

Recently, a national research firm was commissioned to conduct a comprehensive study among upholstered furniture decision-makers to assess usage, attitudes, knowledge and needs related to flexible polyurethane foam (FPF).

The research was sponsored by the Alliance for Flexible Polyurethane Foam (AFPF), a joint program of the Polyurethane Division of The Society of the Plastics Industry, Inc. (SPI) and the Polyurethane Foam Association (PFA).

One of the most significant findings of this research was the discovery that many in the furniture industry are not fully aware of the range of versatility of FPF as a cushioning material. In fact, there have been such dramatic advances in flexible polyurethane foam over the past few years, it is particularly timely to make this FPF technology relevant to those involved in the furniture design and manufacturing process.

The Furniture Industry's Guide to Today's Flexible Polyurethane Foam was developed as an easy-to-use reference tool to help you work with your FPF supplier and better understand how FPF can be used most efficiently to improve the comfort and performance of upholstered furniture.



FPF = Flexible Polyurethane Foam

FPF: A Primer In Comfort.

Flexible polyurethane foam (FPF) is one of the most versatile materials ever created. We're literally surrounded by it in our lives. It's in our cars, in our beds and under our carpets. It's used as a packaging material to protect delicate instruments. And it's the cushioning material of choice in almost all upholstered furniture. Over 2.1 billion pounds of FPF are produced and used every year in the U.S.

*2.1 billion pounds of FPF are produced
every year in the U.S.
That's enough FPF to make approximately
140 million sofas.*

But, while FPF may appear to be a simple product, it's actually very complex. And it can be produced to have an almost infinite variety of properties, which provide three primary functions in upholstered furniture — durability, comfort and support.

Durability:

Durability refers to how well and how long FPF retains its original properties. Typically, the higher the FPF density, the more durable it is, but only by working with your FPF supplier can you determine the specific density needed for your applications.

Comfort:

How comfortable a piece of furniture is has a lot to do with the properties of the FPF used to make the furniture. Comfort refers to at least two factors: the tactile facet, which is the feel when touched by hand; and the sitting comfort. The assessment of comfort depends on who's judging

the FPF and the furniture it's to be used in. FPF is so versatile it can meet many, many comfort levels and requirements.



Support:

The dictionary definition of support is “to carry the weight of, hold up, or keep from falling or sinking.” In upholstery, good support from FPF means that cushions don’t bottom out, fall through or compress to the point where they no longer hold up a person’s weight. It also means the cushion is capable of distributing the weight of a person for maximum performance.

Selecting The Right FPF.

Begin With Your FPF Supplier.

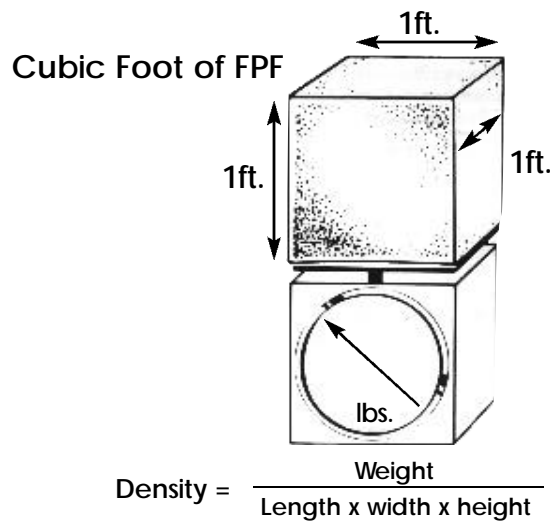
Your FPF supplier is extremely knowledgeable. To ensure you get the right FPF for your project, it’s best to consult with your FPF supplier first — rather than after an item of furniture has begun production. By talking with your FPF supplier as early as the design stage, many potential problems can be avoided. Consulting with your supplier early also gives him the time he needs to custom-create any FPF you may need in a more timely, cost-effective manner.

Involve your FPF supplier early in the design and production process to get the best value and choose the right FPF.

