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IN•TOUCH®

INFORMATION ON FLEXIBLE POLYURETHANE FOAM

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

Flexible Polyurethane Foam in the Transportation Industry

Comfort, durability, safety and economy of operation are requirements of every modern mode of transportation. Manufacturers of private and commercial vehicles meet these prerequisites by using flexible polyurethane foam (FPF) in seating systems and other components.

This issue of IN•TOUCH® discusses how FPF can be produced in an almost unlimited variety of formulations to meet specifications for automobiles, trucks, buses, aircraft and boats. It is one of the most versatile manufacturing materials today, with proven reliability and flexibility. Polyurethane foam can be formulated to dampen the vibration that causes discomfort for the operator of an over-the-road tractor/trailer rig as effectively as providing a smooth ride for the driver of a luxury sedan.

FPF can be combustion modified to meet safety requirements for various types of seating from auto to aircraft, while providing long-term comfort and performance.

Marine applications are compatible with FPF's natural resistance to mold and mildew attack. The addition of antibicrobial chemicals boosts FPF performance in this arena. Consistent physical performance in a constantly moist atmosphere and an ability to support and cradle the body in comfort make FPF the logical choice for boat berths, trim, and seating.Improvements and refinements to the "miracle material" introduced in the early 1950's continue to expand FPF use and add valuable benefits within the transportation industry.

Protecting the environment by recycling vehicle seats to keep them out of landfills is of paramount importance. Elimination of springs in vehicular seating has helped cut the cost of recovery for recycling by about two-thirds. However, the move to deep, all-foam seating brings challenges as well as progress. New research focuses on FPF varieties that dampen the vibration created by the dynamics of the vehicle and irregularities of the roadbed.

Some designers specify that a seat should be highly resilient. Others are much more concerned about vibrational-dampening qualities of the seat. The two specifications appear to be in opposition, but methods have been developed to control vibration and provide resiliency.

More than 40 years of research and product refinements have made polyurethane the material of choice for the transportation industry. Rigorous testing spearheads a search for new technologies leading to foam formulations to meet the changing needs and demands of the future.

Springless seats in vehicles are relatively recent developments. However, springs are rarely used in boats where plywood platforms are often the base for seats and bunks. High resilience (HR) foam, that provides essential support and cradles the body in surface softness, multiplies the comfort quotient in boats.

A new approach in aircraft seating is the introduction of graphite impregnated foam (GIF) which can be produced to meet aviation combustion requirements, while providing lasting comfort for passengers.

Comfort and Safety Come First in Automotive Seating

Manufacturers of automobiles, trucks, and recreational vehicles must practice both ergonomics and aesthetics in designing and engineering seating. This highly visible component, the main interface of the driver and his machine, is the second costliest in a motor vehicle. The engine is number one.

Overall comfort and performance of the seating system, consisting of frame, foam, covers and mechanisms is a key factor in the decision to buy a vehicle.

Increasingly, major auto companies outsource their seating requirements in efforts to improve quality and control costs. Design and engineering often are jobbed out.

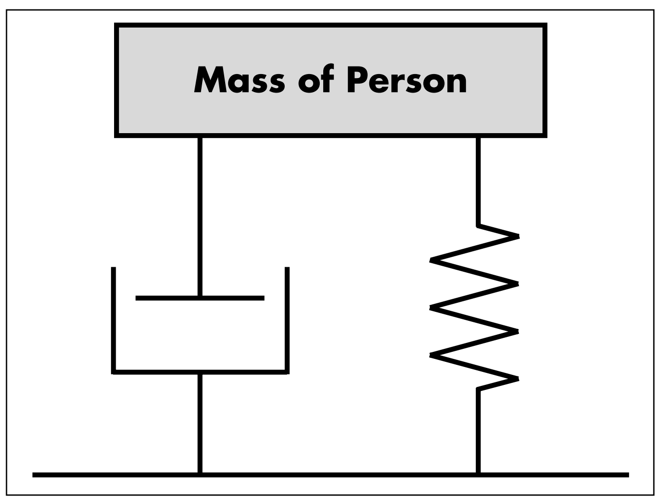
Companies that specialize in the dynamics of seating systems may produce the necessary parts themselves or purchase materials from other companies. As a result, many suppliers may become involved in producing seats for a single vehicle. Auto makers and their several tiers of suppliers explore new technologies and materials testing at every level to control costs and maximize comfort and ease of driving.

