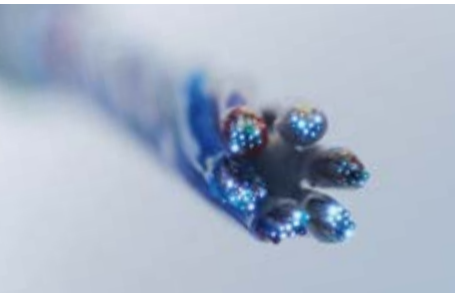
EVONIK INDUSTRIES

Safe, efficient cable protection with high performance polymers

Evonik. Power to create.



Evonik, the creative industrial group from Germany, is one of the world leaders in specialty chemicals. Its activities focus on the key megatrends health and nutrition, resource efficiency and globalization. Evonik is active in over 100 countries around the world.

Materials from Evonik have been protecting cables as sheathing or protection tubing for many years. Continuous improvements have made these materials the first choice for the electronics and cable industry.

Content

Product overview for cable design

High performance polymers for the cable industry

Evonik Industries manufactures a range of polyamide, polybutylene terephthalate and polyetheretherketone extrusion grades for cable and wire coating, jacketing, fiber optical jacketing, loose tubes, and cable protection tubing and profiles.

- VESTAMID® L polyamide 12 (PA 12) for cable and wire coating/jacketing and cable protection tubes
- VESTAMID® E polyamide 12 elastomer (PEBA) for highly flexible cable coating / jacketing
- VESTAMID® *Terra* DS biobased polyamide 1010 (PA 1010) for cable and wire coating
- VESTODUR® polybutyleneterephtalate (PBT) for fiber optical jacketing and loose tubes
- VESTAKEEP® PEEK polyetherether-ketone for cable and wire coating for high end applications

Which material fits the demands?

Material	Temperature stability	Hydrolysis resistance	Chemical resistance
PA 12	++	++	++
PA 12 elastomers	+	+	+
PA 1010	++	++	++
PBT	++	-	+
PEEK	+++	+++	+++

Evaluation from - bad to +++ outstanding

Suitable materials for various applications

Application	VESTAMID® L PA 12	VESTAMID® E PA 12 elastomer	VESTAMID® *Terra* DS PA 1010	VESTODUR® PBT	VESTAKEEP® PEEK
Fiber optical cable	●	●		●	
Polymer optical fiber cable	●				●
Wire sheathing	●				●
Fuel cable	●				
Aviation / aerospace	●				●
Rodent and termite protection	●		●		
Bio-based			●		
Halogen free flame retardant	●			●	●

Fiber optic cables

A fiber optic cable offers many advantages. It can support a much wider range of uses than any conventional copper cable. Fiber optic cables are light-weight and small yet extremely rugged.

The dielectric nature of optical fibers makes them immune to electromagnetic interference. The optical fibers in a cable must be protected against any mechanical stresses caused by manufacturing and the various ambient conditions encountered during the life of the cable. This protection is achieved in a combined way:

- by the individual protection of the fibers with VESTAMID® or VESTODUR®
- by the protection provided by the cable construction

Material requirements

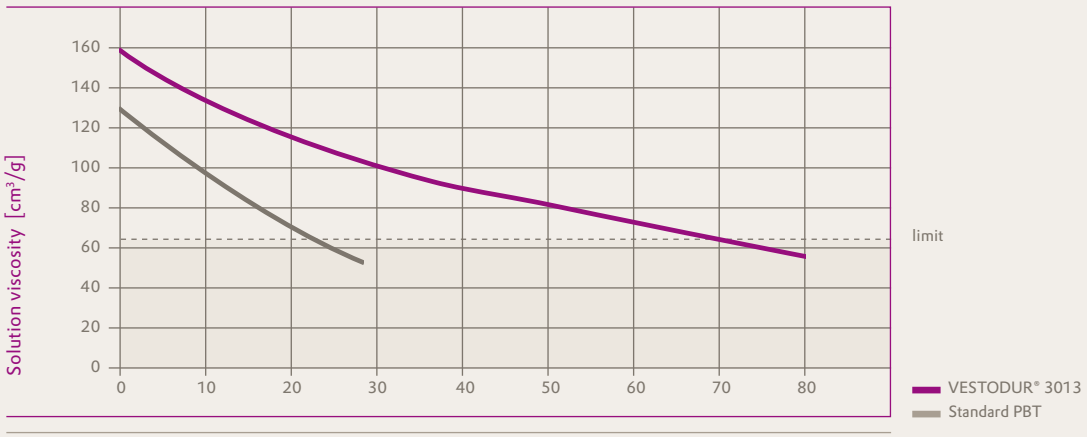
Materials which can be used for secondary fiber optic jacketing have to meet the following requirements

