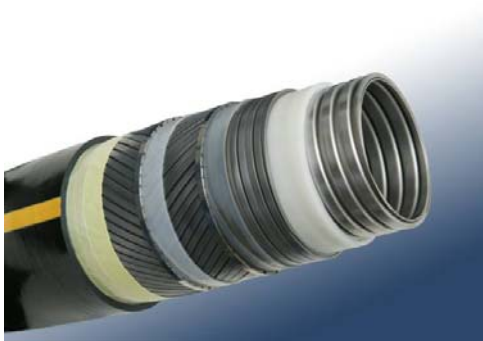


Get Your Oil and Gas with VESTAMID® and VESTAKEEP®



Evonik specializes in manufacturing customized products and systems. We have been developing and manufacturing high-performance polymers for mono-layer and multi-layer tubing, piping, and connections for over 30 years. Our VESTAMID® is the most widely used polyamide 12 worldwide in, for example, fuel lines. In this respect, we are the development partner of choice when it comes to extrusion and connecting materials. We offer VESTAKEEP® PEEK for extreme temperature, wear, and chemical resistance demands.

The enormous stress that occurs under oil field conditions pushes even otherwise extremely resistant materials to their limits. Heat and corrosive media, such as hydrogen sulfide and carbon dioxide, represent major challenges for gas and oil producers. On top of this, the industry faces the task of bringing rising temperatures and pressures under control.

To help the oil and gas industry address this problem, Evonik offers customized, high-performance polymers, such as polyamide 12 (PA 12) and polyetheretherketone (PEEK), which can meet the more difficult requirements.

Applications

Application	VESTAKEEP®	VESTAMID®
Flexible pipes		■
Umbilicals	■	■
Liners	■	■
Compressor parts	■	■
Sealing rings	■	■
Valve parts	■	■
Wear tapes	■	■
Coating	*	■

*on demand

VESTAMID® PA 12 – its Characteristics

Enjoying a track record that reaches back more than 30 years, VESTAMID® PA 12 neat resins and compounds find their way in highly demanding applications such as automotive fuel lines. Our new VESTAMID® grades for the oil and gas industry have been tailored for the manufacture of large-diameter tubes. With this development, Evonik introduced a new platform of PA 12 materials, and since 2006, **more than 300 non-bonded flexible pipes** have been manufactured with VESTAMID® LX9020.

The new VESTAMID® PA 12 platform distinguishes itself from other materials like PA 11 by the following:

- high and constant melt stiffness
- no pre-drying needed
- ease of processing
- tensile creep performance
- compressive stress relaxation
- ductility
- higher resistance to hydrolysis

Applications for VESTAMID® PA 12

VESTAMID® PA 12 is used, for example, as a barrier and outer sheet layer for non-bonded flexible pipes. In addition, multi-layer pipe solutions made with VESTAMID® and other functional layers have the specific property spectrum that makes them suitable for use in umbilicals. VESTAMID® can be used as a liner material in pipes, too. Its corrosion protection increases the value of the system.

Flexible pipes

After 14 years of research, the **Institut Français du Pétrole** chose PA 11 and PA 12 as the best out of several hundred materials tested. In 1988, the OTC paper 5231 "Improved Thermoplastic Materials for Offshore Flexible Pipes," written by Français du Pétrole and Coflexip S.A., underlined the performance of PA 11 and PA 12.

In a joint approval program with an industrial partner cooperating with a leading national oil company, Evonik demonstrated that VESTAMID® LX9020 complies with industrial standards for flexible pipes (API 17J and EN ISO 13628-2). In aging and fatigue crack propagation tests performed by **accredited independent test houses**, the material showed better hydrolysis resistance than PA 11 and it was concluded that VESTAMID® LX9020 showed far greater ductility than any material tested in earlier studies.

