This is to certify that the

thesis entitled

SECONDARY PACKAGING
FOR 250cc
BRIK PAK CONTAINERS

presented by

JAN E. GATES

has been accepted towards fulfillment
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SECONDARY PACKAGING
FOR 250cc
BRIK PAK CONTAINERS

By

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ABSTRACT

SECONDARY PACKAGING

FOR 250CC

BRIK PAK CONTAINERS

By

Jan E. Gates

The Brik Pak container is entering the United States food market from Europe. Brik Pak Incorporated offers a complete Brik Pak packaging, handling, and distribution system based on the European food market--one unit high loads. The United States food market generally handles and distributes packaged foods more than one unit high. One major United States food manufacturer has found the 250cc Brik Pak container attractive for use, except for the cost penalty associated with one unit high load warehousing.

This research tested three case designs for possible two unit high warehousing. Compression tests were performed on individual cases. The compression test results were compared against each other to assure significant statistical differences existed between case types. One case type, the current case extended for two 275#, C-flute, dividers obtained the minimum compression strength required for two unit high load warehouse stacking.

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The help and support of Dr. Jim Goff, Robert Gates, and Barbara Struve was greatly appreciated in completing this thesis.

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I. INTRODUCTION

The Brik Pak container has been used in European countries for many years. Milk and fruit juices are the primary products packaged in the containers. Brik Pak containers are being promoted in the United States for shelf-stable (non-refrigerated) milk and can or glass bottle replacements for liquid food products. The container advantages, for many food companies include:

- lower primary packaging costs compared to cans or glass bottles.
- less empty primary packaging storage space required.
- no heavy metal contamination.
- consumer preference for non-breakable containers.
- more efficient space utilization on pallets.

The packaging sterilization method was a major hindrance for introducing the Brik Pak containers to the United States. The Food and Drug Administration accepted the packaging sterilization method[2] in January of 1981. Food companies, such as General Foods[3], Ocean Spray[4], and Bordens[8], are now test marketing the 250cc (8.45 fl.oz.) containers in the United States.

Tetra Pak, the Brik Pak container developer, came to the United States and formed Brik Pak Incorporated in 1977[6]. Brik Pak, Inc. offers a complete packaging, handling, and distribution system based on the European food market. The European distribution system usually uses racks and one-pallet high stacks for warehousing. The United States

distribution system generally does not use racks and stacks pallets three to four high. Rail car transportation is also used in the United States distribution system; two pallet high stacks are normally used to load freight rail cars for optimum shipping cost rates.

One major United States food manufacturing company, to be called Company G, has tested the 250cc Brik Pak container with a high acid semi-viscous food product and found the shelf life acceptable. Other in-house studies have found the 250cc container attractive for use within the company's distribution system, except for the cost penalty associated with one unit load warehouse stacking. The cost penalty would be substantially decreased with two pallet high stacks.

This research analyzes three shipping case options that will theoretically allow two high unit load stacking of the 250cc Brik Pak containers. Two tested options were adaptable for use with the current Brik Pak, Inc. shipping case equipment. The other tested option used a shipping case design for which equipment is readily available in the United States. All options were statistically analyzed for variance to assure compression test results are significantly different.

II. THEORETICAL STACKING STRENGTH

Brik Pak containers are made from a paper/poly/foil laminate. The containers are filled without headspace and formed into a "brick" shape. The shape and lack of headspace allows the containers' product to hold weight as well as the shipping cases for stacking strength. Since Brik Pak containers are flexible, the shipping cases must keep the containers from flexing to obtain the optimum stacking strengths. Therefore, calculating or testing empty Brik Pak shipping cases for compression strength is not practical.

To obtain a theoretical stacking strength necessary for one shipping case, this information was used:

- One full shipping case weighs 16.3 pounds (Appendix A).
- The cases on the bottom of a unit load are placed there randomly and must be able to hold the weight of all cases above.
- One unit load has 15 cases per layer, 8 layers high, and stacked in an interlocking unit load pattern[1]: Figures 1,2, and 3.
- Corrugated slip sheets are to be used instead of pallets for distribution.

