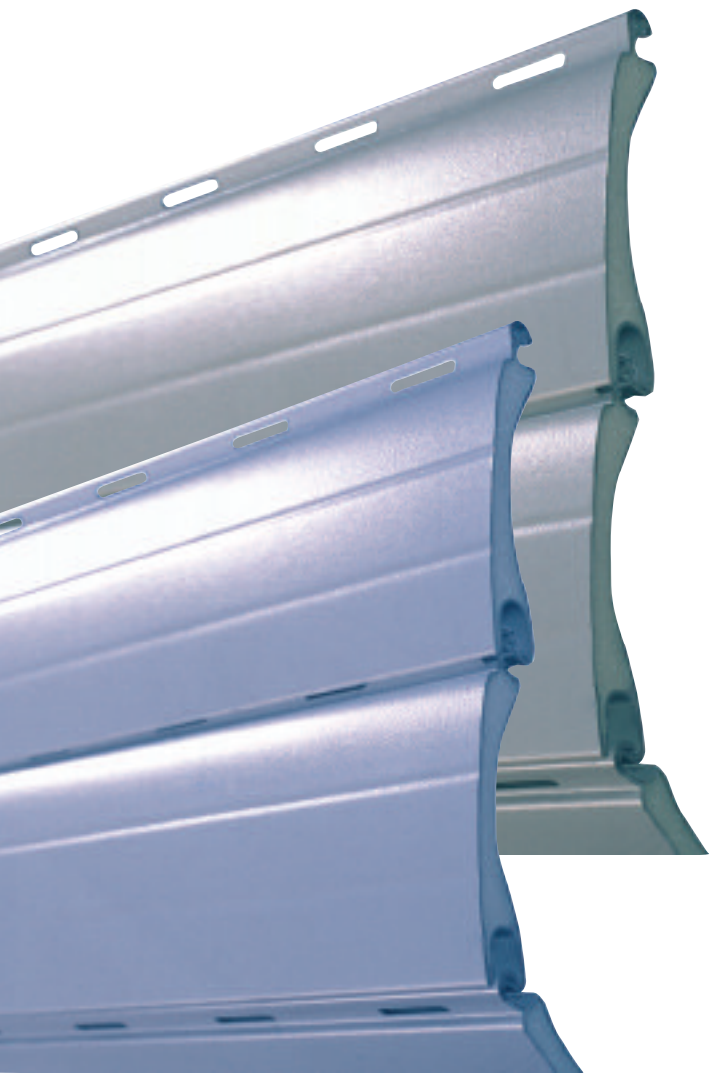


VESTOSINT®

Fine Powder at its Best







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Evonik Industries is the German-based creative industrial group which operates in the three business areas Chemicals, Energy and Real Estate. Evonik is a global leader in specialty chemicals. The High Performance Polymers Business Unit is specialized in manufacturing customized products and systems. We have been producing high-performance plastics for over 40 years.

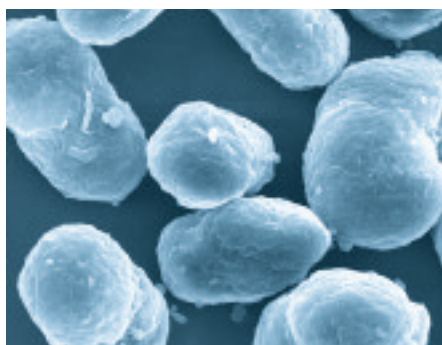
1 Introduction

High Performance Polymers offers a series of polyamide 12 powders (PA 12) sold under the trade name VESTOSINT®. The powders are manufactured by a special physical process and feature a nearly round geometry, which cannot be reproduced by conventional pulverization technologies.

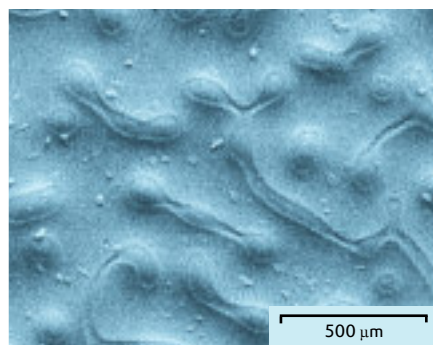
The addition of VESTOSINT® fine powders to paint formulations results in abrasion resistant, highly elastic textured paints. This is where the good mechanical properties of polyamide 12 become use-

ful, especially in such tough applications as extrudates (e.g., fuel lines), injection-molded parts (e.g., gears), and fluidized bed coatings (e.g., pressure rollers, cardan shafts).

