Robert Eller Associates, Inc.

CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES
TECHNICAL / ECONOMIC / MARKET ANALYSIS & MANAGEMENT DECISIONS

4000 Embassy Parkway · Suite 230 · Akron, OH 44333-8328 USA
Phone 330-670-9566 / Fax 330-670-9844
E-mail: bobeller@prodigy.net / Home Page: http://www.robertellerassoc.com

POLYURETHANES IN AUTO INTERIORS . . . OPPORTUNITIES AND CHALLENGES

Prepared for:
URETHANES TECHNOLOGY **Prepared by: Robert Eller**
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OVERVIEW

Polyurethanes are used in auto interiors as skins (a recent intensely competitive arena) and foams (for seating, textile lamination, acoustic barriers and energy absorbers). Foam applications dominate PU usage and have been a stable application for many years. Challenges to the secure position of PU foams are emerging primarily from polyolefin foams in several forms and from recently introduced lightweight fiber constructions. This article examines the intermaterials challenges and opportunities for polyurethane-based plastics applications in automotive interiors. It is based on the recently completed multiclient study "Automotive Interior Soft Trim . . . Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers," prepared by Robert Eller Associates, Inc., Akron, Ohio (***www.robertellerassoc.com***).

PU Functions in Auto Interiors -- Polyurethane plastics (thermoplastic and thermosetting types) are used to satisfy a variety of functions in auto interiors. As shown in Exhibit 1, these include:

- Seating foams
- Textile foam laminates
- Energy absorption
- Skins
- Acoustic applications
- Semi-structural applications
- Glazing seals
- Coated fabrics

Foams are the major class of applications in which polyurethanes are being challenged. The key foam locations in the vehicle are summarized in Exhibit 2. The schematic shown in Exhibit 3 summarizes the foam families competing for share in automotive applications.

Seating Foams -- This is the major application of plastics in auto interiors. PU seating foams have retained their dominant position for many years in seat cushions and headrests. Recently, steam chest molded, expanded polypropylene (EPP) foams have entered the rear seat cushion as anti-submarine inserts and are being examined in rear seat backs and in headrest constructions in European vehicles.

EPP Bead Foams -- are challenging PU foams in a number of energy absorption, semi-structural and cushioning applications. The EPP foams offer a number of advantages:

- Energy absorption during multiple impact
- Semi-structural properties (when incorporated into a rigid skin/foam laminate such as shown in Exhibit 4)
- The ability to be formed into living hinges.

With some exceptions (e.g., from JSPI), the EPP foams do not have adequate acoustic properties to challenge PU foams in the major acoustic applications (headliner and floor module).

Textile/Foam Laminates -- Textiles are generally used in interior applications as laminates with (skived) PU sheet foams in order to achieve a soft contour and a soft touch, padded effect. The typical construction is a polyester or knitted jersey textile, flame laminated to the PU foam sheet. These laminates are used in typical interior body cloth applications (headliner, sun visor, seating, door medallions). Recently, textile/polyolefin sheet foam laminates have been introduced in French vehicles and are likely to appear in German models in the near future.

Initial penetration has been in small applications such as the door medallion (see sketch in Exhibit 2). In addition to avoiding the necessity of flame lamination, the introduction of polyolefin foams into the laminate offers the prospect for an all-polyolefin construction if polypropylene (PP) textiles are used in applications such as door trim panels. The use of PP textiles in auto interiors has previously been restricted by UV resistance and limited color range. These limitations appear to be in the process of being overcome.

Skins – TPU powder slush molded skins were introduced as a competitor to PVC slush molded skins during the late ‘90s. Due to both cost and performance limitations, they do not appear to have the potential for significant growth.

Spray aliphatic PU skins (from Recticel) have enjoyed rapid growth in the high-end auto segments for instrument panels, door trim panels, and console covers in the N. American

and European fleets. The aliphatic spray PU skins must compete with lower cost PVC slush molded skins and several forms of TPO skins. Competition has also emerged in the form of PU-RIM skins and aromatic PU-based sprayed skins used in conjunction with a protective in-mold coating.

The use of polyurethane skins is encouraging the development of multi-station machines in which a polyurethane foam is formed directly behind the skin in the same mold. The prospects for reducing the number of process steps will possibly re-stimulate the emergence of PU-based substrates in applications such as door trim panels.