For many years auto makers have relied on FPF as a cost effective, durable cushioning material with the versatility required for complex designs. Now FPF has become an even more important element in automotive seating.

Emerging from technological advances is the replacement of combination spring/foam seating in favor of components made entirely of polyurethane foam. Until recently, automotive seat engineers and designers depended on tuning the springs (SEE DIAGRAM) to control **transmissivity.** Transmissivity is the transportation industry's term for the amount of vibration transmitted through the seating platform to the driver by the motion of the auto. In systems that incorporate springs, foam is used mainly as an easily applied, economical padding material.

Currently, almost half of all Japanese automobiles and a significant and growing portion of American cars are equipped with deep foam seating. These systems are lighter in weight, high performance and easier to recycle than spring/foam combinations. Manufacture of all-foam seats also is less labor intensive, a major cost-control benefit. Now, in a single molding process, seats can be manufactured to provide a soft, comfortable center section combined with firm perimeters for effective lateral support.

The move away from springs places much greater emphasis on the performance characteristics of the foam. Designers and manufacturers of all types of seating , including residential and commercial furniture, are concerned with the comfort factor. For the transportation industry, achieving a satisfactory level of comfort becomes much more complex.



Spring and dash pot models are used to predict foam cushioning behavior.

For example, sofas and chairs are static. Automobiles are dynamic. Designers and engineers must deal with the mechanical forces that produce the vehicle's motion.

It is imperative to specify foams that will eliminate most of the vibration transmitted through the floor pan by the dynamism of the vehicle and variables in the road bed.

Vehicle seats must perform another vital function. They must establish and maintain the driver in a position that allows ergonomic access to all controls and allows safe operation with unimpaired vision.

If the foam seat of a sofa or chair becomes compressed or stiff over an extended period of use, the consumer-owner may be unhappy. For the automobile driver, degradation of seating can reduce visibility and safety also becomes a factor.

H-Point is the term used by the industry to identify the height at which the driver has adequate visibility for safety. The H-Point is influenced by several situations that may develop in the foam with extended use. The primary influence is creep (settling or compression); which, in turn, is influenced by the amount of "work" put into the foam as measured by dynamic modulus (a measuring of the dynamic firmness), and dynamic hysteresis (a measuring of the change in dynamic firmness, providing information about the foam's ability to maintain original dampening properties).

Intensive Testing Spurs New Technologies

As consumer demands change and auto makers refine seating requirements to meet customer expectations, flexible polyurethane foam has emerged as the material of choice. Intensive testing of materials and components by auto manufacturers and their suppliers spurs innovations such as deep foam seating. This technologically advanced seating system reduces weight, boosts production rates and provides the comfort consumers seek. Research continues to enhance the reliability, flexibility and versatility that allows automotive designers and engineers to achieve their performance goals.

At the same time, the public benefits from seating that is comfortable, pleasing to hand and eye, enhances fuel economy and contributes to overall safety.

A primary target of this on-going research and testing is durability. Durability in vehicles is defined as the consistency of foam characteristics during prolonged use, such as a long trip and as over the life of the car, van, truck or bus. Seating foam is regularly subjected to harsh conditions such as excessive heat, cold and high humidity which can significantly affect performance. Significant advances have been made to improve foam durability.

Field tests as well as laboratory tests measure durability. In one test, for example, urban police cruisers were used as the test vehicles. Results of the study were reported at the