In the various types of paint systems, existing reactive groups integrate the polyamide particles into the coating matrix.



VESTOSINT® 2157 natural color



Coil coating surface

2 Applications

VESTOSINT® for coil coating

The VESTOSINT® powder particles in coatings act as impact absorbers and prevent the surface from cracking. They work in much the same way as impact modifiers work for plastics.

In baking lacquers, VESTOSINT® powders

- create a uniform finely textured surface that can be modified by using different polyamide particle size distributions,
- produce satin gloss due to different refractive indices of polyamide and coating resin.
- show very good resistance to soiling which is important for coatings in external architectural use.
- provide a very good abrasion resistance.

The coatings contain no other matting agents that can decrease weathering resistance and elasticity.

The abrasion resistance is improved by the chemical bonding between the polyamide particles and the coating resins. This prevents the powder from being rubbed out.

Polyamide-reinforced polyester or polyurethane paints are especially suitable for roller-type shutter profiles. The incorporated polyamide particles guarantee an

excellent formability of the metal sheet into the shutter profile. Due to its outstanding abrasion resistance, the coating is suited for long-term use in shutters.

Textural coil coating of appliance goods, for example coating of cases for entertainment electronics in dark colors, is another example of the importance of abrasion resistance.

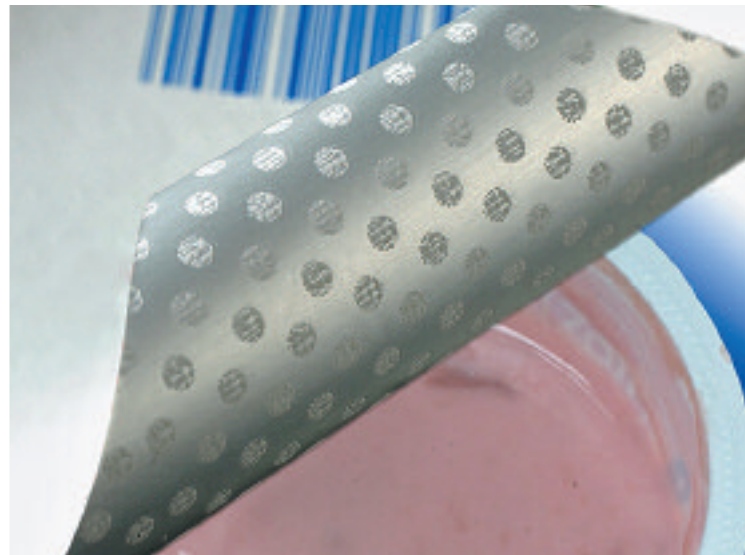
The addition of VESTOSINT® to polyester melamine or polyurethane baking lacquer formulations allows for the perfect, blister-free application of coil coatings with higher layer thickness (high-build primer, thicker top coats).

Further application options are available upon request. Please do not hesitate to contact High Performance Polymers with any questions about the selection of binders or basic formulations.

The offered VESTOSINT® fine powders vary by particle size and particle size distribution. A single powder grade, or a combination of two or more powder grades, can be used to obtain the desired surface or texture.

The particle size distribution is measured by laser diffraction. The value D_{50} stands for the average grain size. Depending on the measuring instruments, the value may vary slightly.





VESTOSINT® for thermo-plastic composites

The easily flowing VESTOSINT® is scattered uniformly onto the surface of thermoplastic composites and sintered on in a downstream oven. Two passes through the scattering station also allow for double-sided coating.

The composite can be cut to size, combined in several layers, and compressed at temperatures above 200 °C to produce moldings that combine high strength with light weight. In contrast to thermoset moldings, they can also be reshaped later. Waste material can be chopped up and re-processed as a filled thermoplastic by any current method for plastics processing.