Energy Management – Passenger safety requirements in U.S. vehicles and (more recently) in European vehicles require the use of energy management systems in applications such as headliners, door trim panels, and (recently, in Europe) in rear seat backs (e.g., ECE 17 -- the beer crate test). Polyurethane foams are the dominant incumbent used in headliner and door trim panel energy absorption applications. Current use is in polyurethane block form, usually added after the headliner or door trim panel is fabricated.

EPP foam blocks have emerged as one of the major challengers to PU foam blocks in these applications. The use of EPP offers the potential for making an all-polyolefin, monomaterial construction when polyolefin textiles are used. Thus far, polyolefin textiles have made limited penetration in automotive interior textile applications, but could be encouraged by the ability to make a monomaterial construction that will facilitate recycling to meet European End-of-Life Vehicle (ELV) regulations.

Research for REA's multiclient study has suggested that it is likely that future constructions will incorporate the energy absorption function into the structure of the headliner or door trim panel. This raises the question of the ability of the competing foam systems to meet both energy absorption and acoustic management properties.

Acoustic Properties -- Acoustic performance is a major driving force in automotive interior inter-materials competition.

If the acoustic construction can be incorporated onto the substrate panel (on-board acoustics), value is enhanced. Floor, overhead systems, and door trim panels are prime targets for this high value property combination. Polyurethane foam systems and regenerated fiber batting are the key acoustic incumbents.

Fiber composites compete with the incumbent polyurethane foams in acoustic and semi-structural applications such as headliner substrates and floor/acoustic systems. The recently introduced lightweight fiber constructions are emerging as major competitors to PU foams.

Due to their closed-cell structure, EPP bead foams have poor acoustic absorption properties. The creation of interstices within the bead foam structure provides a multi-

fold improvement in acoustic absorption. (JSPI has developed this approach to acoustic performance in bead foams.)

Competition with Regenerated Felt Constructions -- Regenerated cellulosic and synthetic fibers are widely used as an acoustic barrier mats (shoddy) in floor, seat backs, package trays, and trunk floors. Although relatively inexpensive, these constructions have a number of disadvantages (most notably water pickup and loss of compression resistance properties with time).

Floor/acoustic systems are a major use of regenerated fiber constructions and are emerging as one of the major foam/fiber inter-materials target zones in automotive interior soft trim. The use of foams and fibers for floor/acoustic constructions differs between N. America and Europe as illustrated in the table below:

LIGHTWEIGHT MATERIALS IN AUTOMOTIVE FLOOR/ACOUSTIC MODULE IN EUROPE AND NAFTA

MATERIAL	CURRENT SHARE, %		NOTE
	EUR	NAFTA	
Regen. cellulose fibers (shoddy)	20	50	Use will decline in both regions
PU foam	75	45	Tuned acoustics accelerate penetration
Other Challengers:	5	5	
Polyolefin foams			Acoustic properties must be improved
New lightweight fiber (PET/PP) fiber constructions			Will be used in both floor/acoustic and headliner constructions
Micro-denier nonwovens			As acoustic modulator

SOURCE: ROBERT ELLER ASSOCIATES, INC. SOFT TRIM MULTICLIENT STUDY, 2003

Load Floors – The evolution of taller cars has created the opportunity for storage space in the floor. These load floors often consist of a tri-laminate of skin or textile and foams. As shown in Exhibit 4, these constructions are emerging as a competitive zone between foams and lightweight fiber constructions.

Headliner Substrates – Glass reinforced PU foams are the dominant incumbent headliner substrate material in both N. America and Europe. Recently, these constructions are facing competition from:

- Lightweight reinforced thermoplastic (LWRT) moldable mats based on glass fiber and polypropylene powder (from Azdel and Quadrant)
- A new generation of lightweight polyester fiber constructions from Rieter and others.

EPP foams have attempted to penetrate the headliner sector, but the current generation does not appear to have adequate heat resistance and acoustic properties for this application.

Coated Fabrics – Coated fabrics are used in conjunction with the increasing use of leather seating. The fabric coating typically is PVC. Recently, TPO and PU-coated fabrics have entered the seating market. The polyurethane coatings are based on dispersions and are relatively expensive, but have found applications in the Japanese and European fleets. Ethylene styrene interpolymer (ESI), from Dow Chemical, appeared to be a promising coated fabric candidate, but has been withdrawn from the market. Other styrenic copolymer formulations are currently targeting the coated fabric market. Alcantara and others have introduced the use of microfiber-based polyurethane textile constructions for high-end seating and some decorative applications (e.g., door trim medallions, pillar trim, instrument panels).

