Product Information

09/99  Electrically conductive semi-finished products
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Advice
Solids and liquids can charge electrostatically through friction. As a result unloading may produce sparks which can ignite explosive materials (solid, liquid or gaseous).

SIMONA® EL-plastics present no such problems. These electrically conductive grades prevent electrostatic build-up. Examples of applications are:

- Packings and linings for flammable liquids
- Pipe lines for the transport of combustible liquids, solvents and vapours as well as their mixtures
- Laboratory exhaust ducts
- Packings and transport pallets for fragile products

In connection with combustible materials an authorization may be necessary.

**Electrostatic charge and electric conductivity**

Electrostatic build up can occur with:

1. solid materials with a surface resistance of more than $10^9$ Ohm (DIN 53486/VDE 0303, part 8).
2. liquids with a specific resistance of $10^8$ Ohm · m (measured according to DIN 51 412/VDE 0303, part 3).
3. unearthed object from conductive materials

Generally, plastics are good insulators. Conductive particles are added to draw out the electrical charge. SIMONA® EL-plastics are mixed with special carbon blacks in order to achieve as small a surface resistance as possible.

**Distribution of carbon black in SIMONA® PE-EL-sheets which are modified for electrical conductivity (schematic)**
Electrically conductive semi-finished products

**Processing effects**
Conductive properties largely depend on the orientation of the individual particles of the conductive filler. Since such particles generally do not have an ideal, spherical shape, such parts are orientated in a plastic melt, e.g. at extrusion, in the direction of flow.

Isotropically distributed particles distribute conductivity uniformly in all directions. Orientated particles generally conduct in the direction of orientation, but offer poorer conductivity than isotropically distributed particles. Various tests with extruded EL-semi-finished products of SIMONA show however an only small influence of the manufacturing process on the conductive behaviour of the semi-finished product. Pressed SIMONA PE-EL sheets show an isotropic behaviour and, accordingly, a more homogenous electrical conductivity than extruded sheets and pipes.

**Measurement of the surface and volume resistance**
(DIN IEC 167, DIN IEC 93)
The result of measurements of the electrical resistance (surface and volume resistance) is decisively influenced by several variables.

The „connection“ of the measuring electrode to the surface of the semi-finished product is an important factor for an exact measurement of the electrical resistance. Measuring errors of the order of approximately 10,000 Ohm may occur through the use of unsuitable electrodes. Hence we recommend to use adhesive electrodes consisting of conductive silver which guarantee a good connection and reproducible results.

The measured values of the resistance can be considerably increased through a mechanical treatment, e.g. wrinkling of surface, so that after checking the finished construction a larger distance between the electrodes might be preferred.

**Effect of the processing method on the carbon black orientation (schematic)**

| Orientation (e.g. extruded sheet) | No orientation (Isotropy) (e.g. pressed sheet) |

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### Electrically conductive semi-finished products

#### SIMONA® PE-EL
- High chemical resistance
- Good UV-resistance
- Application in a temperature range of -50 up to +80 °C
- Good impact resistance
- Normally inflammable
- Can be welded
- Can be thermoformed
- Can be vacuum formed

#### SIMONA® PP-EL
- High chemical resistance
- Satisfactory UV-resistance
- Application in a temperature range of 0 up to +60 °C
- High rigidity
- Flame retardant
- Easy cutting processing
- Can be welded
- Can be thermoformed
- Can be vacuum formed
- Can be glued

#### SIMONA® PVDF-EL
- Excellent chemical resistance
- High UV-resistance
- Application in a temperature range of -50 up to +140 °C
- High rigidity, connected with high tenacity even at low temperatures
- Low flammability
- Can be welded
- Can be thermoformed
- Can be vacuum formed

#### SIMONA® PP-EL-SK
These sheets are lined on one side with a stretch fabric of thermoplastic polyester for direct lamination of sandwich construction. Of course the conductivity refers only to the unlaminated side.

#### SIMONA® PVC-EL
- High chemical resistance
- Satisfactory UV-resistance
- Application in a temperature range of 0 up to +60 °C
- High rigidity
- Flame retardant
- Easy cutting processing
- Can be welded
- Can be thermoformed
- Can be vacuum formed
- Can be glued

#### SIMONA® PVDF-EL-CV
Semi-finished products with chemically pre-treated surface which allows a direct lamination in composite construction.

