

VESTAKEEP®

PEEK—Polyether Ether Ketone Powders



Evonik Industries is the creative industrial group from Germany which operates in three business areas: Chemicals, Energy and Real Estate. Evonik is the global leader in specialty chemicals.

The High Performance Polymers Business Line, together with the Acrylic Monomers and Acrylic Polymers Business Lines, is part of the Performance Polymers Business Unit.

High Performance Polymers has specialized in the manufacture of custom-designed products and systems. For over 40 years, the business line has been producing high performance polymers, and is known for its expertise in powder technology—in development, production, application technology, and service. Expansion of its product portfolio in the area of high-temperature polymers is a logical result of its many years of market success.

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VESTAKEEP®: Expansion of High-Performance Polymers

With the polyether ether ketone compounds and powders VESTAKEEP® (PEEK¹), High Performance Polymers has further expanded its technology leadership in the high-performance plastics sector.

Compounds and powders made of VESTAKEEP® are especially suitable for applications subject to extreme mechanical, thermal, and chemical requirements.

Evonik markets its VESTAKEEP® compounds and powders worldwide. A proven quality management system—from development, through production, all the way to quality assurance—ensures the high quality of products entering the market. Our system is certified to ISO 9001:2000 and ISO/TS 16949:2002, and is constantly optimized. Over the years, numerous customers have tested this quality system and confirmed its superiority.

For R&D and production, we have also launched an environmental management system that is regularly certified to ISO 14001:2005.

This brochure provides an overview of the properties and applications of VESTAKEEP® powders, which are available in various particle sizes and viscosities (molecular weights), depending on the processing method, as well as processing instructions. VESTAKEEP® compounds are described in a separate brochure.

VESTAKEEP® compounds are particularly characterized by the following material properties:

- Very high heat deflection temperature
- Low water absorption and therefore high dimensional stability
- High hardness
- Good strength
- Excellent sliding friction behavior
- Very minimal abrasion
- Good electrical properties
- Excellent chemical resistance
- Excellent hydrolytic stability



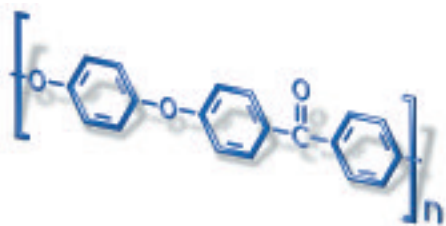
¹PEEK is the official abbreviation for polyether ether ketone according to ISO 1043. In this brochure it will be used only in this context.



1 Introduction

Manufacture

VESTAKEEP® is polycondensed from the building blocks hydroquinone and 4,4'-difluorobenzophenone in a multi-stage process.



Application

VESTAKEEP® powders can be used for a wide range of applications, such as in electrical, electronic, and communications engineering, and in the automotive and food industries. They are also proven suitable for the manufacture of composites.

They can be processed with a number of methods, such as compression molding, electrostatic powder spraying, flame spraying, and scattering. They can also be used as a suspension in aqueous as well as solvent-based systems.

Delivery

VESTAKEEP® powders are delivered in boxes with moisture-proof PE liners.

Powders (P): in 10 kg boxes, 25 boxes with a total weight of 250 kg on one pallet.

Fine powders (FP) and ultrafine powders (UFP): in 15 kg boxes, 25 boxes with a total weight of 375 kg on one pallet.

We will also deliver in bulk packaging upon request. Under normal storage conditions, storage time is practically unlimited provided that the packaging has not been damaged. Avoid storing at temperatures above 45 °C.

Like other partially crystalline polyaryl ether ketones, unmodified VESTAKEEP® appears amber-colored in the melt and grayish in its solid crystalline state (natural colors). VESTAKEEP® is translucent in its solid, amorphous state and has a characteristic amber color.

Our experts will be happy to provide further information and support.



