28	63	0.8	2.4	0.3
W	L	P	C	4	29	70	0.3	3.5	0.1
W	L	P	C	4	30	77	0.3	3.7	0.1
W	L	P	C	4	31	88	0.0	4.9	0.0
W	L	P	C	4	32	55	0.2	1.9	0.1
W	L	P	C	4	33	56	0.3	2.0	0.2
W	L	P	C	4	34	68	84.8	3.1	27.4
W	L	P	C	4	35	116	3.9	8.5	0.5
W	L	P	C	4	36	116	16.0	8.8	1.8
W	L	P	C	4	37	84	3.1	4.5	0.7
W	L	P	C	4	39	82	0.4	4.3	0.1
W	L	P	C	4	40	48	0.6	1.4	0.4
W	L	P	C	4	43	45	0.0	1.3	0.0
W	L	P	C	4	44	41	0.3	1.1	0.3
W	L	P	C	4	45	28	0.4	0.5	0.8
W	L	P	C	4	46	97	0.0	5.9	0.0
W	L	P	C	4	47	46	0.4	1.4	0.3
W	L	P	C	4	48	85	2.6	4.7	0.6
W	L	P	C	4	49	45	0.2	1.3	0.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	P	C	5	1	37	4.8	0.8	6.0
W	L	P	C	5	2	73	0.0	3.3	0.0
W	L	P	C	5	3	27	3.0	0.4	7.5
W	L	P	C	5	4	29	0.5	0.5	1.0
W	L	P	C	5	5	63	3.7	2.5	1.5
W	L	P	C	5	6	102	0.1	6.4	0.0
W	L	P	C	5	7	54	0.2	1.8	0.1
W	L	P	C	5	8	48	0.0	1.5	0.0
W	L	P	C	5	9	30	5.0	0.6	8.3
W	L	P	C	5	10	63	0.8	2.5	0.3
W	L	P	C	5	11	110	8.1	7.7	1.1
W	L	P	C	5	12	123	0.2	10.0	0.0
W	L	P	C	5	13	130	5.8	10.7	0.5
W	L	P	C	5	14	32	0.6	0.7	0.9
W	L	P	C	5	15	87	0.0	4.8	0.0
W	L	P	C	5	16	100	0.2	6.3	0.0
W	L	P	C	5	17	80	0.1	4.0	0.0
W	L	P	C	5	18	57	0.2	2.1	0.1
W	L	P	C	5	19	45	0.0	1.3	0.0
W	L	P	C	5	20	62	0.0	2.4	0.0
W	L	P	C	5	21	58	0.2	2.1	0.1
W	L	P	C	5	22	68	0.8	3.2	0.3
W	L	P	C	5	23	72	0.3	3.8	0.1
W	L	P	C	5	24	35	0.4	0.8	0.5
W	L	P	C	5	25	37	0.3	0.8	0.4
W	L	P	C	5	26	60	15.8	2.3	6.9

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	P	C	5	27	24	0.5	0.4	1.3
W	L	P	C	5	29	142	59.7	13.7	4.4
W	L	P	C	5	31	107	29.7	7.5	4.0
W	L	P	C	5	32	59	1.4	2.2	0.6
W	L	P	C	5	33	75	53.2	3.6	14.8
W	L	P	C	5	34	22	0.4	0.3	1.3
W	L	P	C	5	36	92	72.5	5.4	13.4
W	L	P	C	5	37	93	0.2	5.5	0.0
W	L	P	C	5	38	41	0.0	1.1	0.0
W	L	P	C	5	39	52	0.0	1.7	0.0
W	L	P	C	5	40	103	5.2	6.7	0.8
W	L	P	C	5	42	81	0.2	4.2	0.0
W	L	P	T	4	1	93	1.8	5.5	0.3
W	L	P	T	4	2	37	0.3	0.9	0.3
W	L	P	T	4	3	84	14.4	4.5	3.2
W	L	P	T	4	4	38	0.4	0.9	0.4
W	L	P	T	4	5	42	0.5	1.1	0.5
W	L	P	T	4	7	45	0.2	1.3	0.2
W	L	P	T	4	8	77	10.5	3.7	2.8
W	L	P	T	4	9	40	0.2	1.2	0.2