If the pallet pattern was column stacked, one bottom case would have 15 cases above in a two high unit load stack. Therefore, one case should have a minimum stacking strength of 244.5 pounds.

$$(15 \text{ case} \cdot 16.3 \text{ lbs.}) = 244.5 \text{ lbs.}*$$

*Note: The weight of one slip sheet between the two unit loads is negligible compared to the case weights and, therefore, not added into the minimum stacking strength calculation.

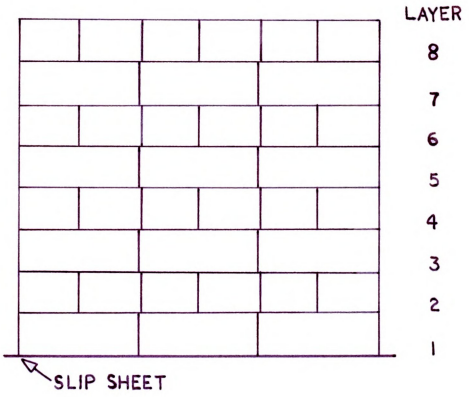

Figure 1--250cc Brik Pak Unit Load

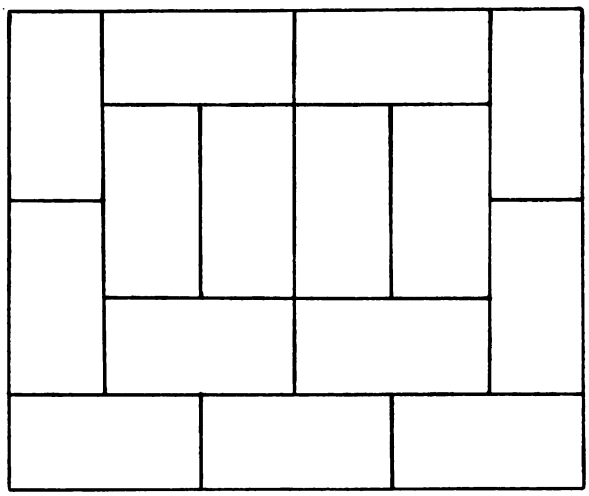

Figure 2--250cc Brik Pak Interlocking Case Pattern
(layers 1,3,5,7)

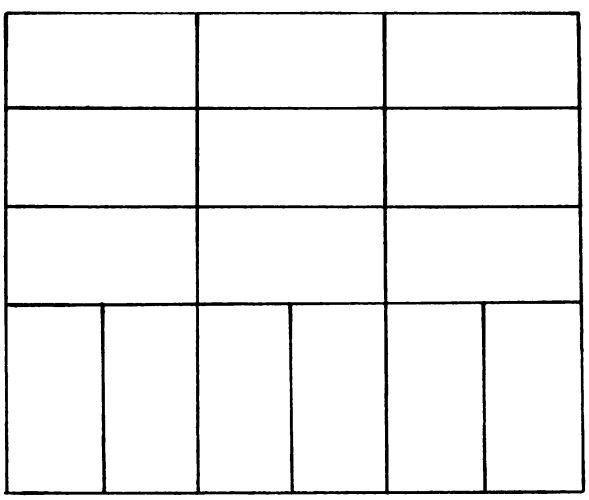

Figure 3--250cc Brik Pak Interlocking Case Pattern
(layers 2,4,6,8)

However, the cases will not be stacked in a column stacked pattern but in an interlocking unit load pattern. An interlocking unit load pattern, hand palletization, case printing, humidity and length of time in storage, slight case manufacturing or set-up imperfections, uneven top unit load placement, dynamic versus static compression test results, case or unit load handling, and distribution transportation require a higher than "minimum" case stacking strength. The various items described are compensated for by a "safety factor" by which the load bearing requirement for the bottom case is multiplied. Through experience with non-rigid primary packages, Company G uses a five safety factor.

(5 safety factor) · (244.5 lbs.) = 1222.5 lbs.