- Easy processability with high melt strength
- Low thermal expansion coefficient
- High flexural modulus with good kink resistance
- Stress cracking resistance against filling compounds and solvents such as alcohols and ketones, used in splicing operations
- Low moisture absorption
- Good hydrolysis resistance
- High compressive strength
- Flame retardant (optional)

Considering the various polymers which would be appropriate for secondary fiber optic jacketing, only a few materials will meet these requirements.

VESTAMID® and VESTODUR® compounds have consistent product quality, offering easy processability with trouble-free continuous production. These engineering thermoplastics have outstanding properties for chemical resistance, dimensional stability and hydrolysis resistance.

Solution viscosity as a function of time at 85°C/85% r.h.



Hydrolysis resistance

Hydrolysis is known as a primary cause of degradation of thermoplastic polyesters at elevated temperatures. Compared to PA 12, standard PBT resins have minor hydrolysis resistance.

Evonik therefore developed PBT grades with improved hydrolysis resistance such as VESTODUR® 3013, a compound with very good hydrolysis resistance. Compared to standard PBT resins, this grade exhibits a threefold improvement in lifetime expectations. Lifetime is determined by the loss of the mechanical integrity of the material. Below the critical viscosity number of 65 cm^3/g, PBT becomes brittle.

The speed of degradation of PBT is determined by the carboxylic endgroup concentration (CEC) of the polymer. The higher the CEC at the beginning of aging, the faster degradation occurs.

The figure shows the viscosity number curve at constant temperature and humidity for fiber optic buffer tubes produced from a standard PBT and VESTODUR® 3013 as a function of time. In a study, we examined the lifetime of VESTODUR® in terms of ambient temperature and humidity, solution viscosity, and carboxylic endgroup concentration (CEC).

With the following formula, the lifetime of a fiber optic buffer tube can be calculated for any given temperature and humidity.

$$t_L = \frac{\ln(J_0/J_b)}{CEC} \cdot \exp\left[\frac{11400}{T} + \frac{0.92}{H} - 25.3\right]$$

t_L	lifetime of VESTODUR® [d]
J_0	solution viscosity before aging [cm^3/g]
J_b	critical limit of solution viscosity (material loses its mechanical integrity) J_b = 65 cm^3/g
T	aging temperature [K]
H	aging humidity [1]
CEC	carboxylic endgroup concentration [mmol/kg]

Fiber optic cables

Design for fiber optic cables

Fiber optic cables are designed to meet a variety of operational specifications for different applications. In order to limit the number of designs, a universal cable concept would be very attractive but cannot be realized.

The following chapters describe some common cable designs from the market:

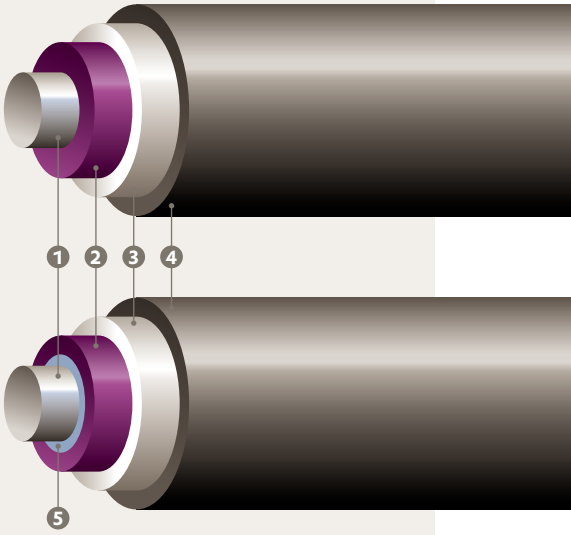
- → Tight and semi-tight buffer cables
- → Loose tube cables
- → Polymer optical fibers

→ Tight and semi-tight buffer cables

Tight and semi-tight jacketing is mainly used for indoor cables, patch cord cables or connector pig-tails. One optical fiber in the core is protected by a multi-layer cable construction.

