IN•TOUCH

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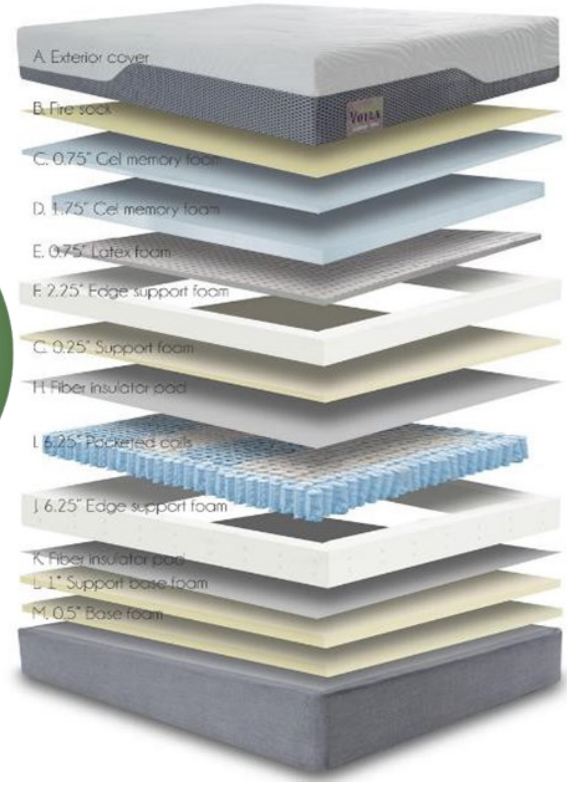
Flexible Polyurethane Foam In Mattress Construction

This issue of IN•TOUCH® highlights some 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 development 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. When foam is correctly specified, it should also be noiseless, dustless and does not crumble, mat down or powder. It should have no residual odor, should not aggravate common allergies, and should breathe, circulating air within the mattress during use.

Foam Firmness should never be specified without also specifying density.

Some concepts discussed in this publication relate to subjects addressed in other IN•TOUCH bulletins. References to these are provided at the end of the document.



Flexible polyurethane foam can be used in numerous ways in mattress construction, to provide comfort, support and durability functions.

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 performance characteristics led to a dominant position in innerspring mattress construction in the early 1970's. FPF also benefitted from its favorable performance in testing under Federal Flammability Standard DOC FF4-72 (now 16CFR Par 302 ¶ 1632), which mandates that all mattresses be resistant to ignition from smoldering cigarettes.

Managing Body Impressions With Foam

One of the most common complaints by consumers, one that can result in bedding replacement and warranty claims, is body impression (height loss due to fatigue). All built-up materials used in mattresses may compact with use. These include: the coil spring unit; primary insulator; upholstering materials (such as shoddy pad, garnetted cotton and polyester fiber; and polyurethane foam).

Excessive compacting often results in undesirable cover loosening. Unlike other upholstering components, flexible 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, 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. **Please note: Load loss (IFD) correlates to height loss.**

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

Within the polyurethane foam industry, standardized test methods are set forth by the ASTM International. ASTM D3574 provides several testing procedures for determining foam thickness loss associated with fatigue. One particular ASTM test, 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 & Lodging Association (AHLA) and the International Sleep Products Association (ISPA).

As the load loss chart on page 3 illustrates, the results of the two testing procedures conducted using 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.