This means the 250cc Brik Pak shipping case will require 1222.5 pounds of compression for two pallet high stacks.

III. DESCRIPTIONS OF THE 250cc BRIK PAK SHIPPING CASE AND OPTIONS

A. Current Shipping Case

The current shipping case consists of a 200# burst, C-flute, corrugated wrap-around shipping tray, Figure 4, with a 2.0 mil polyethylene shrink bundling film wrap[1]. Brik Pak containers are packed 3L x 9W x 1H in the cases.

The case design and shrink film allow the Brik Pak containers to be visible and be opened easily without cutting. Opening the case without cutting helps assure that Brik Pak containers will not be damaged. Cuts in other food product packages made with paperboard or laminates have caused major problems in the food industry. The other case options considered for testing must have some type of easy open case feature. Another consideration is the Brik Pak Inc. wrap-around shipping tray equipment which cannot use corrugated board heavier than 200# burst.*

B. Option One

This option adds two 275# burst, C-flute, corrugated dividers to the current case design, Figure 5. The dividers' flutes are vertical in the case for optimum compression values. The dividers are placed to give three three-by-three Brik Pak container cells in the shipping case. A shrink bundling film wrap is also used with the option. Brik Pak Inc. wrap-around shipping tray equipment can be modified to include the dividers.*

*Discussions with Leif G. Haag, Technical Manager, Brik Pak Inc.

C. Option Two

An increase in the end panel length is used for this option, Figure 6. The case material remains a 200#, C-flute, board. Option 2 uses the general knowledge that most of a case's compression strength is in the corners. The increase in the end panel widths may improve the compression strength enough for two high unit load stacking. This is the preferred option because it requires the least modifications with the Brik Pak Inc. wrap-around shipping tray equipment.

D. Option Three

A Regular Slotted Container (RSC) is option 3, Figure 7. The case would be wrapped around the 250cc Brik Pak containers in the 3x9x1 pack and made from a 275# burst, C-flute, corrugated board with an outside glued manufacturer joint. This option would necessitate buying casing equipment from a company other than Brik Pak Inc.

