IN•TOUCH

Published by the Polyurethane Foam Association www.pfa.org

Volume 4 | No. 3 | July 1994 (Revised 2017)

How Firmness Affects Flexible Polyurethane Foam Performance

Within the upholstered furniture, mattress and carpet cushion industries, the two most commonly used specifications for flexible foam are firmness and density. Firmness should never be specified without density. Specification of either property alone is not sufficient.

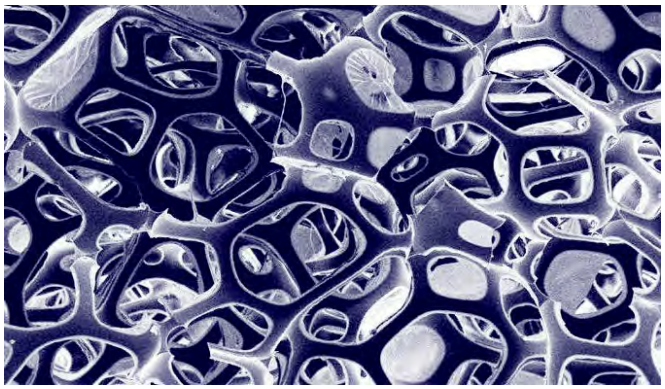
This issue of IN•TOUCH examines the issue of firmness specification and discusses ways foam firmness can be used together with other specification values to improve finished product performance and customer satisfaction.

Foam Firmness should never be specified without also specifying density.

Foam Firmness Measurements: IFD For Most Furniture And Bedding Applications

In upholstered furniture and mattresses, foam firmness is described using a standard measurement value called IFD (Indentation Force Deflection). An IFD number represents the pounds of force required to indent a foam sample by a specified percentage of its original thickness. Specially designed equipment is required to measure IFD. In most cases, a 50 sq. in. round indentor plate is attached to a vertical piston-like cylinder having a precisely calibrated stroke. Following the standard procedures detailed in ASTM D3574, firmness is measured on foam samples having a square surface area typically of at least 20" x 20". In practice, larger sample sizes are often preferred with the objective of duplicating the response of the end-use cushion product. (See IN•TOUCH Volume 4, Number 2.) Sample dimensions, including surface area and thickness are critical to IFD testing results and will be explained later in this issue. Height measurement accuracy is also critical to obtaining consistent IFD results.

Surface firmness is measured at 25% sample indentation (25% IFD). As an example, using a 4" thick sample, the 25% IFD reading would be made while the foam is indented to 3" height under the piston foot plate (25% deflection of the sample height). IFD measurements are also made at other percentages of indentation. In the United States, 65% IFD is used in combination with 25% IFD to determine foam *Compression Modulus* (also known as Support



Flexible polyurethane foam is a network of tiny interlocking support cells. Each cell is made up of struts and windows. Elastic plastic formed into this unique cellular structure allows the system to compress and recover in response to applied loading and unloading conditions.

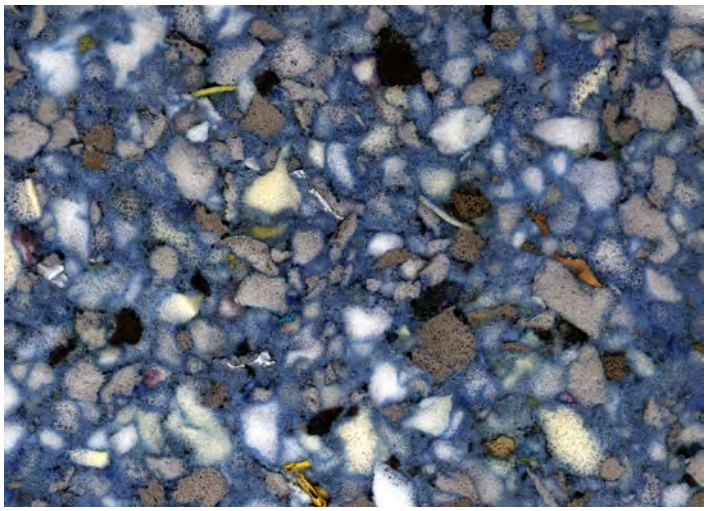
Factor). Compression Modulus is the ratio of the 65% IFD value divided by the 25% IFD. The importance of including Compression Modulus in foam specifications will be discussed briefly in this bulletin. A complete description of Compression Modulus is available in IN•TOUCH Volume 3, Number 1.

