

# QUALITY PERFORMS.



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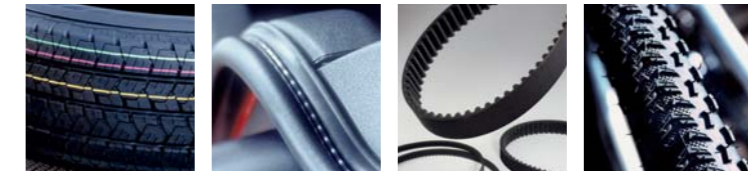
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## Global Rubber Performance Product Catalog



**RheinChemie**  
Additives

**QUALITY WORKS.**

**LANXESS**  
Energizing Chemistry

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# INTRODUCTION

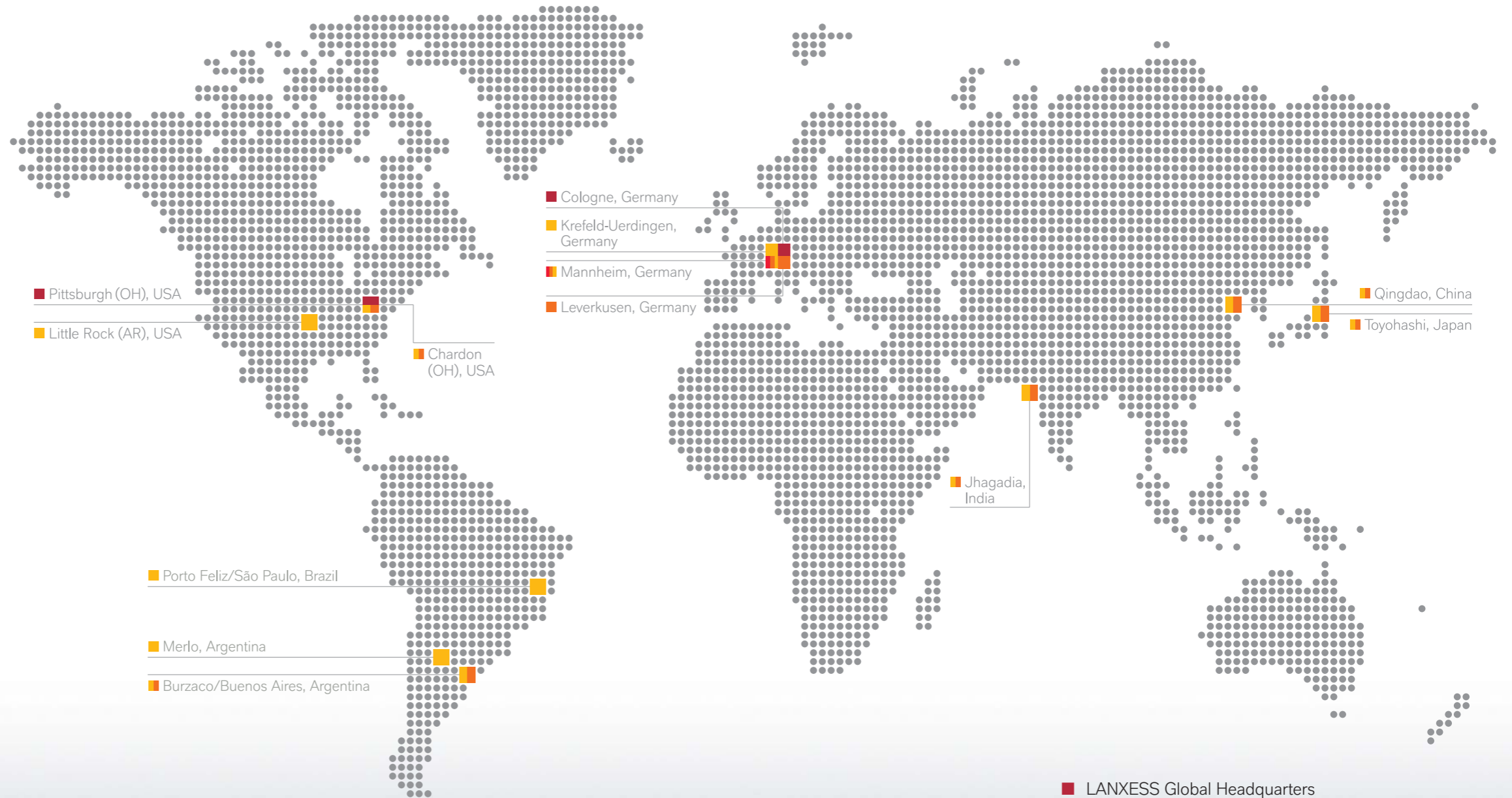
As a leading supplier of rubber additives, release agents, and tire curing bladders, Rhein Chemie, a business unit of specialty chemicals company LANXESS, operates production plants in all relevant regions of the rubber world. We have several regional technical centers to maintain close contact to our customers.

Our mission is to manufacture products of consistently high quality, globally. We work continuously on developing solutions for the rubber industry. As a strong partner with more than 125 years of experience in the rubber industry, we develop tailored solutions to improve rubber processing across the entire production chain. Rubber manufacturers therefore can rely on Rhein Chemie as a leading supplier of products for high-quality rubber compounds and finished rubber articles.

Beyond products, our customers worldwide can receive qualified individual technical assistance. Our global and regional HSEQ departments are constantly monitoring product formulations for compliance with local regulations and chemical inventories. When formulating new products, the global listing situation is considered from the beginning.

Our objective in business is to support our customers in achieving their goals – to our mutual benefit. This added value approach is well-appreciated throughout the global rubber industry.

This brochure provides an overview of products and services that our Specialty Rubber Products (SRP) business line supplies to the rubber industry worldwide.



## HIGHLIGHT RHENOGRAN®

Rhenogran® stands for premium, pre-dispersed chemicals and additives for the manufacture of high-end rubber components. LANXESS is offering a wide range of standard and speciality additives used in the tire and technical elastomer components industry. An innovative and agile player, LANXESS is constantly developing solutions and methods that increase productivity and reduce health risks for the rubber processing industry.

Rhenogran® is perfectly outlining our notion of a “service product”: improving handling and processability of rubber chemicals and enhancing the quality of finished articles, by far compensating the extra costs through benefits across the entire process chain. Especially shorter mixing times in combination with lower processing temperatures are economic reasons.

and transport stability at the same time. Free-flowing granules for easy handling allow more precise weighing and dosing, making automated, continuous processes feasible. As granules are not always the preferred supply form for each customer we also provide our polymer-bound additives in slab form.

The consistent quality of ready-mixed batches is crucial for a trouble-free process during subsequent production steps and an overall improved product quality. Reject rates are minimized and costly reworking processes can be avoided. Excellent dispersion of rubber additives leads to quick incorporation and homogeneous distribution of the rubber chemicals in the compound.

Rhenogran® is dust-free, keeping the working area clean and free of toxic chemical dusts, a prerequisite for the production



Rhenogran® MBTS-80



Rhenogran® CBS-80



Rhenogran® TP-50

In Rhenogran® supply form, chemicals are bound in polymer and protected against oxidation and decay. Therefore, Rhenogran® usually has a longer shelf life than powder chemicals. In case of damaged packaging, pick-up and removal of spilled material is significantly facilitated without residues. The Rhenogran® elastomer binder is especially designed to offer maximum stability during storage and transport without sacrificing performance characteristics.

With Rhenogran®, Rhein Chemie has set the industry standard for pre-dispersed rubber chemicals and additives. Selected raw materials, an elaborate conversion process, and an effective quality assurance method make sure that Rhenogran® is the benchmark in the rubber industry.

The EPDM/EVA standard binder system fits 80% of all Rhenogran® types and most customer applications. Rhenogran® standard binder and Rhenogran® speciality binder stand for safe handling and best compatibility in rubber. The binder system provides optimal dispersibility and long-lasting storage

of high-performance rubber parts and a requirement not only in the automotive industry. Many toxic or otherwise critical additives found in Rhenogran® carry a more favorable labelling than the classification of the respective powder chemical.

For easy identification, selected Rhenogran® grades are equipped with a specific color code. Color code for standard Rhenogran® types, e.g. CBS-80 (blue), MBTS-80 (green), TMTD-70 (orange), S-80 (yellow).

Safe and reliable: rubber components manufactured with Rhenogran® stand for enduring automotive parts and long-lasting functioning, e.g. hoses, belts, seals, O-rings, shaft seals, bearings, axle boots, glass run channels, tires.

Rhenogran® – leading technology for premium rubber components. Customer satisfaction guaranteed!



## MAIN APPLICATION – BACKGROUND INFORMATION

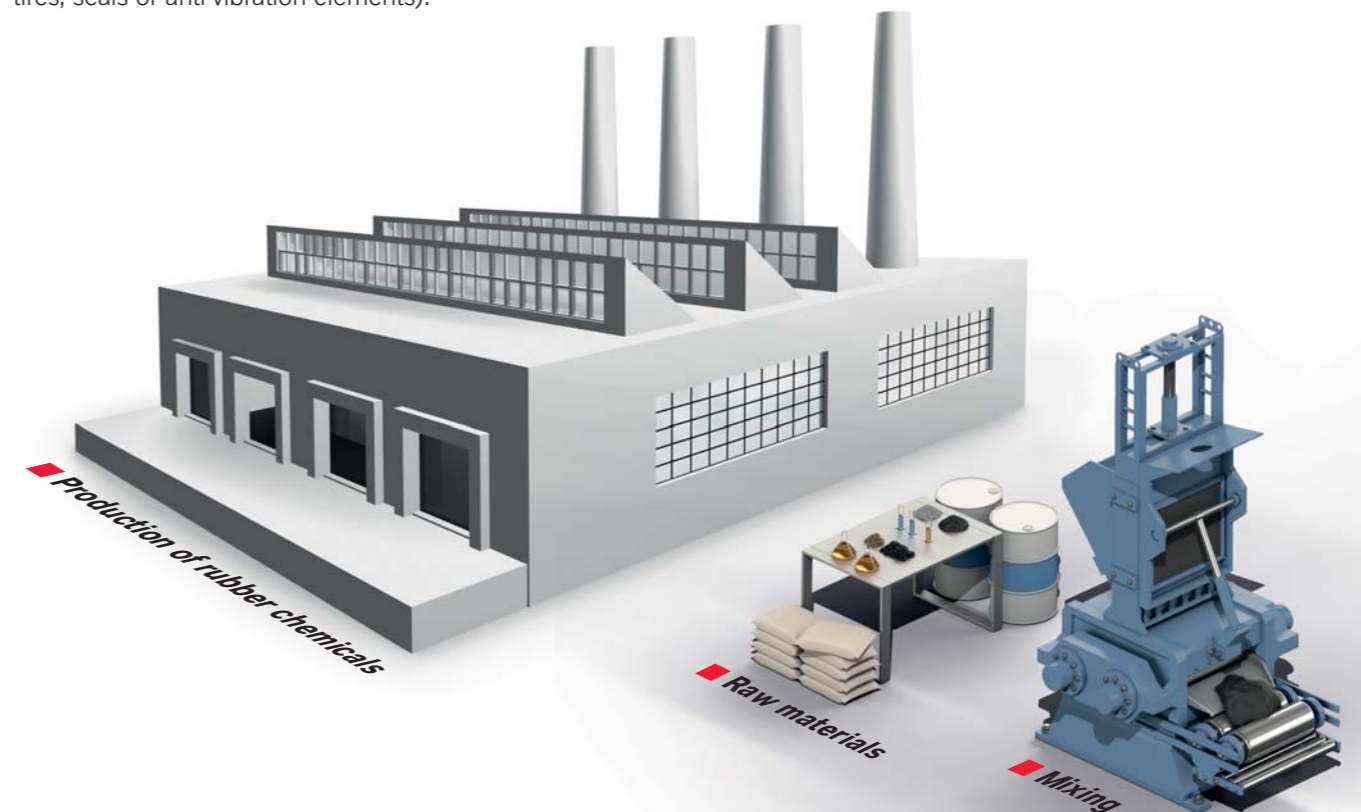
### Technical rubber goods

LANXESS provides a broad range of additive chemicals for the rubber industry, for all different kinds of applications. Continuous R&D driven by our customers' needs means we constantly develop new solutions and novel substances to fulfil the most challenging requirements. By the nature of our company and our understanding of the rubber world, LANXESS is backward integrated to produce many specialities by themselves. LANXESS is therefore the reliable partner for speciality chemicals for the rubber industry.

A real multitalent is **Rhenogran® CLD-80**: this original Rhein Chemie invention is a sulfur donor. Unlike ordinary sulfur, **Rhenogran® CLD-80** ensures an extremely stable vulcanization network by forming mainly mono and disulphidic bridges. This results in an excellent heat aging resistance of the vulcanizates and prevents premature reversion. Unlike thiurams or morpholine, **Rhenogran® CLD-80** does not generate carcinogenic N-nitrosamines during vulcanization, nor do the vulcanizates show any blooming. Therefore, **Rhenogran® CLD-80** is particularly preferred for rubber parts that are exposed to extreme conditions such as high operating temperatures combined with high loads (e.g. high-performance tires, seals or anti-vibration elements).

**Rhenogran® Geniplex-70**, an activator for the sulfur curing of EPDM and other diene rubbers that also reduces the decomposition temperature of blowing agents, has an activating effect on the vulcanization. Processing safety of rubber compounds containing **Rhenogran® Geniplex-70** is increased and curing improved. Thiurams and carbamates forming carcinogenic N-nitrosamines can be replaced by **Rhenogran® Geniplex-70** without any negative effects in terms of processing safety or mechanical properties.

LANXESS is capable to deal with regulatory affairs on a global basis, but also facing the need for toxicological and environmental replacement of old-fashioned rubber chemicals. Dithiophosphates from Rhein Chemie are not only the additives of choice for N-nitrosamine-free curing, which is nowadays mandatory in state-of-the-art automobiles, they also provide versatile solutions to various problems from improving reversion resistance to coping with dispersibility and efficiency problems thanks to their high solubility in all kinds of rubber.



One of such products is **Rhenogran® TP-50** – a world-famous evergreen for the N-nitrosamine-free curing of EPDM extrudates: in combination with standard accelerators, **Rhenogran® TP-50** has set standards in realizing economies of scale in EPDM extrusion while keeping reject rates low. In particular, the considerably high solubility (up to 6 phr) provides high flexibility in a wide range of formulations.

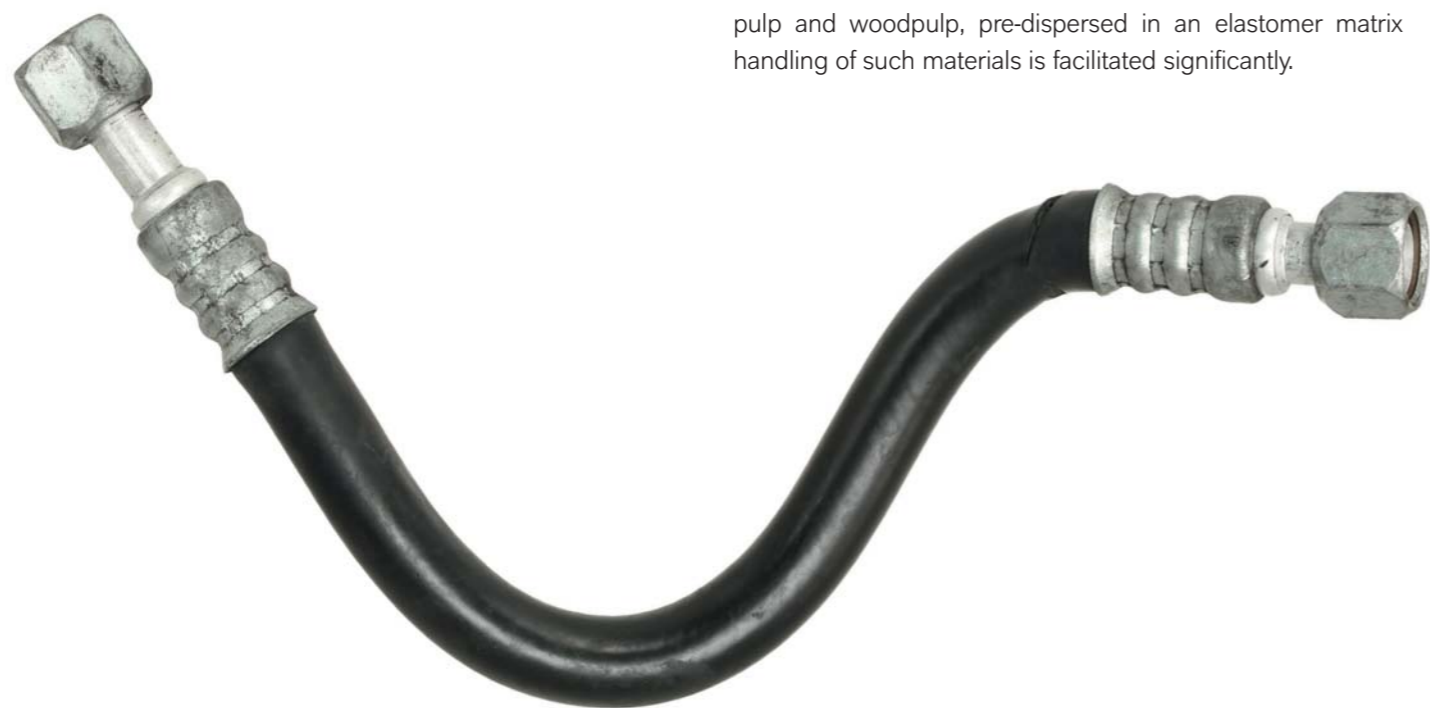
Speciality elastomers, which are becoming more and more common even in standard rubber components, usually require special curing systems. Rhein Chemie offers various curing agents, activators and stabilizers. **Rhenogran® HMDC-70/AEMD**, a cross-linking agent for ethylene acrylic rubber (AEM), is the state-of-the-art curing agent for oil-resistant seals and hoses based on AEM, and ACM rubber for use in vehicles and engineering. **Rhenogran® HMDC-70/AEMD** combined with **Rhenogran® XLA-60** is the cross-linking system of choice when having to deal with high temperature resistant AEM or other diamine cross-linkable elastomers. Not only is this a safe cross-linking system, free of guanidines or other dangerous amines, the physical properties it imparts are better or at least on par with the old unsafe systems.

Due to toxicological reasons for ETU free curing systems the combination of **Rhenogran® MTT-80** with **Rhenogran® HPCA-50** is the perfect choice for the safe cure of chloroprene rubber parts. Whether mercaptan or xanthogen disulphide

modified CR types all can be safely cross-linked with MTT-80 and HPCA-50 while reducing MgO concentration and improving aging resistance.