Overview of the most important properties

Properties*	Test method	Unit	VESTAKEEP® powder	
Physical and thermal properties and fire behavior				
Density	23 °C	ISO 1183	g/cm ³	1.30
Melting range	DSC, 2nd heating		°C	approx. 340
Volume flow rate (MVR)	380 °C/5 kg	ISO 1133	cm ³ /10 min	70
Temperature of deflection under load		ISO 75-1/2		
Method A	1.8 MPa		°C	155
Method B	0.45 MPa		°C	205
Linear thermal expansion	23 °C–55 °C, longitudinal	ISO 11359	10 ⁻⁴ K ⁻¹	0.6
Oxygen index	3.2 mm	ISO 4589	%	38
Flammability acc. UL94	0.8 mm	IEC 60695		V-0
	1.6 mm	IEC 60695		V-0
Glow wire test	GWIT 2 mm	IEC 60695-2-12/13	°C	875
	GWFI 2 mm	IEC 60695-2-12/13	°C	960
Mold shrinkage		ISO 294-4		
	in flow direction		%	0.7
	in transverse direction		%	1.2
Mechanical properties				
Tensile test	50 mm/min	ISO 527-1/-2		
Stress at yield			MPa	100
Strain at yield			%	5
Strain at break			%	30
Tensile modulus		ISO 527-1/-2	MPa	3700
CHARPY impact strength	23 °C	ISO 179/1eU	kJ/m ²	N
	-30 °C	ISO 179/1eU	kJ/m ²	N
CHARPY notched impact strength	23 °C	ISO 179/1eA	kJ/m ²	6 C
	-30 °C	ISO 179/1eA	kJ/m ²	6 C

*measured on a tension bar

N = no break

C = complete break incl. hinge break H

Chemical resistance

Due to its chemical structure VESTAKEEP® features an outstanding chemical resistance. Please direct more detailed inquiries to the indicated contact persons.



2 Overview of VESTAKEEP® powders

VESTAKEEP® powder grades

VESTAKEEP® powder	high-viscosity	medium-viscosity	low-viscosity	Average particle size	Scattering powder	Compression molding	Flame spraying	Electrostatic spraying	Suspension
4000 P	■			approx. 500 µm	■	■	■	■	■
4000 FP	■			approx. 65 µm	■	■	■	■	■
2000 P		■		approx. 500 µm	■	■	■	■	■
2000 FP		■		approx. 50 µm	■	■	■	■	■
2000 UFP20		■		approx. 20 µm	■	■	■	■	■
2000 UFP10		■		approx. 10 µm	■	■	■	■	■
1000 P			■	approx. 500 µm	■	■	■	■	■

