AN AUTOMOTIVE WORLD WITHOUT ELASTOMERS?

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AN AUTOMOTIVE WORLD WITHOUT ELASTOMERS?

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Abstract

The objective of this paper is to examine the role of thermoset rubber (TSR) in the automotive industry and the potential consequences of eliminating rubber. We will:

- Identify the automotive functions and their locations on the vehicle
- Examine the prospects for rubber elimination and substitution
- Identify the challengers to rubber and their interfaces with incumbent TSRs
- Examine the driving forces for substitution
- Evaluate the role of process technology and systems
- Examine the implications of changes in the path to market resulting from rubber substitution.

This presentation is based on several single- and multi-client studies carried out by Robert Eller Associates (REA).

Abbreviations used in this paper are listed in the Appendix.

RUBBER FUNCTIONS AND LOCATIONS ON THE VEHICLE

The systems, functions, and incumbent TSRs used in typical vehicles are shown in Slide 1. As can be concluded from Slide 1, the primary functions of rubber are to:

- Transmit and contain fluids and lubricants
- Transmit power
- Seal various key automotive modules in a manner that allows opening for service
- Absorb vibrations of various frequencies
- Provide shielding against road debris and water.

Some of these functions may diminish in importance with the use of alternative systems such as electronic braking and alternative power systems. For the immediate future, however, conventional internal combustion driven vehicles would not function in the absence of rubber.

The next question is whether the functions can be met by rubber substitutes. The most readily apparent substitutes are thermoplastic elastomers (TPEs). In Slide 1, we have indicated an assessment of the potential for TPEs to replace rubber in the various systems and functions. As indicated, the major potential replacements are likely to be in:

- Body and glazing seals
- Mats and deflectors
- Boots and bellows (already significantly penetrated by TPEs).

To date, there has been limited penetration in the high performance applications such as in the power train. A new generation of high heat/high oil resistant (OR) TPEs are reaching the market, which may have some potential in these applications. It should be noted that a substantial amount of substitution has already occurred in under-hood applications such as grommets and ducting.

The sketch in Slide 2 shows examples of the rubber/TPE interface in typical automotive applications.

Slide 3 identifies the TPE and PVC challengers to rubber in typical applications. TPVs have the potential for challenging rubber over the broadest range of applications due to their performance/price relationship.

In Slide 4, we have quantified rubber usage and type for a range of key automotive functions. The total quantity of rubber per car for these applications is in the vicinity of 22 kg. As is readily apparent from Slide 4, EPDM is the major incumbent likely to see a challenge from TPEs.

THE FAMILIES OF TPEs

Since TPEs appear to be the major challenger to the incumbent position of rubber, it is worth examining the members of the TPE families. A convenient method of viewing the TPE families is presented in Slide 5.

The olefinic TPEs (olefinic TPVs are a member of this family) are the major challengers. The very high-performance TPEs that have been recently introduced to the market are represented on the right side of Slide 5.

DRIVING FORCES FOR TPE SUBSTITUTION

In Slide 6, we have listed the driving forces for substitution of TPEs for incumbent TSRs. The path-to-market differences between TPEs and TSRs result in some surprising driving forces.

Product Uniformity/Supplier Base – For the present, most TPEs are purchased as ready-made compounds with a standard grade number from TPE compounders. As such, they can be processed by conventional thermoplastics processors, thus greatly expanding the range of potential suppliers to the OEMs. This expanded supplier base offers OEM automotive manufacturers the opportunity for increasing price pressure as compared to the relatively smaller population of fabricator/compounders represented by the present TSR path to market.

Color/Aging – The ability to color TPEs has emerged as a significant driving force in the TPV vs. TSR body seal competition. TPEs offer the potential, for example, of a glass run channel or belt line molding which matches body color. The chemical nature of olefinic TPEs in particular appears to offer better long-term aging properties than TSRs, especially in the body seal applications.

Processing/System Cost Savings – TPEs are more expensive on a cost/kilo basis than incumbent TSRs. Substitution must, therefore, be on the basis of improved properties (color/aging), system cost savings, or the inherent fabrication capabilities of TPEs that results from their thermoplastic nature. Some examples of approaches to these system costs savings for both materials and processes are shown in Slide 7. An example of the ability to combine rigid and flexible materials in a single value-added system is illustrated in Slide 8.

PATH TO MARKET

The TPE compound supplier would, of course, like to supply ready-made compounds to potential customers in the rubber industry. As illustrated in Slide 9, these potential customers are currently actively involved in captive TSR compounding. The TPE compound supplier is thus faced with a range of options not available to suppliers of conventional rubber raw materials. The TPE supplier may opt to supply:

- Compound to incumbent TSR fabricator/compounders.
- TPE masterbatch which can be let down by the captive compounder/fabricator. This approach will be acceptable, assuming that the captive TSR compounder/fabricator does not learn how to make the TPE challengers in-house or if the volume remains low. (An illustration of this path to market is shown in Slide 10.)
- TPE compound to some of the numerous thermoplastics processors seeking entry into the marketplace.

OEMs are thus presented with an expanded materials and supplier base and the associated dynamics of competitive price leveraging.

TPE ENABLING TECHNOLOGIES

Some of the technologies that will enable TPEs to penetrate the marketplace are illustrated in Slide 11. Foaming of TPE profiles for body seals, while substantially improved over earlier generation water-blown methods, still remains more difficult to control for TPEs as compared to TSRs due to the lower viscosity of TPEs during the critical blowing stage. Recent technical advances in obtaining microcellular foams via supercritical fluids could present a breakthrough that will allow more rapid penetration of the foam profile sector by TPEs.

Note that decoration and color are among the significant advantages offered by TPEs. Slide 12 offers some visual examples of value-added decoration with TPEs as compared to the all-black option presented by conventional carbon black loaded TSRs. These implications apply to body seals and in-mold decorative sheet beginning to penetrate the non-carpet floor systems in both Europe and the U.S.

TPE PRICING

The prices for TPE compounds are higher than for TSR compounds. The price of TPEs thus becomes a key issue. In Slides 13 and 14, we have indicated some of the factors that will allow TPE price increases and pressures resulting in a price decrease.

PROPERTIES

Compression Set -- Compression set and hardness are two key properties required for the various rubber functions previously illustrated. A comparison of the compression set/hardness map for some typical TPEs, PVC compounds, and typical sulfur cured rubbers is shown in Slide 15.

Stress Relaxation -- The heat resistance/stress relaxation behavior of current generation TPEs is generally inferior to that of TSRs. This is a major impediment to TPE penetration in many rubber applications.

Heat/Oil Resistance – The heat resistance/oil resistance of conventional TPEs is not equal to that of comparable high performance TSRs as shown by the well known heat resistant vs. oil swell graph illustrated in Slide 16. Recent developments have moved some TPEs up into the high heat/high oil resistance range. As illustrated in Slide 17, these new TPE classes include fluoroelastomers, silicones, and acrylics. The NBR-based TPVs have been available for some time.

Property Envelope – A summary of the broadening of the TPE property envelope is shown in Slide 18.

OTHER CHALLENGERS

TPEs must compete with other challengers for both incumbent rubber markets and for non-rubber targets, as illustrated in Slide 19. The growth of TPEs in both TSR and non-TSR applications could increase the use of neat rubber.

PVC is among the incumbents being targeted by TPEs. The PVC applications are illustrated in Slide 20.

Acoustics performance requirements for both drive-by noise and airborne interior noise are increasing. Systems cost economics suggest that the acoustics function be efficiently integrated into the modular design. These trends (see Slide 21) will enhance the penetration of TPEs (often in competition with polyurethanes).

BODY AND GLAZING SEALS

Body and glazing seals have emerged as a major intermaterials competition zone between TPEs and TSRs, as illustrated by Slides 22 and 23. The major TPEs competing in this sector are olefinic TPVs and, to a minor extent, SEBS-type TPEs.

THE AUTO INTERIOR

The auto interior is not a current major user of TSRs. It is, however, a major zone for intermaterials competition and growth of TPEs. The growth of the invisible airbag door (see forecast in Slide 24) will be among the driving forces for growth of olefinic and other TPEs for instrument panel and door trim skins (about 5 kg/vehicle). In the case of olefinic TPEs, this could bring in EPDM and plastomers. The current dynamics of material substitution trends in European vacuum formed skins from our recent photo/supplier database are illustrated in Slides 25 and 26.

SUMMARY

Rubber is used in 500-700 parts/vehicle to meet a number of fundamental automotive requirements. The rubber function is unlikely to be eliminated. In a number of applications, incumbent TSRs are being challenged by TPEs. About 22 kg/vehicle can be identified as a current battleground. EPDM is the major target. As a result of a number of competitive pressures and technology shifts, prices for TPEs are likely to erode.

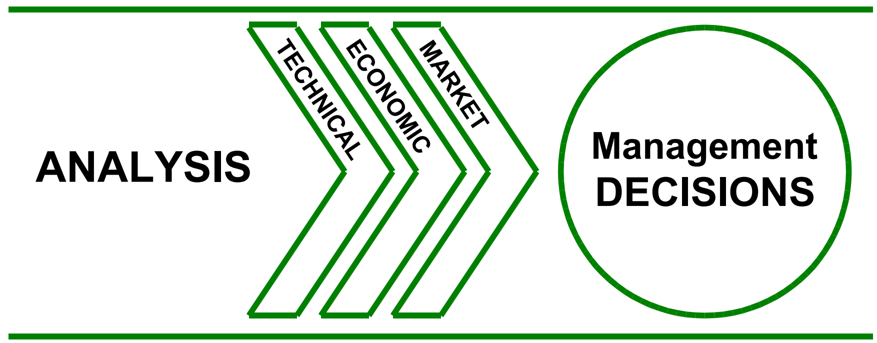
The penetration of TPEs into traditional TSR segments represents a new competitive dynamic in the relationship between automotive OEMs, Tier 1s, and material suppliers. TPEs present the opportunity for a broadened supplier base, change in the path to market, and OEM price pressures. The ability of TPEs to be used in modular systems enhances their value and penetration potential.

Although the prices for TPEs are higher than for incumbent TSRs, there are a number of substitution drivers that enhance their penetration potential. In the U.S., recycling is not a significant material substitution driving force for TPEs vs. TSRs. Our research indicates that it is, however, a significant driver in the European market.