More exotic rubbers with halogen cross-linking site, such as ECO, GECO or CSM can be safely cross-linked by **Rhenogran® Triazine-70** combined with **Rhenogran® TP-50** and **Rhenogran® HPCA-50** or by **Rhenogran® TDD-70** combined with **Rhenofit® NC**.

As reinforcing materials, Rhein Chemie has developed pre-dispersed short-fiber pulp master batches that allow a homogeneous dispersion of the entangled strands in the compound. **Rhenogran® P91-40** is an oil-free pre-dispersed aramid fiber pulp that is used for reinforcement, e.g. in belts, hoses, tires and footwear. Unlike the raw aramid pulp, products of the **Rhenogran® P91-40** series can be incorporated easily and dispersed homogeneously in the compound. Pre-dispersed hardwood short fiber masterbatches are marketed under the brand **Rhenogran® WP**. They are used as reinforcement for tires and technical elastomer products. Extended service intervals and working life of vital parts of the power train require new approaches with respect to materials and component design. With our pre-dispersed polyaramid fiber pulp grades, components like timing belts and turbo charger hoses are expected to be technically feasible with an extended service life even at a reduced weight. The challenge is to incorporate and evenly distribute the single fibers in the rubber compound. With **Rhenogran®**, pre-dispersed aramid short fiber pulp and woodpulp, pre-dispersed in an elastomer matrix handling of such materials is facilitated significantly.



**Rhenocure®** accelerators and curing agents include a selection of specialities, e.g. dithiophosphates, as dry liquids. An assortment of standard accelerators in powder or liquid form completes this product line. Dithiophosphates are multi-functional solutions to various challenges in rubber compounding. Whatever the task is, e.g. N-nitrosamine-free curing systems, formulations for reversion-stable networks, high solubility in rubber, fast curing rates in EPDM extrusion or replacement of otherwise eco-critical chemicals – dithiophosphates from Rhein Chemie are the handy solution for every compounder.

**Rhenocure® TP/S** is a non-staining speciality accelerator for the rapid vulcanization of compounds based on EPDM and other diene rubbers. **Rhenocure® TP/S** causes a high degree of cross-linking. Vulcanizates accelerated by **Rhenocure® TP/S** generally do not show any signs of blooming. EPDM compounds containing **Rhenocure® TP/S** are easy to process and show particularly good flowing properties, even in complicated molds. In the efficient vulcanization of NR and other rubbers, such as IR, SBR, NBR, and IIR, **Rhenocure® TP/S** provides vulcanizates with extraordinarily good heat aging resistance. It offers an economic solution for various problems, in the tire industry and beyond. **Rhenocure® SDT/S**, a dithiophosphate-based sulfur donor, is recommended as a co-accelerator for various challenges in rubber compounding, e.g. as an accelerator for N-nitrosamine-free EV curing systems, as an anti-reversion agent for heat-resistant vulcanizates, or for the replacement of standard accelerators. It offers an economical solution for various problems, not only in the tire industry, but in other applications as well. **Perkalink® 900** is a highly effective anti-reversion agent for NR, NBR, IR, (H)IIR, SBR, BR and their blends. **Perkalink® 900** is active during long vulcanization times and during thermal degradation in service of cured articles. The loss of cross-link density caused by reversion will be reconstituted to the initial level. **Perkalink® 900**, therefore, is the solution for thick molded articles.

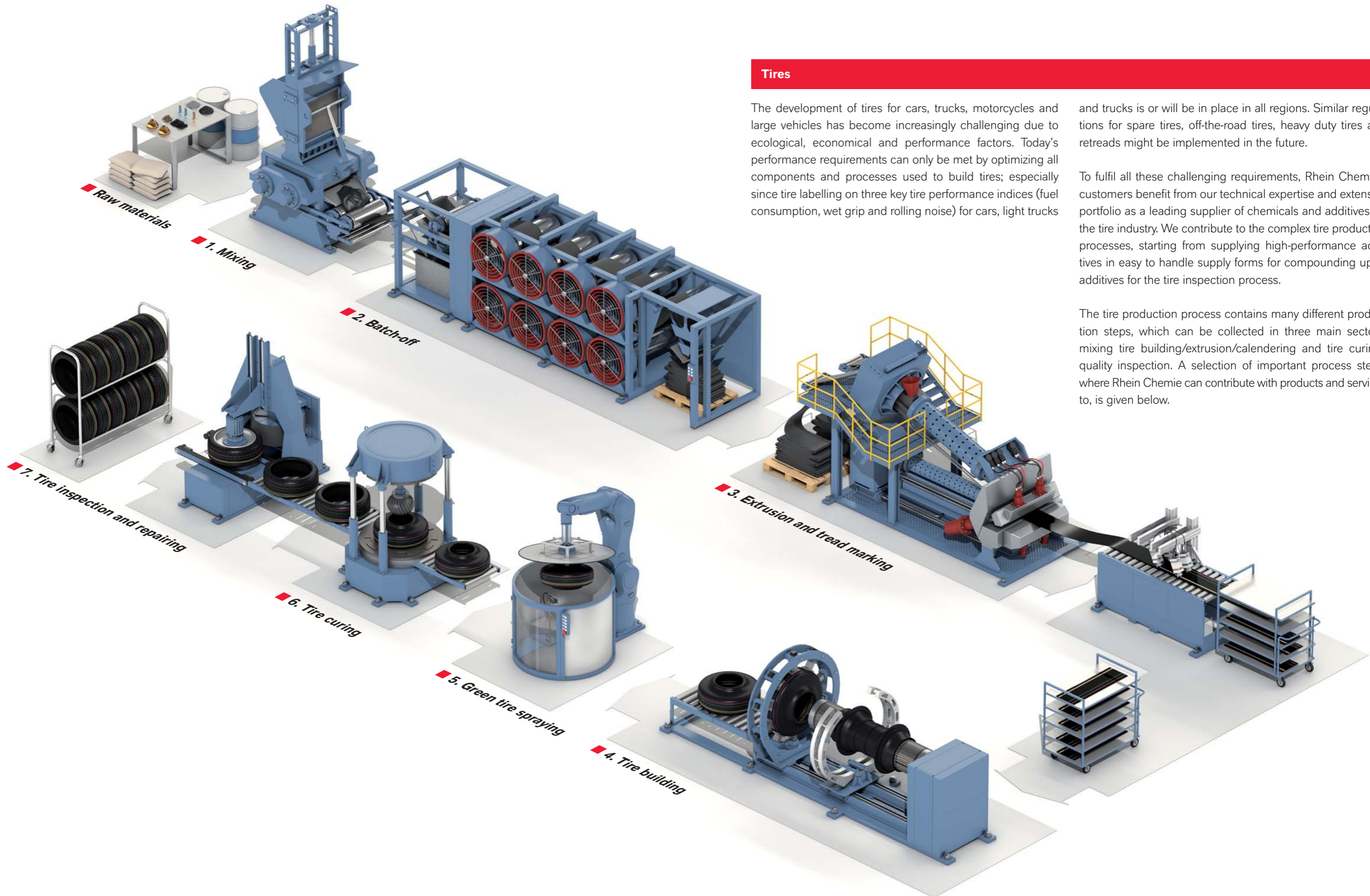
**Rhenofit®** is Rhein Chemie's brand for a wide assortment of functional additives including antioxidants, filler and blowing agent activators, cross-linking activators and desiccants. Depending on the respective raw material and its handling requirements, these products are offered either in powder, pellet, liquid or dry liquid form. If not specified otherwise, liquid additives are offered as dry liquids on inert, inorganic white filler material as a free-flowing white powder for easy handling and mixing conditions.



**Rhenofit® CF**, a specially treated, well dispersed calcium hydroxide, is a cross-linking activator particularly for fluoroelastomers. It is applied to achieve optimal compression set values at higher temperatures. Since calcium hydroxide is hygroscopic, **Rhenofit® CF** is supplied in a special packaging that keeps the material absolutely dry. **Rhenofit® CF** is the preferred cross-linking activator for fluoroelastomers.

**Rhenofit® STA/S**, a combination of activating polar substances bound to highly reinforcing silica, acts as a curing activator and processing promoter for silica and other white fillers. **Rhenofit® STA/S** helps to properly disperse all polar compound ingredients and simultaneously activates silica and other white reinforcing fillers. The vulcanization is accelerated and cure efficiency is improved to an extent that **Rhenofit® STA/S** may be used as a secondary accelerator. **Rhenofit® STA/S** increases the modulus of vulcanizates.

**Rhenogran® AP** is the consequent evolutionary concept of the **Rhenogran®** idea: multiple components of a customer's formulation combined in one **Rhenogran® AP** accelerator package. The package eliminates single component handling, provides easy dosing, and enables continuous production and inline quality measurement.



## Tires

The development of tires for cars, trucks, motorcycles and large vehicles has become increasingly challenging due to ecological, economical and performance factors. Today's performance requirements can only be met by optimizing all components and processes used to build tires; especially since tire labelling on three key tire performance indices (fuel consumption, wet grip and rolling noise) for cars, light trucks

and trucks is or will be in place in all regions. Similar regulations for spare tires, off-the-road tires, heavy duty tires and retreads might be implemented in the future.

To fulfil all these challenging requirements, Rhein Chemie's customers benefit from our technical expertise and extensive portfolio as a leading supplier of chemicals and additives for the tire industry. We contribute to the complex tire production processes, starting from supplying high-performance additives in easy to handle supply forms for compounding up to additives for the tire inspection process.

The tire production process contains many different production steps, which can be collected in three main sectors: mixing tire building/extrusion/calendering and tire curing/quality inspection. A selection of important process steps, where Rhein Chemie can contribute with products and services to, is given below.

### ■ 1. Mixing

Rhein Chemie offers a full range of additives for rubber compounds such as accelerators, curing agents, processing promoters, anti-ozonants, fillers and others to make rubber compounds better. Processing Promoters from the **Aflux®**, **Aktiplast®**, **Rhenosin®**, **Rhenopren®** and **Vulkanol®** families improve the entire mixing process by decreasing compound viscosity and improving filler dispersion. Additives such as **Perkalink®** and **Vulcuren®** enable the tire producer to develop and produce compounds for UHP tires ensuring sustainable rubber performance over lifetime. We do not just deliver the chemical: Rhein Chemie offers a comprehensive portfolio of our **Rhenogran®** pre-dispersed additives. This special supply form offers several advantages to our customers, such as easier handling and more efficient mixing.

### ■ 2. Batch-off

Rubber compounds, milled to sheets after mixing, are dipped in an aqueous anti-tack dispersion of release-active substances. During the so-called batch-off process, the uncured sheets are coated, dried and stacked on pallets. The batch-off release agent needs to equip the sheets with sufficient anti-tack properties effectively during the entire storage time in order to ensure that sheets do not slip off from pallets during storage and transport but can later be easily separated. Also, the batch-off release agent has to be fully compatible with all elastomers of the compound during downstream mixing steps. Besides traditional **Rhenodiv®** powder products and water-based dispersions, Rhein Chemie has invented batch-off grades in pearl form to improve handling during the dispersion step. Additionally, Rhein Chemie provides **Rhenodiv®** powder products for the pellet process.

### ■ 3. Extrusion and tread marking

During extrusion, the shape for most of the green tire components, e.g. tread, sidewall and inner liner, is determined. The challenge for the maker is to ensure a fast and efficient extrusion process also for compounds optimized for ultra-high performance. Under the brand names **Aflux®**, **Aktiplast®**, **Rhenosin®**, **Rhenopren®** and **Vulkanol®** Rhein Chemie offers a wide range of processing promoters and plasticizers for compounds based on different kinds of rubber and filler grades. Tires are often marked by tire paints upon tread extrusion in

order to ensure identification of ready or green tires or their compounds at later stages of the tire production process. Rhein Chemie offers a full range of different water-based **Rhenomark®** tire paints. The brilliance of the colors endures curing of the tire and lasts throughout the storage time of the tires.

### ■ 4. Tire building

In the traditional tire building process, extruded and calendered parts are being mechanically connected on building drums. These building drums are mostly equipped with building bladders, in the center part and for belt folding. Nowadays there are many attempts to improve cycle time and flexibility by using more extrusion technologies within the tire building process.

### ■ 5. Green tire spraying

To ensure a smooth molding and demolding operation during tire curing, release agents are typically applied onto the green tire prior to vulcanization. Water-based and environmentally friendly **Rhenodiv®** inside paints are either applied on every green tire (**Rhenodiv® BP**) or in a frequency up to 1:15 (**Rhenodiv® SP**) according to tire manufacturer's process. Especially for larger tires **Rhenodiv® OP** outside paints are used to improve rubber flow and to reduce blemishes in tread and sidewall area. Application of tire paints is usually done by carousel or robotic spraying devices depending on green tire handling. Rhein Chemie has a comprehensive portfolio of different filled, unfilled and silicone-free **Rhenodiv®** release agents fulfilling increasing demands for sustainable tire quality and an efficient and clean tire production.

### ■ 6. Tire curing

The shaping and vulcanization of most tires is done in compression molding presses. The curing determines the final appearance of the tire, such as tread pattern, but also the final elastic properties. By using hot water/steam and nitrogen a curing bladder shapes the green tire into the hot mold providing heat energy to support vulcanization of the inner parts of the tire. Marketed under the brand name **Rhenoshape®**, Rhein Chemie produces a very wide range of high-performance bladders for different press types. Our bladders stand for high productivity, which means a high number of tire vulcanization cycles, low vulcanization times and an all-over consistent high bladder quality providing a high tire uniformity and low scrap rate. Alternatively to spraying the inside of the green tire **Rhenodiv® BC** grades can be applied onto the bladder. These products are expected to cure up to 100 tires before a renewal of the coating is necessary.

As a manufacturer of tire curing bladders, Rhein Chemie also offers permanently coated bladders. Permanently coated **Rhenoshape®** bladders allow a lifetime use of the bladder without additional use of release agents. This yields in a cleaner production process and makes extra cleaning of vulcanized tires unnecessary, if sealant layers or noise reduction foam should be applied afterwards.

### ■ 7. Tire inspection and repairing

Different quality checks are performed on every tire, e.g. uniformity. Liquid diluted **Rhenodiv® BO** grades may be used to coat the bead area to provide enough slip to get the tire onto the test machine. After removal from the machine and drying no traces of the mounting aid remain visible. For cosmetic repairs of cured tires water-based **Rhenodiv® FP** finishing paints can be used. **Rhenodiv® FP** grades provide a tire finish close to the appearance of the original new tire. They combine excellent cover properties with excellent fixing, high stability and easy application. **Rhenodiv® FP** grades dry to a permanent, flexible film that resists cracking or peeling even during flexion or stretching. **Rhenodiv® FP** grades are resistant to water and detergent washings.





# RUBBER CHEMICALS

During the cross-linking reaction of macromolecules like diene rubbers with additives or radiation, cross-links are formed between the polymer backbones. This is an irreversible reaction and the macromolecule changes its behavior from the thermoplastic state to the elastic one. In the diene rubber area more than 90% of the rubbers are cross-linked by sulfur followed by cross-linking with peroxides. Further possibilities to cross-link polymers are isocyanates, resins or metal oxides. The type of cross-links formed will influence the mechanical and dynamic properties of the vulcanized article. Long cross-links will improve the dynamic performance of the articles whereas short cross-links are the preferred one for static applications due to better thermal stability.

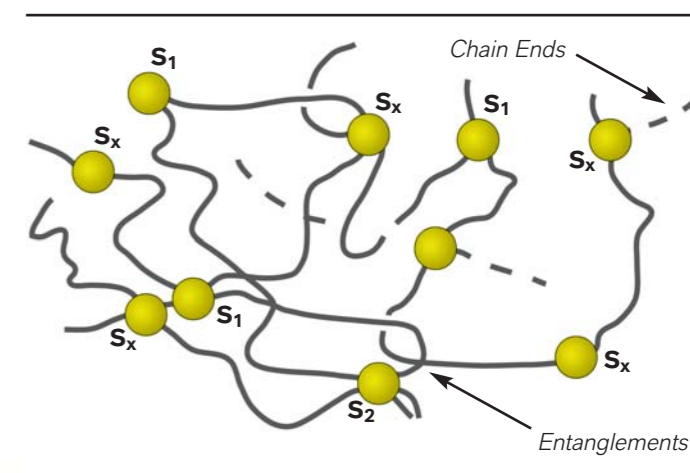
Within the Rhein Chemie portfolio, a wide range of products are available to cross-link polymers. For sulfur vulcanization accelerators and sulfur donors from the **Rhenocure®** product range (e.g. **Rhenocure® TMTD** and **Rhenocure® SDT/S**) range are available. In addition, Rhein Chemie offers rubber chemicals in an optimized polymer-bound delivery form (e.g. **Rhenogran® TP-50** and **Rhenogran® CLD-80**). For peroxide cross-linking, both peroxides (e.g. **Rhenogran® DCP**) and peroxide co-agents (e.g. **Rhenofit® TAC/S**) are available. Moreover, Rhein Chemie provides curing agents for resin cross-linking such as **Rhenogran® PCZ-70/IIR**. To provide our customers with the complete set of rubber chemicals, Rhein Chemie offers a broad range of activators (e.g. **Rhenogran® Geniplex-70** and **Rhenofit® CF**).

## Sulfur cross-linking

### Introduction

The history of sulfur vulcanization starts with the findings of Goodyear and Hancock in 1839. They found that by using sulfur, the behavior of natural rubber changed significantly from the sticky and plastic behavior to the elastic state by forming sulfur cross-links between the polymer backbones. The search for more efficient crosslinking resulted in the development of sulfur accelerators. In 1919 zinc dithiocarbamates were discovered, followed in 1920 by tetra alkyl thiuram mono- and polysulphides and in 1921 by thiazoles and their derivatives. Sulfenamides, today's most used primary accelerators, were discovered in 1931. LANXESS has a broad range of these accelerators and also specialized structures in the portfolio under the trade name **Rhenocure®**.

The length of the sulfur cross-links in the vulcanizates has an influence on the performance of the vulcanizate. Long cross-links improve the dynamic properties whereas short cross-links have better thermal stability due to higher dissociation energy of the cross-link. The amount of mono-, di- and polysulphidic cross-links in a vulcanizate can be influenced by the ratio of accelerators to free sulfur used in the recipe or by the use of so-called sulfur donors to replace free sulfur.



