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IN•TOUCH

INFORMATION ON FLEXIBLE POLYURETHANE FOAM

INTOUCH® is a regular publication of the Polyurethane Foam Association. It covers topics of interest to users of flexible polyurethane foam and is designed as a quick reference e for background information on key issues. To get more detailed information about a particular topic, consult a PFA member.

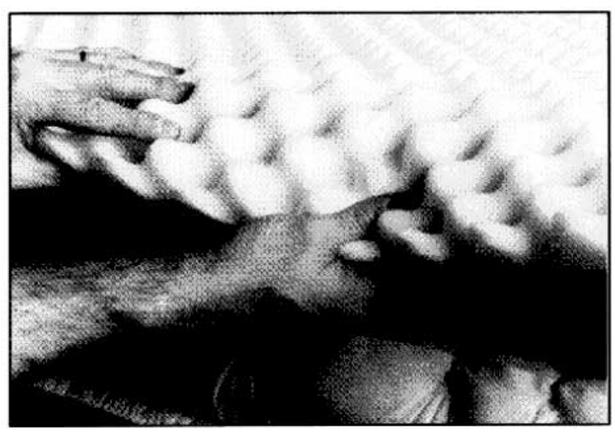
Flexible Polyurethane Foam In Mattress Construction

This issue of IN•TOUCH® addresses many of the physical characteristics of polyurethane foam that can help mattress manufacturers and retailers obtain desired performance and quality.

In mattress construction, overall performance is generally determined by three properties: comfort, support and durability. Proper application of flexible polyurethane foam can contribute to each of these properties, while providing the benefits of a sleeping surface that exactly contours to individual body shape, with excellent recovery capabilities. Foam is also noiseless, dustless and does not crumble, mat down or powder. It has no residual odor, will not aggravate common allergies, and its open cell structure allows the cushioning material to breathe, circulating air within the mattress during use.

Some concepts discussed in this publication relate to subjects addressed in other IN•TOUCH® issues. Such references are shown in the text with parentheses (x) as noted below.

#	SUBJECT	ISSUE	TITLE
(1)	Basic Properties	Vol. 1, No. 1	"Flexible Polyurethane Foam: A Primer"
(2)	Density	Vol. 1, No. 2	"Importance of Density"
(3)	Fiber and Springs	Vol. 1, No. 3	"The Role of Flexible Polyurethane Foam in Relation to Fiber and Springs"
(4)	Handling & Storage	Vol. 2, No. 1	"Proper Handling and Storage of Flexible Polyurethane Foam"
(5)	Furniture Design	Vol. 2, No. 3	"Polyurethane Foam in Furniture Design"
(6)	Support	Vol. 3, No. 1	"Compression Modulus (Support Factors)"
(7)	Performance Tests	Vol. 4, No. 2	"Laboratory Tests of Foam Performance"
(8)	Firmness	Vol. 4, No. 3	"How Foam Firmness Affects Performance"



Flexible polyurethane foam is used in mattress construction to provide to provide lasting comfort and support

Evolution Of Foam In Bedding

Polyurethane foam began appearing as an upholstering layer in innerspring mattress construction and as a solid core for all-foam bedding in the late 1950's. Originally, foam provided a "space age" merchandising option that could be specified at different firmness grades to vary the feel of bedding products. Foam's superior cushioning and fabrication performance characteristics, (1,2) along with the ability to meet Federal Flammability Standard DOC FF4-72 (now 16CFR Par 302 ¶ 1632) led to a dominant position in innerspring mattress construction in the early

1970's. Foam's performance characteristics made it the ideal material for meeting the Federal Flammability Standard, which mandates that all mattresses be resistant to ignition from smoldering cigarettes.

For over 20 years, foam has played an important role in helping to reduce the frequency of household fires, related injuries and loss of life caused by the problem of smoking in bed. Fabric and other outer mattress components can have a significant impact on the ignition potential of a mattress. The PFA or member foam supplier can provide assistance in specifying grades of polyurethane foam for various mattress components.

Managing Body Impressions With Foam Padding

One of the most common complaints by consumers, one that can result in bedding replacement, is body impression (height loss due to fatigue). In the construction of innerspring mattresses, a variety of built-up materials may be used, including: the coil spring unit; primary insulator; upholstering materials, such as shoddy pad, garnetted cotton and polyester fiber; and polyurethane foam.

