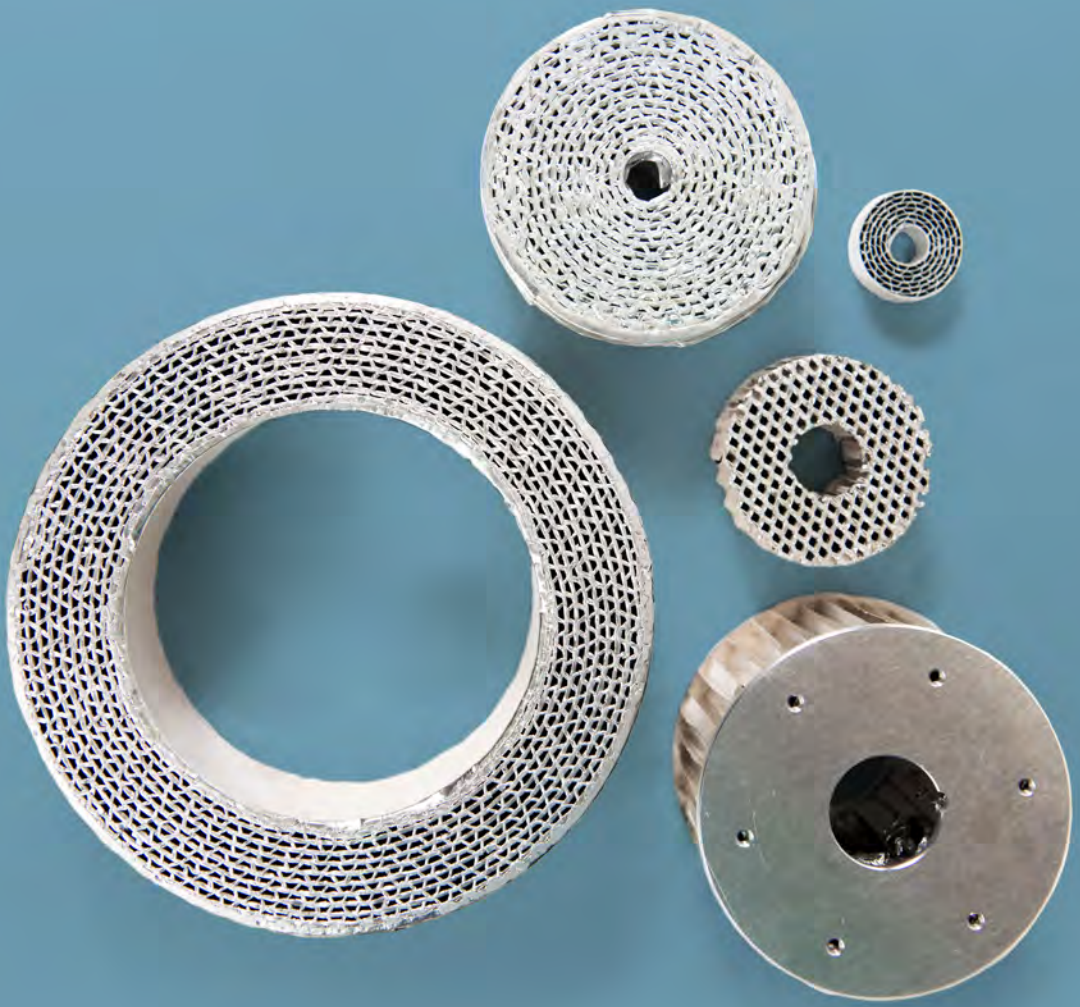
Engineered Honeycomb
Solutions and Services

Energy Absorption

A guide to kinetic energy management systems



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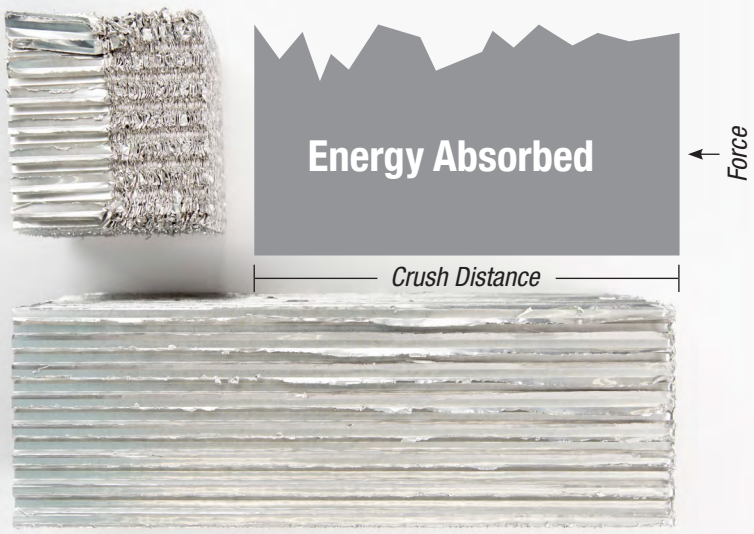
What's in this Guide