W	L	P	T	4	10	59	10.2	2.5	4.1
W	L	P	T	4	11	31	7.0	0.7	10.0
W	L	P	T	4	12	109	8.8	7.7	1.1
W	L	P	T	4	13	56	12.1	2.1	5.8
W	L	P	T	4	14	79	50.0	4.0	12.5
W	L	P	T	4	15	177	31.7	20.6	1.5

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	P	T	4	16	35	3.8	0.8	4.8
W	L	P	T	4	17	27	0.4	0.5	0.8
W	L	P	T	4	18	51	0.2	1.9	0.1
W	L	P	T	4	19	231	31.5	35.1	0.9
W	L	P	T	4	20	104	67.9	7.7	8.8
W	L	P	T	4	21	129	7.6	11.3	0.7
W	L	P	T	4	22	53	6.2	1.8	3.4
W	L	P	T	4	24	69	0.3	3.0	0.1
W	L	P	T	4	25	54	26.7	1.9	14.1
W	L	P	T	4	26	41	0.5	1.1	0.5
W	L	P	T	4	27	30	0.2	0.6	0.3
W	L	P	T	5	1	35	0.2	0.8	0.3
W	L	P	T	5	2	49	0.0	1.7	0.0
W	L	P	T	5	3	39	0.0	1.0	0.0
W	L	P	T	5	4	48	6.3	1.5	4.2
W	L	P	T	5	5	115	0.0	9.6	0.0
W	L	P	T	5	6	44	0.2	1.4	0.1
W	L	P	T	5	7	23	0.2	0.3	0.7
W	L	P	T	5	8	201	40.8	27.9	1.5
W	L	P	T	5	9	116	59.0	8.5	6.9
W	L	P	T	5	10	78	9.1	4.1	2.2
W	L	P	T	5	11	59	1.2	2.2	0.5
W	L	P	T	5	12	40	0.2	1.0	0.2
W	L	P	T	5	13	28	0.5	0.5	1.0
W	L	P	T	5	14	21	1.3	0.3	4.3
W	L	P	T	5	15	192	0.0	23.2	0.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	L	P	T	5	16	114	22.6	8.5	2.7
W	L	P	T	5	17	78	0.6	4.3	0.1
W	L	P	T	5	18	50	0.5	1.8	0.3
W	L	P	T	5	19	66	0.6	2.7	0.2
W	L	P	T	5	21	46	0.5	1.4	0.4
W	L	P	T	5	22	42	0.2	1.1	0.2
W	L	P	T	5	24	80	0.1	4.2	0.0
W	L	P	T	5	25	33	5.9	0.7	8.4
W	L	P	T	5	26	18	65.1	0.2	325.5
W	L	P	T	5	27	102	9.2	6.5	1.4
W	L	P	T	5	28	30	14.6	0.6	24.3
W	L	P	T	5	29	38	0.2	0.9	0.2
W	L	P	T	5	30	18	0.2	0.2	1.0
W	L	P	T	5	31	111	32.6	7.9	4.1
W	L	P	T	5	32	25	0.3	0.4	0.8
W	L	P	T	5	33	54	0.5	1.8	0.3
W	L	P	T	5	34	37	0.2	0.8	0.3
W	L	P	T	5	35	50	0.2	1.6	0.1
W	L	P	T	5	36	45	0.2	1.3	0.2
W	L	P	T	5	39	32	1.2	0.6	2.0
W	L	P	T	5	40	29	3.2	0.5	6.4
W	U	F	C	1	2	78	0.1	3.9	0.0
W	U	F	C	1	3	49	0.0	1.4	0.0
W	U	F	C	1	4	151	2.8	14.2	0.2
W	U	F	C	1	5	108	21.0	7.3	2.9
W	U	F	C	1	6	59	0.8	2.2	0.4

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	F	C	1	7	64	7.6	2.7	2.8
W	U	F	C	1	8	53	3.5	1.8	1.9
W	U	F	C	1	9	115	38.6	9.1	4.2
W	U	F	C	1	10	112	6.5	7.8	0.8
