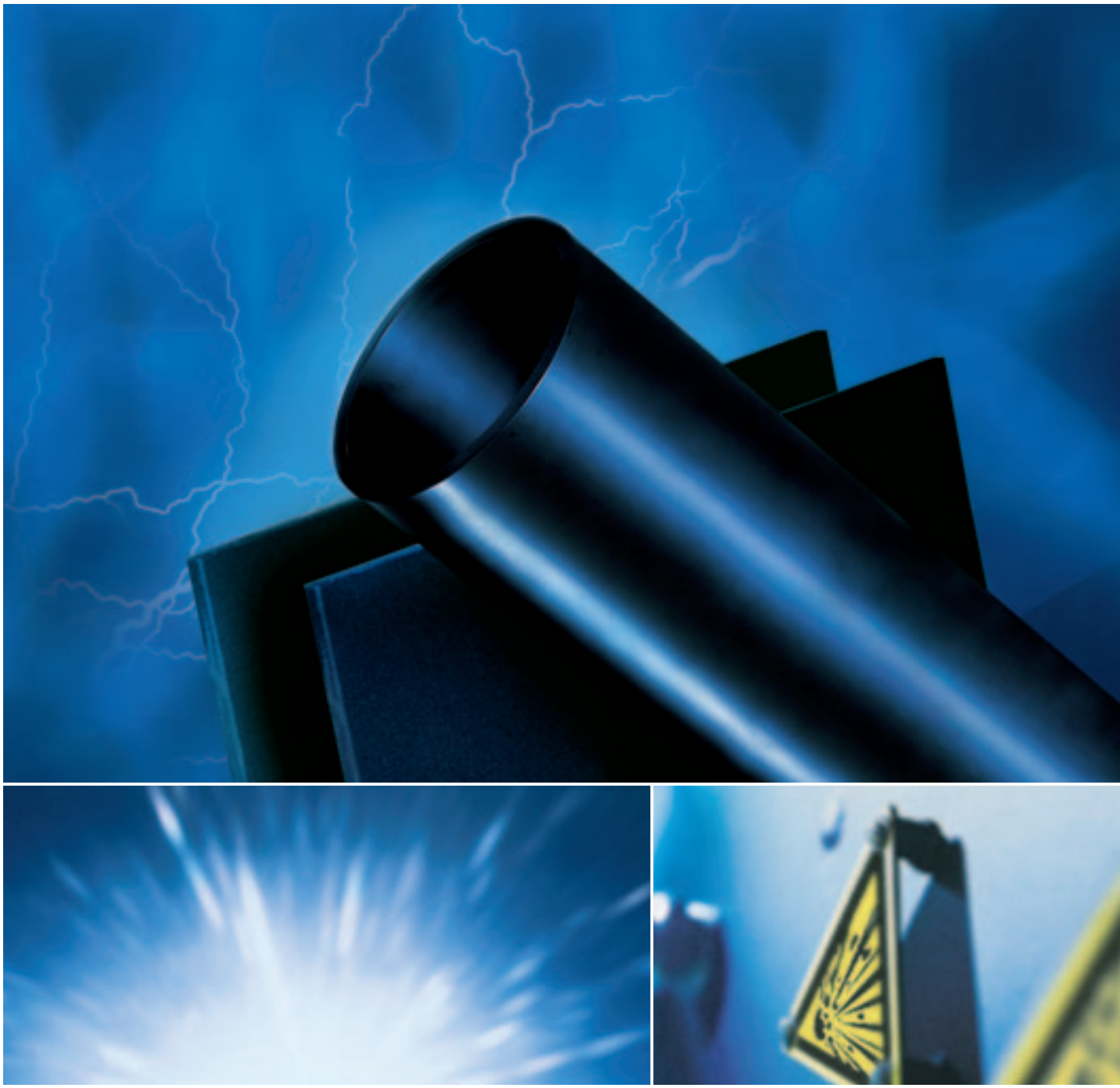
SIMONA



Product Information
Electrically Conductive Plastics

Contents

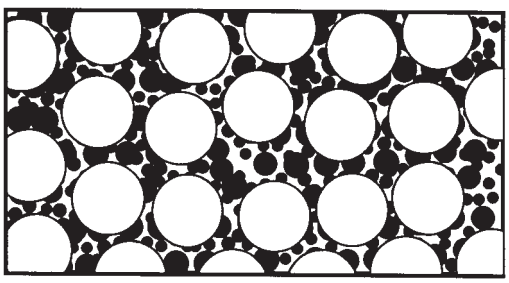
1 Plastics and Explosion Risks

1.1 Conductivity of Plastics

Plastics are contributing to an ever-increasing range of modern-day applications. They are deployed in the chemical industry as well as the manufacture of tanks, apparatus and pipelines. There they are used not only because of their excellent value but also because of their high chemical resistance and good processing capability. The plastics predominantly used in the above-mentioned sectors are polyethylene (PE) and polypropylene (PP).