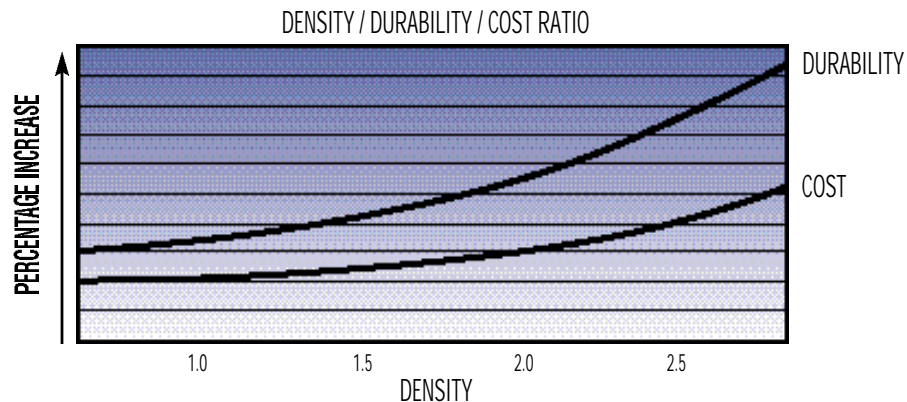
Guidelines for Specifying FPF.

FPF has many different properties, and these properties are measured and described in different ways. The industry uses standardized ASTM tests to determine physical properties.

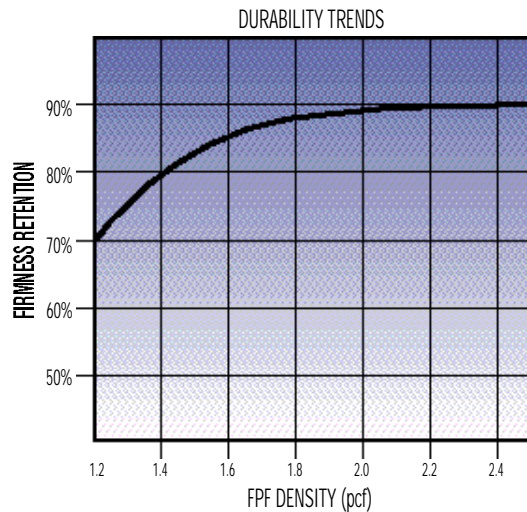
Density. Density is a measurement of mass per unit of volume and is expressed in pounds per cubic foot (pcf). It is a primary measurement used to gauge FPF *durability*. The higher the density, the more durable the FPF, and the more expensive it is to produce due to greater material content.



FPF is available in a broad variety of densities, ranging from as low as 0.8 pcf to as high as 6.0 pcf. Most furniture applications, however, utilize FPF in the 0.9 pcf to 2.5 pcf density range. Typically, the higher the density, the longer the FPF and your furniture will retain their original properties.



Good, long-term cushion performance is a major benefit of higher-density FPF.



Another important aspect of FPF to remember is that density and firmness are independent of each other. This means you can actually select a low-density FPF that's firm, or a high-density FPF that's soft. So if your FPF feels too firm, it doesn't necessarily mean you need a lower density FPF. What you really want to ask for is a softer FPF.

Surface Feel. There are two aspects to surface feel; one relates to the surface feel of FPF, the other is the surface feel of the finished cushion.

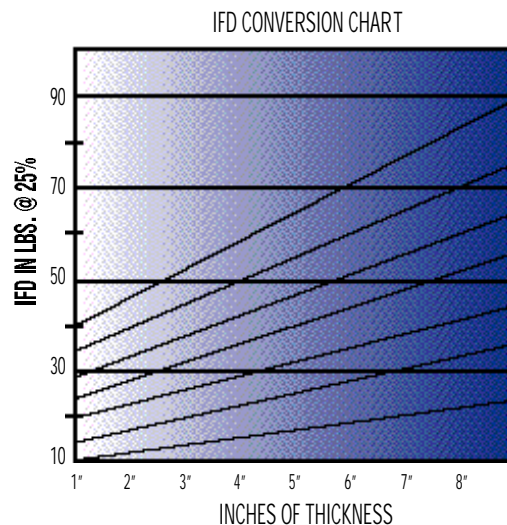
Recent innovations in FPF can deliver a surface feel with an IFD as low as 7, which is similar in surface feel to many fiber-based products.