Tight and semi-tight buffer cables

1. **Optical fiber (OF)**
   for data transfer
2. **VESTAMID® / VESTODUR®**
   (Semi) Tight secondary/inner coating
3. **Aramid yarns**
   Keeps tensile load away form OF
4. **Outer jacketing**
   e.g. PVC, PE
5. **Jelly**



Benefits of using VESTODUR® for tight and semi-tight buffers

- Excellent processability
- Good kink resistance
- High compressive strength
- Low thermal expansion coefficient
- High chemical resistance
  (e.g. filling compound, petro jelly)
- Good hydrolysis resistance
- Low moisture absorption
- Good properties in case of fire
  (with flame retardant)

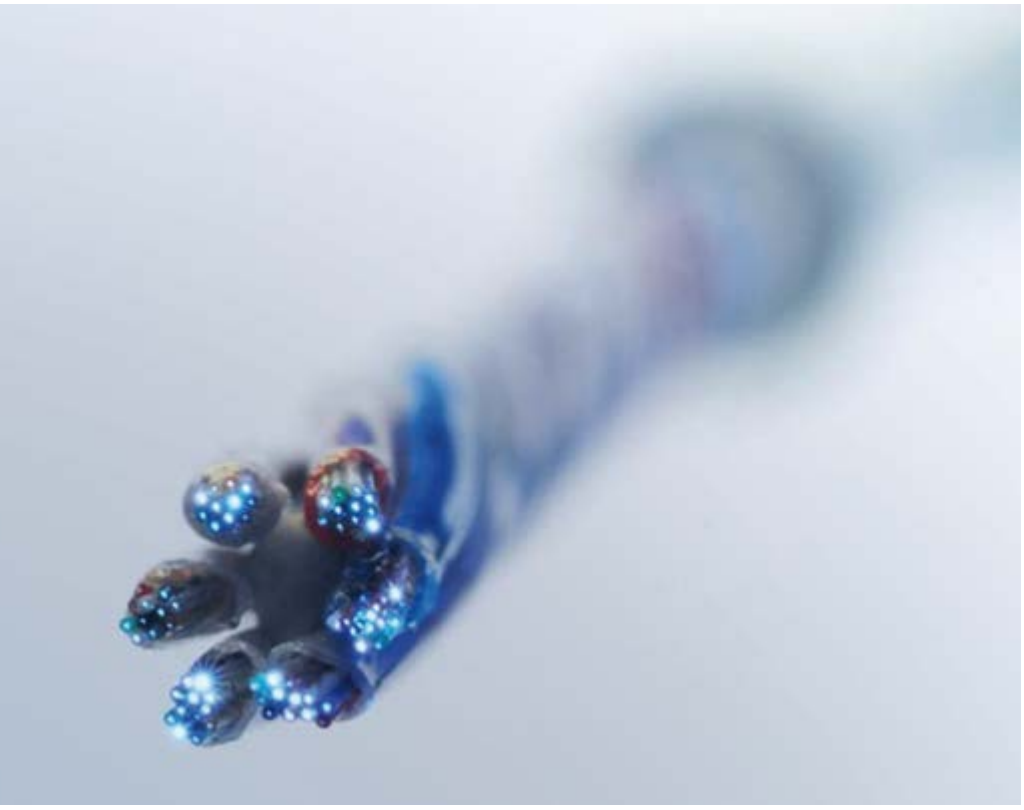
Recommended grades for tight and semi-tight secondary coating

Characteristic	Non-flame retardant	Flame retardant
High stiffness	VESTAMID® L1670 VESTODUR® 3013 VESTODUR® X7396	VESTAMID® X7166 VESTAMID® X7167
High flexibility	VESTAMID® E62-S3 VESTODUR® X4159	VESTAMID® LX9104 VESTAMID® LX9057 VESTODUR® X9426

