

1.2.2008 FINAL



Introduction:

360° Mechanical has been retained to independently test, analyze, and compare 3-competing types of loose fill packaging.

Supplied to 360° Mechanical:

Three loose fill packaging peanut types (pictured at right):

- Grain Protein (Puffy Stuff)
- Starch Corn
- Extruded Polystyrene (EPS)

What follows are the **findings** from our Independent testing and analysis of these competing void fillers.



Compression Testing

A customized test jig with discrete weight step sizes and standardized deflection measurement was used to measure the packing material in identical 7" x 9" x 7" boxes.



Each open top box of packing material is incrementally loaded with weight to 60 pounds. As each weight is added, the deflection of the top of the layer was measured. (relative to the inside bottom)

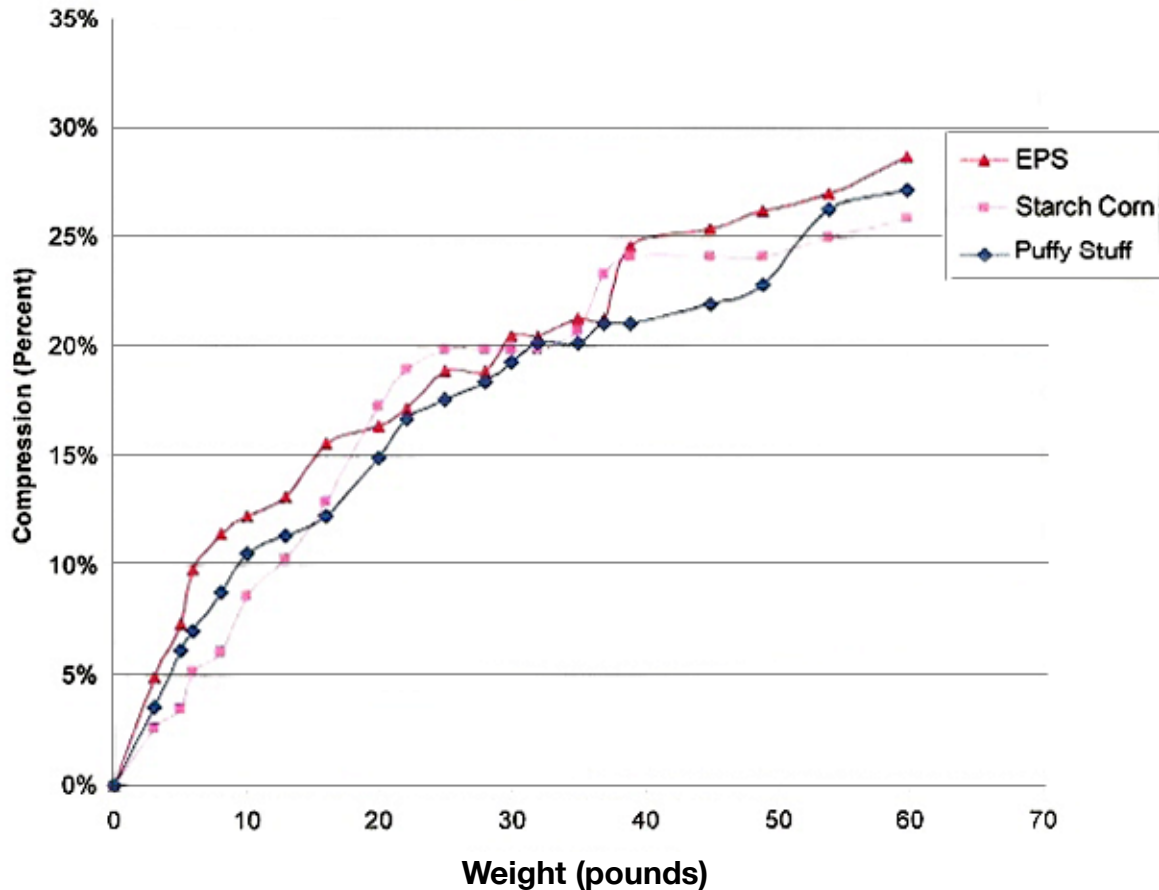
Once the deflection information from each packing material type was collected; the data was subtracted from the initial height to give a deflection for each material type. Finally, the data was normalized to give a percentage deflection.



