LET'S DRIVE THE FUTURE TOGETHER.

High Performance Polymers for designing the cars of tomorrow.

EVONIK
POWER TO CREATE

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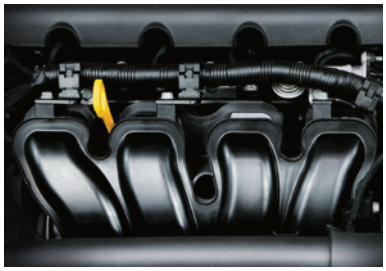


We're your partner
FOR THE FUTURE.

For many years now we've been well acquainted with the automotive sector, its issues, and its challenges. In turn, our customers know us as a trusted partner. We see joint development as a holistic task: We understand you and your requirements. We support you all the way, to the end of the process and beyond. This is our aspiration, and our fundamental conviction about how innovative ideas can be realized.

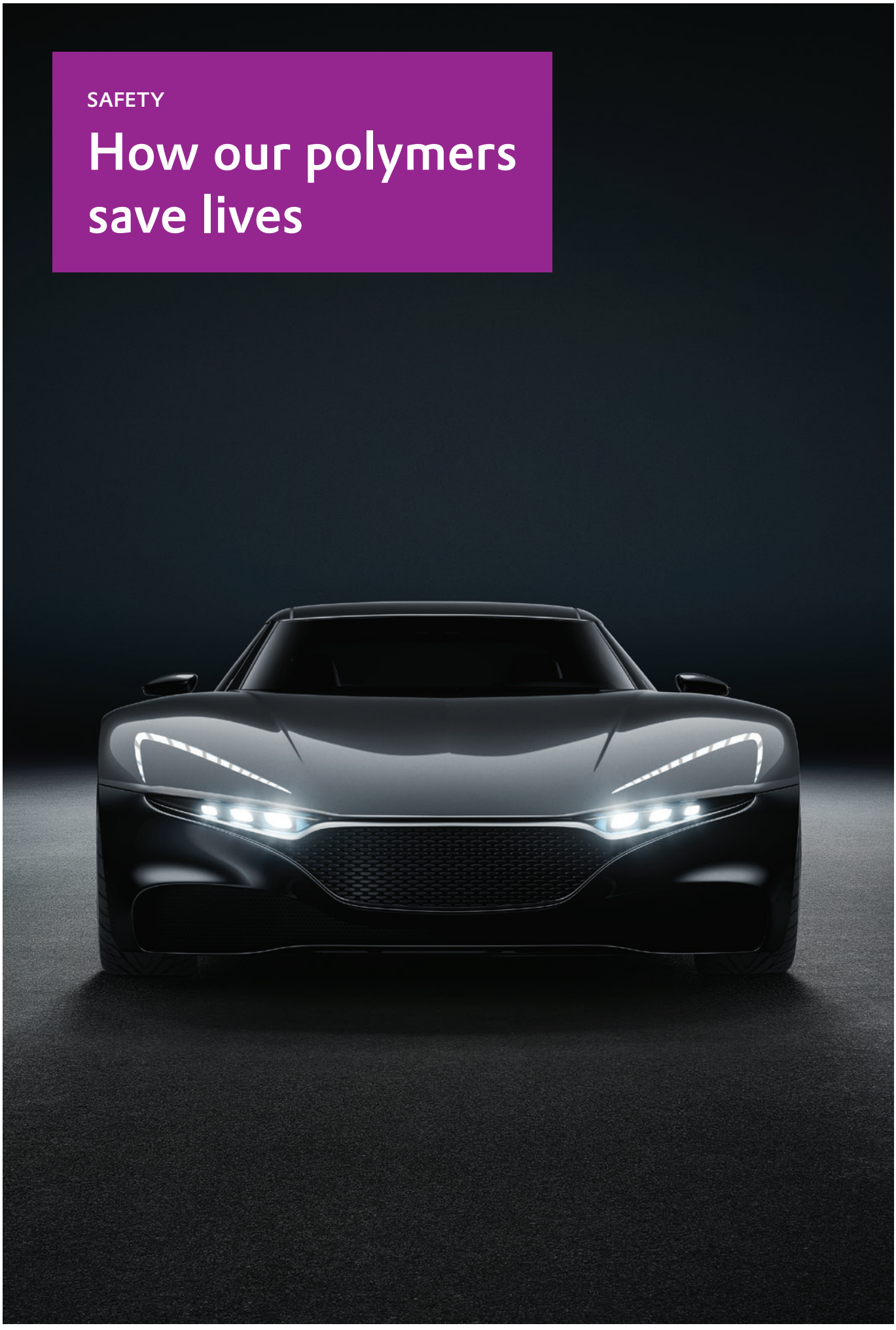
In this brochure, we invite you to take a trip with us through the mobility of the future. Because in every sector where mobility is a concern, now and over the long term, you'll also find our polymers. As a result of our collaboration, these will be transformed into products that are essential for meeting major challenges. In some cases this might be no more than a small cog, but, as you know, small cogs can turn big wheels.

