Bitte decken Sie die schraffierte Fläche mit einem Bild ab.

New Compounding Solutions for PremiumContact 6

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Technology
Performance Overview

- Handling: 103%
- Dry Braking: 100%
- Mileage: 115%
- Rolling Resistance: 105%
- Exterior Noise: 110%
- Interior Noise: 102%
- Wet Braking: 100%
- Hydroplaning: 95%

ContiSportContact 5
PremiumContact 6

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Technology
Performance Overview – Compounding Solutions

Handling 103%
Hydroplaning 95%
Wet Braking 100%
Interior Noise 102%
Exterior Noise 110%
Dry Braking 100%
Mileage 115%
Rolling Resistance 105%

ContiSportContact 5 ➡️ PremiumContact 6
## Technology

### Performance Overview – Compounding Solutions

<table>
<thead>
<tr>
<th>Performance</th>
<th>Tire</th>
<th>Compounding Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handling</td>
<td>103%</td>
<td>Similar or higher stiffness</td>
</tr>
<tr>
<td>Dry Braking</td>
<td>100%</td>
<td>Crystal silica composition</td>
</tr>
<tr>
<td>Wet Braking</td>
<td>100%</td>
<td>Crystal silica composition</td>
</tr>
<tr>
<td>Rolling Resistance</td>
<td>105%</td>
<td>Base + tread compound</td>
</tr>
<tr>
<td>Mileage</td>
<td>115%</td>
<td>Wear optimized polymer</td>
</tr>
</tbody>
</table>

**PremiumContact 6 vs ContiSportContact 5**
Typical Components of Tread Compounds
for Passenger & Light Truck Tires

- Rapeseed oil
- Synthetic rubber
- Natural rubber
- Butadiene rubber
- Sulfur
- Zinc oxide
- Activator
- Anti-ageing agent
- Activator
- Carbon black
- Silica

Other components include:
- Ozone protecting wax
- Resins
- MES oil
What is the origin of these target conflicts?

Viscoelastic properties of rubber:
› Hysteresis
› Abrasion resistance

Compound Development
Target Conflicts

Rolling resistance

Wet grip

Wear

Compound
Compound Development
Target Conflict

Rolling resistance

Wet grip

Wear

Compound
Energy Dissipation in Rubber
Hysteresis

What happens when a body is deformed?

- **Elastic body**: Energy is stored
  \[ \text{Energy in} = \text{Energy out} \]
  \[ \times \text{Lost Energy} = 0 \]

- **Viscous body**: Energy is lost
  \[ \text{Energy in} \]
  \[ \text{Energy out} = 0 \]
  \[ \times \text{All Energy is lost} \]
Energy Dissipation in Rubber

Hysteresis

In viscoelastic materials energy is partially stored and partially transformed into heat.

\[ \sigma = E \varepsilon \]

\[ E^*(\omega) = E'(\omega) + i E''(\omega) \]

Energy in - Energy out = Lost Energy

Rubber slowly recovers from deformed state because of internal viscosity → Energy dissipation.
Energy Dissipation in Rubber Hysteresis

- In viscoelastic materials energy is partially stored and partially transformed into heat.

\[
\text{Energy in} - \text{Energy out} = \text{Damping loss}
\]
Energy Dissipation in Rubber
Target Conflict of Wet-Grip and Rolling Resistance

Braking and Rolling Resistance have different relevant frequency areas
› The hysteresis is determined by the frequency dependent loss-factor and of the tread-compound.
Safety-optimized Silica Compounds
Solution of Target Conflicts

**Cap influence**
- Wear
- Handling
- Wet Braking
- RR

**PremiumContact 6 Cap + Base + Pattern**
- Wear
- Handling
- Wet Braking
- RR

**Base influence**
- Wear
- Handling
- Wet Braking
- RR

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Standard | PremiumContact 6

RR – Rolling Resistance
Tread compounding – Exercise
Identify the Rolling Resistance Optimized Base Compound

Which compound has superior rolling resistance properties
Compound Development
Target Conflict

Rolling resistance is in target conflict with grip

› Can be overcome by performance dedication via cap + base approach

› Difference excitation frequency range for grip and RR utilized in compounding
Compound Development

Target Conflict

Rolling resistance

Compound

Wet grip

Wear
Tire & Rubber Wear
Multiscale Approach from Tire to Tread Block and Compound

Wear is a superposition of various phenomena happening at different scales

- Polymers
- Fillers
- Contact
- Construction
- Wheel
- Vehicle

Influencing factors:
- Thermal stability
- Polymer Flexibility
- Rubber Tear resistance
- Stresses on Compound
- Slip velocity
- Slip distance
- Tire Forces
- Driving severity

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Safety-optimized Silica Compounds
“Low Glass Transition Temperature Technology”: Wear Mechanisms

Frictional wear

- Creep of material due to frictional forces.
- Mass transport: sticky film, rolls

Test drums

Fatigue

- Slow crack growth due to deformation of rubber in contact with a rough surface.
- Detachment of rubber particles.