In conventional diene rubber compounds with a high amount of polysulphidic cross-links, a steady reduction in network density is observed at relatively high vulcanization temperatures and/or with extended vulcanization times, this reduction thus ultimately impairing the mechanical and dynamic properties of the vulcanizates. The same also applies when such vulcanizates are subjected to dynamic loads. This phenomenon is known as reversion. During reversion, polysulphide cross-links are transformed into more thermally stable mono- and disulphidic cross-links. In addition, the formation of intramolecular cyclic compounds and of zinc sulphide is also observed.

To reduce or avoid reversion, products like **Vulcuren®** or **Perkalink® 900** were developed. Vulcanizates formed by **Vulcuren®** comprising hybrid cross-links exhibit a unique combination of high thermal stability and high flexibility. Via a Diels-Alder mechanism **Perkalink® 900** builds up new cross-links during reversion process to stabilize the cross-link density and the properties of the vulcanizates.



## Accelerators and dithiophosphates

Accelerators can be classified in different groups depending on their effects and chemical compositions:

Sulfenamides and thiazoles are called primary accelerators. These chemicals will normally be the major amount of accelerators in a recipe. On the other side, secondary accelerators are used additionally to the above to shift the cure speed to faster cure or induce the formation of shorter cross-links. Here thiurams and dithiophosphates are used as fast curing sulfur donors or also the slow curing sulfur donor caprolactamdisulphide. Ultraaccelerators with very fast curing speed are coming from the class of zinc dithiocarbamates. The size of the amine has an significant influence on the curing speed, small amine like dimethyl amines will give faster cure in comparison to bulky amines like dibenzyl amine. **Rhenocure® 576** as aldehyde amine condensation product will result in the highest cure speed.

### Dithiophosphates

Dithiophosphates (DTPs) are liquid substances available from Rhein Chemie as liquids, dry liquids, and granules (polymer bound – **Rhenogran®**). They have been known to function as (co-)accelerators of sulfur based rubber vulkcanization since the seventies.

Chemically, DTPs are similar to dithiocarbamates but show a slower activation of cure. These products have a very good solubility and can be easily dispersed in rubber compounds. Thus, more homogeneous vulkanizate properties are achieved; e.g. better dynamic properties demonstrated by lower heat built up. In addition to being more soluble in certain elastomers, the dithiophosphates do not form toxic N-nitrosamines.

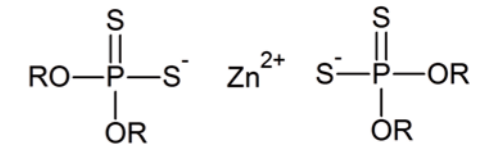
Dithiophosphates generally decrease the tendency towards reversion of natural rubber compounds that is commonly seen in conventional accelerator systems. This is based on their yield of a high amount of monosulphidic cross-links which are more thermostable than di- and polysulphidic ones. The longer scorch times seen with the dithiophosphates can be made shorter using small amounts of other accelerators, increasing the amount of sulfur or adding a sulfur donor.

On the other hand, their high cure rate at low temperatures makes DTPs particularly efficient for the faster cure of articles like tires, belts, molding parts and anti-vibration elements.

Rubber products containing DTP show higher protection against:

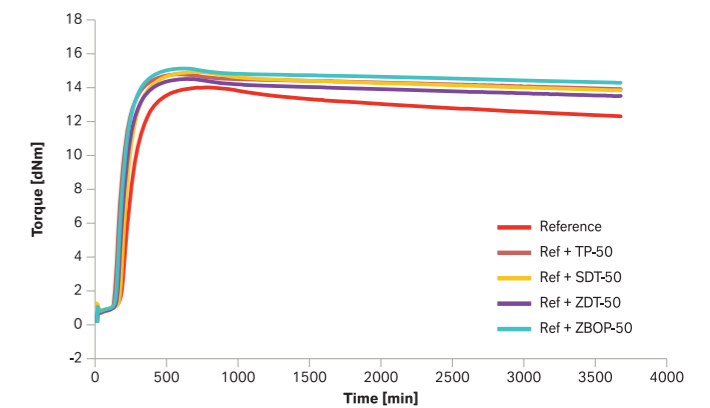
- heat deterioration
- reversion
- dynamic aging
- long-term aging

### Basic chemical structure of dithiophosphates



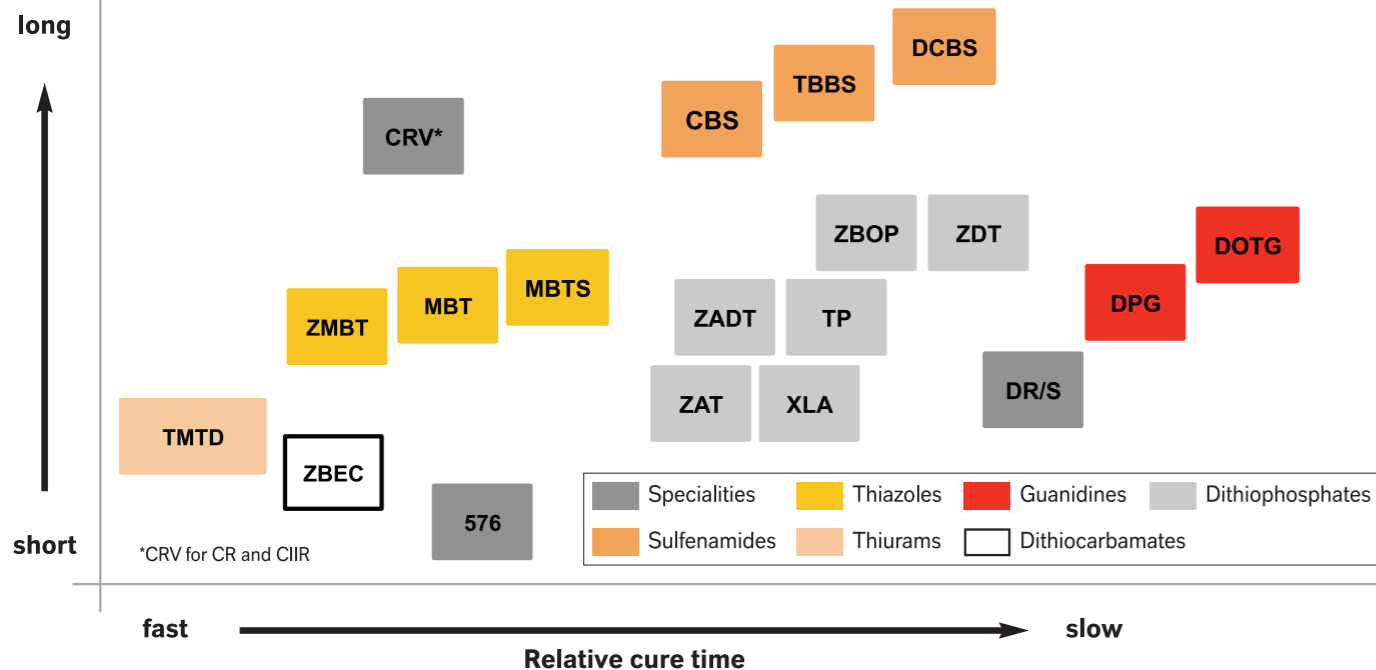
R = Alkyl chain

### Protection of rubber products with dithiophosphates



### Rhenocure® and Rhenogran® accelerators

#### Relative scorch time



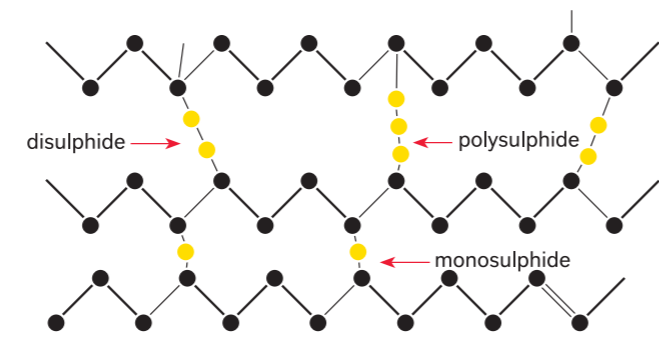
## Sulfur donors

Sulfur donors are of particular interest to the rubber industry. These organic compounds contain sulfur in a thermally unstable form. During vulcanization with sulfur donors, free sulfur is released, which, in contrast to normal sulfur, mainly forms mono- and disulphidic bridges. Because of their higher bond energies, these disulphidic bridges are much more resistant to reversion and are responsible for the excellent heat-aging resistance of the vulcanizates.

Replacing sulfur with sulfur donors results in less free sulfur in the rubber compound formulation, and this leads to advantages such as:

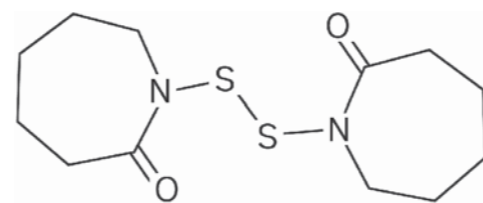
- improved physical properties
- lower compression set
- excellent reversion resistance
- vulcanizates with improved aging resistance
- no sulfur blooming
- no contact staining with heavy metals
- higher processing safety (scorch)

Increasing network strength/Reversion resistance		
Properties	Cross-links	Bond energy [kJ/mol]
	C-	236
Monosulphide	C-S-C	285
Disulphide	C-S-S-	268
Polysulphide	C-S <sub>x</sub> -C	< 268



## Chemical structure of CLD

Dithiodicaproloactam [N,N'-di-thio-bis(hexahydro-2H-azepinone-2)]



**Rhenogran® CLD-80** can be used in rubber compounds when good temperature stability under dynamic-mechanical stress and, in general, physical properties providing long-term durability are required.

**Rhenogran® CLD-80** is recommended if a retarding effect is needed followed by rapid vulcanization with improved reversion resistance, particularly for large molded parts or injection molding, where process safety is of the utmost importance.

## Advantages for curing

- Formation of mono- and disulphidic bridges
- Increased scorch safety
- Rapid vulcanization as soon as the curing temperature is reached (advantage for large molded articles)
- Wide curing plateau (advantage for high-temperature processing, e.g. salt bath vulcanization and injection molding)
- No reversion effect, heat-aging resistance of vulcanizates
- Good compression set, low permanent elongation
- Antioxidants often can be reduced
- Reduced blooming (compared to e.g. thiuram disulphides)

## SDT

**Rhenogran® SDT-50** as a secondary accelerator can replace nitrosamine-generating dithiocarbamates and thiurams in combination with thiazoles or sulfenamides. The accelerator and sulfur donor **Rhenogran® SDT-50** combined with other additives results in the optimal compression set of vulcanizates and makes it possible to replace the OTOS accelerator in natural rubber, particularly in anti-vibration technology.

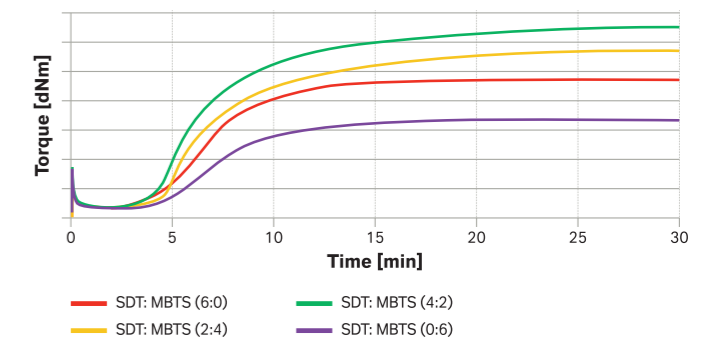


Rhenogran® SDT-50



SDT dithiophosphate is also available as a liquid (Rhenocure® SDT) and a dry liquid (Rhenocure® SDT/S)

## Adjustment of accelerator with SDT/MBTS



## Product advantages

- Formation of mono- and disulphidic bridges
- Safe, nitrosamine-free curing
- No generation of odorous amines
- Easily dispersible, high loading possible
- No dispersion issues due to liquid form
- Rapid curing, accelerator speed widely adjustable (in combination with primary accelerators)
- Produces smooth extrudates
- Low compression set, good heat resistance
- Reduced blooming
- No reversion effects
  - Heat-aging resistance
  - Low heat build-up

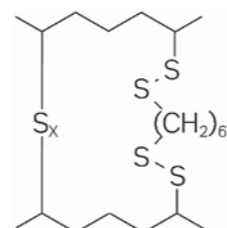
Excellent solubility is an indicator of the good compatibility of dithiophosphates, especially SDT, with a wide range of polymers. As for all dithiophosphates, the accelerating and cross-linking effect of **Rhenogran® SDT-50** is widely adjustable by varying the dosage.

For SSBR/BR-based silica compounds with a high-performance level for tire applications, the sulfur donors CLD and particularly SDT improves reversion and outperform standard curatives in terms of the heat stability of the dynamic network. The dynamic properties indicate a positive impact on filler dispersion and silane coupling efficiency, as well good rolling resistance of the compounds. In addition, it is possible to eliminate or reduce the DPG (diphenyl guanidine) accelerator without sacrificing key physical properties. These curing agents therefore are the products of choice for modern rubber applications.

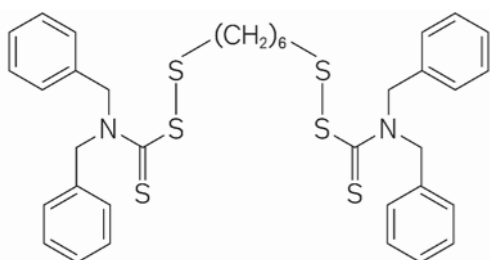
## Perkalink® and Vulcuren®

### Vulcuren®

**Vulcuren®** 1,6-bis(N,N'-dibenzyl thiocarbamoyl dithio)hexane acts as a bifunctional cross-linker in the production of highly reversion-resistant vulcanizates. Flexible and thermodynamically stable hybrid cross-links are formed during sulfur vulcanization in conventional or semi-efficient sulfur curing systems in combination with accelerators, such as mercaptobenzo-thiazoles or sulfenamides. Physically, sulfur-hydrocarbon-sulfur bridges are formed instead of regular sulfur bridges.



### Vulcuren®



In passenger tire treads based on SBR/BR silica compounds, one major problem is the gradual hardening of the tread during its service life due to post-curing reactions and network alterations at high temperatures. Because the traction and wet grip of the tire are affected by hardening, this phenomenon should be avoided for safety reasons.

The heat stability of passenger tire tread compounds with **Vulcuren®** can be improved in comparison to compounds with a standard curing system. Vulcanization with **Vulcuren®** shows fast curing and a stable plateau. Physical as well as viscoelastic properties of the vulcanizates can be easily achieved. But the most significant advantage is the retention of dynamic behavior after aging (storage modulus, fatigue resistance).

Natural and synthetic rubber vulcanizates with **Vulcuren®** change only marginally during overcure due to the special cross-linking structure. High-performance tread compounds with a **Vulcuren®** curing system can be expected to be advantageous wherever it is crucial to retain properties during their service life under severe conditions, such as high service temperatures.

General dosage recommendation	
Application (NR, BR, SBR)	Dosage (phr)
Anti-reversion agent	2.0–4.0
Cross-linker/Secondary accelerator	0.3–1.0

### Perkalink®

Reversion (thermal degradation) of sulfur cross-links occurs either when sulfur-vulcanized rubber compounds are exposed to elevated curing temperatures for extended periods, or later during the service life of a rubber product, particularly when it is exposed to mechanical stresses under elevated temperature conditions.

**Perkalink® 900** protects sulfur-vulcanized rubber compounds from the unwanted effects of thermal degradation, such as reduced physical properties and decreased performance characteristics. Unlike with many other additives, the processing and cure properties (scorch delay, vulcanization rate and cure time) remain unaffected, because **Perkalink® 900** is not reactive during vulcanization or at low temperatures.

When sulfur cross-links degrade during curing or severe service life, **Perkalink® 900** compensates for the loss of sulfur bridges by reacting with the dienes/trienes in the polymer backbone and forming new, thermally stable carbon cross-links that help to maintain physical and performance properties. The increased rate of reversion at higher temperatures is balanced out by increased reactivity.

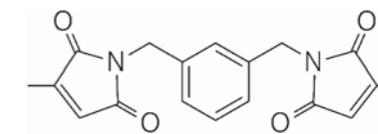


Perkalink® 900

Therefore, **Perkalink® 900** is very effective in the presence of many unstable polysulphidic cross-links, such as NR and IR rubbers, or polymer blends (> 50% NR/IR with BR, SBR or other unsaturated polymers). Key applications are in thick cross-section components, where severe surface reversion may occur due to extended curing cycles. Consequently, higher curing temperatures can be applied to achieve improved productivity.

**Perkalink® 900** is recommended for use in tire compounds, e.g. tread, carcass, NR steel, skim and retreading.

### Perkalink® 900



### Truck tire application

- 10–12 °C reduction in heat build-up
- 15% improvement in endurance mileage
- 7–10% reduction in rolling resistance

**Perkalink® 900** also is the agent of choice for technical rubber articles when an anti-reversion agent is required. The beneficial effect of **Perkalink® 900** on a rubber compound is clearly demonstrated by the improvement in heat build-up under harsh conditions.

### Technical rubber goods application

- Suspension bushings
- Engine mounts fenders
- Conveyor belts

Because the number of compensating cross-links is directly related to the concentration, the dosage level of **Perkalink® 900** depends on the type of polymer and curing system used. After exposure to elevated temperatures, a higher overall cross-link density may influence the physical properties of the vulcanizates, particularly at increased dosage levels, meaning that it is of mandatory importance to adjust the **Perkalink® 900** concentration.