All built-up materials used in mattresses compact with use. Excessive compacting often results in undesirable cover loosening and can case consumer complaints. Unlike other upholstering components, polyurethane foam height loss can be predicted based on laboratory test results. Foam specifications can be used to achieve desired performance within an acceptable tolerance range.

Several factors affect body impression performance in foam. Density, firmness(7) and foam chemical composition all play important parts in determining height loss potential in mattresses. As a general rule with conventional foam, the higher the density, the less height loss potential. Foams with an unfilled density of 2.0 pounds per cubic foot or greater have been shown to provide best results. At these densities, foam thickness loss of less than 5% is achievable.

Correlation Of Standardized Height Loss Tests Used By Foam Producers And Bedding Manufacturers

Within the polyurethane foam industry, standardized test methods(8) are set forth by the American Society for Testing and Materials (ASTM). ASTM D3574 provides several testing procedures for determining foam thickness loss associated with fatigue. One particular ASTM test, identified as Dynamic Fatigue By Constant Force Pounding, is similar in procedure and in results to the Cornell Testing Procedure used throughout the bedding industry on finished products as jointly specified by the American Hotel & Motel Association (AH&MA) and the International Sleep Products Association (ISPA).

As the adjacent load loss chart illustrates, the results of the two testing procedures conducted using the identical foam grades (4" thick samples for ASTM testing, 7" thick mattress cores for AH&MA/ISPA tests) were similar. Another ASTM D3574 test, Dynamic Fatigue By Roller Shear At Constant Force, is essentially a scaled-down version of the bedding industry's Octagonal Roller Test procedure used to determine mattress durability.

Small-scale laboratory tests are useful for determining component characteristics. They are highly replicable and can be conducted quickly and inexpensively. However, small-scale component tests cannot be used to predict the composite performance of a complete sleep system. With full-scale AH&MA/ISPA procedures, all parts of the total system come into play. Use of both ASTM and AH&MA/ISPA tests is recommended.

As with any composite product, component performance data can only be used as a general indication of how the material will perform in a system application. In mattresses, cumulative height loss will be affected by the characteristics of each component used in the build-up.

Your foam supplier can provide ASTM test method result summaries and make recommendations for mattress component specifications.

Foam Helps Reduce Cumulative Firmness Change

Many of the natural and synthetic fiber materials used in bedding construction have a tendency to increase firmness as materials compact(3). When a change in the firmness becomes noticeable, it can also contribute to consumer complaints. In response to concerns about changes in firmness, AH&MA developed a Quality Recommendation for bedding that calls for a maximum change in cumulative firmness (using the Cornell testing procedure) of minus 15% or plus 40%.

At 2.0 density (using the ASTM Dynamic Fatigue By Constant Force Pounding method), conventional polyurethane foam can be expected to lose 15-20% firmness after 75,000 cycles. And, unlike other cushioning materials, cumulative firmness loss with foam tends to occur early in the life of the product. Subsequent losses should be minimal and very gradual. This slight softening effect can offset significant hardening of other fiber build-up materials used in the composite sleep system. The net effect is a mattress that, as a whole, maintains more of its original support and comfort.

Density Specification Should Match Performance Requirements

As you can surmise, density greatly affects foam durability in terms of height loss and firmness change. Density may also impact foam performance in smoldering ignition tests. As a general rule, density specification for foam applications in cover quilting tends to be slightly lower than for foam layers used in built-up construction. Your foam supplier can help you specify density to obtain products that are capable of providing desired performance.

Comfort Can Be Expressed As Pressure Relief

In upholstered furniture engineering, one of the principal factors that determines comfort is Cradling Effect(6). Cradling is the ability of the cushion/fabric to distribute body weight uniformly over the seating area.

In bedding, cradling is equivalent to Surface Pressure. Surface pressure for mattresses is measured by a full-scale laboratory test using human subjects of specific weights and heights. Pressure sensor plates are placed between different areas of the parts of the body and the mattress surface and pressure readings are taken. Several readings are made in each sensor position and the lowest and highest findings are recorded. The minimum and maximum readings from all the test subjects are then averaged by body position. Readings below 45mm of mercury (Hg) are classified as "Pressure Relief" and those below 32 mm Hg are described as providing "Pressure Reduction."