Benefits of using VESTAMID® for tight and semi-tight buffers

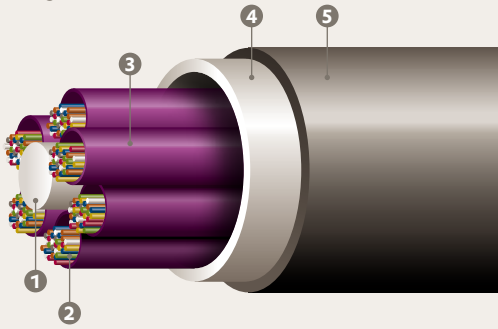
- Low water absorption
- Very high chemical resistance
  (e.g. against fuels, oils,
  filling compound, petro jelly)
- High hydrolysis resistance
- Excellent cold impact performance
- High hardness and abrasion resistance
- High dynamic load behavior
- Excellent properties in case of fire
  (with flame retardant)

Fiber optic cables



Loose tube cable

1. **Central strength member**
2. **Optical fiber (OF)**
   for data transfer,
   filling compound (optional)
3. **VESTAMID® or VESTODUR®**
   Loose tube
4. **Inner jacketing**
5. **Outer jacketing**
   e.g. PVC, PE



→ Loose tube cables

In the loose tube design each fiber or multifiber bundle is held loosely inside a polymer tube. The tube is normally filled with a moisture repellent jelly compound. The jelly-filled tube gives the fibers excellent protection against various external forces acting on the cable. None of these forces will be transferred directly to the fibers. In addition, the tubes are stranded around the central strength member (helically or SZ). This design yields in a strain relief effect and this is the most important advantage of the loose tube design.

The cable core is protected by various wrappings, polymer jackets, and additional reinforcements in the form of strength member layers or armoring.

Recommended grades as a mechanical protection for loose fiber bundle cables are:

- VESTAMID® L1940 and VESTAMID® L2140
- VESTODUR® 3013 and VESTODUR® X7396

Benefits of using VESTAMID® or VESTODUR® for loose tube cables

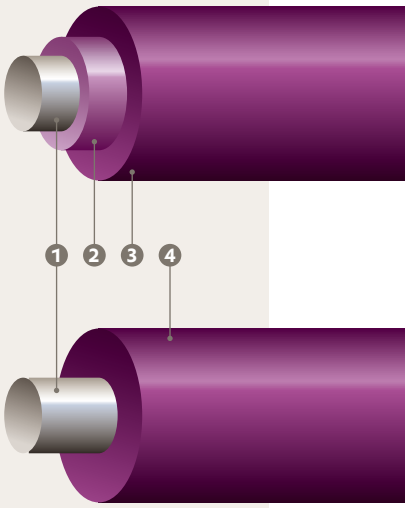
- High line speeds (up to 400 m/min)
- High stability during extrusion (less scrap)
- Fast crystallization for better fiber excess length control
- High chemical resistance (filling compound, inhibits H_2O penetration)
- Good hydrolysis resistance
- In compliance with Belcore test (85 °C / 85 % r.h.)

Double-layer System

1. **PMMA / Polymer optical fiber**
   + PVDF cladding for total reflection
2. **VESTAMID® L1604**
   Non-stabilized PA12
3. **VESTAMID® LX9057**
   Halogen free flame retardant PA12

Mono-layer System

1. **PMMA / Polymer optical fiber**
   + PVDF cladding for total reflection
4. **VESTAMID® L1670**
   UV stabilized PA12



→ Polymer optical fibers

A single or dual-layer jacket system protects the optical data carrier, a PMMA fiber. The inner sheath adheres firmly to the PMMA core. In addition to providing mechanical protection, it increases the refractive index by virtue of its black color, so that light scattering is avoided and optical transmission improved. It is also suitable for laser welding, so that the optical plug-in connectors can be welded on. By contrast, the outer layer adheres only slightly to the first so that the system can be easily fabricated.

The following POF systems are commonly available on the market:

- Double-layer system with an outer layer consisting of VESTAMID® LX9057, a halogen-free flame retardant PA 12, and an inner layer made from VESTAMID® L1604, a non-stabilized PA 12
- Mono-layer system made of VESTAMID® L1670

Benefits of using VESTAMID® for polymer optical fiber protection

- High flexibility / bending radius
- Low weight
- Low water absorption
- Very high chemical resistance
- High hydrolysis resistance
- Excellent burning properties (two-layer system)
- Two layers avoid migration of additives (no attenuation)

Protection

Cable protection tubes and profiles

Corrugated cable protection tubes for railways, tunnels, factories and public buildings, as well as profiles for aircrafts, must fulfill special requirements. VESTAMID® polyamide 12 provides excellent dynamic load behavior, chemical resistance, impact strength, especially cold impact strength, as well as high abrasion resistance and thermostability.