General dosage recommendation		
Polymer system	Cure system	Perkalink® 900 concentration (phr)
100% NR, IR or blend with > 50% NR, IR	EV to SEV	0.25–0.40
	SEV to conventional	0.50–0.75
	high sulfur	0.50–0.75
SBR/BR blends	SEV to conventional	0.25–0.40
Other unsaturated polymers e.g. NBR	SEV to conventional	0.25–0.50

**Product list**



International abbreviation	Chemical substance	Polymer-bound	Other-bound	Compound	Hoses	Seals	Profile	Belts	Conveyor belts	Air springs	Bladders	Tires	Others
<b>Dithiophosphates</b>													
SDT	Phosphoryl polysulphide	<b>Rhenogran® SDT-50</b>	<b>Rhenocure® SDT/S</b> <b>Rhenocure® SDT liquid</b>	NR, SBR, NBR, EPDM	X	X	X	X	X	X			Dock fenders and sheets
TP	Zinc dialkyldithiophosphate	<b>Rhenogran® TP-50</b>	<b>Rhenocure® TP/S</b> <b>Rhenocure® TP liquid</b>	NR, IR, SBR, NBR, IIR			X					X	Engine mounts
ZADT	Zinc amine dithiophosphate	<b>Rhenogran® ZADT-50</b>		EPDM, NR, IR, SBR, NBR, IIR	X		X						Sheeting and tank linings
ZAT	Zinc amine dithiophosphate	<b>Rhenogran® ZAT-70</b>		EPDM, NR, IR, SBR, NBR, IIR	X	X	X	X	X	X	X	X	
ZBOP	Zinc dialkyldithiophosphate	<b>Rhenogran® ZBOP-50</b>	<b>Rhenocure® ZBOP/S</b>	EPDM, NR, IR, SBR, NBR, IIR	X		X						Sheeting and tank linings
ZDT	Zinc dialkyldithiophosphate	<b>Rhenogran® ZDT-50</b>		EPDM, NR, IR, SBR, NBR, IIR	X		X						Sheeting and tank linings
<b>Dithiocarbamates</b>													
TDEC	Tellurium diethyl dithiocarbamate	<b>Rhenogran® TDEC-70</b>		EPDM, IIR	X		X						Cable sheathings and insulations
ZBEC	Zinc dibenzylthiocarbamate	<b>Rhenogran® ZBEC-70</b>	<b>Rhenocure® ZBEC/C</b>	EPDM, NR, IR, SBR, NBR, IIR	X	X	X	X	X	X	X	X	Light or bright coloured rubber articles
ZDBC	Zinc dibutylthiocarbamate	<b>Rhenogran® ZDBC-80</b> <b>Rhenoslab® ZDBC-80</b>	<b>Rhenocure® ZDBC</b> <b>Rhenocure® ZDBC/C</b>	NR, SBR, NBR, EPDM, IR, BR	X	X	X	X	X	X	X	X	All kinds of rubber goods, footwear, cables
ZDEC	Zinc diethylthiocarbamate	<b>Rhenogran® ZDEC-80</b>	<b>Rhenocure® ZDEC</b>	NR, SBR, NBR, EPDM, IR, BR	X	X	X	X	X	X	X	X	Technical articles, footwear, cables
ZDMC	Zinc dimethylthiocarbamate	<b>Rhenogran® ZDMC-80</b>	<b>Rhenocure® L</b>	NR, SBR, NBR, EPDM	X	X	X	X	X	X	X	X	Right-coloured/Transparent articles, cables
ZEPC	Zinc ethylphenylthiocarbamate		<b>Rhenocure® ZEPC</b>	NR, BR, SBR, NBR, EPDM	X	X	X	X	X	X			Repair kits
<b>Guanidines</b>													
DOTG	N,N'-di-o-tolylguanidine	<b>Rhenogran® DOTG-70</b>	<b>Rhenocure® DOTG/C</b>	NR, SBR, BR, AEM, ACM	X			X		X		X	Damping elements, roller coverings, cable sheathing
DPG	N,N'-diphenylguanidine	<b>Rhenogran® DPG-80</b>	<b>Rhenocure® D/EG-C</b>	Natural and synthetic rubbers (only little effect in IIR, EPDM)	X	X	X	X	X	X		X	All kinds of rubber goods, patching compounds, eraser rubber
OTBG	o-tolylbiguanidine		<b>Rhenocure® 1000 C</b>	All rubbers (not very effective in IIR and EPDM), PU	X	X	X	X	X	X			
<b>Thiazoles and sulphenamides</b>													
CBS	N-cyclohexyl-2-benzothiazylsulfenamide	<b>Rhenogran® CBS-80</b> <b>Rhenoslab® CBS-80</b>		EPDM, NR, SBR, BR, NBR, CR	X	X	X	X	X	X		X	Footwear
MBT	Mercaptobenzothiazole	<b>Rhenogran® MBT-80</b>		NR, SBR, IIR, CR	X			X	X			X	Cable insulation
MBTS	Mercaptobenzothiazole disulphide	<b>Rhenogran® MBTS-80</b> <b>Rhenogran® MBTS-70</b>		NR, SBR, NBR, IIR, CR	X	X	X	X	X	X		X	Bright coloured technical articles of all kinds
TBBS	N-tert.-butyl-2-benzothiazylsulfenamide	<b>Rhenogran® TBBS-80</b> <b>Rhenoslab® TBBS-80</b>		Natural and synthetic rubbers (NR, SBR)	X				X			X	Footwear and other technical articles

International abbreviation	Chemical substance	Polymer-bound	Other-bound	Compound	Hoses	Seals	Profile	Belts	Conveyor belts	Air springs	Bladders	Tires	Others
<b>Thioureas</b>													
DETU	N,N'-diethylthiourea	<b>Rhenogran® DETU-80</b> <b>Rhenoslab® DETU-80</b>		CR, EPDM, SBR, NR	X					X		X	All kinds of technical articles
DPTU	N,N'-diphenylthiourea	<b>Rhenogran® DPTU-80</b>	<b>Rhenocure® CA</b>	CR, EPDM, NR, SBR, NBR, BR	X	X		X				X	Molded/Extruded rubber goods
ETU	N,N'-ethylenethiourea	<b>Rhenogran® ETU-80</b> <b>Rhenogran® ETU-70</b> <b>Rhenoslab® ETU-80</b>	<b>Rhenocure® NPV/C</b>	CR	X				X	X			Cable, cuff, shoe soles, windscreen wiper, diving suit
<b>Thiurams</b>													
DPTT	Dipentamethylen thiuram tetrasulphide	<b>Rhenogran® DPTT-70</b> <b>Rhenoslab® DPTT-70</b>		EPDM, IIR	X	X							Cuff
MPTD	N,N'-dimethyl-N,N'-diphenyl thiuram disulfide	<b>Rhenogran® MPTD-70</b>	<b>Rhenocure® MPTD</b>	NR, SBR, NBR, EPDM, BR	X	X	X	X	X	X		X	Heat-resistant technical articles, cable coverings and insulations
TBzTD	Tetrabenzylthiuram disulphide	<b>Rhenogran® TBzTD-70</b>		Natural and synthetic rubbers	X	X	X	X	X	X	X	X	Cable sheathing and insulation, hard rubber
TMTD	Tetramethylthiuram disulphide	<b>Rhenogran® TMTD-80</b> <b>Rhenogran® TMTD-70</b> <b>Rhenoslab® TMTD-75</b>	<b>Rhenocure® TMTD/C</b>	Natural and synthetic rubbers	X	X	X	X	X	X		X	
TMTM	Tetramethylthiuram monosulphide	<b>Rhenogran® TMTM-80</b>	<b>Rhenocure® TMTM/C</b>	NR, SBR, NBR, IIR, CR							X		Cable insulations, ebonite (hard rubber)
<b>Aminic</b>													
HEXA / HMT	Hexamethylenetetramine	<b>Rhenogran® HEXA-80</b> <b>Rhenogran® HEXA-60</b>	<b>Rhenocure® HMTA</b>	NR, SBR, BR, IR, IIR	X	X	X	X	X	X		X	Roller coverings
HX	Cyclohexylethyl amine		<b>Rhenocure® HX</b>	NR, IR, BR, SBR, NBR	X	X	X	X	X	X		X	Dipped goods, fabric proofings, sheetings
<b>Combinations and specialties</b>													
Aniline condensation product	Butyraldehyde aniline condensation product		<b>Rhenocure® 576</b>	NR, BR, SBR									PU wire coating
Combination	Combination of dibenzothiazyl disulphide with basic accelerators	<b>Rhenogran® F-80</b>		NR, IR, SBR, NBR	X	X	X	X	X	X		X	Complicated shaped moldings
Combination	Synergistic combination of dibenzothiazole disulphide (MBTS) and zinc dialkyldithiophosphate (ZBOP)	<b>Rhenogran® MBTS Active</b>		NR, SBR, NBR, IIR			X						Soft compounds, sponge rubber
Combination	Synergistic combination of activated amine with retarder	<b>Rhenogran® XLA-60</b>		AEM, ACM, EPDM	X	X							Cables
Combination	Synergistic combination of 70% zinc-dithiophosphate-, thiazole- and dibenzyl-dithiocarbamate-type accelerators	<b>Rhenogran® AP 7</b> <b>Rhenogran® AP 8</b>		EPDM, NBR, SBR	X	X	X	X	X	X		X	
Geniplex	Zinc dicyanato diamine	<b>Rhenogran® GENIPLX-70</b>		EPDM, NR, SBR, NBR					X				Technical rubber components of all kind
MTT	3-methyl-thiazolidine-thione-2	<b>Rhenogran® MTT-80</b>	<b>Rhenocure® CRV/LG</b>	CR	X	X	X		X				
PEI	Polyethylene imine		<b>Rhenocure® DR/S</b>	All kinds of rubbers including CR and ECO	X	X	X	X	X	X		X	Mills (rollers), cable sheathing

International abbreviation	Chemical substance	Polymer-bound	Other-bound	Compound	Hoses	Seals	Profile	Belts	conveyor belts	Air springs	Bladders	Tires	Others
<b>Sulfur donors</b>													
CLD	Caprolactam disulphide	<b>Rhenogran® CLD-80</b>		NR, SBR, NBR, IIR, EPDM	X	X	X	X	X	X		X	
DPTT	Dipentamethylen thiuram tetrasulphide	<b>Rhenogran® DPTT-70</b> <b>Rhenoslab® DPTT-70</b>		EPDM, IIR	X	X							Cuff, bushing
DTDM	Dithiodimorpholine	<b>Rhenogran® DTDM-80</b>	<b>Rhenocure® DTDM-75/PB</b>	NR, SBR, NBR, EPDM	X	X	X	X	X	X		X	Heat-resistant technical articles, cable coverings and insulations
IS	Insoluble sulfur	<b>Rhenogran® IS 90-65</b> <b>Rhenogran® IS 90-65/SBR</b> <b>Rhenogran® IS-80/SBR</b>	<b>Rhenocure® IS 90-20</b> <b>Rhenocure® IS 60-10</b> <b>Rhenocure® IS 60-5</b>	Natural and synthetic rubbers	X				X			X	
MPTD	N,N'-dimethyl-N,N'-diphenyl thiuram disulphide	<b>Rhenogran® MPTD-70</b>	<b>Rhenocure® MPTD</b>	NR, SBR, NBR, EPDM	X	X	X	X	X	X		X	Engine mounts
S	Sulfur	<b>Rhenogran® S-70</b> <b>Rhenogran® S-80</b> <b>Rhenoslab® S-75/NBR</b> <b>Rhenoslab® S-80</b>	<b>Rhenocure® S-80/PB</b>	Natural and synthetic rubbers	X	X	X	X	X	X		X	
SDT	Phosphoryl polysulphide	<b>Rhenogran® SDT-50</b>	<b>Rhenocure® SDT/S</b> <b>Rhenocure® SDT liquid</b>	NR, SBR, NBR, EPDM	X	X	X	X	X	X		X	Cable sheathing and insulation, hard rubber
TBZDT	Tetrabenzylthiuram disulphide (TBzTD)	<b>Rhenogran® TBZTD-70</b>		Natural and synthetic rubbers	X	X	X	X	X	X	X	X	
TMTD	Tetramethylthiuram disulphide	<b>Rhenogran® TMTD-70</b> <b>Rhenogran® TMTD-75</b> <b>Rhenogran® TMTD-80</b> <b>Rhenoslab® TMTD-75</b>	<b>Rhenocure® TMTD-75/PB</b> <b>Rhenocure® TMTD/C</b>	Natural and synthetic rubbers	X	X	X	X	X	X		X	
<b>Product name</b>													
<b>Anti-reversion agents</b>													
<b>Perkalink® 900</b>	1,3-bis(citraconimidomethyl)benzene			NR, IR, NBR, blends					X	X		X	Rollers, thick section articles
<b>Vulcuren®</b>	1,6-bis(N,N-dibenzylthiocarbamoyl-dithio)hexane			NR, SBR, BR					X	X		X	Rollers, anti-vibration



## Peroxide cross-linking



Rhenogran® DCP-60



Rhenofit® EDMA/S



Rhenogran® TAC-50

### Peroxides

Peroxides interact with polymers in a variety of ways. They can be used to make polymers (initiation), modify their rheological properties, alter polarity or attach functional groups (grafting), and enhance high temperature performance (vulcanization). The effect that a peroxide has on a polymer depends on the nature of the polymer, the type and concentration of the peroxide, and the reactivity of other components that might be present.

Every polymer/peroxide reaction actually consists of several competing mechanisms. The predominance and contribution of each of these reactions is determined by the nature of the polymer, the peroxide type and concentration, and the presence of other reactive species, such as coagents. The cure characteristics and properties of the final cure state are dependent on the balance between these often opposing reactions.

The basic peroxide polymer cross-linking reaction consists of three steps. In this process, thermal energy causes the oxygen-oxygen bond in the peroxide molecule to break yielding two radicals (homolytic cleavage). These radicals then remove hydrogen atoms from the polymer forming a polymer radical (hydrogen abstraction). Eventually two polymer radicals combine to form a covalent cross-link (radical coupling). Although this three-step reaction is relatively simple and well understood, the actual peroxide cure reaction is usually quite complex due to numerous side reactions that can occur. These side reactions happen concurrently with the cross-linking mechanism and compete for the radicals that are involved. Some of these competing reactions detract from the final cure state either by breaking polymer bonds or simply by consuming peroxide in non-productive ways.

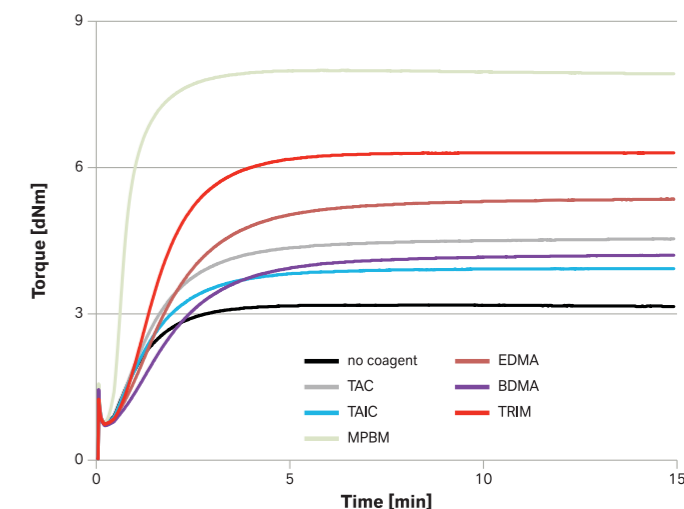
### Coagents

Coagents are multi-functional vinyl monomers, which are highly reactive towards free radicals. These additives are used to improve the physical properties and the processability of peroxide cured elastomers. Since all common coagents contain terminal unsaturation, it can be expected that addition/polymerization is the principal mechanism by which they react in a rubber compound.

Coagents are grouped into two categories based on their effects on the cure rate.

- The first type includes acrylates, methacrylates, and maleimides, which tend to increase the cure rate and may lead to scorch. Most of these contain readily accessible unsaturation without allylic hydrogens, so it can be expected that these react entirely via addition rather than hydrogen abstraction.
- The second class of coagents includes polybutadienes and allylated species like triallyl cyanurate (TAC), triallyl isocyanurate (TAIC), and diallyl phthalate (DAP). These effectively augment the cross-linking efficiency without increasing the cure rate or adding scorch. Unlike the coagents in the first category, these contain both readily accessible vinyl unsaturation sites for radical addition and an abundant number of easily abstractable allylic hydrogens. Addition is still most likely the predominant mechanism behind their incorporation into the rubber matrix, but abstraction could be expected to occur to a significant extent. Hydrogen abstraction at these allylic sites could be achieved by either

### Comparison of different coagents for peroxide cross-linking



primary or polymer radicals. In both cases, this would be expected to retard the cross-linking process by a radical transfer mechanism. This may account for the lack of scorch caused by this class of coagents.

International abbreviation	Chemical substance	Polymer-bound	Other-bound	Compound	Hoses	Seals	Profile	Belts	Conveyor belts	Air springs	Bladders	Tires	Others
<b>Curing agents</b>													
DBDB	Di(2-t-butyl-peroxyisopropyl) benzene		<b>Rhenocure® EF(DBDB)-60</b>	EPDM, NR, IR, SBR, BR, NBR, CR	X	X	X						
DBPH	2,5-dimethyl-2,5-di(t-butylperoxy)hexane		<b>Rhenocure® DBPH-50/S-MC</b> <b>Rhenocure® DBPH-68/S-MC</b>	EPDM, NR, IR, SBR, BR, NBR, CR	X	X	X						
DCP	Dicumyl peroxide	<b>Rhenogran® DCP-60/ACR</b> <b>Rhenoslab® DCP-40/EPM</b>	<b>Rhenocure® EF(DCP)-70</b> <b>Rhenofit® DCP-40 CC</b>	EPDM, NR, IR, SBR, BR, NBR, CR	X	X		X	X				
VC	a,a'-bis(t-butylperoxy) diisopropylbenzene	<b>Rhenogran® VC-60 (ACM/EPDM)</b> <b>Rhenogran® VC-40/EPM</b>	<b>Rhenocure® VC-40 CC</b> <b>Rhenocure® VC-70 MG</b>	EPDM, NR, IR, SBR, BR, NBR, CR	X	X	X			X			
<b>Activators / Coagents</b>													
BDMA	1,4-butandioldimethacrylate		<b>Rhenofit® BDMA/S</b>	EPDM, EPM, NBR, CM		X	X						Bushings, cables
EDMA	Ethylene glycol dimethacrylate		<b>Rhenofit® EDMA/S</b>	EPDM, EPM, NBR, CM		X	X						Bushings, cables
MPBM	N,N'-m-phenylenedimaleimide	<b>Rhenogran® MPBM-70/EPDM</b> <b>Rhenoslab® MPBM-70/EPDM</b>	<b>Rhenocure® MPBM-70/PB</b>	NR, SBR, NBR, BR	X	X	X	X	X	X		X	Molded and extruded technical goods
TAC	Triallylcyanurate bound to silica	<b>Rhenogran® TAC-50</b> <b>Rhenoslab® TAC-50 (ACM/CPM)</b>	<b>Rhenofit® TAC/S</b> <b>Rhenofit® TAC-72/S</b>	EPDM, EPM, CM		X	X						Cable coverings and bushings
TAIC	Triallylisocyanurate		<b>Rhenofit® TAIC/S</b> <b>Rhenofit® TAIC-72/S</b>	Synthetic elastomers		X	X						Technically molded and/or extruded peroxide vulcanised elastomer
TRIM	Trimethylpropane trimethacrylate		<b>Rhenofit® TRIM/S</b>	EPDM, EPM, NBR, CM		X	X						Bushings, cables



## Resin cross-linking

Phenol formaldehyde resins, such as resol and novolac, are often used as additives for rubbers, commonly as tackifiers in rubber adhesives or softeners for processing. Resol is a low-molecular-weight polymer made from the reaction of formaldehyde and a 4-alkylphenol under basic conditions. Unlike its acidically synthesized counterpart novolac, which only has methylene bridges, many of the resol's phenol rings are linked by dimethylene ether bridges and typically have methylol end groups. Hence resols can cure on their own under heat whilst novolacs need an extra formaldehyde donor to cure.

