

# ENGINEERED PLASTICS WORKSHOP

Learn About Thermoplastics | Connect with Experts

**2017**

**KING OF PRUSSIA / PENNSYLVANIA  
(PHILADELPHIA AREA)**

**YOUR GLOBAL COMPOUNDER OF  
CUSTOM ENGINEERED THERMOPLASTICS**





# Everything You Need to Know about TPEs



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**2:30 p.m.**

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

## Everything you need to know about TPEs

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**RTP 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

**RTP 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.”

**RTP WHAT IS TPE**

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

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<b>Thermoset</b>	<b>Thermoplastic</b>

**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**

Soft “s” blocks

Crystalline domains

Amorphous domains

Hard “h” blocks

**SO, HOW CAN TPEs BE MELT PROCESSABLE?**

“Heat fugitive” crosslinks

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

**RTP** SO, HOW CAN TPEs BE MELT PROCESSABLE

“Heat fugitive” crosslinks

Heat + Shear

And applying shear forces typical of thermoplastic processes.

**RTP** UNLIKE THERMOSET RUBBER...

Covalent bonds

Heat

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

**RTP** UNLIKE THERMOSET RUBBER...

Covalent bonds

Heat + Shear

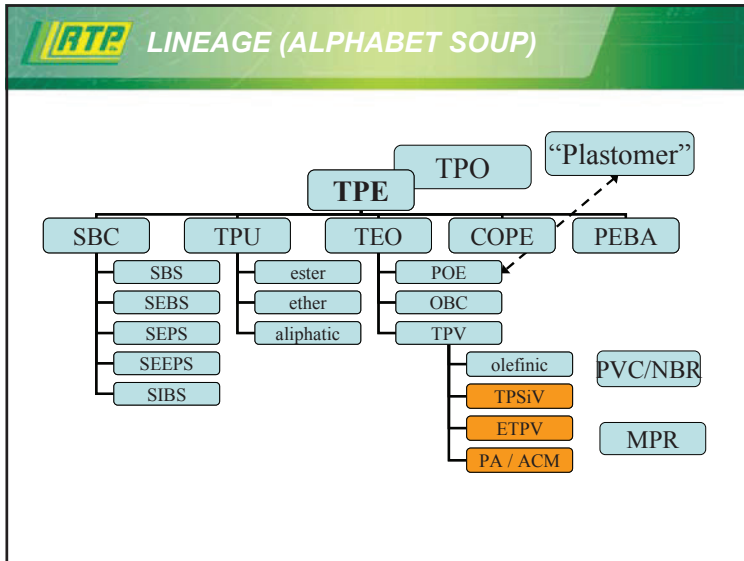
And are unaffected by shear forces.

**RTP** UNLIKE THERMOSET RUBBER...

Covalent bonds

More Heat

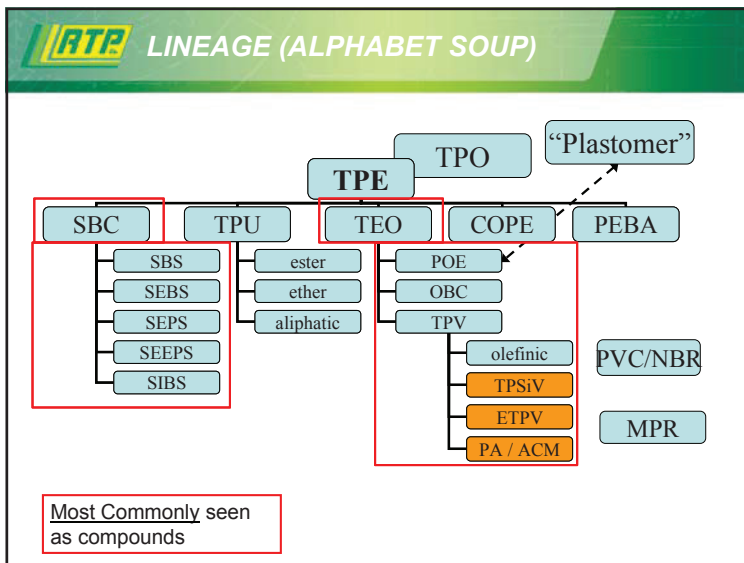
Or increasing heat...



