Short fiber reinforcement for rubber
Rhenogran® P / Rhenogran® WP
**SHORT FIBER REINFORCEMENT FOR RUBBER**

Short fibers such as glass, carbon, aramid or natural fibers have been embedded into many types of polymers to improve and modify certain mechanical properties of the matrix polymer for specific use and to reduce the cost of molded articles. Application areas include V-belts, hose, tire components and miscellaneous molded goods.

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**Reinforcement**
- Cost reduction in manufacturing
- Increased quality and service life of rubber articles
- Improved resistance on exposure to high temperatures, media and pressures
- Easy curing due to dimensional stability

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<table>
<thead>
<tr>
<th>Property</th>
<th>Stiffness</th>
<th>Reinforcement</th>
<th>Flexibility</th>
<th>Degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber</td>
<td>Density (g/cm³)</td>
<td>Youngs modulus [GPa]</td>
<td>Tensile strength [GPa]</td>
<td>Elongation at break [%]</td>
</tr>
<tr>
<td>Cotton</td>
<td>1.5 – 1.6</td>
<td>6 – 13</td>
<td>0.3 – 0.6</td>
<td>3.0 – 10</td>
</tr>
<tr>
<td>Sisal</td>
<td>1.3 – 1.5</td>
<td>9 – 38</td>
<td>0.4 – 0.7</td>
<td>2.0 – 3.0</td>
</tr>
<tr>
<td>Flax</td>
<td>1.4</td>
<td>60 – 80</td>
<td>0.1 – 1.5</td>
<td>1.2 – 1.6</td>
</tr>
<tr>
<td>Cellulose (wood)</td>
<td>1.4</td>
<td>30 – 60</td>
<td>0.4 – 1.0</td>
<td>0.1 – 0.4</td>
</tr>
<tr>
<td>Carbon (PAN)</td>
<td>1.8 – 2.0</td>
<td>160 – 450</td>
<td>3.5 – 7.0</td>
<td>0.7 – 2.0</td>
</tr>
<tr>
<td>E-glass*</td>
<td>2.6</td>
<td>72</td>
<td>1.5 – 3.0</td>
<td>1.8 – 3.2</td>
</tr>
<tr>
<td>Nylon/Polyester</td>
<td>1.1 – 1.4</td>
<td>n.a.</td>
<td>0.9 – 1.1</td>
<td>10 – 25</td>
</tr>
<tr>
<td>Twaron® aramid</td>
<td>1.4 – 1.5</td>
<td>60 – 120</td>
<td>2.4 – 3.6</td>
<td>2.2 – 4.4</td>
</tr>
</tbody>
</table>

* Fibers break down during mixing

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**Selected advantages in applications:**
- Tire innerliner: reduced cord strike-through during cure
- Wire-reinforced hose: wire braiding step eliminated
- Hand-wrapped hose: increased strength of rubber sheet in building
- Tire chafer: increased strength to accommodate tire building process
- Roofing materials: increased green strength for unvulcanized sheeting

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**Application**
- **Belt**: Service life, wear, noise reduction, material fatigue, tooth hardness, creep, load capacity, fracture tendency
- **Hoses**: Thermal stability, rigidity, dimensional stability also at curing, replacement for fabric, solvent swell resistance
- **Tires**: Abrasion resistance, puncture stability, rigidity, running properties, stability
- **Shoes, treads**: Green strength, dimensional stability, abrasion resistance, cutting resistance
- **Membranes**: Puncture resistance, rigidity
- **Gaskets, leathering**: Thermal stability, shrinkage tendency, replacement for fabric, solvent swell resistance
- **Cables**: Modulus, cutting resistance, dimensional stability
- **Tank pads**: Abrasion resistance, cutting resistance
- **Roller covers**: Printing properties, service life
Under high mechanical, dynamic and thermal stresses, an excellent reinforcement performance can be achieved in the finished product with Rhenogran® P91-40, which incorporates the highly resilient and very lightweight Twaron® aramid short-fiber pulp evenly in the rubber compound. Rhenogran® P91-40 is suitable for many rubber grades including NR, IR, BR, SBR, EPDM, CR, NBR and HNBR.

Fiber:
Twaron®, Teijin Aramid’s para-aramid high-performance fiber, commonly used in ballistic protection, optical fiber cables, heat and cut protection, oil and gas as well as the automotive industry.