■ yes

■ no

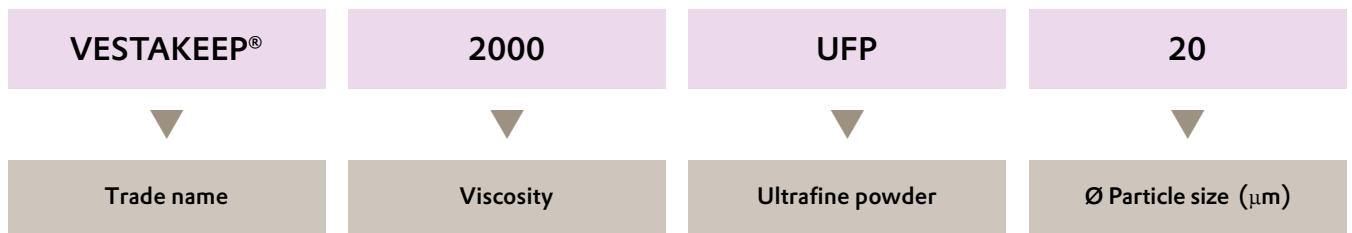
Key to product description

P: Powder

FP: Fine powder

UFP: Ultrafine powder

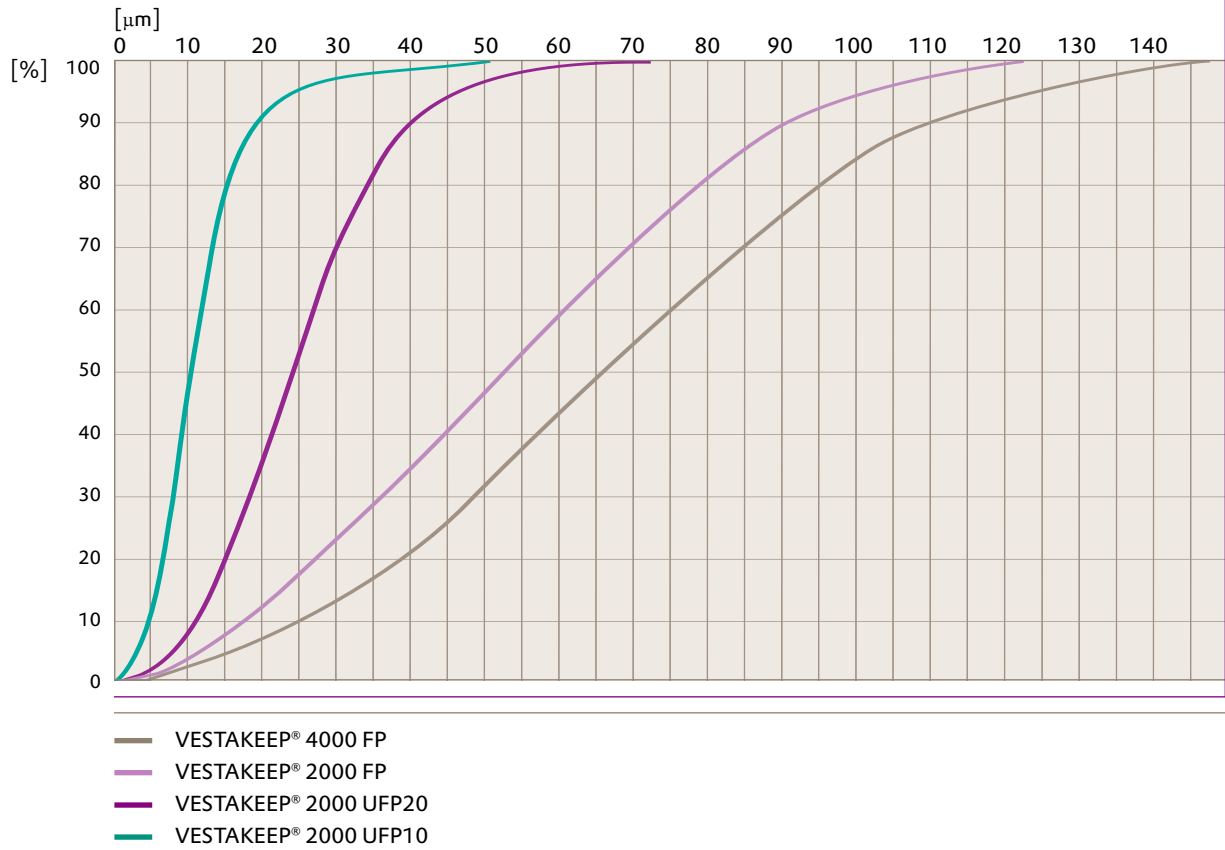
Numbers: Average particle size in micrometers