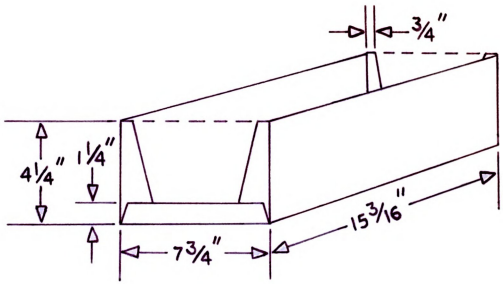

Figure 4--Current 250cc Brik Pak Shipping Case

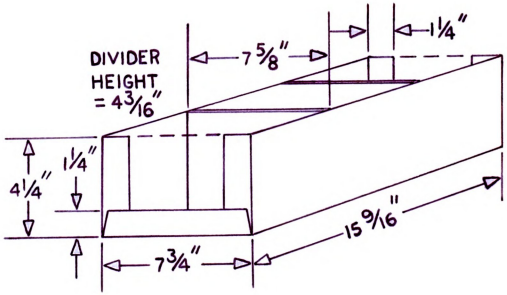

Figure 5--Option 1 Shipping Case with Dividers

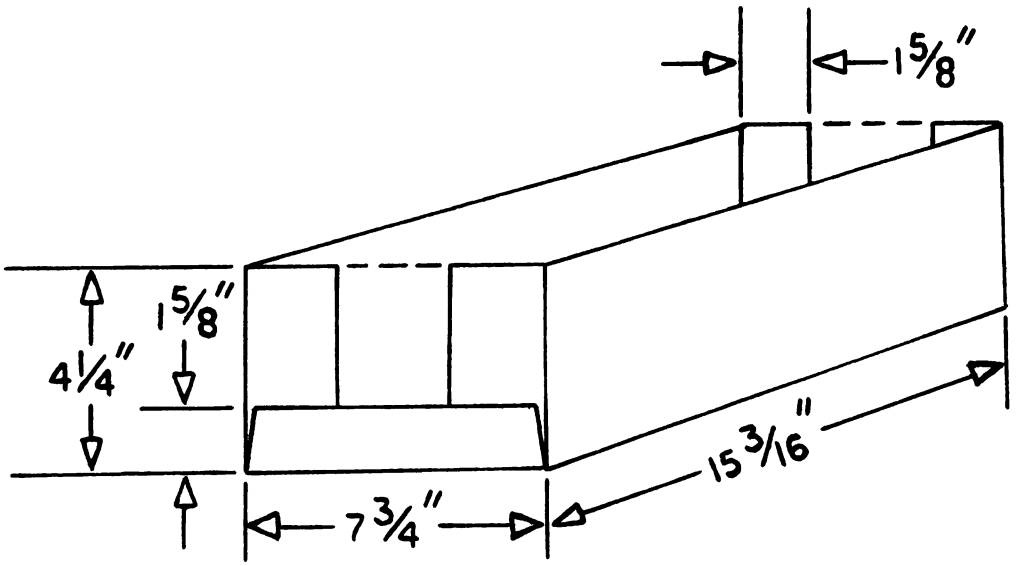

Figure 6--Option 2 Shipping Case with Extended End Panels

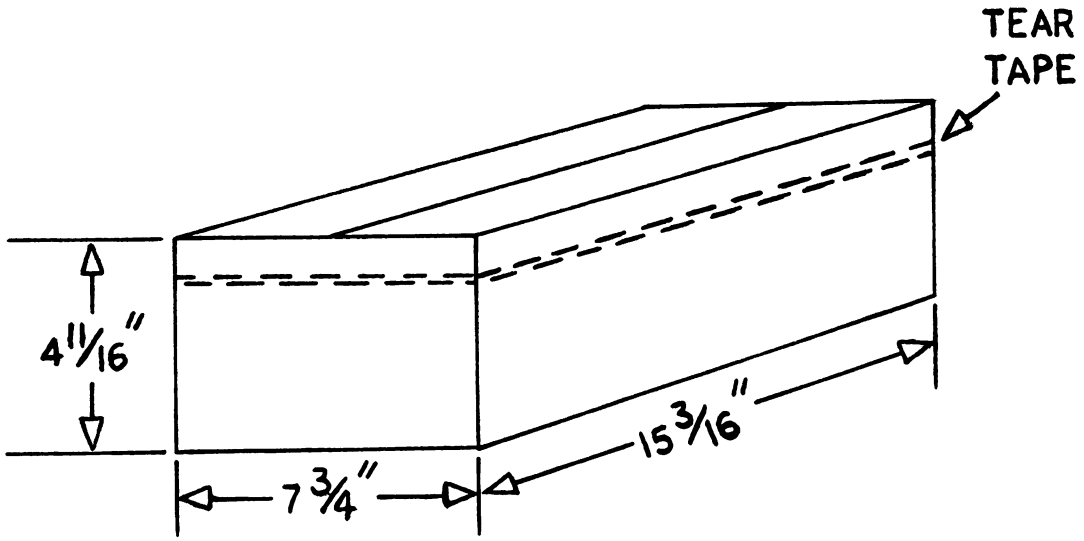

Figure 7--Option 3 Shipping Case, RSC Style

IV. TEST DESIGN

A. Current Shipping Case

Five 250cc Brik Pak packed shipping cases will be compressed, individually, on a Tinius-Olsen compression table, Electomatic 10K Model, at 0.10 inches per minute. The cases and Brik Paks will be observed for damage. Damage is defined as case or Brik Pak bulging, creasing, leakage, and/or flap opening. The compression peak load will be considered the load at 1/8 inch of deflection. A deflection greater than 1/8 inch will be considered damaging to the Brik Pak laminate structure, due to creasing. A twenty pound load will be applied to each case before starting deflection measurements.

The test data will be analyzed for the average compression and standard deviation. The required compression minus the average compression, smallest difference to detect, will be used to determine the sample test size necessary for the other case options with an analysis of variance. A 95% confidence level with a Type I error, $\alpha = 0.05$, and the Type II error, $\beta = 0.20$, will be used for the sample size determination. The test data will be used in the analysis of variance to determine a significant difference between the tested case options at a 95% confidence level.

