CUSHION IMPACT ANALYSIS AND COMPARISON TESTING of the C500, C625 AND C750 PULP CORNER GUARDS and CORRUGATED FIBERBOARD BOXES

Report No. 116-08-0494A-R1
Proposal No. 12020 Rev A

Customer Information

WESTERN PULP PRODUCTS CO.
Rick Hurley
P. O. Box 968
Corvallis, OR 97339

Purpose of Testing

The purpose of this testing is to develop cushion curves for molded pulp corner cushions. In addition, the information will be compared to the cushioning abilities of a corrugated container with no additional cushioning. Testing was conducted according to the specification identified in the table below.

Test Input	Standard Referenced
Transmitted Shock Characteristics of Foam-in-Place Cushioning Materials	ASTM D4168-95

Product Information

Western Pulp C-500, C-625 and C750 Shock Block molded fiber corner protectors and multi-ply corrugated fiberboard boxes

C500 C625 C750

Test Description

Prior to and throughout testing the samples were held at ambient conditions approximately +23°C and 50% relative humidity. The corner protectors and boxes were tested according to ASTM D4168-95 (modified for pulp cushion testing) on the shock test machine using a test block and weights.

The cushions were placed in a 32 ECT C-flute corrugated fiberboard all flaps meet (AFM) box under each base corner of the test block. Cushions were impacted from an equivalent drop height of 12 inches (96 in/sec) and 24 inches (136 in/sec). For the empty box testing the test block was placed directly in the zero clearance box with no additional corner protection. For the corner protector testing the test block was placed in the appropriate clearance box (1/2", 5/8", 3/4") with four corner protectors.

After each set of impacts, the cushions and box were changed, and weights were added to the block to increase the static loading. The transmitted deceleration was measured using an accelerometer placed near the center of the block fixture.

The moisture content of each type of corner was determined. The C500 corners had a moisture content of 8.3%. The C625 corners had a moisture content of 6.5%. The C750 corners had a moisture content of 5.4%.

Laboratory Information

Test Engineer:	Greg Schwinghammer
Test Dates:	May 5th through May 17, 2008
Westpak Laboratory:	San Jose, California

Test Equipment and Instrumentation:

Please refer to Appendix I

BACKGROUND AND TEST PROCEDURES

A. The purpose of testing was to determine and compare the dynamic cushioning characteristics of the molded pulp corner protectors versus the corrugated fiberboard boxes.

B. To conduct the test, the corner protectors were placed in the box under the test block fixture provided by Western Pulp. The test block and box were fastened to the table of the shock test machine in a manner that allowed deflection but restricted excess rebound.

Corners in Empty box

Block with Static Load on Corners

C. The impact velocity change was programmed into the shock test machine equivalent to both 12-inch and 24-inch drop heights at 96 in/sec and 136 in/sec respectively.

D. The surface area used to calculate the static loading for each of the cushion systems was:

1. No Corners - 182.3 square inches (the area of the base of the test block)
2. C500 - 18.4 square inches (the area occupied by 4 corner pads)
3. C625 - 26.8 square inches (the area occupied by 4 corner pads)
4. C750 - 36.4 square inches (the area occupied by 4 corner pads)

E. Metal weights were added incrementally to increase the overall weight of the block thus changing the static loading. Several different static loadings were used for each cushion system to develop the cushion curves. To calculate the static loading the weight of the block and weights was divided by the total surface

area of 4 corners that were placed in the bottom of the box. For the boxes with no corners the total area of the bottom of the box was used to calculate the static loading. Refer to the table below for each loading used for the curves.

Table 1
Static Loadings

Test Specimen	Static Loading Calculation	Static Loading for 12 inch Impacts(PSI)	Static Loading for 24 inch Impacts(PSI)
No Corners	19.8 lbs/182.3 square inches	0.11	0.11
No Corners	24.8 lbs/182.3 square inches	0.14	n/a
No Corners	34.8 lbs/182.3 square inches	0.19	n/a
No Corners	39.8 lbs/182.3 square inches	0.22	n/a
No Corners	44.8 lbs/182.3 square inches	0.25	0.25
No Corners	54.8 lbs/182.3 square inches	0.30	n/a
No Corners	64.8 lbs/182.3 square inches	0.36	n/a
No Corners	79.8 lbs/182.3 square inches	0.44	0.44
No Corners	99.8 lbs/182.3 square inches	n/a	0.55
No Corners	124.8 lbs/182.3 square inches	n/a	0.68
C500 Corners	19.8 lbs/18.4 square inches	1.1	n/a
C500 Corners	24.8 lbs/18.4 square inches	1.3	1.3
C500 Corners	29.8 lbs/18.4 square inches	1.6	1.6
C500 Corners	39.8 lbs/18.4 square inches	2.2	2.2
C500 Corners	54.8 lbs/18.4 square inches	3.0	3.0
C500 Corners	124.8 lbs/18.4 square inches	6.8	6.8
C625 Corners	19.8 lbs/26.8 square inches	0.74	0.74
C625 Corners	44.8 lbs/26.8 square inches	1.7	1.7
C625 Corners	54.8 lbs/26.8 square inches	2.0	2.0
C625 Corners	69.8 lbs/26.8 square inches	2.6	2.6
C625 Corners	94.8 lbs/26.8 square inches	3.5	3.5
C625 Corners	114.8 lbs/26.8 square inches	4.3	4.3
C625 Corners	124.8 lbs/26.8 square inches	4.7	4.7
C750 Corners	24.8 lbs/36.4 square inches	0.68	0.68
C750 Corners	44.8 lbs/36.4 square inches	1.2	1.2
C750 Corners	74.8 lbs/36.4 square inches	2.1	2.1
C750 Corners	94.8 lbs/36.4 square inches	2.6	2.6
C750 Corners	124.8 lbs/36.4 square inches	3.4	3.4

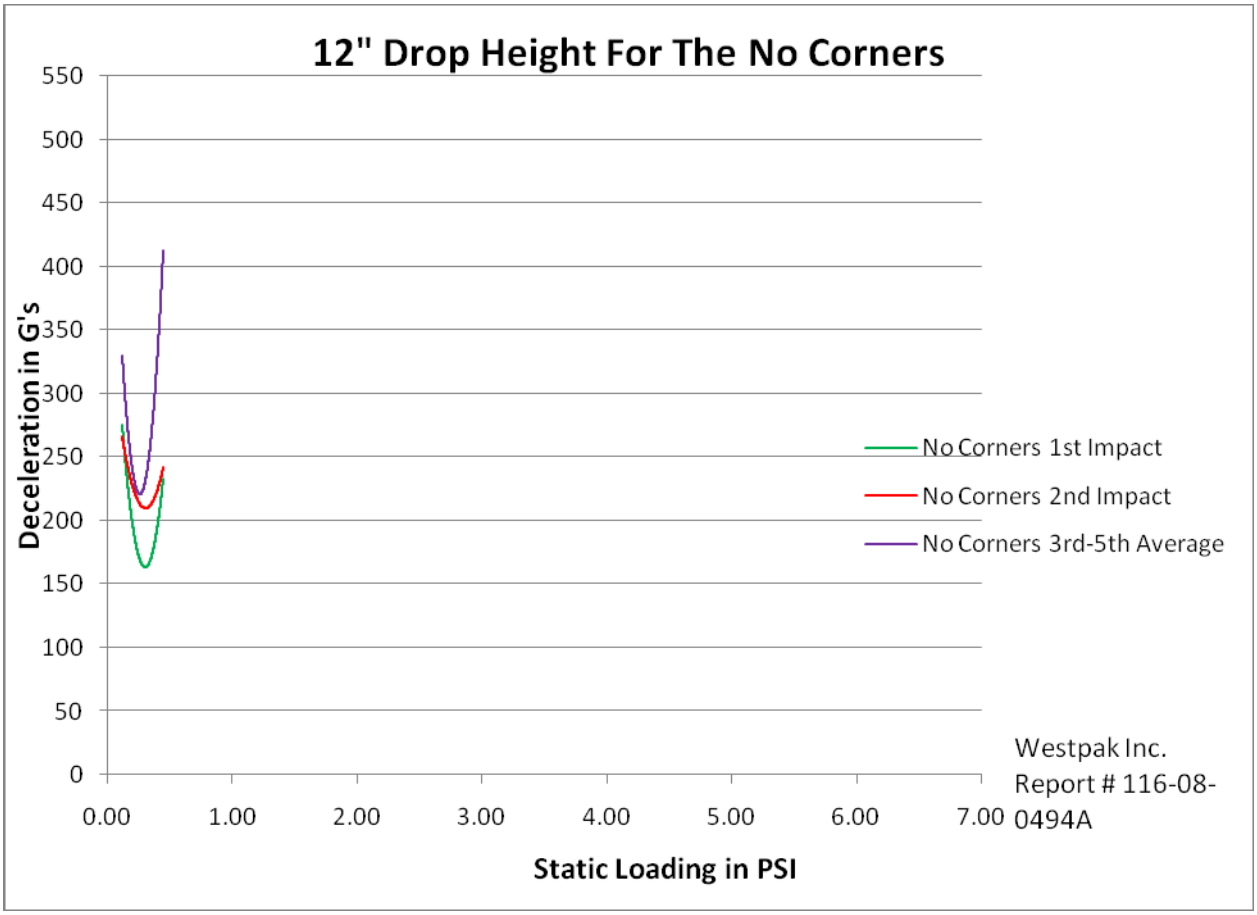
F. The transmitted deceleration levels were measured using a response accelerometer mounted on the fixture. This data shows a typical time domain deceleration versus duration pulse relationship.

G. The results of this test sequence were displayed in the form of a cushion curve showing a transmitted deceleration level versus static loading relationship. The data was divided into three separate curves for each type of cushion; an initial impact curve and a curve for the average of the 2nd and 3rd through 5th impacts as suggested by the ASTM D4168 test standard.

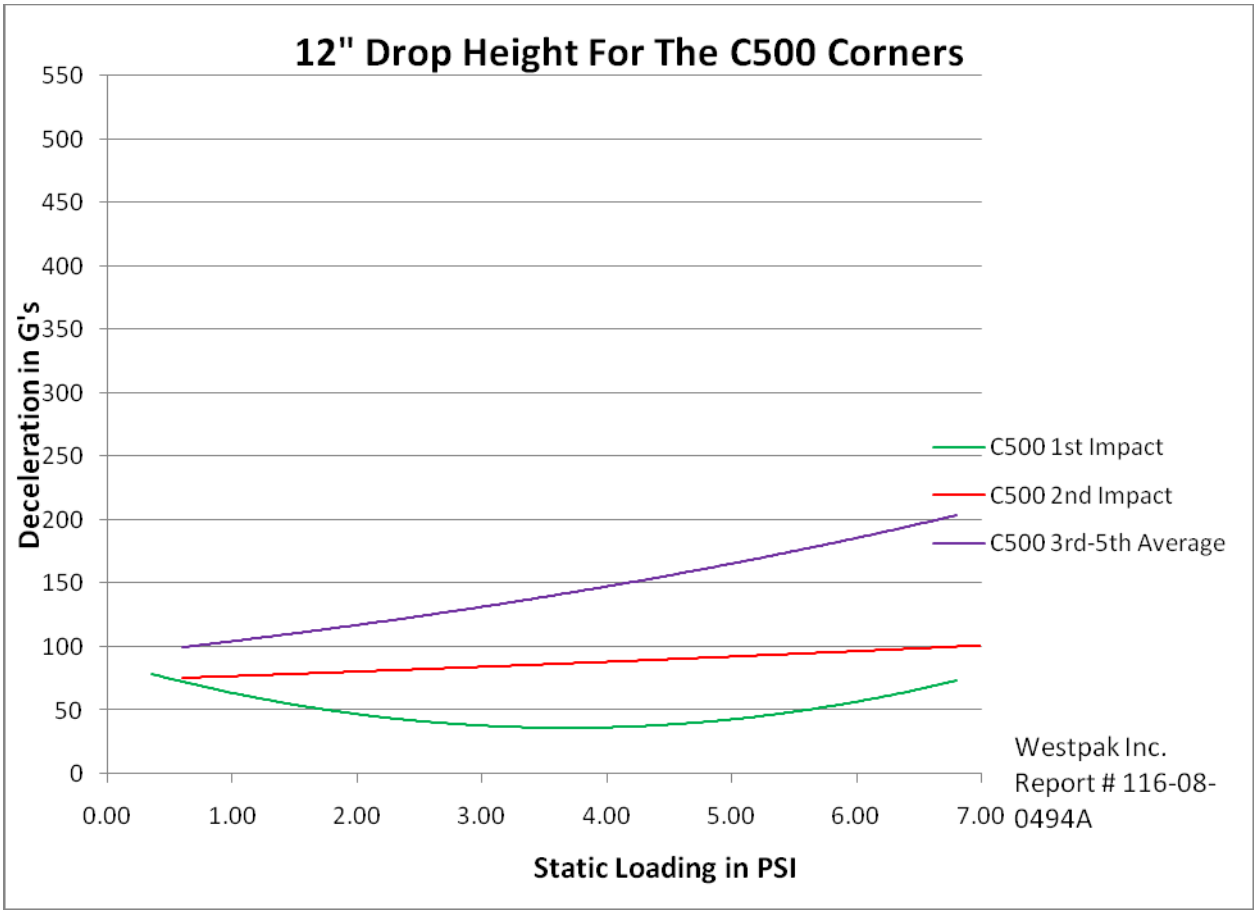
H. This test followed the general guidelines of ASTM D4168-95.

TEST RESULTS

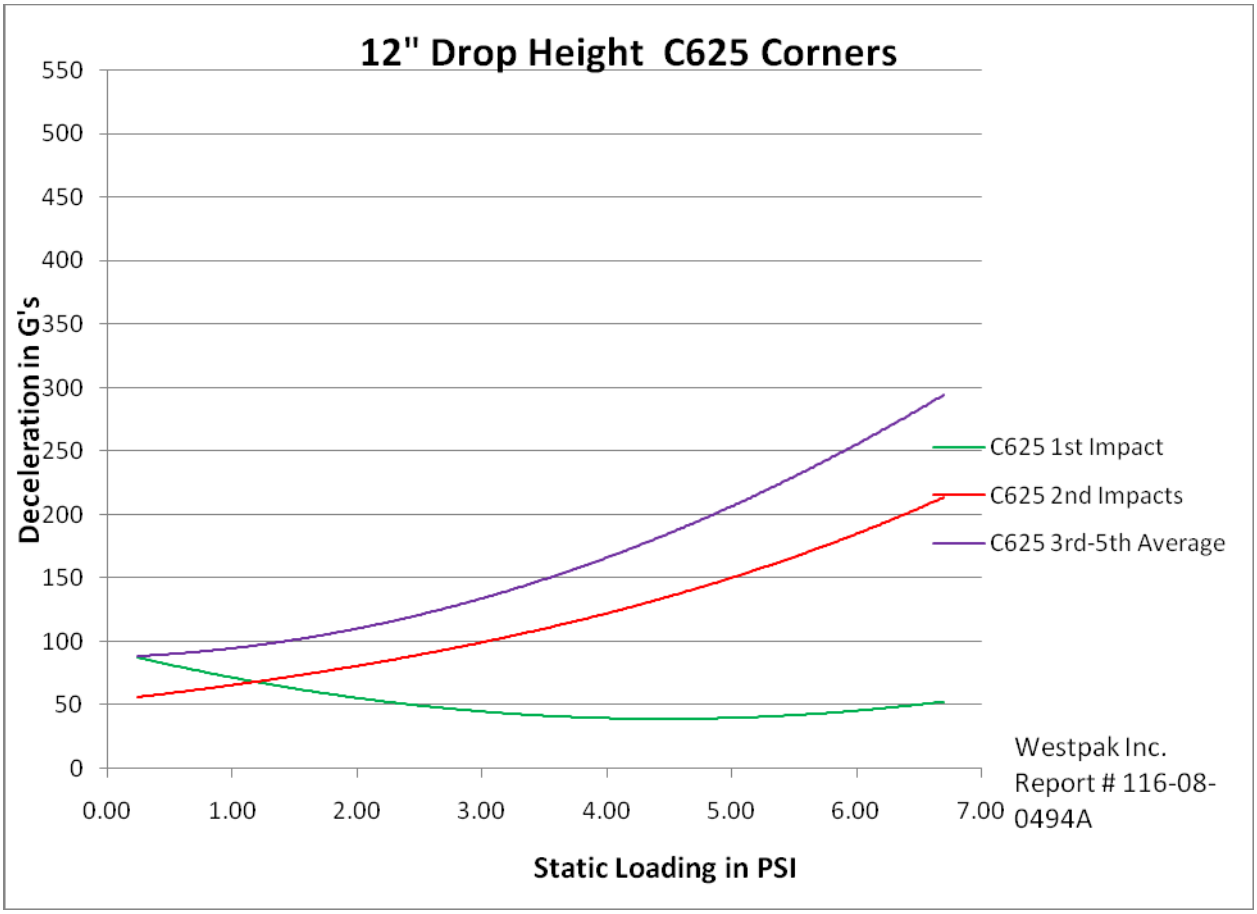
A. Refer to Appendix II for the graphs with weight in the X axis and Appendix III for the individual graphs.