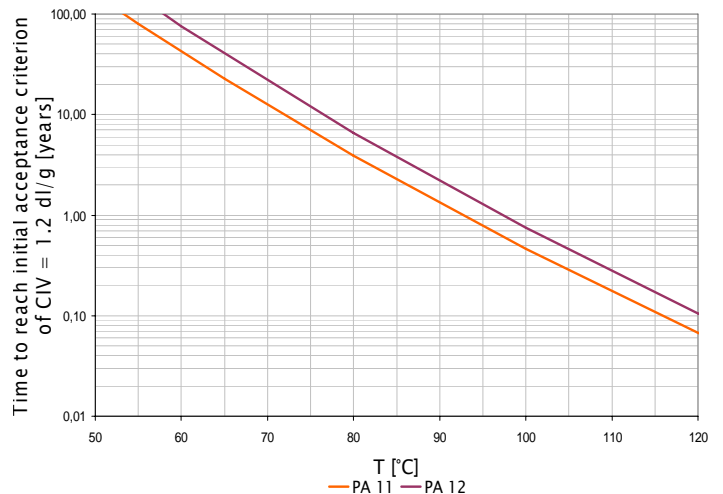
VESTAMID® LX9020 is the first PA 12 grade to be certified by **Lloyd's Register** for the use in and the manufacture of non-bonded flexible pipes. Since late 2006, more than 300 flexible pipes containing VESTAMID® LX9020 as a barrier and/or outer sheet layer have been produced.

Evonik, together with an industry partner, succeeded in qualifying another VESTAMID® PA 12 grade for use in reinforced thermoplastic pipes (RTP). **Bureau Veritas** issued a Certificate of Conformity stating that the new pipe system may be used to convey gas in an offshore environment.

Aging

The following diagram shows the life-cycle curve of PA 11 and PA 12 in water and under neutral conditions. Shell Global Solutions carried out the underlying aging study in line with the API Technical Report 17TR2.

Arrhenius life time curves for PA in H₂O



Umbilicals

Evonik is a pioneer in multi-layer plastic pipe systems and can look back on **more than 30 years' of experience** as a technology leader. One of our core competencies is to make connections between different polymer layers inseparable.

Often an umbilical consists of a bundle of piping systems that contain or convey different media, depending on the task at hand. These pipes have to satisfy certain requirements on chemical resistance and permeation. High permeation rates of the different media can lead to cross-contamination between neighboring pipes and even cause them to fail. For example, flocculation triggered by contamination that could cause the piping to become blocked has been documented within the context of the BASICS JIP.

The newly developed VESTAMID® multi-layer tubing (MLT) has the following properties:

- **lowest permeation** for a broad spectrum of media
- optimized chemical resistance due to internal fluoropolymer layer
- inseparable layer bonding
- minimized cross-contamination
- **no oligomer elution**
- broad application window in umbilicals as a chemical injection and hydraulic line

The pipe structure can also be tailored to the customer's specific requirements



Lining

Important features in the design of a liner, besides the liner material's resistance to process media and the operating temperature, are maximizing the pipe's internal cross-section and the liner's **stability**. The maximum stability of the liner in the host pipe is achieved by ensuring a close fit between the two components after insertion is complete.

In 2003, the OEP paper "Qualification of Plastic-Lined Pipelines for Hydrocarbon Transport" described suitable installation technologies to achieve such close-fit designs. The authors also showed that, in the case of currently available PA 11 liners, it is not possible to specify a tight fitting section without the risk of the liner becoming seizing during the insertion process. Therefore, the PA 11 grades that are currently available are not suitable for close-fit designs. A loose or slightly loose fit design would give rise to uncertainty over the stability of the liner in service.

Evonik has succeeded in combining the **outstanding installation properties** of PE liners with the excellent resistance properties of PA 12 to the production media in the oil and gas industry. Laboratory tests and installation experiments with VESTAMID® PA 12 have shown that the incorporation behavior of VESTAMID® PA 12 is equal to that of PE liners.

Consequently, in addition to the existing installation technologies, the industries now have the option of equipping production lines with PA 12 liners in a close-fit design. VESTAMID® liners provide **extreme operating reliability**.

Under the extreme conditions experienced in recovering oil from oil sands, particular demands are made on erosion and abrasion resistance. Jet slurry tests carried out by an **accredited independent test institute** have shown that VESTAMID liners erode much less than the steel that was tested for a comparison. In other words, VESTAMID® liners can considerably increase the service life and reliability of pipelines under extreme abrasive conditions.

VESTAKEEP® PEEK High-Temperature Polymer

Evonik has further extended its technological lead in the high-performance polymers sector with VESTAKEEP® polyetheretherketone (PEEK) compounds. VESTAKEEP® compounds are suitable for applications with extremely high mechanical, thermal, and chemical requirements.