VESTOSINT® as an additive for textured paints

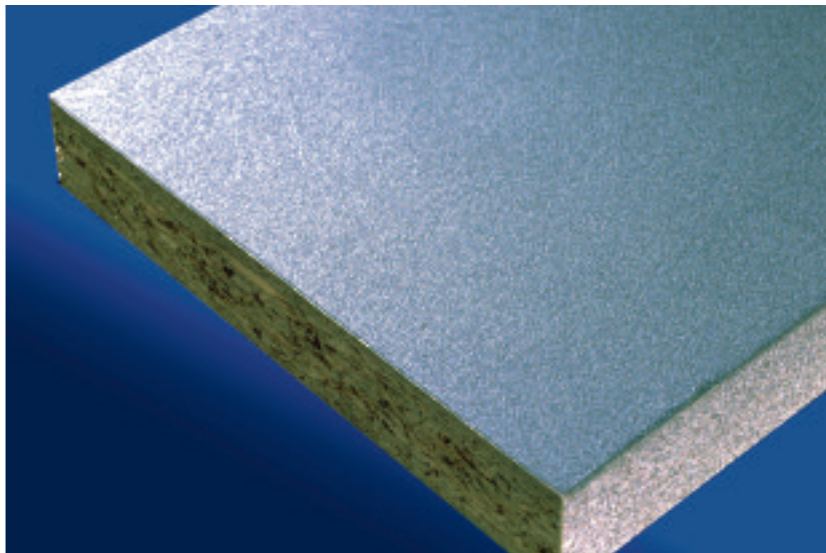
VESTOSINT® powders can be incorporated into both hot-curing and cold-curing coatings, solvent as well as aqueous systems. The resulting coating has a high flexural strength, elasticity and very good abrasion resistance.

Very fine powders with a narrow particle size distribution are used as paint additives. The median particle size is between 5 and 60 µm, although in soft feel coatings coarser powders are used.

The coatings have a textured, matte surface, which can be varied through the particle size and particle size distribution of VESTOSINT® as well as by the amount of powder.

VESTOSINT® for packaging foils

Approved both in Europe and the USA (FDA; Food and Drug Administration) for food-contact applications, and for contact with drinking water, VESTOSINT® fine powders are excellent for use as spacers in such applications as aluminum packaging foils. They also reduce wear of the rollers in foil manufacturing.



VESTOSINT® for rubber surfaces

VESTOSINT® fine powders are used to coat rubber profiles for the automotive industry. The spherical particle shape and the low coefficient of sliding friction with glass reduce the energy needed to open or close windows. Instead of flocking, coarser powders are scattered on adhesive while finer grades may be added directly to the paint.

VESTOSINT® in wood paints

In wood paints, VESTOSINT® powders improve abrasion resistance and are used as a textural additive. The combination of VESTOSINT® fine powders in different colors creates interesting effects (pepper and salt).

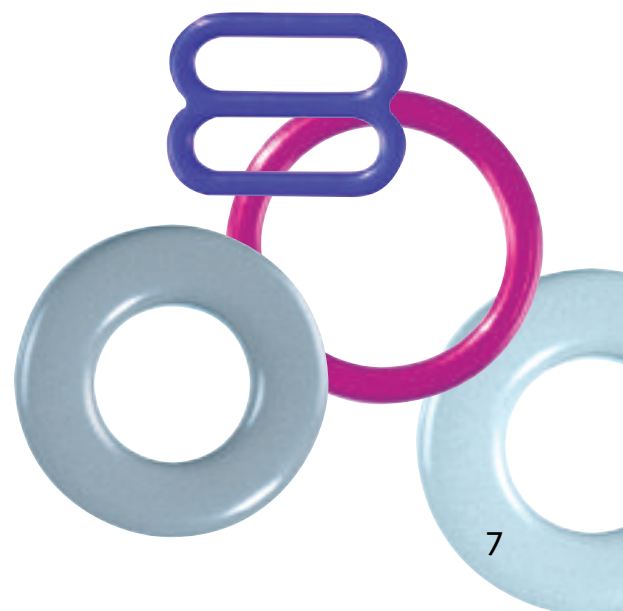
Minicoating process

The main fields of application of minicoating include the coating of brassiere parts and component coating for the electrical and automotive industries. The principle of minicoating is similar to that of fluidized bed sintering. Hot (small) parts drop into a VESTOSINT® powder pan in which the powder is kept in suspension by vibration or air. As the parts fall, the powder sinters to the metallic surface. Subsequently, the objects are conveyed out of the VESTOSINT® container in a vibrating trough and the surface is further smoothed, no matter what the shape of the articles being coated.