TPE substitution has the potential for replacing TSR in a limited number of applications and also replacing non-rubber incumbents. Both of these replacement opportunities offer the potential for enhanced rubber usage as a component of olefinic TPEs.

ABBREVIATIONS USED IN THIS PAPER

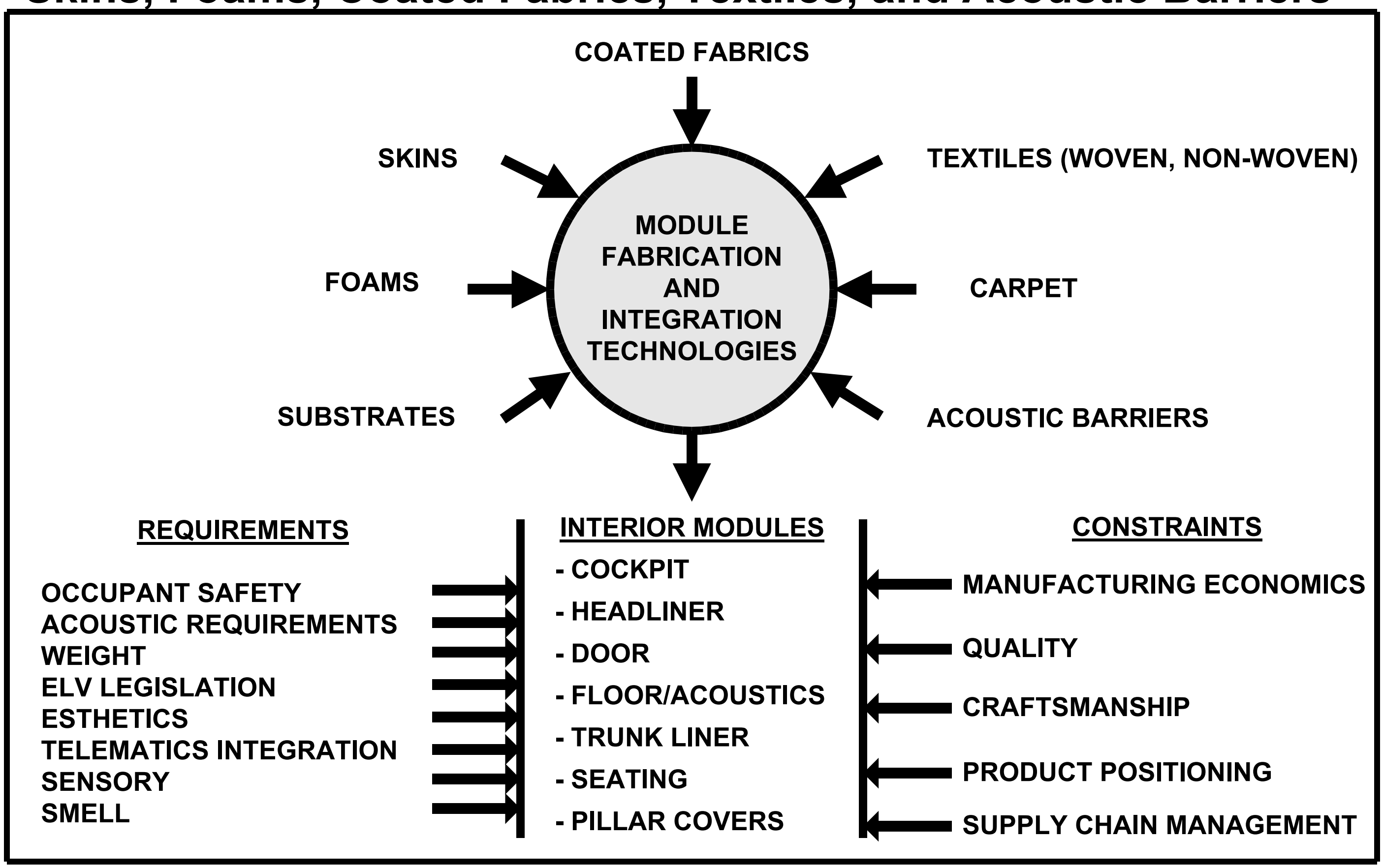
COPE	-	Copolyester type TPEs
F-TPV	-	Fully (>94%) vulcanized TPV
M-PO	-	Metallocene polyolefins
O-TPE	-	Olefinic TPE, thermoplastic elastomers based on olefins
P-TPV	-	Partially (<94%) vulcanized TPV
Physblend TPO	-	TPO based on compounded EPDM and PP
R-TPO	-	Reactor copolymers-based TPO
SEBS	-	Styrene-ethylene-butadiene-styrene TPEs
TPO	-	The general class of unvulcanized olefinic TPEs
TPU	-	Thermoplastic urethane



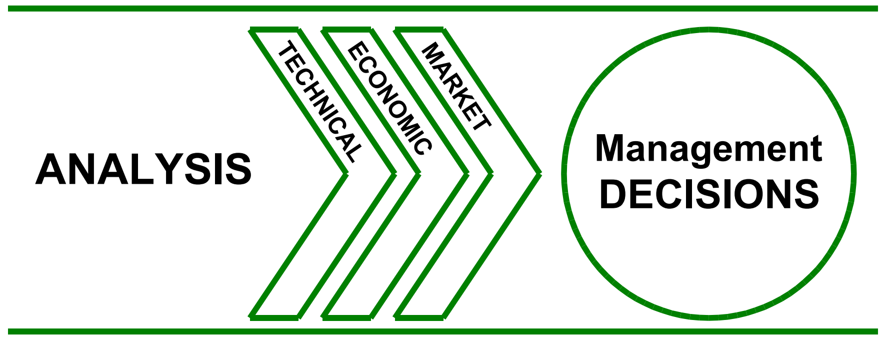
APPENDIX 1

Automotive Interior Soft Trim:

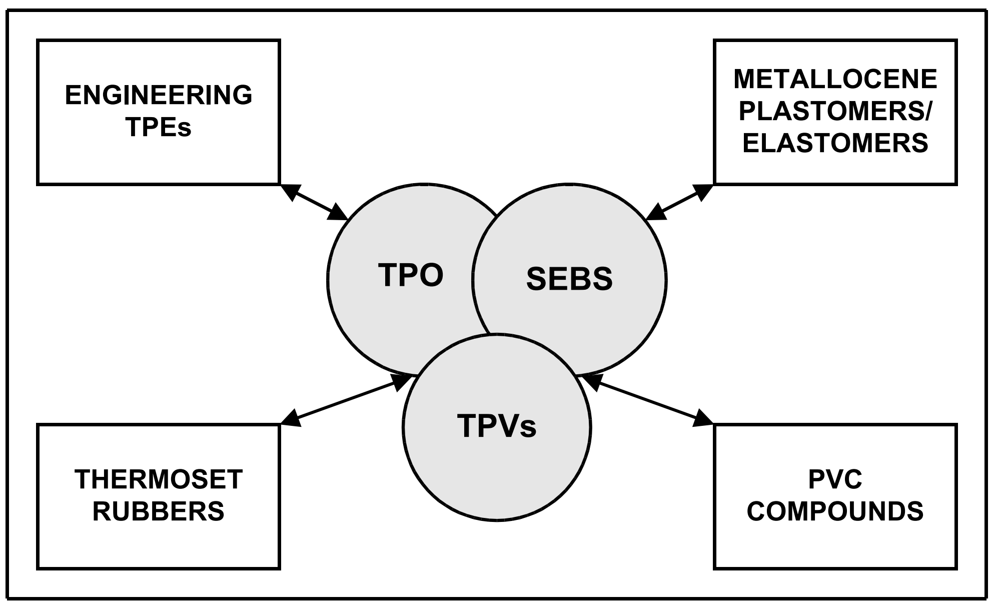
Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers



APPENDIX
2



SEBS, TPV, and TPO-type Thermoplastic Elastomers ... Markets, Economics, Technology, Intermaterials Competition, and the Role of Metallocene Resins



Prospectus for a Euro/US/Japan Multiclient Industry Analysis

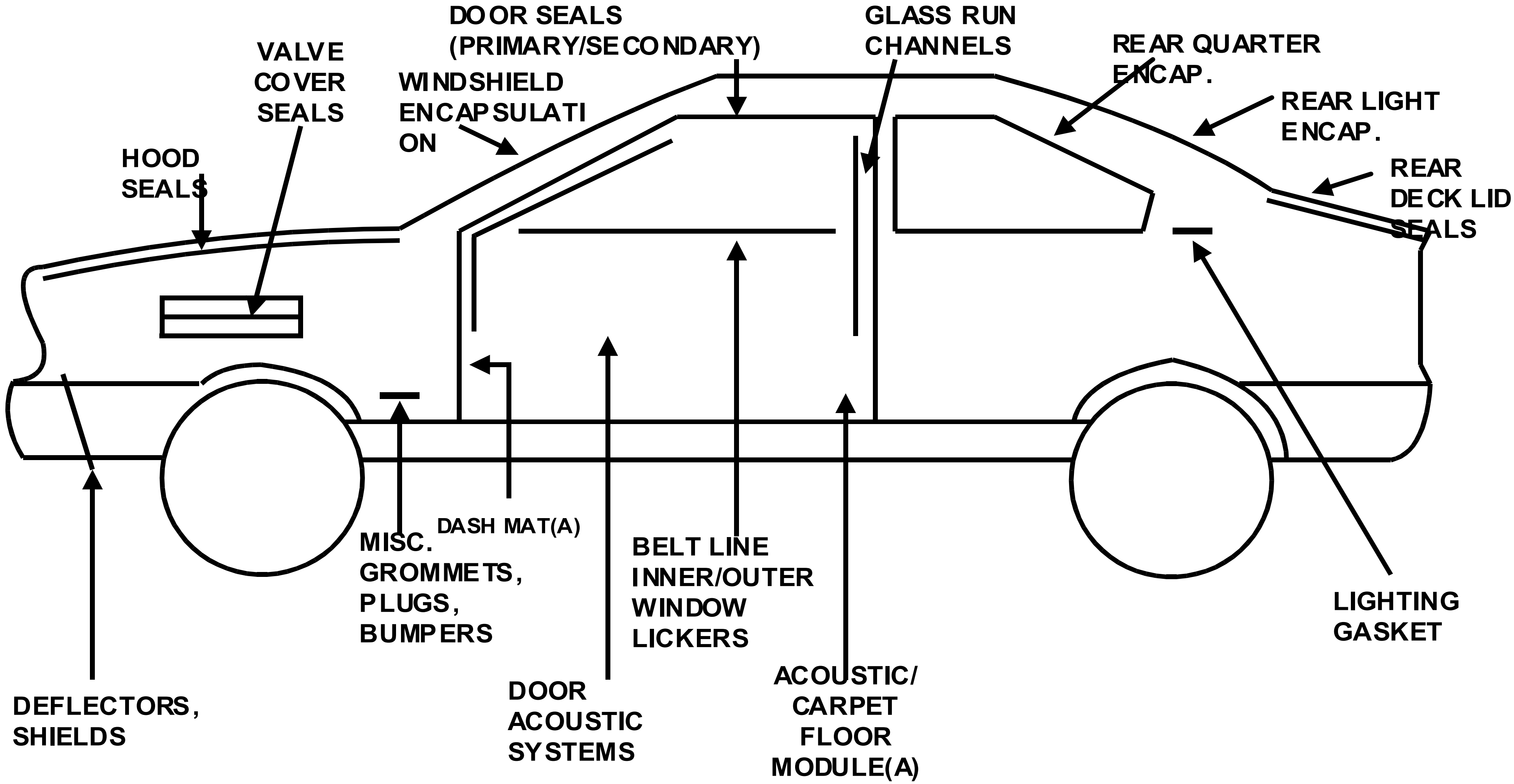
Robert Eller Associates, Inc.

CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

WHERE IS THE AUTO RUBBER?

SYSTEM	FUNCTION	INCUMBENT	TPE?
P. TRAIN	FUEL	SS, NYLON, PTFE, AEM	FLUORO TPEs ?
	ENGINE	SIL, ACM, AEM	NO
	TRANSMISSION	ACM, NBR, SIL, AEM	VERY MINOR
HVAC	COOL	EPDM, SILICONE	NO
	AC	TP VENEERS, CSM,CPE	NO
SEAL	BODY/GLAZE	EPDM, PVC	YES (MAJOR)
SUSPENSION	MOUNTS	NR, HIIR	NO
BRAKES	HOSE	EPDM	NO
MATS/DEFLECTORS		SBR, EPDM, NR(RECLAIM)	R-TPV, TPO
BOOTS/BELLOWS		EPDM	YES (MAJOR)
HOSE	FTS	EPDM, CSM,NBR,AEM,CPE	LIMITED (OR-TPVS?)
BELTING		CR, CSM, H-NBR, EPDM	START?

TPE/RUBBER COMPETITIVE INTERFACE IN AUTO APPLICATIONS



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2002

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CHALLENGERS TO MAJOR AUTOMOTIVE RUBBER APPLICATIONS

APPLICATION	CHALLENGER							
	PVC	TPV	SEBS	TPO	TPU	COPE	r-TPV	OTHER
ACOUSTIC BARRIERS			X					
BELTING		X			X	X		
BODY SEALS		X	X					
BOOTS/BELLOWS		X				X		
DAMPER MOUNTS		X	X					
ELECTRIC		X	X					
FLOOR MATS				X				
FUEL SYSTEMS								X
GLAZING SEALS	X	X	X					
HIGH PERF. GASKETS								X
INTERIOR SKINS		X		X	X			
NON-CARPET FLOOR				X				
UNDERHOOD DEFLECTORS							X	X

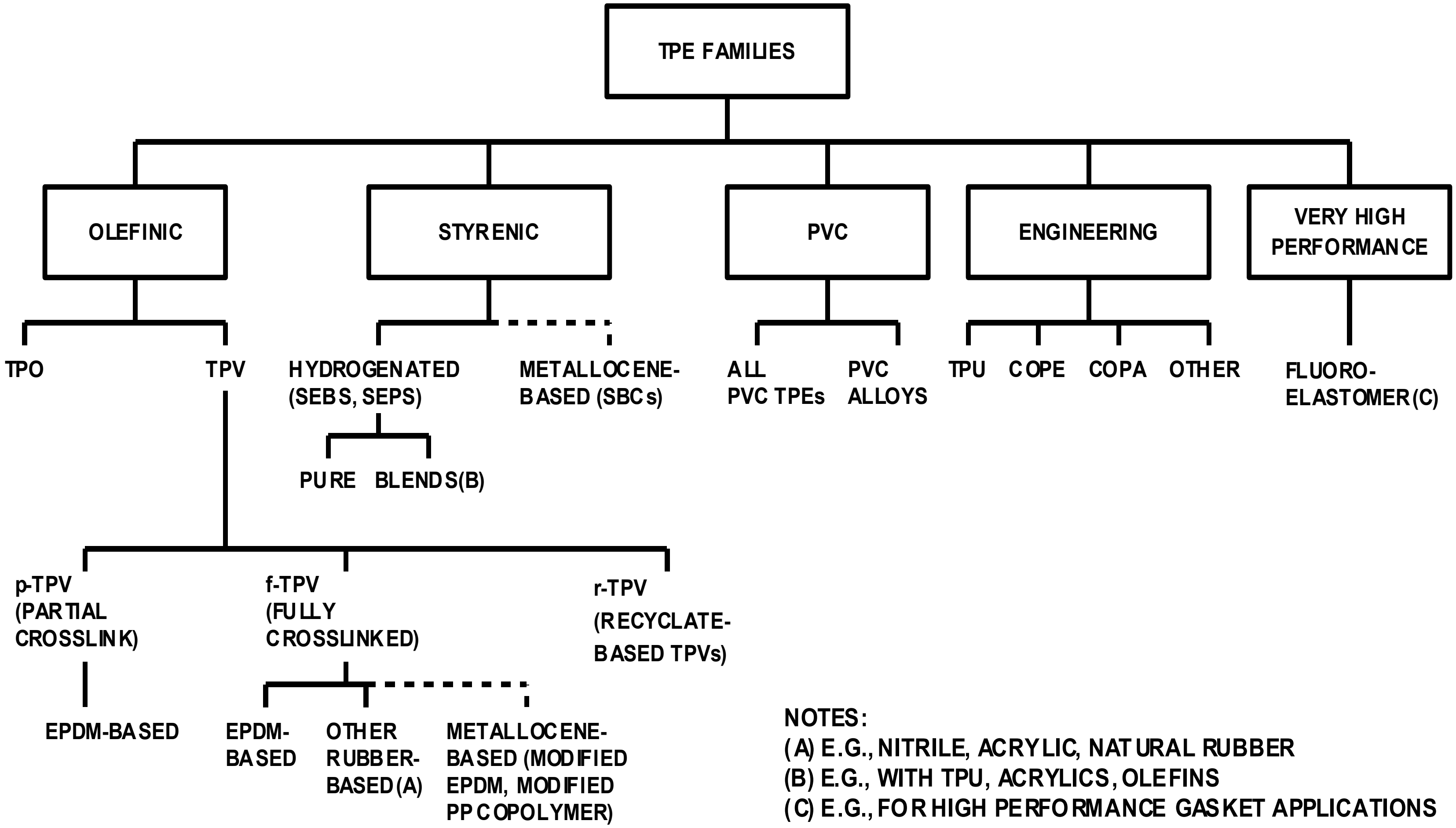
SOURCE: ROBERT ELLER ASSOCIATES TPE AND SOFT TRIM MULTICLIENTS

QUANTITY/VEHICLE FOR AUTOMOTIVE RUBBER INCUMBENTS/TARGETS FOR TPEs

APPLICATION	EPDM	CR	NBR	SBR	TOTAL Kg/CAR
BODY/GLAZE SEAL	X	X		X	8.0
BOOTS/BELLOWS	X	X	X	X	2.1
MATS	X	X		X	2.1
UNDER-HOOD : DEFLECTORS	X			X	5.0
DUCTING	X				0.7
CONNECTORS/TUBING	X				0..3
POWER TRAIN GROMMETS	X				0.1
ELECTRIC	X	X		X	1.5
FUEL SYSTEMS		X			
DAMPER MOUNTS	X	X	X	X	2.4
BELTING	X				-
HIGH PERF. GASKETS					-
TOT., Kg/VEHICLE	**12.6**	**3.4**	**1.0**	**5.2**	**22.2**

SOURCE: ROBERT ELLER ASSOCIATES TPE MULTICLIENT

THE TPE FAMILY STRUCTURE



NOTES:
(A) E.G., NITRILE, ACRYLIC, NATURAL RUBBER
(B) E.G., WITH TPU, ACRYLICS, OLEFINS
(C) E.G., FOR HIGH PERFORMANCE GASKET APPLICATIONS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2002

DRIVING FORCES FOR TPE SUBSTITUTION

- PERCEIVED PRODUCT UNIFORMITY
- EXPANDED SUPPLIER BASE (PRICE EFFECTS)
- COLOR/DECORATION
- SYSTEMS COST SAVE ?
- THERMOPLASTIC PROCESSING
  -BLOW MOLD
  -RIGID/FLEXIBLE COMBINATIONS
- IMPROVED LONG-TERM AGING
- WEIGHT SAVE
- LOW V.O.C. INTERIOR
- RECYCLING (US?, SIGNIFICANT EUROPE)