Plastics have many advantages over other materials. With regard to potentially explosive atmospheres, however, the non-conductive properties of plastics have to be taken into account. Owing to this property, there is a risk of static developing. If such charged materials discharge owing to sparking, they can cause explosive atmospheres – such as mixtures of solvents and air or mixtures of dust and air – to explode. To be able to exploit the advantages of plastics for those fields of application, special types of carbon are added, so-called conductivity carbons, thus significantly increasing their conductivity and considerably reducing their electrical resistance. By taking this precaution, the electrical volume resistivity can be reduced, e.g. that of PE from $10^{16}\,\Omega$ to $<10^{6}\,\Omega$: the plastics become capable of conducting an electrical discharge. If they are earthed, an electrostatic charge can be reliably prevented.

Carbon distribution in SIMONA® PE-EL sheets modified for conductivity (schematic)



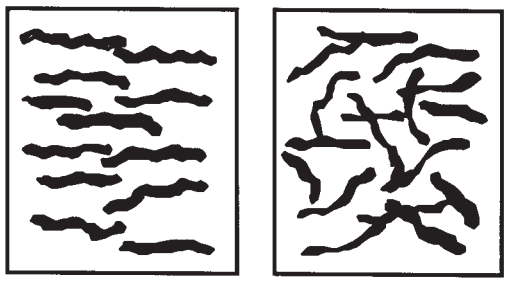
In addition to a decrease in volume resistivity, black staining (conductivity carbon) also provides excellent UV protection, as in the case of electrically conductive polyethylene (PE-EL).

1.2 Influences on Processing

Conductivity properties are highly dependent on the orientation of the individual particles of the conductivity additive. Since such particles generally do not have a perfect spherical shape, they are subject to orientation, e.g. during extrusion, in a plastic melt due to influences on processing.

Isotropically distributed particles create conductivity which is statistically uniform in all directions.
Oriented particles chiefly conduct in the direction of orientation, albeit less efficiently than isotropically distributed particles. Numerous tests on extruded and injection-moulded SIMONA® EL semi-finished products indicate, however, that the manufacturing process only has very little influence on the conductivity of the semi-finished product. Pressed SIMONA® PE-EL sheets exhibit isotropic behaviour and hence more homogeneous electrical conductivity than extruded sheets and pipes.

Influence of processing on carbon orientation (schematic)



Orientation (e.g. extruded sheet)

No orientation (isotropy) (e.g. pressed sheet)

1.3 Measurement of Surface and Volume Resistivity

In some cases the result of measurements of electrical resistance (surface and volume resistivity) is substantially influenced by several determining factors.

The "coupling" of the measuring electrodes to the surface of the semi-finished product being tested is of major importance for accurate measurement of electrical resistance. If unsuitable electrodes are used, measuring errors can occur in the order of approx. 10,000 Ω. For this reason, we recommend using adhesive electrodes made of conductive silver, ensuring that coupling remains good and the test results can be reproduced at any time.

Surface resistivity can be considerably increased by machining, e.g. roughening the surface, so when checking the design it may be necessary to use a larger electrode gap.

1.2 ATEX Directive 94/9/EC

ATEX stands for Atmosphère Explosible. Directive 94/9/EC regulates explosion protection in mining and in industry and applies to any products (products = equipment and protective systems, safety, monitoring and control systems, and any components that are built into equipment and protective systems) which are used in potentially explosive atmospheres. ATEX Directive 94/9/EC is applicable to manufacturers of equipment and protective systems.

In the past, each country had its own requirements and regulations for operating equipment in potentially explosive atmospheres. This situation was a hindrance to the freedom of movement of such products throughout Europe. Within the framework of European harmonisation specific EU directives were developed. In the field of explosion protection Directive 94/9/EC (ATEX 100a being the previous working title, ATEX 95 after renumbering) has been mandatory and in force since 1 July 2003. This directive includes for the first time essential safety and health requirements for those products and non-electrical equipment (e.g. pneumatic actuators).