### RTP 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



- ### RTP 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-h-h-h-h-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**

<p><b>COMPOSITION</b></p> <p><b>OIL</b> (white mineral, other)</p> <p><b>SBC POLYMER(S)</b> (type, MW, and structure)</p> <p><b>FILLER</b> (CaCO3, talc, none)</p> <p><b>POLYPROPYLENE</b> (lots of choices)</p> <p>Stabs, pigments, etc</p>	<p><b>DESIGN FLEXIBILITY</b></p> <p><b>Hardness</b> – Gels (Shore 000) to 50D</p> <p><b>Viscosity</b> – Extrusion to ultra-high flow</p> <p><b>Clarity</b> – Opaque to water clear</p> <p><b>Properties</b> – Tailored elasticity, strength</p> <p><b>Feel</b> – Super grippy to dry</p> <p><b>Fillers</b> – Throw in the kitchen sink</p>
<p><b>STRENGTHS</b></p> <p><b>Elasticity</b>– Highly elastic to "dead"</p> <p><b>Versatility</b>– Broad range of customizations</p> <p><b>Low temp and RT</b> – Great CS and flexibility</p> <p><b>Cost</b>– General purpose to boutique compounds</p> <p><b>Aesthetics</b>– Excellent moldability, consistency</p> <p><b>Colorability</b>– Very bright colors possible</p> <p><b>Bond to PP</b></p>	<p><b>LIMITATIONS</b></p> <p><b>Oil resistance</b>– High affinity for absorption</p> <p><b>High Temp</b>– Max CUT ~100C</p> <p><b>High Temp #2</b>– Properties drop off as temp ↑</p> <p><b>Reputation</b>– A few bad apples . . .</p> <p><b>Balance</b> – Formulations flexibility is capped by inverse requirements – no free lunch</p>

**DYNAMIC VULCANIZATES - MORPHOLOGY**

**Simple melt-mixing**

Rubber domains  
thermo-plastic matrix

**Coarse morphology - TPO**

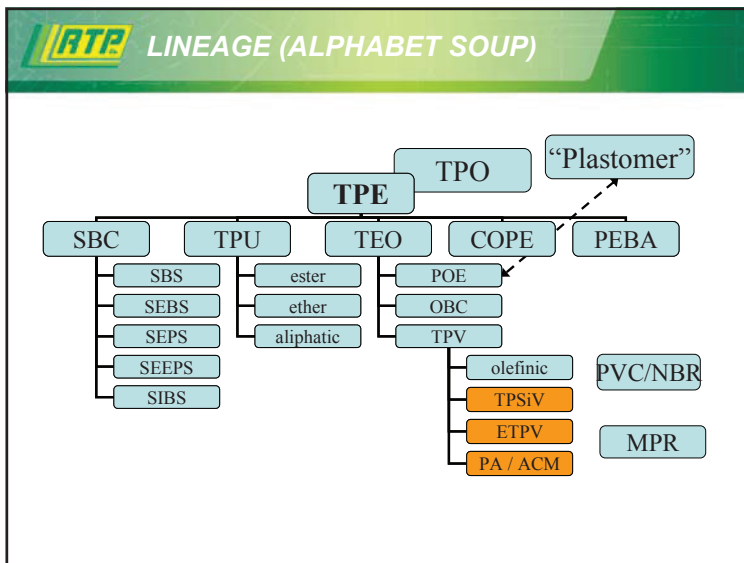
**Dynamic vulcanization**

1 µm  
Vulcanized rubber domains  
Thermoplastic matrix

**Fine morphology - TPV**

**FOCUS – TPVs**

COMPOSITION	DESIGN FLEXIBILITY
<b>EPDM RUBBER</b> (non-vulcanized bale) <b>POLYPROPYLENE</b> (usually GP grades) <b>FILLER</b> (CaCO <sub>3</sub> or talc, low %) <b>CURE PACKAGE</b> (phenolic, peroxide, etc) <b>Oil</b> (generally low % add) <b>Stabs, pigments, etc</b>	<b>ALLOYS</b> <b>Hardness</b> – 35A to 50D <b>Viscosity</b> – Shear dependent flow <b>Clarity</b> – Opaque, nat color vs cure pkg <b>Properties</b> – Driven by hardness <b>Feel</b> – Most “rubber-like” feel <b>Fillers</b> – Crosslinked EPDM limits filler
STRENGTHS	LIMITATIONS
<b>“Industrial”</b> – Higher temp property retention Long term sealability (think auto) Great inherent UV stability Chemical and oil <i>resistance</i> <b>Rubber-like</b> – Most similar TPE to rubber <b>Commoditized</b> – Standard products and stocks <b>Bond to PP</b>	<b>Customization</b> – Technology and mfg limited <b>Aesthetics</b> – Shear sensitivity and gate defects <b>RM flexibility</b> – TPV does not drive inputs <b>Color</b> – Opaque natural, cure technology driven <b>Regulatory vs Cost</b> – Control capable, but “true” TPV has major cost implications