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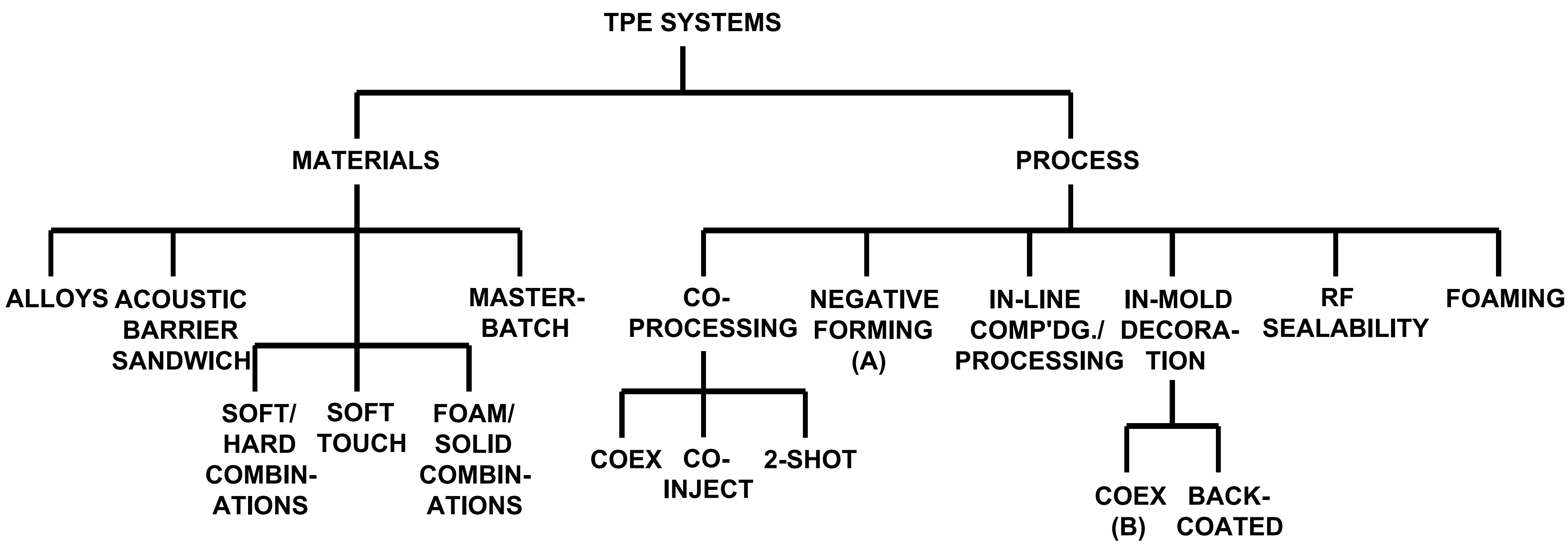
EXAMPLES OF TPE GROWTH/VALUE-ADD OPPORTUNITIES VIA SYSTEMS

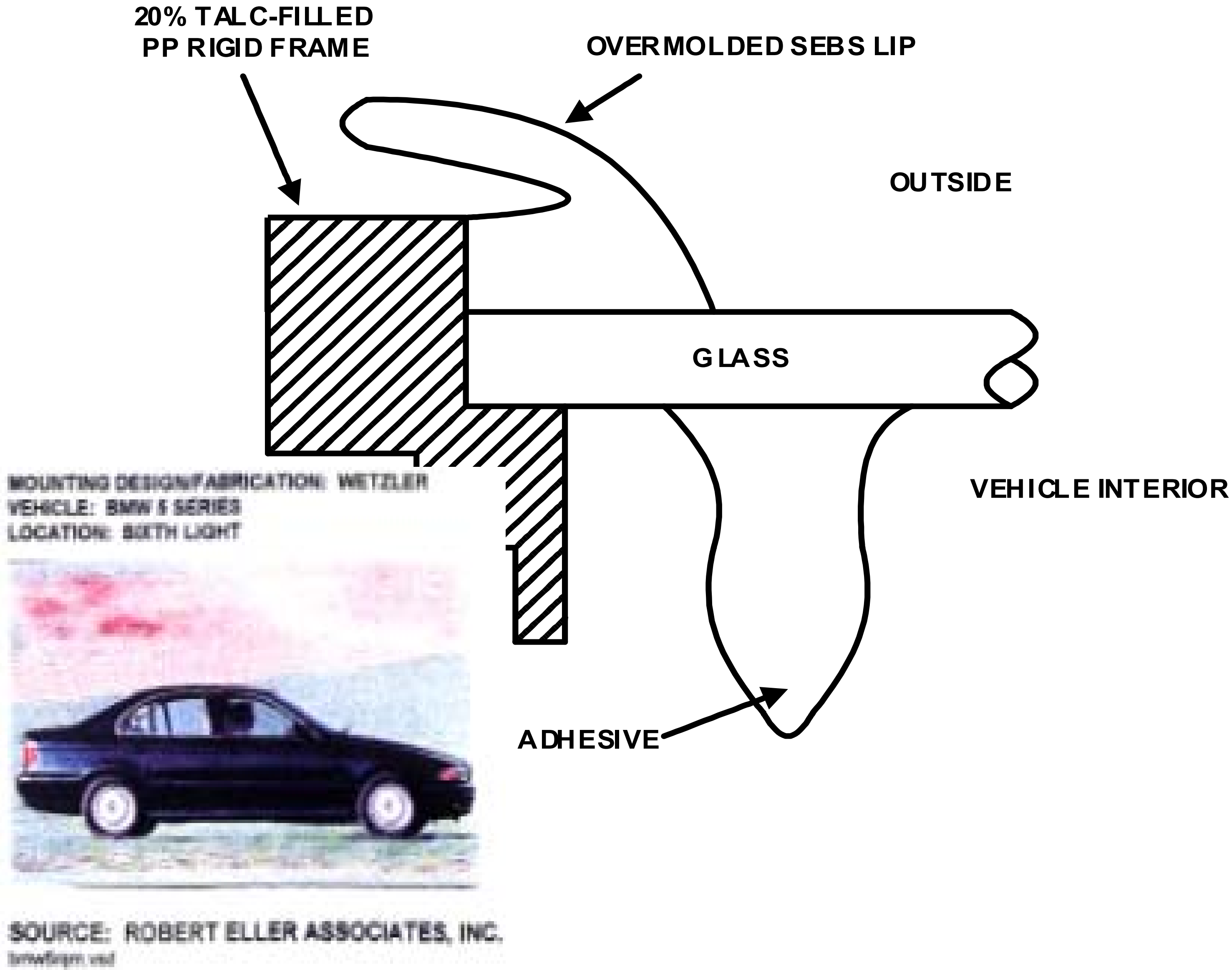


NOTES:
(A) OF IP SKINS BY VISTEON AND OTHERS
(B) FOR AUTOMOTIVE APPLICATIONS; TPEs COMPETING WITH ETP FILMS

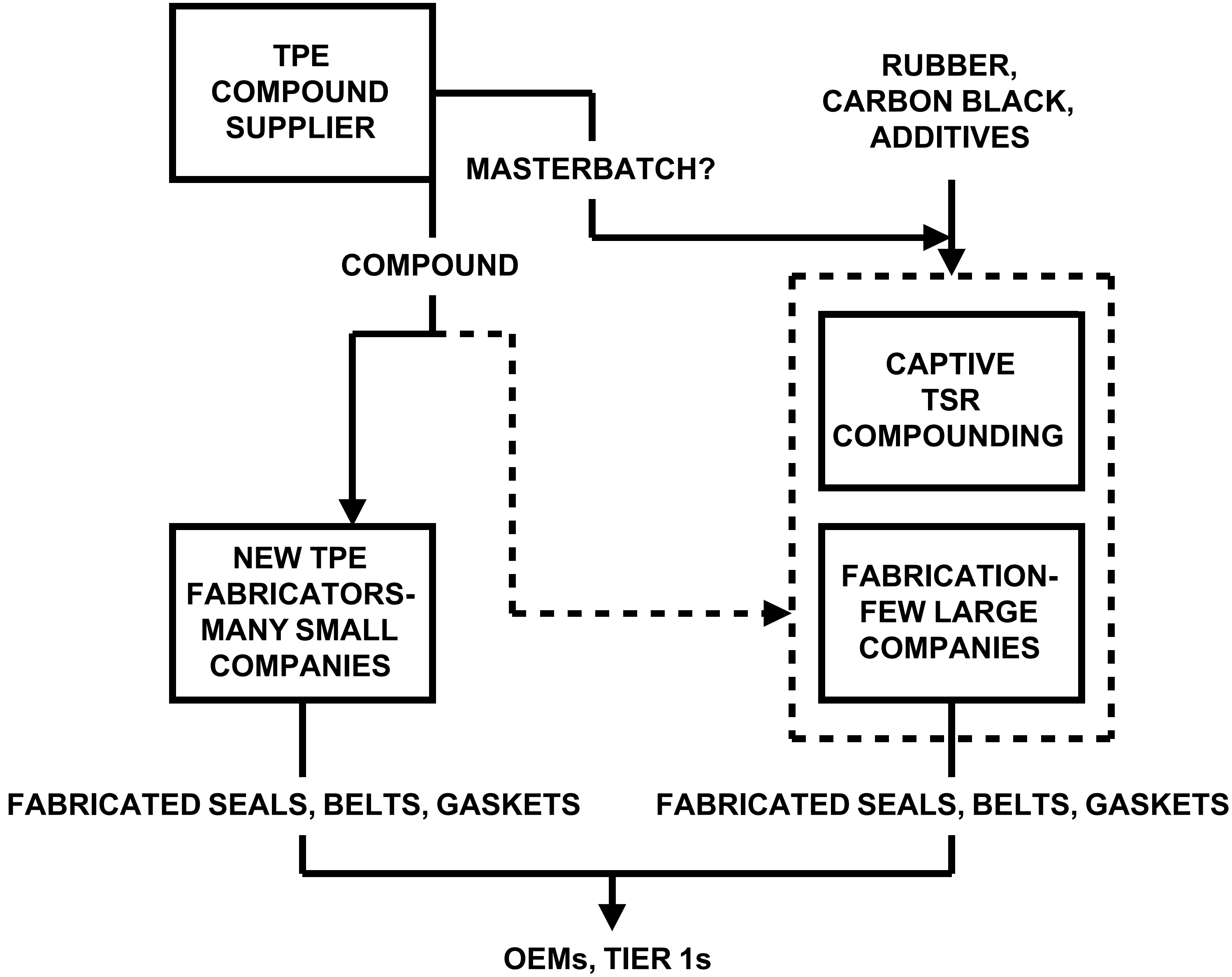
SOURCE: ROBERT ELLER ASSOCIATES, INC., 2002