#### SIMONA® PP-EL-S
Unlike PP-EL this material disposes of a flame resistant additive. With this it achieves a more favourable fire classification.
Examples of applications

- Packings and transport pallets for dust-susceptible products to avoid electrostatic charge
- Tanks with flammable liquids
- Pipe lines for the transport of combustible liquids, solvents and vapours as well as their acid mixtures
- Laboratory exhaust ducts
- Transport pipes for flammable gases
- Gas collecting mains for land fill sites
- Container and machine parts in explosion-proof rooms
- Lining of tanks for storing and bottling of dustlike materials
- Offtakes in coal manufacturing factories
The following SIMONA® EL-semi-finished products can be delivered as special design on request.

<table>
<thead>
<tr>
<th></th>
<th>PE-EL</th>
<th>PP-EL</th>
<th>PVC-EL</th>
<th>PVDF-EL</th>
</tr>
</thead>
<tbody>
<tr>
<td>sheets</td>
<td>10 · 80</td>
<td>10 · 80</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>pressed</td>
<td>2 · 12</td>
<td>2 · 12</td>
<td>1.5 · 10</td>
<td>2 · 6</td>
</tr>
<tr>
<td>extruded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>solid rods</td>
<td>on request</td>
<td>on request</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>pipes</td>
<td>up to da 630</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>fittings</td>
<td>up to da 315</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>welding rod</td>
<td>2 · 4</td>
<td>on request</td>
<td>3 · 6</td>
<td>on request</td>
</tr>
</tbody>
</table>

also on request:
- PP-EL-S, black, sheets extruded and pressed
- PP-EL-SK, extruded, 3 · 6 mm
- PVDF-EL-SK, 3 · 6 mm, PVDF-EL-GK

Our sales department will be pleased to answer further questions to the a/m dimensions.
## Technical information

### Characteristic values of material

<table>
<thead>
<tr>
<th>Test method</th>
<th>Dimension</th>
<th>PE-EL</th>
<th>PP-EL</th>
<th>PP-EL-S</th>
<th>PVC-EL</th>
<th>PVDF-EL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>DIN 16776</td>
<td>g/cm³</td>
<td>0.99</td>
<td>0.94</td>
<td>1.18</td>
<td>1.4</td>
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<tr>
<td>E modulus at tensile test</td>
<td>DIN EN ISO 527</td>
<td>MPa</td>
<td>900</td>
<td>1400</td>
<td>1400</td>
<td>3000</td>
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<td>Yield stress</td>
<td>DIN EN ISO 527</td>
<td>MPa</td>
<td>25</td>
<td>28</td>
<td>26</td>
<td>50</td>
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<tr>
<td>Tensile strain at break</td>
<td>DIN EN ISO 527</td>
<td>%</td>
<td>30</td>
<td>45</td>
<td>50</td>
<td>15</td>
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<tr>
<td>Impact strength</td>
<td>DIN EN ISO 179</td>
<td>kJ/m²</td>
<td>6</td>
<td>&gt;4</td>
<td>&gt;4</td>
<td>5</td>
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<tr>
<td>Notched impact strength</td>
<td>DIN EN ISO 179</td>
<td>kJ/m²</td>
<td>6</td>
<td>&gt;4</td>
<td>&gt;4</td>
<td>5</td>
</tr>
<tr>
<td>Ball indent. hardn. H 358/30</td>
<td>DIN EN ISO 2039-1</td>
<td>N/mm²</td>
<td>60</td>
<td>66</td>
<td>66</td>
<td>120</td>
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<tr>
<td>Shore hardness D</td>
<td>ISO 868</td>
<td>-</td>
<td>63</td>
<td>72</td>
<td>70</td>
<td>81</td>
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<tr>
<td>Vicat softening point B/50</td>
<td>DIN ISO 306</td>
<td>°C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>78</td>
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<td>Mean linear expansion coefficient</td>
<td>DIN 53752</td>
<td>K1</td>
<td>1.8·10⁴</td>
<td>1.6·10⁴</td>
<td>1.6·10⁴</td>
<td>0.8·10⁶</td>
</tr>
<tr>
<td>Thermal conductivity *</td>
<td>DIN 52612</td>
<td>W/mK</td>
<td>0.38</td>
<td>--</td>
<td>--</td>
<td>0.159</td>
</tr>
<tr>
<td>Volume resistivity (Annular electrode)</td>
<td>DIN IEC 93</td>
<td>Ohm·cm</td>
<td>≤ 10⁶</td>
<td>≤ 10⁶</td>
<td>≤ 10⁶</td>
<td>≤ 10⁶</td>
</tr>
<tr>
<td>Surface resistance **</td>
<td>DIN IEC 167</td>
<td>Ohm</td>
<td>≤ 10⁶</td>
<td>≤ 10⁶</td>
<td>≤ 10⁶</td>
<td>≤ 10⁶</td>
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<tr>
<td>Water absorption</td>
<td>DIN 53495</td>
<td>%/24 h</td>
<td>&lt; 0.006</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* measured on test pieces of 10 mm thickness

** electrode order B

These standard figures can vary according to the processing and production methods used.
The above characteristic values are obtained from 4 mm extruded sheets and can vary in other thicknesses. The suitability of our material for a specific application must be verified by the fabricator or user.

