VESTAMID®

AUTOMOTIVE FUEL TUBING SYSTEMS

EVONIK
POWER TO CREATE

VESTAMID®
THE POLYAMIDE OF CHOICE IN MULTILAYER TUBING

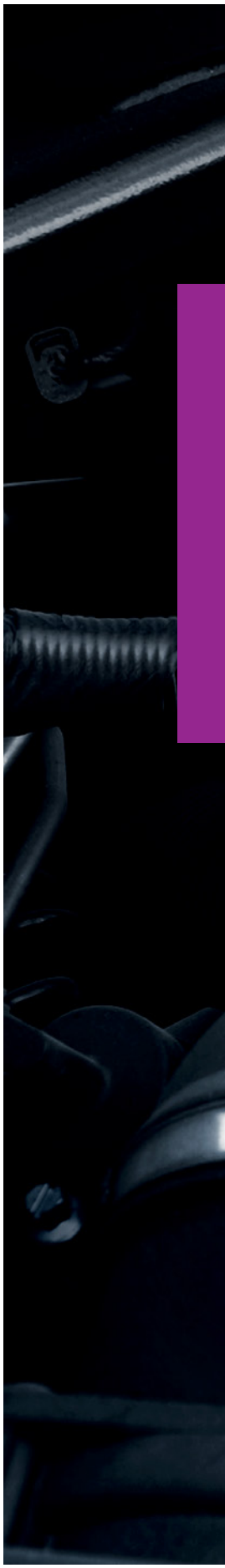
The requirements of automakers and of their suppliers are extremely high and continue to rise. Evonik's developers have been striving for more than 50 years to provide the best solutions for automotive monolayer and multilayer tubing. Throughout this period Evonik has been a reliable partner to the automotive and supply industry, especially when it comes to turning innovative ideas into new products and system solutions. Our success is based on a range of high-performance polyamides and many years of experience, which ensure that we can always select the right solution for your application.

The material of choice for automotive tubing is VESTAMID® polyamide 12, which is used more than any other polyamide 12 for tubing systems in cars.

Polyamide 12 is a semicrystalline polymer with good dimensional and temperature stability and good damping characteristics for noise and vibrations. It has the lowest density of any polyamide and absorbs the least water. The suffix "12" refers to the molecular structure of the individual building blocks: These are composed of 12 carbon atoms and are distinguished by a particularly long alkyl chain. This, and the interactions between specific parts of the molecule, make the plastic especially impact-resistant and resistant to oils, fuels, and other chemicals. In addition, polyamide 12 can be used over a wide temperature range. Virtually no other polymer material in this price range exhibits these properties.

PA12 – Most important properties

- Extraordinarily high impact resistance and notched impact strength immediately after processing and well below the freezing point
- Good to very good resistance to greases, oils, fuels, hydraulic fluids, and many solvents as well as to salt solutions
- Excellent resistance to stress cracking, even for metal parts that are encapsulated by injection molding or embedded
- Excellent abrasion resistance
- Noise and vibration damping properties
- Excellent resistance to fatigue caused by frequent load change
- High processability
- Lowest water absorption of all commercially available polyamides. As a result, the properties vary only slightly and molded parts exhibit almost no dimensional changes with variations in humidity.
- Low coefficient of sliding friction in dry running against steel, polybutylene terephthalate, polyacetal, and other materials



VARIOUS TUBING SYSTEMS

Initially, both diesel and gasoline lines were made from the same compounds. However, stricter emission legislation called for the development of multilayer systems with a barrier layer for gasoline lines because spark-ignition fuels have greater permeation.

Permeation is not a problem with diesel fuels. On the other hand, the common rail technology employed in diesel vehicles causes the temperature of the fuel to increase, which raises requirements on the heat aging resistance of the lines.

This has resulted in a divergence in the development of fuel line systems for gasoline and diesel vehicles. Evonik offers one group of compounds for gasoline multilayer tubing systems and another group of specially developed compounds for diesel fuel lines.