tpegrowth 02.vsd

EXAMPLE OF RIGID/FLEXIBLE TPE VALUE ADDED SYSTEM



TPE vs. TSR -- SHIFTING SUPPLY CHAIN DYNAMICS

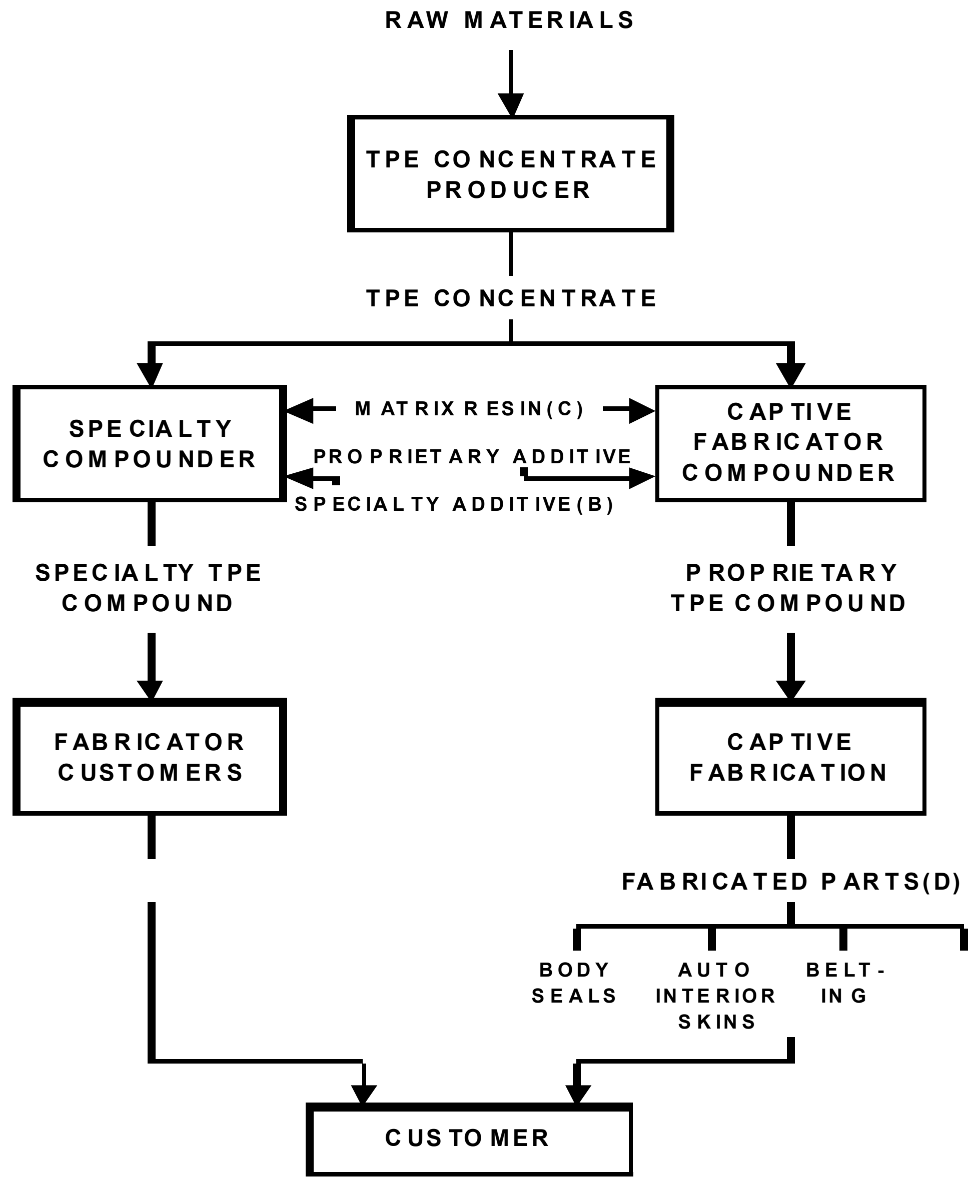


SOURCE: ROBERT ELLER ASSOCIATES, INC., 2002

tpevtsrshift02.vsd

PATH-TO-MARKET SHIFT FOR TPE COMPOUNDS

NEW PATH



SOURCE: ROBERT ELLER ASSOCIATES, INC. TPE MULTICLIENT

TPE ENABLING TECHNOLOGIES

- FOAMING (SHEET FOAM, PROFILES)
- CONTROLLED ACOUSTICS (FLOORS)
- MOLDED-IN DECORATION (FLOORS, SKINS)
- IN-MOLD DECORATION (PAINT AVOIDANCE)
- TWO-SHOT MOLDING (IP, DOOR TRIM, DUCT)
- 3D AND MULTI-MAT'L BLOW MOLDING

VALUE-ADDED DECORATION WITH TPEs

RUBBER:

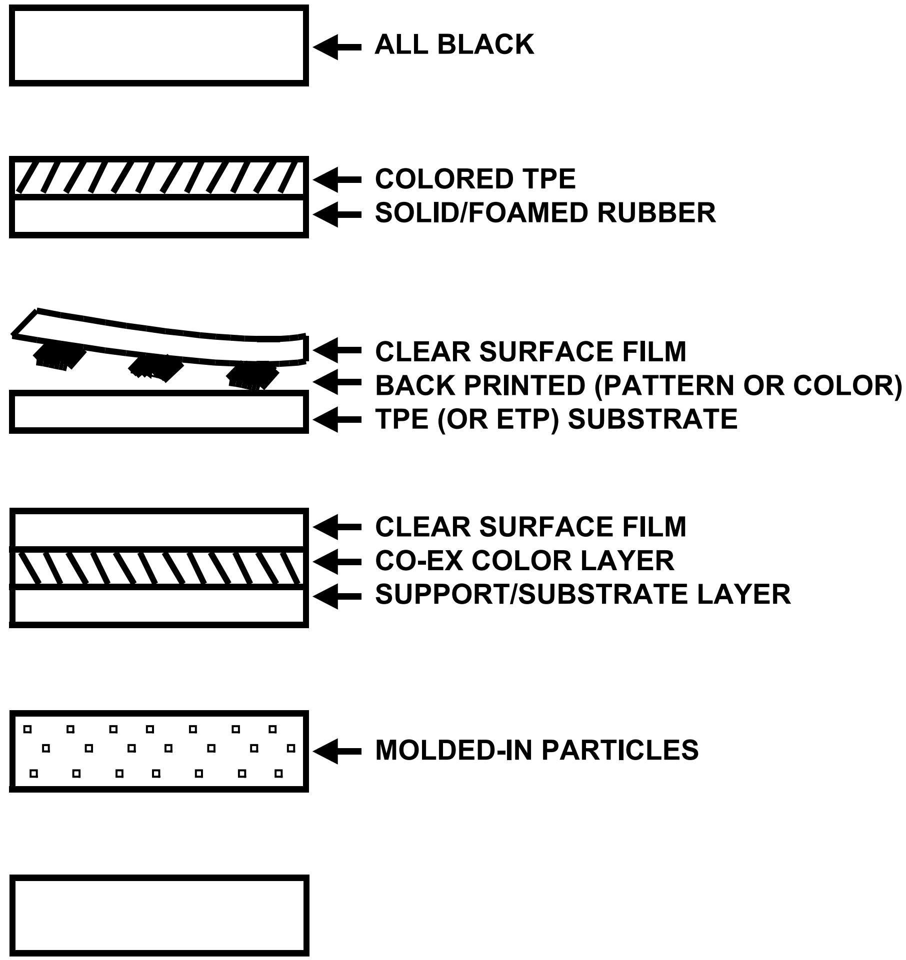
TPE VENEER:

IN-MOLD DECORATION (IMD):
BACK-PRINTED LAMINATES

IN-MOLD DECORATION (IMD):
CO-EX FILM/SHEET

MOLDED-IN DECORATIVE
(MID) EFFECTS:

TRANSPARENT



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2002

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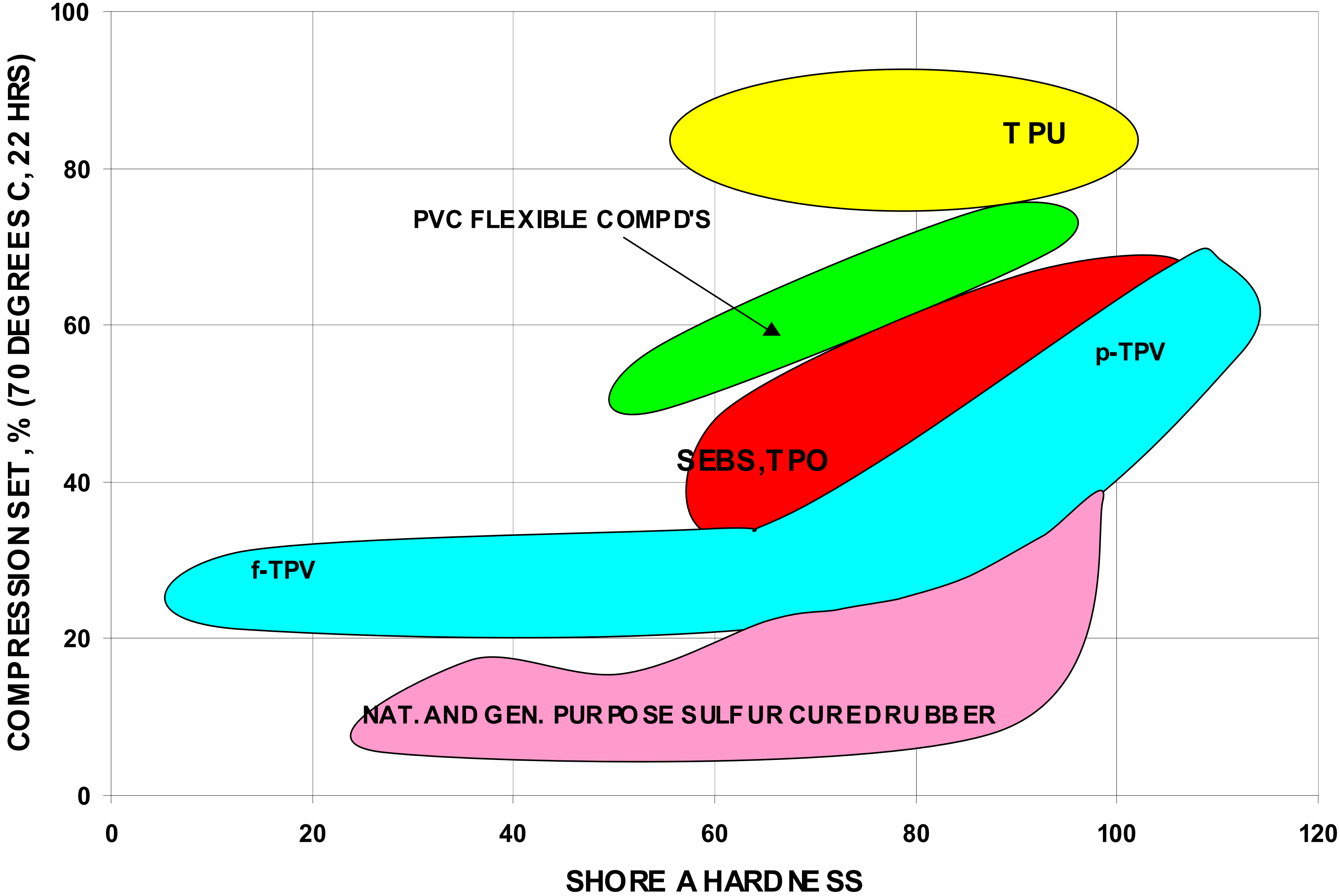
TPE PRICE INCREASE ENABLERS