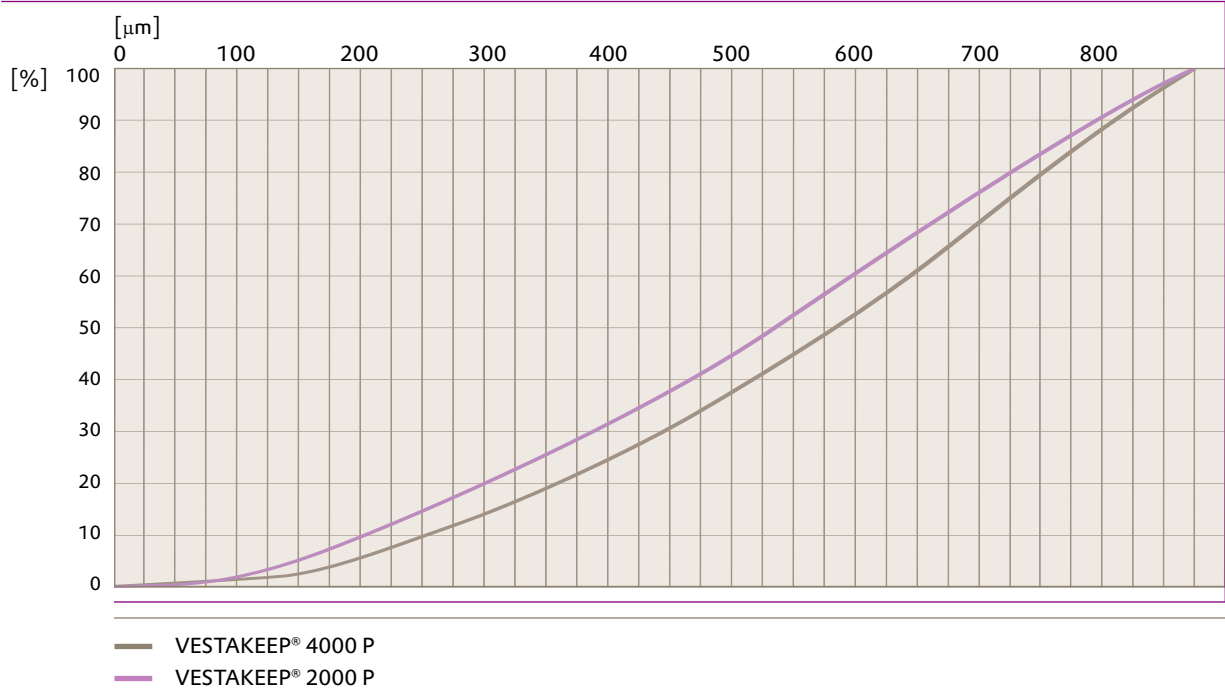
Particle size distribution

VESTAKEEP® powders are offered in a variety of particle size distributions.

VESTAKEEP® Sympatec Helos



VESTAKEEP® particle size distribution





3 Processing

3.1. Coating processes

Electrostatic spraying

In the EPS (electrostatic powder spraying) process, the powder is electrostatically charged by an electrical field of high field strength on the spray nozzle. Depending on the spraying system, this involves either direct charging, which occurs in direct contact with the electrode, or ionization charging, in which the powder particles are charged through accretion of free air ions. In this case, the electrode, as the corona point, generates the required air ions. The powder particles are transported along the electrical field lines to the grounded workpiece.

The parts to be coated should be preheated to anywhere from 400 to 420 °C. Before cooling, the parts should be heated in an oven until the coating is evenly melted on them. The degree of crystallinity can be set through the cooling process. Water and sudden cooling result in amorphous and therefore transparent coatings. The crystallinity of amorphous layers can be increased by conditioning the coating. This is usually done at 200 °C in a circulating air oven. The amount of time required depends on the mass of the coated parts.

Concerning components with a large thermal mass, slow cooling rates can result in cracks in the coating. In these cases the suitable cooling rates should be determined empirically. Chilling in water can lead to thermal shock and should be avoided.

Fluidized-bed coating

VESTAKEEP® powders are extremely difficult to process in the fluidized-bed coating process. Not only is the fluidizing effect difficult to control due to the irregular particle shape, but preheating temperatures have to be considerably higher than 400 °C because of the high melting temperature.

Flame spraying

Flame spraying, developed at the beginning of the last century, is one of many types of thermal spraying processes. In this process, the combustion of a gas/oxygen mixture generates the thermal energy to melt the powder and warm the surface of the substrate. A carrier gas—normally compressed air—serves as the medium for transporting the melted particles to the substrate surface.

The advantages of this process include low investment costs and the option of coating large parts on site, without an oven. VESTAKEEP® 2000 FP is best suited for this application because it has a sufficiently low melt viscosity.

Dispersion coating

Aqueous dispersions based on VESTAKEEP® fine powder can be used to coat metal surfaces. These can be processed by dipping or by spray gun. Dispersions are particularly suitable for the manufacture of thin layers and for geometries that cannot be electrostatically coated because of the “Faraday cage.” No costly equipment is needed.

Medium-viscosity VESTAKEEP® powder is especially suitable for dispersion coating. Its low melt viscosity generates good flow properties and produces smooth-flowing layers.





Fiber composites

To produce fiber composites, unidirectional fiber layouts or fabrics made of glass, carbon or aramid fibers are given VESTAKEEP® as a matrix. The composites are coated using powder coating processes or dispersion coatings, as described above. For the production of composites, we recommend the low-viscosity VESTAKEEP® powders of the 1000 and 2000 lines. The particle size is geared to processes for which FP and UFP powders are preferred.