W	U	F	C	2	1	28	98.9	0.5	197.8
W	U	F	C	2	2	102	0.0	6.5	0.0
W	U	F	C	2	3	114	8.1	8.1	1.0
W	U	F	C	2	4	32	3.4	0.7	4.9
W	U	F	C	2	5	57	2.5	2.1	1.2
W	U	F	C	2	6	55	0.0	1.9	0.0
W	U	F	C	2	7	22	0.1	0.3	0.3
W	U	F	C	2	8	176	30.0	21.4	1.4
W	U	F	C	2	9	56	0.2	2.0	0.1
W	U	F	C	2	10	17	0.2	0.2	1.0
W	U	F	T	1	1	190	33.2	23.2	1.4
W	U	F	T	1	2	62	1.7	2.4	0.7
W	U	F	T	1	3	29	0.1	0.5	0.2
W	U	F	T	1	4	77	24.5	3.8	6.4
W	U	F	T	1	5	127	1.9	9.9	0.2
W	U	F	T	1	6	50	12.5	1.8	6.9
W	U	F	T	1	7	61	4.2	2.4	1.7
W	U	F	T	1	8	59	87.9	2.2	40.0
W	U	F	T	1	9	64	10.8	2.6	4.2
W	U	F	T	1	10	92	16.0	5.4	3.0
W	U	F	T	1	11	93	0.2	5.8	0.0
W	U	F	T	1	12	30	0.2	0.6	0.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	F	T	1	14	71	6.9	3.2	2.2
W	U	F	T	1	15	91	7.3	5.3	1.4
W	U	F	T	1	16	16	38.7	0.2	193.5
W	U	F	T	1	17	52	0.0	1.7	0.0
W	U	F	T	1	18	45	8.8	1.3	6.8
W	U	F	T	1	19	103	48.1	6.9	7.0
W	U	F	T	1	20	42	70.4	1.1	64.0
W	U	F	T	1	21	42	20.8	1.1	18.9
W	U	F	T	1	22	78	0.2	3.8	0.1
W	U	F	T	1	23	37	0.2	0.9	0.2
W	U	F	T	1	24	51	8.0	1.7	4.7
W	U	F	T	1	25	143	6.0	12.7	0.5
W	U	F	T	1	26	34	1.2	0.7	1.7
W	U	F	T	1	27	64	7.0	2.5	2.8
W	U	F	T	1	28	60	0.1	2.3	0.0
W	U	F	T	1	29	101	12.3	6.4	1.9
W	U	F	T	1	31	32	14.4	0.6	24.0
W	U	F	T	1	32	33	0.2	0.7	0.3
W	U	F	T	2	1	59	21.5	2.3	9.3
W	U	F	T	2	2	25	14.0	0.4	35.0
W	U	F	T	2	3	53	19.0	1.8	10.6
W	U	F	T	2	4	51	0.0	1.6	0.0
W	U	F	T	2	5	73	0.2	3.4	0.1
W	U	F	T	2	6	42	18.5	1.1	16.8
W	U	F	T	2	7	66	0.2	2.8	0.1
W	U	F	T	2	8	62	0.2	2.4	0.1

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	F	T	2	9	37	0.2	0.9	0.2
W	U	F	T	2	10	67	55.9	3.0	18.6
W	U	F	T	2	11	78	0.0	3.8	0.0
W	U	F	T	2	12	81	8.9	4.1	2.2
W	U	F	T	2	13	86	11.7	4.6	2.5
W	U	F	T	2	14	51	0.0	1.6	0.0
W	U	F	T	2	15	32	1.3	0.7	1.9
W	U	F	T	2	16	92	0.0	5.2	0.0
W	U	F	T	2	17	73	0.2	3.4	0.1
W	U	F	T	2	18	68	22.4	3.3	6.8
W	U	F	T	2	19	34	6.5	0.7	9.3
W	U	F	T	2	20	40	0.6	1.0	0.6
W	U	F	T	2	21	16	0.2	0.2	1.0
W	U	F	T	2	22	137	0.0	11.7	0.0
W	U	F	T	2	23	37	2.7	0.9	3.0
W	U	F	T	2	24	54	9.7	1.8	5.4