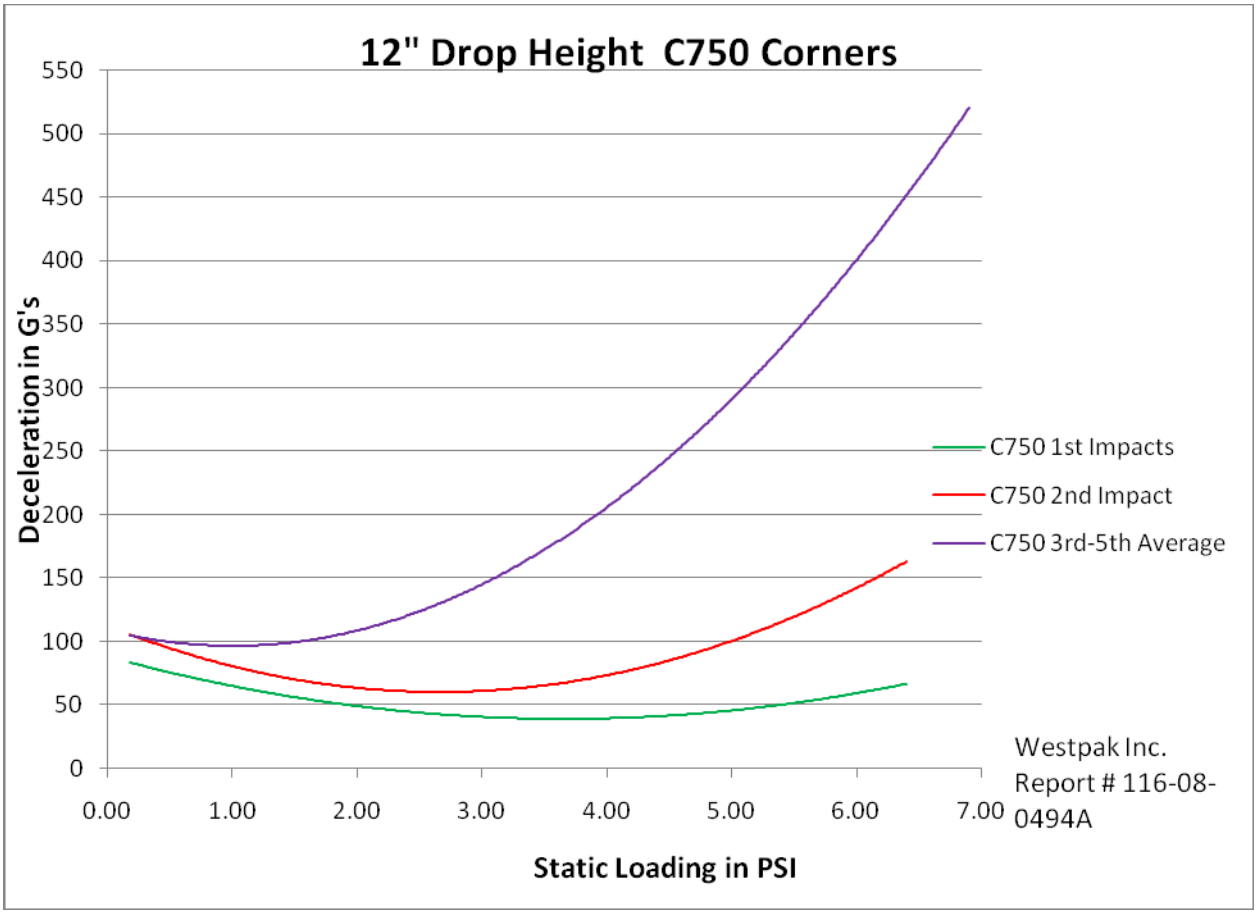
Static Loading Calculation	Static Loading(PSI)
19.8 lbs/182.3 square inches	0.11
24.8 lbs/182.3 square inches	0.14
34.8 lbs/182.3 square inches	0.19
39.8 lbs/182.3 square inches	0.22
44.8 lbs/182.3 square inches	0.25
54.8 lbs/182.3 square inches	0.30
64.8 lbs/182.3 square inches	0.36
79.8 lbs/182.3 square inches	0.44



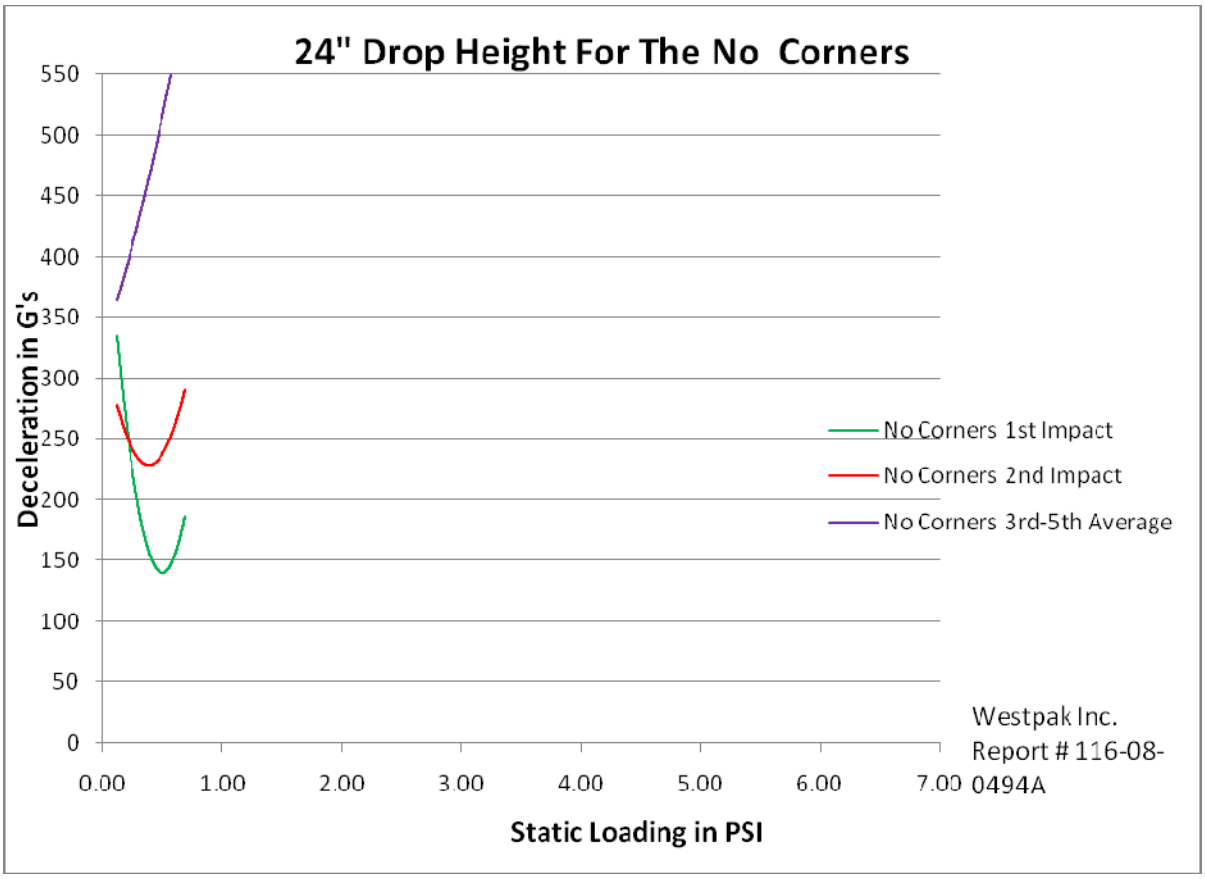
Static Loading Calculation	Static Loading(PSI)
19.8 lbs/18.4 square inches	1.1
24.8 lbs/18.4 square inches	1.3
29.8 lbs/18.4 square inches	1.6
39.8 lbs/18.4 square inches	2.2
54.8 lbs/18.4 square inches	3.0
124.8 lbs/18.4 square inches	6.8



Static Loading Calculation	Static Loading (PSI)
19.8 lbs/26.8 square inches	0.74
44.8 lbs/26.8 square inches	1.7
54.8 lbs/26.8 square inches	2.0
69.8 lbs/26.8 square inches	2.6
94.8 lbs/26.8 square inches	3.5
114.8 lbs/26.8 square inches	4.3
124.8 lbs/26.8 square inches	4.7

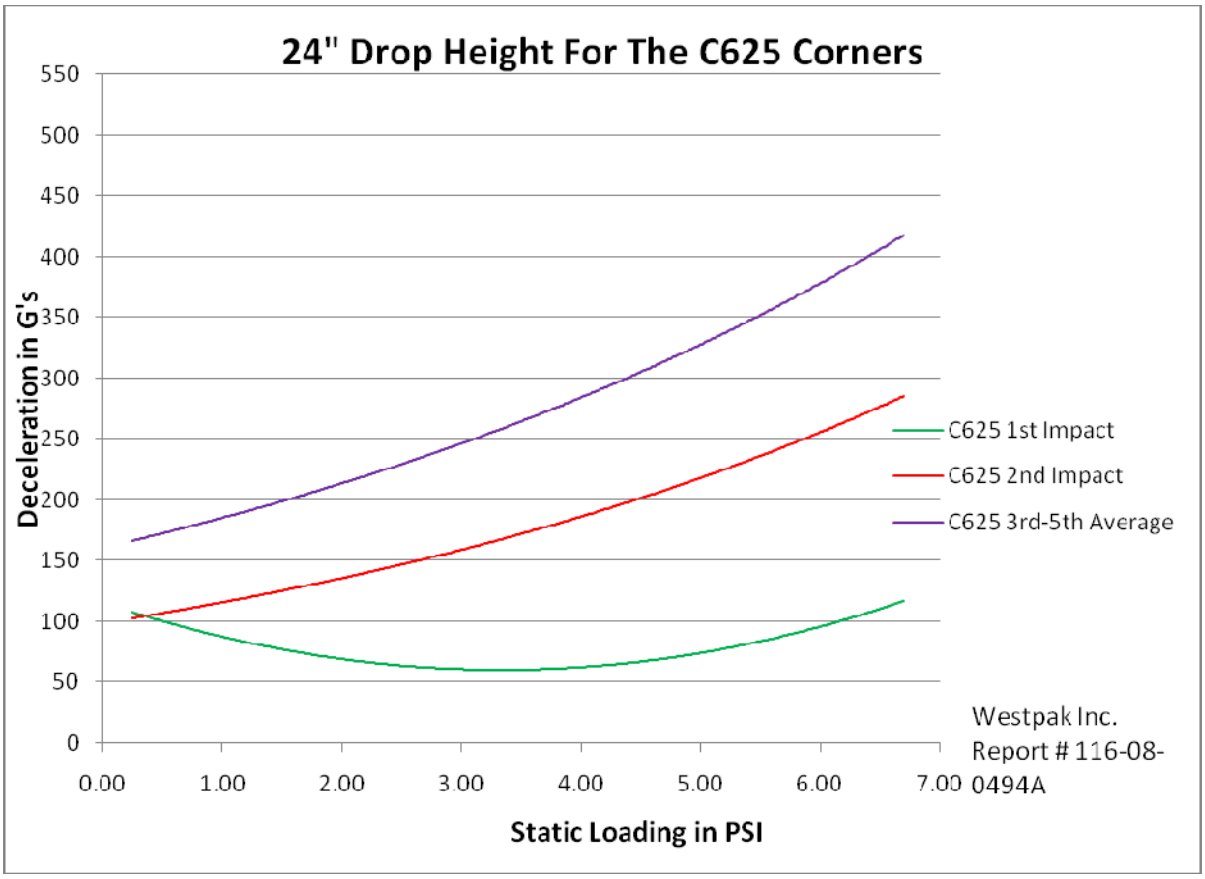


Static Loading Calculation	Static Loading (PSI)
24.8 lbs/36.4 square inches	0.68
44.8 lbs/36.4 square inches	1.2
74.8 lbs/36.4 square inches	2.1
94.8 lbs/36.4 square inches	2.6
124.8 lbs/36.4 square inches	3.4

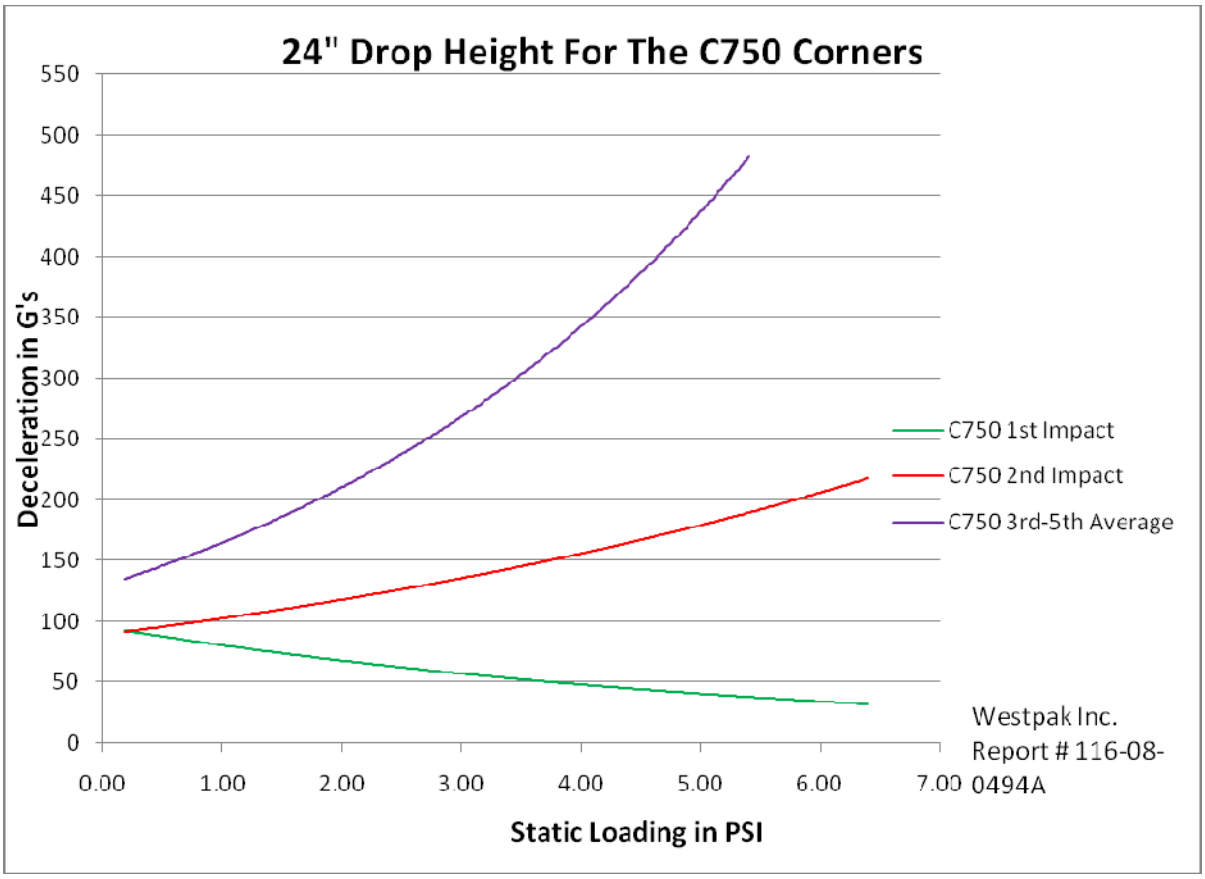


Static Loading Calculation	Static Loading (PSI)
19.8 lbs/182.3 square inches	0.11
44.8 lbs/182.3 square inches	0.25
79.8 lbs/182.3 square inches	0.44
99.8 lbs/182.3 square inches	0.55
124.8 lbs/182.3 square inches	0.68

Static Loading Calculation	Static Loading (PSI)
24.8 lbs/18.4 square inches	1.3
29.8 lbs/18.4 square inches	1.6
39.8 lbs/18.4 square inches	2.2
54.8 lbs/18.4 square inches	3.0
124.8 lbs/18.4 square inches	6.8



Static Loading Calculation	Static Loading (PSI)
19.8 lbs/26.8 square inches	0.74
44.8 lbs/26.8 square inches	1.7
54.8 lbs/26.8 square inches	2.0
69.8 lbs/26.8 square inches	2.6
94.8 lbs/26.8 square inches	3.5
114.8 lbs/26.8 square inches	4.3
124.8 lbs/26.8 square inches	4.7



Static Loading Calculation	Static Loading (PSI)
24.8 lbs/36.4 square inches	0.68
44.8 lbs/36.4 square inches	1.2
74.8 lbs/36.4 square inches	2.1
94.8 lbs/36.4 square inches	2.6
124.8 lbs/36.4 square inches	3.4

CONCLUSIONS AND RECOMMENDATIONS

The molded pulp corners responded to the first impacts at the static loadings in a similar fashion. There were higher transmitted deceleration levels for the 2nd and average of the 3rd through 5th impacts. The no corner boxes responded to the first impact, 2nd impact and average of the 3rd through 5th impacts at the static loadings in a similar fashion with higher deceleration levels and a limited static loading range over which the box with no corner protection was effective at cushioning the impact.

For the first impacts from the 12" drop height the C500 corners provided 4 times more cushioning than the package with no corners from the same drop height. Over all for the 12" drops the corner (C500, C625, C750) pads provided greater protection than the box with no corner pads.

The boxes with no corner protectors had a very narrow range of static loading over which they were effective. All of the static loadings were below 1 psi which means that the cushioning properties of the box work for very light weights only. The corner protectors had a static loading range of 0.68 psi to 6.8 psi. The boxes with no corner protectors also had higher deceleration levels than the boxes with the corner protectors at both the 12 inch and 24 inch drop heights. Deceleration levels can be broadly defined as amount of energy transmitted into the product.

WESTPAK™ is pleased to present this report to **Western Pulp** covering the cushion curve development of the **C500, C625, C750 corner protectors and empty boxes**. The equipment used to conduct this testing has been recently calibrated and is known to be in good operating condition. In addition the test operator uses good laboratory practice at all times. Therefore, the data is considered accurate and reliable. However, there is no warranty expressed or implied with the submission of this report, and **Western Pulp** assumes all liability for use of the data contained herein.

Respectfully submitted,

WESTPAK, INCORPORATED

Greg Schwinghammer
June 5, 2008

Reviewed By

Mark Escobedo
June 5, 2008

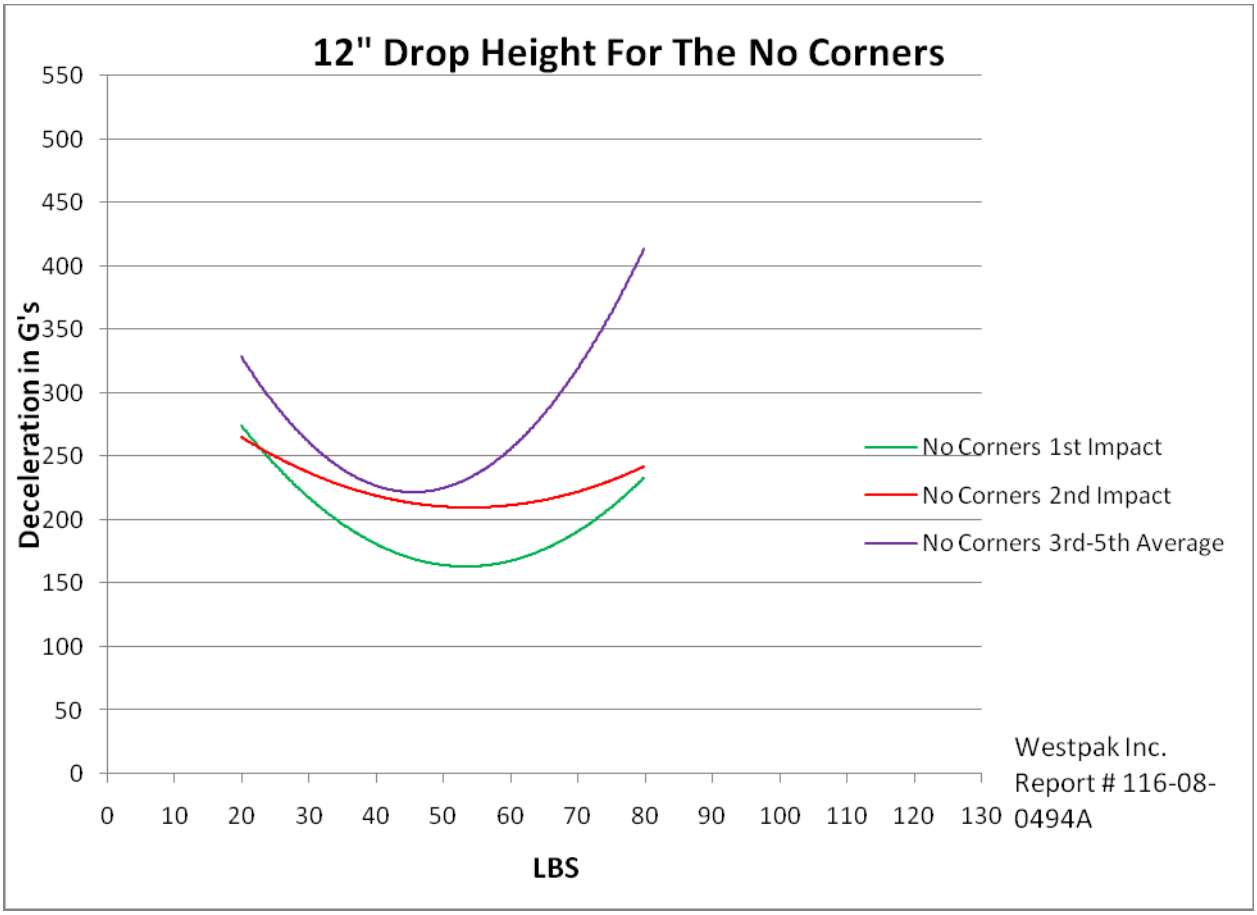
APPENDIX I

EQUIPMENT AND INSTRUMENTATION

Instrumentation & Equipment	Westpak ID	Model	Last Calibration
PCB Accelerometer	5	353B15	6/26/2007
Endevco Accelerometer	85	2224C	2/27/2008
GHI Transient Capture and Analysis System	119	MiniCAT-4	6/21/2007
Kistler Dual Mode Amplifier	437	5010B	6/25/2007
Kistler Dual Mode Amplifier	438	5010B	6/25/2007
Lansmont Shock Test Machine	370	95	Not Required
Note: All calibration conducted annually on instrumentation only			

