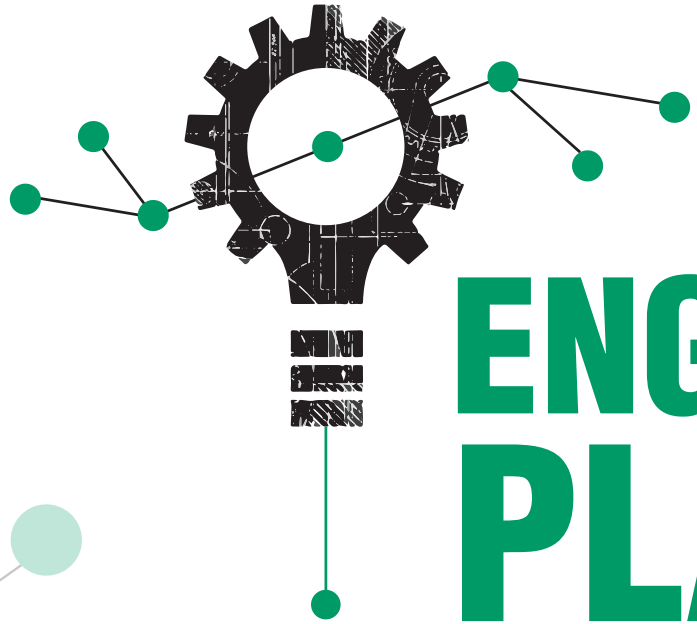

ENGINEERED PLASTICS WORKSHOP

Learn About Thermoplastics I Connect with Experts

2016 TENNESSEE / NORTH CAROLINA

YOUR GLOBAL COMPOUNDER OF
CUSTOM ENGINEERED THERMOPLASTICS

RTP Co.
Imagineering Plastics®

Everything You Need to Know about TPEs

Karl Hoppe | Senior Product Development Engineer
khoppe@rtpcompany.com
(507) 474-5367

4:00 p.m.

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

Everything You Need to Know about TPEs

Karl Hoppe
Senior Product Development Engineer

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TPE DIVISION

AGENDA

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

GOALS:

- A basic understanding of various TPEs
- Relate this knowledge to the RTP 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.

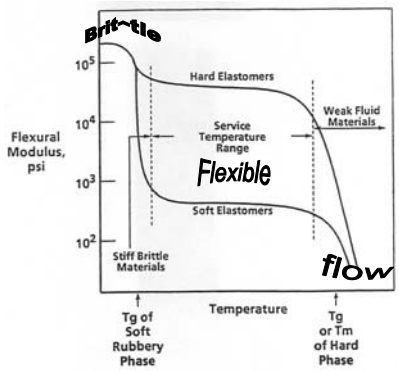
Hard phase contributes "plastic" properties such as:

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

Soft phase contributes "elastomeric" properties:

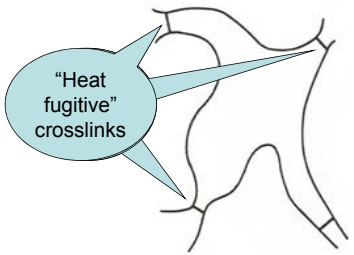
- Low-temperature performance
- Hardness
- Flexibility
- Compression & tension set

BUT WHY ARE TPE'S RUBBERY?



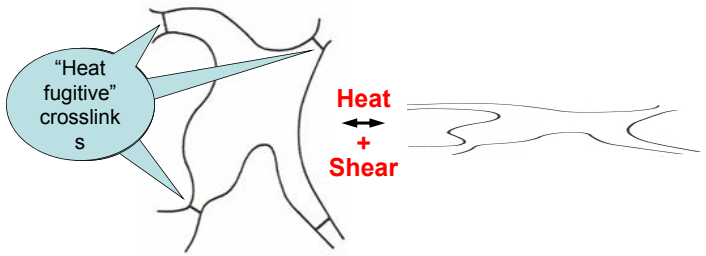
The design temperature range of a TPE is bounded by the glass transition temperature of the rubbery phase and the glass transition or melt temperature of the hard phase.

SO, HOW CAN TPE'S BE MELT PROCESSABLE?