Our products are small building blocks from which everything can be fabricated. Our granulate can in principle assume any form, entirely according to your wishes. That, together with our flexibility, is our great strength – regardless of whether the end product is a pipe, a spindle nut, or a thin surface film.

We're your go-to people for especially tough challenges.
We're your partner for the future.

SAFETY

How our polymers save lives



SAFETY

» How our polymers save lives

All car-makers are always working on making their products safer, whether on their own initiative, because obliged by public policy to do so, or because case law in some countries makes it appear advisable to rule out risks as far as possible. Over the last few years the options in this area have steadily improved – and in consequence, safety requirements have become more stringent. We are convinced that this trend will continue. Safety is one of the topics of the future. Fortunately we have available a material that can meet even the toughest requirements.

INDESTRUCTIBLE IN THE RIGHT PLACE

A car-maker required for his new series a spindle nut in the steering column that would not break even under the heaviest load. In fact the maker had already fitted his vehicles with spindle nuts of polyetheretherketone (PEEK). But not all PEEK is the same: The material used could not stand up to the new and more stringent requirements. It broke – or, to be exact, it splintered into a large number of small fragments. And that's exactly where the problem lay, because the steering column also housed the airbag, which must not be damaged under any circumstances, and most certainly not by small, sharp-edged plastic splinters. The maker did not want to take this risk.

It so happened that the developers had in stock another PEEK variant – Evonik's VESTAKEEP®. "Our production process is somewhat different," explains Frank Lorenz, Director VESTAKEEP® Components. "So our material has different properties; it's more ductile and more impact resistant." It turned out, in fact, that under the identical conditions VESTAKEEP® did not break; the spindle nut was only warped. The requirement for high dimensional stability at different temperatures was also satisfied. The component is now used in series production – because it holds up where other materials might splinter.

ELASTIC UNDER ALL CONDITIONS

You sometimes need a material that reacts elastically, cushions impact, expands – and thus ensures safety. This is why our VESTAMID® polyamide 12 is used in fuel lines:

"MY COMPONENT MUST BE PROVEN TO WITHSTAND EVEN THE HIGHEST STRESS."

REQUEST

You define the safety requirements.

it retains its elasticity even at extreme temperatures and does not become brittle when cold or soft when heated. Polyamide 12 can even withstand the impact of an ice chunk on the line at minus 40 degrees Celsius – consistently, and over the entire lifetime of the car. This safety advantage is also exploited in very different components, such as airbags. Could VESTAMID® be the solution for your specific safety challenge? We look forward to developing entirely new ideas, together with you.

If you want the highest level of safety, you need the right material: PEEK has impressive impact resistance, while PA12 is ideal for features where elasticity is of key importance.

STRESS TEST

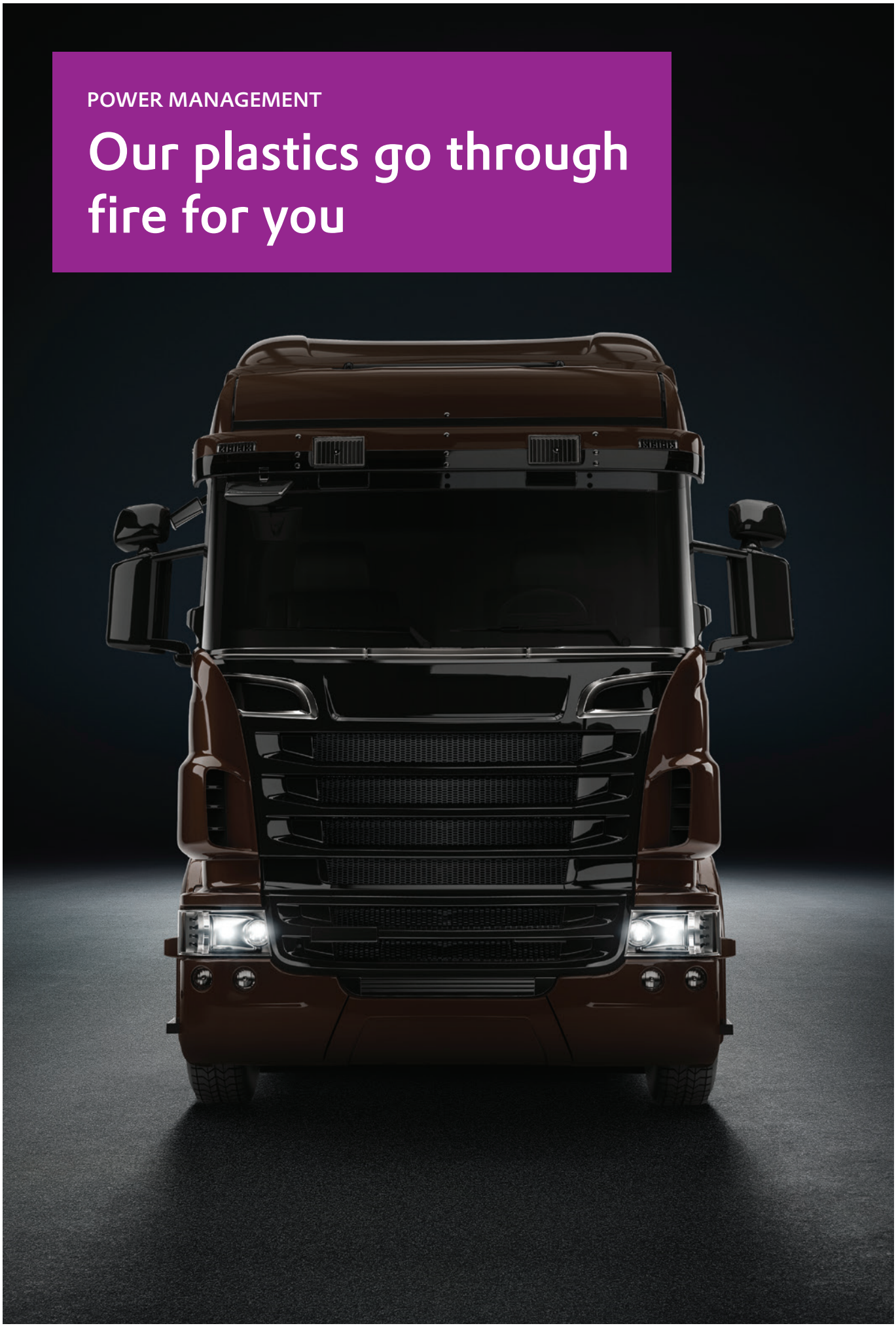
We test our material in accordance with your requirements.