W	U	F	T	2	25	126	78.8	10.3	7.7
W	U	F	T	2	26	53	80.3	1.7	47.2
W	U	F	T	2	27	77	8.0	3.8	2.1
W	U	F	T	2	28	64	1.2	2.6	0.5
W	U	F	T	2	31	30	0.2	0.6	0.3
W	U	F	T	2	32	39	3.3	1.1	3.0
W	U	P	C	1	1	60	8.3	2.4	3.5
W	U	P	C	1	2	36	0.3	0.8	0.4
W	U	P	C	1	3	16	0.3	0.2	1.5
W	U	P	C	1	4	20	0.6	0.3	2.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	C	1	5	14	0.2	0.1	2.0
W	U	P	C	1	6	28	7.8	0.5	15.6
W	U	P	C	1	7	49	0.3	1.5	0.2
W	U	P	C	2	1	27	0.2	0.5	0.4
W	U	P	C	2	3	31	0.2	0.6	0.3
W	U	P	C	2	5	47	2.0	1.3	1.5
W	U	P	C	2	6	103	57.1	7.7	7.4
W	U	P	C	2	7	17	0.2	0.2	1.0
W	U	P	C	2	9	23	1.3	0.3	4.3
W	U	P	C	2	10	53	0.0	1.7	0.0
W	U	P	C	2	11	79	20.4	3.9	5.2
W	U	P	C	2	13	35	0.4	0.8	0.5
W	U	P	C	2	14	31	0.3	0.6	0.5
W	U	P	C	2	15	98	8.4	6.1	1.4
W	U	P	C	2	16	147	11.9	13.6	0.9
W	U	P	C	2	17	54	0.0	1.8	0.0
W	U	P	C	2	18	23	0.2	0.3	0.7
W	U	P	C	2	19	38	0.1	0.9	0.1
W	U	P	C	2	20	15	2.7	0.1	27.0
W	U	P	C	2	21	49	1.5	1.5	1.0
W	U	P	C	2	22	52	3.0	1.7	1.8
W	U	P	C	2	23	99	15.1	6.3	2.4
W	U	P	C	2	24	49	9.9	1.5	6.6
W	U	P	C	2	25	63	0.9	2.6	0.3
W	U	P	C	2	26	52	19.0	1.7	11.2
W	U	P	C	2	27	109	2.6	8.6	0.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	C	2	28	127	17.6	11.4	1.5
W	U	P	C	2	29	103	2.9	7.5	0.4
W	U	P	C	2	30	110	3.2	8.0	0.4
W	U	P	C	2	31	273	29.1	50.4	0.6
W	U	P	C	2	32	88	0.2	4.9	0.0
W	U	P	C	2	33	25	0.2	0.4	0.5
W	U	P	C	2	34	33	1.0	0.7	1.4
W	U	P	C	2	35	19	1.6	0.2	8.0
W	U	P	C	2	36	51	87.2	1.6	54.5
W	U	P	C	2	37	21	1.6	0.3	5.3
W	U	P	C	2	38	34	0.3	0.8	0.4
W	U	P	C	2	39	28	0.2	0.5	0.4
W	U	P	C	2	41	45	0.0	1.3	0.0
W	U	P	C	2	44	40	61.4	1.0	61.4
W	U	P	C	2	45	82	0.0	4.2	0.0
W	U	P	C	2	46	23	0.2	0.3	0.7
W	U	P	T	1	1	126	0.0	9.9	0.0
W	U	P	T	1	2	19	1.4	0.2	7.0
W	U	P	T	1	3	22	8.2	0.3	27.3
W	U	P	T	1	4	40	1.5	1.0	1.5
W	U	P	T	1	5	48	0.6	1.5	0.4
W	U	P	T	1	6	77	13.1	3.7	3.5
W	U	P	T	1	7	23	0.4	0.3	1.3
W	U	P	T	1	8	57	7.6	2.2	3.5
W	U	P	T	1	9	92	18.7	5.2	3.6
W	U	P	T	1	10	61	0.6	2.3	0.3

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	T	1	11	44	0.0	1.4	0.0