### Designation of material

- PVC-EL extruded: PVC-U, EDLZ, 078-04-33 (DIN 7748, 9/85)
- PE-EL extruded: PE, ECYL, 45 T 003 (DIN 16776, 12/84)
- PE-EL pressed: PE-ECY, 45 T 003 (DIN 16776, 12/84)
- PP-EL extruded: PP-H, ECY, 95 T 006 (DIN 16774 T1, 12/84)
- PP-EL-S extruded: PP-H, ECFY, 95 T 006 (DIN 16774 T1, 12/84)
Physiological safety
SIMONA* EL-materials do not satisfy the requirements of the law governing foodstuffs and consumables, therefore direct contact with foodstuffs should be avoided.

Chemical resistance
SIMONA* EL-materials are - like the basic materials - resistant to many chemicals. Specific resistance depends on the medium, on the temperature and on the medium's concentration. Therefore, we recommend to contact our Technical Application Department, if required.

Outdoor use
In comparison to the standard products PE-HWU/PVDF, SIMONA* PE-EL/PVDF-EL show a similarly good UV-resistance. SIMONA* PP-EL, PP-EL-S and PVC-EL reach a sufficient UV-resistance during outdoor use by a modification of the conductive carbon black. It should be mentioned in this respect that SIMONA* PVC-EL should not be heated (absorption of sun rays) above 60 °C.
Processing

**Humidity/Pretreatment**
The carbon black added to the respective plastic tends - when stored for prolonged time or under unfavorable conditions - to absorb a small amount of humidity due to its chemical-physical properties. However, trials with PE-EL/PVDF-EL-samples, stored in water for a period of 14 days, showed no significant difference to the original samples when being processed. Pre-drying is recommendable as the adsorption of (atmospheric) humidity is influenced to a large extent by handling and logistic (see also product information ,,Welding“).

**Welding/Thermoforming**
The partially crystalline SIMONA® products PE-EL, PP-EL, PP-EL-S and PVDF-EL can be as easily welded as the analog basic materials. Values for short-term welding factors and bending angles which can be compared with those achieved with PE-HD (DVS guideline 2201, part 2) are reached especially at heated element butt welding (HS) and hot gas extrusion welding (WE) of SIMONA® PE-EL.

The conductive PP-grades, PVC-EL and PVDF-EL can also be perfectly joined by means of HS-, WE- and hot gas string-bead welding.

The mechanical short-term values of watered and HS-welded PE-EL/PVDF-EL-samples do not significantly differ from the untreated sample.

Due to the polar character of the basic material PVC/PVDF, the conductive grades PVC-EL/PVDF-EL may also tend to absorb water at extremely unfavourable (atmospheric) conditions.

Depending on the content of humidity, a formation of bubbles in the weld seam area or during vacuum-forming might occur. Therefore, pre-drying of SIMONA® EL-products could possibly be required.

**Processing parameters and measured values of resistance**
SIMONA® EL-semi-finished products principally can be welded with the same parameters as their basic materials. Exception: Please use special EL-welding wire for hot gas welding.

Further processing aids can be taken from our product information ,,Welding“ and ,,Vacuum-forming,, Thermoforming, Bending“ or contact our Technical Application Department.

The surface or volume resistance (DIN IEC 167 and 93) of thermoformed and with same welding addition welded SIMONA® EL-materials can be compared with the measured values of untreated EL-semi-finished products. The excellent electric conductivity of SIMONA® EL-products remains even after processing with the well-known welding and forming methods. Strong orientation caused by forming can affect the electrical conductivity.
Information about security
Under the conditions indicated in this product information, the processing of SIMONA® PVDF-EL is not at all dangerous. Extensive measurements on the welding place have proved without doubt that no measurable concentrations of harmful substances occur. However, due to processing errors or breakdowns, the temperature of the material could exceed the critical limit of 350 °C. This can result in the production of hydrogen fluoride and/or related fluorine combinations.

To prevent this we ask you to observe the following rules:

1. Do not expose SIMONA® PVDF-EL to the naked flame.
2. Do not smoke in areas in which an accumulation of PVDF-dust can be expected.
3. Observe the recommended air and tool temperatures when welding; this prevents the exceeding of the critical temperature of 350 °C.

Advice
Our Export Department and Technical Application Department are long-experienced in the application and processing of thermoplastic semi-finished products. We look forward to helping you.