ENGINEERED PLASTICS WORKSHOP

Learn About Thermoplastics I Connect with Experts

2017 WESTBOROUGH / MASSACHUSETTS
(BOSTON AREA)

YOUR GLOBAL COMPOUNDER OF
CUSTOM ENGINEERED THERMOPLASTICS

RTP Co.
Imagineering Plastics®

Everything You Need to Know about TPEs

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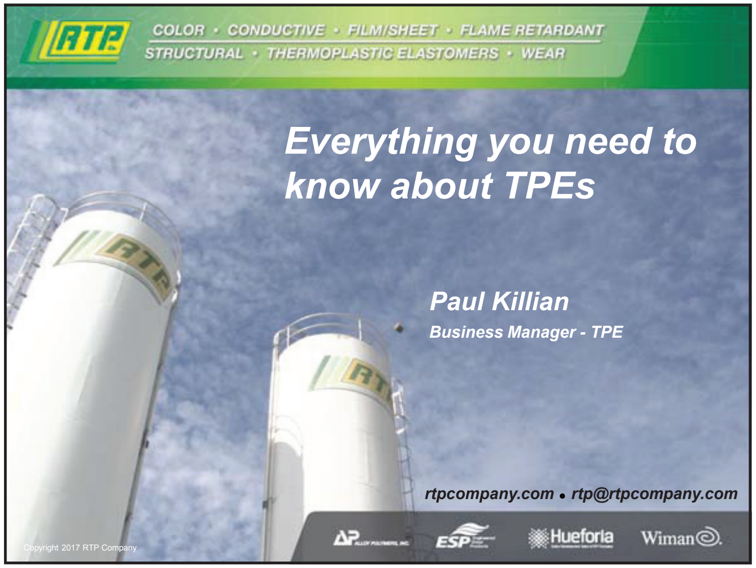
2:30 p.m.



TPE DIVISION

AGENDA

- Establish a Definition
- Understanding how TPEs work
- TPE Types
- RTP Company Product offering
  - Additive Capability
  - Styrenic Based TPEs
  - TPV Alloys
  - Bondable Technology

GOALS

- A basic understanding of various TPEs
- Relate this knowledge to the RTP Company TPE product line

DEFINITION

THERMOPLASTIC ELASTOMER

"…Having the property of softening or fusing when heated and of hardening again when cooled…"

"…Any of various elastic substances resembling rubber…"

Int'l Inst. of Synthetic Rubber Producers (IISRP) definition:

"Polymers, polymer blends or compounds which, above their melt temperatures, exhibit thermoplastic character that enables them to be shaped into fabricated articles and which, within their design temperature range, possess elastomeric behavior without cross-linking during fabrication. This process is reversible and the product can be reprocessed and remolded."

WHAT IS TPE

A diverse family of rubber like materials that, unlike conventional vulcanized rubber, can be processed and recycled like thermoplastic materials.

Thermoset

Thermoplastic

HOW TPEs WORK

TPEs are composed of **hard** and **soft** domains; they are **multiphase** materials in their solid state.

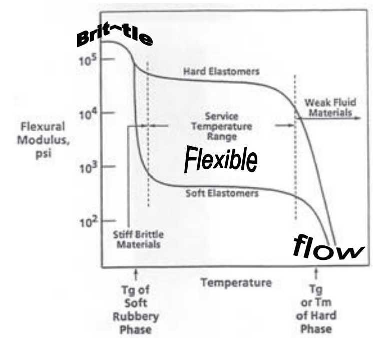
Hard phase contributes "plastic" properties such as:

- High-temperature performance
- Thermoplastic processability
- Tensile strength
- Tear strength

Soft phase contributes "elastomeric" properties:

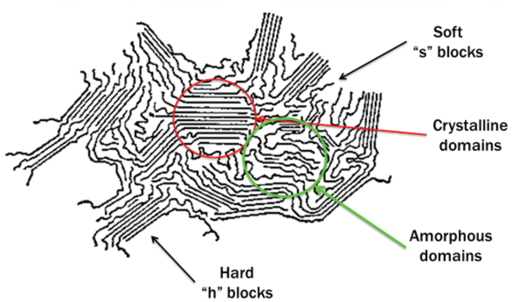
- Low-temperature performance
- Hardness
- Flexibility
- Compression & tension set

BUT WHY ARE TPEs RUBBERY?