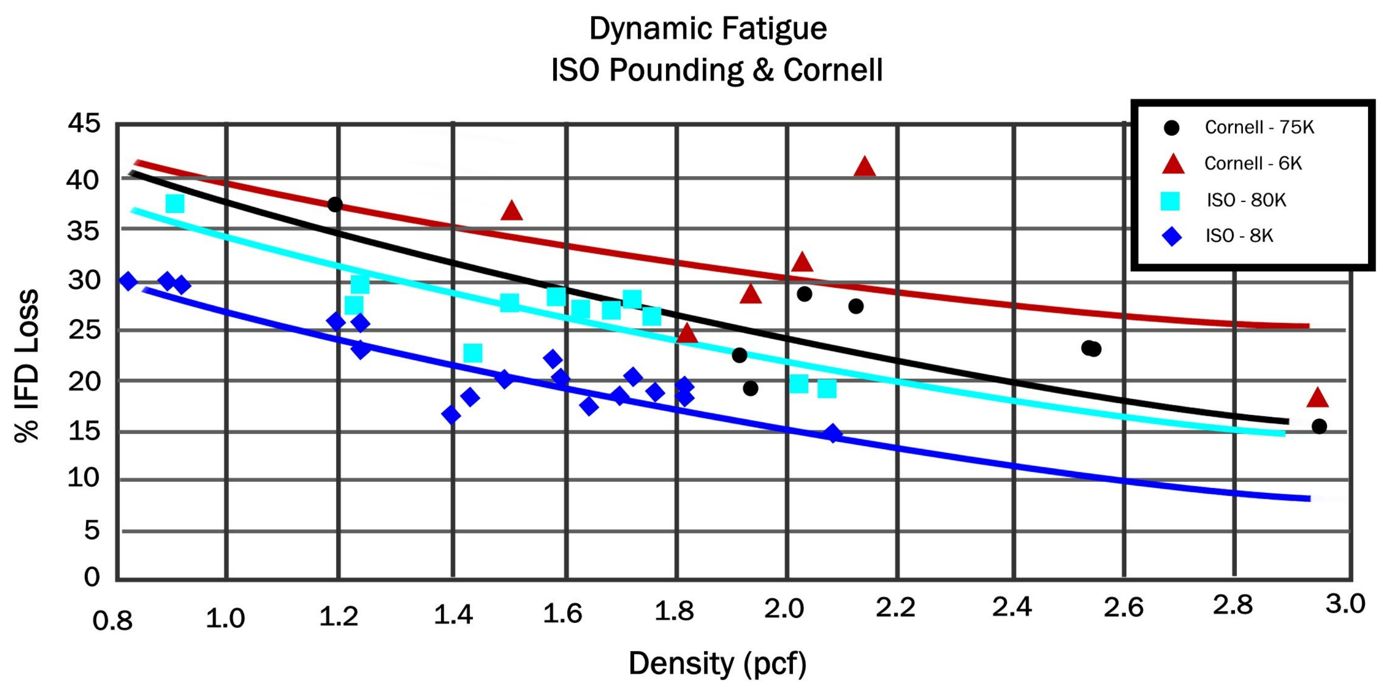
Small-scale laboratory tests can be useful for determining component characteristics. They are highly replicable and can be conducted quickly and inexpensively. However, small-scale component tests cannot be used to predict the composite performance of a complete sleep system. With full-scale AHLA/ISPA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