In Directive 94/9/EC the products to which the directive applies are classified in equipment groups and categories, according to hazard potential. The requirements for equipment and protective systems are also governed by these provisions. For further information about ATEX Directive 94/9/EC, please refer to the SIMONA website: **www.simona.de/atex**

1.5 Explosion Hazards

Potentially explosive atmospheres (explosive zones) are characterised by a mixture of air and combustible gases, vapours, mists or dusts and can in principle occur wherever combustible liquids, gases or dusts are manufactured, filled into containers, transported or stored.

Potentially explosive mixtures with gases, mists or vapours	**Potentially explosive mixtures with dusts**	**Ignition sources**
Chemical factories	Chemical factories	Hot surfaces
Tank storage depots	Power plants	Flames
Refineries	Paint factories	Hot gases
Sewage treatment plants	Grain mills	Mechanically generated sparks
Airports	Cement factories	Electrical equipment (sparks)
Power plants	Port installations	Electrical equalising currents
Paint factories	Feedstuff factories	Electrostatic discharges
Paint spraying shops	Wood-processing companies	Shock waves inflowing gases
Port installations	Metal-processing companies	Chemical reactions
	Plastic granules processing companies	Ionising radiation
		Ultrasound
		Lightning strike

2 Product Properties

2.1 Characteristic Properties

SIMONA® PE-EL

PE-EL is a high-heat resistant, UV-stabilised product provided with electrical conductivity for explosion protection against static. Consequently, PE-EL can not only be used in chemical tank and apparatus manufacture but is also ideal for applications in the electrical industry and all other potentially explosive atmospheres where sparks can be caused by static. For solutions in composite construction we also offer electrically conductive PE sheets in the form of backed sheets.

Special properties

- Electrically conductive
- High resistance to UV rays
- Service temperature range –20 °C to +80 °C
- Good impact resistance
- Normal flammability
- Weldable
- Warm bending and thermoforming capability
- Good chemical resistance
- High abrasion resistance

Approvals

- DIN 4102 normal flammability

Areas of use

- Electrical industry
- Chemical apparatus and tank construction
- Bulk commodities industry

Product range

- Sheets
- Welding rods
- Pressure pipes
- Fittings

SIMONA® PP-EL / PP-EL-S

PP-EL is an electrically conductive homopolymeric polypropylene. This material features electrically conductive particles which discharge static. PP-EL has a low surface resistivity and is ideal for use in potentially explosive atmospheres. In the form of PP-EL-S the material has a flame-retardant additive.

Special properties

- Electrically conductive
- Normal flammability (PP-EL)
- Low flammability (PP-EL-S)
- Weldable
- Warm bending and thermoforming capability
- Satisfactory resistance to UV rays
- Permanent heat resistant
- High chemical resistance
- High corrosion resistance
- Excellent processing capability

Approvals

- DIN 4102 normal flammability (PP-EL)
- DIN 4102 low flammability (PP-EL-S)

Areas of use

- Tank construction
- Linings
- Laboratory construction
- Packaging industry

Product range

- Sheets (PP-EL, PP-EL-S)
- Welding rods (PP-EL)
- Pressure pipes (PP-EL)
- Ventilation ducts (PP-EL-S)
- Fittings

SIMONA® PVDF-EL

PVDF ranks among the high-performance materials. In the form of PVDF-EL the material features electrically conductive particles and has low surface resistivity. Areas of use include not only chemical tank and apparatus construction but also the electrical industry and all other potentially explosive atmospheres.

Special properties

- Electrically conductive
- High resistance to UV rays
- High rigidity, in conjunction with high impact strength even at low temperatures
- Low flammability
- Weldable
- Warm bending and thermoforming capability
- High-performance material
- Excellent chemical resistance
- Outstanding ageing resistance

Approvals

- DIN 4102 low flammability

Areas of use

- Chemical apparatus and tank construction
- Electrical industry
- Nuclear industry
- Ventilation industry

Product range

- Sheets
- Welding rods

2.2 Examples of Applications of Electrically Conductive Plastics

- Packagings and transport pallets in order to prevent static for high-quality products exposed to dust
- Tanks with fire-hazard contents
- Pipelines for conveying combustible liquids, solvents, vapours and their acid mixtures
- Laboratory extraction systems
- Pipelines for conveying combustible gases
- Gas collection pipes on landfill sites
- Tanks and parts of machinery in explosion-proof rooms
- Tank linings for storage and container filling of powders
- Vent pipes at coal-processing plants
- Tanks and linings for fire-hazard contents
- Pipelines for conveying combustible liquids, solvents, vapours and their mixtures
- Laboratory ducts
- Packagings and transport pallets for sensitive products

In conjunction with combustible materials an approval certificate may be required.

