Engineers' Notebook:

Getting to the Bottom of Comfort

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VISCOELASTIC FOAMS SIMPLIFY DESIGN OF SEATING APPLICATIONS

In many applications, substituting a specialty component for a commodity improves some characteristic, such as performance, durability or even appearance. A titanium bicycle frame, for example, is stronger and lighter than aluminum. Or, leather upholstery breathes better and feels more luxurious than vinyl. Generally, though, premium properties come with a higher price.

Applications engineers at E-A-R Specialty Composites in Indianapolis have developed techniques that the designers of chairs and seats can employ to take advantage of a specialty cushioning foam and yet hold the line on materials costs.

The proprietary material is a highly damped viscoelastic urethane called CONFOR® foam, a medium-density, semi-reticulated foam. Developed a couple of decades ago as a seating material for the space program, CONFOR foam exhibits a unique combination of ergonomic, almost space-age properties that can be duplicated only by use of multiple materials plus mechanical or structural components. The foams are formulated to have the "feel" of a very soft or very thick cushioning foam yet offer the support and protection of a stiffer material.

How CONFOR foams perform

As a cushioning material, CONFOR foams provide the structural support of a solid, the low-pressure comfort of a fluid, and the shock absorption of a very thick material. Thus they offer a singular combination of comfort, anti-fatigue and impact-safety components found in virtually no other material.

Most urethane foams are *elastic*. That is, they deflect under a load and return a force to the load that is equal to the deflection of the elastic material multiplied by its stiffness. (Force = deflection x stiffness.)

Likewise, when a person sits on a common urethane foam, the material deflects and returns a force that is proportional to the amount of deflection, similar to a spring. Areas of greatest deflection receive the greatest return force. These pressure *hot spots* can restrict blood circulation to portions of the body. They account for the discomfort and fatigue that can result from remaining in a seat for extended periods. Long-term exposure to pressure points can cause *decubitus ulcers*, commonly referred to as bed sores.

Viscoelastic foams do not respond in the same way. They are a hybrid of properties. The viscous response allows the even distribution of load while the elastic response allows the foam to support a static load.

Viscous refers to a fluid response—flowing away from the load or force. The fluid redistributes the applied pressure. Viscoelastic materials, such as CONFOR foams, "flow" away from the point of contact. The force that is returned—the elastic part of the equation—is not proportional to the displacement. Ideally, all of the loaded area of the foam should return the same force to the body, no matter what its deflection.

CONFOR foams' key property that accounts for this behavior and sets the foams apart from other viscoelastic materials is *damping*. As highly damped materials, CONFOR foams dissipate energy through hysteretic loss, directly converting mechanical energy into low-grade heat. This ability is derived from the chemical makeup of the material—a unique polyurethane polymer structure that gives the material its energy-absorption capabilities and slow-recovery behavior.

How to design with CONFOR foam

E-A-R applications engineers employ computer-based pressure mapping technology to help customers optimize their seating designs. With this system, computer-linked sensors detect and measure the loading on a surface and translate it into colors that form a *pressure map* of the area being measured. Areas of greatest pressure show as red and orange, moderate pressure shows as yellow and green, and areas of lightest pressure glow as shades of blue.

Engineers use this technology to compare the various CONFOR formulations—the material comes in a variety of stiffnesses and several densities—when used in a particular design, and they can pinpoint areas that may require special treatments, such as the base of the spine or under the thighs. (See Figure 1.)

Key properties of CONFOR foams

- Highly damped, viscoelastic
- Slow recovery after compression
- Energy-absorbent—resist bottoming out
- Excellent memory
- Comfort of a soft foam, support of a stiff foam
- Hypo-allergenic
- Pass California Flame 117, FAR 25.853(a) and British standard Crib 5
- Temperature responsive—conform to the body

With CONFOR foams, it is possible to achieve numerous ergonomic properties in a design that traditionally would require the use of multiple materials, some of them used in great quantity and at great cost, coupled with structural or mechanical elements. A relatively thin layer of CONFOR foam, used in combination with traditional high-resilience (HR) seating foams, can significantly and cost-effectively increase comfort levels in most applications.(See Figure 2.)