Low V.O.C. Interior -- Reduction of V.O.C.s is emerging as a key driving force for the selection of interior materials. Early pressure has come from European OEMs and is likely to spread to N. America and will be a factor in materials selection.

SUMMARY

PU foams in several applications are facing challenges from polyolefin foams. In seat cushion applications, steam chest-molded EPP foams are entering the rear seat sector as anti-submarine inserts and rear seat backs.

Textile/polyolefin sheet foam laminates are entering the competition with the currently widely used textile/PU foam laminates.

In the major energy absorption applications (headliner and door trim panels), molded PU foam blocks are competing with EPP molded blocks.

In floor acoustics applications, PU foams are competing with lightweight fiber sandwich mats.

Glass reinforced PU foams are the dominant incumbent headliner substrate. They are facing competition from:

- Recently introduced new lightweight PET fiber constructions
- Lightweight reinforced thermoplastics (LWRTs) in moldable mat form
- EPP foams (possibly)

Spray aliphatic PU skins have enjoyed rapid growth in the high-end auto segments for instrument panels, door trim panels and console covers. In addition to competing with lower cost PVC slush molded skins and several forms of TPO skins, competition has also emerged in the form of PU-RIM skins and aromatic PU-based sprayed skins used in conjunction with a protective in-mold coating. The use of polyurethane-based formulations is likely to increase in the automotive interior skins market.

ABBREVIATIONS USED IN THIS PAPER

EA - Energy absorber
BF - Bead foam
ELV - End-of-Life Vehicle
EPP - Expanded PP (or PP copolymer) bead foam
ESI - Ethylene styrene interpolymer
GF - Glass fiber
HMS - High melt strength PP
HVAC - Heating, ventilation, and air conditioning
LWRT - Lightweight reinforced thermoplastics in moldable mat form
TP - Thermoplastic
TPE - Thermoplastic elastomer
UEV - Unsupported expanded vinyl (e.g., PVC foam)
V.O.C. - Volatile organic compounds
XLPO - Crosslinked polyolefin (usually sheet foam)

REFERENCES

1. Multiclient Study, "Automotive Interior Soft Trim: Skins, Foams, Coated Fabrics, Textiles and Acoustic Barriers," Robert Eller Associates, Inc. (2003)

2. European Automotive Instrument Panels and Supplier/Materials Database CD-ROM, Robert Eller Associates, Inc., 2002 (a searchable photo and supplier database)

3. "Optimizing Position in the Interior Soft Trim Value Chain to Ensure Profitable Growth," Plastics in Automotive Interiors; Oct. 2003; Frankfurt, Germany; R. Eller

4. "Driving Forces for Foam Substitution in Automotive Interior Soft Trim," Plastics in Automotive Interiors; Oct. 2003; Frankfurt, Germany; R. Eller

AUTHOR'S BIO

Robert Eller is President of Robert Eller Associates, Inc. (REA), a consulting company providing analysis and support of management decision-making in the automotive plastics and rubber industries. REA has offices in N. America (Akron, Ohio), France, Switzerland and Spain. His coordinates are: 4000 Embassy Parkway, Suite 230, Akron, Ohio 44333, USA; Phone: 330-670-9566; E-mail: bobeller@prodigy.net; Home Page: http://www.robertellerassoc.com.

His firm has completed numerous single-client studies in automotive plastics and multi-client studies (see References) of:

- Automotive interior soft trim in Europe and N. America
- The role of advanced nonwoven textiles in automotive interiors (study underway)
- Automotive instrument panels (photo/supplier databases for Europe and N. America)