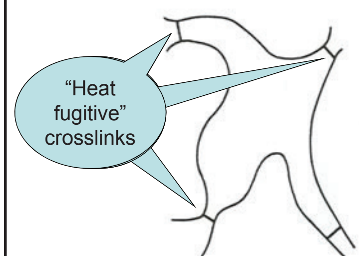


The design temperature range of a TPE is bounded by the glass transition temperature of the rubbery phase and the glass transition or melt temperature of the hard phase.

HOW TPE'S WORK

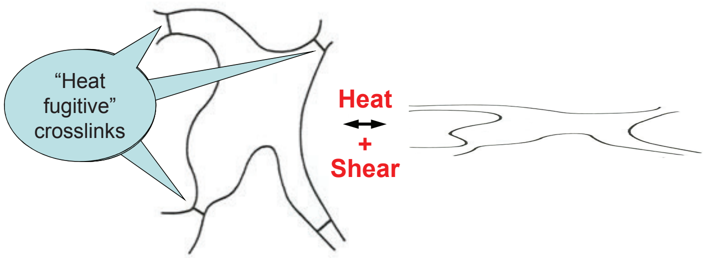


SO, HOW CAN TPEs BE MELT PROCESSABLE?



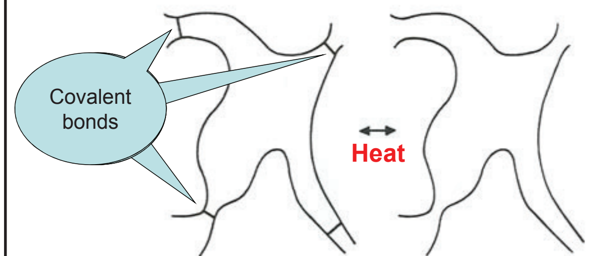
By raising the temperature of the TPE above the glass transition or melting temperature of the **plastic phase**.

SO, HOW CAN TPEs BE MELT PROCESSABLE



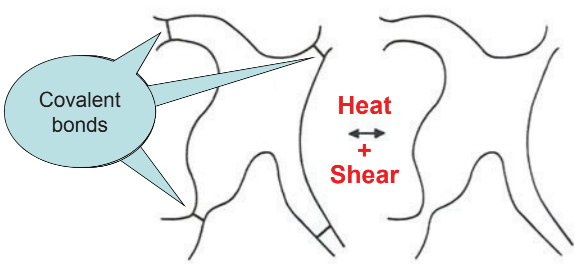
And applying shear forces typical of thermoplastic processes.

UNLIKE THERMOSET RUBBER...



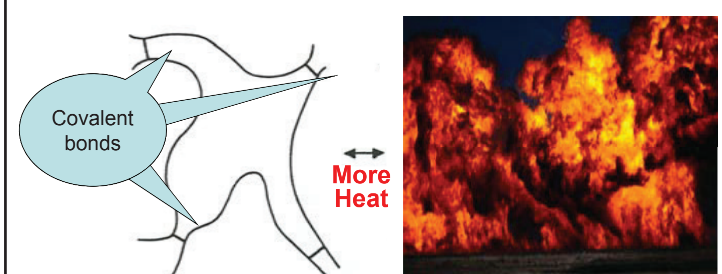
By comparison, thermoset rubbers (TSRs) are **single phase** materials with **non-reversible** chemical (covalent) bond cross-links.

UNLIKE THERMOSET RUBBER...



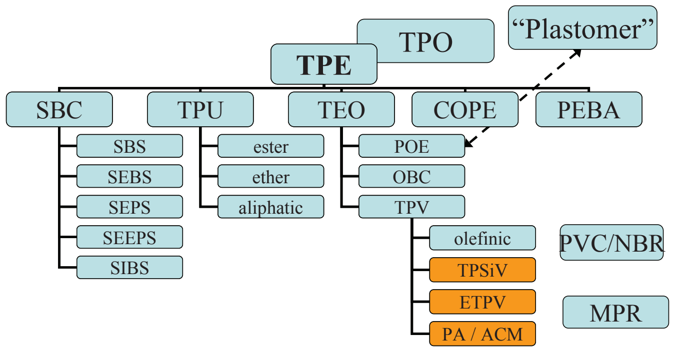
And are unaffected by shear forces.