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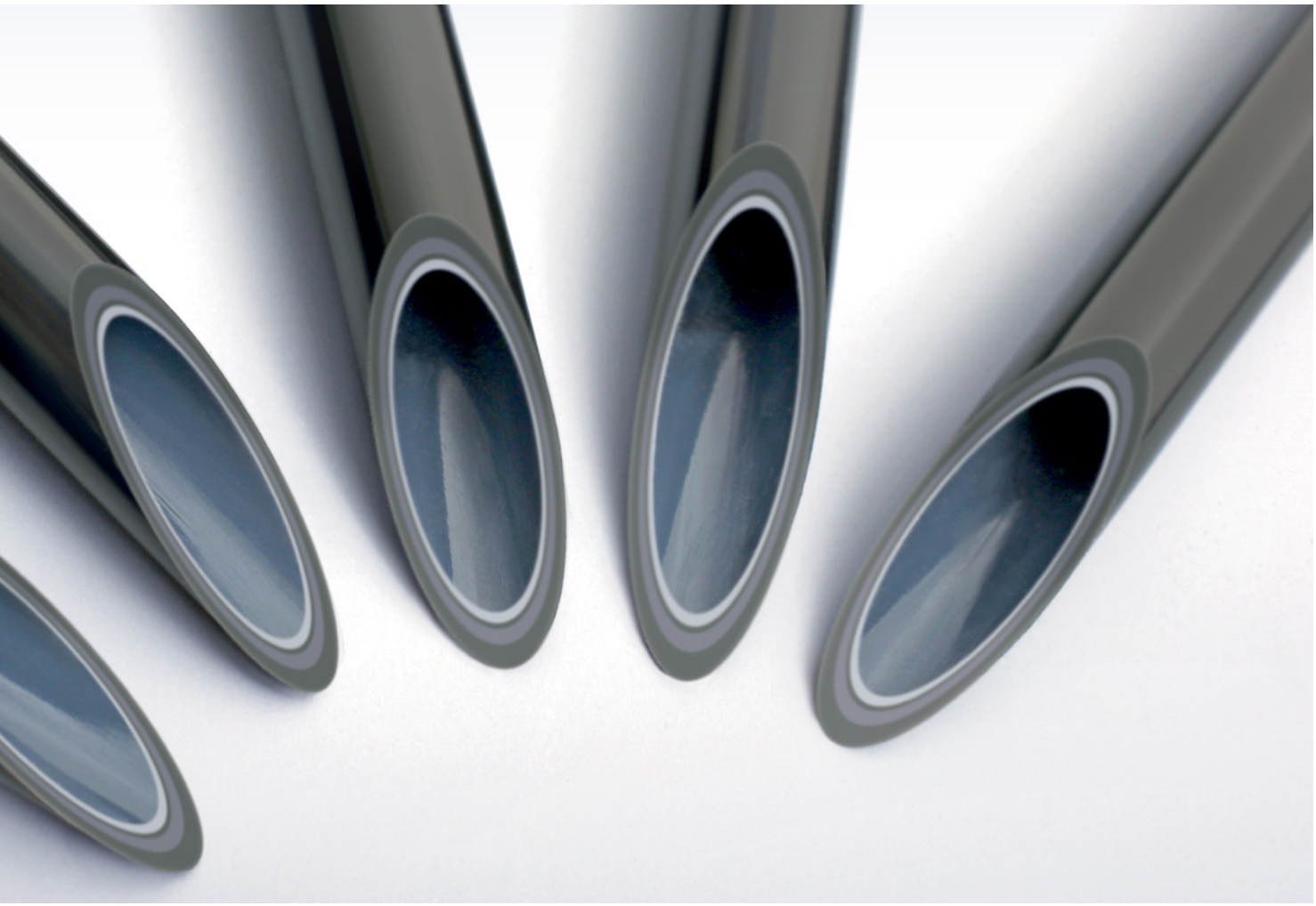
PIONEERING MULTILAYER TECHNOLOGY FOR **OVER 25 YEARS**

VESTAMID® **GASOLINE LINES**

Today, fuel lines are made of multilayer tubing (MLT) to meet current and future legal and application requirements:

- reduction in hydrocarbon emissions
- proper handling of electrostatic charges
- increase in corrosion resistance
- provision of excellent mechanical properties



As the market leader in polyamides for fuel lines, Evonik has developed a series of patented MLT systems based on VESTAMID® and various barrier layers. How well the barrier effect works against permeation of hydrocarbons depends on which barrier material is used. The barrier layers are made of

- polyvinylidene fluoride (PVDF)—DYFLOR®
- ethylene-perfluoroethylenepropene copolymer (EFEP)—NEOFLON™
- polybutylene terephthalate (PBT)—VESTODUR®
- ethylene vinyl alcohol (EVOH)

A developer of MLTs must basically work within the following constraints:

- the best possible barrier effect
- the lowest possible price for multi-layer tubing systems
- guarantee of physical and chemical properties

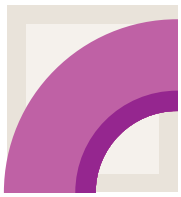
The use of fluoropolymers or ethylene vinyl alcohol is unavoidable if very low permeation values are required for alcohol-containing fuels. MLT designs with PVDF barrier layers are responsible for lowering fuel line emissions by more than 95 percent. MLT systems with EVOH barrier layers are the most cost-efficient. MLT systems with EVOH and EFEP barrier layers combine the benefits of two different barrier materials, such as protection against aggressive substances within the fuel and low level of extractables due to a fluoropolymer inner layer, and offer a more favorable cost situation than MLT solutions with thick EFEP inner layers.