ENHANCEMENT

If necessary, we will develop an ideal material to your specifications.

POWER MANAGEMENT

Our plastics go through fire for you



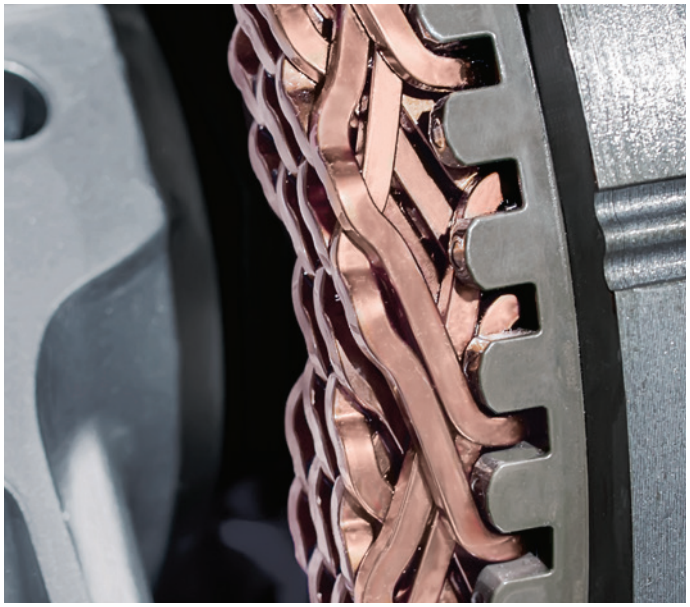
POWER MANAGEMENT

» Our plastics go through fire for you

The future is electric: Car manufacturers worldwide are investing enormous amounts in electrification, spanning the range from hybrid, through fully electric, to hydrogen powered vehicles. This departure into the new mobility, new markets, and entirely new challenges has long since taken hold of the entire industry.

Efficient management of electric power and permanently effective insulation of electrical components are key elements in e-mobility. The challenges include management of high voltage, high temperatures, and fire protection.

A high level of fire protection is expected of the plastics used over the entire vehicle lifetime. In addition to this fire protection, insulative materials must also have outstanding dielectric properties. This applies particularly to power buses in high-voltage batteries, which is why these are preferably insulated with polyamide 12 (PA12). Coolant lines often need to be fire protected in this environment, too. Evonik VESTAMID® PA12 is available at all UL fire protection levels to V0 and includes halogen-free variants in the portfolio.



High fire protection over the entire lifetime of the vehicle: we offer customized variants.

FOR EVERY REQUIREMENT THE APPROPRIATE SOLUTION

Fire protection is also of fundamental importance for the electric drive motor. In this case the inherent fire protection of VESTAKEEP® PEEK is particularly useful for insulating the motor's winding wire. Moreover, Evonik materials are easily handled in all common processes from injection molding through extrusion to powder coating. High processing speeds can lead to particularly cost-effective extrusion production, for example.

Evonik offers a large number of material solutions for the challenging and diverse requirements of electromobility. This is where our strength lies: in innovative, powerful, and custom-designed material solutions. We've been demonstrating that for decades in our collaboration with the automotive industry.

"I NEED FIRE PROTECTION FOR MY COMPONENTS"

DEFINITION

You describe the operating conditions and specify your requirements, including UL classification.

ADVICE

We advise you on the best possible polymer material solution.