VESTAKEEP® key properties:

- very high thermal stability and high long-term thermal stability
- good balance of extreme rigidity and hardness with good flexural fatigue strength
- low water absorption and thus high dimensional stability and stable electrical and mechanical properties
- self-extinguishing and halogen-free with low toxicity and optical smoke density
- excellent sliding friction behavior, minimal abrasion
- outstanding chemical and hydrolysis resistance
- low tendency to form stress cracks and low creep at high load
- low compression set for good sealing properties

VESTAKEEP® recommended product range

Application	VESTAKEEP® grade
Umbilicals	L4000 G, 5000 G
Liners	L4000 G, 5000 G
Compressor parts	L4000 G, 5000 G from rods, 4000 GF30, 4000 FP for HCM
Sealing rings	L4000 G, 5000 G from rods, 4000 FP for HCM
Valve parts	L4000 G, 5000 G from rods, 4000 GF30, 4000 FP for HCM
Wear tapes	L4000 G
Coating	on demand



Applications for VESTAKEEP® PEEK

Sealing rings, valve parts

Common PEEK materials tend to suffer brittle fracture when the PEEK rings are inserted into the groove. Because, however, it is up to 15% tougher under impact, VESTAKEEP® L4000 G is the ideal material for thin, large-diameter sealing rings inserted into valves and fittings. The glass fiber-reinforced VESTAKEEP® molding compounds benefit from the higher impact toughness, too.

VESTAKEEP® Powder from Evonik is suitable for manufacturing sealing rings using high compression molding (HCM) processes.

VESTAKEEP® L4000 G and, especially, VESTAKEEP® 5000 G are used to manufacture semi-finished products from which fitting parts are produced.

Umbilicals, liners

Their excellent chemical resistance, even at very high temperatures, combined with their high mechanical stability, makes VESTAKEEP® L4000 G and 5000 G the materials of choice for umbilical lines subject to harsh conditions. Evonik is thus uniquely able to offer solutions in high-end areas in addition to its VESTAMID® MLT solutions for umbilicals.

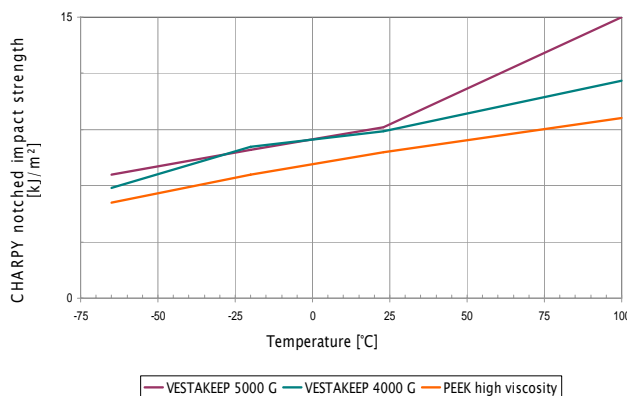
Compressor parts, wear tapes

Standard PEEK materials exhibit excellent tribological properties. To make VESTAKEEP® even better for applications where severe sliding abrasion occurs, Evonik is working intensively on developing products with enhanced tribological properties.

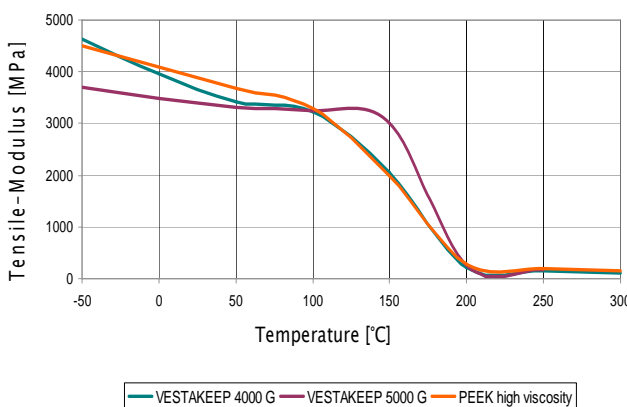
VESTAKEEP® fine powders are suitable for composites used in the aviation industry as well as the oil and gas industry.

Evonik, as a system provider, also markets PPSU and PEEK-based anti-wear tapes in addition to the above products. They for example, minimize wear between the individual steel reinforcement layers in flexible pipes and thus ensure that oil-conveying pipelines last longer.

Notched impact strength, -65 to 100°C



Tensile modulus, -50 to 300°C



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