UNLIKE THERMOSET RUBBER...



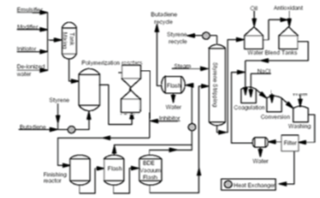
Or increasing heat...

LINEAGE (ALPHABET SOUP)

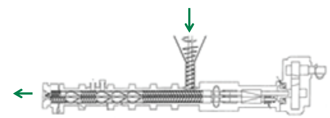


NEAT POLYMER VS COMPOUND

NEAT POLYMER
Created in a reactor, polymerizing thermoplastics chemically from feedstock



COMPOUND
Using a mechanical mixing process to improve one or more neat polymers



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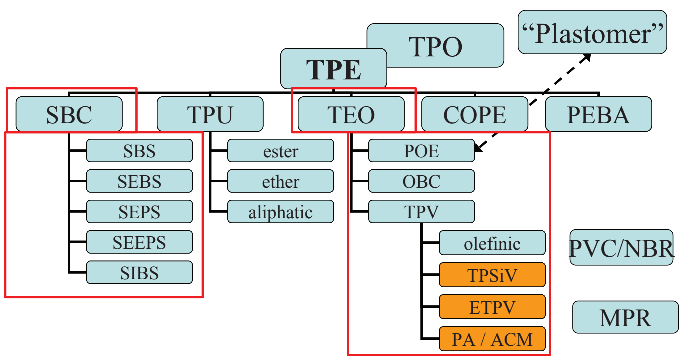


Most Commonly seen as compounds

CLASSIFICATION & NOMENCLATURE

- Performance (heat & oil resistance following ASTM, SAE, etc.)
- Chemistry (styrenic, olefinic, urethane, etc.)
- Structure
  - Block copolymers
  - Blends & alloys
  - Dynamic vulcanizates

BLOCK COPOLYMERS - MECHANISM

Block copolymer based TPEs are made of polymers that have both hard (semi-crystalline or glassy) blocks and soft (amorphous) blocks along the backbone.

s-s-s-s-s-h-h-h-h-h-s-s-s-s-s-h-h-h-h

In the bulk, as they cool from the melt, the hard blocks will coalesce into crystalline or glassy domains creating physical crosslinks.

The soft blocks are left to form amorphous rubbery domains that provide the elastomeric bridges between the crystalline domains.

BLOCK COPOLYMERS - EXAMPLES

Styrenic block copolymers "SBC"

- SBS, SEBS, SIS, SIBS, SEEPS (neat rubber)
- **Rarely used in their neat form**

Polyolefin elastomer "POE"

Thermoplastic urethane "TPU"

Copolyether-ester "COPE"

Polyether-block-amide "COPA" or "PEBA"

BLENDS & ALLOYS - EXAMPLES

Styrenic block copolymers "SBC"

- SBS, SEBS, SIS, SIBS, SEEPS → RTP 2700 S Series
- Most frequently compounded with PP, PE, or POE

Bondable TPES

- Polabond™
- Nylabond™

FOCUS – SBC BASED TPEs

COMPOSITION

OIL *(white mineral, other)*
SBC POLYMER(S) *(type, MW, and structure)*
FILLER *(CaCO3, talc, none)*
POLYPROPYLENE (lots of choices)
Stabs, pigments, etc

DESIGN FLEXIBILITY

Hardness – Gels (Shore OOO) to 50D
Viscosity – Extrusion to ultra-high flow
Clarity – Opaque to water clear
Properties – Tailored elasticity, strength
Feel – Super grippy to dry
Fillers – Throw in the kitchen sink

STRENGTHS

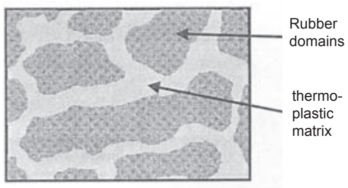
Elasticity– Highly elastic to "dead"
Versatility– Broad range of customizations
Low temp and RT – Great CS and flexibility
Cost– General purpose to boutique compounds
Aesthetics– Excellent moldability, consistency
Colorability– Very bright colors possible
Bond to PP