- ENTRY INTO NEW SECTORS (BELTING, SEALS, HIGH PERFORMANCE GASKETING)
- OFFERING MATERIALS/PROCESS SYSTEMS
- INCREASED FUNCTIONAL VALUE (COLORS)
- BROADENED PROPERTY ENVELOPE (LOWER HARDNESS, BETTER COMPRESSION SET)
- TPV CONCENTRATES
- FOAMING
- LONG TERM AGING

TPE PRICE DECREASE PRESSURES

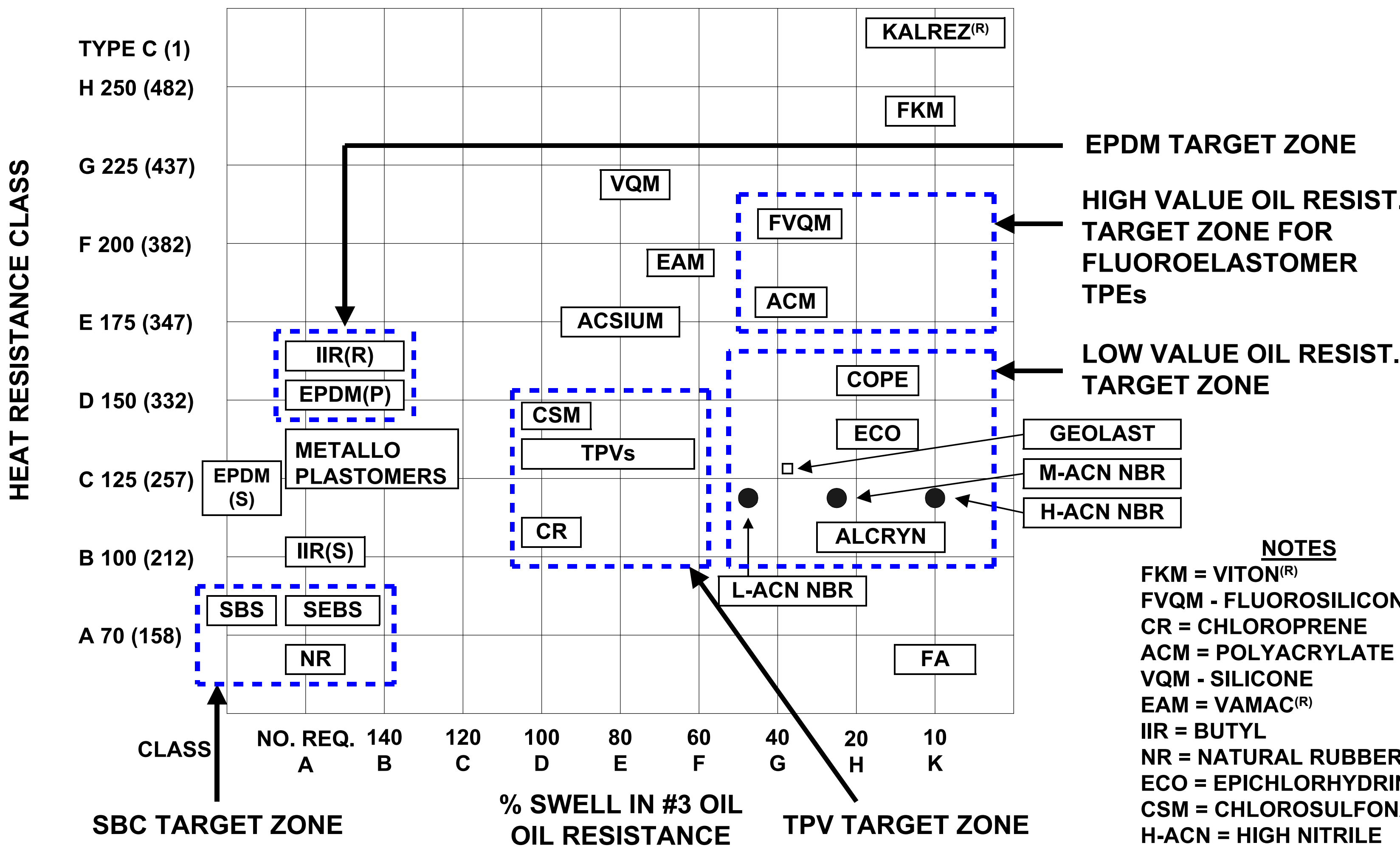
- RECESSIONARY GLOBAL ECONOMY
- BASE RESIN PRICE DECREASE (IN 2001)
- BROADENED MATERIAL/SUPPLIER BASE
- BACK INTEGRATION TO COMPOUNDING BY FABRICATORS
- PURCHASE POWER OF GLOBAL CUSTOMERS
- PROLIFERATION OF TPV TECHNOLOGY
- MARKET ENTRY BY ASIAN TPE PRODUCERS
- REACTOR-BASED COMPOUNDS

C-SET VS HARDNESS FOR TPEs AND RUBBER



SOURCE: ROBERT ELLER ASSOCIATES TPE MULTICLIENT

OIL RESISTANCE/HEAT RESISTANCE OF TPEs AND THERMOSET RUBBERS



NOTES

FKM = VITON(R)
FVQM - FLUOROSILICONES
CR = CHLOROPRENE
ACM = POLYACRYLATE
VQM - SILICONE
EAM = VAMAC(R)
IIR = BUTYL
NR = NATURAL RUBBER
ECO = EPICHLORHYDRIN
CSM = CHLOROSULFONATED PE
H-ACN = HIGH NITRILE
FA = THIOKOL
(S) = SULFUR CURE
(P) = PEROXIDE CURE
(R) = RESIN CURE

SOURCE: ROBERT ELLER ASSOCIATES, INC. TPE MULTICLIENT

tpetsrorhr 02.vsd

EXPANDING THE OIL /TEMP RANGE OF TPEs

- THERMAL/DYNAMIC PROPERTIES OF TSRs UNLIKELY TO BE REPLACED BY TPEs (WITHOUT SEVERE PRICE PENALTY)

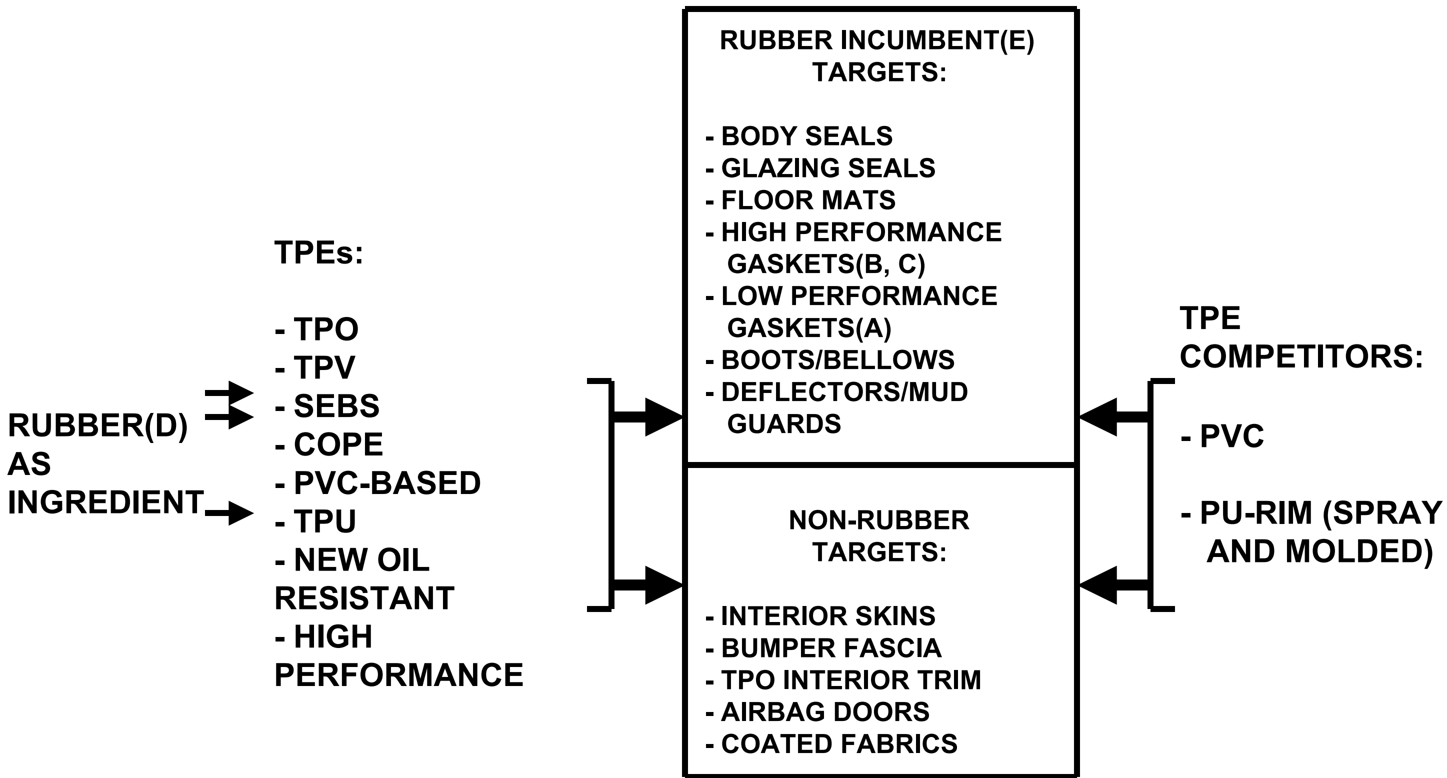
- NEW CLASSES OF TPEs ENTERING THE OR, HR SECTORS