FPF Surface Feel. The measurement used to determine FPF surface feel is expressed in terms of the Indentation Force Deflection at 25%, or IFD25. IFD25 is determined by measuring the pounds of force required to indent a 4-inch-thick FPF sample 25% of its thickness (1 inch). Depending on the furniture design, the IFD25 specification may range from as low as 7 pounds of force (IFD25) to as high as 45 pounds of force (IFD25). This covers the range from “frumpy” cushions to thin cushions for commercial bar stools.



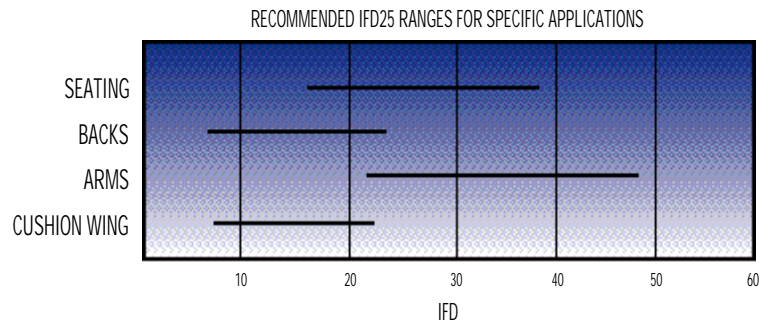
IFD25 Test

When requesting FPF using the IFD25 value, remember that the surface feel is usually tested on 4-inch-thick samples. So if you’re specifying FPF that is more or less than 4 inches, the IFD25 value will vary based on cushion thickness.



Cushion Surface Feel. One of the principal factors that impacts the cushion surface feel is the cradling effect. Cradling is the ability of the cushion or fabric to distribute body weight uniformly over the seating area. Cushion surface feel is also affected by IFD25, cushion dimensions, cushion thickness, surface wrap and layered construction, amount of cushion over-sizing, upholstery fabric, and cover upholstery.

technique (tight cushion vs. loose cushion construction). Spring system, decking construction and cushion design will also impact the feel of the cushion and must be considered when specifying FPF.



Support Factor. This is the measurement used to gauge FPF *support*. Typically, the support factor (also known as compression modulus) can be found by indenting the FPF 65% of the cushion thickness, then measuring the pounds of force required to reach this level of indentation, then dividing this number by the IFD25. The resulting number is the support factor, which should range from about 1.8 to 2.6. The higher the number, the better the ability of the FPF to provide support.

$$\text{Support Factor} = \frac{\text{IFD65}}{\text{IFD25}}$$

Why be concerned about the support factor of your FPF? Because a higher support factor means your cushions will be more capable of distributing weight evenly as the cushion is indented beyond 25% for maximum performance. A high support factor also allows you to specify a softer surface feel so you get extra surface softness without worrying about your FPF “bottoming out” when weight is applied.

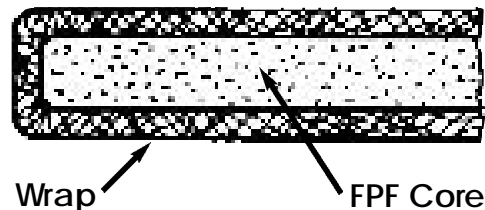
In general, support factor increases as density increases and different grades of FPF can have different support factors. Consult your FPF suppliers to determine the support factor that’s right for you.

For most applications, the FPF IFD25 and support factor specified should allow a seated person to sit "into the cushion" rather than on top of it. The objective is to improve cradling, thus reducing pressure points so body weight is distributed evenly without allowing the springs and decking system to be felt underneath. In fact, in some ways the support factor may be a more valid measurement of FPF's cushioning ability than other specifications because you sit deeper than 25% into a seat cushion.

Additional Factors Affecting FPF Performance.