INDIVIDUAL

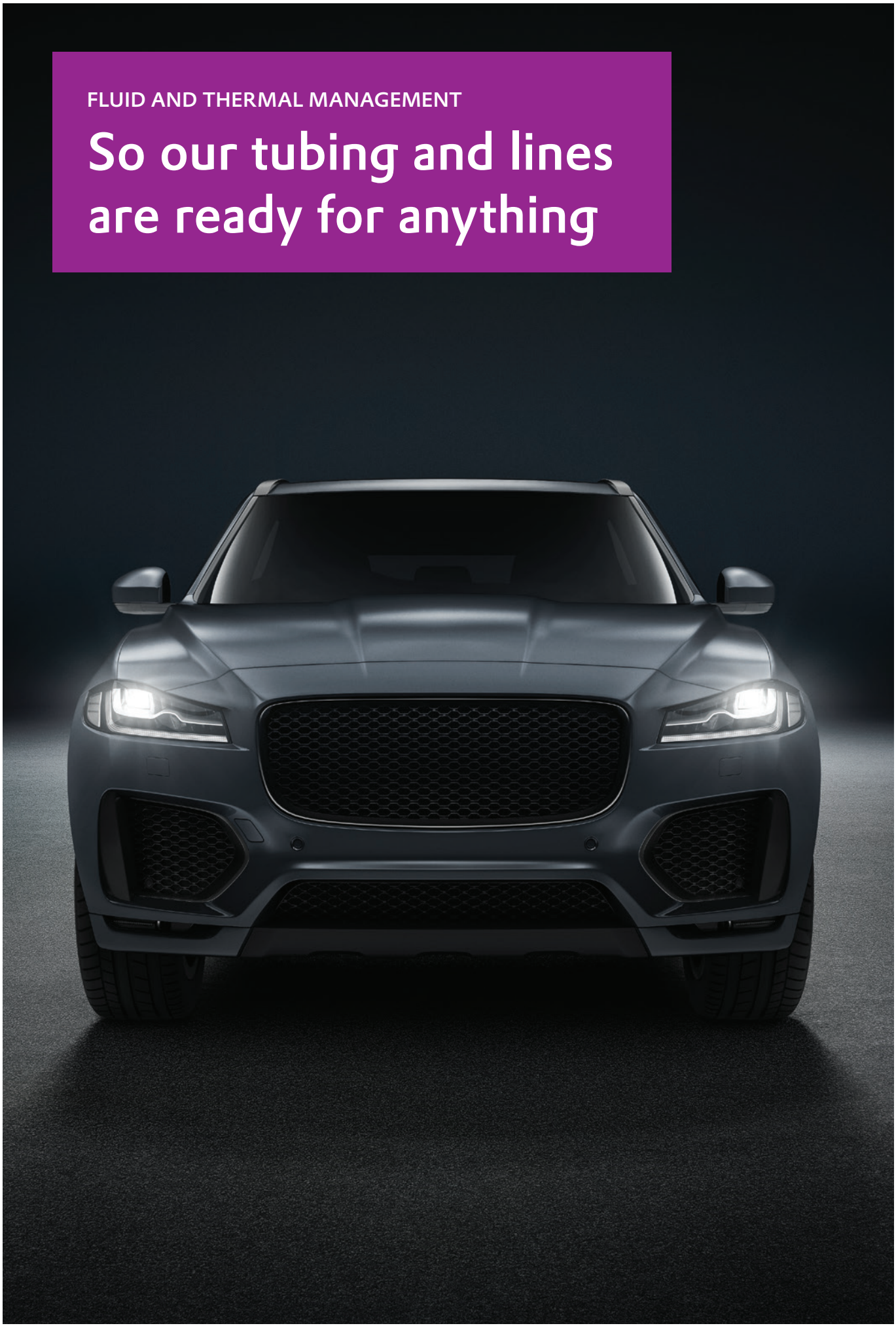
We will, if necessary, develop a customized solution. An expert with process experience will support you during the first production run.

PARTNERSHIP

We'll continue to provide support as your partner over the long term.

FLUID AND THERMAL MANAGEMENT

So our tubing and lines are ready for anything



» The fuel of the future flows through our lines

What will the fuel of the future look like? To be honest, nobody yet knows. But one thing seems quite certain: it will flow through lines. And as far as multilayer fuel lines go, we've been global market leaders for decades.

This means that we have a wealth of experience regarding changes, new requirements, and innovations in the area of fuel. Gasoline, for example, is not what it was 30 years ago: it has changed, along with its environment and the associated mechanical systems and safety requirements. We've kept pace with all of this. And, having kept an ear to the ground for car-makers' ideas, we've also been able to look ahead. We're adapting to changed circumstances. And so we're convinced that the fuel of the future will also flow through lines made of our plastics.

WHAT TUBING MUST BE ABLE TO DO

Even monowall tubing must satisfy a host of requirements, such as impact strength and resistance to chemicals. But what if these requirements are partially contradictory or difficult to reconcile? This is the reason why multilayer tubing has been in use for decades – for example to reduce permeation and therefore release of environmentally harmful fuel components to the environment, or to prevent alcohol-containing fuels from dissolving components of the plastic that would then block modern fuel injection systems. In questions such as these we have more than four decades of experience that we can apply for your benefit, as also our flexibility, to think of new solutions.