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

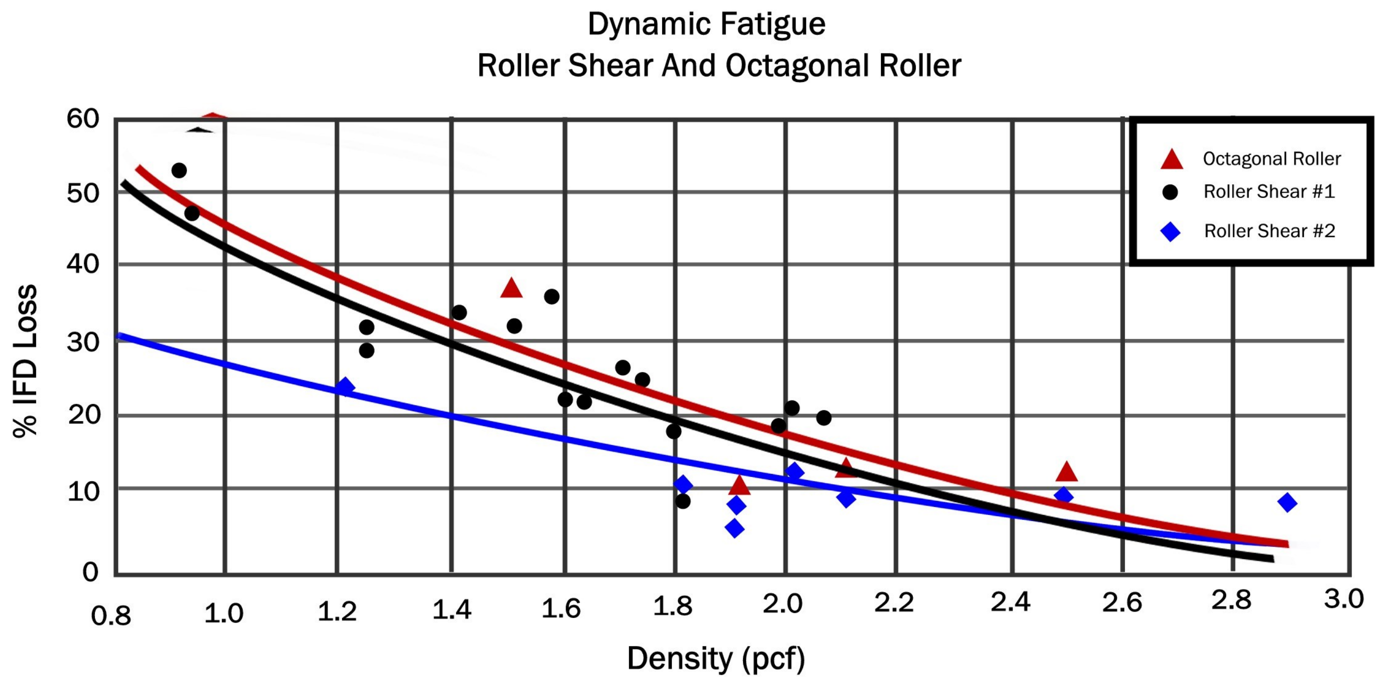
Foam Helps Reduce Cumulative Firmness Change

Many of the natural and synthetic fiber materials used in bedding construction have a tendency to increase firmness as materials compact. When a change in the firmness becomes noticeable, it can also contribute to consumer complaints. In response to concerns about changes in firmness, AHLA developed a Quality Recommendation for bedding that calls for a maximum change in cumulative firmness

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. *Current ASTM testing uses hexagonal rollers rather than the original octagonal rollers.

(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

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 the Cradling Effect. 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."

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.

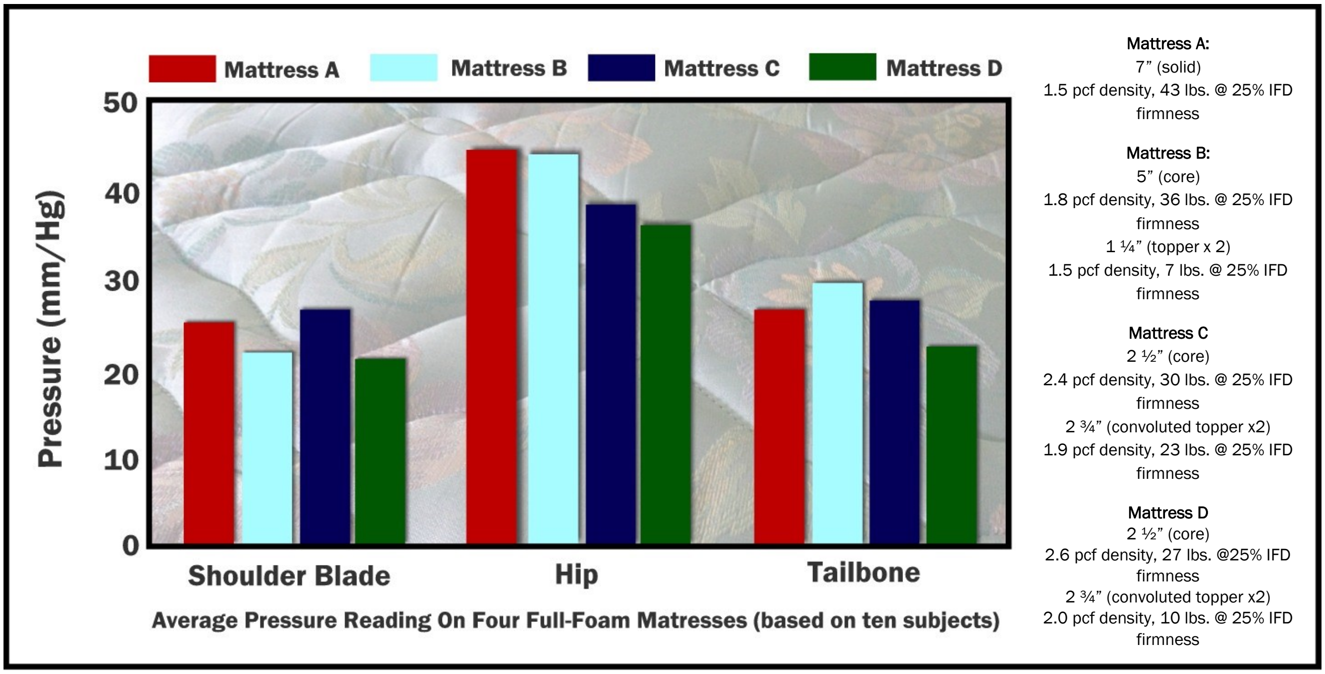
Flexible polyurethane foam is comprised of a network of tiny interlocking elastic plastic struts and cavities that form cell structures. Most high performance foams are characterized by their fairly coarse, random size cells. By comparison, conventional polyurethane foam has a more consistent, finer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

