IN•TOUCH

Published by the Polyurethane Foam Association www.pfa.org

Volume 6 | No. 1 | January 1997 (Revised 2019)

Flexible Polyurethane Foam In Transportation

Flexible polyurethane foam (FPF) is a critical component in transportation because it offers numerous benefits for automobiles, trucks, buses, aircraft, boats and other vehicles.

Both slabstock and molded foam provide:

Comfort for operators and passengers, not just for seating but also to control vibration and minimize sound.

Safety through positioning of occupants for operation, crash protection, and flame resistance

Foam use in transportation provides comfort, support—and safety.

Improved vehicle performance through light-weighing and better fuel efficiency

Durability for long-lasting performance, even in challenging applications like boating

Cost effectiveness through parts consolidation and compliance with industry safety standards for impact, flammability, and other criteria.

This issue of IN•TOUCH® discusses how FPF is produced in an almost unlimited variety of formulations to meet needs in transportation. And as foam technology advances, this "miracle material" continues to find more uses in vehicle applications.

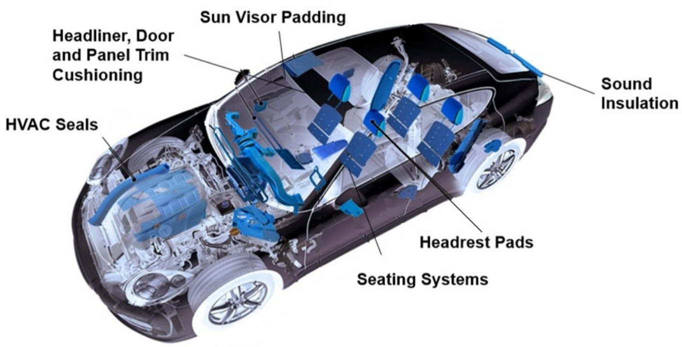
Comfort and Safety Come First in Vehicle Applications

Flexible polyurethane foam has been used since the 1950s in automobiles. Initially, manufacturers used a layer of slabstock FPF over spring systems to provide additional comfort in seating. As molded FPF technology developed, it became the material of choice for seating systems.

Today, both **molded** and fabricated **slabstock** FPF products are used for a wide array of vehicle applications (Figure 1).

Figure 1

Automotive Component Using Flexible Polyurethane Foam



Seating Systems

The seating system is one of the most costly components in a vehicle. It is a major contributor to both function and style. It is the main interface between the driver and the machine, so manufacturers must attend to both ergonomics and aesthetics in designing and engineering.

For transportation applications, achieving a satisfactory level of comfort from seating becomes much more complex. While sofas and chairs are static, automobiles are dynamic. Designers and engineers must deal with the mechanical forces that accompany the vehicle's motion.

For example, the seating system must eliminate most of the vibration transmitted through the floor pan by the moving vehicle and variables in the road bed. This is called **transmissivity.**

Vehicle seats must also establish and maintain the driver in a position that allows ergonomic access to all controls and safe operation with unimpaired vision. When designing and specifying FPF for vehicle seating, all these variables must be considered.

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 potential developments from extended use. The primary influence is **creep** (settling or compression). If you're driving a long distance, and you may have to adjust your seat because you're sitting lower than when you started. Such creep is influenced by "work" put into the foam from the weight of the driver, driver and vehicle movements, and even humidity and temperature changes.

As creep occurs, the ability of the foam to prevent transmission of vibration can change. This is by **dynamic modulus** (a measurement of the dynamic firmness), and **dynamic hysteresis** (a measurement of the change in dynamic firmness, providing information about the foam's ability to maintain original dampening properties).

To provide the performance needed to mitigate the negative effects of creep, higher density foams are used, with densities ranging from 3.5 pcf for seat inserts to 1.5 pcf for less load bearing components or trim. Premium foam chemistries such as high resilience foam are also utilized to avoid creep.

Molded FPF technologies can yield different foam densities and firmnesses in differ areas of the cushion to offer better durability and comfort characteristics, along with saving weight and cost. This also allows the seating system to be carefully customized for the vehicle and use. Seat cushion inserts position you so you sit comfortably, see the road well, and easily reach controls. Bolsters and wings keep you centered and supported during turns.

Auto/Truck Cushion Components

The foam in many seats also works with mechanical devices such as adjustable lumbar support or heating systems to further enhance driver comfort.

Often, major auto companies outsource their seating systems to improve quality and control costs. Companies (typically Tier 1 suppliers) 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 supplier tiers explore new technologies and materials testing ("validation") at every level to control costs and spur innovation.