In a test of four different foam core mattress constructions using ten subjects, by an independent laboratory for the Society of the Plastics Industry, certain foam constructions provided high levels of pressure relief and pressure reduction. Softer foam grades with high density tended to be more efficient at distributing surface pressure away from the point of deepest compression.

To obtain very soft foam grades that will perform well in bedding applications, higher densities are required. High performance polyurethane foam formulations may also be desirable.

Foam Chemistry Can Affect Performance

While conventional polyurethane represents the majority of foam used in mattresses, additional high performance foam formulations are available. High performance foams tend to provide greater support, more resilience and better resistance to softening in use. They can be produced using one or a combination of different chemical technologies and mechanical processes.

Within the bedding industry, high resilience (HR) foam is the best known member of the high performance category. Since 1978, HR foam grades have been distinguished from conventional foam on mattress law labels.

True HR foam must fall within a specific physical property and performance range as specified by ASTM (HRI and HRII varieties) and recognized by ABFLO (The Association of Bedding and Furniture Law Officials). HRI foams must meet or exceed the following minimum standards:

- Density- HRII foam must posses a minimum density of 2.5 pounds per cubic foot.
- Resilience- Measured by how far a steel ball rebounds from the surface of the foam when dropped from a fixed height. HRI foam must rebound the ball at least 60 percent of the distance from which it was dropped.
- Support Factor- The support factor (compression Modulus) is the ratio of how many pounds it takes to compress a piece of foam to 65 percent of its height (65% IFD) divided by the pounds required to compress it to 25 percent of its height (25% IFD). The ratio for HRII foam is a minimum of 2.4 to 1.

If foam does not comply with these standards, it cannot by law be labeled HR foam.

Other "branded" high performance foams are now widely available. They are capable of providing performance similar to the original HR foam formulations, but at lower densities. Currently, there is no accommodation for these brand names on ABFLO law labels and they should not be labeled as HR foam.

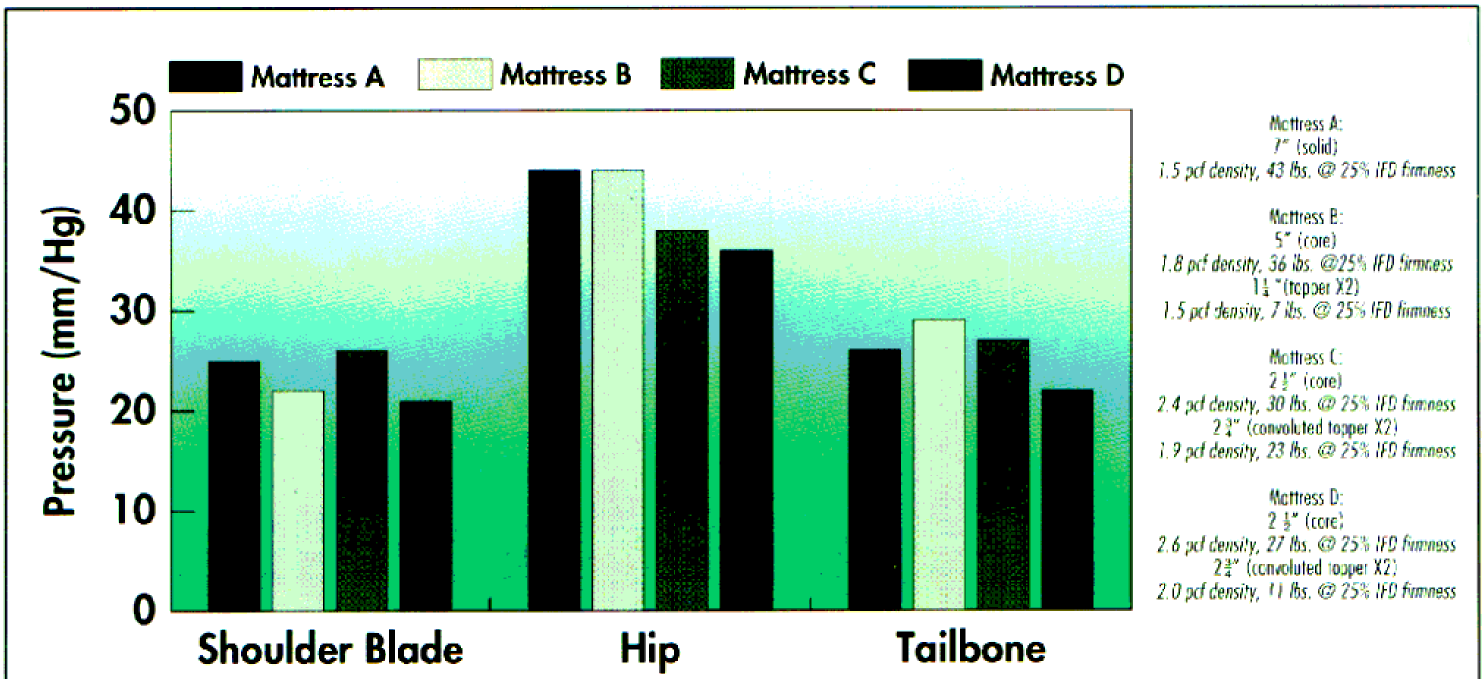
In general, high performance formulations provide greater engineering flexibility for mattress component specifiers. These foam grades can be used to improve mattress support(6) and surface liveliness. They can help to extend the range of available firmnesses and can make softer foams perform better with less fatigue loss.