CFD For Carpet Cushion, Firmer Foams & Undersized Samples

With carpet cushion, very firm foams, or undersized foam samples, CFD (Compression Force Deflection) is often used instead of IFD. CFD is the force in pounds required to compress an entire sample surface area to 50% sample height deflection. The CFD measurement is made using the same laboratory equipment as in the IFD procedure. To perform a CFD measurement, a sample with minimum surface dimensions of 2" x 2", and a thickness of 3/4", is required. Thinner carpet cushion foam samples must be stacked to achieve the minimum height requirement. The maximum height for CFD measurement is limited to 75% of the width or length of the sample size. So, a 4" x 4" sample could not be thinner than 3/4", or thicker than 3". Surface area is also limited to a size that can be completely covered by the compression plate.

To make a CFD measurement, the entire surface of the foam sample is compressed beneath the plate.

CFD measurements are frequently made at 25%, 65% or other height compressions as agreed upon by supplier and foam purchaser. Non- standard measurements may be necessary for very firm structural foams, or undersized test samples. Firmness, in terms of specifying desired foam softness or hardness, is certainly one of the most important characteristics of flexible foam. But, other physical characteristics must also be considered when working with this versatile cushioning material. CFD should never be specified without density.



Bonded Carpet Cushion

Firmness And Density: Independent Properties

Flexible polyurethane foam is made up of a network of cellular shapes comprised of tiny struts and cell windows. The struts form the exterior support structure of the cells, while the windows are voids which are created as foam bubbles burst during the foam production process. Common struts are shared among cells to create a unified material with good structural integrity and handling strength. This unique structure complements the elasticity of the plastic material allowing polyurethane cells to compress and recover in response to applied load, much like coil springs. The amount of plastic material contained in a given volume is critical to the long term performance of flexible foam. The number of pounds of material contained in a cubic foot (12" x 12" x 12") is the density of the foam sample. (See IN•TOUCH Volume 1, Number 2.)

Lower density values mean there is less cellular material available to perform under loading conditions. On the other hand, higher density products have more strut material to provide desired long term cushioning performance.

Using various chemical formulation and processing technologies, foam firmness can be controlled during the production process independent of the density within broad ranges. A high density foam can be produced to have low or high IFD values. Lower IFD numbers indicate softer foam, while higher values represent firmer cushioning products.

Like all load-bearing structural materials, with extreme or repeated flexing, the physical properties of foam will change as strut fatigue occurs. In flexible foam cushioning, fatigue (sometimes referred to as “flex fatigue”) may be observed as changes in physical strength, height, recovery or firmness properties. Higher density foam products usually exhibit better resistance to this fatigue than lower density products. Simply stated, there's more load bearing material to share the work. Depending on the end-use application, certain

fatigue loss characteristics may be more acceptable than others. To avoid undesirable fatigue losses, cushioning application objectives and performance requirements should be shared with your foam supplier. A minimum density should always be established in conjunction with a firmness specification. Flex fatigue testing may also be used to evaluate the performance of various foam grades.

As a general rule, with conventional virgin polyurethane foam, higher density products (1.8 pcf or greater polymer density) can provide excellent long-term performance with less firmness loss in use.

Some Firmness Change Should Be Anticipated

With all types of cushioning materials, some firmness change should be expected in normal use. A slight amount of softening is normal with virgin polyurethane products. However, some filled foams having a high percentage of filler material may exhibit increased firmness as inert additives compact (see IN•TOUCH. Volume 1, Number 2). As a rule, firmness change with foam cushioning will be less than with alternative cushioning materials such as polyester and natural fibers. Your foam supplier can provide information on the amount of firmness change that should be expected for particular grades of foam used in your application.

Specifying Ideal Firmness In Upholstered Furniture

Cushion firmness is affected by foam firmness, cushion surface dimensions, cushion thickness, surface wrap and layered construction, amount of cushion oversizing, upholstery fabric, and cover upholstering technique (tight cushion vs. loose cushion construction). Spring system, decking construction and Total Vertical Motion (TVM) will also impact the feel of the cushion and must be considered when specifying foam firmness. (See IN•TOUCH. Volume 2, Number 3.)

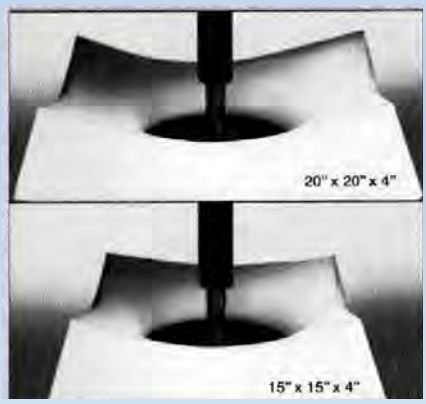
For most applications, foam firmness should be specified to allow a seated person to sit slightly "into the cushion" rather than on top of it. The objective is to reduce interfacial pressure to a point where body weight is distributed evenly without hardness or allowing the springs and decking system to be felt underneath.