**TPE DESIGN FLEXIBILITY**

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

**Mass Reduction**

**Complex Geometries**

**Multi-Material Design**



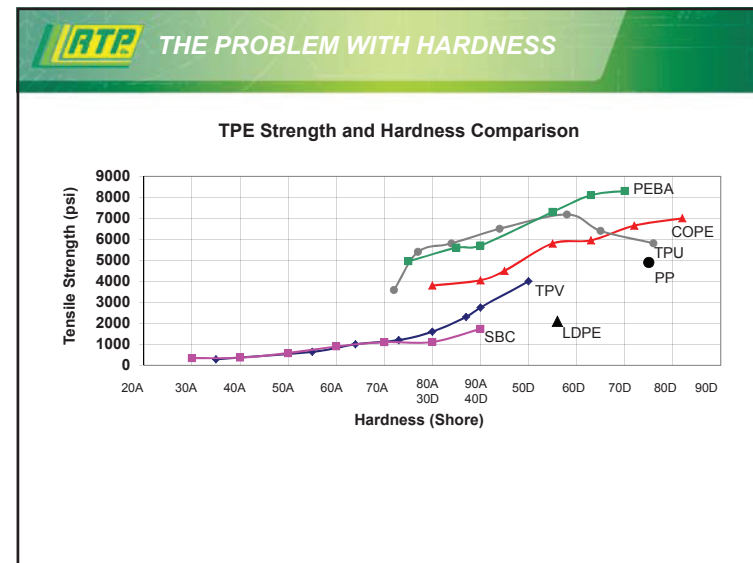
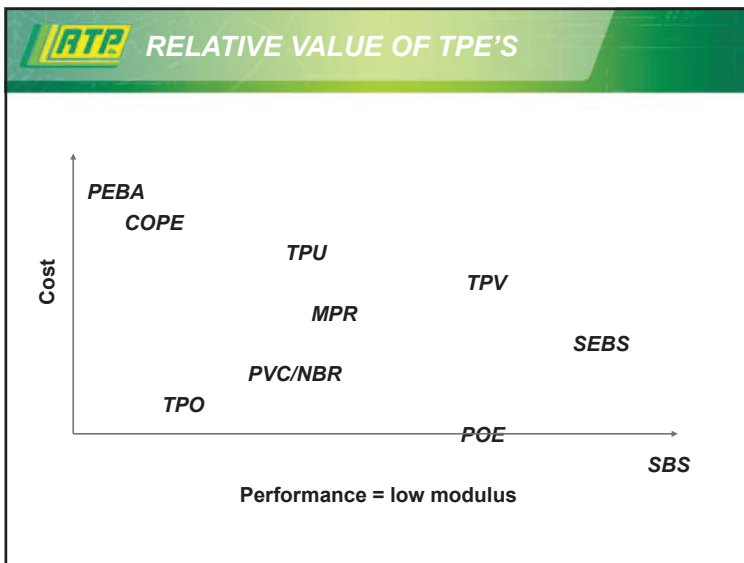
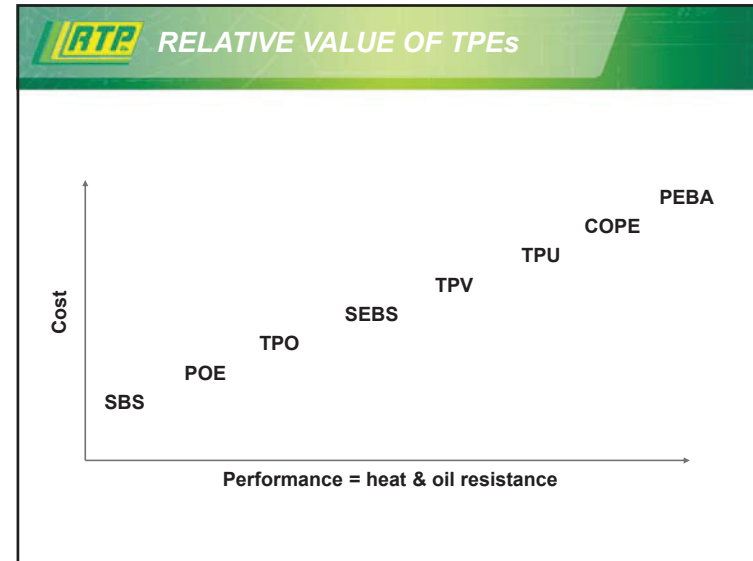