Image of Puffy Stuff 100% Biodegradable Packing Peanuts

Weight (lbs)	Compression (inches)		
	Puffy Stuff	Starch Corn	EPS
0	0.0%	0.0%	0.0%
3	3.5%	2.6%	4.9%
5	6.1%	3.4%	7.4%
6	7.0%	5.2%	9.8%
8	8.8%	6.0%	11.5%
10	10.5%	8.6%	12.3%
13	11.4%	10.3%	13.1%
16	12.3%	12.9%	15.6%
20	14.9%	17.2%	16.4%
22	16.7%	19.0%	17.2%
25	17.5%	19.8%	18.9%
28	18.4%	19.8%	18.9%
30	19.3%	19.8%	20.5%
32	20.2%	19.8%	20.5%
35	20.2%	20.7%	21.3%
37	21.1%	23.3%	21.3%
39	21.1%	24.1%	24.6%
45	21.9%	24.1%	25.4%
49	22.8%	24.1%	26.2%
54	26.3%	25.0%	27.0%
60	27.2%	25.9%	28.7%

Packing Compression



Some weight loadings appear to have no change (near 30-35 pounds), then suddenly jump to a higher deflection (near 35 pounds). Static Friction (the internal friction between individual packing materials) is likely the cause behind this finding. Once a higher force is applied, the individual pieces settle.

Post Compression Measures

- 1) After weights were removed from each packing material, the natural height that the material “rebounded” to was measured.
- 2) Additionally, the packing material was placed into a compacting mechanism applying roughly 1-ton compacting force. The value measured is after the load was removed.

Parameter Description	Puffy Stuff	Starch Corn	EPS
Weight removed and natural return after 10 minutes	13.2%	9.5%	9.0%
Compactor	12.2%	NA ¹	12.8%

Note that the packing material was undamaged (neither broken nor crushed) after all compression tests had completed.

¹There was not sufficient volume of Starch Corn packing material for this test

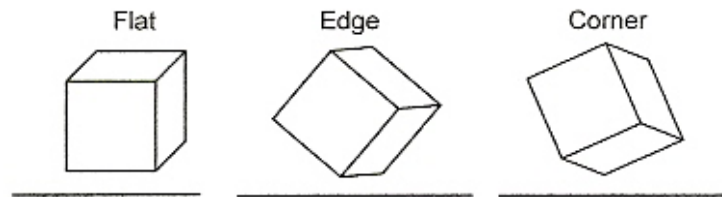
Drop Testing

A fixed weight (5 pounds) was placed in the middle of each identical 7" x 9" x 7" cardboard box containing one of three packaging materials (Puffy Stuff, Starch Corn, or Extruded Polystyrene). The packing material and boxes are reused from the previous compression testing. Three (3) shock trip sensors are attached to the padded weight. Each sensor has a fixed trip indication that measures if the rated G-force has been exceeded (Red 50G, Orange 75G, and Green 100G). Each package is then dropped from 2 feet, 4 feet, and 6 feet (unless noted otherwise).



The U.S. Code of Federal Regulations (CFR), Title 49 "Transportation", Part 178 "Specifications for Packaging", Section 603 "Drop Tests", was used as a test guide the packages for the drop tests.² Accordingly, prepared packages were dropped three times representing three different orientations (flat, edge, and corner).

Each package was dropped flat against a bare concrete floor. Next, the package is dropped on its edge on the bare concrete floor. Finally, the package is dropped on its corner on the bare concrete floor. The sensors area inspected after every drop. After each orientation is tested, then the package is elevated to the next drop height.



Note: All drops were conducted flat, then edge, then corner for each elevation. **Bolded** values in the data tables indicated that the test caused a particular sensor to trip. The sensors were not replaced unless noted otherwise.

Puffy Stuff Results

Drop Height	Flat			Edge			Corner		
2 feet	50G	75G	100G	50G	75G	100G	50G	75G	100G
4 feet	50G	75G	100G	50G	75G	100G	50G	75G	100G
6 feet	50G	75G	100G	50G	75G	100G	50G	75G	100G

The 50G sensor first tripped at 4 feet elevation in the flat orientation. The sensor remains tripped throughout the rest of the testing. The 75G sensor first tripped at the 6 feet elevation in the edge orientation and remains tripped throughout the rest of testing. Finally, the 100G sensor trips in the last drop from 6 feet elevation in the corner orientation.

² The referenced code section is intended for the qualification of crates and other hazardous material packaging. This testing does not qualify the packaging for the transport of hazardous material.

Starch Corn Results

Drop Height	Flat			Edge			Corner		
2 feet	50G	75G	100G	50G	75G	100G	50G	75G	100G
4 feet	50G ³	75G ⁴	100G ⁵	50G	75G	100G	50G	75G	100G
6 feet	50G	75G	100G	50G	75G	100G	50G ⁶	75G ⁷	100G ⁸

All three shock sensors tripped from the drop at 4 feet elevation in the flat orientation.