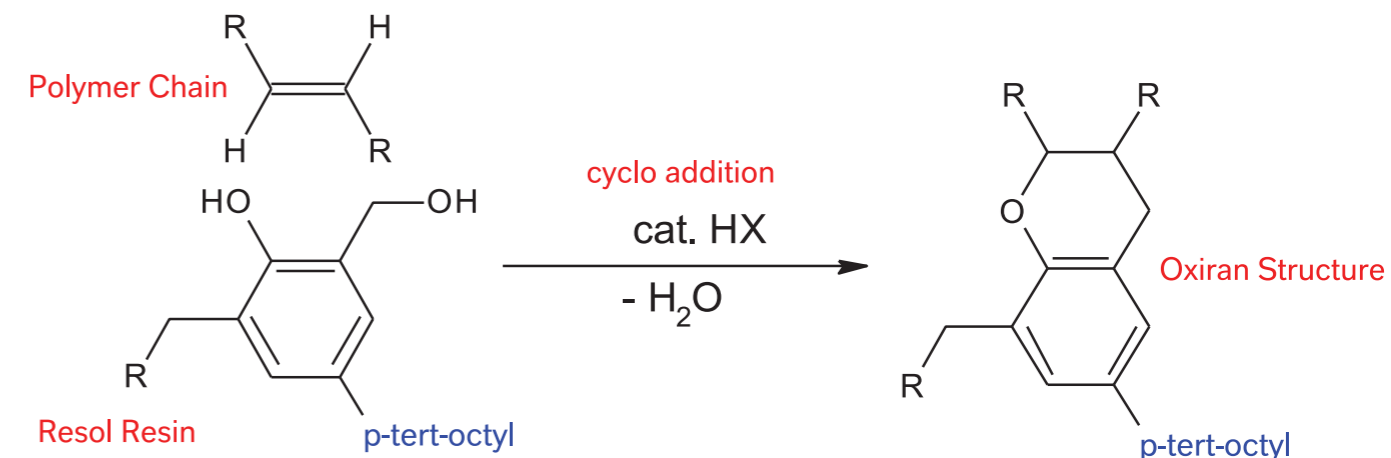
Phenol formaldehyde resins (resols) curing was discovered in the 1930s. A long cure time and often low final cross-link density prevented this system from gaining commercial use until the late 1950s, when resol curing was patented for the production of butyl rubber (IIR) tire curing bladders. Resol creates stable C-C bonds without backbone scission, making it ideal for this application. A lengthy cure time is offset by a much longer working life, making it a cost and time effective alternative. Other advantages to resol include a better smell than

sulfur curing, as well as much less blooming (chemicals rising to the surface of the rubber and causing blemishes) than peroxide.

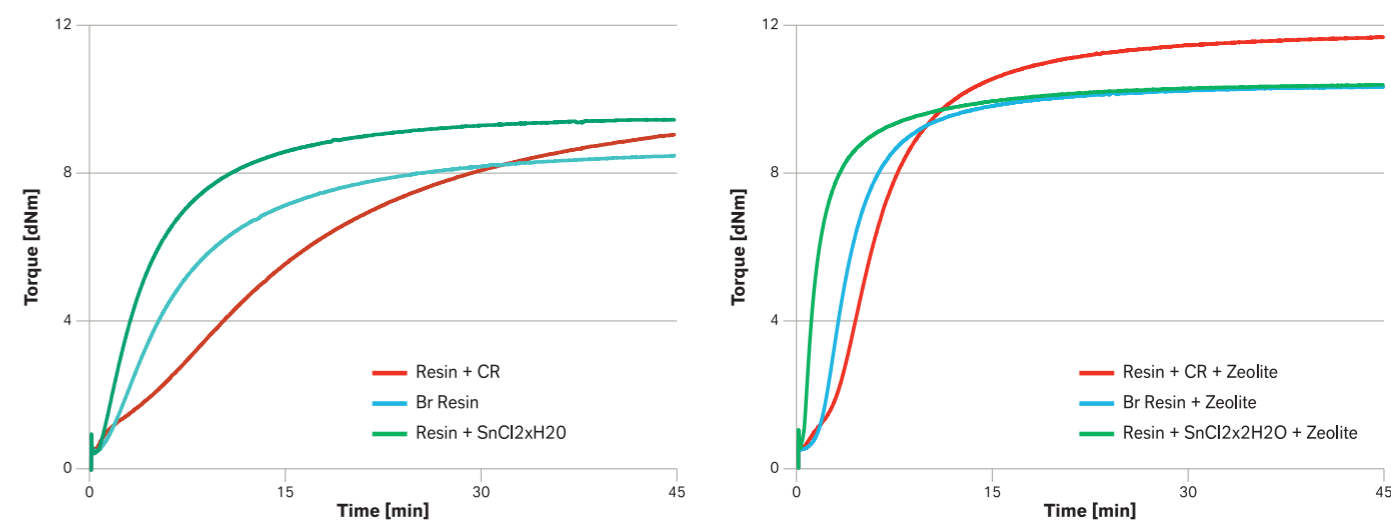
Usually stannous chloride is added as acid. ZnO is often added to slow the reaction and minimize the probability of premature cross-linking, referred to as scorch. In the case of halogenated resols or rubbers, an acid is not necessary, as the ZnO can form zinc halides in situ. On occasion, a separate halogen donor can be added with the ZnO, for example chloroprene rubber (CR). These methods can be preferable for many industrial applications, due to the relative expense of stannous chloride when compared to alternatives like ZnO and CR.

A more recently discovered form of activation is the addition of dry zeolite. Discovered by LANXESS when zeolite was added to the curing system, originally to prevent the formation of pores that are formed upon the evaporation of volatiles, such as water.

## Resol cure basics cross-linking mechanism



## Improved curing characteristics of resins with Rheogran® ZEOLITE-70



Chemical substance	Product name	Dosage form	Application
<b>Curing agent</b>			
Thermo-reactive alkylphenol resin with zinc oxide	<b>Rhenogran® PCZ-70/IIR</b>	Off-white granules	Curing agent for butyl and other rubbers; especially suitable for the vulcanization of bladders and curing bags based on IIR
Thermo-reactive alkylphenol resin with zinc oxide	<b>Rhenogran® WBC-41/IIR</b>	Off-white granules	Curing agent for butyl and other rubbers; especially suitable for the vulcanization of bladders and curing bags based on IIR
Thermo-reactive brominated alkylphenol resin with zinc oxide	<b>Rhenogran® WBC-560/IIR</b>	Off-white granules	Curing agent for butyl and other rubbers; especially suitable for the vulcanization of bladders and curing bags based on IIR
<b>Curing activator</b>			
Active Zeolite	<b>Rhenogran® ZEOLITE-70</b>	Off-white granules	Activator for resol cure providing improved cure rates while keeping physicals on similar level

## Special cross-linking activators

A wide variety of vulcanization agents are used in the rubber industry. Besides sulfur, peroxides and resins, also other cross-linkers can be used.

- Special activators cross-linking: sulfur modified chloroprenes and carboxylated NBRs (XNBR) can be cross-linked with **Rhenogran® MgO-70** and **Rhenogran® ZnO-80**. Certain chlorosulfonated polyethylenes (CSM) can also be cured with **Rhenogran® MgO-70**. Linear polysulphide polymers are cross-linked with **Rhenogran® ZnO-80**.
- ETU or MTT cross-linking: mercaptane modified chloroprene rubbers can be cross-linked with **Rhenogran® ETU-80** or its safe alternative **Rhenogran® MTT-80**.
- Diamine cross-linking: certain ACM types, AEM terpolymers and FKMs are cured with Hexamethylene diamine or its modification **Rhenogran® HMDC-70**.
- Soap/Sulfur cross-linking: acrylic copolymers (ACM) with chlorine cure site can be cross-linked with combinations of **Rhenogran® NaSt-50**, **Rhenogran® KSt-50** and **Rhenogran® S-80**.
- Triazine cross-linking: several ACM, ECO types can be cross-linked with 2,4,6-mercapto-S-triazine.

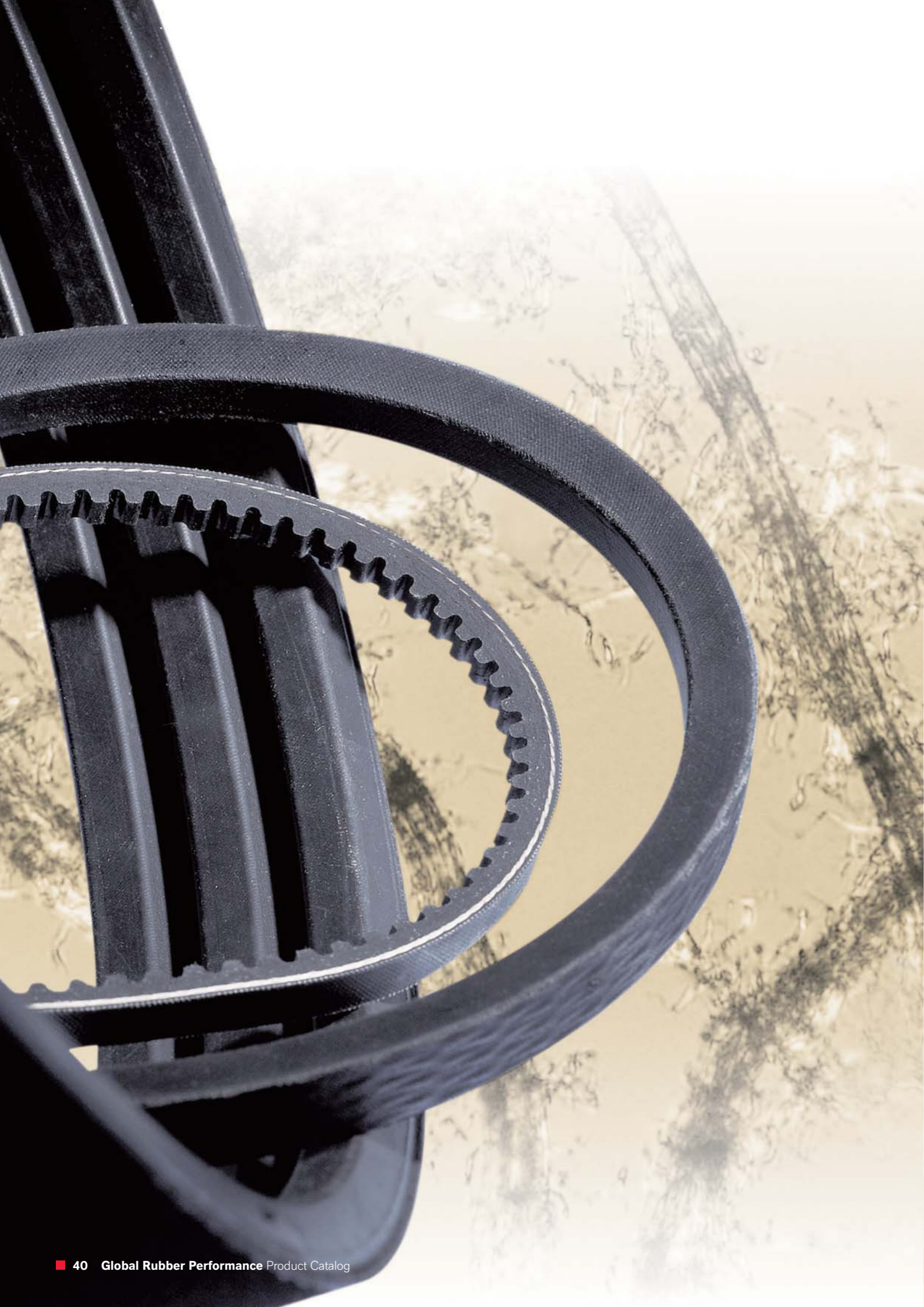
Function	Chemical substance	Polymer-bound	Other-bound	Compound	Hoses	Seals	Profile	Belts	Conveyor belts	Air springs	Bladders	Tires	Others
<b>Speciality activators</b>													
Accelerator/Curing agent	Diuron [N'-(3,4-dichlorophenyl)-N,N'-dimethyl urea]	<b>Rhenogran® DIURON-80/ACM</b>		ACM		X							
Activator and stabilizer	Synergistic combination of aminic co-activator and antioxidant	<b>Rhenogran® HPCA-50</b>		CR, HIIR, ECO, CO, ACM, AEM	X	X							
Activator for blowing agents	Zinc dicyanato diamine	<b>Rhenogran® GENIPLEX-70</b>		EPDM, NR, SBR, NBR			X						Technical rubber components of all kind
Curing activator	Potassium stearate	<b>Rhenogran® KST-50/ACM</b>		ACM	X	X							Molded parts for vehicles, engineering
Curing activator	Sodium carbonate	<b>Rhenogran® Na2CO3-70/CO</b>		Halogenated polymers	X	X							Technical rubber articles
Curing activator	Sodium stearate	<b>Rhenogran® NAST-50/ACM</b>	<b>Rhenofit® NAST-80</b>	ACM	X	X							Molded parts for vehicles, engineering
Curing activator	Active zeolite	<b>Rhenogran® ZEOLITE-70</b>		NR, IR, BR, SBR, NBR, CR, IR, IIR, XIIR, EPDM			X				X		Windscreen wiper
Curing activator	Synergistic combination of activated amine with retarder	<b>Rhenogran® XLA-60</b>		AEM, ACM, EPDM	X	X							Cables
Curing activator	Thiadiazole derivative (TDD)	<b>Rhenogran® TDD-70/CM</b>		CM (saturated halogen-containing elastomers)	X	X							Technical rubber goods
Curing activator	2,4,6-Trimercapto-s-triazine	<b>Rhenogran® TRIAZINE TM-70/AEMD</b>		CO, ECO, CR, ACM	X	X							Diaphragms, roller coverings
Curing agent	Hexamethylene diamine carbamate	<b>Rhenogran® HMDC-70/AEMD</b>		AEM, ECO/CO, ACM	X	X							Vehicles and engineering
<b>Metal oxides</b>													
Curing activator	Activated magnesium oxide	<b>Rhenogran® MgO-60</b> <b>Rhenogran® MgO-75</b>	<b>Rhenofit® D/A</b> <b>Scorchguard O</b>	CR, CSM, CM, CIIR and FPM	X	X	X			X	X		Extruded and injection molded technical articles, bladders, roofing
Curing activator	Lead oxide	<b>Rhenogran® Pb3O4/ECO</b> <b>Rhenogran® Pb3O4/EPDM</b> <b>Rhenoslab® Pb3O4/EPM</b> <b>Rhenogran® PbO-80</b>		EPDM, CR, CO and ECO	X	X							Technical rubber articles, X-ray proofed articles
Curing activator	(Active) zinc oxide	<b>Rhenogran® ZnO-80</b> <b>Rhenogran® ZnO-80/SBR</b> <b>Rhenogran® ZnO Active-80</b> <b>Rhenoslab® ZnO-85</b>	<b>Zinkoxyd aktiv®</b> <b>Zinkoxid transparent</b> <b>(Zinc carbonate)</b> <b>Zic Stick</b>	Natural and synthetic rubber	X	X	X	X	X	X	X	X	
Curing activator	Specially treated, finely divided calcium hydroxide		<b>Rhenofit® CF</b>	Fluoroelastomers		X							
Curing activator	Specially treated, finely divided calcium oxide	<b>Rhenogran® CaO-80</b>	<b>Rhenofit® F</b>	Fluoroelastomers		X							

## Others

Chemical substance	Product name	Dosage form	Compound	Hoses	Seals	Profile	Belts	Conveyor belts	Air springs	Bladders	Tires	Others
<b>Bonding agents and adhesion promoters</b>												
Hexamethoxymethyl melamine ether	<b>Cohedur® A200</b>	Colourless liquid	NR, SBR, CR	X	X	X	X	X	X		X	
Hexamethoxymethyl melamine ether with inorganic filler	<b>Cohedur® A250</b>	White powder	NR, SBR, CR	X	X	X	X	X	X		X	
Hexamethylene tetramine with silica	<b>Cohedur® H30</b>	White powder	NR, SBR, BR	X	X	X	X	X	X		X	
Resorcinol derivative	<b>Cohedur® RK</b>	White powder	CR		X		X	X				
Resorcinol with stearic acid	<b>Cohedur® RS</b>	Beige pastilles	NR, SBR, CR	X	X	X	X	X	X		X	
Hexamethylene tetramine	<b>Rhenocure® HMTA</b> <b>Rhenogran® HEXA-80</b>	Beige granules	NR, SBR, BR, IR, IIR								X	
Resorcinol	<b>Rhenogran® RESORCIN-80</b>	Off-white to brown granules	NR, SBR, BR, IR, IIR	X			X	X	X		X	Fabric proofings
Resorcinol	<b>Rhenogran® RESORCIN-80/SBR</b>	Gray to beige granules	SBR	X			X	X	X		X	Thick walled articles, roller coverings
Combination of resorcinol and mixed etherified methylol melamines	<b>Rhenofit® RL200-75/S</b>	Off-white free flowing bead	Natural and synthetic rubber								X	Roller coverings
<b>Antioxidants</b>												
Diphenyl amine derivative	<b>Rhenofit® DDA</b>	Yellow to reddish-brown viscous liquid	NR, IR, BR, SBR, and especially CR			X					X	Shoe soles
Diphenyl amine derivative as aqueous emulsion	<b>Rhenofit® DDA-50 EM</b>	Reddish-beige viscous liquid	Latex									Latex articles
Diphenylamine derivative with silica filler	<b>Rhenofit® DDA-70</b>	White to reddish-brown, non-dusting powder	NR, IR, BR, SBR and especially CR			X					X	Footwear
2-mercaptotoluimidazole	<b>Rhenofit® MTI-75/PB</b>	Free flowing light red bead	Natural and synthetic rubbers	X	X	X	X	X	X			Transparent, white and coloured rubber articles, fabric proofings
Nickel dibutyl dithiocarbamate (NDBC)	<b>Rhenofit® NDBC-70/PB</b>	Free flowing green bead	Acrylic, CO and ECO	X	X							Technical rubber articles
octylated diphenylamine	<b>Rhenofit® OCD</b>	Light gray to reddish brown pastilles	CR, NR, IR, BR, SBR, NBR, EVM			X					X	Footwear
Phenyl- $\alpha$ -naphthylamine	<b>Rhenofit® PAN</b>	Pale brown to pale violet powder	SBR, BR, NBR, CR and IR	X			X	X			X	Buffers, soles, heels, boots, extrudates, rollers, roller covers
2,2'-Methylenebis(4-methyl-6-tert-butylphenol)	<b>Rhenogran® BPH-80/L</b>	White-gray to blueish granules	Natural and synthetic rubber	X	X	X	X	X	X			
Methyl-2-mercaptobenzimidazole	<b>Rhenogran® MMBI-70</b>	Beige granules	Natural and synthetic rubber		X	X			X			Transparent, white and coloured rubber, fabric proofings
Nickel dibutyl dithiocarbamate	<b>Rhenogran® NDBC-70/ECO</b>	Granules	Acrylic, CO and ECO	X	X							
Polycarbodiimide	<b>Rhenogran® PCD-50/EVA</b>	Beige granules	EVA	X	X	X	X	X	X			Molded and extruded articles, cable sheatings and insulations, fabric proofings
Zinc methyl-2-mercaptobenzimidazole	<b>Rhenogran® ZMMBI-50</b>	Beige granules	SBR, IR, NBR	X	X	X	X	X	X			Rubber goods, fabric proofings, toys
Nickel dibutyl dithiocarbamate	<b>Rhenoslab® NDBC-70/EPM</b>	Dark green slabs	Acrylic, CO and ECO	X	X							Technical rubber articles