B. Shipping Case Options

The other case options will be compressed on the same Tinius-Olsen compression table and observed for damage. A 5/32 inch deflection will be considered the compression peak

load on the shipping case options. Obtaining test wrap-around shipping trays or cases was not possible due to the limited availability of 250cc Brik Pak test packing equipment in the United States. The extra 1/32 inch deflection allows the filled Brik Pak containers to compress into the extra space required for hand packing cases before the product compression forces start.

The case options tested were handmade, on a corrugated sample table, from corrugated sheets stocked by Company G. Sheets are tested on arrival for Mullen burst values and basis weights, in accordance to ASTM Methods[20,21]. The case options were sized to allow hand packing the 250cc Brik Pak containers without damage. Outer case dimensions are given in Figures 7,8, and 9, for each case option. All the Brik Pak containers used in packing the case options were inspected for creases and/or indentations before testing; no creased or indented Brik Paks were used in the tested case options. The Brik Paks used had been packed approximately three months before testing. The Brik Pak pallet had been stored at TAPPI conditions[22] since arrival at Company G. The Brik Pak shipping cases were stored six layers high with 15 cases per layer in an interlocking pallet pattern.

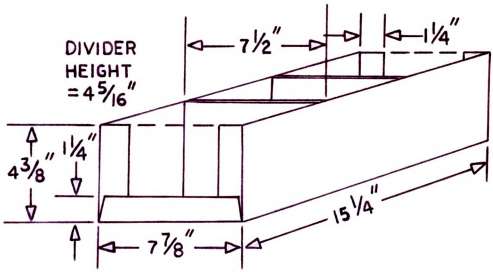

Figure 8--Tested Option 1 Case

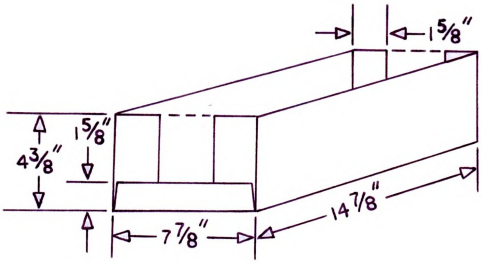

Figure 9--Tested Option 2 Case

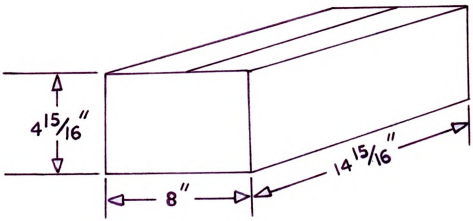

Figure 10--Tested Option 3 Case

V. RESULTS AND DISCUSSION

A. Determining Maximum Case Deflection

Cases from each case type were compressed without recording the loads. The first cases were compressed up to 1/2" deflection for establishing a compression profile. The other cases were compressed to deflections in 1/32" increments before, during, and after compression profile changes. Cases and Brik Paks were inspected at each tested deflection point for damage. The maximum case load was chosen at a deflection as close as possible to 1/32" before the failure deflection. Failure deflections could be detected by compression profile changes, hesitations in load. The Brik Paks exhibited damage with permanent bulging and creases at the failure loads. Brik Pak damage was not visible at the maximum case load deflections. The current shipping case maximum load was determined at 1/8" of deflection; the failure load was between 5/32" to 3/16". The other case options exhibited Brik Pak damage at a 3/16" deflection. A 5/32" deflection was established as the maximum compression load for the case options.

B. Current Shipping Case Compression Strength

Five filled 250cc Brik Pak shipping cases with shrink overwrapping were compression tested, individually, on the Tinius-Olsen compression table described on page 11. Deflection was measured as the compression platens moved with a metal ruler, 1/16 inch divisions. The cases and Brik Paks were observed during and visually inspected after

compression. Compression was continued past the maximum 1/8 inch deflection load to find the case and Brik Pak failure point in terms of deflection and strength. The 1/8 inch deflection load averaged 880.4 pounds with a standard deviation, σ, at 73.1. The failure load averaged 1052.8 pounds with a σ = 24.1 at approximately 5/32 inch; the Brik Pak exhibited damage in the top edge areas. Appendix B contains the compression data obtained in testing.