Flexible polyurethane foam is comprised of a network of tiny interlocking elastic plastic struts and cavities that form cell structures. Most high performance foams are characterized by their fairly coarse, random size cells. By comparison, conventional polyurethane foam has a more consistent, finer cell structure.

But, silky smooth conventional cells have a drawback. Since all the cells in a conventional foam pad have about the same size cavities and strut structure, all cells react to compression force the same way. So when sufficient force is applied, all the cells collapse at about the same rate.

The random sized cells interspersed throughout most high performance foam grades perform quite differently. Some cells are very fine and give way easily to slight force, providing a plush surface feel. Other cells have more developed struts and resist compression force to prevent "bottoming out" while providing buoyant support. The combined effect of all the different cavity sizes and strut dimensions found within high performance grades of flexible polyurethane foam help to create a very unique, "cradling" feel with higher support than can be obtained using conventional foam formulations at the same density.

Several high performance polyurethane foam grades available today provide physical performance that can meet or exceed the performance of high quality latex foam rubber products. Your foam supplier can provide more information on how high performance polyurethane foam products can help you achieve comfort and durability objectives.



Average Pressure Reading On Four Full-Foam Mattresses (based on ten subjects).

How To Prevent Odor Problems

One of the big advantages of polyurethane foam, compared to latex foam rubber, is polyurethane's lack of residual odor. Despite latex foam's physical performance, its rubbery odor will not dissipate significantly with time. When properly produced, cured and adequately ventilated prior to mattress assembly, polyurethane foam has no residual odor.

Complaints of "chemical" odor always require careful examination. The primary cause of most odor complaints is inadequate foam ventilation. Just-in-time manufacturing practices and polyethylene film packaging systems may frequently contribute to odor problems. If time is not allowed after foam curing for ventilation, temporary odors may be trapped within the packaging film and be passed on to the consumer. This also applies to non-foam components, such as ticking. To prevent trapped odor problems, the mattress manufacturer must ventilate the foam and/or finished mattress prior to encasing in polyethylene film for shipment.