W	U	P	T	1	12	68	5.1	2.9	1.8
W	U	P	T	1	13	94	9.3	6.4	1.5
W	U	P	T	1	14	62	3.1	2.6	1.2
W	U	P	T	1	15	208	28.3	27.0	1.0
W	U	P	T	1	16	30	0.1	0.5	0.2
W	U	P	T	1	17	23	0.5	0.3	1.7
W	U	P	T	1	18	22	0.4	0.3	1.3
W	U	P	T	1	19	88	0.0	4.8	0.0
W	U	P	T	1	20	27	49.6	0.5	99.2
W	U	P	T	1	21	35	8.2	0.8	10.3
W	U	P	T	1	22	124	12.4	10.1	1.2
W	U	P	T	1	23	38	10.6	0.9	11.8
W	U	P	T	1	24	68	1.9	2.9	0.7
W	U	P	T	1	25	92	6.0	5.4	1.1
W	U	P	T	1	26	139	18.0	12.4	1.5
W	U	P	T	1	27	74	7.3	3.4	2.1
W	U	P	T	1	28	44	9.0	1.2	7.5
W	U	P	T	1	29	31	0.2	0.6	0.3
W	U	P	T	1	30	126	12.7	10.2	1.2
W	U	P	T	1	31	37	0.8	0.9	0.9
W	U	P	T	1	32	84	0.3	4.4	0.1
W	U	P	T	1	33	53	19.2	2.0	9.6
W	U	P	T	1	34	91	5.8	5.3	1.1
W	U	P	T	1	36	25	1.8	0.4	4.5
W	U	P	T	1	37	13	0.3	0.1	3.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	T	1	38	104	0.0	6.8	0.0
W	U	P	T	1	39	51	0.0	1.6	0.0
W	U	P	T	1	40	41	1.2	1.0	1.2
W	U	P	T	1	42	20	65.1	0.3	217.0
W	U	P	T	1	43	26	0.3	0.4	0.8
W	U	P	T	1	45	29	1.1	0.5	2.2
W	U	P	T	1	46	34	0.4	0.7	0.6
W	U	P	T	1	48	84	47.5	4.4	10.8
W	U	P	T	1	50	22	5.2	0.3	17.3
W	U	P	T	1	51	37	0.3	1.0	0.3
W	U	P	T	1	52	29	0.2	0.5	0.4
W	U	P	T	1	53	43	0.0	1.2	0.0
W	U	P	T	1	54	55	5.1	1.9	2.7
W	U	P	T	2	1	33	3.3	0.7	4.7
W	U	P	T	2	2	90	0.3	5.1	0.1
W	U	P	T	2	3	22	10.5	0.3	35.0
W	U	P	T	2	4	32	0.3	0.6	0.5
W	U	P	T	2	5	51	0.3	1.7	0.2
W	U	P	T	2	6	147	7.0	13.6	0.5
W	U	P	T	2	7	58	33.4	2.1	15.9
W	U	P	T	2	8	49	7.3	1.5	4.9
W	U	P	T	2	9	100	79.5	6.3	12.6
W	U	P	T	2	10	65	9.9	2.8	3.5
W	U	P	T	2	11	58	5.9	2.4	2.5
W	U	P	T	2	12	116	0.5	8.6	0.1
W	U	P	T	2	13	272	10.6	45.2	0.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	T	2	14	126	0.6	10.1	0.1
W	U	P	T	2	15	203	27.4	27.4	1.0
W	U	P	T	2	16	42	9.2	1.3	7.1
W	U	P	T	2	17	130	0.9	10.3	0.1
W	U	P	T	2	19	46	4.0	1.3	3.1
W	U	P	T	2	20	27	0.4	0.5	0.8
W	U	P	T	2	21	46	25.2	1.3	19.4
W	U	P	T	2	22	43	20.4	1.3	15.7
W	U	P	T	2	23	29	0.4	0.5	0.8
W	U	P	T	2	25	62	43.5	2.4	18.1
W	U	P	T	2	26	165	8.3	17.1	0.5
W	U	P	T	2	27	32	0.2	0.7	0.3