Pretreatment

No matter the coating process: The better the pretreatment, the better the adhesion. This is why the parts to be coated must be prepared by sandblasting and degreasing in suitable solvents prior to coating. This step removes impurities and prepares the surface of the metal for optimal adhesion.

Corundum or marcasite should be used as the blasting agent. Spherical blasting agents like glass pearls are not suitable because they do not roughen the surface. Blasted grease- and oil-free metal parts corrode very quickly, and should therefore be processed as soon as possible after blasting.

A primer for improving adhesion is not required. Zinc and iron phosphatizing should also be avoided. These conversion layers begin to disintegrate above 200 °C and generate a separating layer, which impairs adhesion.

3.2. Compression molding

Compression molding produces molded parts by subjecting them to pressure in a mold. The properties of compression-molded parts are different from those of injection-molded parts. Normally, pressed parts have a higher level of crystallinity, and are therefore more rigid and solid but also harder and more brittle.

The form press cycle includes

- Thickening the polymer in a mold
- Heating the system over the melt temperature
- A holding phase for further thickening
- A cooling phase

P and FP powder grades are normally used in compression molding. If granulates were used, the air inclusion would be too large, and with finer powders the molds are difficult to fill. Here, bridging can also cause air pockets, which results in porous components. By adding PTFE, graphite, nanoscale titanium oxide or silicon oxide, glass or carbon fibers, for example, certain properties such as surface hardness, frictional coefficient and abrasion resistance can be selectively improved.

To prevent bubble formation through moisture, the powder should be dried for 3 hours at 150 °C or overnight at 120 °C, either in the drying cabinet or in the mold prior to processing.

For easier demolding, small amounts (2–3%) of PTFE can be added to the powder. A silicon-free mold-release agent can also be used, provided its temperature-resistance is higher than 400 °C.

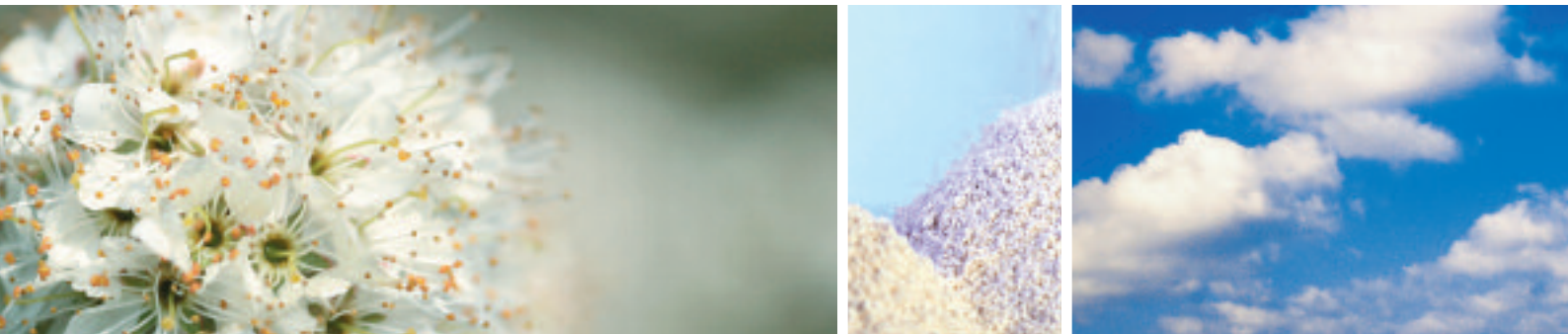
Before the mold is heated, the powder is thickened to allow air to escape. Processing parameters such as pressure, temperature, holding time, etc. depend on the quantity of powder, the surface area and geometry of the form, and must be determined case by case.

To prevent stresses in the mold, cooling should be slow and controlled and not exceed 40 K/hour. Beginning at approximately 140–150 °C, the pressed article can be demolded.