The challenge lies not so much in generating new properties for tubing, but rather in adding a new property to a material (or, in a multilayer system, to a combination of different materials) while retaining all the other properties. If, for example, you want a line with even lower flammability, you would not be willing to trade this off against existing advantages, such as impact strength or resistance to the media

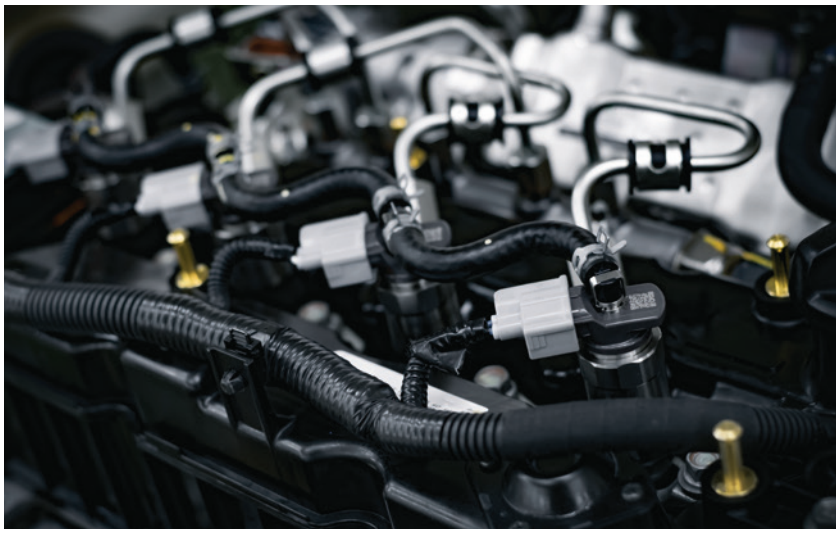
"I NEED MULTILAYER TUBING WITH VERY SPECIFIC PROPERTIES."

ADVICE

Our many years of experience enable us to advise you directly and individually.

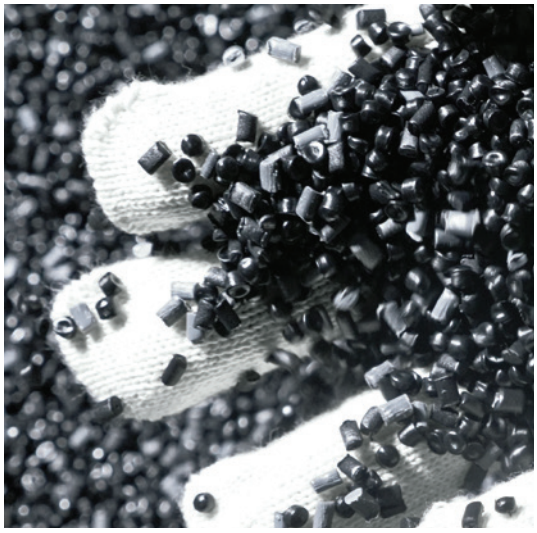
MATERIAL

If necessary, we will expand the property profile of a material to include new properties.



Lines almost always have to stand up to the most highly challenging environments: they must be resistant to heat, impact, and media.

present in the vehicle. Individual requirements and standards also come into play here, depending on carmaker and region. In this regard we draw on our formidable expertise and our longstanding partnerships with our customers for your benefit. We know the standards, and our laboratories are situated locally in the regions so as to be able to carry out testing for you individually. Challenging material mixtures are our forte!



COMBINATION

Different materials with different properties can be combined in multilayer systems if required.

TEST

New materials and multilayer systems can be tested in our laboratories.

GUIDANCE

An expert with process experience will support you during the first production run.

SUPPORT

We will continue to offer support even later, for example with the validation of new products and systems.