Chemical substance	Product name	Dosage form		Compound	Hoses	Seals	Profile	Belts	Conveyor belts	Air springs	Bladders	Tires	Others
<b>Retarder</b>													
N-(Cyclohexylthio)phthalimide	<b>Rhenogran® CTP-80</b>	Beige granules		Natural and synthetic rubber	X	X	X	X	X	X		X	Shoe soles
N-(Cyclohexylthio)phthalimide	<b>Rhenoslab® CTP-80</b>	Beige slab		Natural and synthetic rubber	X	X	X	X	X	X		X	
Sulfonamide derivative	<b>Rhenogran® Retarder E-80</b> <b>Rhenoslab® Retarder E-80</b>	Off-white to beige granules		Natural and synthetic rubber	X	X	X	X	X	X		X	
Phthalic anhydride	<b>Vulkalent® B/C</b>	White powder oil coated		Natural and synthetic rubber	X	X	X	X	X	X		X	Flooring, roofing
Sulfonamide derivative	<b>Vulkalent® E/C</b>	White powder oil coated		Natural and synthetic rubber	X	X	X	X	X	X		X	
N-(Cyclohexylthio)phthalimide	<b>Vulkalent® G</b>	Beige powder		Natural and synthetic rubber	X	X	X	X	X	X		X	
<b>Miscellaneous</b>													
		<b>Function</b>	<b>Dosage form</b>										
Antimony trioxide	<b>Rhenogran® Sb2O3-80</b>	Flame retardant	Off-white granules	Natural and synthetic rubber (e.g. NR, CR)	X		X		X				Flame-resistant articles
Titanium dioxide (anatase)	<b>Rhenogran® TiO2-80/CIIR</b> <b>Rhenoslab® TiO2-80/NBR</b>	White pigment	White pellets	NR, SBR, BR, CIIR								X	Printing blankets, roll compounds, white side walls
Iron III oxide	<b>Rhenogran® Fe-Red-70</b>	Red pigment	Red-brown granules	Natural and synthetic rubbers	X							X	Shoes, floor coverings, bicycle tires
Phosphorus-p-oxybis (benzenesulfonyl)hydrazide	<b>Rhenoslab® OBSH-75</b>	Organic blowing agent	White slabs	Natural and synthetic rubbers			X						
Phosphorus-p-oxybis (benzenesulfonyl)hydrazide	<b>Rhenofit® EC(OBSH)-72 DG</b>	Organic blowing agent	Off-White/Pale Yellow granule	Natural and synthetic rubbers			X						Sponge and foam rubber articles
Calcium oxide (specially treated, finely divided)	<b>Rhenofit® F</b>	Desiccant	White powder	Fluoroelastomers		X							





# REINFORCEMENT AGENTS

Short fibers such as glass, carbon, aramid or natural fibers have been embedded into many types of polymers to improve and modify certain mechanical properties of the matrix polymer for specific use and to reduce the cost of molded articles. Application areas include V-belts, hose, tire components and miscellaneous molded goods.

### Advantages of using reinforcing agents

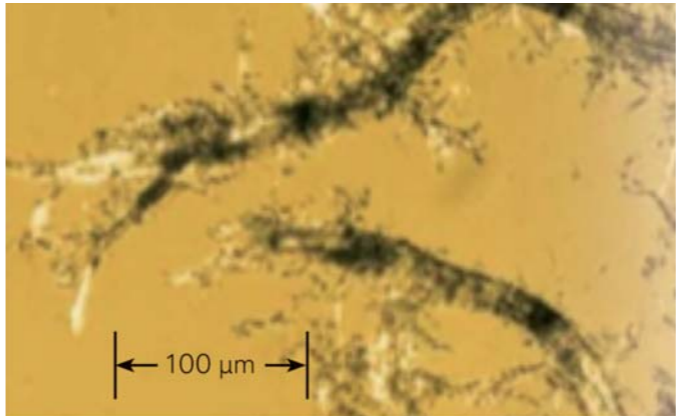
- Cost reduction in manufacturing
- Increased quality and service life of rubber articles
- Improved resistance on exposure to high temperatures, media and pressures
- Easy curing due to dimensional stability

### Aramid fibers

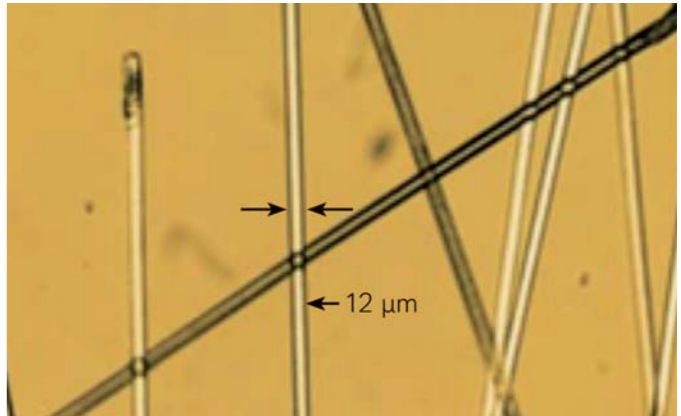
Under high mechanical, dynamic and thermal stresses, an excellent reinforcement performance can be achieved in the finished product with **Rhenogran® P91-40**, which incorporates the highly resilient and very lightweight **Twaron®** aramid short-fiber pulp evenly in the rubber compound. **Rhenogran® P91-40** is suitable for many rubber grades including NR, IR, BR, SBR, EPDM, CR, NBR and HNBR.

### Properties

- Excellent reinforcement, high flexibility
- Extremely durable; heat-, cut- and chemical-resistant
- Lightweight applications
- Non-conductive
- No melting point, low flammability



Pulp



Fiber

### Cellulose fibers

In **Rhenogran® WP**, cellulose fiber pulp enables the reinforcement of finished products made of polymers such as EPDM, SBR, NR and PVC. This is an economical solution for increasing the quality and service life of end products that are exposed to high temperatures, media and pressures.

### Properties

- Effective reinforcement, less flexibility
- Bio-degradable material
- Higher reinforcement than cotton or sisal
- Low conductivity
- Cost-efficient



Pulp

**Rhenogran®** fiber pulp masterbatches offer all the advantages of pre-dispersed additives: increased process safety, dust-free properties and thereby reduced loss of material and lower cleaning effort. **Rhenogran®** fiber masterbatches can simplify processing and provide substantial improvement to the properties of final products.

We offer comprehensive technical support, starting with recommendations for formulations and continuing with the development of application-specific fiber pulp masterbatches.



Fiber

### Advantages of Rhenogran® fiber masterbatch

- No pre-treatment and manual preparations
- Mixing and processing using common elastomer equipment
- Shorter mixing cycles
- Better dispersion in rubber compound
- Better uniformity in products

Fiber	Product*	Active content	Polymer binder	Colour
Aramid (Twaron® 1091)	<b>Rhenogran® P91-40/EPDM</b>	40%	EPDM	Yellow
Aramid (Twaron® 1091)	<b>Rhenogran® P91-40/NBR</b>	40%	NBR	Yellow
Aramid (Twaron® 1091)	<b>Rhenogran® P91-40/NR</b>	40%	NR	Yellow
Aramid (Twaron® 1095)	<b>Rhenogran® P95-50/EPDM</b>	50%	EPDM	Yellow
Wood pulp	<b>Rhenogran® WPD-70/SBR</b>	70%	SBR	Black
Wood pulp	<b>Rhenogran® WPDX-73/SBR</b>	73%	SBR	Black
Wood pulp	<b>Rhenogran® WPH-65/EPDM</b>	65%	EPDM	Black
Wood pulp	<b>Rhenogran® WPW-77/PVC</b>	77%	PVC	Gray

\* Available on request: Rhenogran® P91-40/CR, Rhenogran® P91-50/HNBR, Rhenogran® P95-50/NBR

### Vulkasil®

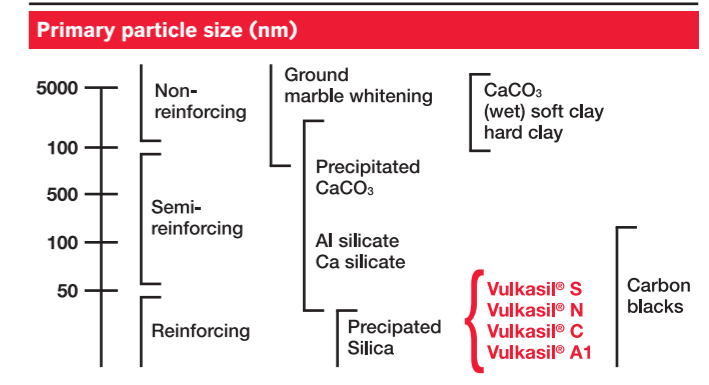
#### Characteristics

- **Vulkasil®** products are precipitated silica types
- Fillers with medium to strong reinforcing effect
- Available in wide range of pH values

#### Applications

Suitable for all rubber polymers except silicone rubber. **Vulkasil® S** and **Vulkasil® N** are used mainly for hard transparent, light or colored rubber goods, e.g. footwear soles and heels, hoses, profiles, cable sheatings, technical goods, and as ingredients of RFS bonding systems (e.g. **Cohedur®** systems). **Vulkasil® C** and **Vulkasil® A 1** are not suitable for transparent goods. **Vulkasil® S/KG** is the preferred grade for tire compounds.

**Vulkasil®** products can also be used as fillers in non-rubber polymers, paint or adhesives. With the different pH values, **Vulkasil®** silica is an excellent choice as raw material for the formulation of dry liquids.



Chemical composition	Product	Density (g/cm³)	BET surface area (m²/g)	pH value	Physical form	Standard packaging	Remarks
Reinforcing precipitated silica	<b>Vulkasil® S</b>	2.0	175	6.2	White amorphous powder	20 kg paper bags on pallets	Products are free from crystalline silica and silicates
Reinforcing precipitated silica	<b>Vulkasil® S/KG</b>	2.0	175	6.2	White granules	25 kg paper bags on pallets and FIBC	
Reinforcing precipitated silica	<b>Vulkasil® N</b>	2.0	125	6.9	White amorphous powder	20 kg paper bags on pallets	
Precipitated silica with a medium reinforcing effect	<b>Vulkasil® C</b>	2.0	50	9.0	White amorphous powder	20 kg paper bags on pallets	
Precipitated sodium aluminium silicate with a medium reinforcing effect	<b>Vulkasil® A1</b>	2.0	50	11.3	White amorphous powder	25 kg paper bags on pallets	



# PROCESSING PROMOTERS

## Flow improver

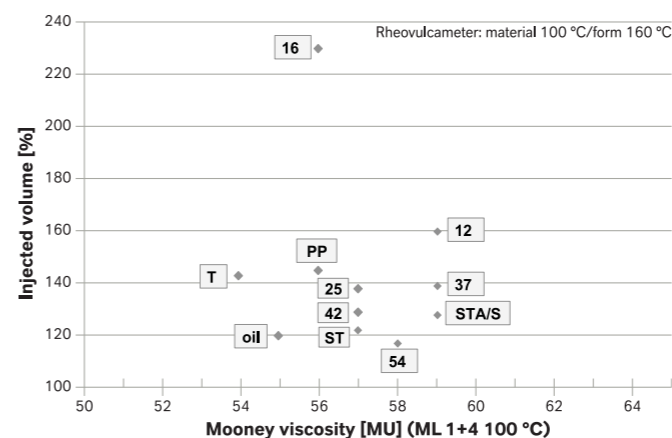
### Improving the efficiency of compound mixing and processing

Processing promoters are additives based on mostly renewable ingredients. These products enable producers of tires and technical rubber goods to improve the efficiency of compound mixing and processing, facilitating complex manufacturing processes. The average elastomer content in rubber articles is approximately 50%, the remaining ingredients comprise fillers, plasticizers, chemicals and additives. This often means that more than ten ingredients with different chemical structures, polarities and consistencies must be processed to form a homogeneous compound. Processing promoters regulate plasticity, homogeneity and flow properties, and have a positive impact on the quality of the finished articles.

Using of processing promoters to optimize a process also helps to reduce costs by:

- reducing power consumption and machine wear
- shortening mixing and molding cycles by improving flow properties of compound
- enhancing reproducibility of compound properties
- reducing reject rates in extrusion and injection-molding process.

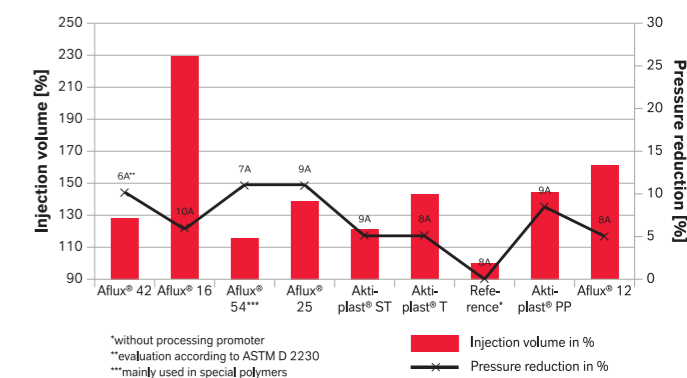
### Aflux® and Aktiplast® in sidewall compound



The products of the **Aktioplast®** range are characterised by their high solubility in diene rubbers improving dispersion of most of the ingredients. **Aktioplast®** as it provides soluble zinc. All **Aflux®** grades are zinc-free and, hence have a minor effect on vulcanization.

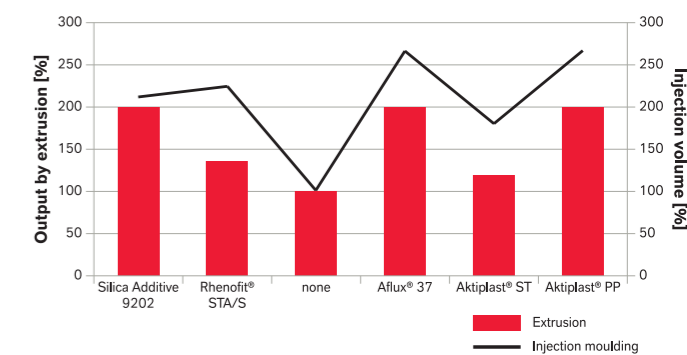
The flow properties can be dramatically improved by addition of processing promoters. This is shown by the output increase and pressure reduction during extrusion of a NR/BR sidewall compound. The evaluation of extrudates is done according to ASTM D2230. The number, ranging from 1 (poor) to 10 (excellent), rates the sharpness and continuity of the edge; the letter, ranging from A (excellent) to E (poor) rates the smoothness of surface.

### Injection volume increase/pressure reduction by the Aflux® and Aktiplast® range



**Aflux® 37** and **Aktioplast® PP** exhibit excellent performance in extrusion as well as injection molding in silica-based tire tread compounds. **Rhenofit® STA/S** contains active components on a carrier and is designed for use in silica filled compounds. **Rhenofit® STA/S** exhibits the same scorch as the reference, reinforces the compound and improves the flow behavior.

### Processing in silica tread compounds



In Garvey extrusion, the silica compound containing **Aflux® 37** shows an excellent edge compared to reference's saw-tooth texture. With **Aktiplast®** and **Aflux®**, Rhein Chemie does not only offer dispersants and lubricants but also a number of special solutions for practical challenges in rubber compounding.

**Aktiplast® PP** is a versatile processing promoter for rubber compounds, e.g. for tires. It decreases the viscosity of compounds based on NR and synthetic rubbers resulting in easier processing. This leads to higher extrusion rates, better dimensional stability and a constant level of die swell.

**Aflux® 42** can be used for NR, SBR, NBR, CR, and EPDM-based compounds. It acts as an excellent dispersing agent for fillers and chemicals. **Aflux® 42** increases the plasticity of uncured compounds and improves the flow properties. The output and the rate of extrusion of profiles are increased. It gives smooth surfaces to extrudates and calendered foils. The properties of vulcanizates are practically unaffected by **Aflux® 42**.

**Aflux® 37** is specially designed for silica compounds based on SSBR, BR, NR and combinations thereof. Thanks to its defined polarity, **Aflux® 37** enables silica to be easily incorporated into rubber compounds while not affecting physical parameters. Moreover, higher extrusion rates are obtained due to reduced compound viscosity.

**Aflux® 54** decreases the viscosity of rubber compounds, resulting in easier processing and faster compounding, especially of mixes based on CO, ECO, and FPM. It noticeably reduces the sticking of the compounds to the mixing units. **Aflux® 54** improves the incorporation of diverse fillers and the extrusion properties of the compounds.

**Aflux® 18** is a dispersant/lubricant especially suited for acrylic rubbers, such as AEM, ACM, and EVM. **Aflux® 18** significantly reduces the tackiness/stickiness of rubber compounds based on AEM, ACM, and EVM on metal surfaces. When used in combination with diaminic cross-linking systems (e.g. **Rhenogran® HMDC-70/AEMD**), scorch times can be extended. The flowability of the compound is improved.