Vehicle Trim Applications

FPF is used in multiple places for interior trim, including dashes, doors, and headliners. Foams can be formulated and fabricated so they adhere to the outer skins of components (like a dash) or to substrates. Such foams are typically thin. For the interior roof of the cabin (or headliner), FPF may be flame laminated to fabric to prevent it from separating even after years of use. Headliners may even be thermoformed after lamination so that installation is easier and more precise.

NVH Applications

FPF is also used to control NVH (Noise, Vibration and Harshness) issues. A key to controlling vibration is to lower the foam resonance to a frequency below the critical human discomfort level while avoiding the natural frequencies of the vehicle.

For these uses, viscoelastic and high resilience foam are typically used. Weight is always critical. But even small amounts of FPF, installed in the right places, improve the quality of the vehicle ride by minimizing squeaks, creaks, and rattles.

Energy Absorption Foam

Foam can also enhance vehicle safety in energy absorption applications, such as door panels and knee bolsters. For these purposes, both rigid and flexible polyurethane foams are often used. FPF may be slabstock or molded. They dissipate energy in case of accidents and provide extra cushioning for occupants.

HVAC System Foam

In the automotive HVAC system, FPF is used in a variety of applications. Due to the ability of FPF to compress easily, it is used as an air seal between various hard substrates, such as molded polypropylene parts. The easily compressed foam allows for smaller-sized actuator mechanisms to open and shut damper doors with FPF seals attached, for example. This physical characteristic can also be used to seal small water leaks around the air conditioner cooling coil to direct condensed water to the outside of the passenger compartment.

Glossary of Terms

Slabstock Foam: Flexible polyurethane foam manufactured in large buns, then fabricated into specific sizes and shapes.

Molded Foam: Flexible polyurethane foam manufactured in custom molds, producing a finished cushion for a specific application.

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

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

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.

Testing Methods Tailored For Transportation

Since both slabstock and molded foams are used in transportation, there are a number of test methods that can be used to evaluate foam performance. Testing procedures for foam covered in ASTM D3574 address many key foam properties such as density, firmness, compression modulus, and others that determine the material's suitableness for vehicle use. Molded standards, in general, follow the same standards as flexible foams.

Fogging, volatile organic compounds (VOCs), and vibration dampening tend to be more important when testing automotive foams. For fogging, standards SAE J1756 or ISO 6452 are used, to collect volatile materials coming off a hot foam sample onto a cooled glass plate. (As of this update, an industry panel is further investigating VOC measurement methods used in the transportation industry to determine which are most effective. Updates will be provided in future issues or on www.pfa.org.)

ASTM E756 – Vibration Damping Measurement (SAE J1637) is used for evaluating vibration absorption, while ASTM E1050 – Sound Absorption Measurement evaluates noise properties.

Automotive companies generally have their own specifications that must be met in addition to standardized testing.

In North America, FPF used in motor vehicle applications must meet Federal MVSS-302 standards for flammability. This relates to both slabstock and molded foam. Typically, a fire retardant is required in the foam to meet this standard.

(*PFA offers a video training series that covers Foam Testing Methods in more detail at www.pfa.org/training,)*

Safety Sets Criteria for Aircraft Seating

Flame resistance is the first consideration in specifications for aircraft seating. While weight of components (impacting fuel efficiency) is a concern for the airlines and comfort a priority for passengers, the Federal Aviation Administration (FAA) insists that safety comes first. Mandatory Federal specifications for flammability are contained in Federal Aviation Regulation Section 25.853(a) and FAR 25.853(c) Appendix F.

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

Two 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 resist ignition or burn less rapidly.

2. Creating firehard foam with special additives.

Combustion modifying additives such as flame retardants (FRs) are added during the foaming process to achieve similar results.

Seat design issues with commercial airlines become very complex. Seat cushions must also float and be available as a safety device in case of water landing. 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.

Another FPF use in aircraft is the use of reticulated foam in fuel tanks. This open celled foam allows liquids to flow through, but in the case of an accident, prevents fuel spray that can cause explosions and fires.

Marine Applications Mandate Durability and Comfort

Among both marine manufacturers and boaters, 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.

High Resilience 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.

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.

1. FPF is used in a spectrum of transportation applications, for seating, interior components, decorative trim, sound and vibration absorption, and energy absorption in case of accidents.

2. Both slabstock and molded FPF are used.

3. In transportation, foam must accommodate not just static forces but also dynamic forces of vehicle movement and vehicle operation.

4. A variety of test methods are used to evaluate foam performance, including some specifically created for vehicle applications.

5. In addition, vehicle manufacturers often have their own unique specifications.

6. Federal regulations governing flammability requirements very between different modes of transportation. Therefore, foam formulations may require different additives to meet these requirements.

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