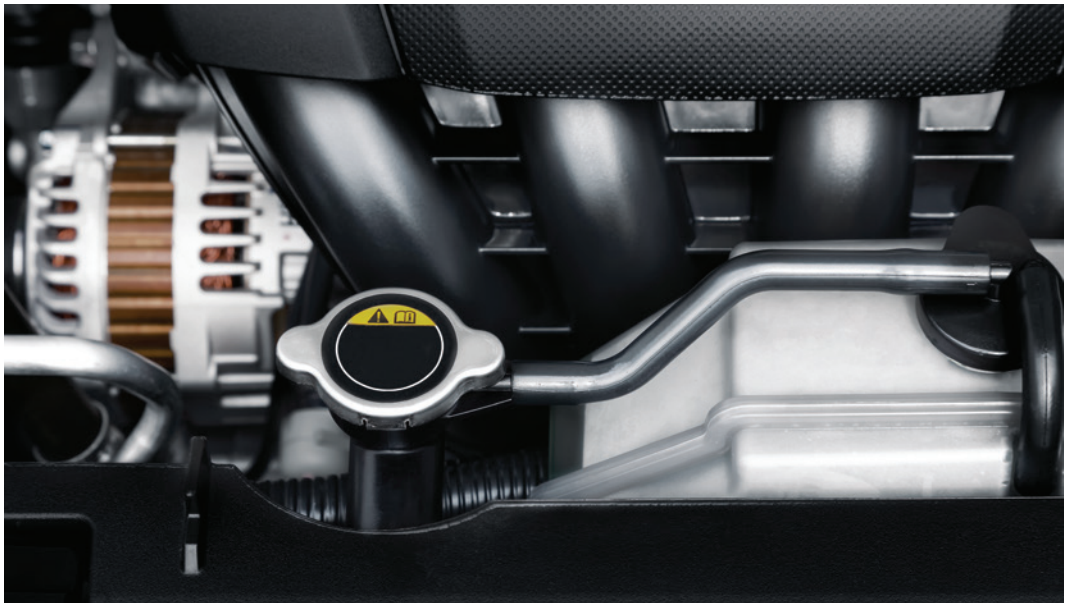
THERMAL MANAGEMENT

» How our plastics always stay cool

It isn't just fuel that needs lines but also other materials, such as cooling media, whether for combustion engines, electric batteries or motors that must be cooled or air conditioners – or indeed for a technology of the future that is as yet unknown.

What we do know is that every line poses different challenges. A common feature of most of the lines in a car is that they must be able to withstand extreme conditions: they must withstand the high temperatures near the engine; they must be impact resistant, even well below the freezing point; and they must be resistant to oils, greases, hydraulic fluids, and solvents. This is taken for granted in almost every car. At the same time, lines must be easy to produce and to process further. In most cases polyamide – or, more precisely, our VESTAMID® polyamide 12 (PA12) – is the only practical alternative here.

It takes a lot of experience – and the right material – to produce excellent properties in coolant lines. We have both.



THE CHALLENGE FOR COOLANT LINES

Glycol-water mixtures are a challenge for lines because they corrode metals. Even certain plastics may become brittle as a result of the hydrolysis effect. What happens if, on the one hand the "tough" properties of polyamide, such as heat resistance and impact strength, are needed – but, on the other, the temperatures near the hot engine could lead to hydrolysis? The solution is provided by multilayer tubing systems. The use of different layers prevents direct contact between the water-containing coolant and the polyamide. Here too, you benefit from our many years of experience with multilayer tubing systems and our materials expertise, enabling you to produce coolant lines combining all the relevant properties.

As you can see from this example, we think along with you. We see ourselves as a development partner that addresses your concerns and challenges. And that extends well beyond the technical design of tubing. If required, we will also support you in your first production run as well as in the following period, drawing on our process experience. It's important to us that you produce exactly the perfect tubing that you had in mind. Because, just like you, we too are passionate engineers and developers!

"I NEED A VERY SPECIAL KIND OF LINE."

EXPERTISE

We discuss the specifications with you, bringing to the table our expertise in multilayer tubing systems.

DEVELOPMENT

We will, if necessary, extend the property profile of a material to include new properties, or combine materials with different properties in multilayer systems.

TEST

New materials and multilayer systems can be tested in our laboratories.

GUIDANCE

An expert with process experience will support you in the first production run.

SUPPORT

We'll continue to stand by you all the way – for validations of new products and systems, for example.

SHARED MOBILITY

A new design world


AUTO
P

SHARED MOBILITY

» A new design world

There's reason to believe that the vehicle of the future will not be privately owned. It could be ordered as and when needed – and it could be driven to you autonomously. This means radical changes in interior design and in how the interior is used. Currently less highly stressed components will be used more often; in the autonomously driven vehicle, completely new control elements and screens will be used. The car will presumably be cleaned more often and will regularly come into contact with chemical cleaning agents.

What is required, then, is a material that is resistant to chemicals and abrasion but at the same time allows creative design freedom; ideally it should also be highly transparent and fade resistant. At present, hard coatings are often used to protect standard plastics at such points. But this means additional costs and extra process steps. Wouldn't it be wonderful to think in terms of component geometries that could be fabricated in a single process step?

POLYAMIDES LIKE TROGAMID® ARE THE ANSWER TO THESE REQUIREMENTS OF THE FUTURE.

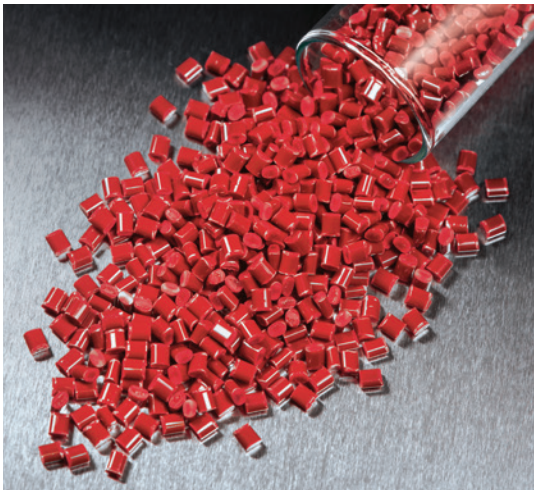
They are extremely resistant to chemicals but also relatively insensitive to abrasion and light. They are suitable for transparent light guides and trim strips – and even as single- or multilayer decorative films. For elements with particular design requirements TROGAMID® offers a number of advantages: thanks to their high transparency, our products are perfectly suited for production of components in a variety of colors with a deep gloss effect, or for simulation of chrome metallic effects. The high mold surface reproduction allows accentuation of particularly small and individual textures. This is the material for all designers wanting to exploit and test the new freedom of the changed interiors of the future.