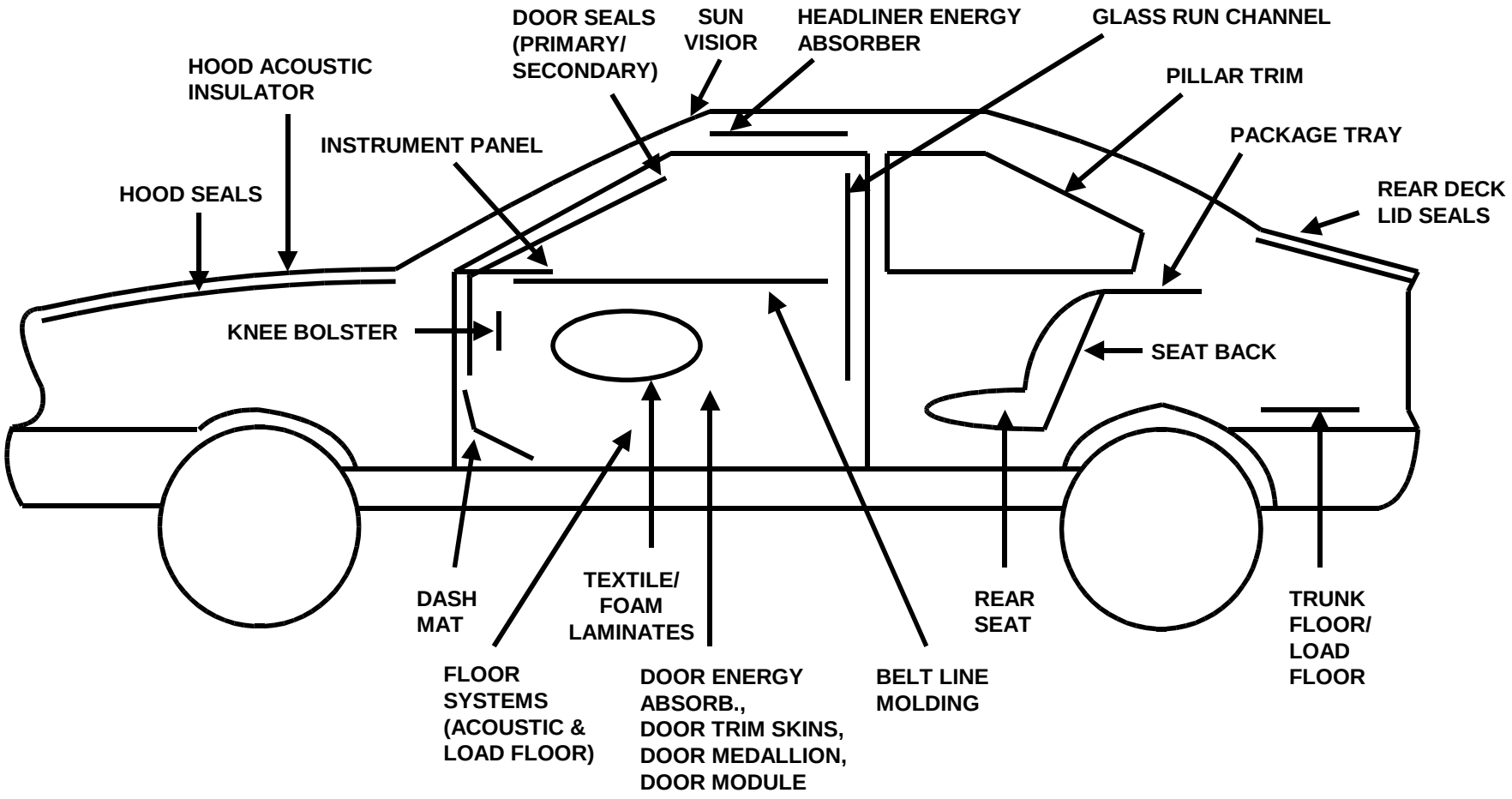
EXHIBIT 1
PU APPLICATIONS AND COMPETITORS IN AUTO INTERIORS (EXAMPLES)

INTERIOR MODULE	PU APPLIC.(S)	PU FORM	MAJOR COMPET.	NOTE
HEADLINER	ENERGY ABSORBER	FOAM BLOCKS	-LWRTs -LIGHTWEIGHT FIBERS	-INTENSE COMPETITION -COULD EVOLVE TO COMPLETE SYSTEM
	SUBSTRATE	GLASS FIBER REINF. POURED FOAM	EPP, GLASS MAT TPs(1)	- GR-PU LOSING SHARE
DOOR TRIM	SUBSTRATE	S-RIM	LOW PRESSURE INJ. MOLD PP	- S-RIM PHASE-OUT
	ENERGY AB.	FOAM BLOCKS	EPP, OTHER PO FOAMS(2)	
	MEDALLION	POURED	EPP	
	SKIN	PU SPRAY	TPO SHEET	-PU SPRAY MAJOR RECENT SHARE GAIN
		PU-RIM		-RECENT ENTRY; RAPID GROWTH LIKELY
		TPU SLUSH MOLD	TPO SLUSH	-TPO SLUSH LOSING SHARE
SEATING	MOLDED CUSHION	POURED FOAM	EPP STARTING(3)	-MAJOR PU APPLIC. -HOT POUR PU FOAMS BEING ELIM.
	HEADREST	POURED	EPP	-EPP STARTING IN EUROPE
	SUN VISOR	SHEET	EPP	-STARTING IN EUR.
FLOOR	LOAD FLOOR SANDWICH	POURED	EPP, LWRTs(1)	-GROWTH APPLIC.
	ACOUSTIC MODULE	POURED	-LTWT. FIBERS -REGENERATED FIBER MATS	-LONG-TERM ACOU. PERFORM. REQ'D.
INSTRUMENT PANELS	CUSHION	BACKFOAM	PO SHEET FOAM	-PO SHEET FOAM LESS VERSATILE
TEXTILES	SEAT, HEADLINER, DOOR TRIM	LAMINATED(4) SKIVED, SHEET	PO SHEET FOAM	-STARTING (IN EUROPE)
GASKETS	--	POURED	PVC, TPEs, RUBBER	