- What is an Energy Absorber?
- Energy Absorption Terminology
- Types of Plascore Energy Absorbers
- Example: Drop Protection
- Example: Damping

Applications

- Crash Test Dummy Calibration
- Impact Protection
- Large Mass Drop Protection
- Overrun Protection
- Nuclear Industry Compliance
- Aerospace
- Automotive
- Blast Mitigation

What is an Energy Absorber?



"The basic concept of energy absorption is to take a moving object's kinetic energy and convert it into internal work."

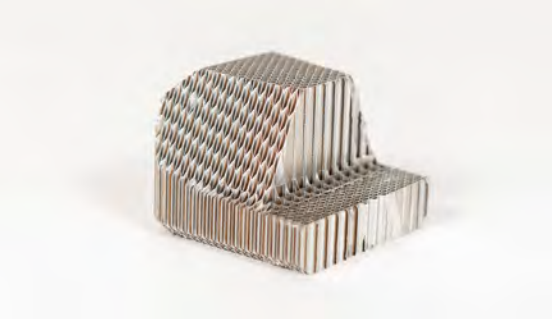
Before and after crushlite and AlTuCore assembly crushing

When a load is applied to the honeycomb it exhibits plastic deformation, in the form of crushing.

This deformation results in a constant force through the crushed thickness.

The work (Force x Distance) done by the energy absorber defines how much kinetic energy the system has absorbed.

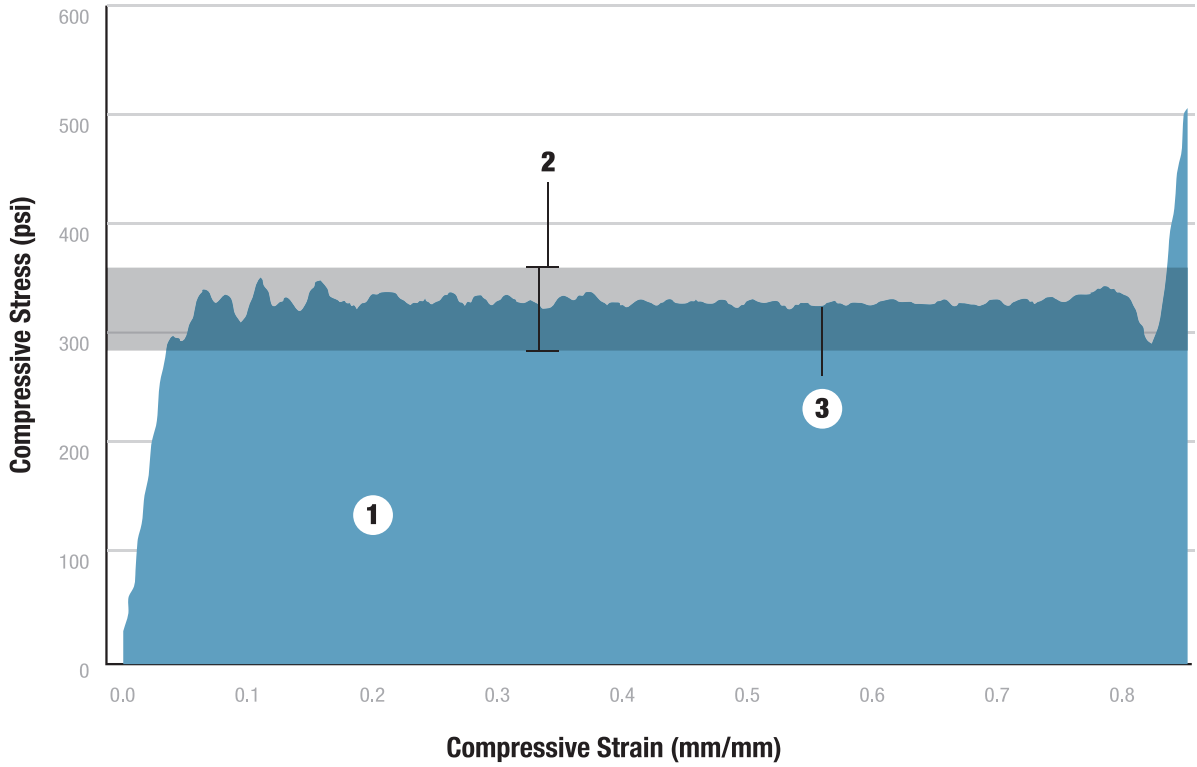
Bitzer T. (1997). *Honeycomb Technology Materials, Design, Manufacture, Applications and Testing*. Great Britain: Chapman & Hall.