Extruded Polystyrene (EPS) Results:

Drop Height	Flat			Edge			Corner		
2 feet	50G	75G	100G	50G	75G	100G	50G	75G	100G
4 feet	50G	75G	100G ⁹	50G	75G	100G	50G	75G	100G
6 feet	50G ¹⁰	75G ¹¹	100G	50G	75G	100G	50G	75G	100G

The 50G and 100G shock sensors tripped from the drop at 4 feet elevation in the flat orientation. The 100G sensor was destroyed (glass tube was smashed).



³ Sensor was replaced to allow further testing.

⁴ Ibid.

⁵ Ibid.

⁶ The 50G sensor tripped again from the 4 foot elevation when dropped in the corner orientation and remained tripped throughout the remainder of the testing.

⁷ The 75G sensor tripped again from the 4 foot elevation when dropped in the corner orientation and remained tripped throughout the remainder of the testing.

⁸ The 100G sensor trips from the 6 feet elevation in the edge orientation. No further testing is performed after this second shock sensor trips.

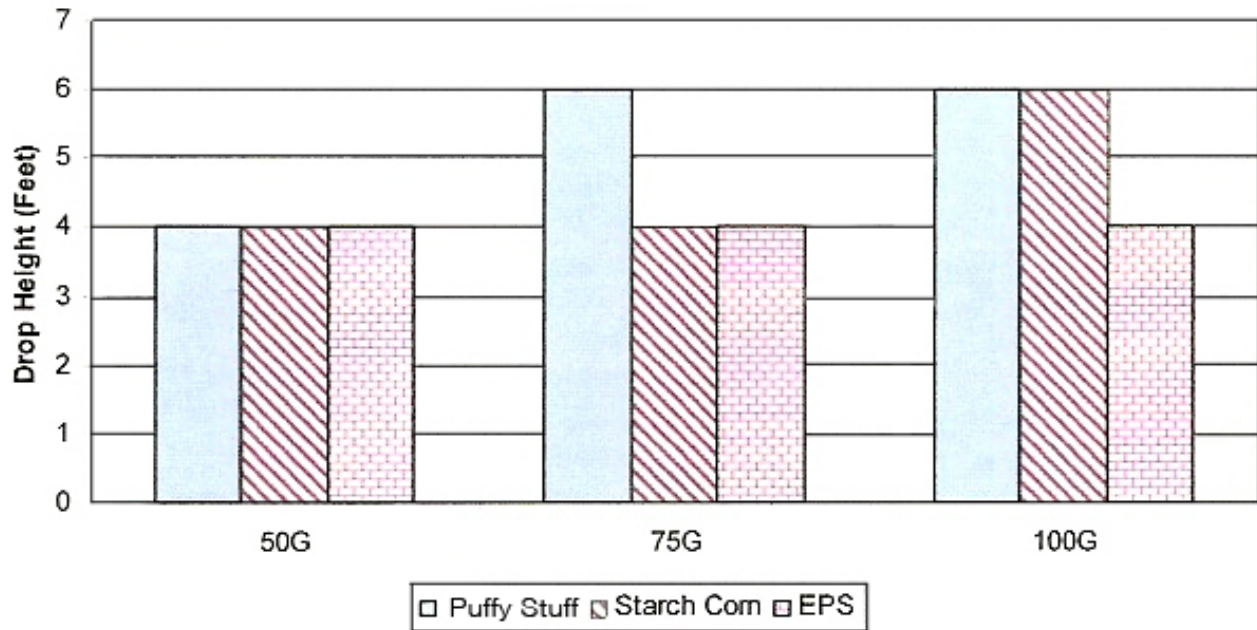
⁹ The 100G sensor was replaced to allow further testing, but again tripped from the 4 foot elevation when dropped in the edge orientation. Sensor not replaced for the remainder of testing.

¹⁰ The 50G sensor tripped from 4 feet elevation in the flat orientation and was not replaced.

¹¹ The 75G sensor tripped from 4 feet elevation in the corner orientation and was not replaced.

Drop Test Summary:

Drop Summary (All Orientations)



The graph above visualizes the drop data by displaying the shock value trip from each drop height for the tested packing materials.

The 50G shock sensor trips at the 4 foot drop regardless of the packing material used.

The 75G shock sensor trips at a greater height when using Puffy Stuff packing material.

The 100G shock sensor trips at greater heights with both Puffy Stuff and Starch Corn packing materials.

The Extruded Polystyrene (EPS) packing material suffers extreme shocks at the 4 foot drop.