Electrostatic coating

Electrostatic coating is used in almost all areas of corrosion protection and decorative metal coating. In this process, VESTOSINT® powder is electrostatically charged as it exits a powder gun and sticks to the grounded metallic portions to be coated. These portions are subsequently heated to a temperature above the melting point of the powder (appr. 184 °C), causing the powder to fuse into a smooth, nonporous plastic film. In contrast to coating with thermosets, the polyamide 12 powder VESTOSINT® does not crosslink, and the coating retains its thermoplastic character.

VESTOSINT® fine powders are also used as an additive in crosslinkable powder paint systems. They improve elasticity, impact strength and abrasion resistance. Depending on particle size distribution textured surfaces can be designed.



3 Product overview

Characteristics of various VESTOSINT® grades and their applications

VESTOSINT®	TiO ₂ Content [%]	Average particle diameter Malvern Mastersizer [µm] (D ₅₀)	Average particle diameter Sympatec Helos [µm] (D ₅₀)	Applications	Coatings	Composites	Minicoat	Electrostatic
2157 natural color	-	56	54		+	-	+	-
2158 natural color	-	21	20		+	-	-	-
2159 natural color	-	11	10		+	+	-	-
2161 natural color	-	28	26		+	-	-	+
2162 natural color	-	45	45		+	-	-	-
2070 natural color	-	6	5		+	-	-	-
1111 natural color	-	90	-		+	+	-	-
1164 white	11	55	-		+	-	+	-
1184 white	11	50	-		+	-	+	-
2178 white	15	20	-		+	-	-	+
1258 black	-	22	-		-	-	-	+

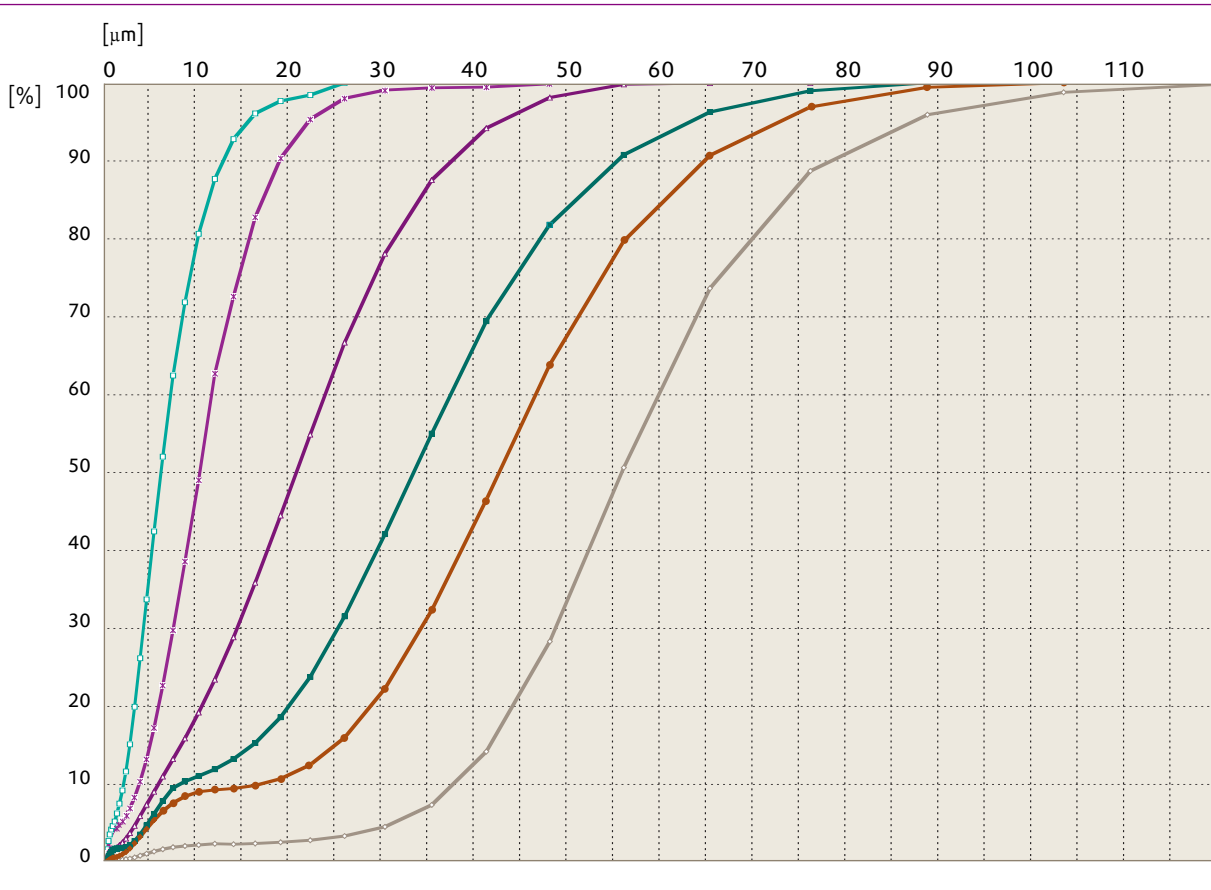
Key to symbols:

+ = suitable

- = not suitable/untested

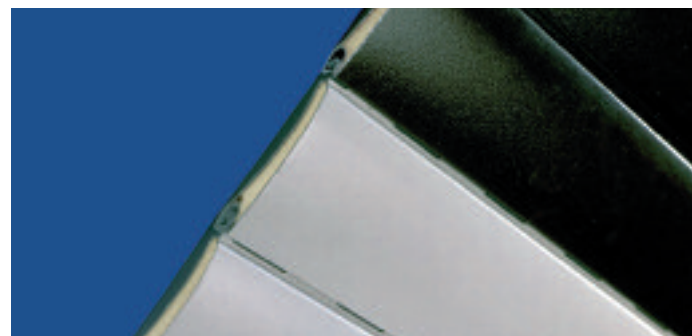


Typical particle size distribution of selected VESTOSINT® fine powders

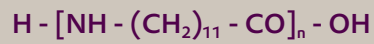


- VESTOSINT® 2070 natural color
- VESTOSINT® 2157 natural color
- VESTOSINT® 2158 natural color
- VESTOSINT® 2159 natural color
- VESTOSINT® 2161 natural color
- VESTOSINT® 2162 natural color

(average of the lot, measured with laser diffraction Malvern Mastersizer)



4 Properties



The structural characteristic of the polyamides are carbonamide groups [-CO-NH-], which form hydrogen bonds to link the molecular chains to one another. They are responsible for characteristic properties, such as:

- high wear resistance
- high mechanical strength and elasticity, even at low temperatures
- low coefficient of sliding friction in dry motion contact with metals and other polymer materials
- sound and vibration absorption

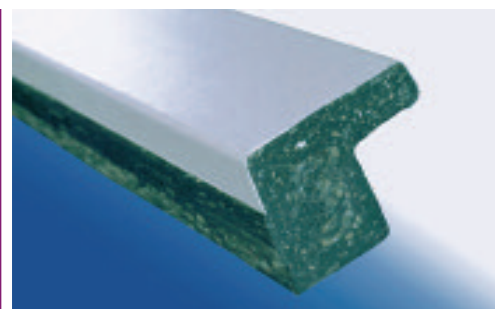
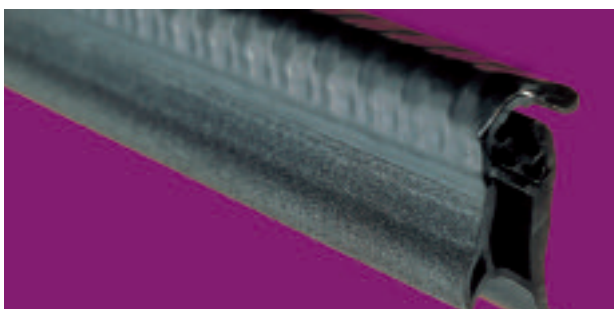
In polyamide 12, the concentration of carbonamide groups is particularly well balanced, resulting in specific properties such as:

- lowest water absorption of any commercially available polyamide
- good resistance to water that is boiling or contains detergents
- very good resistance to fats, oils, fuels, hydraulic fluids, saline solutions and many organic solvents
- excellent stress cracking resistance
- good electric strength and insulation

The melting point of 184 °C allows for favorable processing temperatures.

The properties of VESTOSINT® are adapted to specific application requirements by means of the particle size and particle size distribution and by using additives such as stabilizers, flow control agents and colored pigments.

VESTOSINT® can be employed in all processing methods typically used for polymer powders. Coatings made of VESTOSINT® can be used at temperatures down to -40 °C without significant change in properties. They are stable on long-term exposure to heat of up to +80 °C and for brief periods may be heated without damage, in the absence of mechanical stress, to temperatures of up to +160 °C.