A Case For Standardized Sample Sizes

More than 20 years ago, work by the Joint Industry Polyurethane Foam Committee (JIPFC) provided insight into the effect of foam test sample size on IFD measurement. While charts are available to help convert 25% IFD from one sample thickness to another, there is no conversion formula to project IFD variation resulting from differences in surface area dimensions. JIPFC IFD testing of identical grades of foam cut to different surface area dimensions demonstrated that sample size has a significant affect on IFD measurement.

IFD values increase as surface area becomes larger. This means that the measured IFD will be greater for a foam sample measuring 20" x 20" than for an identical grade and thickness of foam having 15" x 15" surface dimensions. This phenomenon can be explained by observing the IFD measurement procedure. On larger sample sizes there is more edge bow around the indentor plate. The resulting increased surface tension affects IFD measurement. To simulate the surface tension "edge effect" that occurs with full-size cushions in use, JIPFC recommends that IFD be specified based on a minimum sample size of 20" x 20" x (purchased thickness).

In all cases, the end-user and foam supplier must agree to specify and measure IFD using identical foam sample dimensions to ensure consistency with evaluations. For more information on IFD variation based on surface dimensions, contact a PFA member, or contact the American Home Furnishings Alliance (www.ahfa.us)



Sample size can create different "edge effects" in IFD measurement. JIPFC recommends a minimum sample size of 20" x 20" x (purchased thickness) to more closely simulate the natural "edge effect" that occurs in actual cushion use.

Depending on the total design of the seating system, IFD specifications may range from as low as 10 lbs. in thick "frumpy" cushions and loose pillow back constructions to as high as 45 lbs. for thin cushions over solid decking as might be found in a commercial bar stool. In all cases, there's no textbook answer to specifying firmness. A slight change in seating construction can cause two identical cushions to feel very different. After carefully considering every functional and construction aspect of the seating system, experimentation is required to determine the best foam firmness for a particular application.

Relating Cushion Fatigue To Firmness

Roundtable discussions conducted by the Joint Industry Polyurethane Foam Committee concluded that some cushion fatigue and softening problems may be due to specifying too low an IFD in seating applications. Since all virgin foam products will lose some firmness with use, IFD must be specified to allow for anticipated softening. Starting with too soft a foam may have showroom appeal, but can result in later durability problems and customer complaints. Seating may begin to "bottom out" as the cushion exhibits normal wear characteristics.

The JIPFC report also noted that durability problems may result from excessive cushion deflection. While some degree of ride is desirable, excessive vertical motion may create unusual stress within the foam cell structure that can contribute to later performance problems.

These problems can be greatly reduced or eliminated through careful consideration of all the factors that affect IFD specification. "High performance" grades of flexible polyurethane foam may allow specification of a soft surface feel without excessive vertical motion or lack of deep down support. Your foam supplier can provide samples of "high performance" foam cushioning products for evaluation.

Summary

While firmness values are commonly used in specifying flexible polyurethane foam, they should never be used as single specification criteria. Other physical properties must also be specified to affect the durability characteristics of the foam product. The following points relate to all flexible polyurethane foam applications.

- Surface firmness is expressed as a 25% IFD value. It is the number of pounds of force necessary to indent a foam sample by 25% of its original height.
- IFD is measured differently than CFD. IFD indents a portion (50 sq. in.) of the sample surface area. CFD compresses the entire sample surface area.
- Firmness is independent of density. High density foam can be produced to be very soft or very firm, or any firmness in between.
- Some change in firmness during end-use should be anticipated with all foam products. As a general rule, higher density virgin foams will exhibit less firmness loss.
- Your foam supplier can help you develop firmness specifications to serve your application objectives.
- The following summary points are specific to the use of flexible foam in upholstered furniture.
- In specifying foam firmness, all characteristics of the application must be considered, including: cushion surface dimensions, cushion thickness, surface wrap and layered construction, cushion oversizing, upholstery fabric, cover upholstering technique, spring system, decking construction, Total Vertical Motion (TVM), ride and interfacial pressure dispersion objectives. See IN•TOUCH Vol. 2.3, "Foam In Furniture Design."

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