In addition, the mentioned applications call for materials that are

- Halogen- and phosphorus-free
- Self-extinguishing
- And have a high oxygen index (LOI), low smoke, low toxicity

We therefore recommend the halogen-free and phosphorus-free flame retardant grades VESTAMID® X7167, X7229, LX9104, and EX9203 black for cable protection tubing and profiles.

In addition, VESTAKEEP® L4000 G PEEK is suitable for convoluted and corrugated tubes. The high temperature resistant PEEK is inherently flame retardant, has a high LOI, a low smoke density, and releases no toxic gases in case of fire.

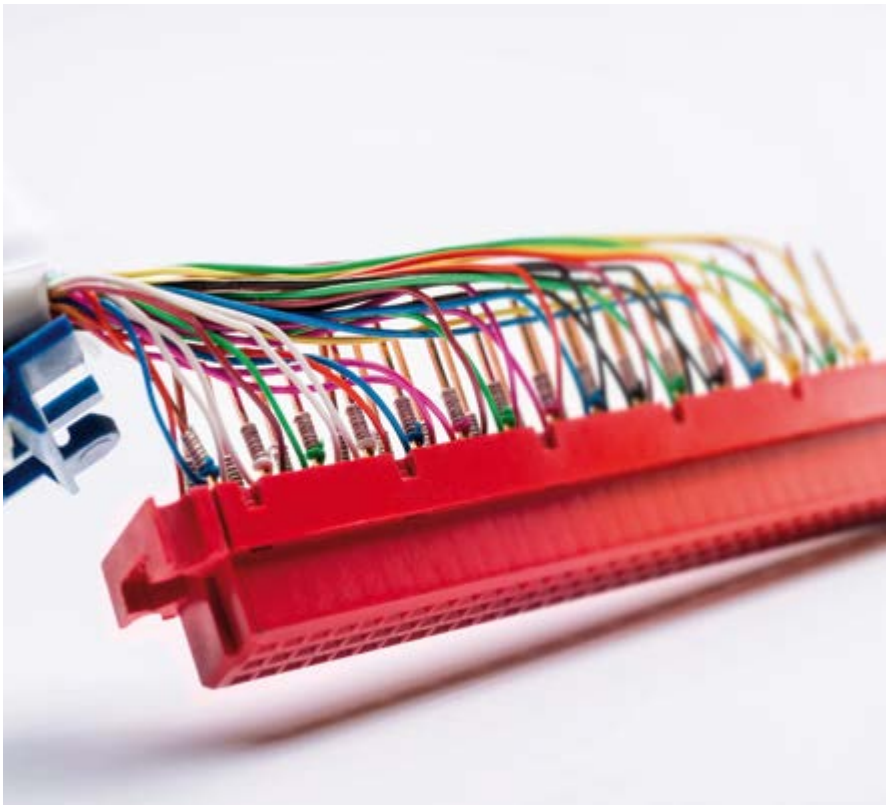
Ant, termite and rodent resistant cable jacketing

Telephone operators in certain countries in the southern hemisphere such as in Australia, India, Brazil, and Thailand have specified PA 12 compounds as a protective cladding for underground cables.

In addition to its particularly high weathering resistance, rigid VESTAMID® compounds have a high degree of ant and termite resistance.

The outstanding toughness also protects telecommunication cables against attacks by rodents. While standard polyethylene (PE) jacketing is destroyed by rats within two days, rodents stop gnawing cables protected with polyamide 12 grades VESTAMID® L1970 or L2170, or by the 100 precent biobased polyamide 1010 VESTAMID® Terra DS2210 after six days because they fail to make any progress.

Insulation



The same happens with ant and termite attacks: Not only do termites gnaw the cable sheathing, they also secrete aggressive formic acid, which can corrupt the cable sheathing. PA 1010 and PA 12 have excellent resistance to formic acid; they do not swell, and prevent gnawing attacks.