When selecting an FPF, you must also keep in mind that there are a number of other factors that can affect the performance of your FPF. These include:

Surface Wrap. Historically, FPF cushion cores have been wrapped with fiber and other materials to help produce an extra-soft feel. Technological advances in FPF though, have eliminated the



need to rely on these other, less durable wraps. Today's new, softer FPFs can provide an extra-soft feel and produce a good "hand" for the cushion, along with providing support and comfort.

Benefits Of FPF As A Surface Wrap:

- Won't mat or lump.
- Retains its shape.
- Retains its feel.
- Does not percolate through cover material.
- Reduces wrinkles and cushion height loss.
- Provides support and comfort.
- Provides an extra-soft feel.

Upholstery Fabric. Stiffness, breathability, “hand,” thickness of fabric and upholstering technique (loose wrap or tight wrap) can significantly affect the feel of any cushion.

Spring Systems. FPF is not the only material that provides support in furniture. The spring systems — such as 8-way hand-tied coils, sinuous wire springs and decking materials — do, too. FPF serves as a bridge between upholstery fabric and the spring system being used.

FPF is used as a bridge between the cushion surface and the spring system because it's the only material to provide both lasting comfort and support.

Thickness. Cushion thickness affects seating comfort and support. The IFD25 and support factor must be carefully chosen, with respect to thickness, to give seat cushions proper ride.

In cushion performance tests conducted at Mississippi State University and Detroit Testing Laboratories, Inc., cushions made with only FPF were tested against cushions made with fiber only, as well as cushions made with combinations of FPF and fiber. All cushions were subjected to equal and rigorous durability tests to measure retention of thickness and IFD values.

Result: FPF-only cushions outperformed all other cushions in the tests. In cushions where FPF was used with different amounts of fiber, performance was directly related to the amount of FPF in the cushion, that is, the greater the percentage of FPF, the better the cushion performed.

Fabrication. It should be noted that most fabrication processes affect the cost of FPF pieces, but the only way to truly evaluate the final cost of a piece is to look at the entire manufacturing process. A fabricated piece that costs a few cents more from your FPF supplier may actually save several dollars of expense in product handling or assembly and produce more consistent shapes in the finished product. The end cost of the finished furniture may actually be less because of proper fabrication. Your FPF supplier can help you get the best value by working with you to evaluate the advantages of different fabrication processes.

Factors Affecting Cushion Comfort:

- Amount of cushion over-sizing
- Cover upholstery technique (tight cushion vs. loose cushion construction)
- Cradling
- Cushion design
- Cushion dimensions
- Cushion thickness
- Decking construction
- IFD25
- Layered construction
- Spring system
- Support factor
- Surface wrap
- Type of upholstery fabric and whether or not it has backing

Other Considerations When Specifying FPF.

Even though durability, comfort and support are the three primary considerations when selecting an FPF, there are other factors to keep in mind.

FPF Consistency. FPF properties are maintained within reasonable ranges. It's always a good idea to speak with your FPF supplier before establishing or changing FPF specifications, acceptable characteristics and ranges of variation.

Flammability. A wide variety of combustion-modified FPFs are available because a variety of combustion resistance requirements for furnishings, transportation, and other uses have evolved which range from moderate to very stringent. Most require that the finished furniture or components be tested and approved before they can be used in applications requiring compliance with a standard. Make sure the FPF you select has been approved for your use. And work closely with your supplier where flammability requirements apply.

Safety When Storing. Proper storage and handling of FPF is an important fire safety precaution. FPF should not be exposed to open flames or other direct or indirect high-temperature ignition sources such as burning cigarettes, matches, fireplaces, space heaters, forklifts, welding sparks or bare light bulbs. As an added precaution, it is recommended that all areas where FPF is stored or handled need to be protected by automatic sprinkler systems. Your FPF supplier, local fire officials and your insurance handler can provide additional information on safe practices regarding FPF.

Environmentally-Friendly. FPF manufacturers have devoted a tremendous amount of capital and effort to comply with ever-changing environmental regulations, and have been one of the first industries to virtually eliminate CFC use well ahead of the mandatory deadlines established by the Montreal Protocol. Recycling of scrap FPF is also more important than ever, which is why you'll find rebond materials made from FPF scrap are now being used for the production of the most widely used carpet underlay material. These recycled materials are also used in other specialized applications.