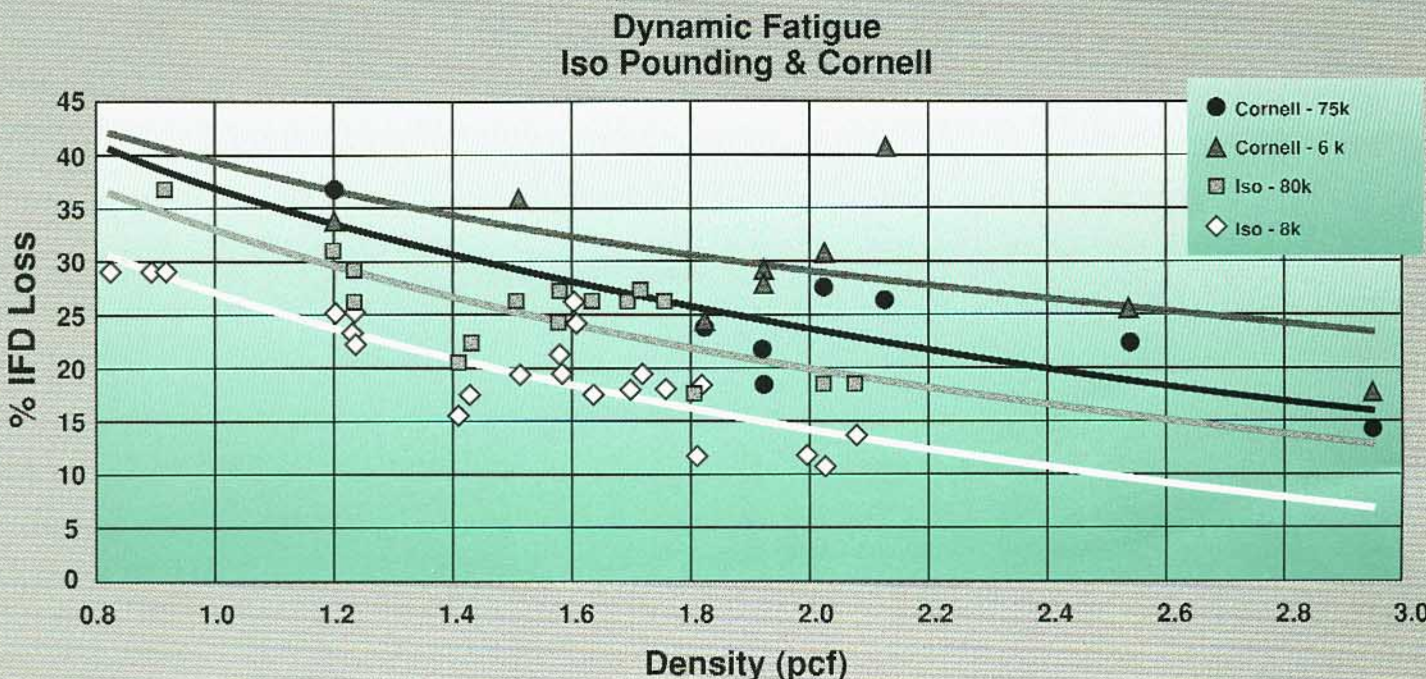
Temporary odors from dyes and colorants, flame retardants, surface soil resistant treatments and lubricants may also be associated with other components used in mattress construction. While just-in-time manufacturing systems offer attractive efficiencies, the value of time savings can be lost with just a few customer complaints. Although most trapped odor will dissipate quickly when bedding is installed in the home, this may not be acceptable to all consumers. Time must be provided for adequate ventilation prior to final packaging.

Combustion Modified Polyurethane Foam Helps Meet Open-Flame Ignition Requirements