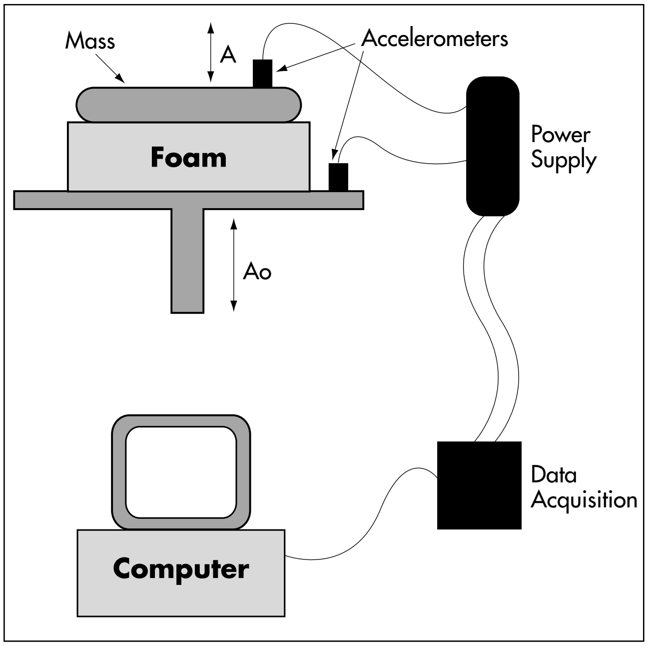
EA Foam Increases Vehicle Safety

Flammability and injuries from impact also are safety concerns that are addressed by advanced foam technology. Foam can be produced to meet the combustion requirements of federal Motor Vehicle Safety Standard 302 without the addition of flame retardant chemicals.

Energy-absorbing (EA) polyurethane foam increases protection for the occupant during impact. EA foam can be slabstock fabricated to required dimensions or molded to dashboard and interior trim specifications and can be formulated to slowly return to shape after impact or to crush completely for maximum energy absorption with minimum displacement.

Manufacturers and suppliers are continually experimenting and testing designs and components that increase safety and reduce vibration and the resulting discomfort.

Adding to the complexity of designing, engineering and making the "perfect" seat is each consumer's perception of comfort. Age, sex, height, weight and body type influence each person's comfort level. These individual, subjective factors represent about 50 percent of the comfort quotient. The other half comprises objective elements such as dampening vibration, establishing proper firmness, equitable distribution of body pressure, initial feel and durability. Continued research brings the transportation industry closer to a precise definition of comfort and to the techniques to achieve and measure total driving satisfaction.



ACDF testing uses accelerometers to gather vibrational wave data from the source as well as through different foams to document transmissivity rates over real time.

IPolyurethane cushions in these high-use vehicles were subjected to the equivalent of one vehicle lifetime (160,000km). After more than 2000 hours of ride evaluation, the cushions were evaluated in the laboratory and their physical properties compared with virgin foam. Over the period of testing, properties were virtually unchanged. Evaluations were made of several different grades of foam, and foam containing about 20 percent of recycled polyol content. All performed well and were considered to offer a good degree of support and comfort. Cushions manufactured from other fibrous materials, both natural and synthetic, failed in the field. These cushions were removed from the test fleet because of unacceptable performance before completion of one vehicle lifetime. Field test conclusion: FPF cushioning has proved to be the most durable seating material even in exceptionally high-use vehicles.

With the trend toward deep-foam seating in automobiles, controlling transmissivity has taken on new importance. Key to controlling transmissivity is to lower the foam resonance to a frequency below the critical human discomfort level while avoiding the natural frequencies of the vehicle.

In a significant stride to solving the problem of vibration, a laboratory scale model has been developed to measure foam transmissivity. It has been proven effective in comparing the vibration dampening performance of different foam systems.

The transmissivity test is used along with others, including the ASTM Constant Force Pounding (CFP) test, ball rebound to measure resiliency (ASTM D3574 Test H) BMW durability tests, IFD tests and others to determine specifications that individual manufacturers or suppliers may require.

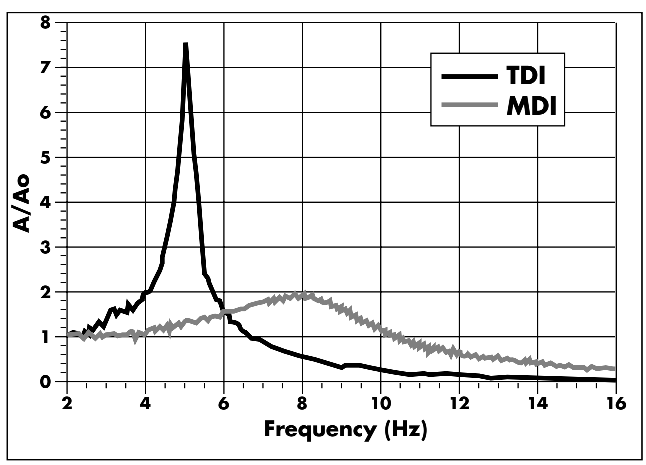
There are essentially three polyurethane molded foam technologies currently used worldwide in the manufacture of automotive seating. These are generally known as TDI HR; MDI HR; and TDI hot cure.

