# Proper Performance Data Ease the Task of Specifying Cushioning Materials

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## Introduction

With the wide range of damping and cushioning materials available today, selecting the one best-suited to a particular shock- or vibration-control application involves examining a broad—and potentially confusing—spectrum of physical and performance properties.

It is a common misconception that the softer a material feels, the better it absorbs shock or cushions an impact. In reality, a product's subjective feel provides little, if any, information needed to select the proper material grade and energy-absorption properties.

A cushioning material performs its fundamental role—reducing the forces created when one surface comes abruptly into contact with another—by compressing or deforming in such a way as to produce a gradual, rather than instantaneous, change in velocity. This reduces potentially high decelerations to more moderate values and thereby minimizes damaging impact forces.

## Quick recovery vs. slow

Typical cushioning materials are foams, in various densities and thicknesses, and solid elastomers. These materials differ not only in their relative stiffnesses—foams are almost universally softer, or more compressible, than solids—but also in their "recovery" behavior during and after an impact.

Quick-recovery materials will return to their original height immediately upon removal of a compressional load. Being highly resilient, they also return a fairly high percentage of the stored compressional energy in the process.

These high-rebound materials include natural rubber, sponge rubber foams, neoprenes and some types of urethane products. Materials of this type are used in applications requiring a combination of cushioning and resilience, such as shoe inserts, gaskets and constant-load contact switches.

Slow-recovery materials do not instantaneously recover their full thickness and therefore do not return stored energy. This low resilience makes them desirable for applications requiring low rebound and high energy absorption, or damping.

Slow-recovering foams conform gradually to static loads while retaining a natural resistance to overcompression, or bottoming out, during higher, short-duration dynamic loading. This performance characteristic proves advantageous in applications such as transportation seating, and medical, athletic and orthotic products.

In addition, due to the nature of their polymer chemistry, slow-recovery foams often exhibit a degree of temperature sensitivity, softening as temperatures rise. Particularly useful in medical applications, this temperature-softening behavior provides a desirable softer zone adjacent to the skin, supported by a stiffer region away from the skin.

## Data for materials selection

In general, shock-cushioning materials are selected by matching material firmness, or load/compression behavior, to impact severity. Material firmness is often represented by graphical display of compression force deflection (CFD), which indicates the resistance to compression (lbs. force of static load) at a given deflection (% compression).

CFD data prove most useful when evaluating quick-recovery materials. CFD values increase as both firmness and compression percentage increase. Such information can be used in engineering calculations to determine a product's behavior under various loadings.

A similar test method, used almost exclusively for slow-recovery foam materials, provides indentation load deflection (ILD) values for a material, which indicate its compression resistance *after* it has been allowed to adjust to the applied load. ILD and CFD values usually are interchangeable only when evaluating quick-recovery materials, and when tested with the same apparatus.

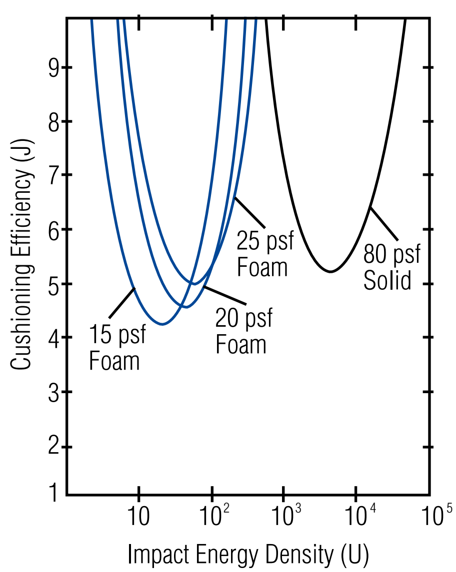

*Figure 1*

Perhaps the most direct method for selecting an impact-cushioning material is the use of cushioning efficiency curves, or *J-curves.* (See Figure 1.)

## Using J-curves

A typical J-curve plots cushioning efficiency, J, as a function of impact energy density, U. A small shock has a small value of U, and U-values increase as a shock becomes more severe. Use of J-curves allows the easy selection of materials to accommodate an actual shock event.

J-curves are generated using standard impact tests, and can be obtained for practically any type of material or component.

An idealized impact cushioning material should exhibit a J-value of 1. Real, physically realizable materials will always produce values higher than 1, but can approach this value when properly selected. Flexible foams and high-density foams typically have minimum J-values between 2 and 4, whereas solid materials may only rarely achieve results below a value of 5.

J-curves prove invaluable in the selection of materials, as they clearly indicate the energy density, or impact severity, over which a material is effective.

## BRIEF PRIMER FOR SELECTING CUSHIONING MATERIALS

The bar graph in Figure 2 depicts how the dynamic properties of both slow- and quick-recovery energy-control materials are affected by stiffness, in the case of solid materials, or density, in foams.