- THESE TPEs ENTERING TO CHALLENGE TSRs INCLUDE:
  - VQM-TPVs (SILICONE)
  - FKM-TPVs (FLUOROELASTOMER)
  - ACM-TPVs (ACRYLIC)
  - NBR-TPVs

TPE PROPERTY ENVELOPE BROADENING

- **COMPRESSION SET -** ***ADEQUATE***
- **HEAT RESIST/STRESS RELAX -** ***FLUORO TPEs ENTERING***
- **ADHESION -*****FIBERS, GLASS, SUBSTRATES***
- **HARDNESS -** ***SOFTER GRADES ENTERING, SOFT TOUCH***
- **SURFACE QUALITY -** ***IMPROVED/FOAMING***
- **FUEL RESISTANCE -** ***FUEL RESISTANT GRADES ENTER***
- **LONG-TERM AGING-*****IMPROVED vs. EPDM (S,PEROX CURE)***
- **FOAM QUALITY -** ***MAJOR IMPROVEMENT → NEW MKTS.***
- **DECORATION/COLOR -** ***SIGNIFICANT TPE DRIVER***

TPE/RUBBER AUTOMOTIVE INCUMBENTS AND CHALLENGERS



NOTES:
(A) E.G., LIGHTING
(B) E.G., VALVE COVER
(C) E.G., FLUOROELASTOMER-BASED TPEs
(D) E.G., EPDM, NITRILE, ACRYLIC
(E) E.G., EPDM, SBR, NITRILE, CHLOROPRENE, SILICONE, POLYURETHANE, FLUOROELASTOMERS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2002

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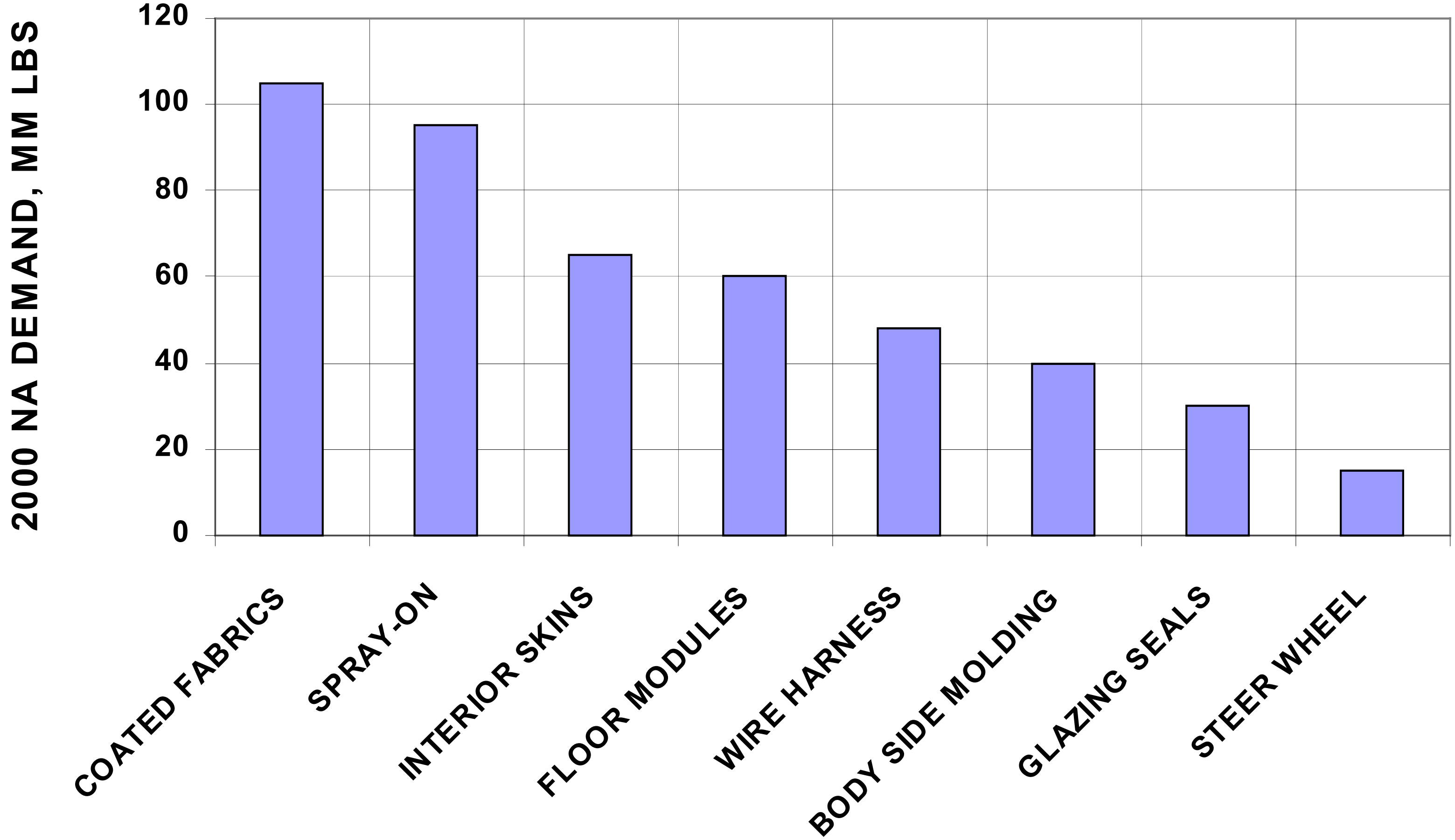
PVC AUTO APPLICATIONS/VULNERABILITY



SOURCE: ROBERT ELLER ASSOCIATES, INC., TPE MULTICLIENT

ACOUSTICS

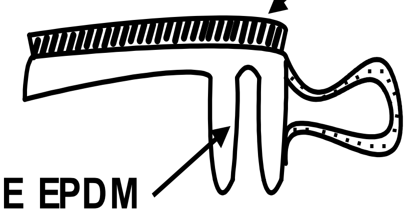
- SEBS, PU, ASPHALTICS ARE INCUMBENTS
- MULTI-LAYERS (LOW/HIGH DENSITY)
- CURRENTLY AN “ADD-ON”
- TREND TOWARD “ON BOARD” ACOUSTICS
- GROWTH IN PLASTOMERS AND TUNABLE PU
- ALL PO CARPET/ACOUSTIC SYSTEMS (EUROPE)
- PERFORMANCE REQUIREMENTS INCREASE
- OPPORTUNITY FOR TPEs AND PLASTOMERS

BODY AND GLAZING SEALS

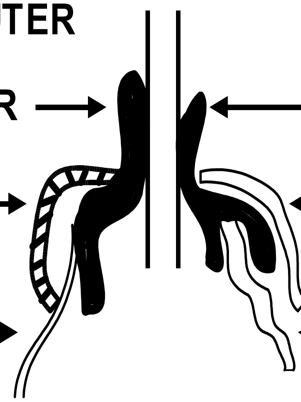
- TARGET MKT. IS 240-280 kT IN EUROPE AND N. AMERICA
- THE STRONGHOLD OF EPDM
- PVC, PU-RIM COMPETE
- PARTS INTEGRATION, COLOR, AGING, MAJOR DRIVERS
- COLORED EPDM PERFORMANCE LIMITED
- TPVs LIKLEY TO DOMINATE BODY SEALS
- PROPERTIES ARE ADEQUATE
- TPV AND SEBS WILL COMPETE IN GLAZING SEALS
- PATH TO MARKET BATTLE LOOMING
- TPE FOAM CONTROL/C-SET LIMIT PRIMARY/SEC DOOR SEALS THUS FAR

CROSS-SECTIONS OF BODY SEALS

PRIMARY DOOR SEAL WITH TPE VENEER:



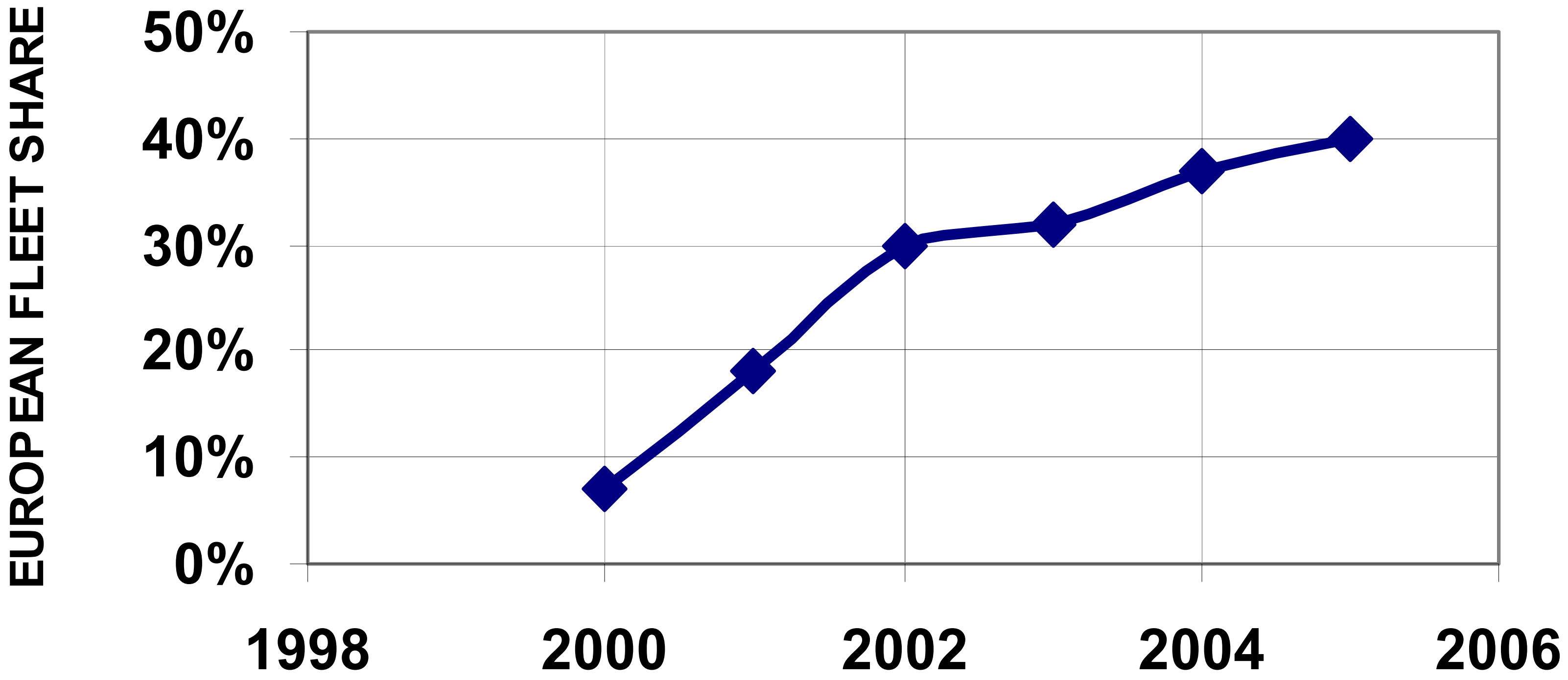
OUTER/INNER BELT MOLDINGS:



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2000

bdyslxsec slide 02.vsd

SHARE OF EUROPEAN FLEET WITH INVISIBLE AIRBAG DOORS



SOURCE: ROBERT ELLER ASSOCIATES EUROPEAN INSTRUMENT PANEL DATA BASE

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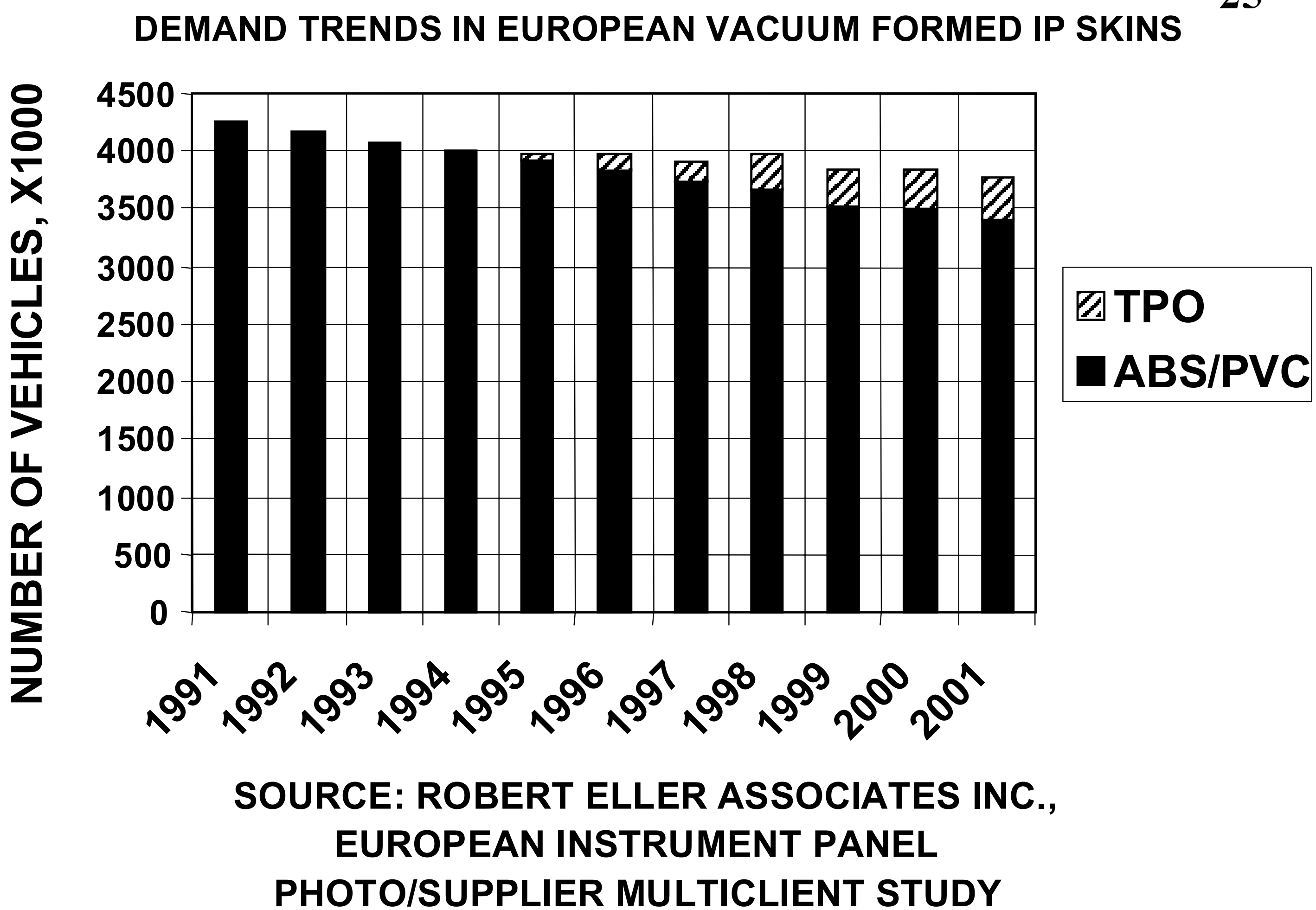
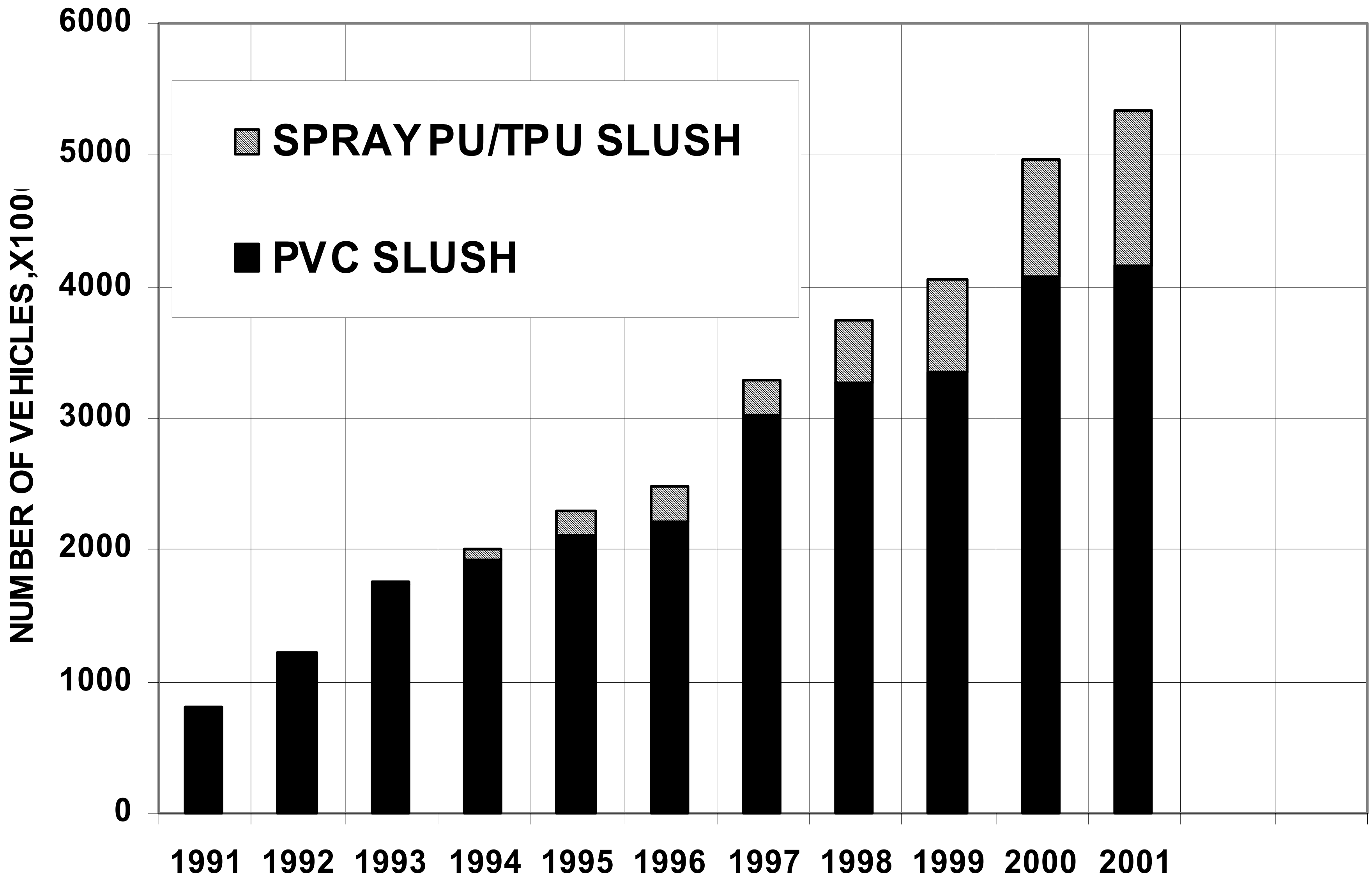

DEMAND TRENDS IN EUROPEAN VACUUM FORMED IP SKINS
NUMBER OF VEHICLES, X1000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
TPO
ABS/PVC
SOURCE: ROBERT ELLER ASSOCIATES INC.,
EUROPEAN INSTRUMENT PANEL
PHOTO/SUPPLIER MULTICLIENT STUDY

DEMAND TRENDS IN EUROPEAN SLUSH MOLDED IP SKINS



SOURCE: ROBERT ELLER ASSOCIATES INC.,
EUROPEAN INSTRUMENT PANEL PHOTO/SUPPLIER MULTICLIENT STUDY