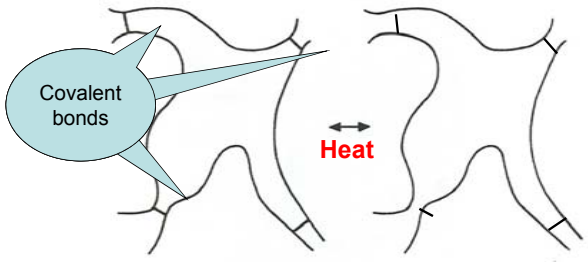
By raising the temperature of the TPE above the glass transition or melting temperature of the **plastic phase**.

SO, HOW CAN TPE'S BE MELT PROCESSABLE



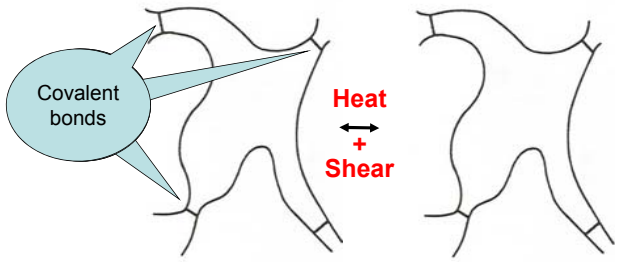
And applying shear forces typical of thermoplastic processes.

UNLIKE THERMOSET RUBBER…



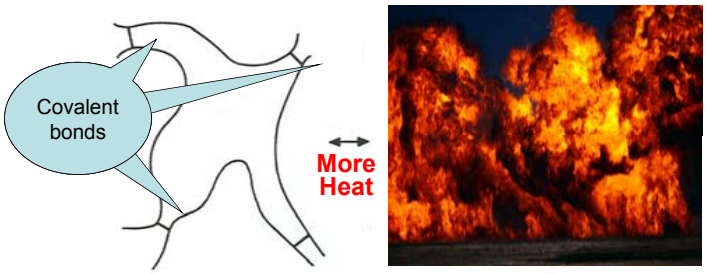
By comparison, thermoset rubbers (TSRs) are **single phase** materials with **non-reversible** chemical (covalent) bond cross-links.

UNLIKE THERMOSET RUBBER…



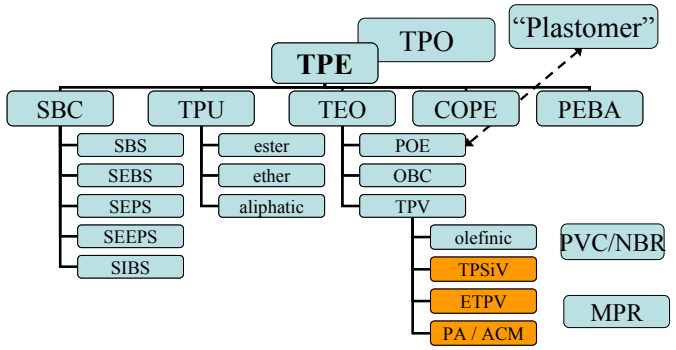
And are unaffected by shear forces.

UNLIKE THERMOSET RUBBER…



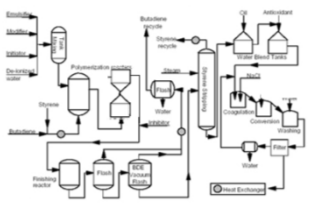
Or increasing heat…

LINEAGE (ALPHABET SOUP)

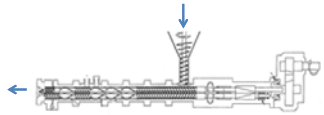


NEAT POLYMER VS COMPOUND

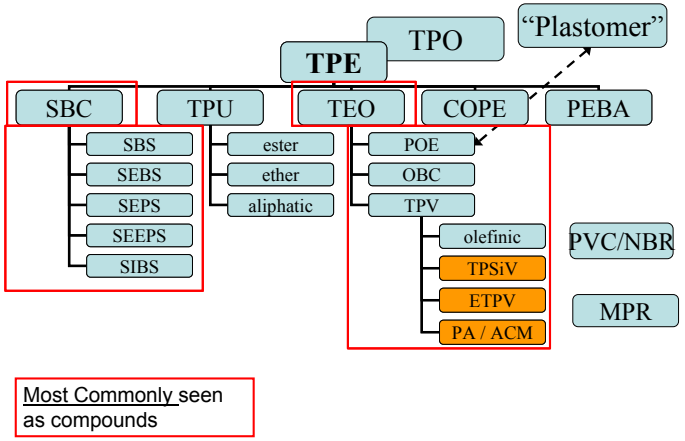
NEAT POLYMER
Created in a reactor, polymerizing thermoplastics chemically from feedstock