VESTAKEEP® powder applications and correction of defects

Process	Problem	Cause	Solution
Flame spraying	The adhesion failed, even though the surface of the substrate was roughened prior to sandblasting.	This is caused by the extreme difference in the coefficient of thermal expansion between the substrate and layer materials.	Preheat substrate
	Cracks form during cooling	Recrystallization and thermal shrinking cause extreme tensions in the layers, which then result in crack formation. The longer the plastic is held above the glass transition temperature, the better tensions in the plastic are dissipated and the greater the degree of crystallization.	Preheat substrate Temper
	Pores	Air inclusions caused by too many layers on top of each other	Reduce number of powder layers
Compression molding	Pores Bubbles in the pressed article	Moisture Air inclusions	Predry at least for 3 h at 150 °C Increase pressure before melting, increase holding time Increase temperature
	Flashing	Gap too large between male and female molds Temperature too high Pressure too high	Gap should be < 0.15 mm Lower temperature Lower pressure
	Demolding difficult or impossible	Surface of male and female molds too rough No mold-release agent used Wrong mold-release agent used (not heat resistant)	Electropolishing Use mold-release agent (heat-resistance > 400 °C) Add 2–3% PTFE to the powder
	Crack formation	Tensions caused by shrinkage and recrystallization	Temper Reduce cooling rate Demold below 150 °C
	Mold incompletely filled	Melt viscosity too high Pressure too low	Increase temperature Increase pressure
ES coating	Chipping	Foundation unclean (not degreased and/or not sandblasted)	1. Degrease AND 2. Sandblast
	Agglomeration	Moisture in powder due to improper storage	Powder must be stored dry and at room temperature
		Sintering on deflector cone and nozzles because pressure of feed air too high	Reduce conveying air
	Low powder deposition	Workpieces insufficiently grounded	Clean or replace support
		Field intensity too low	Change tension and interval
	Poor fluidization	Humid compressed air or clogged fluid plate, fluid pipes	Test compressed air for impurities, replace fluid plate or fluid pipes
			Vibrating the powder container is recommended for difficult powders, equipment can be easily retrofitted with a vibration table.
		If clumps appear in the fluidized powder, the powder was damp as a result of either storage or humid compressed air.	Use new powder and check the storage conditions of the powder
Fluid air pressure set too low		Check the pressure setting of the fluidizing air	
Too much fluidizing can also significantly reduce powder output			

Process	Problem	Cause	Solution
ES coating	Powder adhesion	If the air pressure is too high, it will blow the powder out of the corners and cavities.	Reduce air pressure
		Too little penetration into the corners and recesses because tension is too high or the wrong nozzle is used	Reduce tension and use suitable nozzles
		Foundation unclean, oils, etc.	Supervise pretreatment
		Powder cloud too big, distance between gun and workpiece too great	Minimize interval, use the correct nozzle, work with more dosage air
	Cratering	Craters appear when gas escapes from the workpiece, the powder is contaminated, or impurities are not completely removed—e.g. oil in compressed air, silicon spray	Use new powder, clean spray guns and lines, degrease and sandblast substrate, install oil separator
	Pulsation	Powder hose is too long	Shorten powder hose or increase diameter
		Powder with poor fluidity	Using a powder container with fluidizing air and vibration can be helpful.
	Irregular powder output	Interfaces or radii too small when powder hose is run	The radii must be at least 150–200 mm.
	Mutual repulsion	Mutual repulsion occurs when the powder layer is too thick.	Reduce the flow Mutual repulsion is also affected by temperature and atmospheric humidity. Climatization of the coating zone may be required in the case of very difficult powder.
	Yellowing	Temperature for powder baking too high or bake time too long	Lower temperature
	Black spots	Contamination	Contamination with foreign powder can be prevented through careful cleaning of the plant. Also, different powders should not be mixed.
		Layers too thick or too thin	Adjust powder output.
	Regular maintenance	<p>Blow out guns and check for sintered areas</p> <ul style="list-style-type: none"> ▪ Check the settings of the powder spray guns ▪ Blow out injectors and hoses ▪ Check grounding control ▪ Check to ensure the compressed air is clean, dry and oil-free ▪ Check powder hoses for sintered areas and marks 	



4 Toxicological evaluation of VESTAKEEP® powders, as well as information on environmental compatibility and safety

VESTAKEEP® powders are water-insoluble, solid polymers. Because of their high molecular weight (>30,000 g/mol), they are not absorbed through the skin, or through the respiratory or gastrointestinal tracts. VESTAKEEP® powders are, therefore, largely inert physiologically and do not cause systemic toxicity.