VARIOUS **MLT SYSTEMS**

MLT without barrier layer

MLT 140

Conductive MLT for applications requiring performance of PA 12 monowall tubes



- **VESTAMID®** PA 12
- **VESTAMID®** PA 12 conductive

MLT 1000 with PBT barrier layer

MLT 1000

MLT with improved permeation resistance against alcohol-containing fuels and good cold impact performance; extraction close to zero

- **VESTAMID®** PA 12
- **VESTODUR®** PBT adhesive
- **VESTODUR®** PBT

MLT 2000 with PVDF barrier layer

MLT 2030

MLT with very good permeation resistance against alcohol-containing fuels and excellent cold impact performance

- **VESTAMID®** PA 12
- **DYFLOR®** PVDF modified
- **VESTAMID®** PA 12

MLT 2040

Conductive MLT with very good permeation resistance against alcohol-containing fuels and excellent cold impact performance

- **VESTAMID®** PA 12
- **DYFLOR®** PVDF modified
- **VESTAMID®** PA 12
- **VESTAMID®** PA 12 conductive

MLT 4000 series with EVOH barrier layer

MLT 4300

MLT with very good permeation resistance against ethanol-containing fuels and good cold impact performance

MLT 4500

MLT with very good permeation resistance against ethanol-containing fuels and excellent cold impact performance

MLT 4540

Conductive MLT with very good permeation resistance against ethanol-containing fuels and excellent cold impact performance

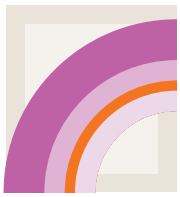
MLT 4800

Low-extractable MLT with very good permeation resistance against ethanol-containing fuels and excellent cold impact performance; significantly reduced extraction

MLT 4840

Conductive low-extractable MLT with very good permeation resistance against ethanol-containing fuels and excellent cold impact performance; significantly reduced extraction

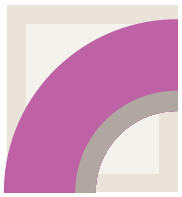
MLT 7000 series with EFEP barrier layer



- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive
- **EVOH**
- **VESTAMID®** PA 6

MLT 7000

MLT with very good permeation resistance against alcohol-containing fuels and superior chemical resistance, extraction close to zero

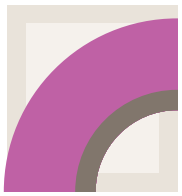


- **VESTAMID®** PA 12
- **NEOFLON®** EFEP

- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive
- **EVOH**
- **VESTAMID®** PA adhesive
- **VESTAMID®** PA12

MLT 7040

Conductive MLT with very good permeation resistance against alcohol-containing fuels and superior chemical resistance of inner tube surface, extraction close to zero. Applicable for aggressive bio-diesel fuels.



- **VESTAMID®** PA 12
- **NEOFLON®** EFEP conductive

- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive
- **EVOH**
- **VESTAMID®** PA adhesive
- **VESTAMID®** PA12 conductive

MLT 7400

Low-extractable MLT featuring two barrier layers with very good permeation resistance against alcohol-containing fuels and superior chemical resistance of inner tube surface; extraction close to zero

- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive
- **EVOH**
- **VESTAMID®** PA adhesive, low extract
- **NEOFLON®** EFEP low extract

- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive
- **EVOH**
- **VESTAMID®** PA adhesive, low extract
- **VESTAMID®** PA 612 low extract

MLT 7440

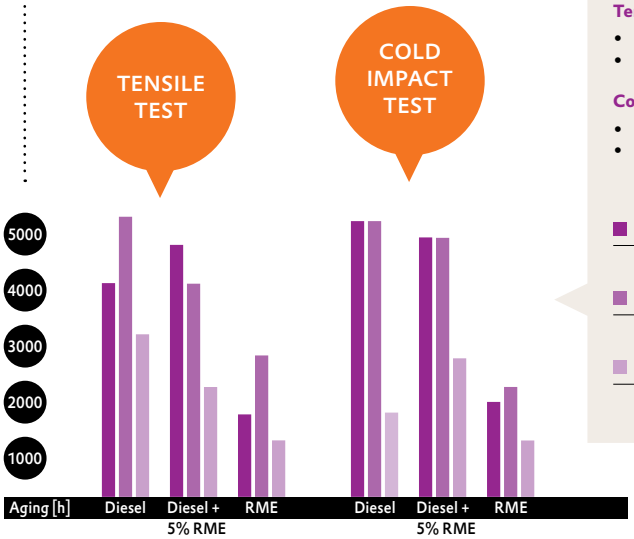
Low-extractable, conductive MLT featuring two barrier layers with very good permeation resistance against alcohol-containing fuels and superior chemical resistance of inner tube surface; extraction close to zero

- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive
- **EVOH**
- **VESTAMID®** PA adhesive, low extract
- **NEOFLON®** EFEP conductive, low extract

- **VESTAMID®** PA 12
- **VESTAMID®** PA adhesive, low extract
- **EVOH**
- **VESTAMID®** PA adhesive, low extract
- **VESTAMID®** PA 612 conductive, low extract

Diesel fuel lines made from VESTAMID® polyamide 12 have performed sterling service for many years. The compounds fulfill the fundamental requirements for low-temperature impact strength and chemical and diesel resistance. Manufactured tubes can be thermoformed by all common methods and offer sufficient aging resistance for engines featuring traditional injection.

VESTAMID®
DIESEL LINES



Tensile test
- ISO 527,
- elongation at break < 50%

Cold impact test
- SAE 2260, -40 °C
- more than 1 break of 5 tested tubes

VESTAMID® LX9013
PA12-HIPHL

VESTAMID® LX9008
PA12-HIHL

VESTAMID® X7293
PA12-HIPHL

Common rail diesel tubing systems

Two specialty polyamide 12 grades, VESTAMID® LX9008 and LX9013, have been developed for use in fuel return lines and fuel lines located close to engines in diesel vehicles with common rail injection systems. They are far superior to other polyamides in resisting aging at temperatures up to 125°C continuously, as well as up to 140°C peak temperature. Tubing systems made from these grades are much more economical than systems based on vulcanized elastomers. Due to the efficiency and the success of common rail injection systems throughout the entire range of diesel vehicles in the market, VESTAMID® LX9008 and VESTAMID® LX9013 are used in diesel fuel tubing systems of passenger cars and light commercial vehicles all the way up to heavy-duty trucks.

The common rail system operates at far higher pressures than previous systems, injecting the fuel in a time-controlled sequence. During expansion, the diesel heats up to such an extent that the temperature rises to about 100°C. Most affected by this is the fuel return line, which receives the uncooled fuel and feeds it to the tank. The design of the vehicle determines whether the diesel is delivered to the feed pipe or is mixed with the contents of the tank, whose temperature increases as a result. To ensure dependable hot diesel aging resistance, the entire tubing system is therefore usually made of the more resistant VESTAMID® LX9008 or LX9013 grades.

Resistance to biodiesel

The above applies to diesel fuels produced from mineral oil; biodiesel, i.e., methyl esters obtained from various plants (RME), must be considered separately. The composition of biodiesels varies according to feedstock base and batch and so their chemical properties vary; they are apparently influenced by the age of the fuel and oxidative pre-damage. Results from individual test series therefore differ more than usual, the extent of the difference depending on the time of testing and the frequency of fuel replacement. Although these results are therefore not reproducible, they do provide important information.

A general observation is that 100% biodiesel always generates much higher stress than mineral-based diesel. This applies not only to the tubing but also to all aggregates tied into the fuel system. With a view to reducing the aggressiveness of biodiesel and decreasing wear in vehicles, various European countries therefore permit biodiesel to be added to conventional diesel fuel only to the extent of 5%.

All tests so far have shown that the specialty polyamide 12 grades VESTAMID® LX9008 and LX9013 offer the best aging resistance to biodiesel.

Detailed data are available from our materials database **www.plastics-database.com**

SETTING
GLOBAL STANDARDS

VESTAMID®
CONNECTORS

High-performance fuel handling systems demand highly precise and leakage-free quick connectors. The easily injection moldable VESTAMID® PA 12 portfolio offers perfect solutions. Due to the unique chemistry of VESTAMID®, molded components such as housings, spacers, or adapters have the highest dimensional stability and show consistently high mechanical performance in various harsh conditions such as cold temperatures and hot and humid environments.

VESTAMID® L1833, 23% GF reinforced and VESTAMID® L-GF30, 30% GF reinforced are the global standards for quick connectors used in gasoline and diesel systems. The laser-transparent VESTAMID® L-GF30 black E70285 can be used for high pressure and leakage requirements, e.g. at the fuel rails, because it can be welded directly onto the tube. For more stringent long-term temperature requirements VESTAMID® LX9111 is an established product for diesel and VESTAMID® DX9321 for gasoline systems. Independently of the fuel used, it might be necessary to fulfil antistatic requirements: Our antistatic grade VESTAMID® L-CF15 is successfully used for this purpose in the automotive industry.

More detailed information on connectors can be found in a separate brochure on injection molding applications.

Data for these products are available from our materials database **www.plastics-database.com**

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