Based on the 1/8 inch deflection load, the current shipping case averages 342.1 pounds below the necessary compression strength, 1222.5 lbs., determined on page 4. A new Brik Pak option will need to average approximately 350 pounds more compression strength than the current case to be acceptable for two high unit load stacking. The other case options will need five samples each compressed, see Appendix C, for an analysis of variance.

C. Case Option Compression Strength

The shipping case options were tested in the same method as the current 250cc shipping cases. The case options 1 and 2 samples were made to a 4-1/4" outer height to match the current shipping case height. The 4-1/4" outer case heights caused the Brik Pak containers to be between 1/32" to 1/16" above the case option edges, the Brik Pak heights above the case edges were visually the same as the current shipping case. The compression average on Option 2 nearly equalled the current case. Option 1 results averaged approximately 200 pounds more than the current case. These

results were not close to the 350 pounds additional strength needed for two high unit load stacks. The outer case heights were raised 1/8", on all options, to assure the Brik Paks were below the case edges. Figures 7,8, and 9 show the added 1/8" case height used for compression testing.

Compression results for the case options were:

Option	Maximum Load at 5/32", lbs.	Failure Load at 3/16", lbs.
1	$\bar{X}$ = 1271.6; σ = 94.4	$\bar{X}$ = 1542.2; σ = 90.3
2	$\bar{X}$ = 1132.4; σ = 130.2	$\bar{X}$ = 1186.8; σ = 96.0
3	$\bar{X}$ = 360.4; σ = 32.4	$\bar{X}$ = 421.6; σ = 33.7

All the Brik Pak containers exhibited creasing damage on the bottom edges after the 3/16" failure load in all case options except 3. In Option 3, only the nine containers on each case end exhibited damage. Compression data is contained in Appendix 4.

Maximum compression load data from each case tested was entered into a computer program analysis of variance[20]. F-test results indicated a significant difference between the tested cases at a (rounded) 99.9% confidence. Simple contrast evaluation between cases showed all the cases to be significantly different from each other. An analysis of variance was also made on the case failure loads. The F-test results indicated significant difference between failure loads.

The Option 3 compression results were significantly lower than the current case. Damage inspection data showed

the minor case flaps to press into the end sets of nine Brik Pak containers. Therefore, the compression load was not distributed evenly across all the Brik Paks and case edges as in the other Brik Pak cases tested.

Option 1 case averaged the highest compression strength at 1271.6 pounds. The strength is 49.1 pounds above the minimum required strength, 1222.5 pounds. Damage inspection data showed the same type of Brik Pak creasing in Option 1 as the current case; except Option 1 showed damage on the bottom edges while the current case Brik Pak damage was on the top edges. The damage location differences show the current wrap-around shipping case to be packed tighter at the case bottom and Option 1 tighter at the case top.

VI. RECOMMENDATIONS

The Option 1 case compression average, 1271.6 pounds, meets the required minimum average stacking strength, 1222.5 pounds, for two high unit load warehouse stacking. An outer case height of 4-3/8" is necessary for the 250cc Brik Pak case. The Option 1, 275# C-flute, dividers must be even with or no more than 1/16" above the case edges for optimizing compression strength.

Further testing is necessary to determine if the Option 1 shipping case is capable of two unit high transportation. Another 250cc Brik Pak container test pack using the Option 1 dimensions in Figure 5, except the height which should be 4-3/8", should be made. The filled Brik Paks would then be in wrap-around cases, with shrink bundling wrap, holding the containers tightly together. Transportation simulation tests should be conducted on 16 layer high stacks. The two test modes recommended are 1) 0.45 gravity for 10 minutes and 2) 0.25 gravity for 30 minutes at the frequency which causes the top cases to bounce most severely. The modes represent the high level discontinuous rail car and low level continuous rail car and truck motion respectively[14,17]. The top two test layer cases must be inspected for damage as defined on page 11. Five cases from each vibration stack should be compression tested; the resulting data should be compared with the data in Appendix D for case Option 1. If no significant damage or compression strength loss occurs, the case should be acceptable for two unit load distribution.