Fiber pulp generation:
Step 1: Polymerization of monomers to para-aramid grains
Step 2: Dissolving grains and spinning of filament yarn, orientation parallel to the axis
Step 3: Cutting of filament yarn to specific length, suspension in water
Step 4: Fibrillation (mechanical) to specific surface area, followed by drying

Rhenogran® masterbatch:
Pure fiber pulp predispersed in rubber matrix. No treatment necessary to disperse and bind in compound matrix.

Properties:
- Excellent reinforcement, high flexibility
- Extremely durable; heat, cut and chemical-resistant
- Lightweight applications
- Non-conductive
- No melting point, low flammability
In Rhenogran® WP, cellulose fiber pulp enables the reinforcement of finished products made of polymers such as EPDM, SBR, NR and PVC. This is an economical solution for increasing the quality and service life of end products that are exposed to high temperatures, media and pressures.

**Fiber:**
Naturally occurring non-regenerated cellulose from hardwood, commonly used in paper industry or (bio-) composites

**Fiber pulp generation:**
Step 1: Preparation of wood chips from trees
Step 2: Pulping of chips (chemical or mechanical breakdown and refining)
Step 3: Drying of pulp to approx. 10% moisture

**Rhenogran® masterbatch:**
Cellulose pulp plus resorcinol-based resin. Additional methylene donor (e.g. Cohedur A 200) should be used to maximize bonding to rubber matrix.

**Properties:**
- Effective reinforcement, less flexibility
- Bio-degradable material
- Higher reinforcement than cotton or sisal
- Low conductivity
- Cost-efficient
Rhenogran® fiber pulp masterbatches offer all the advantages of predispersed additives: increased process safety, dust-free properties and thereby reduced loss of material and lower cleaning effort. Rhenogran® fiber masterbatches can simplify processing and provide substantial improvement to the properties of final products.

We offer comprehensive technical support, starting with recommendations for formulations and continuing with the development of application-specific fiber pulp masterbatches.

<table>
<thead>
<tr>
<th>Fiber (Twaron® 1091)</th>
<th>Product*</th>
<th>Active content</th>
<th>Polymer binder</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aramid</td>
<td>Rhenogran® P91-40/EPDM</td>
<td>40%</td>
<td>EPDM</td>
<td>Yellow</td>
</tr>
<tr>
<td>Aramid</td>
<td>Rhenogran® P91-40/NBR</td>
<td>40%</td>
<td>NBR</td>
<td>Yellow</td>
</tr>
<tr>
<td>Aramid</td>
<td>Rhenogran® P91-40/NR</td>
<td>40%</td>
<td>NR</td>
<td>Yellow</td>
</tr>
<tr>
<td>Aramid (Twaron® 1095)</td>
<td>Rhenogran® P95-50/EPDM</td>
<td>50%</td>
<td>EPDM</td>
<td>Yellow</td>
</tr>
<tr>
<td>Wood pulp</td>
<td>Rhenogran® WPD-70/SBR</td>
<td>70%</td>
<td>SBR</td>
<td>Black</td>
</tr>
<tr>
<td>Wood pulp</td>
<td>Rhenogran® WPDX-73/SBR</td>
<td>73%</td>
<td>SBR</td>
<td>Black</td>
</tr>
<tr>
<td>Wood pulp</td>
<td>Rhenogran® WPH-65/EPDM</td>
<td>65%</td>
<td>EPDM</td>
<td>Black</td>
</tr>
<tr>
<td>Wood pulp</td>
<td>Rhenogran® WPW-77/PVC</td>
<td>77%</td>
<td>PVC</td>
<td>Gray</td>
</tr>
</tbody>
</table>

*Available on request: Rhenogran® P91-40/CR, Rhenogran® P91-50/HNBR, Rhenogran® P95-50/NBR

**Fiber orientation**

Rhenogran® fibers strongly affect mechanical properties such as strength, dimensional stability, compression modulus, creep, and cut growth characteristics depending on the orientation of the fibers. During calendering or extrusion, the fibers will orient in the direction of shear; thus, one can obtain a product which is, for example, relatively stiff in one direction and flexible in the other.
Our technical advice – whether verbal, in writing or by way of trials – is given in good faith but without warranty, and this also applies where proprietary rights of third parties are involved. It does not release you from the obligation to test the products supplied by us as to their suitability for the intended processes and uses. The application, use and processing of the products are beyond our control and, therefore, entirely your own responsibility. Should, in spite of this, liability be established for any damage, it will be limited to the value of the goods delivered by us and used by you. We will, of course, provide products of consistent quality within the scope of our General Conditions of Sale and Delivery.

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Twaron® is a registered trademark of TEIJIN ARAMID BV, the Netherlands.