APPENDIX II

Curves With Weight in the X axis


12" Drop Height For The No Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
LBS
No Corners 1st Impact
No Corners 2nd Impact
No Corners 3rd-5th Average
Westpak Inc.
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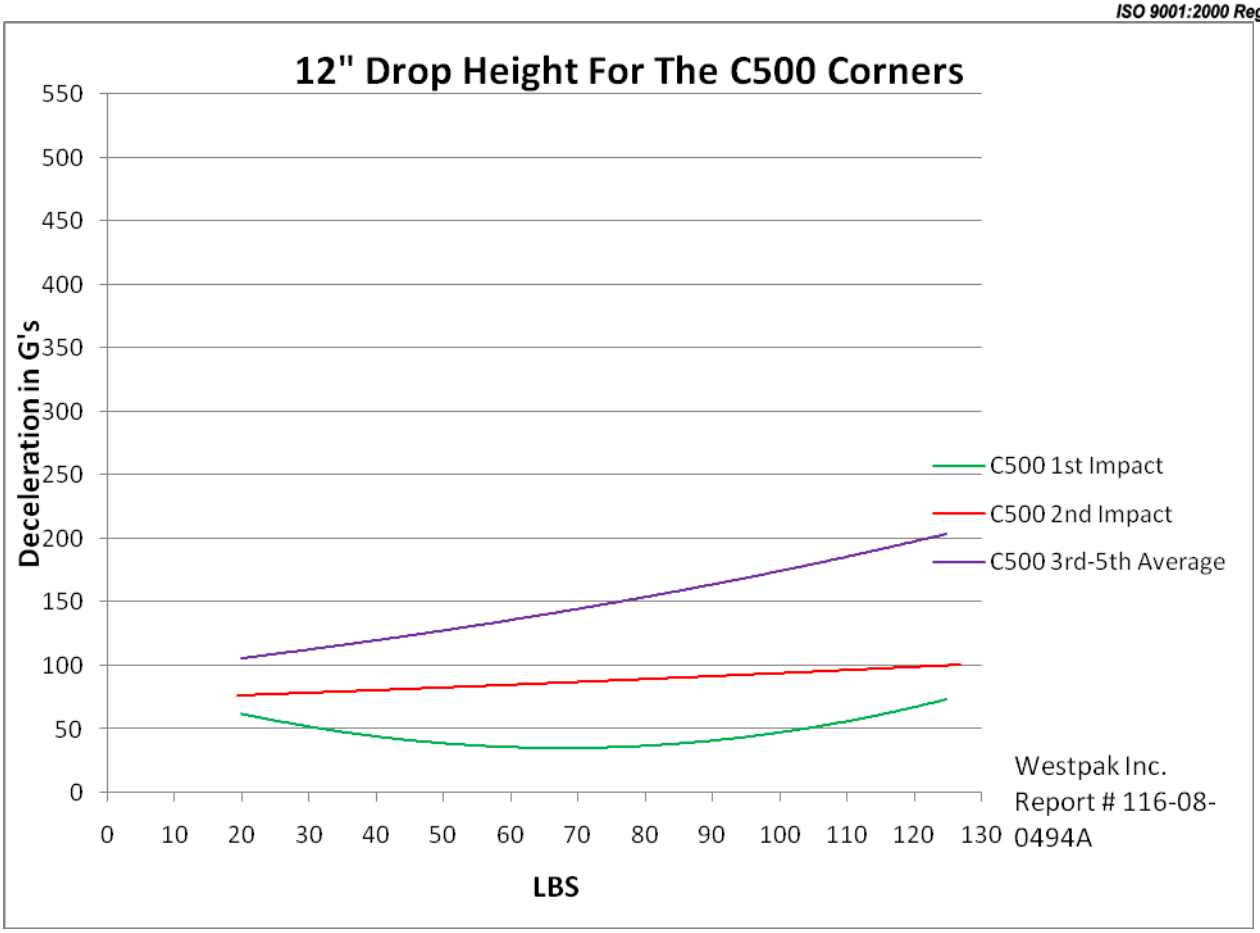
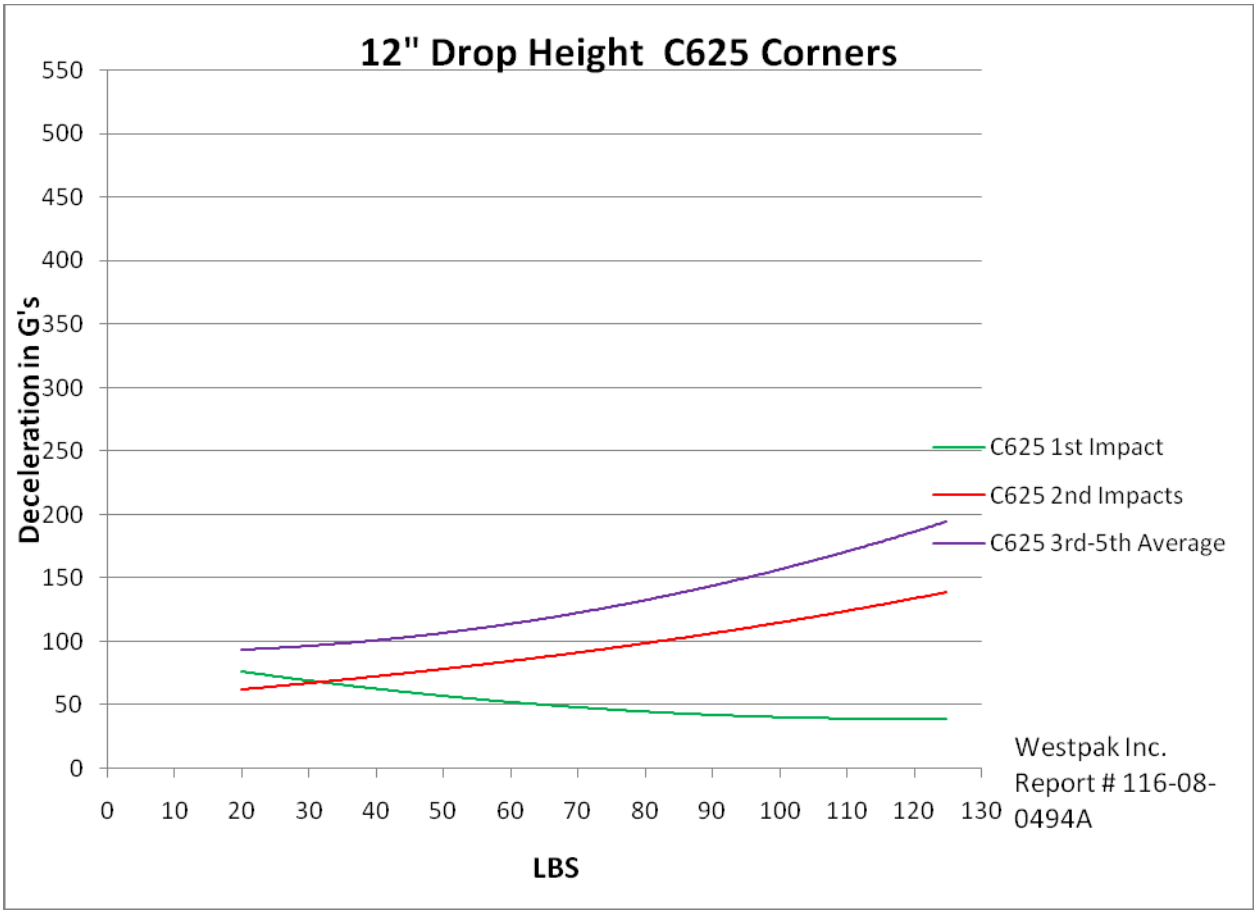
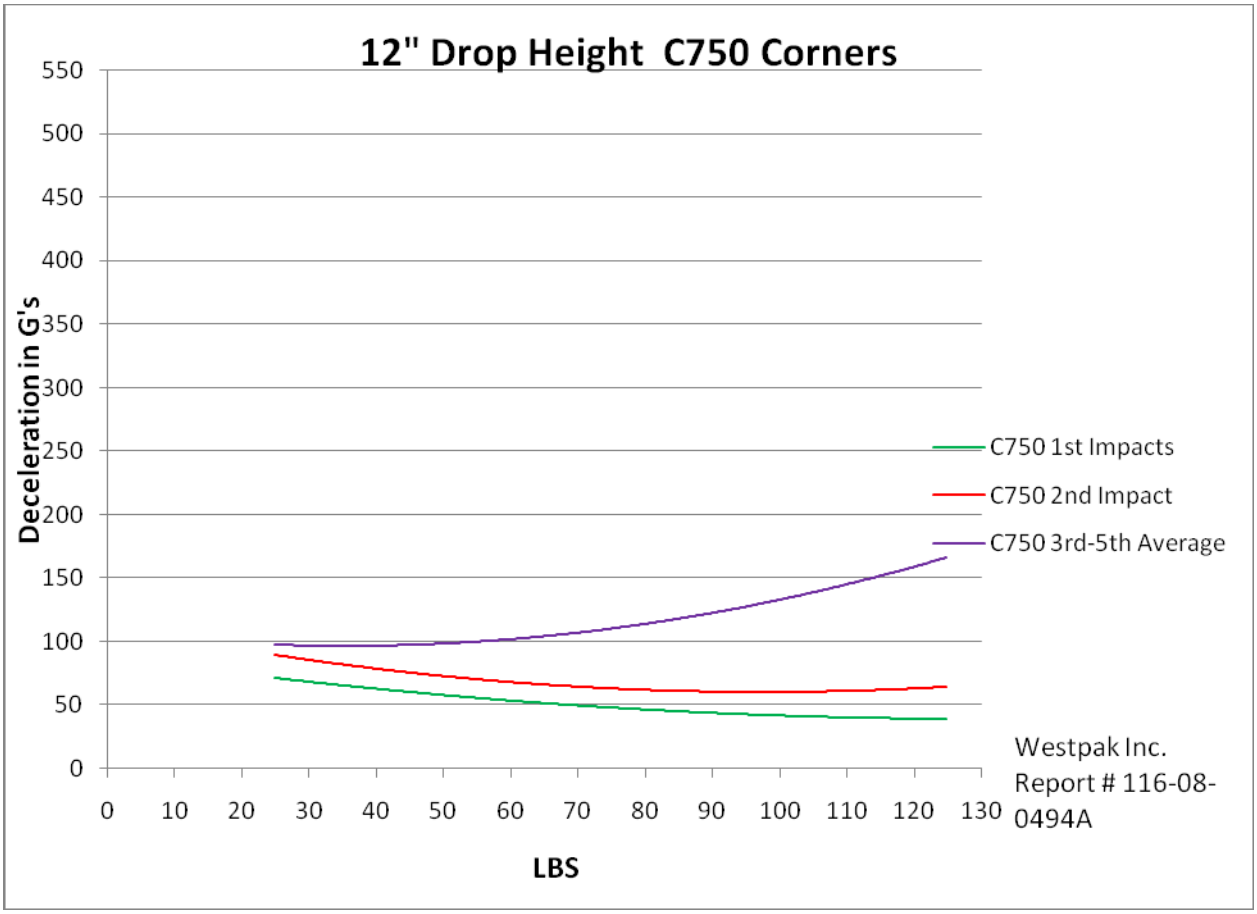
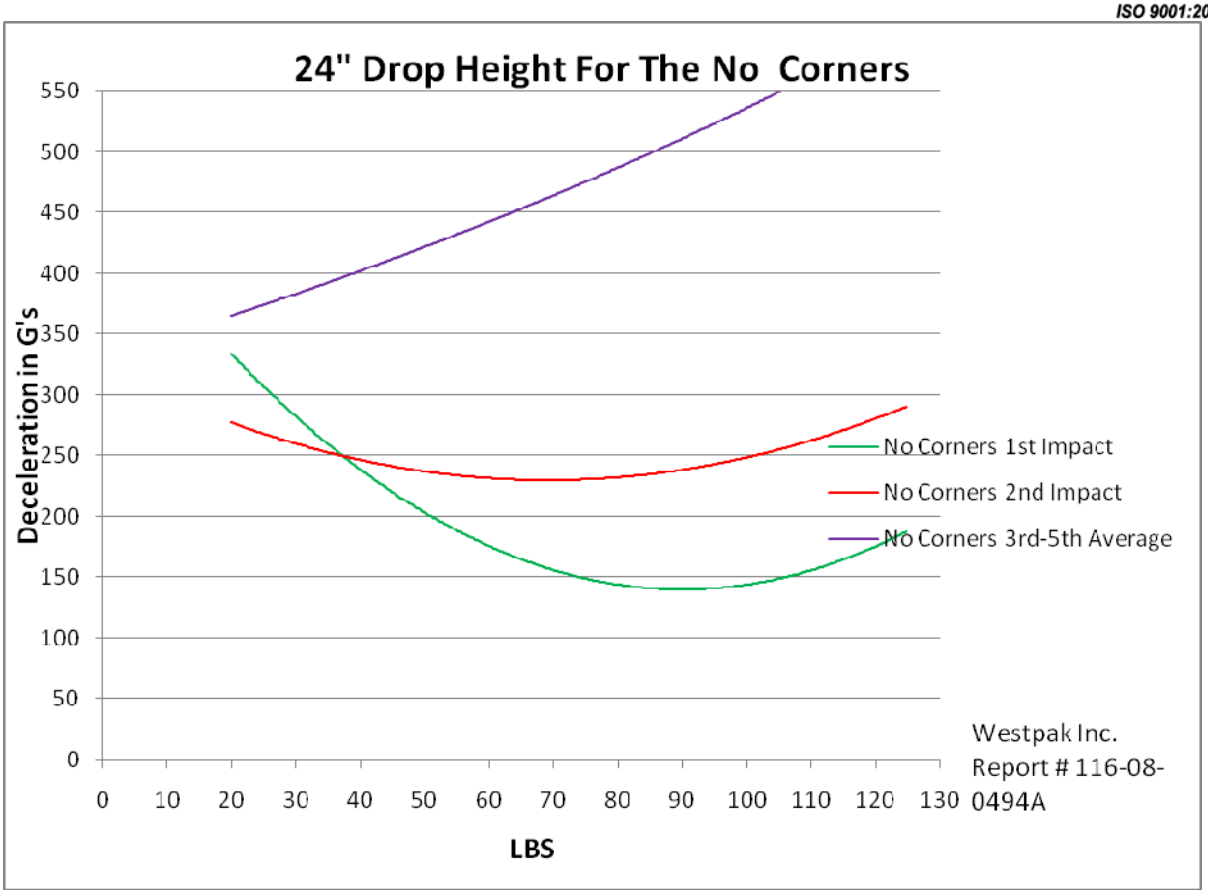
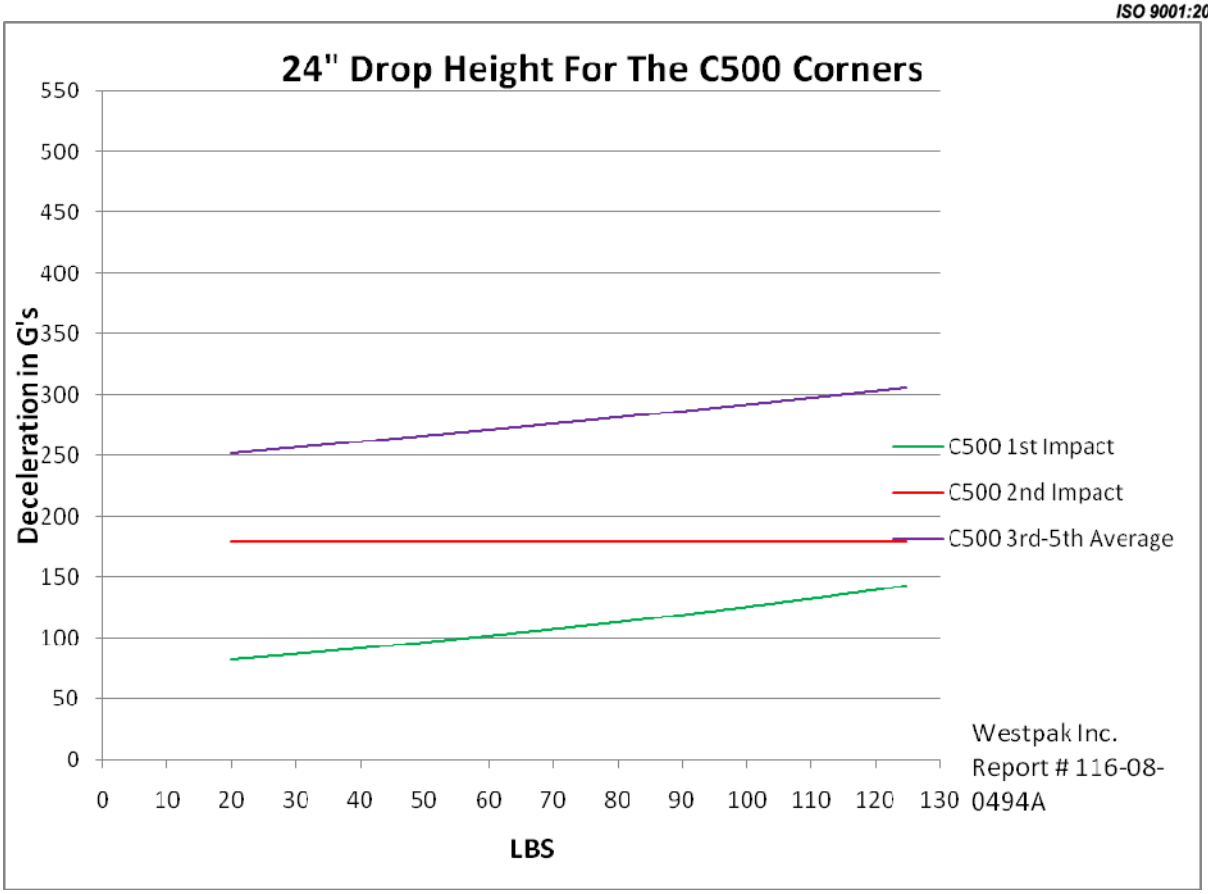