As in the case of other inert dusts, exposure to VESTAKEEP® dusts could possibly result in mechanical irritation in the upper respiratory passages and the mucous membranes of the eye. Product dust can remove the skin's natural moisture, and this dryness can cause patchy irritation. Sensitization of the skin is not expected.

Steps must always be taken to ensure adequate ventilation and exhaust when processing thermoplastics.

Based on our best current understanding, VESTAKEEP® powders do not have any adverse effects on man, animals, plants, or microorganisms. For labeling in accordance with applicable legislation, as well as the water hazard classification, please consult the most recent safety data sheet.

VESTAKEEP® powders can be disposed of in accordance with local regulations. The EU safety data sheet for VESTAKEEP® contains more information. For environmental and economic reasons, recycling of the product is preferred.

Please direct more detailed inquiries on product safety to the indicated contact persons.

Integrated expertise: your direct contacts in your region

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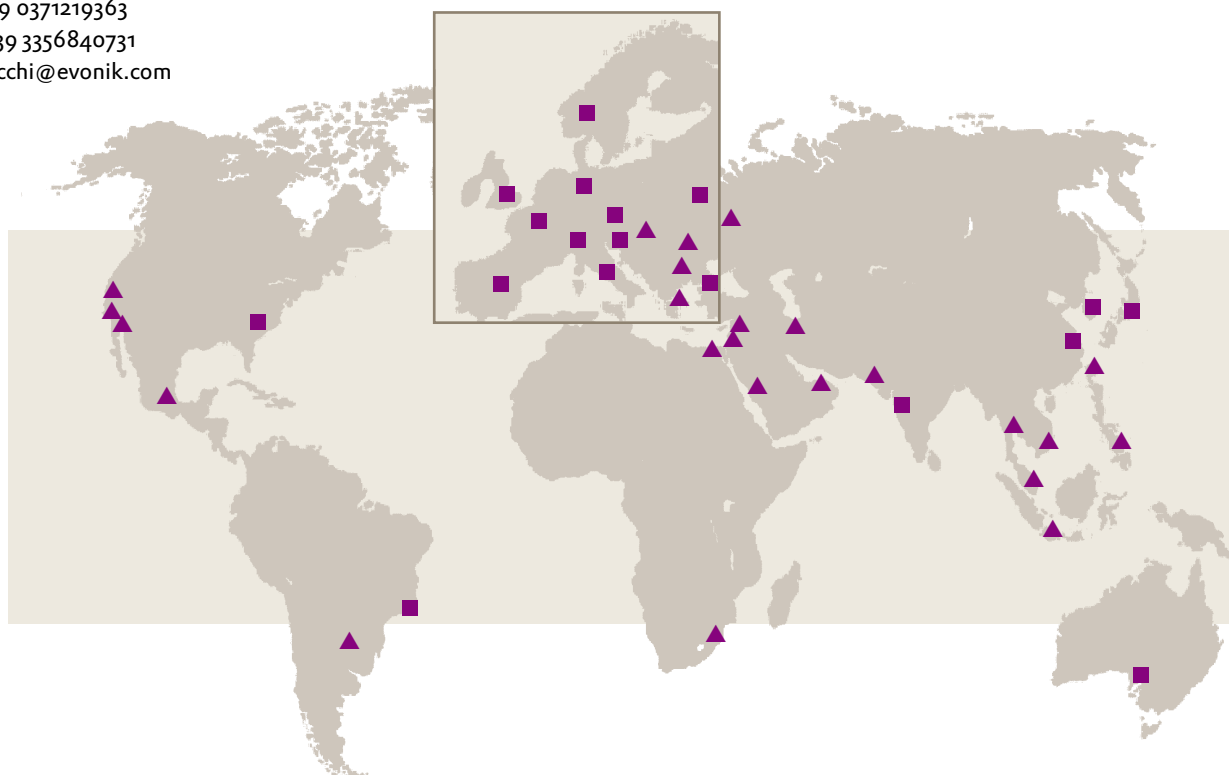
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