NOTES: (1) E.G., FROM AZDEL AND QUADRANT
(2) E.G., DOW'S STRANDFOAM®
(3) E.G., IN REAR SEAT ANTI-SUBMARINE BLOCKS AND BACKS
(4) USUALLY FLAME LAMINATION

SOURCE: (REFERENCE 1) ROBERT ELLER ASSOCIATES, INC. AUTOMOTIVE INTERIOR SOFT TRIM MULTICLIENT STUDY, 2003

EXHIBIT 2
AUTOMOTIVE INTERIOR FOAM/FIBER APPLICATIONS



SOURCE: ROBERT ELLER ASSOCIATES, INC. SOFT TRIM MULTICLIENT STUDY, 2003
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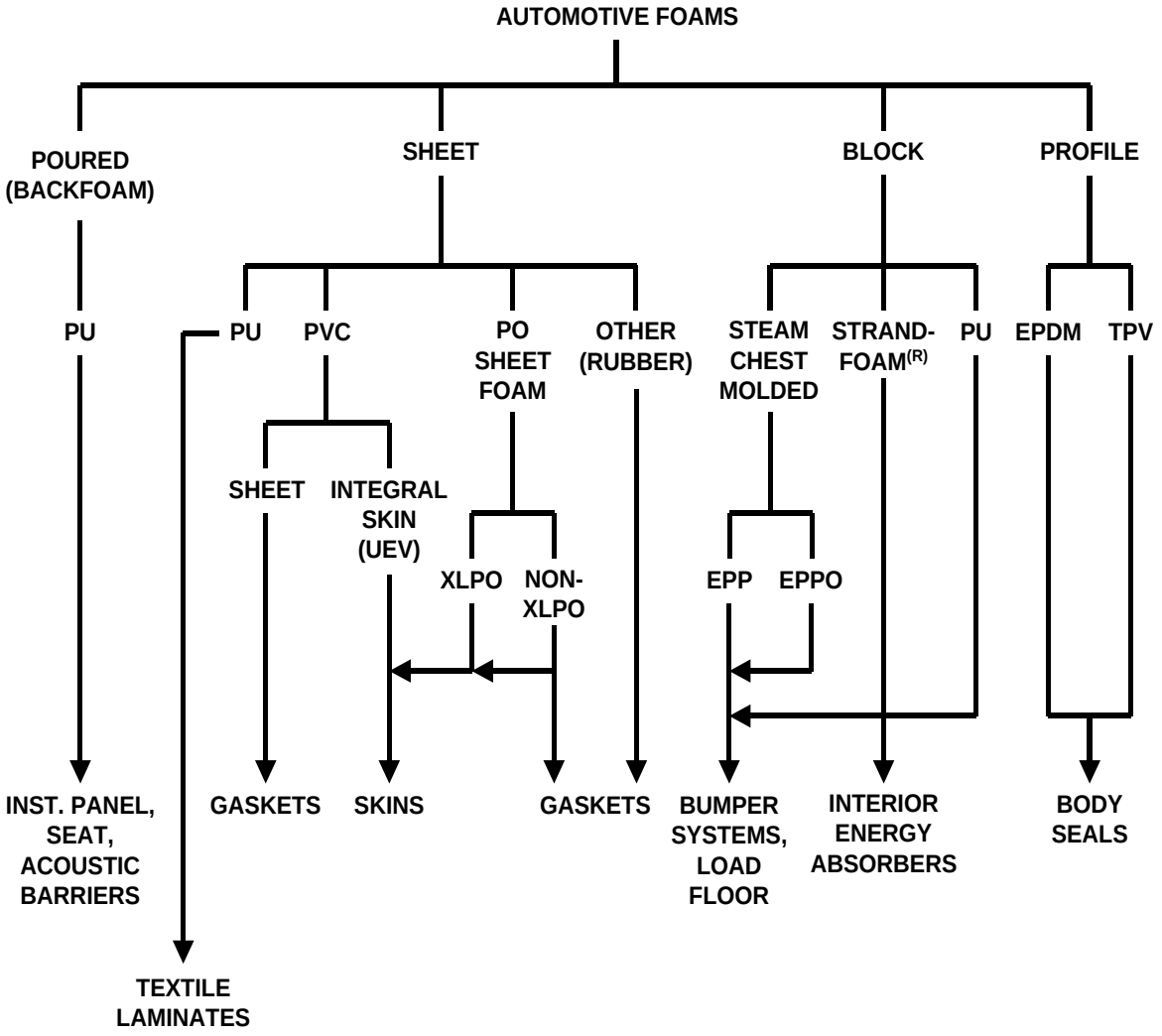
EXHIBIT 3