Evonik has a wealth of experience in the development of polyamide as a material for design elements; after all, our products are widely used in consumer goods close to the end customer, such as eyeglasses and shoes. We know how to produce a special visual appearance or particular color shades. And you, as our customer and partner, also benefit from this expertise!

"I WANT A COMPONENT FOR THE INTERIOR THAT'S HARD WEARING BUT DOES NOT NEED TO BE COATED."

REQUEST
Together we'll discuss your requirements and specifications.

DEVELOPMENT
If necessary, we'll develop improved variants of our material especially for you.



Surfaces that are frequently touched need to be correspondingly tough. TROGAMID® is resistant to chemicals and light – and opens up new possibilities.

PARTNERSHIP

We'll develop your desired material together, as partners.

OPTIONS

You then test our options and select the best.

EMISSIONS REDUCTION

Into a whisper-quiet future

EMISSIONS REDUCTION

» Into a whisper-quiet future

Entire groups of developers are currently examining the question of how to reduce the weight of their models, even if only by a single kilogram. Lightweight construction is the watchword because, first, combustion engines should use less fuel and second, electric vehicles need to get more performance out of the battery.

The material that is most suitable for lightweight construction is plastic. But not every metal part can be replaced by plastic without further ado: the plastic also needs to have the right properties. In addition, it takes engineers and chemists with enough creativity to come up with ideas about where plastics might make a rethink possible. We are convinced that there will be many more ideas in the future about the role of plastics in lightweight construction. Do you already have something in mind? Let's talk about it and discuss how we can jointly realize the idea!

THE LIGHTNESS OF THE GEARS

Polyetheretherketone (PEEK) is a king among plastics. Given its special capabilities, it is definitely not for use in each and every component. But in terms of

PEEK gears are the ideal solution for lightweight construction: they are light, quiet, and heat-resistant.

flame retardancy, safety, or special requirements on impact strength, high temperatures, or tribological properties, PEEK is unsurpassed. Weight reductions of about 70 percent are possible when metal components are substituted by PEEK. Yet another plus is noise reduction: Plastic gears running on metal gears are about three decibels less than one metal gear on top of another. These requirements are becoming even more important in these times of quieter hybrid and electric vehicles.

Lightweight, low-noise, heat resistant, and unaffected by hydraulic fluids and oil, our VESTAKEEP® is the answer to the automotive construction of the future. Not many metals or other plastics can offer this special combination of strengths.

Substitution of metal with plastic also takes good engineering skills because there is not necessarily more installation space available. It is helpful here to have the support of developers who understand both the chemical material process and the engineering challenge, and take both into consideration when developing answers. As your partner in development, we think along with you and possess the appropriate expertise, stemming from decades of experience.

"I WANT TO SUBSTITUTE A METAL COMPONENT WITH A PLASTIC ONE."

REQUEST

We discuss the material requirements jointly with you.

ADVANCED KNOWLEDGE

Thanks to our expertise extending over many years, we can ensure that the material for the new component is appropriate to your design and fully satisfies all the requirements placed on it.

STANDARDS

We thoroughly test the important properties of the various requirements, specifications, and OEM standards for you in advance.

AUTONOMOUS DRIVING

AI does the thinking while the gears do the steering


d=25'
Light = "red"
σ/√n
d=9' 6''
σ=.5''
σ/√n
d=9' 10''
σ=.6''
σ/√n

AUTONOMOUS DRIVING

» AI does the thinking while the gears do the steering

Who or what is actually doing the steering when the car drives autonomously? Sensors? Artificial intelligence? Of course – but what would the self-driving car be without the mechanical systems in the interior that translate all this input into motion sequences?

The vehicle of the future is expected to be even more dependent on gears than present-day cars. These must work quietly and reliably, and also withstand all tolerance deviations that might arise from external influences such as atmospheric humidity, lubrication, or temperature fluctuations. Precision requirements on the gear parts of the autonomous vehicle are even higher. Because there is no human co-steering or counter-steering, they must be able to translate all inputs very accurately at all times.

ALL-ROUND TESTING: OUR GEAR TEST BED

When the highest precision is required, how can important gear parameters such as tooth root strength, tooth flank strength, and wear on the gearwheel be reliably measured? High-performance plastic gears must prove under maximum torque conditions that they are made for the lifetime of the vehicle, with no cracks, pitting, or flaking away of the teeth. Evonik uses its Competence Center Friction and Motion (FRIMO) for this purpose. This test bed for gears, designed in-house, allows testing over a temperature range between minus 20 degrees Celsius and 260 degrees Celsius, and in the dry state as well as lubricated with oil or grease.