Energy Absorption Terminology

Below is a sample graph (using data from pre-crushed 320 PSI Crush Core) that explains the basic terminology of Plascore's energy absorbers.

320 PSI Crush Core (Pre-crushed)

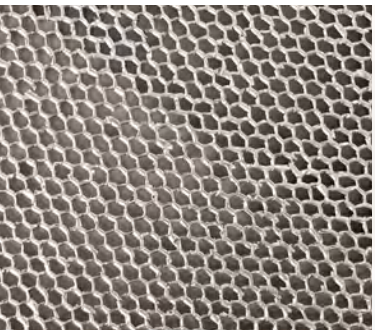


1. **Kinetic Energy Absorbed:** Defined as the work (force x distance) done.
2. **Crush Strength Tolerance:** The acceptable range the average crush strength can be.
3. **Crush Strength:** Defined in accordance to ASTM D7336 as the average compressive stress during the core's stable crush strength region.
4. **Crush Stroke:** The length a part is crushed.
5. **Densification:** Occurs when all material has been fully crushed. Compressive stress will increase exponentially from that point forward.
6. **Pre-crush:** A procedure to eliminate peak bare compressive loading by initiating the crushing process on one side of the core.

Types of Plascore Energy Absorbers

Plascore manufactures two different materials that are ideal for energy absorption applications. The first of these is CrushLite, a lower density expanded aluminum honeycomb. The second is AlTuCore, a high-density corrugated material.

CrushLite



- Typically manufactured in 4′ x 8′ sheets
- Customer specified thicknesses
- Crush strengths ranging from 7.5 – 750 psi
- Tested per ASTM D7336
- Can be provided with or without pre-crush
- Typical thickness range: 1″ – 30″
- Minimum stroke of 70% of part thickness.

Standard* crush strength ranges:

Density	1.0	1.6	1.6	2.0	2.3	2.3	3.4	3.1	3.7	4.2
Cell Size	3/8	3/8	1/4	3/16	1/4	1/4	1/4	1/8	3/8	3/8
Foil Gauge	0.0007	0.001	0.0007	0.0007	0.001	0.001	0.0015	0.0007	0.0025	0.003
Foil Alloy	5052	5052	5056	5052	5052	5056	5052	5056	5052	5052
Crush Strength (psi)	25	45	50	75	90	100	140	170	180	210

Density	5.2	4.5	4.5	5.4	5.7	6.0	5.7	6.1	8.1	8.1
Cell Size	1/4	1/8	1/8	3/8	3/16	1/4	3/16	1/8	1/8	1/8
Foil Gauge	0.003	0.001	0.001	0.004	0.002	0.003	0.002	0.0015	0.002	FC
Foil Alloy	3003	5052	5056	5052	5052	5052	5056	5056	5052	5052
Crush Strength (psi)	245	275	320	350	380	420	440	535	700	750

*Alternative crush strengths available on our Crush Lite data sheet. Minimum order quantity may apply.

AlTuCore

- Cylindrical built to order energy absorber
- Customized ID and OD, based on customer's needs
- Test method similar to ASTM D7336
- Can be provided with or without pre-crush
- Typical thickness range: 0.30″ – 20″
- Custom crush strength ranges from ~1,000 psi to 8,000 psi
- Typical Stroke between 55% and 70% of part length, depending on density

Example: Drop Protection

The Problem: An engineer has been tasked with arresting a large tensioning weight used on an industrial conveyor belt. The tensioning weight poses a significant risk to equipment if it is allowed to plunge to the ground.