Physical properties of natural colored materials

Properties	Test method	Unit	Value
Melting temperature	ISO 3146	°C	184
Density 23 °C	ISO 1183	g/cm ³	1.016
Shore hardness D	ISO 868		75
Ball indentation hardness	ISO 2039-1	N/mm ²	90
Tensile test	ISO 527-1/-2		
Stress at yield		MPa	43
Strain at yield		%	6
Stress at break		MPa	49
Strain at break		%	311
Water absorption	ISO 62	%	
100 °C, immersion			1.93
23 °C, 96% r.h.			1.33
23 °C, 50% r.h.			0.52
Linear thermal expansion	ISO 11359	10 ⁻⁴ ·K ⁻¹	1.09
Thermal conductivity	in accordance to DIN 52612	W·m ⁻¹ ·K ⁻¹	0.23-0.29
Specific heat	DIN 53765	J·g ⁻¹ ·K ⁻¹	2.35
Abrasion	DIN 53754 (Taber)	mg/100 turns	<1
Refractive index n _d 589 nm/20° C	DIN 53491		1.52

Electrical properties

Properties	Test method	Unit	Value dry	Value wet*
Relative permittivity 23 °C/1 MHz	IEC 60250		3.8	6.7
Dissipation factor 23 °C/1 MHz	IEC 60250		5 x 10 ⁻²	17 x 10 ⁻²
Volume resistivity	IEC 60093	Ω cm	7 x 10 ¹⁴	3 x 10 ¹²
Breakdown voltage	IEC 60243-2	kV	12-14	
Electric strength K 20/P 50	IEC 60243-2	kV/mm		92

*after immersion in water at 23 °C



5 Chemical resistance of polyamide 12

Chemical resistance of polyamide 12

Medium	Concentration [%]	Test duration and temperature	
		6 months/20 °C	4 weeks/60 °C
Acetic acid	10	++	-
Acetone (b.p. 56.3 °C)	100	++	++
Ammonia, aq	conc.	++	++
Aniline	100	+	
Anti-freeze		++	+
Apple juice		++	++
Asphalt		++	++
Barium salts		++	++
Battery acid		±	--
Beer		++	
Benzene	100	++	±
Brake fluid		++	++
Butane, gaseous	100	++	++
Butane, liquid	100	++	
Butter		++	
Caustic potash	50	++	++
Caustic soda	50	++	++
Chlorine, liquid	100	--	--
Chrome plating solutions (commercial)		--	--
Chromic acid	20	--	--
Citric acid, aq.	c.s.	++	±
Coffee, ready for drinking		++	
Cyclohexanone	100	++	±
Detergent solutions ¹⁾	ready for use	++	++
Dibutyl phthalate (VESTINOL® C)		++	++
Diethyl ether (b.p. 35 °C)	100	+	
Diocetyl phthalate (VESTINOL® AH)		++	++
Dishwashing agents	ready for use	++	++
Edible oils (animal or vegetable)		++	++
Ethyl acetate		++	-
Ethyl alcohol, not denatured	100	++	+
Fish		++	
Formic acid	10	++	++
Fuel oils	100	++	++
Glycerin	100	++	++
Glycol	100	++	++
Hydrochloric acid	10	--	--
Hydrofluoric acid	40	-	-
Hydrogen peroxide, aq	30	++	

Chemical resistance of polyamide 12

Medium	Concentration [%]	Test duration and temperature		
		6 months/20 °C	4 weeks/60 °C	
Lactic acid, aq	10	+	±	
Lemon juice		++	++	
Linseed oil		++	++	
Magnesium salts, aq	100	++	++	
Methanol		++	+	
Methyl ethyl ketone		++	±	
Milk		++	++	
Nitric acid	10	--	--	
Ozone (0.5 ppm)		±		
Paraffin oil	100	++	++	
Petrol		++	++	
Petroleum	100	++	++	
Potassium chlorate, aq	c.s. (7.3)	+	±	
Potassium permanganate, aq	c.s. (6.4)	-	--	
Propane, gaseous	100	++	++	
Pyridine	100	++		
Rum	40	++	++	
Sea water	c.s.	++	++	
Silicon oils		++	++	
Sodium chloride, aq (common salt)		++	++	
Sodium hypochlorite, aq		5	+	-
Soft soap		++	++	++
Sugar solutions		any	++	++
Sulphur		100	++	++
Sulphuric acid		10	+	-
Toluene	100	++	-	
Tomato juice		++	++	
Trichloroethylene	100	±	-	
Water	100	++	++	
Whisky	40	++		
Xylene	100	++	±	