Autonomous driving places new requirements on actuator precision and will also radically change the interior of the vehicle. In both cases our polymers can help.

This versatility is unique. All the data – whether particular properties of materials, a particular rotational speed, or a particular torque – are then analyzed by simulation software so that the designer can build on them. Most importantly, the results will directly benefit you, as our customer.

Moreover, the increased trend toward electromobility is now leading to developments with higher rotational speeds. Here again there might be entirely new applications for plastic, and thus also opportunities for innovations such as VESTAKEEP® 5000G, which we developed some years ago; this is very highly viscous and has a very high molecular weight – and is therefore even tougher and more ductile. This is just one example of how Evonik continuously addresses new developments for the future, in line with its customers' needs and wishes.

NEW WORLDS IN THE INTERIOR

Moreover, the increase in automation, all the way to autonomous driving, is also changing the interior of the vehicle. If the steering wheel needs to be used less often, or not at all, space is freed up for entirely new design, new screens, or other elements. Here again our products could come into their own. A good example is the microcrystalline polyamide TROGAMID®: As a particularly robust material, it is resistant to chemicals and thus protected against even frequent contact with any aggressive substances, from sunscreens to sweat; and, being transparent, individually colored, and color-fast, it opens up new worlds for designers. We are keen to hear your ideas because we're convinced we have the right solution lined up.

"I WANT TO DEVELOP A GEAR WITH VERY SPECIFIC PROPERTIES."

PROJECT

We will discuss the precise outline data with you.

DEVELOPMENT

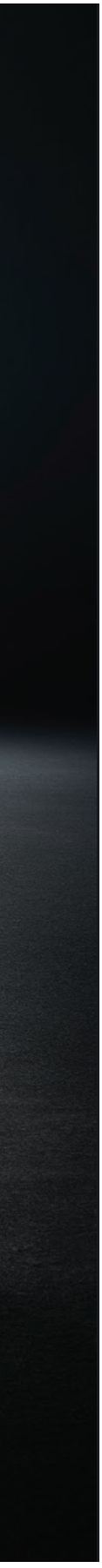
We will develop an individually tailored granulate for you if required.

PARTNERSHIP

You produce your gears; we will, if required, share our knowledge for the optimum production.

SUPPORT

We'll support you in CAE design and tool design



Take a trip with us into THE MOBILITY OF THE FUTURE

Individual and intelligent, interlinked and multilayered; a mix of traffic systems; artificial intelligence and mobile traffic apps, and people who change their mode of transport several times a day; electromobility, autonomous driving, drones as suppliers, air taxis…

Our fascination with the visions and mobility concepts of the future lies partly in the fact that some have already been realized while still sounding like science fiction – to say nothing of the grand predictions that appeared to be within reach but never became reality. So where is the story of our mobility heading?

We believe that automobiles will continue to exist, whatever they may look like, to whoever they belong to, and however they are controlled. And certain fundamental concepts will not change in the vehicle of the future, regardless of whether it drives autonomously, which fuel powers it, and whether it drives on or off the road – or indeed flies through the air.

The vehicle of the future will continue to need transport lines, whether for fuel or other fluids, power or data. The vehicle of the future will need components that withstand the highest pressures, heat, aggressive chemicals, and high voltage. People will communicate and interact with this vehicle; they will touch it and use it, and they will undoubtedly want to delight in its new functions, interior and exterior design.

In all of these areas our polymers offer exciting and innovative answers to the immense challenges of the future. We're prepared. And we would be delighted to support you as a reliable development partner in the mobility innovations of the future.

OUR PORTFOLIO:

VESTAMID®	PA12, PA612, PA610, PA1010, PA1012
TROGAMID®	transparent PA
VESTAKEEP®	PEEK
VESTODUR®	PBT
VESTOSINT®	PA12 powders

In addition, we offer polymer specialties such as polymethacrylimide ROHACELL® and polyimide P84® NT. We are looking forward to talking to you about our range of high performance polymers!

TALK TO US!

Come to us with your questions; it could be that we already have an answer! And if we don't, we'll develop one together. This is, after all, about the future. And sometimes you need to ask open-ended questions to be able to master the challenges of the future.

Let's develop ideas together – even on questions that nobody's yet asking.

Of one thing we're certain: we'd be happy to support you in this – and to go all the way with you.

Your Automotive Team for High Performance Polymers

EVONIK RESOURCE EFFICIENCY GMBH
High Performance Polymers
45764 Marl
Germany

Phone +49 2365 49-9878
evonik-hp@evonik.com

EVONIK CORPORATION
High Performance Polymers
Parsippany, NJ 07054
United States
Phone +1 973 929-8000

EVONIK SPECIALTY CHEMICALS (SHANGHAI) CO., LTD.
55 Chundong Road
Xinzhuang Industry Park
Shanghai 201108
Phone +86 21 6119-1000

www.vestamid.com
www.vestakeep.com
www.evonik.com