Aflux® 18



Aflux® 37



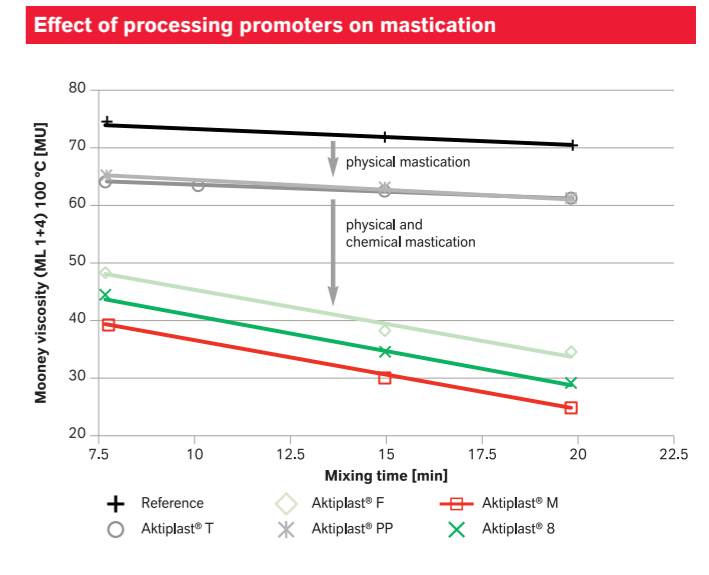
Aflux® 42



Aktiplast® 8

Since natural rubber has got a very high and inconsistent viscosity, it is typically masticated prior to compounding. Mastication is performed with high shear forces. To increase efficiency of this process, special additives are typically used.

**Aktiplast® PP** and **Aktiplast® T** are physically operating during mastication showing a minor effect. **Aktiplast® 8**, **Aktiplast® F** and **Aktiplast® M** contain additional chemical boosters, yielding a more pronounced mastication effect resulting in reduced mixing time and energy consumption.



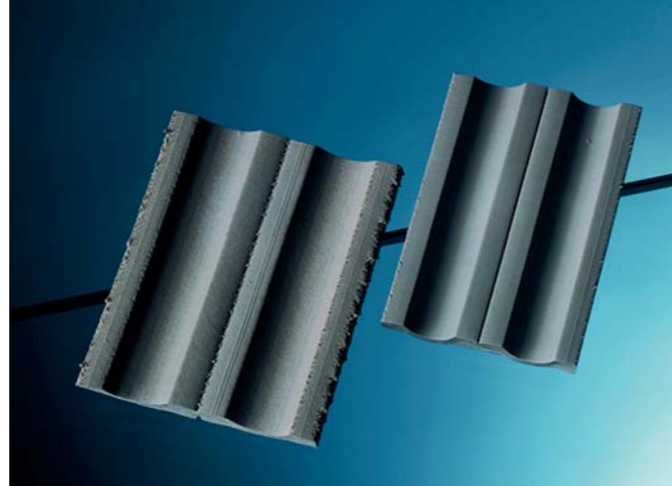


## Factice

**Rhenopren®** products are factices based on cross-linked vegetable oils, promoting dispersion of fillers and absorption of plasticizers. **Rhenopren®** enhances the form stability of unvulcanized extrudates. Improved air release whilst extrusion leads to non-porous final articles, high extrusion rates and reduced swelling. This is particularly important for large-volume extrudates. The surface appearance can be adjusted individually.

The addition of **Rhenopren® EPS** to a rubber compound results in excellent form stability with sharper edges and less bubbles in the extrudate. **Rhenopren® EPS** can be used in both natural and synthetic rubber compounds. It is based on vegetable oil and cross-linked without sulfur or chlorine.

**Rhenopren® EPS** acts as a polymeric plasticizer giving green compounds reliable dimensional stability and excellent processability. Due to its minimal influence on vulcanization, **Rhenopren® EPS** can be used both for sulfur and peroxide cross-linking.



Dimensional stability illustrated for forms without and with Rhenopren®

Application areas of Rhenopren®											
	Injection molding/Calendering	Extrusion	Dimensional stability of uncured compound	Heat stability of uncured compound	Dispersing	Foaming	Degassing	Swelling resistance	Good surface/grinding	Staining	Food contact (BfR XXI, category 4)
Rhenopren® 14		+	+	+							+
Rhenopren® ASOLVAN		+						+			+
Rhenopren® ASOLVAN T		+						+			
Rhenopren® C	+	+	+		+						+
Rhenopren® EPS	+	+	+				+	+	+	+	
Rhenopren® HF	+	+		+	+	+					+
Rhenopren® ZD	+	+		+	+						

## Resins

The **Rhenosin®** range summarizes resins with homogenising, dispersing and special properties. As consequence, the range of application areas of the **Rhenosin®** products is exceptionally broad.

**Rhenosin®** resins act as phase mediators and filler dispersants in rubber blends. They reduce batch-to-batch variation by improving the homogeneity of the rubber compounds. These resins can be used to adjust viscosity and to create tack during manufacturing of tires and technical rubber goods.

**Rhenosin® 145A/P**, **260**, **268**, and **Rhenosin® TT 100** improve homogeneity and flow behavior of compounds. **Rhenosin® T** is an aqueous solution of resorcinol formaldehyde resin. It is used as an adhesion promoter for rubber-to-fabric applications (RFL system). **Rhenosin® A** and **Rhenosin® RB** are reinforcing resins used in highly filled compounds for further increasing the shore hardness. In contrary to **Rhenosin® RB**, **Rhenosin® A** contains an additional hardening agent. **Rhenosin® RB** is best to be applied together with **Rhenogran® Hexa-80**.

**Rhenosin® 145A/P** is a homogenising agent and softening resin mainly used in halobutyl-based inner liner compounds for tires. It improves the homogeneity of various rubber blends. Dispersion of fillers and rubber chemicals are enhanced and the viscosity of rubber compounds is decreased. **Rhenosin® 145A/P** generally improves processing, e.g. compounding, extrudability, calendering and mold flow. A clear improvement of tear strength is achieved by **Rhenosin® 145A/P** as well.

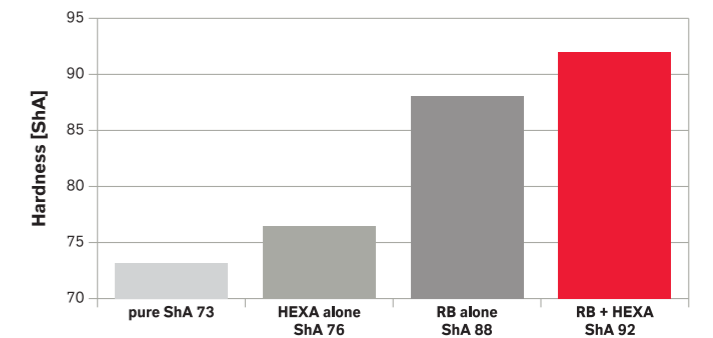


Rhenosin® RB



Rhenosin® T

Hardening behavior of a NBR/SBR compound



Application areas of Rhenosin®				
	Dispersing	Homogenising	Rubber to fabric bonding	Reinforcing
Rhenosin® 145A/P	X	X		
Rhenosin® 260		X		
Rhenosin® 268		X		
Rhenosin® A				X
Rhenosin® RB				X
Rhenosin® T			X	
Rhenosin® TT 100	X			

## Plasticizers

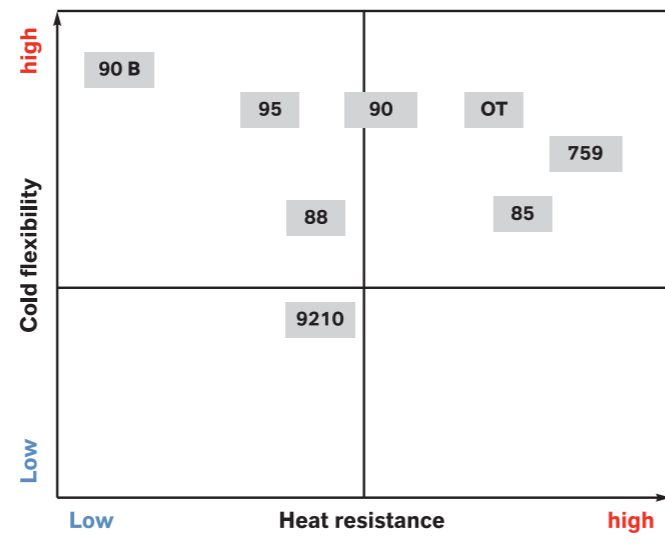
Under the brand name **Vulkanol®**, Rhein Chemie offers special plasticizers based on selected ethers/esters and thioethers used in different application areas. The **Vulkanol®** products show different characteristics with regards to their cold and heat resistance. Particularly in polar rubber grades such as NBR, HNBR, ACM, and AEM, **Vulkanol®** plasticizers improve the low-temperature flexibility and elasticity of technical rubber components. The heat resistance is not sacrificed. Under cold conditions the **Vulkanol®** plasticizers show a strong improvement of brittleness temperature TS and low temperature index TR.

**Vulkanol®** plasticizers are highly stable under high ambient temperatures. This gives constant properties during long-term use of technical rubber goods at elevated temperatures.

**Vulkanol® TOF** is a polar plasticizers providing a higher loss factor at 0 °C and a lower tan delta at 60 °C in silica-filled tire tread compounds. This yields in a significant improvement of wet and ice grip as well as rolling resistance in these compounds.

**Vulkanol® OT** combines low temperature flexibility with high temperature resistance. It is mainly used in applications with a wide range of ambient temperatures. This is especially of importance for use in automotive seals and hoses. **Vulkanol® OT** maintains most of the rubber properties after extended periods at temperatures up to 125 °C. **Vulkanol® OT** has practically no effect on compression set at high temperatures and reduces compression set at ambient and lower temperatures.

Classification of the Vulkanol® plasticizers



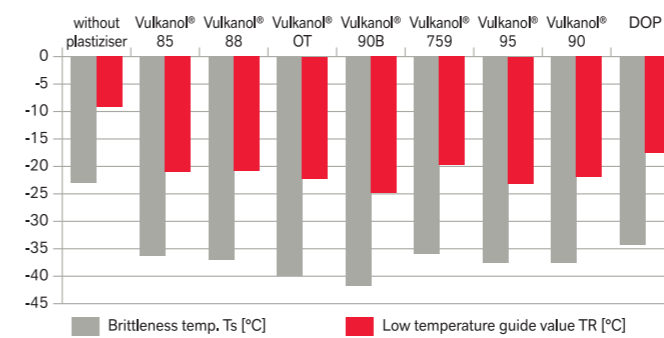
**Vulkanol® 88** is a general purpose plasticizers for natural and synthetic rubber. **Vulkanol® 88** is commonly used in rubber compounds requiring polar plasticizers.

**Vulkanol® 90** has excellent compatibility with all types of polymers. It significantly increases rebound resilience of the vulcanizates. **Vulkanol® 90** has little influence on the swelling tendency of rubber goods.

**Vulkanol® 759** can be used in rubber articles over a wide range of temperatures. **Vulkanol® 759** can easily be mixed into rubber compounds and has minimal effects on the physical properties. It has a particularly beneficial effect on the heat aging of rubber products. **Vulkanol® 759** is suitable for use in acrylic rubber compounds.

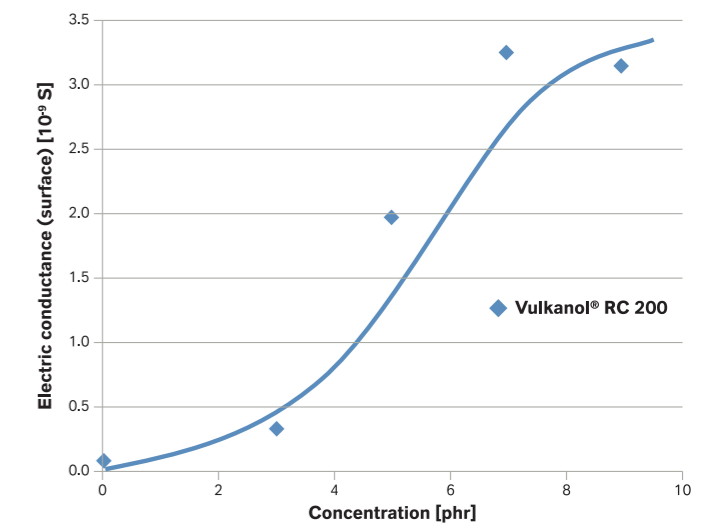
**Vulkanol® 95** exhibits a flexibilizing effect at low temperatures and has a low vapor pressure at high temperatures. It is easily dispersible and affects the physical properties of rubber compounds only slightly. It is compatible with CR, NBR, NR, SBR, ECO as well as EPDM, IIR.

Low-temperature behavior of the Vulkanol® plasticizers in NBR compound



**Vulkanol® FH** considerably enhances the tack of compounds based on synthetic rubbers. The product can be used in the production of technical rubber goods based on synthetic rubber if high building tack is needed. These include conveyor belts, V-belts, roll covers and other built-up rubber articles. The product is also suitable for bonding compounds. The tack remains practically unchanged during storage of the green compound.

Improvement of electric conductance of a black NBR compound



**Vulkanol® RC 200** is an antistatic plasticizer, which increases electrical conductivity and reduces surface and volume resistivity of rubber vulcanizates.

Application areas of products in the Vulkanol® range

	Processing aid	Reduction of hardness	Tackifier	Anti-static	Low temp. flexibility	Heat resistance	Flame resistance
<b>Vulkanol® 85</b>	+	+		+	+	+	
<b>Vulkanol® 88</b>	+	+			+		
<b>Vulkanol® 90</b>	+	+			+		
<b>Vulkanol® 90 B</b>	+	+		+	++		
<b>Vulkanol® 95</b>	+	+			+	+	
<b>Vulkanol® 759</b>	+	+			+	++	
<b>Vulkanol® FH</b>	+		+				
<b>Vulkanol® OT</b>	+	+			+	+	
<b>Vulkanol® RC 200</b>	+	+		++			
<b>Vulkanol® TOF</b>	+	+			++		+

Product name	Composition	Dosage form	Compound	Curing system		Suggested dosage [phr]	Application										
				Sulfur	Peroxide		Pepti- sation	Mixing time	Mould flow	Extru- sion	Tacki- ness	Dis- persion	De- molding	Form stability	Re- claiming	Plasti- zising	Harden- ing
<b>Flow improver</b>																	
<b>Aflux® 12</b>	Blend of fatty acid esters and hydrocarbons	Pellet	NR/IR, BR/SBR, NBR/HBR, IIR/CIIR/BIIR, EPM/EPDM, ACM/AEM/EVM	X	X	2.0–4.0		X	X	X	X	X	X				
<b>Aflux® 16*</b>	Calcium salts of natural fatty acids in combination with amide ester waxes	Pastille	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM, CM/CSM, ACM/AEM/EVM	X		1.0–5.0			X	X	X		X				
<b>Aflux® 18</b>	Primary fatty amine	Flakes	ACM/AEM/EVM	X		0.5–1.0						X					
<b>Aflux® 25</b>	Combination of paraffine and fatty acids	Pastille	NR/IR, BR/SBR, NBR/HBR, CR, EPM/EPDM, ACM/AEM/EVM	X		2.0–5.0		X	X	X				X			
<b>Aflux® 28E**</b>	Mixture of fatty alcohols and fatty acid esters	Pastille		X	X												
<b>Aflux® 37</b>	Blend of surface active substances with fatty acids	Pastille	NR/IR, BR/SBR, NBR/HBR, EPM/EPDM, silica compound	X		2.0–5.0		X	X	X	X	X					
<b>Aflux® 42</b>	Blend of fatty acids, fatty alcohols and fatty acid esters	Pastille	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM, CM/CSM, CO/ECO	X	X	1.5–3.5		X	X	X			X	X			
<b>Aflux® 52**</b>	Mixture of fatty alcohols and fatty acid esters	Pellet	NR/IR, BR/SBR, NBR/HBR, CR, EPM/EPDM	X	X	2.0–5.0			X	X			X				
<b>Aflux® 54</b>	Pentaerythryl tetrastearate	Micro pearls	NBR/HBR, IIR/CIIR/BIIR, EPM/EPDM, CM/CSM, CO/ECO, ACM/AEM/EVM, FPM	X	X	1.0–2.0			X				X	X			
<b>Aktiplast®</b>	Zinc salts of unsaturated/saturated fatty acids	Pastille	NR/IR, BR/SBR, NBR/HBR, IIR/CIIR/BIIR, EPM/EPDM	X	X	1.0–3.0		X	X	X			X				
<b>Aktiplast® 8</b>	Metal complex in an organic carrier material	Pastille	NR/IR, BR/SBR	X		0.05–2.0	X										
<b>Aktiplast® 79</b>	Polysulphide	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, EPM/EPDM	X		0.1–3.0									X		
<b>Aktiplast® F</b>	Combination of zinc salts of unsaturated fatty acids with an activator	Pastille	NR/IR, BR/SBR, NBR/HBR	X	X	1.0–3.0	X	X	X	X			X				
<b>Aktiplast® GT**</b>	Zinc salts of selected, high-molecular weight, mainly saturated fatty acids	Pastille	NR/IR, BR/SBR, IIR/CIIR/BIIR, EPM/EPDM, silica compound	X	X	1.0–4.0			X	X			X				
<b>Aktiplast® M</b>	Combination of zinc salts of mainly saturated fatty acids with an activator	Pastille	NR/IR, BR/SBR, NBR/HBR	X	X	1.0–3.0	X	X	X	X			X				
<b>Aktiplast® PP</b>	Zinc salts of higher molecular fatty acids	Pastille	NR/IR, BR/SBR, IIR/CIIR/BIIR, EPM/EPDM, silica compound	X	X	2.0–3.0		X	X	X			X	X			
<b>Aktiplast® ST</b>	Blend of hydrocarbons, zinc soaps and fillers	Pastille	NR/IR, BR/SBR, CR, EPM/EPDM, CM/CSM, silica compound	X	X	3.0–5.0		X	X	X			X	X			
<b>Aktiplast® T</b>	Zinc salts of unsaturated/saturated fatty acids	Pastille	NR/IR, BR/SBR, NBR/HNBR, IIR/CIIR/BIIR, EPM/EPDM	X	X	2.0–3.0	X	X	X	X			X				
<b>Rhenofit® STA/S*</b>	Mixture of polyols	Powder	NR/IR, BR/SBR, NBR/HBR, EPM/EPDM, silica compound	X		2.0–7.0			X	X			X	X			
<b>Factice</b>																	
<b>Rhenopren® 14</b>	Pure rapeseed oil cross-linked with sulfur	Crumb	NR/IR, BR/SBR, CR, EPM/EPDM	X		5.0–40.0		X	X	X			X		X		
<b>Rhenopren® ASOLVAN</b>	Castor oil cross-linked with sulfur	Ground material	NBR/HNBR, CR, CM/CSM	X		5.0–30.0		X	X	X			X				
<b>Rhenopren® ASOLVAN T</b>	Castor oil cross-linked with sulfur, blended with refined rapeseed oil	Ground material	NBR/HNBR, CR, CM/CSM	X		5.0–30.0		X	X	X			X				
<b>Rhenopren® C</b>	Refined rapeseed oil cross-linked without sulfur and hardened	Ground material	NR/IR, BR/SBR, NBR/HNBR, CR, EPM/EPDM, CO/ECO, ACM/AEM/EVM, FPM	X		5.0–30.0		X	X	X			X		X		
<b>Rhenopren® EPS</b>	Vegetable oil cross-linked without sulfur and chlorine	Crumb	NR/IR, BR/SBR, NBR/HNBR, CR, EPM/EPDM, CO/ECO, ACM/AEM/EVM, FPM	X	X	5.0–20.0 for eraser: 50–300		X	X	X			X		X		
<b>Rhenopren® HF</b>	Refined rapeseed oil cross-linked with sulfur	Crushed material	NR/IR, BR/SBR, EPM/EPDM	X		5.0–15.0		X	X	X			X				
<b>Rhenopren® ZD</b>	Refined rapeseed oil cross-linked with sulfur in a mineral oil	Crushed material	NR/IR, BR/SBR, EPM/EPDM	X		5.0–20.0		X	X	X			X		X		