12" Drop Height For The C500 Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
LBS
C500 1st Impact
C500 2nd Impact
C500 3rd-5th Average
Westpak Inc.
Report # 116-08-0494A


12" Drop Height C625 Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
LBS
C625 1st Impact
C625 2nd Impacts
C625 3rd-5th Average
Westpak Inc.
Report # 116-08-0494A


12" Drop Height C750 Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
LBS
C750 1st Impacts
C750 2nd Impact
C750 3rd-5th Average
Westpak Inc.
Report # 116-08-0494A


24" Drop Height For The No Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
LBS
No Corners 1st Impact
No Corners 2nd Impact
No Corners 3rd-5th Average
Westpak Inc.
Report # 116-08-0494A


24" Drop Height For The C500 Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
LBS
C500 1st Impact
C500 2nd Impact
C500 3rd-5th Average
Westpak Inc.
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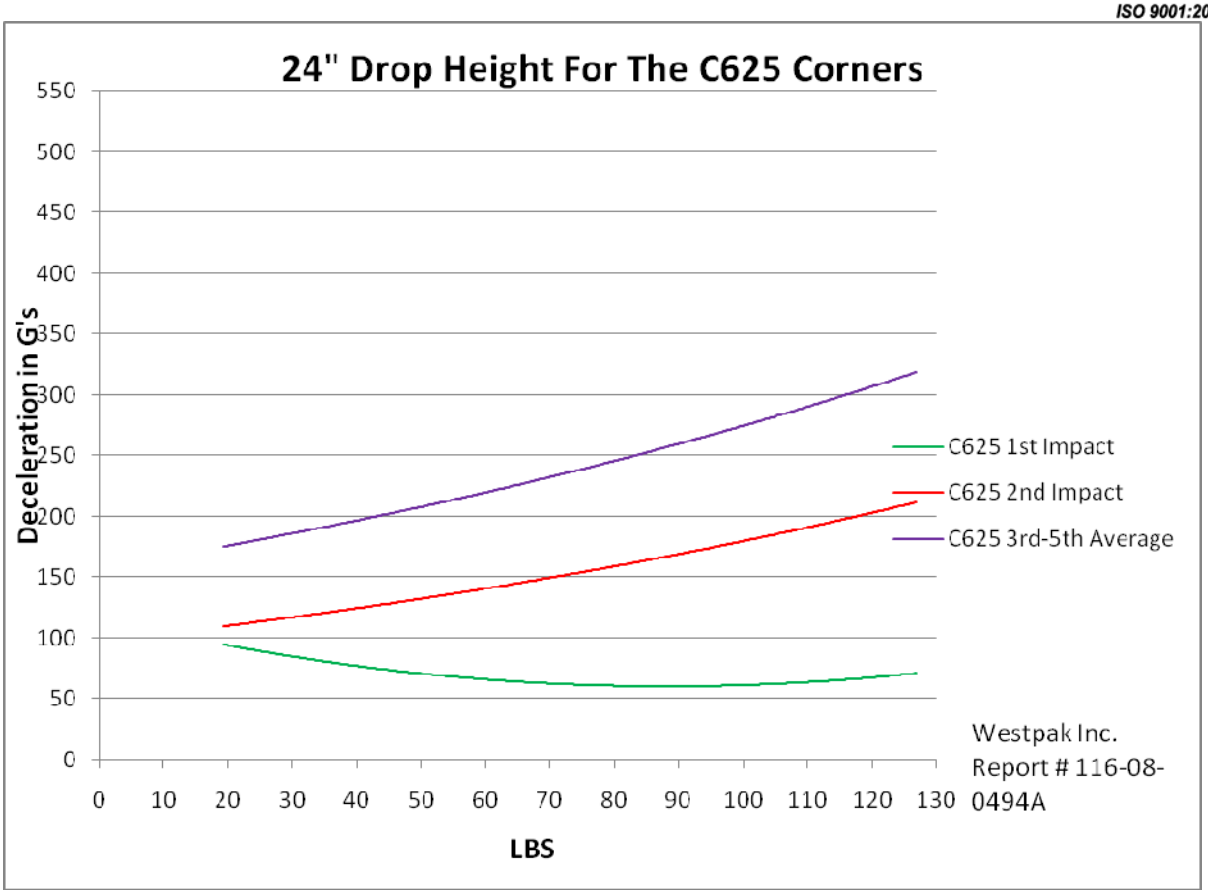
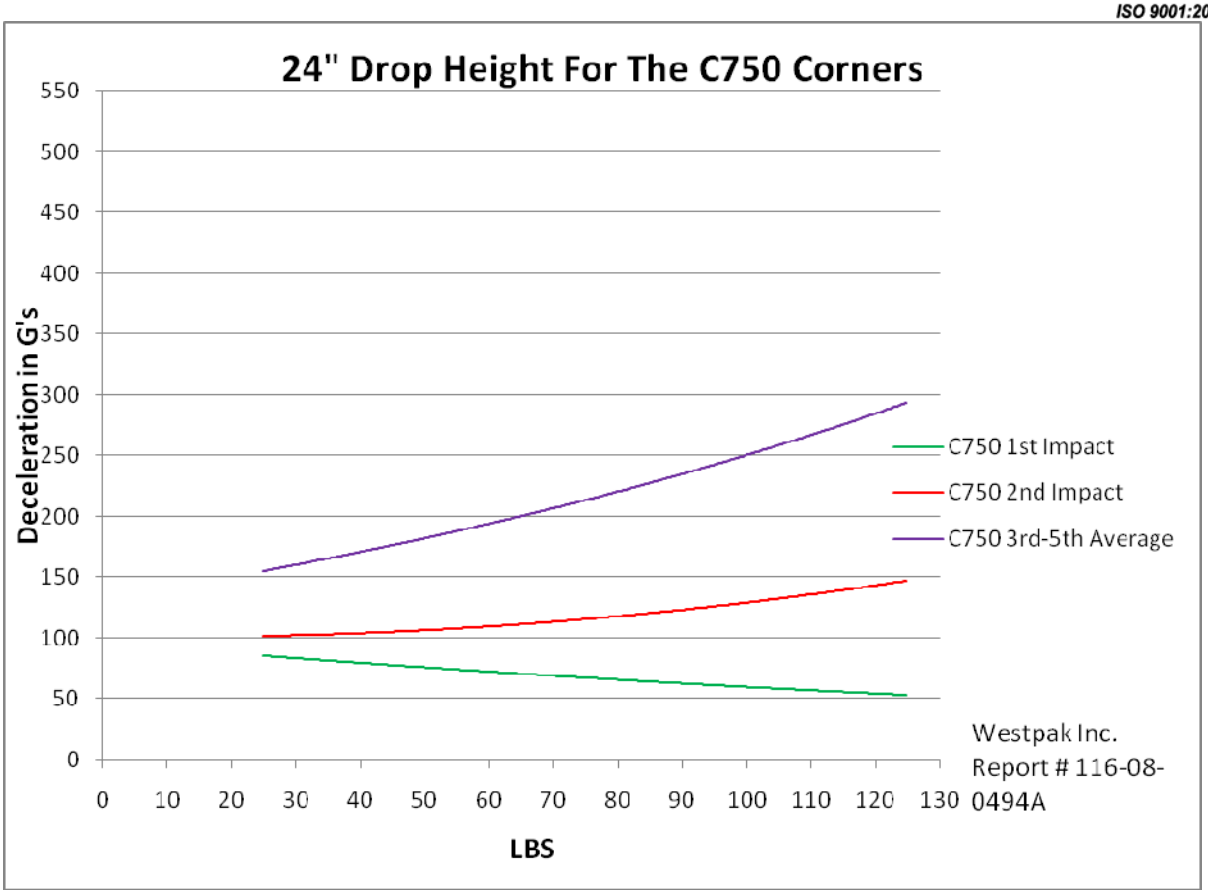
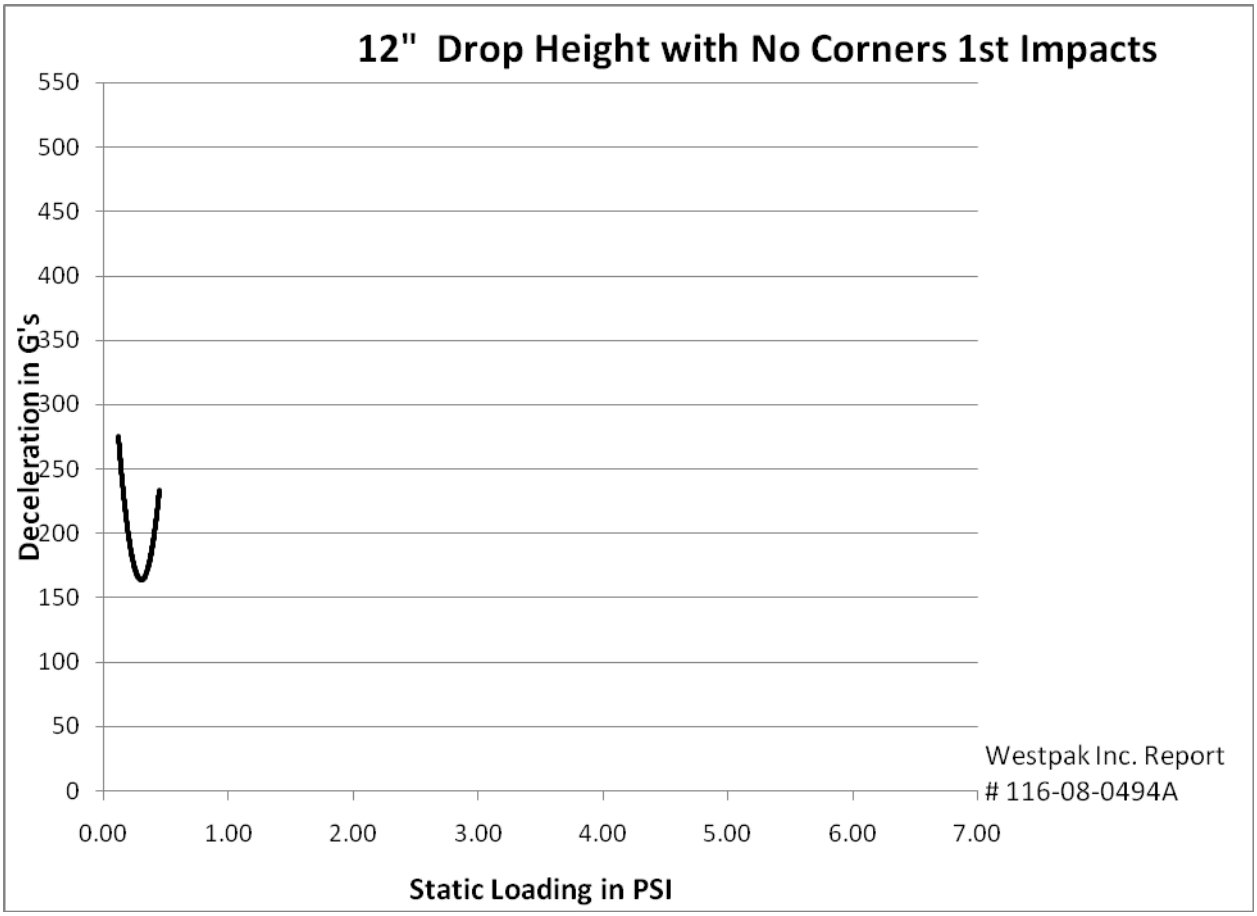
0494A

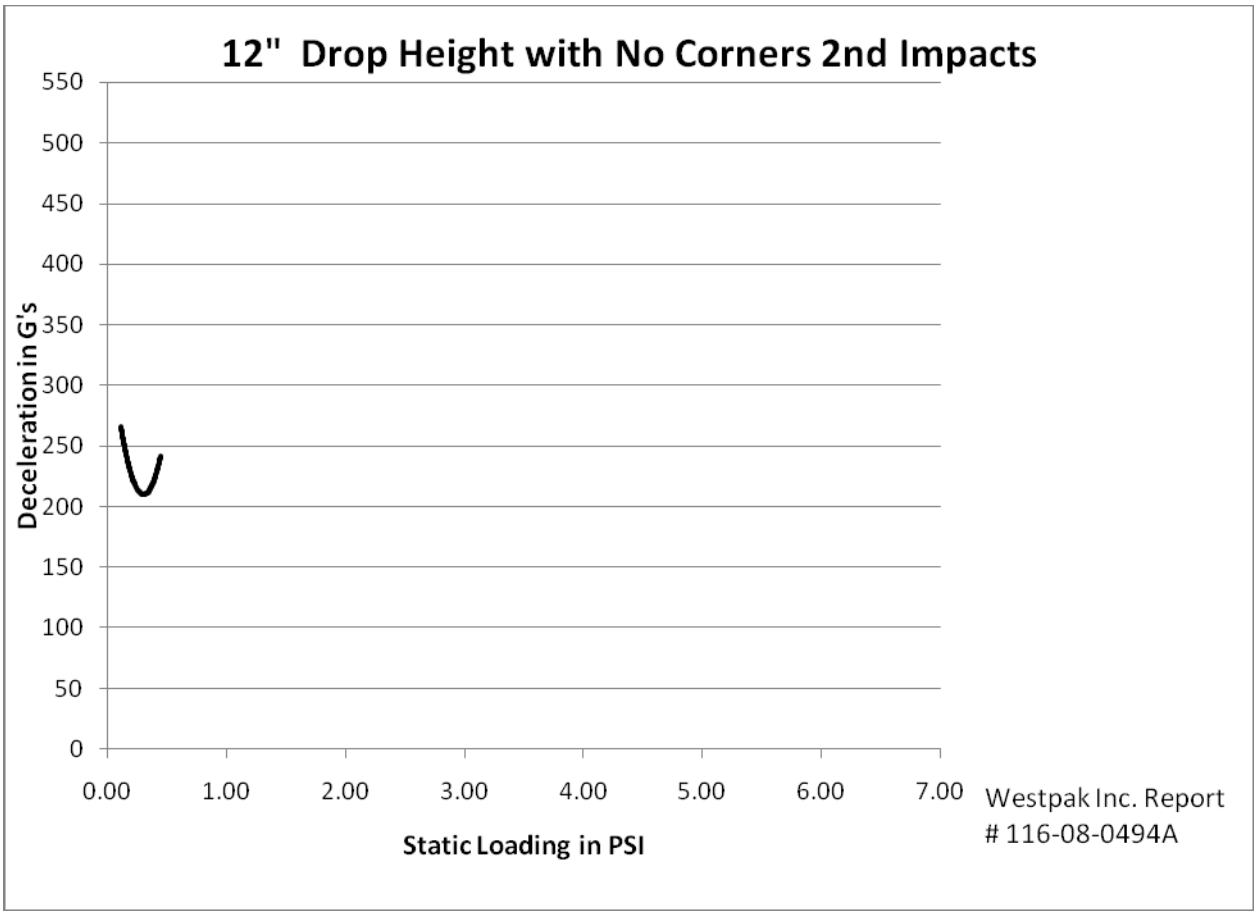

24" Drop Height For The C625 Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
LBS
C625 1st Impact
C625 2nd Impact
C625 3rd-5th Average
Westpak Inc.
Report # 116-08-
0494A

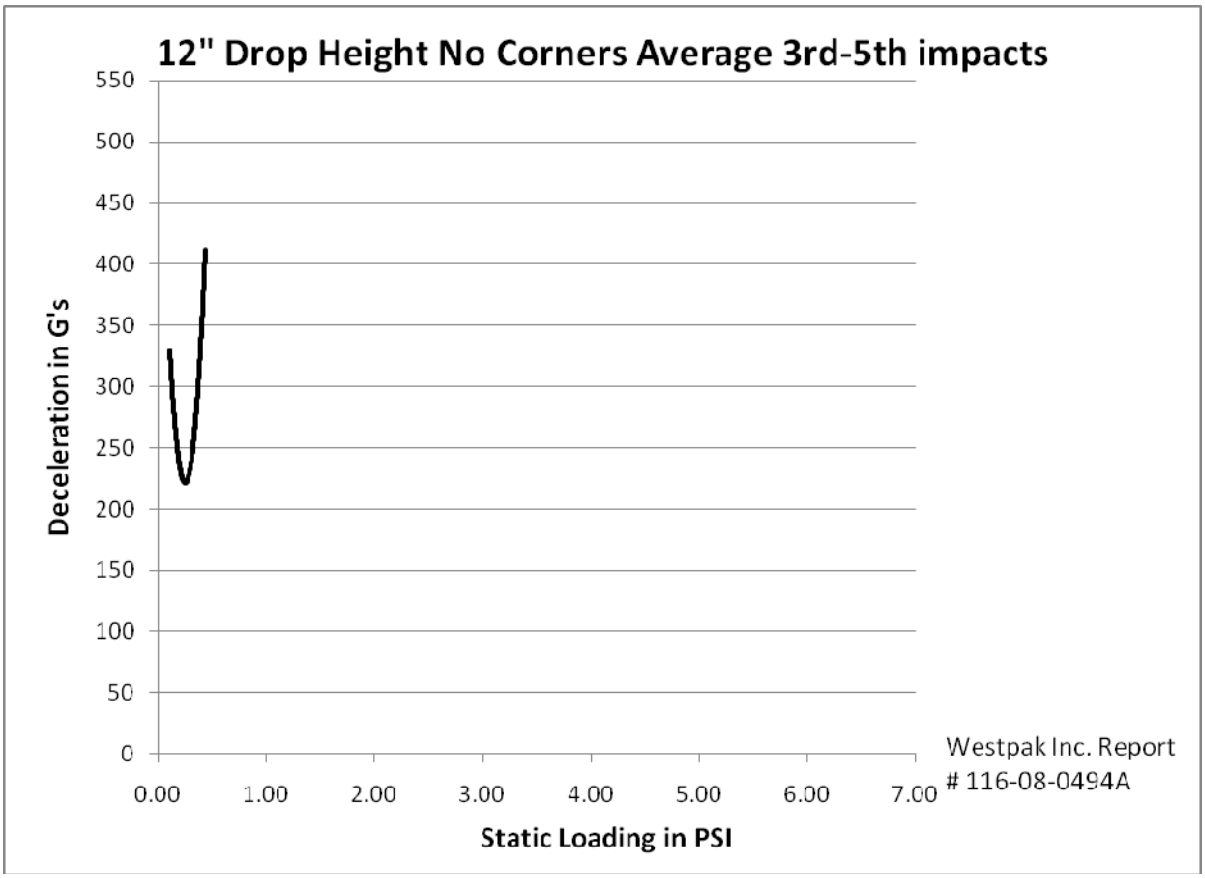

24" Drop Height For The C750 Corners
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
LBS
C750 1st Impact
C750 2nd Impact
C750 3rd-5th Average
Westpak Inc.
Report # 116-08-
0494A