3 Range of Products

3.1 SIMONA® PE-EL

PE-EL sheets

Process	Colour	Format (mm)	Thicknesses (mm)
extruded	black	2000 x 1000	3.0 – 12.0
extruded	black	3000 x 1500	3.0 – 12.0
pressed	black	2000 x 1000	10.0 – 120.0
pressed	black	4120 x 2010	10.0 – 120.0
pressed	black	6200 x 2010	10.0 – 80.0

Available on request:
- Polyester-backed sheets (PE-EL-SK)

PE-EL welding rod

Type	Form	Thicknesses (mm)
Round rod	1-metre rod	3.0 / 4.0
Round rod	2-metre rod	3.0 / 4.0
Round rod	Coil	3.0 / 4.0
Round rod	Spool	3.0 / 4.0

PE-EL pressure pipes

Standard length: 5000 mm

Pressure class	Diameter (mm)
SDR 17.6	63.0 – 630.0
SDR 11	32.0 – 400.0

PE-EL fittings

- Bends
- Tees
- Stub flanges
- Loose flanges
- Custom fittings and custom components

3.2 SIMONA® PP-EL / PP-EL-S

PP-EL / PP-EL-S sheets

Process	Colour	Format (mm)	Thicknesses (mm)
extruded	black	3000 x 1500	3.0 – 12.0
pressed	black	2000 x 1000	10.0 – 80.0
pressed	black	4120 x 2010	10.0 – 80.0
pressed	black	6200 x 2010	10.0 – 80.0

Available on request:
- Polyester-backed sheets (PP-EL-SK)
- Glass fibre-backed sheets (PP-EL-GK)

PP-EL / PP-EL-S welding rod

Type	Form	Thicknesses (mm)
Round rod	1-metre rod	3.0 / 4.0
Round rod	2-metre rod	3.0 / 4.0
Round rod	Coil	3.0 / 4.0
Round rod	Spool	3.0 / 4.0

PP-EL pressure pipes

Standard length: 5000 mm

Pressure class	Diameter (mm)
SDR 17.6	63.0 – 630.0
SDR 11	32.0 – 400.0

PP-EL-S ventilation ducts

Standard length: 5000 mm

Diameter (mm): 90.0 – 500.0

PP-EL fittings

- Custom fittings and custom components

If you require further information about availability, sizes, formats or minimum quantities, please contact our Sales Department.

3.3 SIMONA® PVDF-EL

PVDF-EL sheets

Process	Colour	Format (mm)	Thicknesses (mm)
extruded	black	2000 x 1000	3.0 / 4.0
pressed	black	2000 x 1000	10.0 – 50.0

Available on request:
- Polyester-backed sheets (PVDF-EL-SK)
- Glass fibre-backed sheets (PVDF-EL-GK)

PVDF-EL welding rod

Type	Form	Thicknesses (mm)
Round rod	1-metre rod	3.0 / 4.0
Round rod	2-metre rod	3.0 / 4.0
Round rod	Coil	3.0 / 4.0

If you require further information about availability, sizes, formats or minimum quantities, please contact our Sales Department.