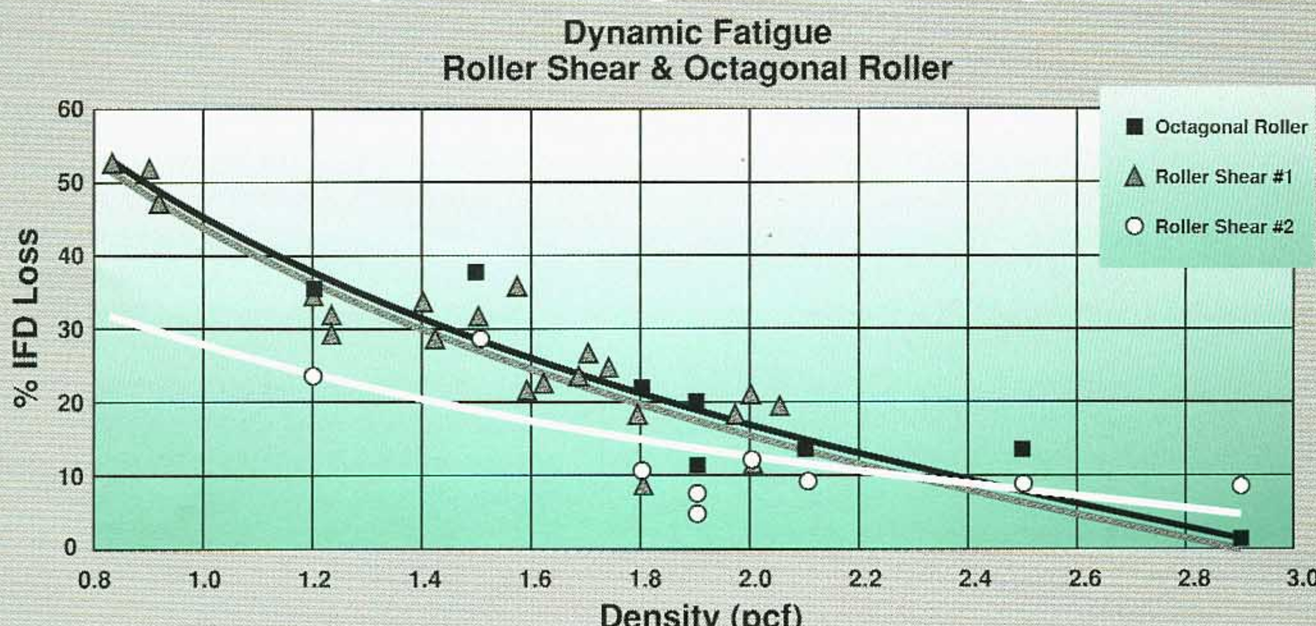
Although residential and traditional commercial products make up the bulk of the mattress business, you may occasionally receive a request for high risk bedding. In constructing mattresses for high risk applications, compliance with certain composite open flame ignition tests such as California Technical Bulletin 129 (TB 129), may be specified. Unlike the case with smoldering ignition, for open-flame testing, large amounts of combustion modifying additives and/or fillers including melamine or aluminum hydrate are generally added to the foam. The addition of flame retardants provides a mechanism to modify the combustion characteristics of the foam. Combustion modified foams usually have higher densities.

The Polyurethane Foam Association cautions that laboratory flammability tests cannot replicate actual fire conditions. Additives used to enhance combustion resistance may have an adverse effect on foam performance. The type of ticking fabric and the design and construction of the mattress can also affect the flammability characteristics of products made with polyurethane foam.

Firmness change from ASTM constant force pounding @ 8K and 80K cycles compared to height loss from AH&MA/ISPA Cornell test @ 6K and 75K cycles



Firmness change from ASTM dynamic fatigue by roller shear compared to octagonal roller testing



Correlation has been found between test results obtained from small-scale laboratory foam producer testing and full-scale tests used by mattress manufacturers. Small scale tests are routinely performed by foam producers on production samples.

In testing, as in use, safety must always be practiced. Once ignited, most grades of polyurethane foam can burn rapidly, consuming oxygen at a high rate while generating enormous heat. Except in carefully controlled testing situations, polyurethane foam should never be exposed to open flames or other direct or indirect high-temperature ignition sources such as, burning cigarettes, matches, fireplaces, space heaters, naked lights, welding sparks or heated tail pipes from fork lifts. The storage and handling of polyurethane foam(4) in bulk requires special fire safety considerations.

Summary

Flexible polyurethane foam is one of the most commonly used components in bedding construction. Foam comfort, support and durability characteristics can be controlled by foam producers during processing giving mattress manufacturers a great deal of product engineering flexibility. In addition, at recommended performance levels, foam provides the following benefits for mattress manufacturers, retailers and consumers:

▶ 1. Helps reduce the chance of smoldering ignition.

▶ 2. Minimizes consumer complaints related to body impressions, height loss, and firmness change resulting from mattress fatigue.

▶ 3. Can be evaluated for performance using small-scale laboratory tests that correlate with common full-scale bedding industry testing procedures.

▶ 4. Provides significant surface Pressure Relief and Pressure Reduction to increase mattress comfort.

▶ 5. Available in conventional and High Performance grades to support specific mattress engineering objectives.

▶ 6. Can meet or exceed latex foam rubber performance without residual odor.

This information is provided as a service of the Polyurethane Foam Association to improve the understanding of key issues that affect flexible polyurethane foam cushioning. To learn more about specific foams, contact your foam supplier.

Subscription Prices: PFA members, $20/year; non-members, $60/year. Add $15 for subscriptions outside continental USA.

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