LIMITATIONS

Oil resistance– High affinity for absorption
High Temp– Max CUT ~100C
High Temp #2– Properties drop off as temp ↑
Reputation– A few bad apples . . .
Balance – Formulations flexibility is capped by inverse requirements – no free lunch

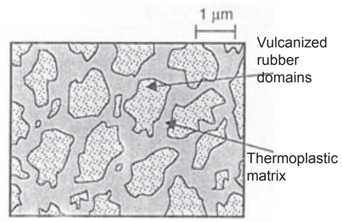
DYNAMIC VULCANIZATES - MORPHOLOGY

Simple melt-mixing



Coarse *morphology - TPO*

Dynamic vulcanization



Fine *morphology - TPV*

FOCUS – TPVs

COMPOSITION

EPDM RUBBER	*(non-vulcanized bale)*
POLYPROPYLENE	*(usually GP grades)*
FILLER	*(CaCO3 or talc, low %)*
CURE PACKAGE	(phenolic, peroxide, etc)
Oil	(generally low % add)
Stabs, pigments,etc	

DESIGN FLEXIBILITY **ALLOYS**

- **Hardness** – 35A to 50D
- **Viscosity** – Shear dependent flow
- **Clarity** – Opaque, nat color vs cure pkg
- **Properties** – Driven by hardness
- **Feel** – Most "rubber-like" feel
- **Fillers** – Crosslinked EPDM limits filler

STRENGTHS

"Industrial"– Higher temp property retention
Long term sealability (think auto)
Great inherent UV stability
Chemical and oil *resistance*

Rubber-like– Most similar TPE to rubber

Commoditized– Standard products and stocks

Bond to PP

LIMITATIONS

Customization– Technology and mfg limited

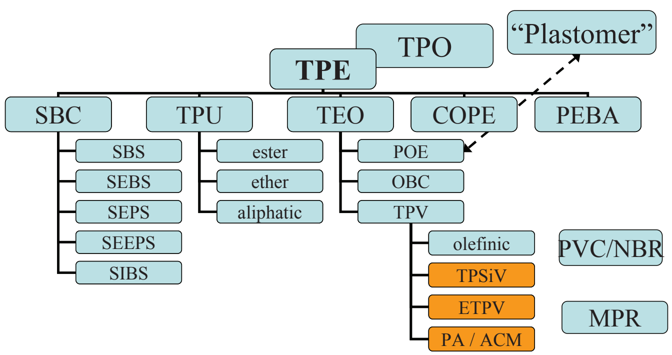
Aesthetics– Shear sensitivity and gate defects

RM flexibility– TPV does not drive inputs

Color– Opaque natural, cure technology driven

Regulatory vs Cost– Control capable, but "true" TPV has major cost implications

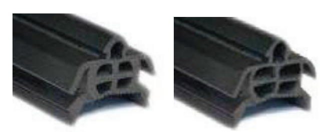
LINEAGE (ALPHABET SOUP)



TPE DESIGN FLEXIBILITY

Design Flexibility is a key component in leveraging the value of TPE's

Mass Reduction



Complex Geometries

Multi-Material Design

TPE ≠ RUBBER

Keep in mind:

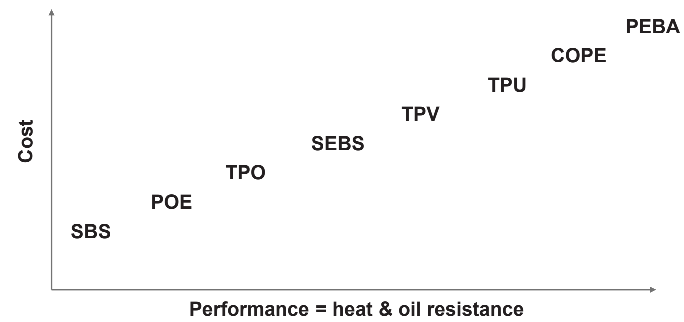
This is a broadbrush of many (very) different technologies that make up generic "TPE", relative to many (very) different technologies making up thermoset elastomers.