The Five Most Common Mistakes Made When Selecting FPF:

1. Equating firmness with density.
2. Failing to estimate for the effect of over-stuffing.
3. Not realizing that cover materials affect firmness.
4. Believing the least expensive FPF is the best value.
5. Not discussing needs and expectations with FPF suppliers.

FPF Glossary.

Air Flow – Amount of air expressed in cubic feet per minute, that can be drawn through a 2"x 2"x 1" FPF sample at .5-inch water pressure differential.

ASTM – American Society For Testing and Materials. An organization devoted to the establishment of standard methods and procedures for testing materials.

Auxiliary Blowing Agent (ABA) – An additive used in the production of FPF which supplements the primary blowing agent and can be used to make FPF softer or lighter. Compounds used to produce gases to expand, or blow, FPF during production. Auxiliary blowing agents are low temperature boiling solvents, such as methylene chloride, acetone, hydrochlorofluorocarbons, and isopentane.

Ball Rebound – A test procedure (ASTM D3574) used to measure the surface resilience of FPF. The test involves dropping a standard steel ball of known mass from a predetermined height onto an FPF sample and measuring the percent of rebound.

Board Foot – A unit of FPF measurement equal to a square foot of material one inch in thickness.

Boardy – FPF with a stiff or rigid feel, generally indicated by high 25% IFD values and low compression modulus.

Bonded FPF – FPF particles or shredded FPF (often manufacturing scrap) that has been glued to form a useful product. The resultant FPF block is "peeled" into the desired thickness. Largest use is for carpet cushion.

Bonding – The combination of two or more components into a multiple-layer composite. In furniture applications, FPF is often adhered to other FPF grades or to polyester fiber.

Boston Chair Test – Boston Fire Department test method to measure performance of FPF padding materials when exposed to a fairly severe flaming ignition source. This test is a full scale composite test. Test method is now similar to California TB 133 with additions.

Bottom Out – Lack of support under full weight load.

Bun – A segment of FPF cut off from continuously produced slabstock type of FPF.

California Technical Bulletin 117 FPF – FPF that will meet the component combustibility requirements of this standard.

Cell – The cavity remaining in the structure of FPF surrounded by polymer membranes or the polymer skeleton after blowing is complete.

Cell Opening – In FPF materials, the breaking of membranes within the cell structure, permitting flow of air through the material.

Closed Cells – FPF cells having intact cell membranes thereby reducing or eliminating passageways for airflow.

CFC-Free FPF – FPFs that have been made without the use of chlorofluorocarbons as auxiliary blowing agents.

Combustion Modified FPF – FPFs manufactured by using additives based on chlorine, bromine, or phosphorus chemistry to reduce ease of ignition. Hydrated alumina or melamine are also used.

Comfort – The ability of the cushioning structure to deflect at the surface and to conform to body shape, preventing a concentration of pressure on the body.

Compression Modulus – Ratio of an FPF's ability to support force at different indentation (or compression) levels. It is determined by taking the ratio of the FPF's IFD at 25% indentation and 65% indentation (65% IFD/25% IFD). The compression modulus is typically a function of FPF chemical formulation and the manufacturing process. In most cases, the higher the density the greater the compression modulus. Other terms that are used interchangeably are: support factor, and modulus.

Compression Set – A permanent loss of initial height of an FPF sample after compression due to a bending or collapse of the cell framework within the FPF sample. It is most commonly expressed as a percentage of original height.

Conventional FPF – Polyether type FPFs made by the basic manufacturing process.

Convoluted – An FPF product resulting from a fabrication process involving the use of special cutting equipment to produce an FPF sheet with peaks and valleys.

Cradling – The ability of the cushion system to distribute body weight uniformly over the seating area.

Crushing – A conditioning process using a mechanical or vacuum-assisted procedure to open the closed cells of a high resilience slabstock or molded FPF.