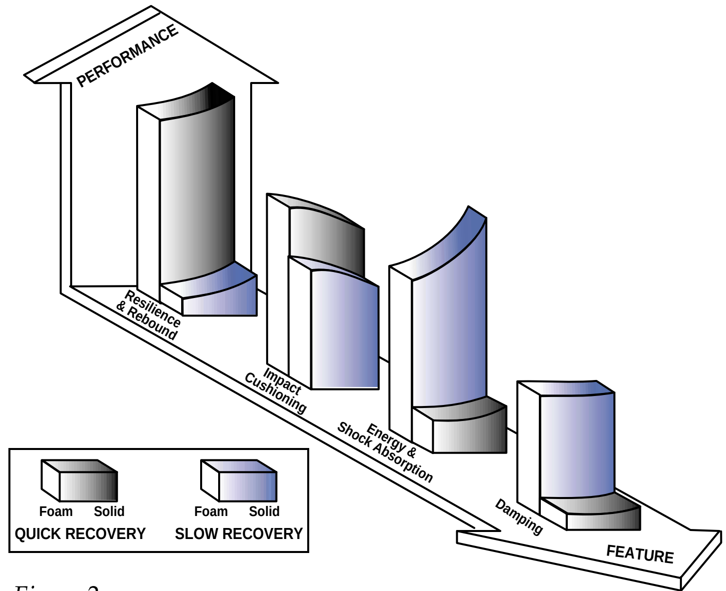


*Figure 2*

*Resilience* refers to a material's ability to recover from a compressional load, while *rebound* indicates the degree to which an impacting body bounces off. *Impact cushioning* describes a material's cushioning capability at or below some level of fragility, e.g., better impact cushioning produces lower impact decelerations.

A material's *energy and shock absorption* properties are its ability to dissipate impact energy, while *damping* performance refers to the ratio of energy dissipated to energy stored. Generally, if two materials have the same static stiffness but different damping capabilities, the one with higher damping will be slower to recover from impact, and will absorb and dissipate more energy during an impact.

## RULES OF THUMB FOR MATERIALS SELECTION

The graph represents a couple of key correlations to keep in mind when specifying a material for a shock- or vibration-control application.

- Impact cushioning, resilience and rebound are usually better with quick-recovery materials. This assumes linearity of the load/stiffness (CFD) curve. If the material is overloaded, as in the bottoming-out of a foam, then it cannot cushion effectively in the application.
- Impact cushioning and shock absorption are not the same. Shock absorption relates to the *amount of energy removed* from the system during the event; impact cushioning relates to the *minimum achievable deceleration* obtainable by using a given thickness of material. Slow-recovery materials will almost always remove more energy, but they may or may not produce the minimum value of deceleration.

Combinations of slow-recovery and quick-recovery materials into composite laminates can produce a blending of effects, to achieve an attractive balance of energy absorption and impact cushioning.

**HERE'S HOW E-A-R'S CUSHIONING MATERIALS LINE UP**

The proprietary materials within E-A-R's various product lines provide a continuum of performance properties for energy absorption and cushioning applications.

### Quick-recovery materials

As fine-celled, high density urethanes, the ISOLOSS® LS group of foams combines inherent softness with physical toughness, providing low compression set, high energy absorption and dimensional stability for applications such as gaskets, low-load isolators and shock-protective padding, including shoe inserts and athletic gear.

### Slow-recovery materials

The ergonomic foams in E-A-R's CONFOR® line offer temperature-softening behavior, impact absorption properties and a slow rate of return from deflection, for a wide variety of padding and cushioning applications, including occupational seating, medical products, protective packaging and gasketing. As sheets or in molded form, these semi-open-celled urethanes absorb and dissipate shock energy, returning little energy to the impacting body. The line offers excellent compression-set resistance and a moderate recovery rate.

ISODAMP® C-3000 Series foams, semi-closed cell thermoplastics, provide high impact absorption and low rebound properties, ideal for low-load crash stops, protective packaging and shoe padding. Acoustic gaskets and seals take advantage of their controlled recovery characteristics. The foams are available in a range of thicknesses and densities, in four temperature-tune formulations.

Moldable, cross-linked thermoset polyurethanes, ISOLOSS HD formulations combine high damping characteristics with excellent mechanical strength and environmental resistance properties throughout a broad temperature range. Available as sheets, and die-cut and molded parts, the materials are ideal for gasketing, sealing, padding and impact-absorption applications.

Available in three temperature-tuned formulations, ISODAMP C-1000 Series thermoplastics provide optimum combinations of high level shock protection and damping in applications including appliances electromechanical equipment, communications devices and vehicles of all types.

VersaDamp™ 2000 Series thermoplastic elastomers are ideal for vibration- and shock-isolation applications because their formulations can be adjusted, up or down, for damping and durometer. Ten standard formulations range from 40 Shore A durometer to 74, and their maximum loss factors (damping performance) can reach an impressive .75.

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