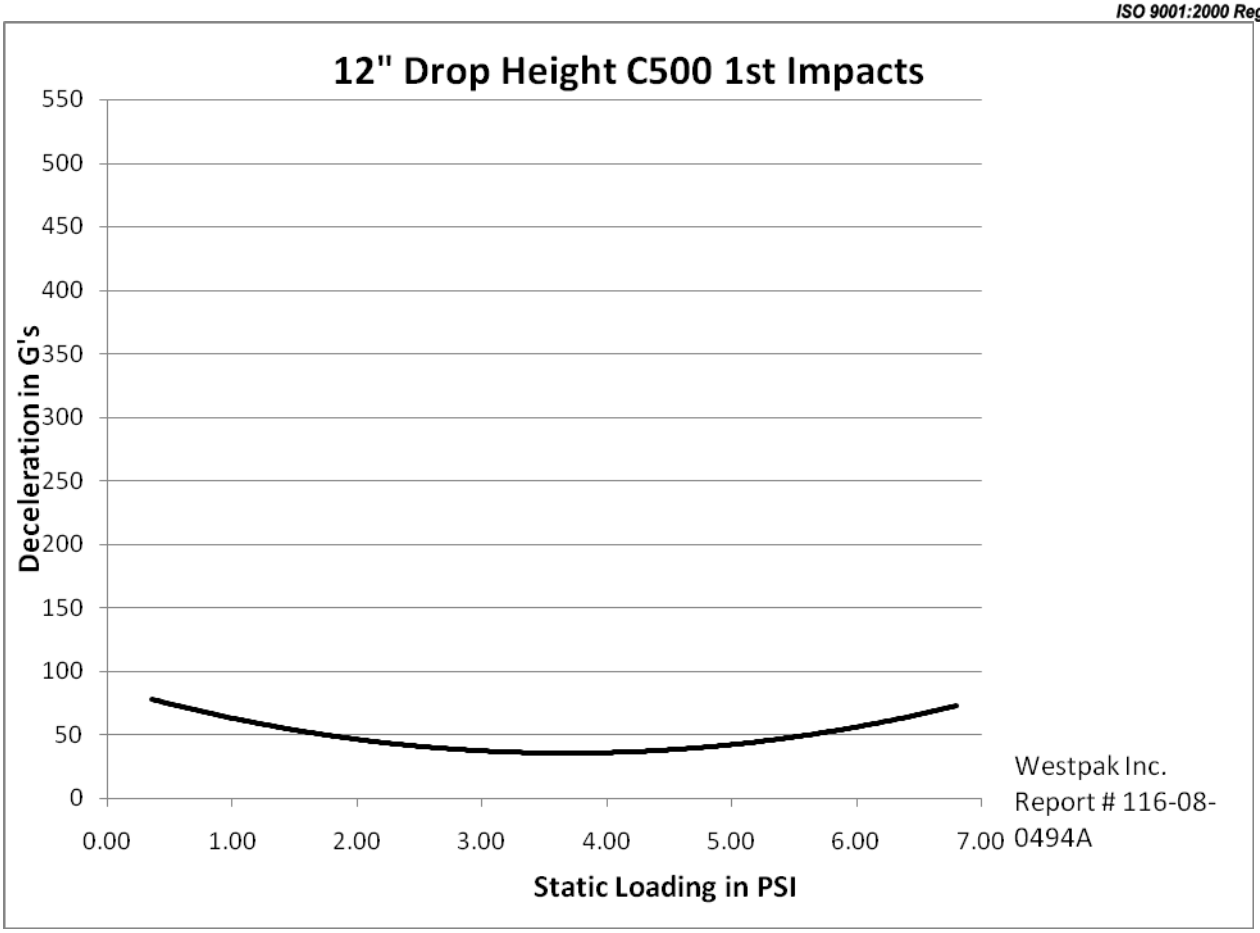
APPENDIX II

Individual Cushion Curves


12" Drop Height with No Corners 1st Impacts
550
500
450
400
350
300
250
200
150
100
50
0
Deceleration in G's
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A


12" Drop Height with No Corners 2nd Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A


12" Drop Height No Corners Average 3rd-5th impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A


12" Drop Height C500 1st Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
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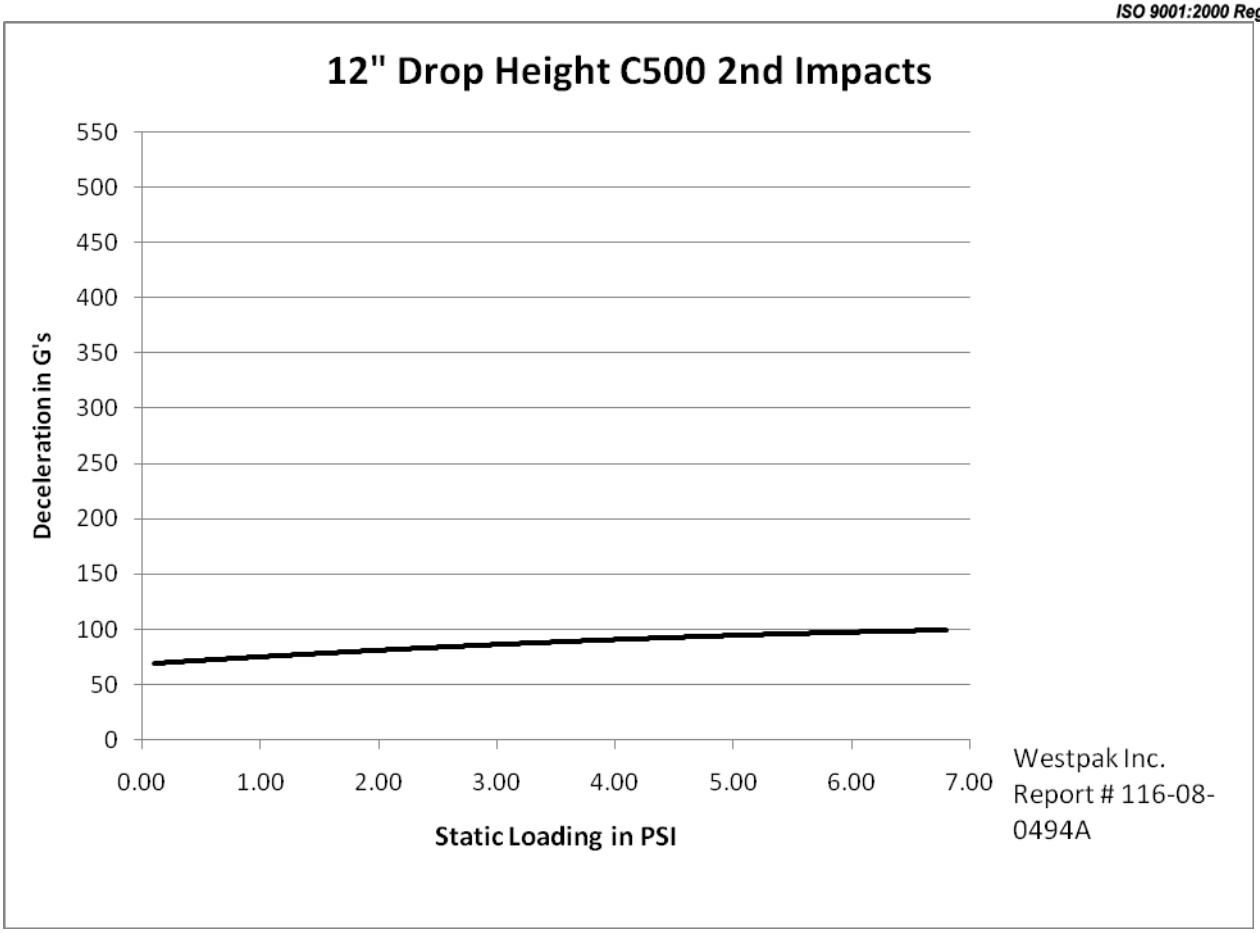
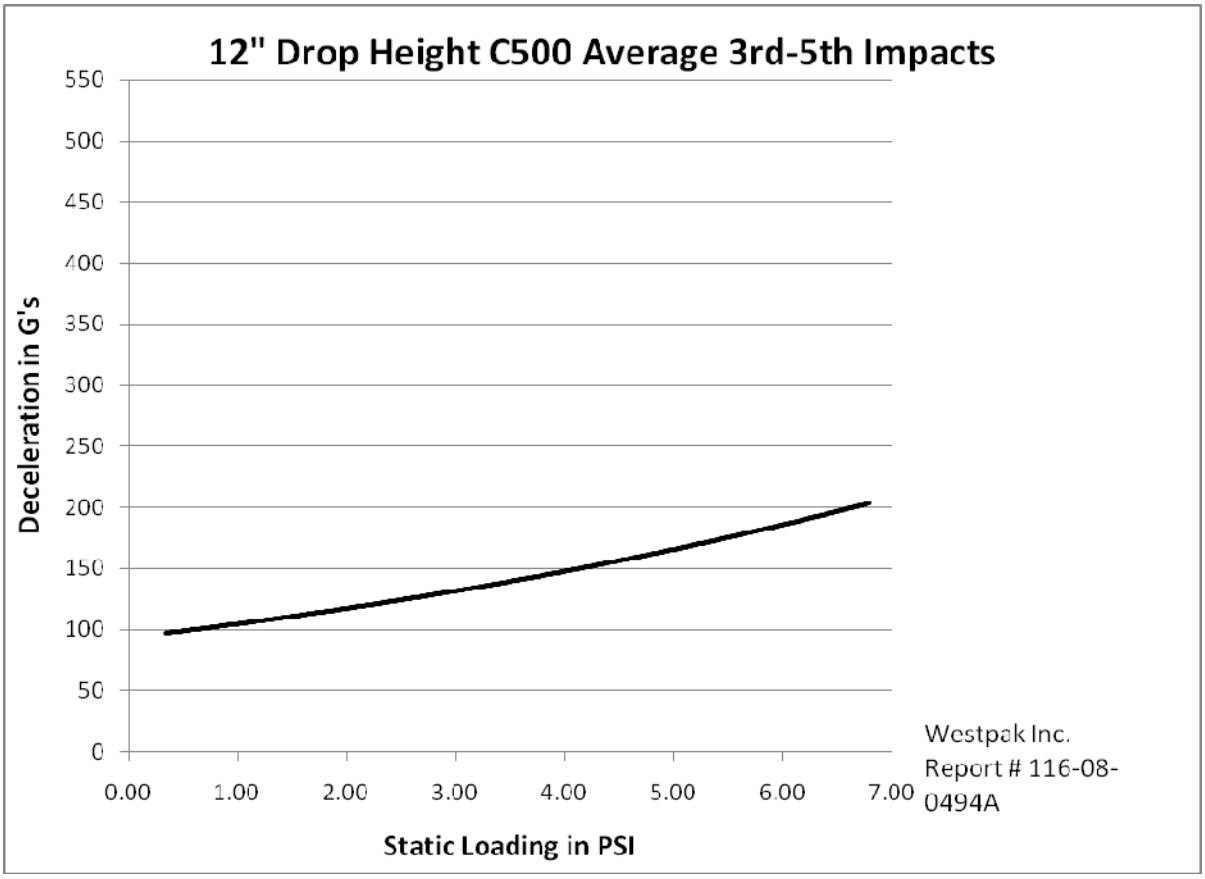

12" Drop Height C500 2nd Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc.
Report # 116-08-0494A