Long distance

Cutting abrasion

- Fast rupture of rubber.
- Tearing of large rubber pieces.
- Formation of abrasion pattern and/or cracks on rubber surface

Severe application

Smooth surface

Rough rounded surface

Rough sharp surface

$P_0 \downarrow$

$v$
Safety-optimized Silica Compounds
“Low Polymer Glass Transition Temperature Technology” = Nano Technology

Nano mechanism

- Crack resistance improvement due to low polymer glass transition temperature $T_G$
- Technology improves wear performance on nano-scale
- Significant wear improvement while keeping wet performance via shift of compound glastemperature $T_G$
The stiffness $E'$ of rubber compounds varies as a function of temperature and deformation frequency.

- **Temperature $T$**: High stiffness (glassy) at low temperature, low stiffness (flexible) at high temperature.
- **Deformation frequency $f$**: High stiffness (glassy) at low frequency, low stiffness (flexible) at high frequency.
Flexible or Glassy Polymer Chains?
Temperature Dependence

Summer and Winter tread compound with different glass transition temperatures

Samples were cooled down to $T=-40^\circ C$
Flexible or Glassy Polymer Chains?
Temperature Dependence

The stiffness $E'$ of rubber compounds varies as a function of temperature.
Flexible or Glassy Polymer Chains/Matrix?
Frequency Dependence

Test specimen:
Corn starch (200g) + water (150 ml)
Flexible or Glassy Polymer Chains/Matrix?
Frequency Dependence

Test specimen:
Corn starch (200g) + water (150 ml)
Flexible or Glassy Polymer Chains/Matrix? Frequency Dependence

The stiffness $E'$ of rubber compounds varies as a function of deformation frequency.

- High $T_g$ compound
- Low $T_g$ compound

Deformation frequency [Hz]

Stiffness $E'$ [MPa]

Flexible

Glassy
Flexible chains

“Low Polymer Glass Transition Temperature Technology” = Nano Technology

Flexible polymer chains (= low Tg) do not break under high local stress

Stiff polymer chains (= high Tg) break irreversibly under high local stress → Polymer network degrades → wear
Polymer Chain Design
Micro - Structure

Reaction scheme for Styrene Butadiene Rubber (SBR)

Styrene + Butadiene = Styrene Butadiene Rubber

Tg- Dependency of Styrene / Vinyl Ratio

Styrene [%] vs Vinyl [%]

Tg -30 °C
Tg -40 °C
Tg -50 °C
Tg -60 °C
Tg -70 °C
Tg -80 °C

0 10 20 30 40 50 60 70

0 10 20 30

SBR

Continental
### Safety-optimized Silica Compounds

Impact of Polymer Parameter on $T_g$ - Glass Transition Temperature

<table>
<thead>
<tr>
<th>Micro - Structure</th>
<th>Macro - Structure</th>
<th>Functionalization</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Micro Structure" /></td>
<td><img src="image2" alt="Macro Structure" /></td>
<td><img src="image3" alt="Functionalization" /></td>
</tr>
</tbody>
</table>

- Butadiene
- Styrene
- Vinyl - group
- Reactive - group

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# Technology Overview – A New Level of Comfort

<table>
<thead>
<tr>
<th>Customer Benefit</th>
<th>Safety without compromises</th>
<th>Extended driving convenience over lifetime</th>
<th>Sporty driving in every car</th>
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<tbody>
<tr>
<td>Technology</td>
<td>Safety-optimized silica compounds</td>
<td>Comfort-optimized performance footprint</td>
<td>Handling-optimized pattern design</td>
</tr>
<tr>
<td>Feature</td>
<td>Crystal silica composition</td>
<td>Wear optimized polymer blend</td>
<td>Smooth pattern stiffness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advanced macro-block design</td>
<td>Asymmetric rib geometry</td>
</tr>
</tbody>
</table>
Compound Solution for safety without compromises
Crystal silica composition

Crystal silica composition

› Highest quality grade with increased homogenity of primary particles

› Highly dispersable even at very high filler amounts in compound

› Tailored silica surface structure for enhanced bonding via Silane to Polymer Matrix

Polymer – Filler – Interaction

Silica

Silica – primary particle  Silane coupler  Polymer
Compound solution for extended driving convenience over lifetime

Wear optimized polymer blend

- Low Polymer Glass Transition Temperature Technology
- Specially designed low Tg polymer blend with tailor made micro and macro structure
- Enhanced bonding to crystal silica particles by functionalization

Polymer - Structure

- Butadiene
- Styrene
- Vinyl - group
- Reactive - group
Virtual Compound Development Exercise
Solve Target Conflicts at highest level

Rolling resistance

Wet grip

Wear

Compound
Thank you for your attention!