Density – A measurement of the mass per unit volume. It is measured and expressed in pounds per cubic foot (pcf) or kilograms per cubic meter (kg/m³).

Durability – How well an FPF retains its comfort, support and shape with use.

Dynamic Fatigue – A durability test performed in the laboratory using roller-shear or pounding type mechanisms.

Flex Fatigue – The loss of FPF firmness after flexing the FPF a predetermined number of cycles.

FPF – The new acronym used to describe flexible polyurethane foam.

Hand – The feel of the FPF as the hand is rubbed lightly over the surface. In home furnishings, FPF with a good hand has a springy, velvet feel.

High Comfort (HC) FPF – Low density (1.8 - 2.2 pcf) high resilience FPF.

High Resilience (HR) FPF – High Resilience FPFs have a high support factor and greater surface resilience than conventional FPFs and are defined in ASTM D3770. High resilience FPF has a less uniform (more random) cell structure, different from conventional products. The different cell structure helps add support, comfort, and resilience or bounce.

Hysteresis – The ability of FPF to maintain original characteristics after flexing. Lower hysteresis values, or less IFD loss are desirable.

Indentation Force Deflection (IFD) – IFD is generally measured as the force (in pounds) required to compress a 50-square-inch circular indenter foot into a four-inch-thick sample, typically 15 inches square or larger, to a stated percentage of the sample's initial height. Common IFD values are generated at 25 and 65 percent of initial height. Note: Previously called "ILD (Indentation Load Deflection)."

FPF Glossary Cont'd.

Open Cell Structure – A permeable structure in FPF in which there is no barrier between cells, and gases or liquids can pass through the FPF. Most cell walls have been ruptured to varying extent.

Percolation – Staple fiber migration through cover material.

Polymer Density – The density of the material made up strictly by the FPF chemistry without fillers or reinforcements included.

Preflex – The practice of compressing an FPF sample up to six times to a predetermined thickness before determining IFD.

Recovery – The amount of return to original dimension and properties of an FPF sample after a deforming force is removed.

Resilience – An indicator of the surface elasticity or “springiness” of FPF. It is measured by dropping a standard steel ball onto the FPF cushion from a given height and measuring what percentage the ball rebounds.

Slab Stock – FPF made by the continuous pouring of mixed liquids onto a conveyor, creating a continuous run of FPF.

Static Fatigue – The loss in load-bearing properties of an FPF sample after being under constant compression.

“Supersoft” FPF – FPFs that have an IFD measurement within the 7 to 10 pound range with a softness comparable to the feel of fiber.

Support Factor (see Compression Modulus) – Support Factor is a ratio of 65% IFD/25% IFD. When the support factor is known, it can be used in conjunction with a known 25% IFD value to determine the 65% IFD value. Seating FPFs with low support factors are more likely to bottom out.

Surface Firmness – The number of pounds of force necessary to indent an FPF sample by 25% of its original height.

Note: A more complete glossary is available from the Polyurethane Foam Association (see page 16 for the address).

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FPF Resources.

Alliance for Flexible Polyurethane Foam (AFPF)
1300 Wilson Blvd., 8th Floor
Arlington, VA 22209
1-800-696-AFPF
(<http://www.afpf.com>)
attn: Neeva-Gayle Candelori

The Alliance for the
Polyurethanes Industry (API)
1300 Wilson Blvd., 8th Floor
Arlington, VA 22209
703-253-0656
Fax: 703-253-0658
(<http://www.polyurethane.org>)
attn: Fran W. Lichtenberg

Polyurethane Foam Association (PFA)
P.O. Box 1459
Wayne, NJ 07474-1459
973-633-9044
Fax: 973-628-8986
(<http://www.pfa.org>)
attn: Lou Peters

Available from PFA:

- *In Touch*® — a teaching bulletin with information about FPF
 - *PFA Glossary*
 - *FPF Performance* slide show
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To receive a copy of the American Furniture Manufacturers Association's "Flexible Polyurethane Foam Voluntary Test Standards & Performance Guidelines," send \$30.00 (per copy) to:

AFMA
P.O. Box HP-7
High Point, NC 27261