PROS	CONS
• Recyclable	• High Temp performance
• Mass reduction	• Material cost
• Manufacturing cost	• Elastomeric properties
• Design flexibility	• No in-house compounding

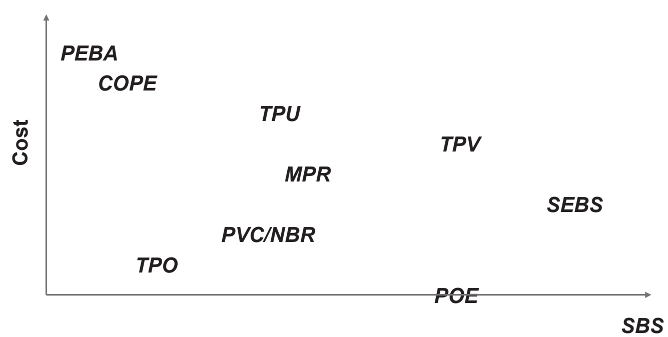
TPEs are not a one-to-one replacement for Thermoset Elastomers

Proper material selection is highly dependent on the application requirements, design, and ability to take advantage of the strengths inherent to TPE or Thermoset Elastomers

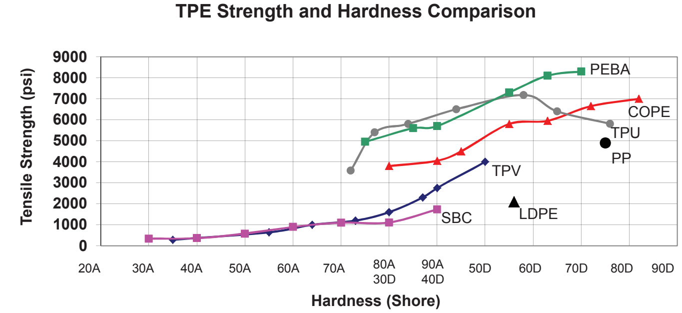
RELATIVE VALUE OF TPEs



RELATIVE VALUE OF TPE'S



THE PROBLEM WITH HARDNESS



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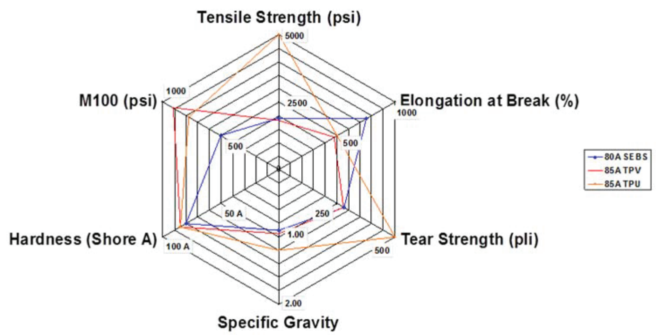


WHY RTP COMPANY?

RTP Company has been built on several basic principles:

- Independent, Value Added Custom Compounding
- Incorporating Specialty Additives into a Wide Variety of Base Resins
- Very Highly Focused on (and invested in) R&D, Technology, and Engineering

SBS • POE • TES • SBC • TPV • TPU • COPE • PEBA

TPE compounding requires the exact same approach – Only different?

- Mix R&D / Engineering capability with ability to supply "volume" compounds

- **Standard – Compounds common to the market**
- **TPE Alloys – Combining neat technologies to optimize performance**
- **Specialties – Incorporating RTP Company additive expertise**

STYRENIC BASED TPEs

RTP 2700 S & 2740S Standard Products

- **<u>RTP 2700 S Series</u> - 30A to 80A unfilled**
  - Translucent to clear, low gravity, excellent elasticity
  - Medical and FDA compliant grades available (MD and Z)
- **<u>RTP 2740 S- HF Series</u> – 30A to 90A filled SBC**
  - Opaque, higher gravity, FDA compliant grades available

<u>Attributes</u>

- *Highly elastic*
- *Highly customizable*
- *Design flexibility*
- *Broad cost spectrum*
- *Great RT compression set*

<u>2799 SX Design Flexibility</u>

- Water clear
- Increased elasticity
- Low hardness + strength
- EU food contact compliant
- Processing tweaks
- Haptics (touchy-feely)

VULCANIZATE BASED TPEs

Permaprene™ 2800 B & 2840 B Standard Products

- **<u>Permaprene™ 2800 B Series</u> - 45A to 50D TPV Products**
  - HF Grades preferred for cost & appearance improvement
  - FDA compliant grades available in non-HF only
- **<u>Permaprene™ 2840 B Series</u> – 55A to 90A TPV VA/VE Option**
  - Higher Gravity, Lower temp, good extrusion, smoother feel