4 Technical Information

4.1 Material Specifications

	Test method	Unit	PE-EL	PP-EL	PP-EL-S	PVDF-EL
Density	ISO 1183	g/cm^3	0.990	0.940	1.180	1.780
Tensile modulus of elasticity	DIN EN ISO 527	MPa	1100	1400	1400	1800
Yield stress	DIN EN ISO 527	MPa	26	28	25	45
Elongation at break	DIN EN ISO 527	%	50	45	40	10
Impact strength	DIN EN ISO 179	kJ/m^2	No break	No break	No break	No break
Notched impact strength	DIN EN ISO 179	kJ/m^2	5	> 4	> 4	6
Ball indentation hardness H 358/30	DIN EN ISO 2039–1	N/mm^2	50	66	66	110
Shore hardness D	ISO 868	–	63	72	70	78
Vicat softening temp. B/50	DIN ISO 306	°C	–	–	–	132
Mean coefficient of linear thermal expansion	DIN 53752	K^{-1}	$1.8 * 10^{-4}$	$1.6 * 10^{-4}$	$1.6 * 10^{-4}$	$1.3 * 10^{-4}$
Thermal conductivity *	DIN 52612	W/mK	0.38	–	–	0,14
Volume resistivity	DIN IEC 60093	Ohm * cm	$\leq 10^6$	$\leq 10^6$	$\leq 10^6$	$\leq 10^6$
Surface resistivity **	DIN IEC 60093	Ohm	$\leq 10^6$	$\leq 10^6$	$\leq 10^6$	$\leq 10^6$
Water absorption	DIN 53495	% 24 h	< 0.006	< 0.02	< 0.02	< 0.02

* Measured on test specimens 10 mm thick
** Electrode arrangement B

The figures are approximate and may vary depending on fabrication processes and how test specimens are made. They are usually averages of measurements on extruded sheets 4 mm thick. There may be discrepancies if sheets are not available in that thickness. The information cannot necessarily be applied to finished products. The processing company or user is responsible for testing whether materials are suitable for a specific application. The specifications are merely a planning aid. In particular, they are not guaranteed properties.

Names of moulding compounds

PE-EL	extruded	PE, ECYL, 45 G 045	DIN EN ISO 1872 Part 1
	pressed	PE, QCYL, 45 G 045	DIN EN ISO 1872 Part 1
PP-EL	extruded	PP-H, ECLY, 16-05-003	DIN EN ISO 1873 Part 1
PP-EL-S	extruded	PP-H, ECFY, 16-05-003	DIN EN ISO 1873 Part 1

4.2 Physiological Safety

SIMONA® EL materials do not meet the requirements of the German Food and Commodities Act, i.e. they must not be brought into direct contact with food.

4.3 Chemical Resistance

Like the base materials, SIMONA® EL materials are resistant to many chemicals. In specific applications usability depends on the medium, temperature and the concentration of the medium. In such cases, we therefore recommend contacting our Applications Technology Department.

4.4 Outdoor Applications

In relation to SIMONA standard products PE-HWU und PVDF, SIMONA® PE-EL and PVDF-EL have comparatively good UV resistance. Owing to modification with conductivity carbon, SIMONA® PP-EL and PP-EL-S reach satisfactory UV resistance in outdoor applications.

5 Processing

5.1 Moisture/Pretreatment

Owing to its chemical and physical properties, the carbon added to the respective plastic tends to absorb a slight amount of moisture if subjected to lengthy storage or unfavourable conditions. However, tests on PE-EL/PVDF-EL specimens immersed in water for 14 days did not show any significant differences in processing by comparison with the original samples.

In practice the absorption of (atmospheric) moisture is essentially influenced by handling and logistics. Thus, under the above circumstances pre-drying may be advisable (see also Product Information leaflet "Welding").

5.2 Welding/Thermoforming

The partially crystalline SIMONA® materials PE-EL, PP-EL, PP-EL-S and PVDF-EL are just as easy to weld as the respective base materials.

Especially when performing heated tool butt welding (HS) and hot-gas extrusion welding (WE) on SIMONA® PE-EL in accordance with DVS Guideline 2201, Part 2, it is possible to achieve short-time welding factors and V-bending angles which are comparable with those of PE-HD.

The electrically conductive PP types and PVDF-EL are also easy to join by heated tool butt welding, hot-gas extrusion welding and hot-gas string bead welding.

The mechanical short-time figures for PE-EL/PVDF-EL specimens immersed in water and subjected to heated tool butt welding are not significantly different from those of untreated samples.

Blistering near the welding seam or during vacuum thermoforming may occur, depending on the level of moisture. It may therefore be necessary to pre-dry SIMONA® EL materials.

5.3 Processing Parameters and Resistance Measurements

SIMONA® EL semi-finished products can always be welded with the same parameters as those applicable to their base materials. Exception: for hot-gas welding, please use special EL welding rod.

For further processing information, please refer to our Product Information leaflets "Welding" and "Vacuum Forming, Thermoforming, Bending" or contact our Applications Technology Department.