Knowns

Maximum Load on Support Structure	345,000 Kn
Usable Support Structure Width	1 meter
Usable Support Structure Length	1.1 meters
Maximum Drop Height	3 meters
Mass of Tension Weight	9,100

Unknowns

Required Crush Strength	TBD	psi or MPa
Required Material	TBD	CrushLite
Required Part Thickness	TBD	in or m

Step 1:

Determine required crush strength to maximize load distribution.

Maximum Crush Strength = Maximum Load / CrushLite Area

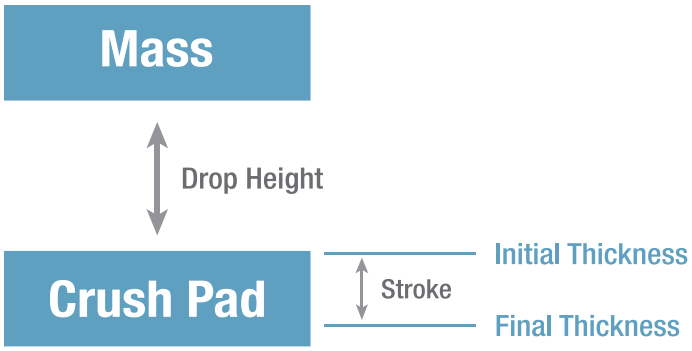
Crush Strength = 0.38 MPa, or 56 psi

Step 2:

Select a material.

Referencing Plascore's CrushLite data sheet:

PACL - 1.6 - 1/4 - 0.0007 - 5056 with a Crush Strength of 50 psi +/-10% would be a perfect fit.



Step 3:

Determine required part thickness:

Governing equation

Potential Energy (PE) = Work (W)

In this case:

PE = Mass x Gravity x (Drop Height + Stroke)

And

Work = Crush Strength x Area x Stroke

This results in the following equation:

Mass x Gravity x (Drop Height + Stroke) = Crush Strength x Area x Stroke

Solving the above equation for stroke:

Stroke = 0.92 m

Using this information and Plascore's advertised minimum stroke of 70%:

Part thickness = Stroke / Minimum Percent Stroke

Part thickness = 1.314 m of honeycomb

Step 4:

Request a quote from Plascore.

Example: Damping

The Problem: An engineer is designing an amusement park ride and has the responsibly of ensuring the safety of the occupants. In this case the engineer is designing for a catastrophic cart-to-cart impact, and needs to ensure that the occupants are able to safely walk away. Based upon the usable area, the AlTuCore OD and ID have been predefined.

Knowns

Maximum Allowed "G" Load	3 Gs
Cart Mass	2,000 Kg
AlTuCore Outside Diameter	0.1 meters
AlTuCore Inside Diameter	0.025 meters
Worst-Case Cart Velocity	4 m/s

Unknowns

Required Stroke	TBD	inches or meters
Part Length Required for Safe Deceleration	TBD	inches or meters
Required Part Thickness	TBD	inches or meters
Crush Strength	TBD	psi

Step 1:

Determine the required part length to achieve safe deceleration. First, we have to determine the required stroke.

"G" Load = $(\text{Velocity})^2$ / (2 x Gravity x Stroke)

Solving for stroke

Stroke = 0.272 meters or 10.70 inches

Now we can use this information along with minimum available stroke of 55% to determine the required part length.

Part length = Stroke/Expected Percent Stroke

Part length = 0.494 meters or 19.458 inches

Step 2:

Determine the required crush strength.

Governing equation

Kinetic Energy = Work

in this case:

Kinetic Energy = ½ x Mass x Velocity^2

And

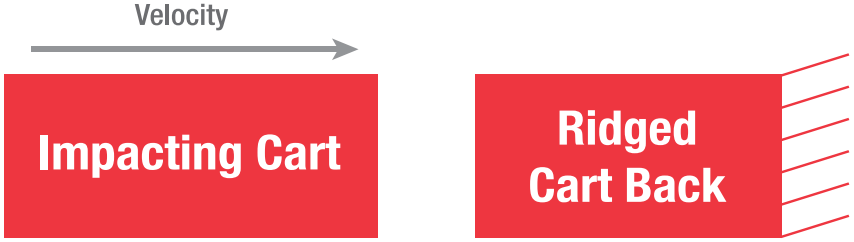
Work = Crush Strength x Area x Stroke

We arrive at the equation:

½ x Mass x Velocity^2 = Crush Strength x Area x Stroke

Solving for crush strength:

Crush Strength = 8.0 MPa or 1159 psi



Step 3:

Request a quote for AlTuCore from Plascore.