<u>Attributes</u>

- *Broad temp range*
- *Improved chem resistance*
- *Easily colorable*
- *Broad cost spectrum*
- *Great RT compression set*

<u>2899 X Design Flexibility</u>

- Targeted viscosity
- Targeted properties
- Improved UV (good to great)
- Application tailoring
- Splitting the difference
- Haptics (touchy-feely)

NYLABOND™

Nylabond™ 6091 Series: Nylon Bondable TPVs

- Formulated specifically for melt bonding to Nylon 6 and 6/6
- Available in durometer levels of 55A to 85A
- TPV based product based on Santoprene® technology
- Market leading technology, unequalled property set
- Significant value in automotive – temp & chem resistance

Attributes

- Superior heat resistance
- *Superior chemical resistance*
- Superior compression set
- *Automotive approvals*

Automotive Specifications

- GMW 15817 Type 1
- GMW 15817 Type 2
- MSAR 100 AAN
- MSAR 100 BAN
- MSAR 100 CAN
- VW 50123 Conformance
- Daimler DBL5562-30
- SAE J200 callouts
- ASTM D4000 callouts



POLABOND™

Polabond 6042 Series: ABS, PC, and PC/ABS Bondable SEBS Alloys

- Excellent Bonding due to unique technology
- Great grip and feel, very durable
- Good aging properties relative to competitors
- Excellent processability and aesthetics
- Specialty versions available for unique applications

Attributes

- *RTP Company offers multiple technology platforms*
- *Variety of feel and performance*
- *Colorability*
- *Excellent bond strength in both insert and multishot processes*

Polabond 6041 Series - 55A and 70A TPV based

- Excellent Bonding to PC, ABS, PMMA, RTPU
- Premium polar bonding product
- Excellent chemical resistance at high temps
- Superior weatherability

ADDITIVE INCORPORATION

Color | Conductive | Structural | Wear | FR

PEBA (RTP 2900)
COPE (RTP 1500)
TPU (RTP 1200) (RTP 2300)
TPV (RTP 2800)
SBC (RTP-2700)
2-Shot (RTP 6000)
TEO (RTP 2600)

RTP Company's Bread & Butter, Applied to TPE

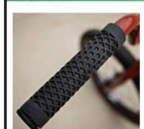
- Strong market leadership
- Leverage expertise and resources
- Deliver unique solutions & functionality

Precolor anything	CoF modified TPEs
Conductive anything	FR TPEs
Glass RTPU	ATEX Bondables
Wear TPU / COPE	Density modified


Side Benefit - Uniquely Experienced with all TPE chemistries

- Technical acumen to create custom formulations and alloys
- Culture of customer co-development – create what you NEED

WHAT TO TAKE AWAY FROM TODAY



RTP 2700 S - SBCs

- Common stand-alone TPE; 20A to 90A hardness
- **2700 S** – higher cost, lower gravity, translucent
- **2740 S-xx HF** – lower cost, higher gravity, opaque
- Bonds to PP; Custom tailoring possible
- Temp limited ~100C

Permaprene™ –TPV Alloys

- **2800 B-xx HF** - TPV offset in most non-auto applications
- 45A to 50D hardness, can be FDA
- **2840 B** –xx – VA/VE where TPV over-engineered
- Good chemical resistance, smooth feel, extrusion

Nylabond™ Polabond™

- **6091** – TPV based PA bonding, lots of auto approvals
  - 125 °C CUT, 55A to 85A,campaign products
- **6092** – in development, targeting Powertool market
- **6041** – TPV based polar bondable, high performance
- **6042-xx HF** – Cost effective, excellent bonding

Specialty

- Elastomeric + Any RTP Company core competency
- Conducive to "typical" RTP Company sales process

APPLICATION GUIDELINES

- What is the operating temperature range for my application?
- What chemical and/or environmental exposures might there be?
- What are the key performance requirements for the application (beyond just shore hardness)?
- What kind of process will be used to produce final parts?

COLOR • CONDUCTIVE • FILM/SHEET • FLAME RETARDANT
STRUCTURAL • THERMOPLASTIC ELASTOMERS • WEAR