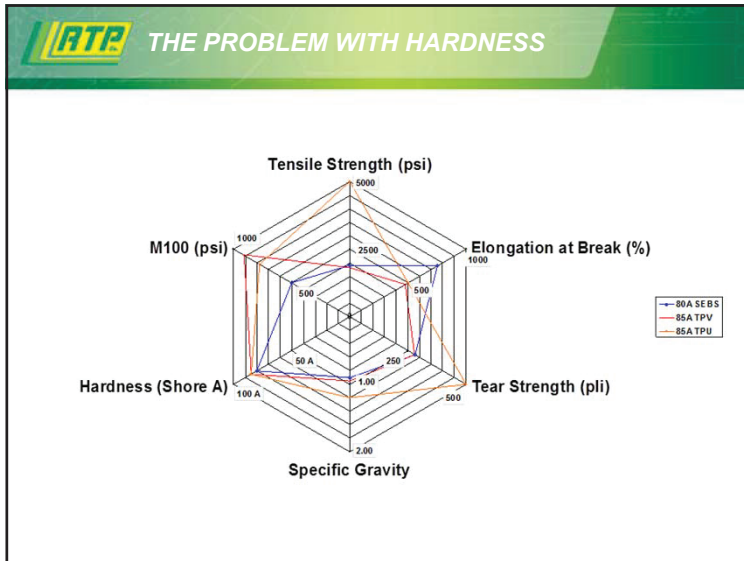
### RTP TPE ≠ RUBBER

**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
<ul style="list-style-type: none"> <li>Recyclable</li> <li>Mass reduction</li> <li>Manufacturing cost</li> <li>Design flexibility</li> </ul>	<ul style="list-style-type: none"> <li>High Temp performance</li> <li>Material cost</li> <li>Elastomeric properties</li> <li>No in-house compounding</li> </ul>

**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





### 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

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

#### 2799 SX Design Flexibility

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




**Attributes**

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



### VULCANIZATE BASED TPEs

#### Permaprene™ 2800 B & 2840 B 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

#### 2899 X Design Flexibility

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

**Attributes**

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

**RTP 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

**RTP 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

**RTP ADDITIVE INCORPORATION**

	Color	Conductive	Structural	Wear	FR
<b>PEBA</b> <small>(RTP 2900)</small>					
<b>COPE</b> <small>(RTP 1500)</small>					
<b>TPU</b> <small>(RTP 1200) (RTP 2300)</small>					
<b>TPV</b> <small>(RTP 2800)</small>					
<b>SBC</b> <small>(RTP-2700)</small>					
<b>2-Shot</b> <small>(RTP 6000)</small>					
<b>TEO</b> <small>(RTP 2600)</small>					

**RTP Company's Bread & Butter, Applied to TPE**

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

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

**RTP WHAT TO TAKE AWAY FROM TODAY**

<p><b>RTP 2700 S</b> - SBCs</p>	<ul style="list-style-type: none"> <li>• Common stand-alone TPE; 20A to 90A hardness</li> <li>• <b>2700 S</b> – higher cost, lower gravity, translucent</li> <li>• <b>2740 S-xx HF</b> – lower cost, higher gravity, opaque</li> <li>• Bonds to PP; Custom tailoring possible</li> <li>• Temp limited ~100C</li> </ul>
<p><b>Permaprene™</b> -TPV Alloys</p>	<ul style="list-style-type: none"> <li>• <b>2800 B-xx HF</b> - TPV offset in most non-auto applications</li> <li>• 45A to 50D hardness, can be FDA</li> <li>• <b>2840 B</b> -xx – VA/VE where TPV over-engineered</li> <li>• Good chemical resistance, smooth feel, extrusion</li> </ul>
<p><b>Nylabond™</b> <b>Polabond™</b></p>	<ul style="list-style-type: none"> <li>• <b>6091</b> – TPV based PA bonding, lots of auto approvals               <ul style="list-style-type: none"> <li>• 125 °C CUT, 55A to 85A, campaign products</li> </ul> </li> <li>• <b>6092</b> – in development, targeting Powertool market</li> <li>• <b>6041</b> – TPV based polar bondable, high performance</li> <li>• <b>6042-xx HF</b> – Cost effective, excellent bonding</li> </ul>
<p><b>Specialty</b></p>	<ul style="list-style-type: none"> <li>• Elastomeric + Any RTP Company core competency</li> <li>• Conductive to "typical" RTP Company sales process</li> </ul>



**RTP** 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?

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