12" Drop Height C500 Average 3rd-5th Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
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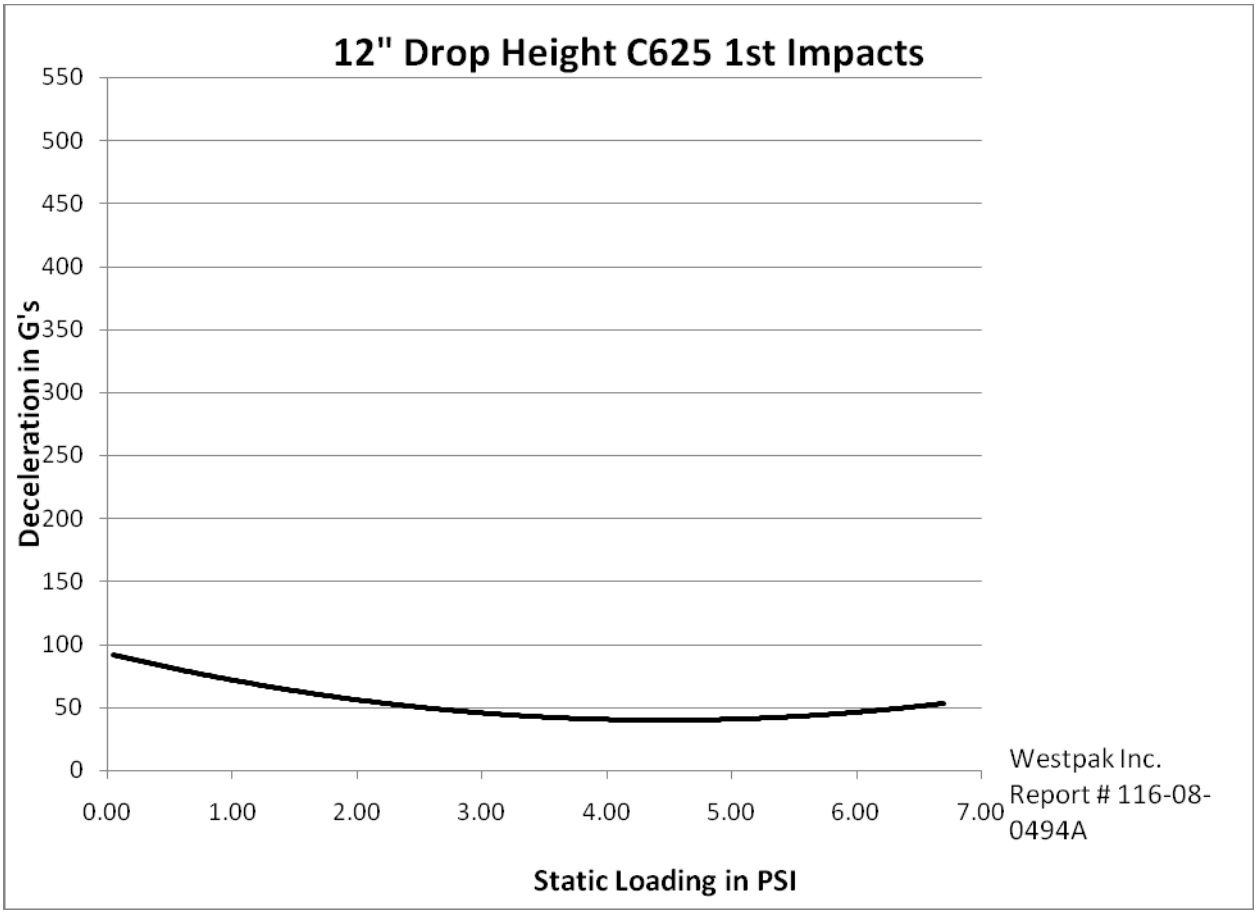
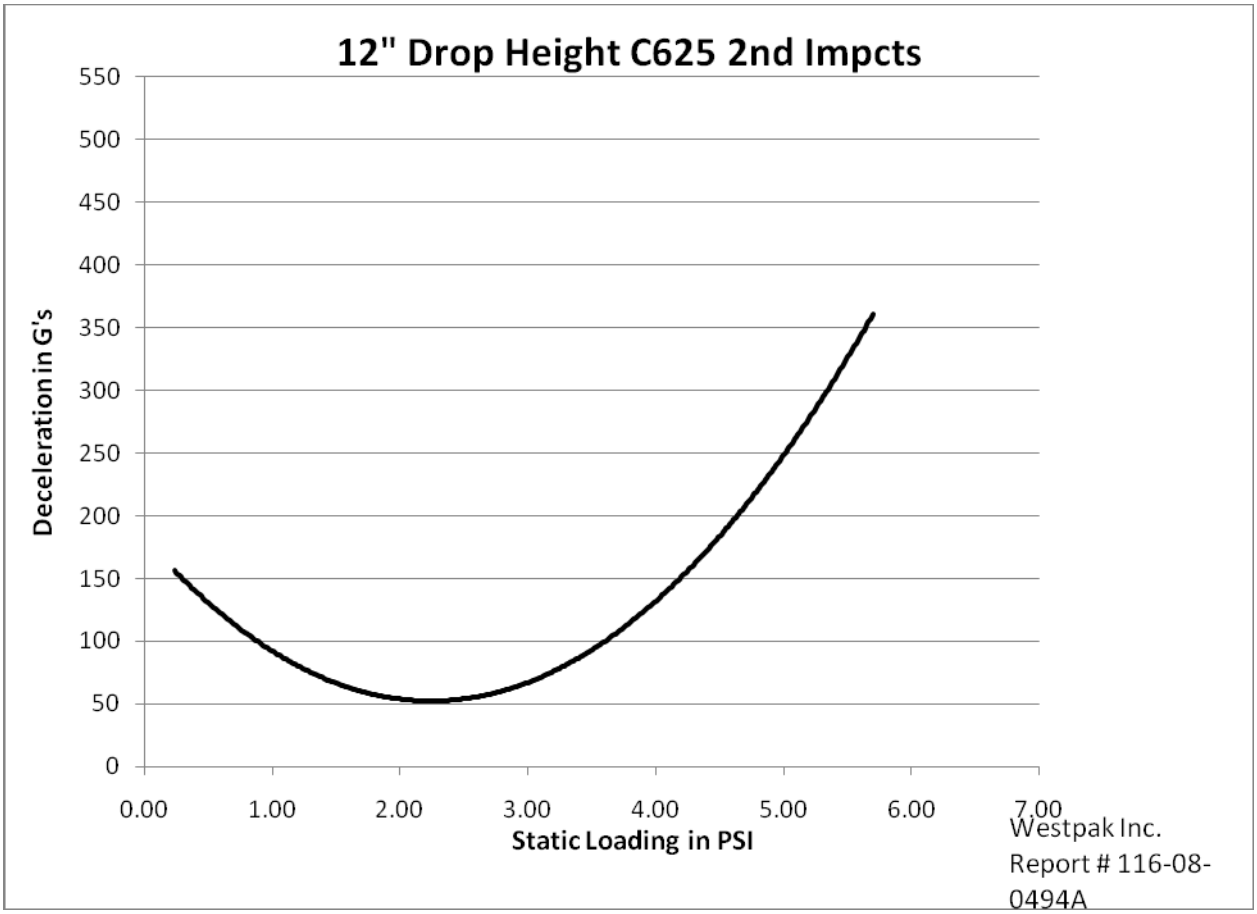
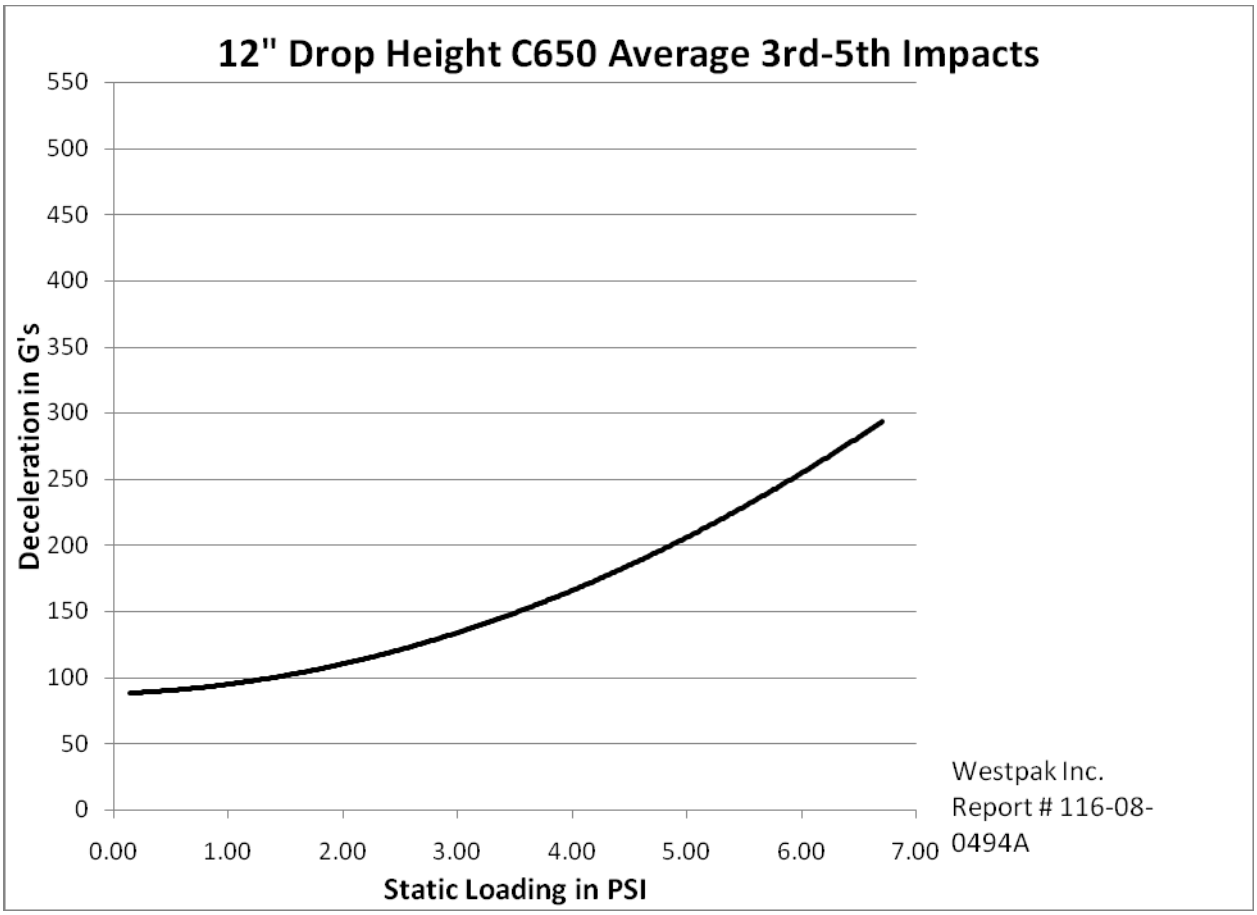
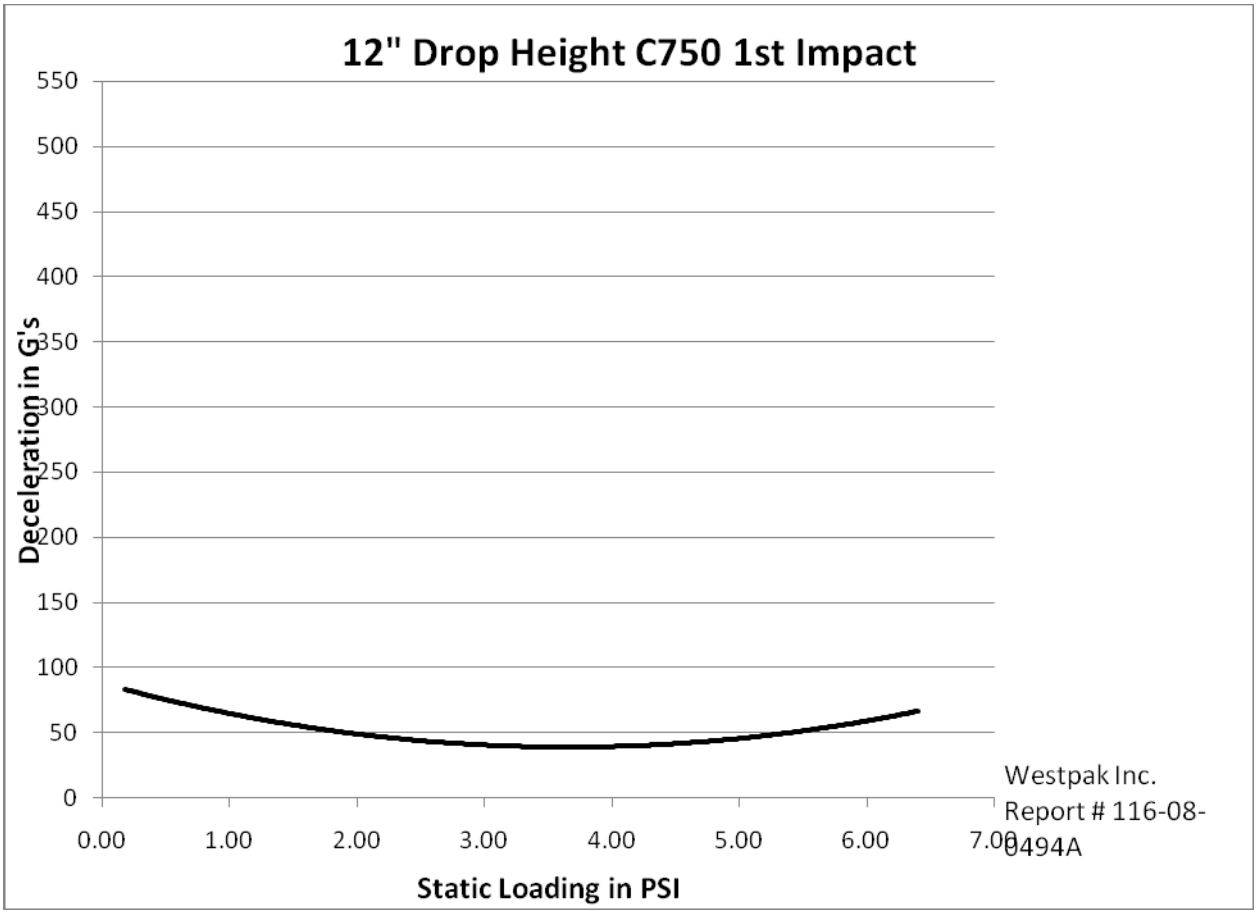
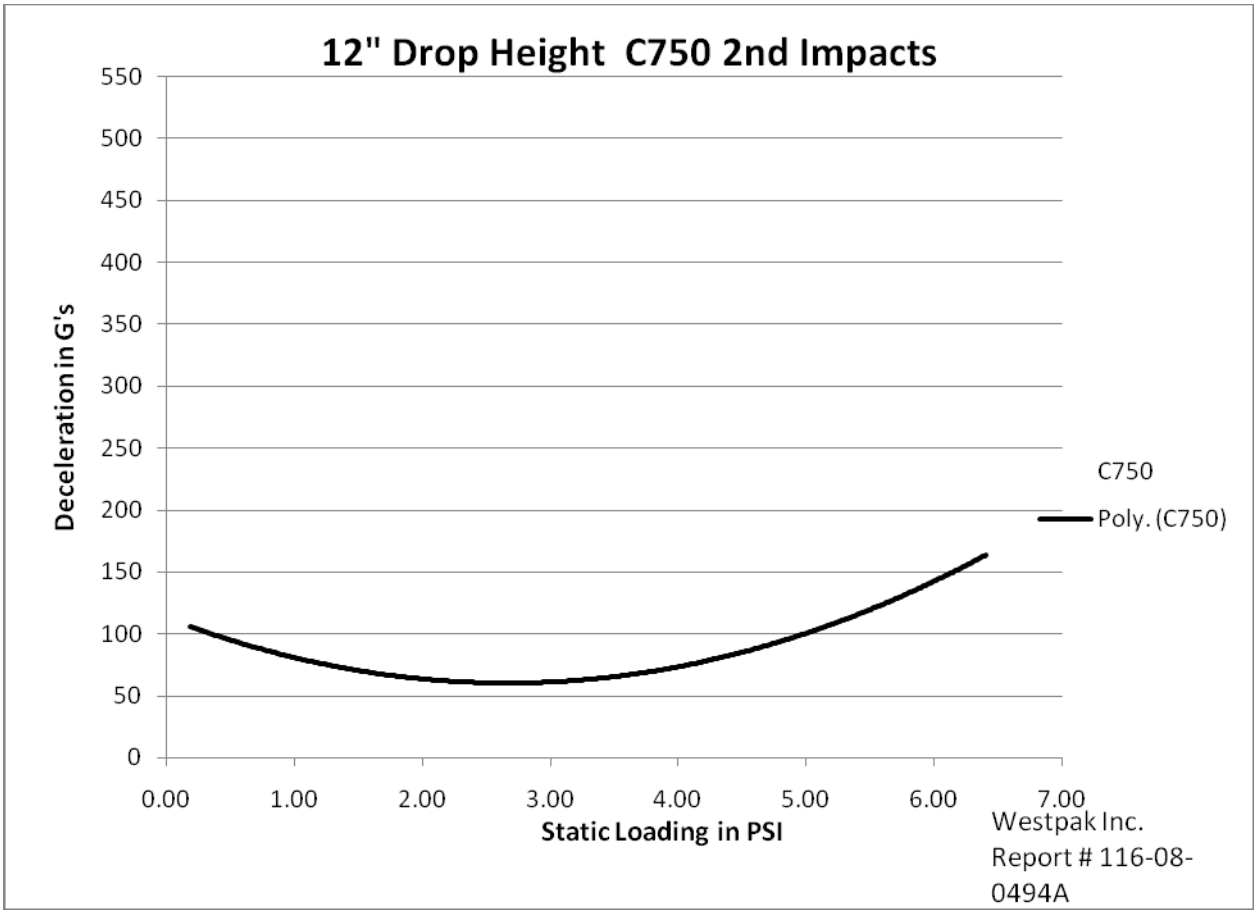
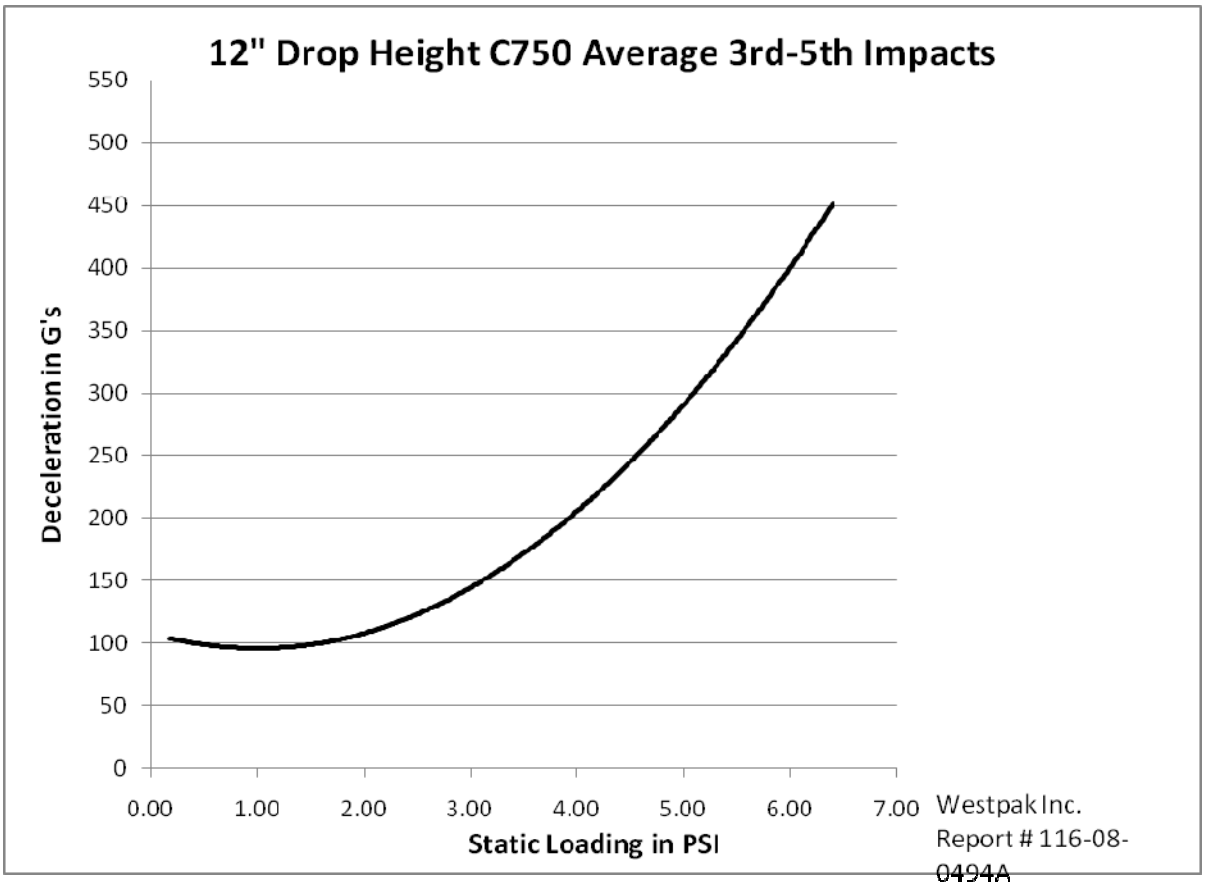

12" Drop Height C625 1st Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc.
Report # 116-08-0494A

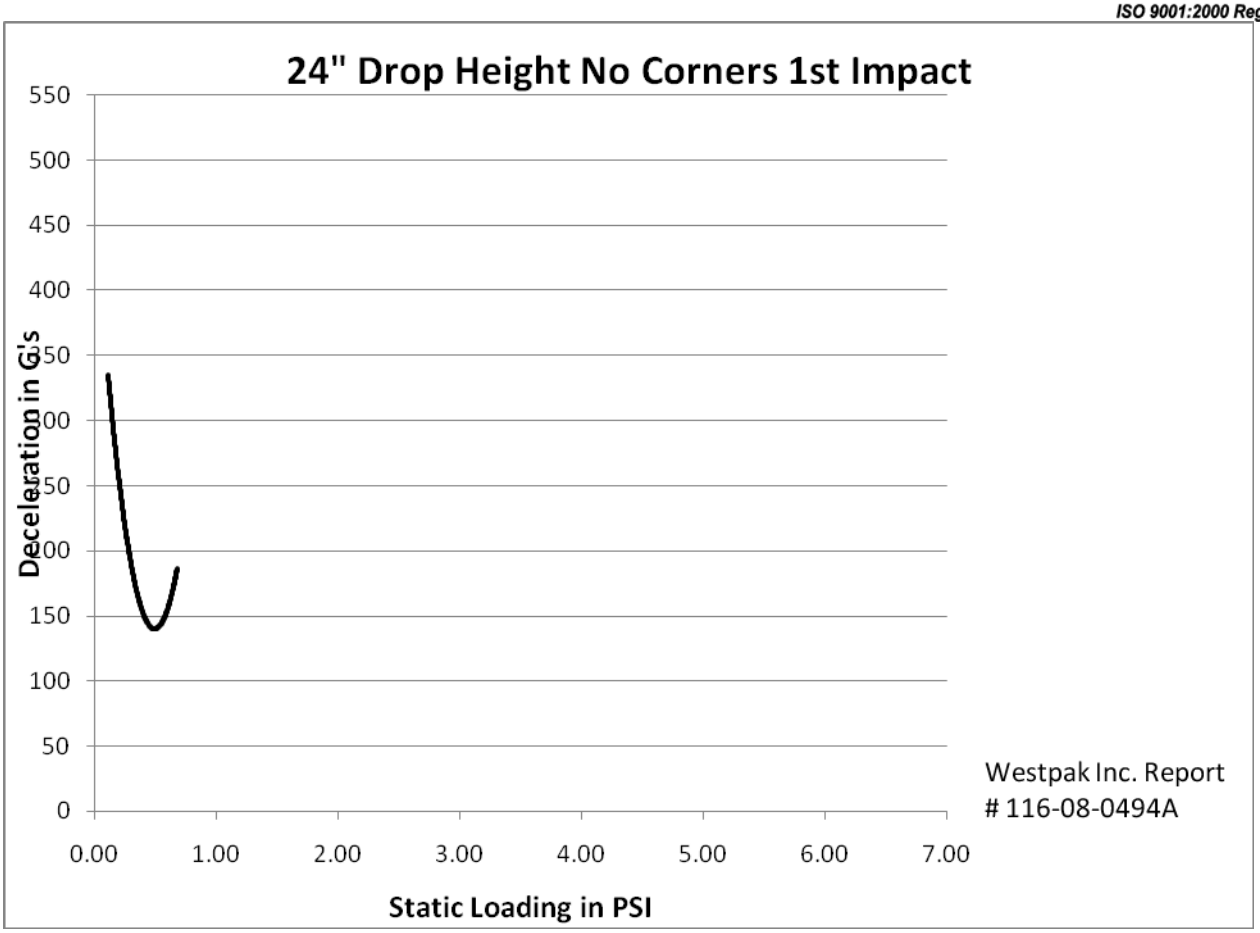

12" Drop Height C625 2nd Impcts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc.
Report # 116-08-0494A

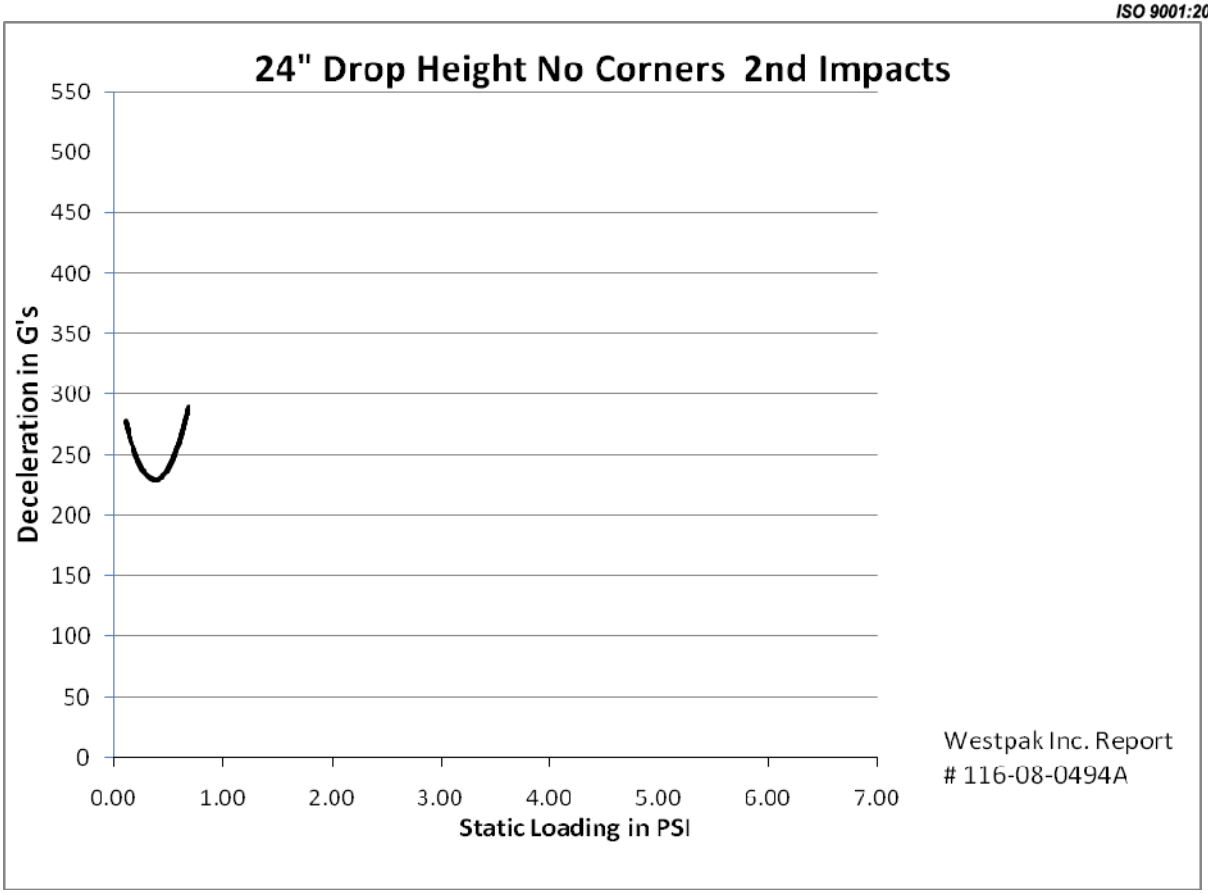

12" Drop Height C650 Average 3rd-5th Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc.
Report # 116-08-0494A