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



LINEAGE (ALPHABET SOUP)



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 → Styreflex Compounds
- Most frequently compounded with PP, PE, or POE

Bondable TPES

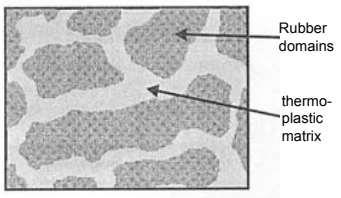
- Polabond
- Nylabond

FOCUS – SBC BASED TPE'S

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

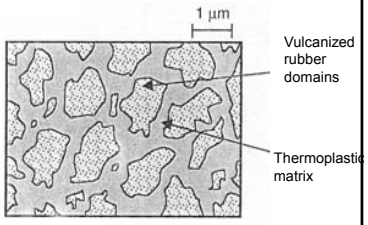
DYNAMIC VULCANIZATES - MORPHOLOGY

Simple melt-mixing



***Coarse** morphology*
TPO

Dynamic vulcanization



***Fine** morphology*
TPV

FOCUS – TPV'S

COMPOSITION		DESIGN FLEXIBILITY	
EPDM RUBBER	*(non-vulcanized bale)*	**Hardness –** 35A to 50D	**ALLOYS**
POLYPROPYLENE	*(usually GP grades)*	**Viscosity –** Shear dependent flow	
FILLER	*(CaCO3 or talc, low %)*	**Clarity –** Opaque, nat color vs cure pkg	
CURE PACKAGE	(phenolic, peroxide, etc)	**Properties –** Driven by hardness	
Oil	(generally low % add)	**Feel –** Most "rubber-like" feel	
Stabs, pigments,etc		**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

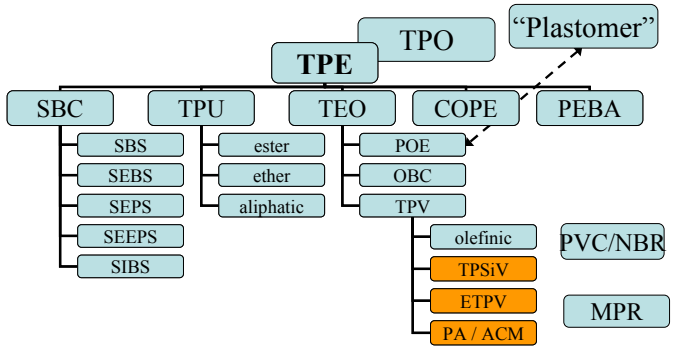
Aesthetics– Shear sensitivity and gate defects

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 ≠ RUBBER

Keep in mind:

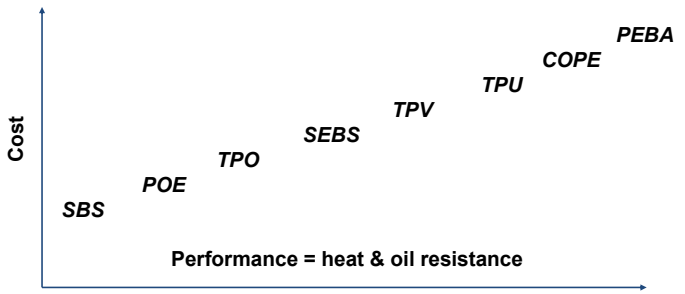
This is a broadbrush of many (very) different technologies that make up generic "TPE", relative to many (very) different technologies making up thermoset elastomers.