The transmissivity study used to create the model examined these three foaming technologies with specific emphasis on the vibrational characteristic responses over a frequency range of 1 to 16 Hz.

Generally, TDI chemistry provided the desired lower natural frequency response and was the least sensitive to processing variables.

Recycling: A Responsible and Profitable Option

Expense of recovering foam has been the major deterrent to re-use, but new techniques and technologies are sharply lowering costs and spurring efforts to recycle automotive seating. Even when fabric is adhered directly to the foam, it is relatively easy to separate the two materials.



An ARCO Chemical study presented at SAE (February 1996) indicates that TDI foam is effective at dampening vibration waves at typical highway speeds.

Studies show that the cost of recovery is reduced when seats are designed of molded foam without springs, fasteners and encapsulating frames. Cost of recovering a molded foam seat is currently about one-third the cost of recovering materials from combination seating.

A major thrust of the FPF industry is to develop an infrastructure to remove foam from scrapped vehicles before they are shredded. Another objective is to explore applications and test how recovered foam can be used in new seating. In fact, there are new vehicles on the market today that contain recycled foam.

In a major breakthrough in methods of recovery, polyurethane foam can be separated after shredding. The proprietary process removes the foam from the automotive shredder residue and cleans it to remove contaminants, oils, dirt and metal. After cleaning, the foam is dried and baled. The process produces small foam chunks that meet requirements of the rebond (bonded foam) carpet cushion market.

There are several options for recycling polyurethane foam. The floor covering industry is a ready market for recycled foam for use as carpet padding. Scrap foam is shredded into small pieces and placed in a processing unit with a chemical adhesive to produce rebond carpet cushion.

Another possibility is to shred the used foam components and introduce them back into the automotive seats as filler material or other components. For example, one of today's popular auto models contains a carpet padding/insulator component made from recycled foam.

It also is possible to return the foam back into its original raw materials by using appropriate chemical solvents.

A final option is energy recovery, burning the used foam as fuel to satisfy industry's energy needs. Energy recovery is widely used in other parts of the world but seldom in the U.S. where burning scrap materials is not generally considered recycling.

The American Plastics Council is currently working on the issue of energy recovery as an acceptable method of recycling.

Economies of recovery allow companies to create new profit centers while protecting the environment, a strong incentive to recycling. Also, industry will likely place greater emphasis on reuse of foam from vehicular seating as the United States moves to be in step with environmental concerns and requirements of the European community.

Safety Sets Criteria for Aircraft Seating

Flame resistance is the first consideration in specifications for aircraft seating. While weight of components that impact fuel efficiency is a concern for the airlines and comfort is a criteria for passengers, standards and regulations for the use of flexible polyurethane foam in aircraft seating are determined by the Federal Aviation Administration. Safety comes first. Federal Aviation Regulation (FAR) 25.853 sets the specifications for aircraft seating.

Commercial airlines are stewards of the regulations, or FARS, and exercise significant influence over the manufacture of airline seating.

Three basic techniques are used to meet composite and stand-alone flammability standards:

1. **Using flexible polyurethane foam in combination with a fireblock.**
   In this process foam is wrapped with a special cover fabric that resists fire. The reinforced fabric serves as a shield, making the foam more difficult to ignite or to burn less rapidly.

2. **Creating firehard foam with the addition of special additives.**
   Combustion modifying additives such as chlorinated phosphate esters or melamine are added during the foaming process to produce a product that is more resistant to ignition.

3. **Graphite Impregnated Foam (GIF).**
   This relatively new technology produces a foam that can meet FAR 25.853 with minimal fire-blocking. By eliminating the fireblock fabric GIF modified foams can be priced competitively.

For corporate and general aviation aircraft GIF seating is becoming an important method for controlling flammability. Manufacturers of this type of aircraft are typically smaller and are able to respond more quickly to new technology. They readily recognize the merits of investing in a product that provides long-lasting comfort as well as meeting required safety. GIF technology also allows the design and fabrication of complex, comfortable and aesthetically pleasing seating for private aircraft.