AUTOMOTIVE FOAM FAMILIES AND EXAMPLE APPLICATIONS



SOURCE: ROBERT ELLER ASSOCIATES, INC. SOFT TRIM MULTICLIENT STUDY, 2003

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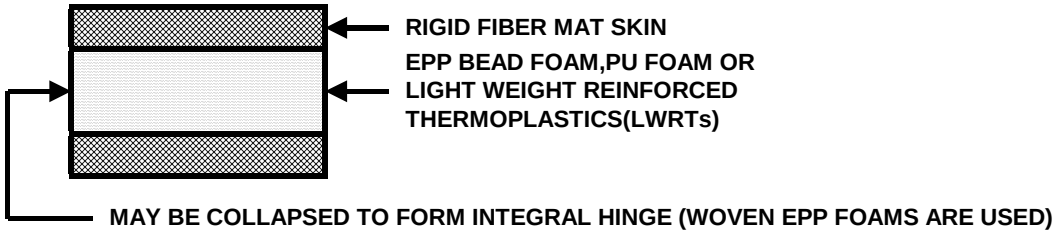
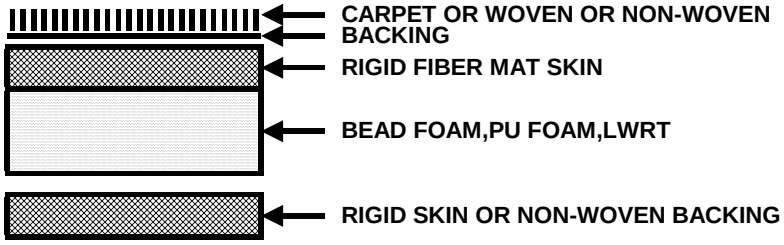
EXHIBIT 4

RIGID SEMI-STRUCTURAL FOAM SANDWICH STRUCTURES

BARE:



CARPET/NON-WOVEN/WOVEN TEXTILE LAMINATE:



SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003

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EXHIBIT 5

DIFFERENCES BETWEEN EUROPE AND N. AMERICAN AUTOMOTIVE FOAM MARKETS AND DRIVING FORCES

FACTOR/SECTOR	EUROPE	N. AMERICA
IP AND DT SKIN/FOAM LAMINATES	HIGHER USE OF XLPO SHEET FOAMS	WILL GROW WITH NEGATIVE THERMOFORM
SHODDY IN FLOOR ACOUSTIC BARRIERS	20% SHARE	50% SHARE (DECLINING)
SUN VISORS	EPP FOAMS	SEVERAL SYSTEMS
LOAD FLOORS	RIGID SKIN/EPP FOAM LAMINATES STARTING	SLOWER START
INTERIOR EA REQUIREMENTS	LOWER (NOT MAJOR DRIVER YET)	MAJOR FOAM DRIVER FOR HEADLINER/DOOR TRIM PANELS
INTERIOR V.O.C. STANDARDS	INCREASING	NOT A FACTOR YET
ZERO SMELL INTERIOR	MATERIALS PERFORMANCE CRITERION	STARTING AS EVALUATION CRITERION
RECYCLING	SIGNIFICANT DRIVER	LESS IMPORTANT
ELV LEGISLATION	IN PLACE	NONE YET
LD-RIM IN DT PANELS	VERY MINOR	SIGNIFICANT USE

SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003