PRO's	CON's
• Recyclable	• High Temp Performance
• Mass Reduction	• Material Cost
• Manufacturing Cost	• Elastomeric Properties
• Design Flexibility	• No in-house compounding

TPE's are not a one to one replacement for Thermoset Elastomers

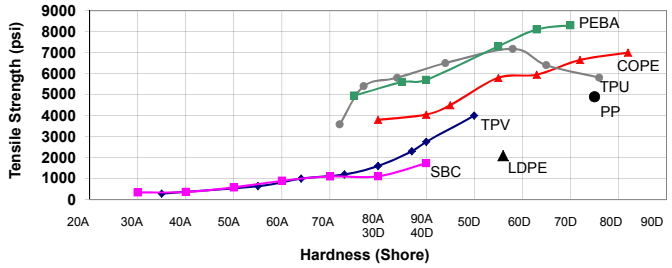
Proper material selection is highly dependent on the application requirements, design, and ability to take advantage of the strengths inherent to TPE or Thermoset Elastomers

RELATIVE VALUE OF TPE'S

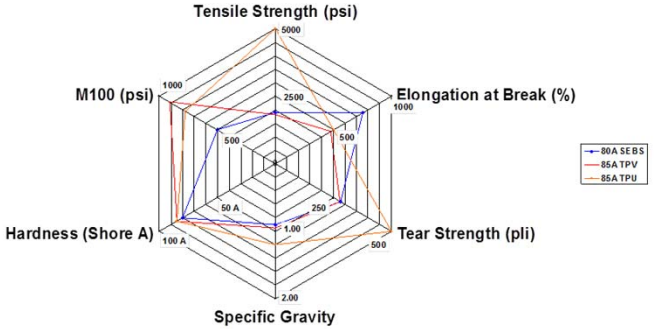


THE PROBLEM WITH HARDNESS

TPE Strength and Hardness Comparison



THE PROBLEM WITH HARDNESS



WHY RTP?

RTP 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 additive expertise**

STYRENIC BASED TPE'S

Styreflex™ 2700S & 2740S Standard Products

Styreflex™ 2700 S Series - *30A to 80A unfilled*

- Translucent to clear, low gravity, excellent elasticity
- Medical and FDA compliant grades available (MD and Z)

Styreflex™ 2740S Series - *30A to 80A filled SBC*

- Opaque, higher gravity, FDA compliant grades available

Attributes

- *Highly Elastic*
- *Highly Customizable*
- *Design Flexibility*
- *Broad Cost Spectrum*
- *Great RT Compression Set*

2799 SX Design Flexibility

- Water clear
- Increased Elasticity
- Low Hardness + Strength
- EU food contact compliant
- Processing Tweaks
- Haptics (Touchy-Feely)

VULCANIZATE BASED TPE'S

Permaprene™ 2800B & 2840B Standard Products

Permaprene™ 2800 B Series - *45A to 50D TPV Products*
- HF Grades preferred for cost & appearance improvement
- FDA compliant grades available in non-HF only

Permaprene™ 2840 B Series – *55A to 90A TPV VA/VE Option*
- Higher Gravity, Lower temp, good extrusion, smoother feel

Attributes
- *Broad temp range*
- *Improved chem resistance*
- *Easily Colorable*
- *Broad Cost Spectrum*
- *Great RT Compression Set*

2899 X Design Flexibility

- 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

COMPETITION

ALL SEBS BASED
- Tekbond 1158A&C, 1372A *[Teknor Apex]*
- Versaflex OM-6059, OM-6200 *[GLS]*
- *Thermolast K CO PA, CO NY [Kraiburg]*
- Starbond *[Star Polymers]*

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 Conformance
- 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

COMPETITION
- Various Tekbond Products *[Teknor Apex]*
- Versaflex OM-3060, OM-1000 series *[GLS]*
- *Thermolast AD1 Grades [Kraiburg]*
- Starbond *[Star Polymers]*

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's Bread & Butter, Applied to TPE

- Strong Market Leadership
- Leverage Expertise and Resources
- Deliver Unique Solutions & Functionality

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

Styreflex™
- SBCs

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

Permaprene™
– TPV Alloys

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

Nylabond™
Polabond™

- **6091** – TPV based PA bonding, lots of auto approvals
  - 125C 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 core competency
- Conducive to "typical" RTP 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)?

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