While GIF foam seating promises the possibility of eliminating the need for fireblock fabrics, there are tradeoffs. When the fireblock is removed, comprehensive composite flammability testing will be required on each new seat design. Total fabricated seat weight may also change.

Seat design issues with commercial airlines become very complex. In addition to safety and comfort concerns, total seat weight can affect bottom line economics. For a commercial aircraft that contains hundreds of seats, a difference of a few pounds per seat can make a long term impact on fuel economy and operating costs. As commercial carriers restructure to minimize expenses, seat manufacturing costs are also under scrutiny. Since how seating comfort relates to airline profits has yet to be measured, seat production costs are often weighed against the benefits of fuel economy and seat durability. FPF that is light in weight, meets stringent safety requirements, in addition to providing lasting comfort, will become increasingly important as the aircraft industry strives for value and profitability in the 21st century.

Marine Applications Mandate Durability and Comfort

Among both manufacturers and end-users, durability is a major concern. Materials must give long service and still allow designers to create the fashionable interiors that boat purchasers demand. Higher density and high performance foam formulations allow design versatility in cushioned surfaces that stand up to rugged wear and ever-present moisture.

Although FPF is inherently resistant to mold and mildew, antimicrobial compounds are added to ensure long service in the moist atmosphere of marine applications.

HR foams fulfill the requirements of boat manufacturers for comfortable, durable seats and berths. HR foams, with their high support factor and greater surface resilience, provide proper support and cradle the body even when installed over a solid decking.

Index to More Information

For in-depth information discussed briefly in "Flexible Polyurethane Foam in the Transportation Industry," see these issues:

"Support," "Comfort" and "Durability" and "Properties That Affect Foam Performance" – **Volume 1, Number 1**

Types of Fabrication (slabstock and molded) – **Volume 1, Number 5**

Foam Recycling and Bonded Carpet Cushion – **Volume 4, Number 1**

NOTE: The contents of this issue have been digested from a paper entitled, "Flexible Polyurethane Foam: Applications in the Transportation Industry." You may request a copy of the complete paper from PFA offices.

Transportation Industry Terminology

You may want to copy this section and save it for future reference by attaching it to the inside back cover of your PFA Flexible Polyurethane Foam Glossary. You can obtain a free copy of the PFA Glossary by writing the Polyurethane Foam Association, PO Box 1459, Wayne, NJ 07474-1459, or calling 201/633-9044.

Creep: The amount of settling or compression that occurs in foam over an extended period of use, such as a long auto trip.

Dynamic Modulus: The "felt" firmness of polyurethane foam during small amplitude vibration such as experienced in a moving vehicle.

Dynamic Hysteresis: The in-use measurement of the dampening properties of foam for small amplitude vibration. Measured by indenting foam samples and evaluating recovery of firmness.

H-Point: Safety measurement for adequate visibility in transportation driver side seating. Measurement of driver height influenced by creep, modulus and hysteresis.

GIF: A recent technological development widely used in private aircraft Graphite Impregnated Foam resists combustion and retards fire without compromising performance of the cushioning.

Transmissivity: In private and commercial transportation seating systems, the amount of vibration transferred through the seating platform to the driver or passengers.

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Summary

Flexible polyurethane foam (FPF) can be produced in an almost unlimited variety of formulations to meet requirements of the transportation industry. Polyurethane foam is the material of choice for seating in private and commercial vehicles because of its durability, comfort and design versatility. Use of polyurethane foam allows manufacturers to achieve aesthetic and ergonomic objectives while practicing cost-effective production methods. Following are some of the current developments and benefits of flexible polyurethane foam in vehicular seating.

1. New methods make it possible to combine high resiliency for safety and comfort with characteristics to control transmissivity.
2. Trend to deep-foam eliminates spring components, reduces weight and cuts production time.
3. Springless seating makes recovery process for recycling quicker, easier and much less costly.
4. Absence of springs places greater emphasis on foam to dampen vibration produced by dynamics of the vehicle and irregularities of the roadbed.
5. A laboratory scale model has been developed to evaluate foam technologies and their ability to control transmissivity, dynamic modulus and dynamic hysteresis.
6. HR foam provides lasting support and comfort in springless seating and in applications over hard decking, such as in boats.

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.

A complete library of PFA IN•TOUCH issues and information on fire safety can be found on the Internet World Wide Web at http://www.pfa.org

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