Key to symbols:

Resistance levels

- ++ = resistant
- + = almost resistant
- ± = limited resistance
- = low resistance
- = not resistant

Concentrations

aq = aqueous solution

c.s. = cold saturated

¹⁾ tested Dixan® and Persil®





6 Physiological and toxicological evaluation

Upon request the department of Environment, Health and Safety, responsible for the High Performance Polymers Business Line, provides a survey of the toxicological properties of VESTOSINT® powders or evaluations relating to contact with foods. This department is responsible for providing information on all product safety aspects as well as authoring EC safety data sheets for VESTOSINT®. Please send inquiries, also for US Material Safety Data Sheets, to the contact addresses provided.

Food Contact – EU-Status

Uniform regulations for plastics that come into contact with foodstuffs exist at the European level. The consolidated EU Directive 2002/72/EC and its amendments apply. It lists approved monomers and, since December 31, 2006, approved plastic additives as positive. In other words, in Europe only approved monomers and additives on the EU positive lists may come into contact with food. Nationally approved additives are no longer permitted. However, nationally approved additives that had been submitted to the EU Commission for approval prior to 12/31/06 constitute an exception. These additives may continue to be used for food contact beyond 12/31/06 during a transition period until final evaluation and approval by the EU Commission.

In respect to the monomers the VESTOSINT® polyamide 12 powders have been approved for direct food contact in the European Union because the basic monomer lauro lactam is positively listed in the Directive 2002/72/EC. It specifies a migration value limit of 5 milligrams per kilogram for lauro lactam, which must be tested on the finished article itself and be kept within limits there. Due to various additives it is not possible to make any general statements here. For further information, please contact the indicated contact persons.

Food Contact – FDA status

According to 21 CFR, § 177.1500 (a) (9) (Nylon 12 Resins), of the U.S. Food and Drug Administration (FDA), PA 12 powder, the polymer base of our VESTOSINT®, is currently listed for coatings intended for repeated use. The listing excludes contact with alcohol-containing foods and beverages.



7 Environmental aspects, quality and delivery

Environmental impact and safety

VESTOSINT® powders are non-toxic, not subject to labeling under the hazardous materials regulation and are not water-polluting. They do not contain any heavy metals. They can be disposed of in landfills or incinerated as normal household waste in accordance with local ordinances. The EC Safety Data Sheet for VESTOSINT® provides further instructions.

If VESTOSINT® powders are properly processed, no hazardous byproducts are formed. Cadmium-containing pigments are not used at all.

VESTOSINT® powders are combustible. At mass temperatures above 350 °C, flammable gases are formed by degradation. Combustion with sufficient air supply yields CO, CO₂, H₂O and nitrogen-containing compounds as end products. Since the spectrum of cracking and combustion products greatly depends on the combustion conditions, it is not possible to make any general statements here.

Quality

Like all high-performance polymers of the High Performance Polymers Business Unit, VESTOSINT® powders satisfy the highest quality standards. Our system for quality assurance is certified according to ISO 9001. In several audits conducted by our customers, this quality management system received excellent ratings.

Supply form

VESTOSINT® powders can be delivered in several particle size distributions tailored to the different processing methods. Delivery is, depending on bulk density, in bags with 20 kilograms net weight or in cardboard boxes with an inner bag with 15 kilograms net weight. A unit of shipment consists of a pallet with 50 bags (1,000 kg) or 25 boxes (375 kg) depending on the product. In rooms protected from the weather, the minimum shelf life is at least 2 years from the production date if the packaging is not damaged or opened. A storage temperature of 30 °C should not be exceeded. The product should be processed on a first in first out basis.

Your technical contact

Paul-Ludwig Waterkamp
paul-ludwig.waterkamp@evonik.com

Your contact for the Americas

Jay Hatfield
jay.hatfield@evonik.com

Your contact for Asia & Pacific

Shengjun Tian
shengjun.tian@evonik.com

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EVONIK
INDUSTRIES

Evonik Industries AG

High Performance Polymers
45764 Marl
Germany

PHONE +49 2365 49-9878
evonik-hp@evonik.com
www.vestosint.com

Evonik. Power to create.