Here are a few key principles to guide seating design with CONFOR foams.

1. Use softer formulations on top of stiffer ones. A layer of soft or medium-stiff CONFOR foam gives a seat cushion a pleasing feel while the stiffer formulations provide substantial support.
2. Use a thin layer of high-resilience urethane, fabric or a padding material over the CONFOR foam core as a wear layer.
3. Use stiffer formulations in areas of the seat that will have the highest load—at the base of the spine, for example. This prevents *bottoming out*, or complete collapse.
4. Match the stiffness of the CONFOR foam to the weight of the intended occupant—greater stiffnesses for higher weights. Or, use multiple stiffnesses in layers, to accommodate a wider range of weights.
5. Consider the environment of use. In higher-temperature applications—80° F or greater—use stiffer foams to accommodate CONFOR foam's temperature responsiveness.

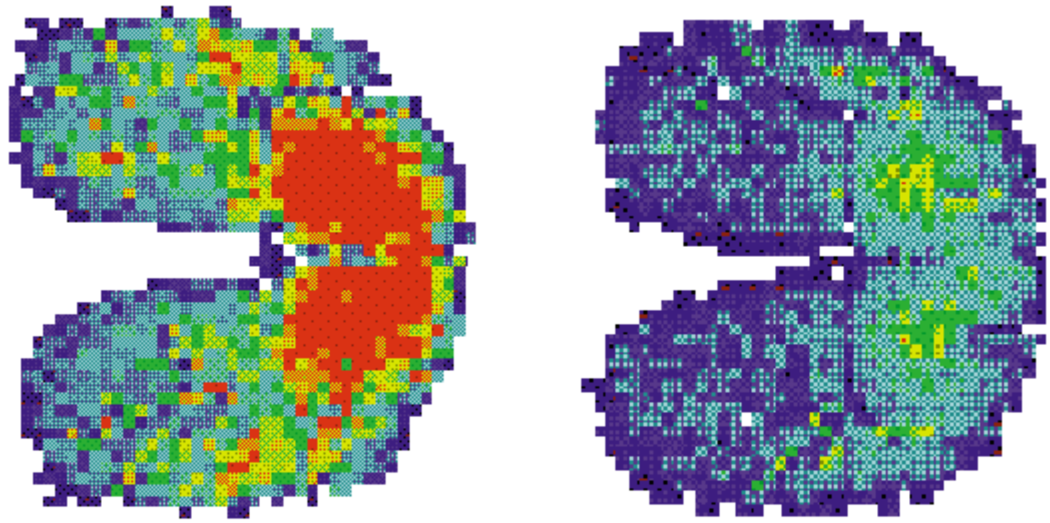

Figure 1 Pressure Maps

These pressure maps represent the distribution of weight of a 170-pound man seated on high-resilience urethane (left) and CONFOR foam (right). Red depicts areas of 0.6-0.8 psi, and dark blue represents areas of less that 0.2 psi. Because the CONFOR foam distributes the weight evenly, loading is significantly reduced.

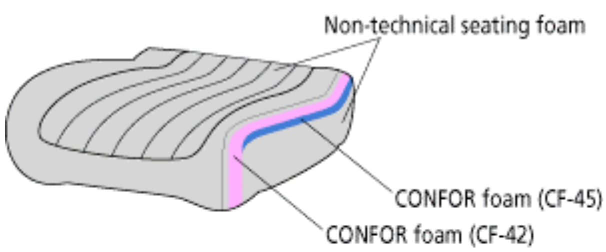

Figure 2: Example of Composite Ergonomic Cushion

Combining CONFOR foams with traditional high-resilience urethanes allows seat designers to build in *specialty* properties but at a *commodity* price. Here, a common construction sandwiches two layers of CONFOR foam between a base core and thin top layer of traditional seating foam. For aesthetics—a nice soft *feel*—the softer formulation, CF-42, is layered over a supportive layer of the stiffer foam, CF-45.

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