Approvals

VESTAMID® L and VESTAMID® Terra DS
by Laboratory Animal Science, Fudan, China,
JB/T10696.9-2011

VESTAMID® L
by Union of Wildlife at Justus-Liebig-University,
Gießen, Germany

Copper wire insulation

VESTAMID® and VESTODUR® are not only used to protect optical fibers, these engineering thermoplastics are also processed into copper wire insulation. For these purposes, VESTAMID® grades are distinguished by their

- Exceptional high mechanical strength
- Outstanding chemical resistance
- Low sliding friction coefficient
- Exceptional abrasion resistance
- Excellent weathering resistance

Suitable grades for copper wire insulation are VESTODUR® X9426, VESTAMID® L1670, VESTAMID® X7166, and VESTAMID® LX9057.

For continuous operating temperatures up to 260 °C, we deliver two PEEK grades for copper wire insulation:

VESTAKEEP® 2000 G, which allows for a high line speed, and VESTAKEEP® 3300 G.

Copper wire insulation with VESTAKEEP® offers

- Highest possible chemical resistance
- High resistance to electromagnetic radiation
- Outstanding long-term temperature performance
- Self-extinguishing with high LOI and low smoke densities

Supply and quality

Delivery and handling

VESTAMID® and VESTODUR® compounds are delivered dry in moisture-proof bags or in octabins. Therefore, further drying before processing is not required. The compounds will absorb moisture from the atmosphere. The amount absorbed depends on the ambient conditions of the area where they are used. During processing, a dehumidifying hopper dryer is therefore recommended. The temperature may be set at 60 to 80 °C.

Granules from opened or damaged bags must be dried in a desiccant type dryer for a minimum of 2 hours at 120 - 125 °C for VESTODUR® and at 90 - 100 °C for VESTAMID®, or on trays in layers not exceeding 2 - 3 cm thickness at a temperature of 120 °C for VESTODUR® and 90 - 100 °C for VESTAMID® in a circulating air oven for about 5 hours. The moisture content must not exceed 0.05 % for VESTODUR® or 0.10 % for VESTAMID®.

VESTAKEEP® compounds are packed in 25 kg boxes with PE inliners. The water content of the compounds should not exceed 0.25 %.

Characteristics

Characteristics of the recommended compounds

	Base material	Viscosity	Tensile modulus [MPa]	Flame retardant	Flammability acc. UL94	Oxygen index LOI [%]	Remark
Test method			ISO 527-1 ISO 527-2		IEC 60695	ISO 4589	
VESTAMID® L1670	PA12	Low	1400		HB	23	Excellent weathering resistance
VESTAMID® L1940 / L1970	PA12	Medium	1400		HB	23	- / Excellent weathering resistance
VESTAMID® L2140 / L2170	PA12	Medium	1400		HB	23	- / Excellent weathering resistance
VESTAMID® E55-S3	PA12 elastomers	Medium	220		HB	24	
VESTAMID® E62-S3	PA12 elastomers	Medium	370		HB	24	
VESTAMID® *Terra* DS2210	PA1010	High	1800		HB		Bio-sourced
VESTODUR® 3013	PBT	High	2600		HB	23	Improved hydrolysis resistance
VESTODUR® X7396	PBT blend	Medium	2600		HB		Reduced shrinkage
VESTODUR® X4159	PBT	High	500		HB	25	
VESTODUR® X9426	PBT	Medium	750	•	V-2, 0.8 mm	31	
VESTAMID® X7166	PA12	Low	1800	•	V-2, 0.8 mm	33	
VESTAMID® X7167	PA12	High	1700	•	V-2, 1.6 mm	26	
VESTAMID® X7229	PA12	High	1000	•	V-2, 1.6 mm	25	
VESTAMID® LX9057	PA12	Low	1300	•	V-0, 0.8 mm	28	
VESTAMID® LX9104	PA12	High	750	•	V-0, 0.8 mm	28	
VESTAMID® EX9203	PA12	Medium	750	•	V-2, 0.8 mm	30	Black color
VESTAKEEP® 2000G	PEEK	High	3700	•	V-0, 3.2 mm	>30	Inherently flame retardant
VESTAKEEP® 3300 G	PEEK	Medium	3600	•	V-0, 3.2 mm	>30	Inherently flame retardant
VESTAKEEP® L4000 G	PEEK	Low	3500	•	V-0, 3.2 mm	>30	Inherently flame retardant

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