Consistent 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.

The Rise of Viscoelastic Foam In Bedding

Viscoelastic foam, also known as memory or temper foam, was first commercialized during the mid 60's as a result of NASA's AMES Research technology transfer program. This open-cell variety of flexible polyurethane foam (FPF) is distinguished by properties



allowing it to redistribute the GForce suffered by astronauts during take-off and re-entry, and providing commercial pilots a more comfortable seating surface during long flights.

Viscoelastic pressure distribution performance represents one of the most significant comfort innovations from the FPF industry.

Viscoelastic foam is typified by its slow recovery after compression. When a weighted object (for example, the human body) is positioned on viscoelastic foam, the foam progressively conforms to the shape of the object, and after the weight is removed, the foam slowly reassumes its initial shape. Due to this gradual recovery, viscoelastic foam also can be described as "slow recovery" foam. Other characteristics include viscoelastic foam's ability to dampen vibration as well as absorb shock. In fact, certain viscoelastic foam products claim to absorb up to 90% of impact.

While lack of resilience may appear to be a disadvantage, a "dead" foam can be highly desirable in some applications. In addition to these key advantages, many viscoelastic products also react to body temperature and ambient temperatures, softening with heat and more easily adjusting to body contours. These have been recognized as significant advantages in bedding.

The expanding variety of foam grades and performance characteristics have also led to new mattress constuctions that are lightweight and easily shipped. These "bed in a box" products are popular for both their performance and their ease of delivery.

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 should ventilate the foam and/or finished mattress prior to encasing in polyethylene film for shipment.

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.

Additional Issues Of In•Touch To Review:

Vol. 1, No. 1: Flexible Polyurethane Foam, A Primer
Vol. 2, No. 1: The Importance Of Density
Vol. 3. No. 1: Foam, Fiber, and Springs
Vol. 2, No. 3: Foam In Furniture Design
Vol. 3, No. 1: Compression Modulus
Vol. 4, No. 2: Laboratory Tests of Foam Performance
Vol. 4, No. 3: How Firmness Affects Performance
Vol. 8, No. 1: FPF and Latex Foam
Vol. 11, No. 1: Viscoelastic Foam
Vol. 13, No. 1: Understanding the U.S. Mattress Standard

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PFA
Polyurethane Foam Association

334 Lakeside Plaza, Loudon, TN 37774
Phone (865) 657-9840 | Fax (865) 381-1292

www.pfa.org