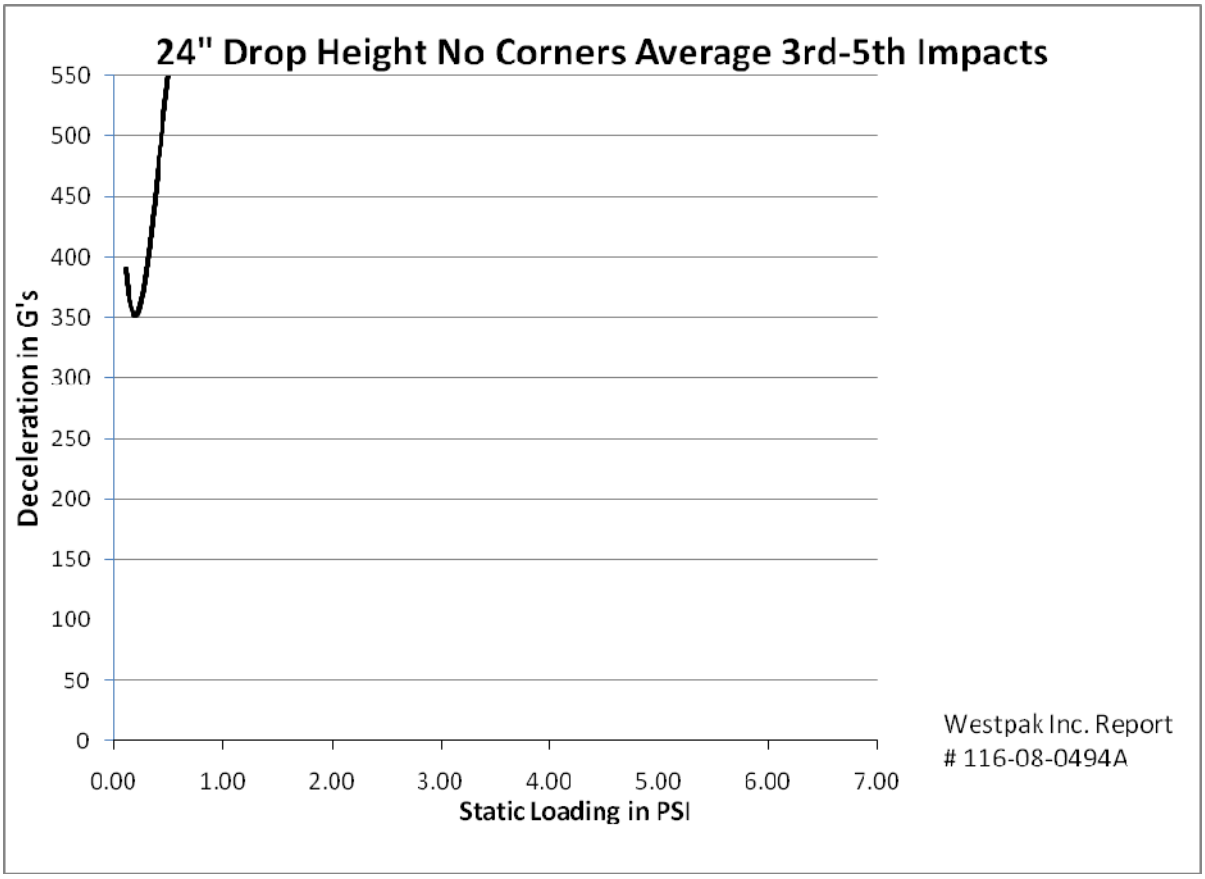

12" Drop Height C750 1st Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc.
Report # 116-08-0494A

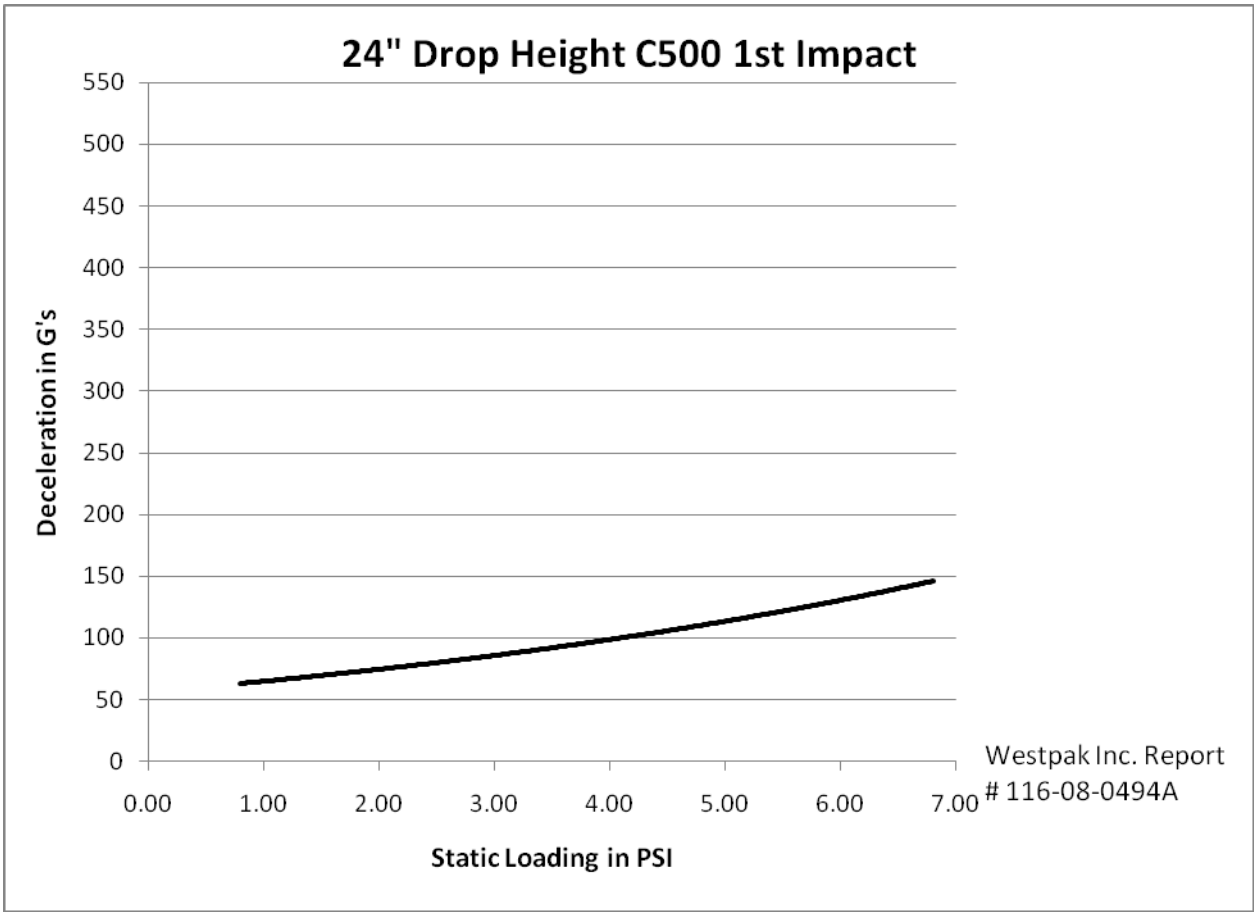

12" Drop Height C750 2nd Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
C750
Poly. (C750)
Westpak Inc.
Report # 116-08-0494A

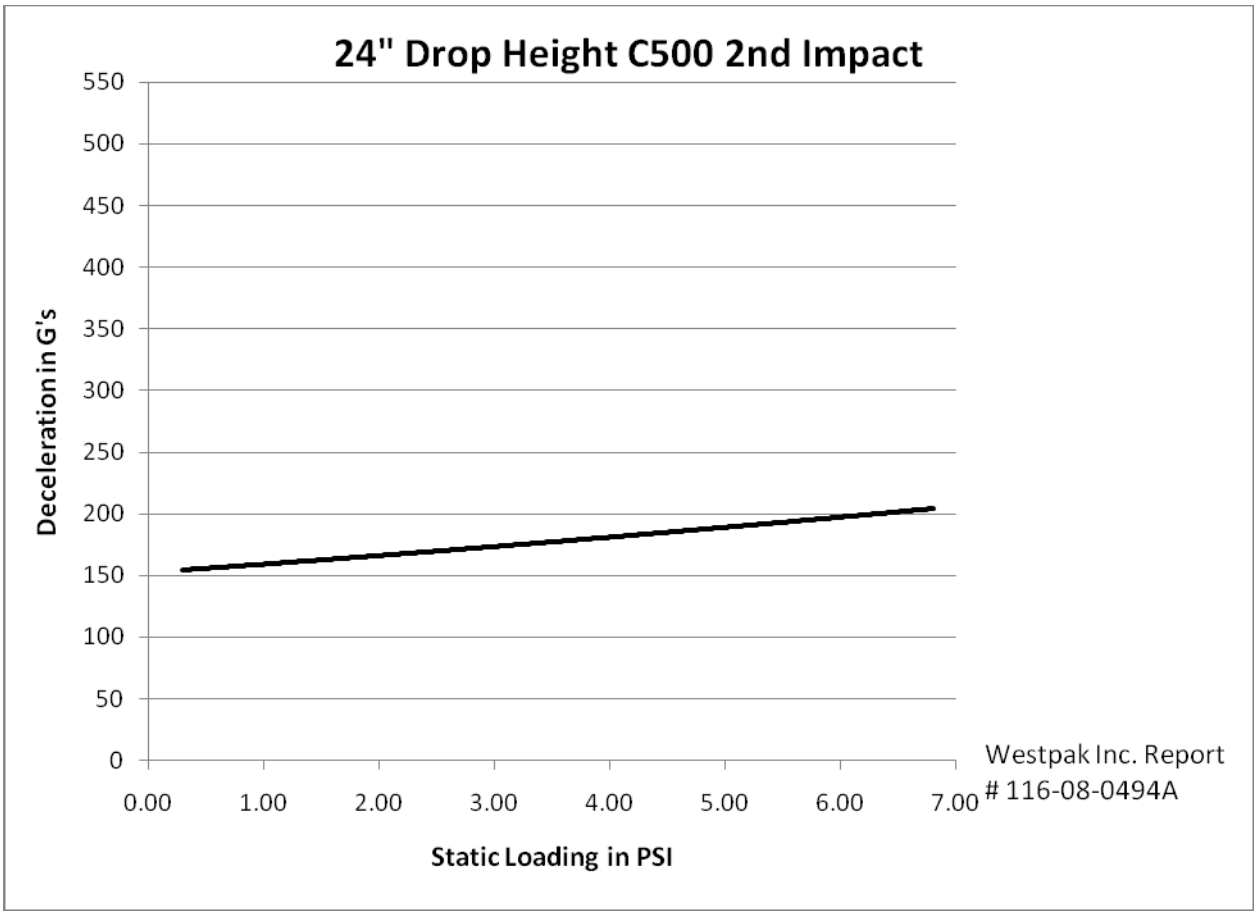

12" Drop Height C750 Average 3rd-5th Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc.
Report # 116-08-0494A

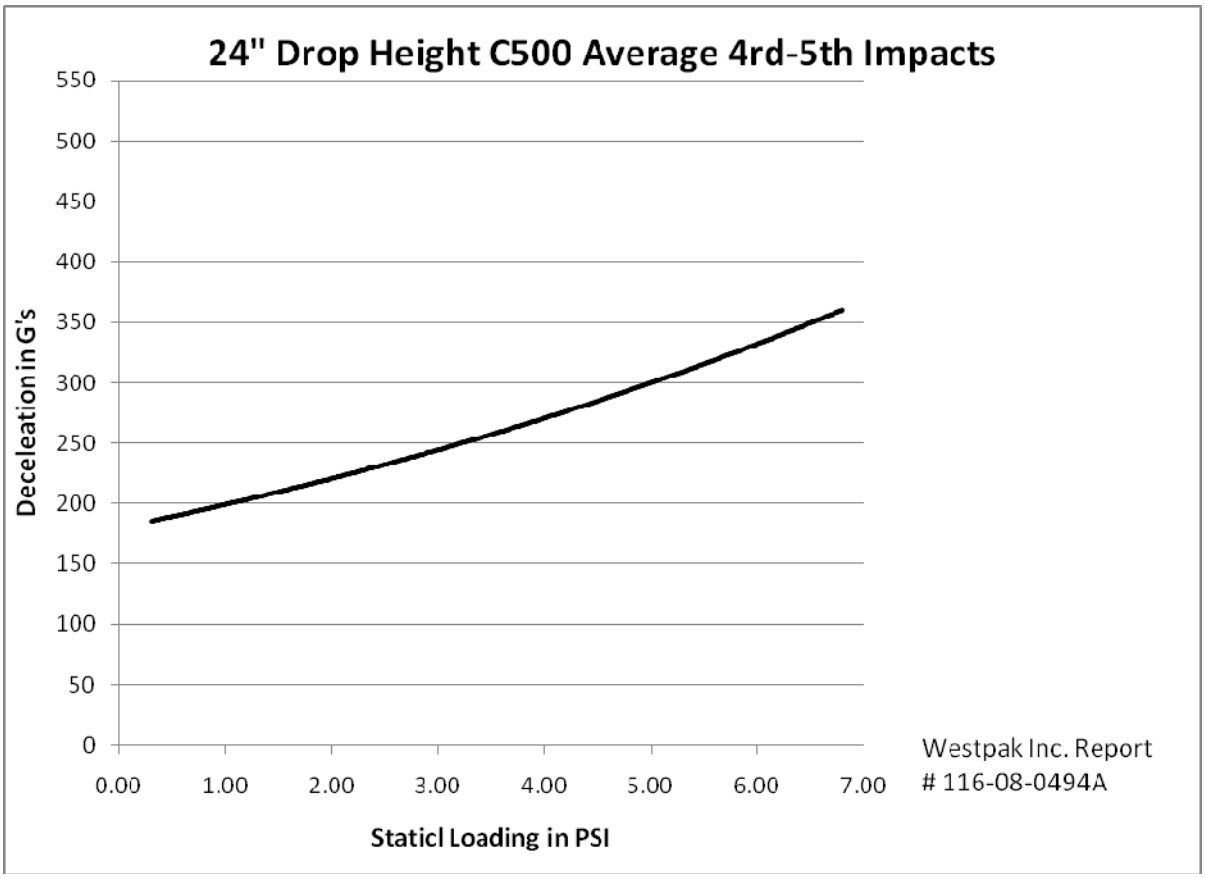

24" Drop Height No Corners 1st Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A

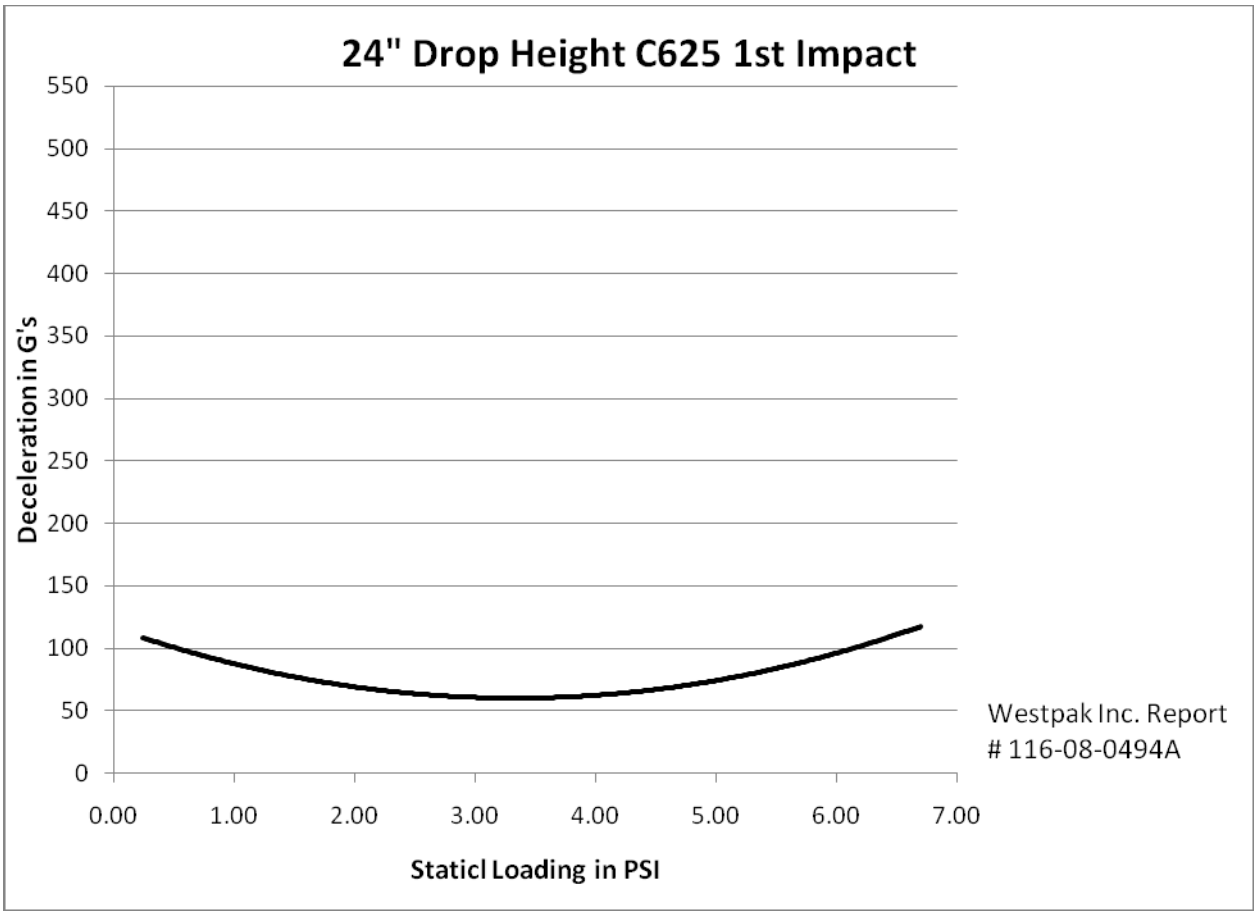

24" Drop Height No Corners 2nd Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A