The surface and volume resistivity figures for SIMONA® EL materials thermoformed and welded with the same welding filler are comparable with the measurements for unprocessed EL semi-finished products.
The excellent electrical conductivity of SIMONA® EL materials always remains intact after processing by standard methods of welding and forming. Electrical conductivity can be impaired by excessive orientation due to deformation.

SIMONA – A Proven Track Record in the Plastics Sector

SIMONA AG is recognised as one of the world's leading manufacturers of semi-finished thermoplastics. Drawing on more than 40 years of experience in formulation, production and machining, we have established the credentials and unrivalled expertise of high-calibre specialists. This also applies to the full range of SIMONA products and consulting services associated with plastics deployed in explosive atmospheres.

SIMONA is the only manufacturer of semi-finished plastics to have established a training programme for electrically conductive plastics. The specialist courses are designed to provide an in-depth understanding of material specifications and properties, as well as focusing on the specific characteristics of plastics welding, product dimensions, chemical resistance and behaviour in various temperature ranges. Upon successful completion of the practical exercises at the end of the course, participants receive a certificate confirming their expertise as processors of electrically conductive plastics.

For your safety as well as the safety of your staff and your company.

SIMONA Worldwide

SIMONA AG
Teichweg 16
D-55606 Kirn
Phone +49 (0) 67 52 14-0
Fax +49 (0) 67 52 14-211
mail@simona.de
www.simona.de

Plant I/II
Teichweg 16
D-55606 Kirn
Phone +49 (0) 67 52 14-0
Fax +49 (0) 67 52 14-211

Plant III
Gewerbestraße 1–2
D-77975 Ringsheim
Phone +49 (0) 78 22 436-0
Fax +49 (0) 78 22 436-124

SIMONA S.A. Paris
Z.I. 1, rue du Plant Loger
F-95335 Domont Cedex
Phone +33 (0) 1 39 35 49 49
Fax +33 (0) 1 39 91 05 58
domont@simona-fr.com

SIMONA S.A. Lyon
Z.I. du Chanay
2, rue Marius Berliet
F-69720 Saint-Bonnet-de-Mure
Phone +33 (0) 4 78 40 70 71
Fax +33 (0) 4 78 40 83 21
lyon@simona-fr.com

SIMONA S.A. Angers
Z.I. 20, Bld. de l'Industrie
F-49000 Ecouflant
Phone +33 (0) 2 41 37 07 37
Fax +33 (0) 2 41 60 80 12
angers@simona-fr.com

SIMONA UK LIMITED
Telford Drive
Brookmead Industrial Park
GB-Stafford ST16 3ST
Phone +44 (0) 17 85 22 24 44
Fax +44 (0) 17 85 22 20 80
mail@simona-uk.com

SIMONA AG SCHWEIZ
Industriezone
Bäumlimattstrasse
CH-4313 Möhlin
Phone +41 (0) 61 8 55 90 70
Fax +41 (0) 61 8 55 90 75
mail@simona-ch.com

SIMONA S.r.l. ITALIA
Via Padana
Superiore 19/B
I-20090 Vimodrone (MI)
Phone +39 02 25 08 51
Fax +39 02 25 08 520
mail@simona.it

SIMONA IBERICA SEMIELABORADOS S.L.
Doctor Josep Castells, 26–30
Polígono Industrial Fonollar
E-08830 Sant Boi de Llobregat
Phone +34 93 635 41 03
Fax +34 93 630 88 90
mail@simona-es.com

SIMONA-PLASTICS CZ, s.r.o.
Zděbradská ul. 70
CZ-25101 Říčany-Jažlovice
Phone +420 323 63 78 3-7/-8/-9
Fax +420 323 63 78 48
mail@simona-plastics.cz
www.simona-plastics.cz

SIMONA POLSKA Sp. z o. o.
ul. H. Kamieńskiego 201–219
PL-51-126 Wrocław
Phone +48 (0) 71 3 52 80 20
Fax +48 (0) 71 3 52 81 40
mail@simona.pl
www.simona.pl

SIMONA FAR EAST LIMITED
Room 501, 5/F
CCT Telecom Building
11 Wo Shing Street
Fo Tan
Hongkong
Phone +852 29 47 01 93
Fax +852 29 47 01 98
sales@simona.com.hk

SIMONA AMERICA Inc.
PO Box 158
755 Oakhill Road
Mountaintop, PA 18707
USA
Phone +1 570 474 5106
Fax +1 570 474 6523
mail@simona-america.com
www.simona-america.com