APPENDICES

APPENDIX A

250cc (3x9x1) BRIK PAK SHIPPING CASE WEIGHT

Ten shrink overwrapped shipping cases packed, 3x9x1, with 250cc filled Brik Pak containers were weighed on a Toledo Honest Weight Scale, Model 2181 with 1/10 lb. gradient.

Results:

Sample No.	Weight, lbs.
1	16.2
2	16.3
3	16.3
4	16.4
5	16.3
6	16.2
7	16.2
8	16.3
9	16.4
10	16.4

Average, $\bar{X}$ = 16.3 lbs.
σ = .082

APPENDIX B

CURRENT 250CC BRIK PAK SHIPPING CASE COMPRESSION STRENGTH

Data on the subject shipping case compression tests:

Sample No.	1/8 in. Deflection Load, lbs.	Failure Load	
		Deflection in.	Lbs.
1	776	5/32	1070
2	878	3/16	1064
3	868	3/16	1068
4	900	5/32	1012
5	980	5/32	1050
$\bar{X}$	880.4	5.5/32	1052.8
σ	73.1	.57/32	24.1

Inspection Summary:

The middle row case end Brik Paks showed minor bulging at 2/16 inch deflection during compression. The Brik Paks exhibited major bulging and creasing at 3/16 inch deflection. After compression, the Brik Pak end rows remained bulged. All Brik Paks exhibited creasing damage on the top edge areas. The cases had minimal to no evidence of compression strain. The shrink overwrapping remained intact.

APPENDIX C

SAMPLE SIZE FOR CASE OPTION COMPRESSION TESTS

To determine the sample size necessary for an analysis of variance, the following information was required:

1. The test hypothesis assumes the current Brik Pak case equals Option 1, which equals Option 2, which equals Option 3.

$$H_o: C = 1 = 2 = 3$$

2. The standard deviation associated with hand set-up and packed cases is approximately 140 pounds.*

3. The Type I error, α, is 0.05 and the Type II error, β, is 0.20

4. The required compression strength is 1222.5 pounds (page 4) and the current case averages 879.6 pounds. Therefore, an acceptable case option must have approximately 350 pounds more compression strength than the current case.

1222.5 lbs. - 879.6 lbs = 342.9 lbs. rounded to 350 lbs.

5. The sample size determination tables require the difference detected to be divided by the standard deviation

$350 \div 140 = 2.5$

There are four cases being tested for four levels. In accordance to Batcher, et al.[10], the number of cases to test for each variable is five.

*Based on unpublished research data at Company G.

APPENDIX D

COMPRESSION DATA ON SHIPPING CASE OPTIONS

Compression data on the case options:

Case	Sample No.	5/32" Deflection Load, lbs.	3/16" Deflection Failure Load, lbs.
Option 1	1	1120	1400
	2	1280	1546
	3	1278	1650
	4	1300	1545
	5	1380	1570
	$\bar{X}$	1271.6	1542.2
	σ	94.4	90.3
Option 2	1	1160	1240
	2	920	1030
	3	1112	1162
	4	1250	1268
	5	1220	1234
	$\bar{X}$	1132.4	1186.8
	σ	130.2	96.0
Option 3	1	410	458
	2	354	410
	3	354	430
	4	320	370
	5	364	440
	$\bar{X}$	360.4	421.6
	σ	32.4	33.7

The cases exhibited minimal to no evidence of compression strain after compression. All Brik Paks in Options 1 and 2 exhibited minor to moderate creasing damage in the bottom areas after compression inspection. Option 3 exhibited damage only on the end sets of three-by-three Brik Paks; no damage was visible on the middle Brik Pak set of three-by-three. The shrink wrap remained intact.

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