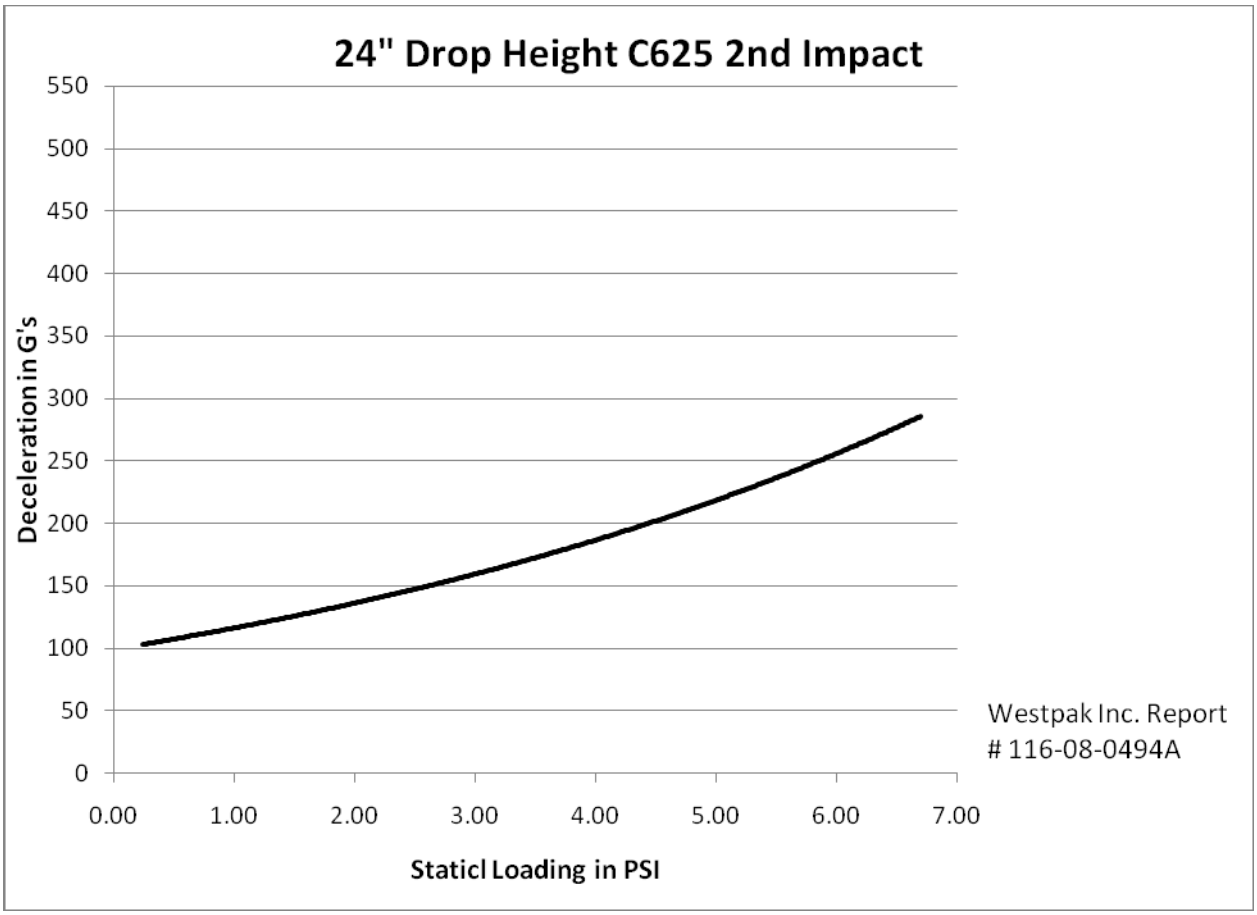

24" Drop Height No Corners Average 3rd-5th Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A

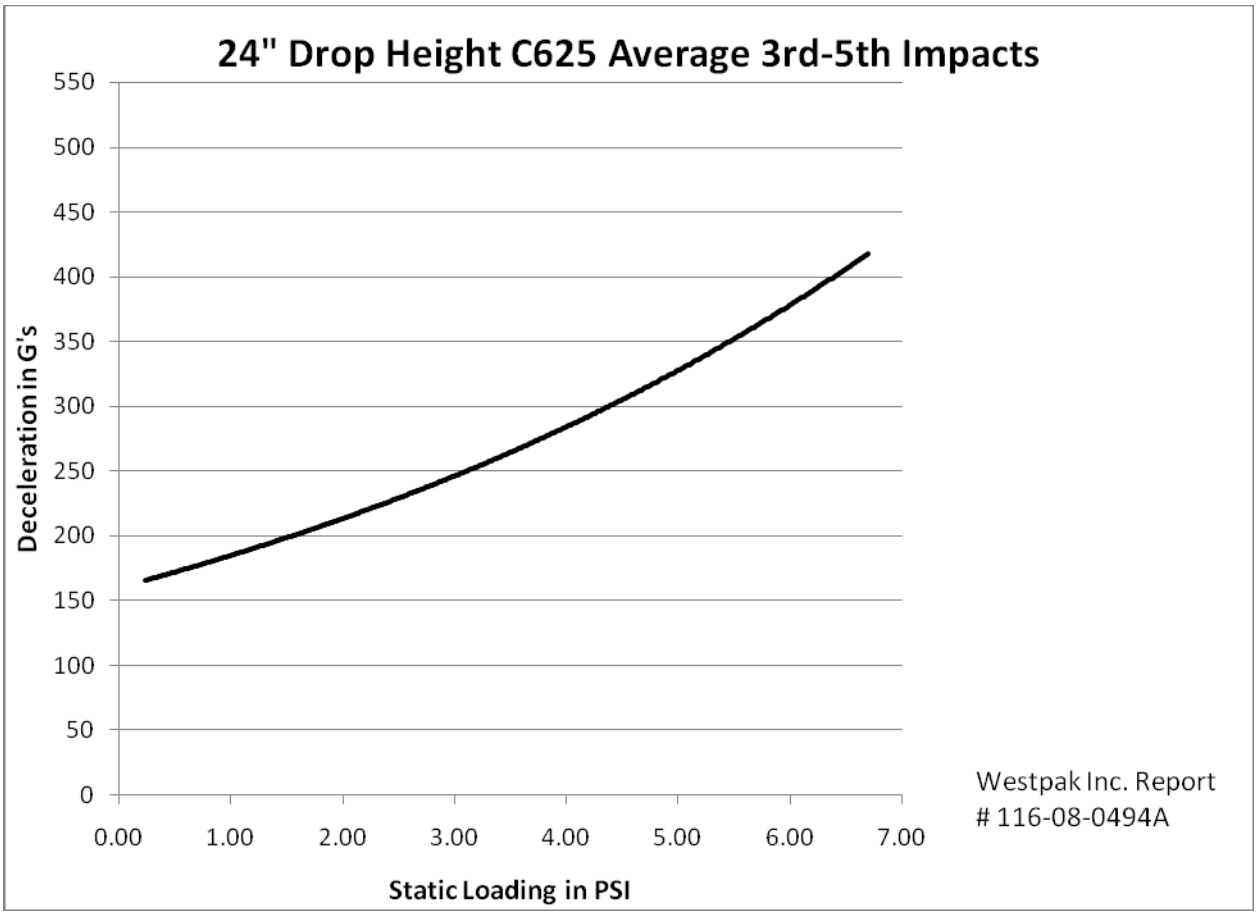

24" Drop Height C500 1st Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A

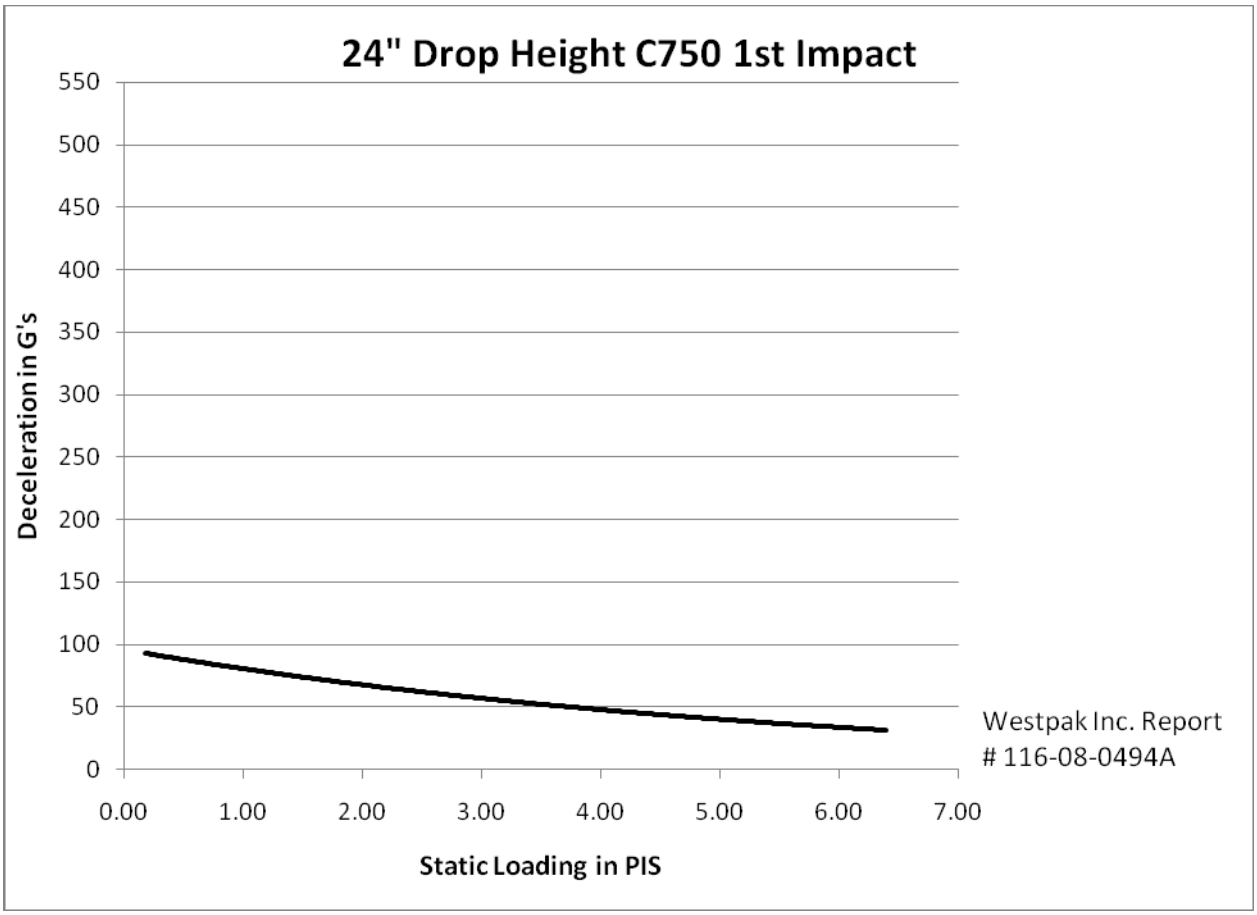

24" Drop Height C500 2nd Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A

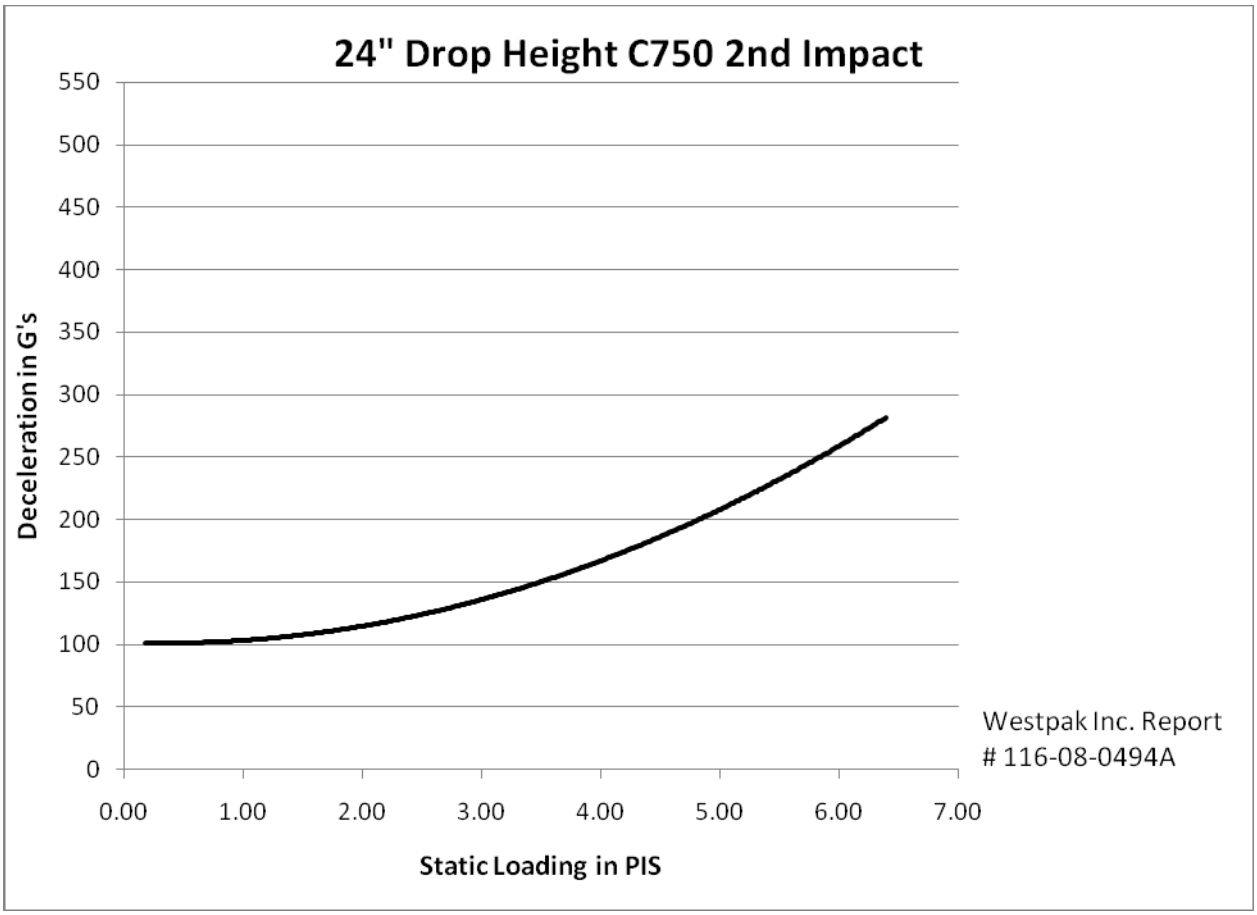

24" Drop Height C500 Average 4rd-5th Impacts
Deceleation in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Staticl Loading in PSI
Westpak Inc. Report
116-08-0494A

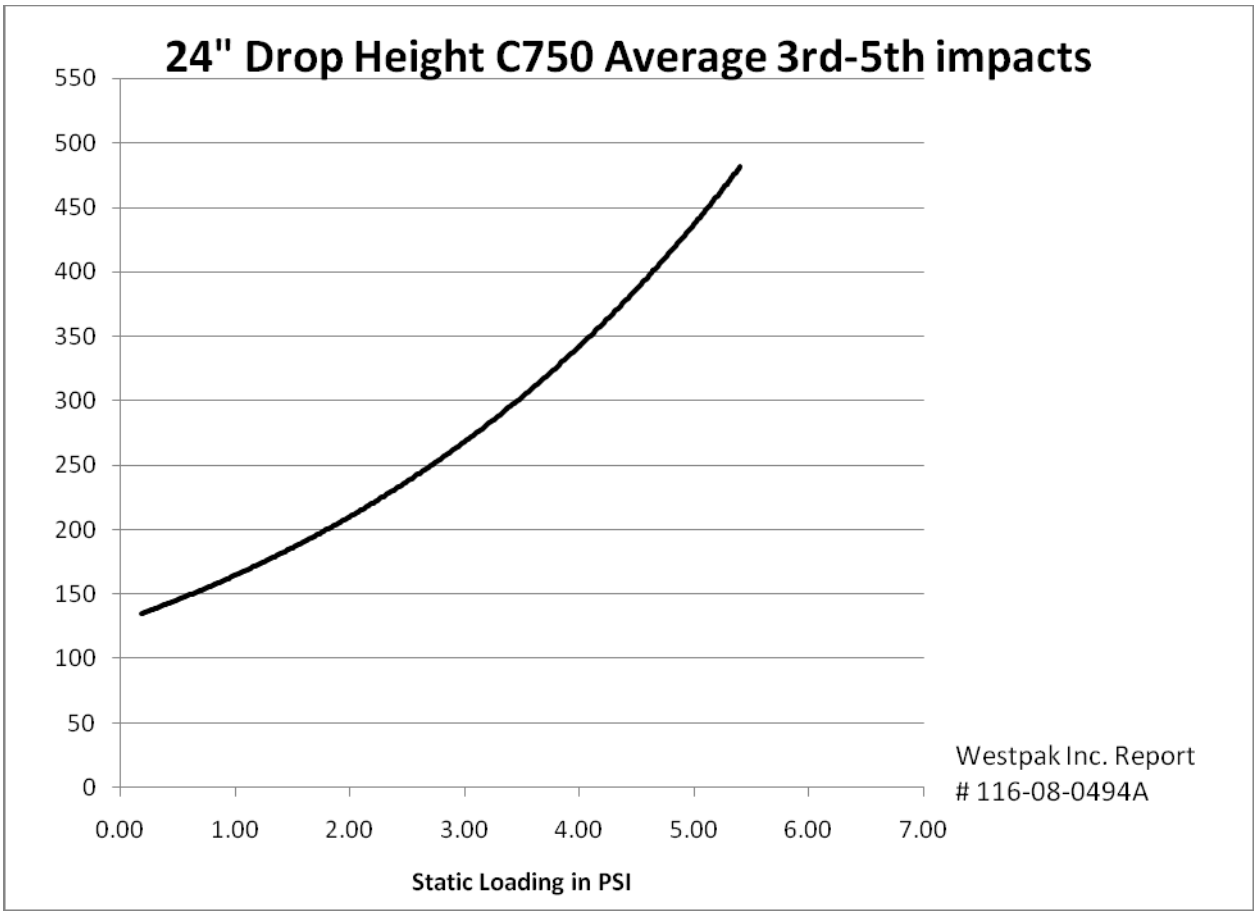

24" Drop Height C625 1st Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Staticl Loading in PSI
Westpak Inc. Report
116-08-0494A


24" Drop Height C625 2nd Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Staticl Loading in PSI
Westpak Inc. Report
116-08-0494A


24" Drop Height C625 Average 3rd-5th Impacts
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A


24" Drop Height C750 1st Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PIS
Westpak Inc. Report
116-08-0494A


24" Drop Height C750 2nd Impact
Deceleration in G's
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PIS
Westpak Inc. Report
116-08-0494A


24" Drop Height C750 Average 3rd-5th impacts
550
500
450
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Static Loading in PSI
Westpak Inc. Report
116-08-0494A