W	U	P	T	2	28	32	0.2	0.6	0.3
W	U	P	T	2	29	22	52.4	0.3	174.7
W	U	P	T	2	30	315	17.7	61.4	0.3
W	U	P	T	2	31	125	21.3	9.7	2.2
W	U	P	T	2	32	42	0.0	1.2	0.0
W	U	P	T	2	33	61	45.0	2.3	19.6
W	U	P	T	2	34	84	3.7	4.4	0.8
W	U	P	T	2	35	87	6.0	4.8	1.2
W	U	P	T	2	36	33	0.2	0.7	0.3
W	U	P	T	3	2	113	25.4	8.1	3.1
W	U	P	T	3	3	26	1.4	0.4	3.5
W	U	P	T	3	4	33	1.6	0.7	2.3
W	U	P	T	3	5	25	0.4	0.4	1.0
W	U	P	T	3	6	63	5.4	2.5	2.2

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	T	3	7	56	0.0	2.0	0.0
W	U	P	T	3	9	38	0.3	0.9	0.3
W	U	P	T	3	10	16	0.3	0.2	1.5
W	U	P	T	3	13	13	0.7	0.1	7.0
W	U	P	T	3	14	15	0.2	0.1	2.0
W	U	P	T	3	15	17	31.0	0.2	155.0
W	U	P	T	3	16	35	16.5	0.8	20.6
W	U	P	T	3	17	13	0.5	0.1	5.0
W	U	P	T	3	18	16	0.3	0.2	1.5
W	U	P	T	3	19	98	20.0	6.0	3.3
W	U	P	T	3	20	60	8.5	2.4	3.5
W	U	P	T	3	21	52	27.9	1.7	16.4
W	U	P	T	3	22	32	5.1	0.6	8.5
W	U	P	T	3	23	78	0.2	3.8	0.1
W	U	P	T	3	24	81	8.1	4.2	1.9
W	U	P	T	3	25	170	39.6	19.2	2.1
W	U	P	T	3	26	75	4.4	4.0	1.1
W	U	P	T	3	29	55	9.3	2.0	4.7
W	U	P	T	3	30	39	0.7	1.0	0.7
W	U	P	T	3	31	170	18.3	20.9	0.9
W	U	P	T	3	32	44	0.0	1.4	0.0
W	U	P	T	3	33	46	0.0	1.4	0.0
W	U	P	T	3	34	45	0.0	1.3	0.0
W	U	P	T	3	35	39	0.0	1.0	0.0
W	U	P	T	3	36	19	0.2	0.2	1.0
W	U	P	T	3	37	13	0.3	0.1	3.0

Appendix A Shock event data

File #						Velocity change (in/sec)	Drop Height Zero-G (in)	Drop Height Equivalent (in)	Unit Ratio
W	U	P	T	3	38	40	27.6	1.0	27.6
W	U	P	T	3	41	37	0.2	0.9	0.2
W	U	P	T	3	42	146	14.7	13.3	1.1
W	U	P	T	3	43	89	10.2	5.0	2.0
W	U	P	T	3	45	21	0.2	0.3	0.7
W	U	P	T	3	46	78	4.1	3.9	1.1
W	U	P	T	3	47	41	1.9	1.0	1.9
W	U	P	T	3	48	112	0.2	8.0	0.0
W	U	P	T	3	49	25	4.6	0.4	11.5
W	U	P	T	3	51	38	0.2	0.9	0.2
W	U	P	T	3	52	26	0.2	0.4	0.5
W	U	P	T	3	53	53	9.7	1.8	5.4
W	U	P	T	3	54	22	3.0	0.3	10.0
W	U	P	T	3	55	26	99.8	0.4	249.5
W	U	P	T	3	56	41	0.5	1.1	0.5
W	U	P	T	3	57	139	17.3	12.2	1.4
W	U	P	T	3	58	50	0.4	1.6	0.3
W	U	P	T	3	59	83	1.7	4.5	0.4
W	U	P	T	3	60	49	0.7	1.5	0.5

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