\* not available in EMEA / \*\* only available in APAC

Product name	Composition	Dosage form	Compound	Curing system		Suggested dosage [phr]	Application										
				Sulphidic	Peroxide		Pepti- sation	Mixing time	Mould flow	Extru- sion	Tacki- ness	Dis- persion	De- molding	Form stability	Re- claiming	Plasti- zising	Harden- ing
<b>Resins</b>																	
<b>Rhenosin® 145 A/P</b>	Polymerised blend of paraffinic, naphthenic and aromatic hydrocarbons	Pastille	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM		X	X	3.0–12.0				X	X		X			X
<b>Rhenosin® 260**</b>	Polymerisate on unsaturated aromatic C9/C10 hydrocarbons	Granule	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM		X	X	3.0–12.0				X	X	X				X
<b>Rhenosin® 268**</b>	Polymerisate on unsaturated aromatic C9/C10 hydrocarbons	Granule	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM		X	X	3.0–12.0				X	X	X				X
<b>Rhenosin® A</b>	Phenol formaldehyde resin with hardening agent	Powder	NR/IR, BR/SBR, NBR/HBR, EPM/EPDM		X		5.0–25.0										X
<b>Rhenosin® RB</b>	Phenol formaldehyde resin (Novolak) without hardening agent	Flakes	NR/IR, BR/SBR, NBR/HBR, EPM/EPDM		X		5.0–25.0										X
<b>Rhenosin® T</b>	Precondensed resorcinol formaldehyde resin in aqueous solution	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM, silica compound		X		not applicable										
<b>Rhenosin® TT 100**</b>	Polymerisate on unsaturated aromatic C9/C10 hydrocarbons	Granule	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM		X	X	3.0–10.0				X	X	X	X			
<b>Plasticizer</b>																	
<b>Rhenofit® FH 70</b>	70% aromatic polyether (Vulkanol® FH), 30% silica filler	Powder	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR		X		5.0–20.0										X
<b>Vulkanol® 85</b>	Ether/Thioether	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR		X		10.0–30.0				X						X
<b>Vulkanol® 88</b>	Methylene bis (thioglycolic acid butyl ester)	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR		X		20.0–30.0				X						X
<b>Vulkanol® 90</b>	Di-2-ethylhexyl-thio-di-glycolate	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, CM/CSM		X		5.0–40.0				X		X				X
<b>Vulkanol® 90 B</b>	Polyether	Liquid	NBR/HBR, CR		X		5.0–50.0				X						X
<b>Vulkanol® 95</b>	Adipic diester	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM, CO/ECO		X	X	3.0–30.0				X						X
<b>Vulkanol® 759</b>	Ether/Ester	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, EPM/EPDM, CO/ECO		X		5.0–30.0				X						X
<b>Vulkanol® FH</b>	Aromatic polyether	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR		X		5.0–20.0				X		X				
<b>Vulkanol® OT</b>	Ether/Thioether	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR		X	X	10.0–30.0				X						X
<b>Vulkanol® RC 200</b>	Fatty alkyl ether of polyethylene glycol	Liquid	NBR/HBR, CR		X		3.0–10.0				X						X
<b>Vulkanol® TOF</b>	Tris(2-ethylhexyl)phosphate	Liquid	NR/IR, BR/SBR, NBR/HBR, CR, IIR/CIIR/BIIR, silica compound		X	X	10.0–20.0				X						X

\* not available in EMEA / \*\* only available in APAC





## ANTI-SUN CHECK WAXES, ANTIOZONANTS

### Antilux® – the protector of choice against weathering and oxidation

Antilux®, widely used in the tire industry, is the protector of choice against the effects of weathering and oxidation when rubber articles are exposed to light and ground-level ozone. Antilux® migrates to form a self-regenerating, sealed protective film on the surface of the article. This film is elastic, flexible at low temperatures and has good adhesion properties.

Antilux® provides optimal protection against oxidation under dynamic stress. The molecular weight distribution of the paraffins determines the ratio of migration to solubility. The protective effects of Antilux® can therefore be adjusted to the operating temperature of the finished article.

Antilux® anti-sun check waxes and antiozonants are blends of selected paraffins and micro waxes comprising grades of different molecular weight distribution and congealing ranges. Supplied as free-flowing pellets, regular in size and color, they ensure easy handling in weighing and mixing. For technical rubber articles that come into contact with foodstuffs or toys and medical rubber articles, two grades with special approval for such applications are available.

The Antilux® 500 grades are suitable for technical rubber goods with low operating temperatures. The broad-band Antilux® 654 grades provide excellent protection for tires in all climates at high and low operating temperatures. Antilux® 500 and Antilux® 654 L are in compliance with BfR XXV and FDA 21 CFR as well as related European regulations for food contact applications.



Antilux® 111



Antilux® 654

Product name	Composition	Dosage form	Congeaing range	Applications
Antilux® 111	Blend of selected paraffins and micro waxes with broad molecular weight distribution	Pastille	63–68	Anti-sun check wax to protect rubber articles against cracking caused by ozone and weathering influences
Antilux® 500	Blend of selected paraffins and micro waxes with medium-broad molecular weight distribution	Pastille	53–58	Rubber articles and articles, which come in contact with foodstuffs, toys, surgical and pharmaceutical rubber articles
Antilux® 500 PE	Blend of selected paraffins and micro waxes with medium-broad molecular weight distribution with 2% low molecular polyethylene	Pastille	54–59	Anti-sun check wax to protect rubber articles against cracking caused by ozone and weathering influences
Antilux® 654	Blend of selected paraffins and micro waxes with medium-broad molecular weight distribution	Pastille	62–67	Anti-sun check wax to protect rubber articles against cracking caused by ozone and weathering influences
Antilux® 654 A	Blend of selected paraffins and micro waxes with medium-broad molecular weight distribution with 2% low molecular polyethylene	Pastille	64–69	Anti-sun check wax to protect rubber articles against cracking caused by ozone and weathering influences
Antilux® 654 L	Blend of selected paraffins and micro waxes with medium-broad molecular weight distribution	Pastille	63–67	Rubber articles and articles, which come in contact with foodstuffs, toys, surgical and pharmaceutical rubber articles

# MILLABLE POLYURETHANE RUBBERS

## Urepan® overview

Urepan® is a line of polyurethane-based synthetic rubbers. Thus, Urepan® combines the advantages of polyurethane elastomers with those of high-performance rubbers. In addition, Urepan® can be processed using the standard machinery and methods applied in the rubber industry.

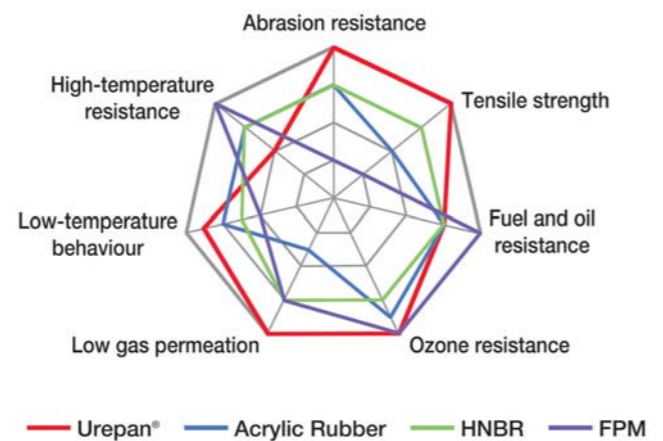
## Urepan® qualities

Vulcanizates based on Urepan® are characterised by the following qualities:

- excellent abrasion resistance
- high tear and tensile strength
- excellent fuel and oil resistance
- brilliant ozone and weather resistance
- low gas permeation
- good low-temperature behavior

The figure below demonstrates the quality of Urepan® vulcanizates in comparison with other speciality elastomers. In particular with regard to abrasion resistance and tensile strength, Urepan® shows superior characteristics when compared to Acrylic Rubber, HNBR and FPM.

Comparison of Urepan® with other high-performance elastomers



## Processing of Urepan®

The Urepan® product range offers excellent processing properties. As standard rubbers it can be processed on conventional rubber processing machinery using internal mixers or open mills. Depending on the specific Urepan® type, it can be cross-linked using sulfur, isocyanate and peroxide.

As synergistic functional additives, LANXESS offers Rhencure® AUR and Rhencure® TT, which are specific cross-linking agents, which are optimally suited for Urepan® applications.

## Selecting the right Urepan® type for your application

Urepan® types offered by LANXESS differ with respect to the vulcanizate properties. The following table gives an overview and a guideline on how to select the right Urepan® product for your application.



Urepan® 600



Urepan® 640 G

### Selection of the right rubber

Physical/Mechanical properties	Urepan® 600	Urepan® 640 G	Urepan® 643 G	Urepan® 50EL 06 G
Tensile strength	++	++	++	+
Rebound resilience	+	+	++	++
Elongation at break	++	+	+	+
Abrasion resistance	++	+	+	++
Tear resistance	++	o	o	+
Mechanical properties at high hardness	++	+	+	+
Compression set	o	+	++	o
Heat resistance	-	+	+	o
Low temperature performance	+	+	++	o
Impermeability to gases	+	++	+	+
Resistance to hydrolysis	-	o	o	++
Oil resistance	+	++	++	o
Resistance to diesel fuels	+	++	++	+

### Functional additives

Compression molding	++	++	++	++
Transfer molding	++	++	++	++
Injection molding	-	++	++	+
Extrusion	o	++	++	+
Steam vulcanization	-	-	-	++
Hot air vulcanization	+	o	o	++
Applications (selection)	Tiles molds; hydraulic gaskets; rollers	Diaphragms seals in petroleum industry; rollers	Automotive seals; rollers	Pump stators; sand blaster; roller coverings

Product range and applications			
Urepan® portfolio	Chemical composition	Curing system	Supply form
Urepan® 600	Polyester polyurethane rubber	Isocyanate	White bales
Urepan® 640 G	Polyester polyurethane rubber	Peroxide	Yellowish granules
Urepan® 643 G	Polyester polyurethane rubber	Peroxide	Yellowish granules
Urepan® 50 EL 06	Polyether polyurethane rubber	Sulfur or peroxide	Yellowish granules
Functional additives			
Rhencure® AUR	Combination of zinc chloride and mercaptobenzothiazole disulphide	Curing agent for Urepan® 50 EL 06 G	Yellowish powder
Rhencure® TT	Dimeric toluylene-2,4-diisocyanate	Cross-linking agent for Urepan® 600	White to yellowish powder

# BLADDERS

LANXESS Business Unit Rhein Chemie is one of the biggest independent producers of tire curing bladders in the world. Marketed under the brand name **Rhenoshape®**, Rhein Chemie produces a very wide range of high-performance bladders for different tire press types. Our bladders stand for high productivity, so high number of tire vulcanization cycles, low vulcanization times and an all-over consistent high bladder quality, providing a high tire uniformity and low scrap rate.

Rhein Chemie has four bladder production plants in different regions: in Argentina, Brazil, China and the United States. Rhein Chemie constantly invests in bladder-related research and development, e.g. for new compounds or bladder production processes. We can support our customers also by developing new, dedicated bladders and molds – both compression or injection production technology.

Producing also a wide portfolio of high-performance release agents, marketed under the brand name **Rhenodiv®**, Rhein Chemie has bundled competence for bladder coating. One example are permanently coated bladders. They either allow to completely refrain from using tire inside paints (TIP) in the tire production process, or if used together with TIP, bladder life can be extended significantly. Rhein Chemie runs two dedicated coating lines for permanent bladder coating, one in Burzaco, Argentina, another in Little Rock, USA.

Both coating lines are just one example of Rhein Chemie's considerable investments in its bladder business. Other recent investments were the opening of our bladder production sites in Brazil (2013) and China (2015) or capacity increases by new presses installed also at our sites in Argentina and USA. Moreover, Rhein Chemie constantly invests in its worldwide sales and distribution network in order to safeguard a very high supply reliability as well as local service by technical specialists in all major markets.

Please contact us at [bladders@lanxess.com](mailto:bladders@lanxess.com) and ask for your copy of our comprehensive brochure specially about **Rhenoshape®** high-performance tire curing bladders.



## RELEASE AGENTS

The production of high-performance tires and molded elastomer products relies on the use of effective release agents. Release agents prevent the sticking of uncured rubber contact surfaces to cured or uncured rubber surfaces. They are inevitable where rubber is vulcanized in molds, on mandrels or bladders. Without the use of Release agents, the cured rubber would stick to molds and mandrels, while bladders would be vulcanized into the tire. Process safety and low scrap rates are key for the efficient production of tire compounds and molded elastomer articles.

The LANXESS business unit Rhein Chemie has the solutions, market understanding, production knowledge and comprehensive service to support you at every stage of the process chain. We focus on improving quality and driving down costs.

**Rhenodiv®** release agents are strictly water-based, solvent-free and free of volatile organic compounds (VOCs) and, therefore, environmentally friendly. The same applies to **Rhenomark®**.

An optimal release agent is more than just a product; it is a solution to a certain challenge, either in the production process, storage and handling, HE&S, procurement, or elsewhere.

### Tire systems

Modern tire manufacturing requires state-of-the-art tire release solutions. Effectiveness, efficiency, scrap reduction, and economic use of resources typically is what tire manufacturers are demanding. Automated and continuous processes require adequate and reliable solutions. Occupational safety is also of major concern as is the long-term availability of release agents in view of global and regional HE&S regulations.

Rhein Chemie meets these demands by providing the tire industry with tailored technical solutions:

- single-release inside tire lubes, filled and non-filled, reactive and non-reactive, with silicone or without, water-based and free of VOC
- semi-permanent inside lubes for multiple-release of tires – aqueous and solvent-free silicone emulsions
- with ready-to-use solutions for operators
- safe and handy packaging solutions, appropriate for product and application
- formulations in accordance with the regulations of the global chemical inventories and the Global Harmonized System (GHS)







### Tire systems: single-release inside tire lubes

State-of-the-art single-release inside tire lubes allow for efficient processes and economic use in mass production of all kinds of tires. **Rhenodiv® BP** single-release inside tire lubes provide tire manufacturers with solutions tailored for the respective tire category, e.g. PCR, LCV, TBR, OTR, AGR, or Moto.

Article	Chemical composition	Appearance, supply form	Characteristics	Solid content %	Reactive H <sub>2</sub>	Reactive H <sub>2</sub> -free	PCR, LCV, Moto	TBR	OTR, AGV
<b>Rhenodiv® BP-161</b>	Aqueous dispersion of mineral filler in reactive silicones	Amber-silver liquid	Product to be applied on every tire. The residual lubricity left on the bladder might last for the following cure cycle	29	X		XX	X	X
<b>Rhenodiv® BP-165</b>	Aqueous dispersion of mineral filler in reactive silicones	Black liquid	Product to be applied on every tire. The residual lubricity left on the bladder might last for the following cure cycle	35	X		XX	X	X
<b>Rhenodiv® BP-166</b>	Aqueous dispersion of mineral filler, silicone-free	Amber-silver liquid	Product to be applied on every tire	28		X	XX	X	X
<b>Rhenodiv® BP-286</b>	Thixotropic aqueous dispersion of inorganic fillers	Black liquid	Good release and excellent slip properties, excellent air bleeding	44		X	XX	X	XX
<b>Rhenodiv® BP-2864</b>	Thixotropic aqueous dispersion of inorganic fillers	Jetblack liquid	Good release and excellent slip properties, excellent air bleeding	44		X	XX	X	XX
<b>Rhenodiv® BP-3091</b>	Aqueous formulation of partly cross-linkable silicone polymers	Milky white liquid	Improved load-carrying capacity and lubricity, particularly for demanding applications	14	X		XX	XX	X
<b>Rhenodiv® BP-337</b>	Unfilled, water-based product, containing silicones, H <sub>2</sub> -free	Milky white liquid	Provides suitable lubricity and shiny finish	23		X	XX	XX	X
<b>Rhenodiv® BP-338</b>	Unfilled, water-based product, containing silicones, H <sub>2</sub> -free	Milky white liquid	Provides high lubricity and shiny finish	23		X	XX	XX	X
<b>Rhenodiv® BP-450 F, N, GT</b>	Aqueous dispersions of mineral filler in non-reactive silicones	Amber-silver liquid	Provides suitable lubricity, high release properties and improve the inside appearance of the cured tire	45		X	XX	X	XX
<b>Rhenodiv® BP-550 N, T</b>	Thixotropic aqueous dispersion with inorganic fillers	Gray-black liquid, ambersilver liquid	Suitable lubricity, high release properties, outstanding air bleeding; improves inside appearance of cured tire	50		X	XX	X	XX
<b>Rhenodiv® BP-70 N, R*</b>	Aqueous dispersion of mineral filler in reactive silicones	Gray-black liquid, black liquid	Good release and excellent slip properties, the cross-linkable silicone prevents flaking of the release agent from the cured tire and the bladder	45	X		XX	X	XX
<b>Rhenodiv® BP-9092/G</b>	Aqueous suspension of inorganic pigments, polydimethylsiloxanes and additives	Gray-white liquid of high viscosity	Very good slip of bladders; excellent air bleed and bladder release; short drying time and low consumption	50		X	XX	X	XX
<b>Rhenodiv® BP-9092/W</b>	Aqueous suspension of inorganic pigments, polydimethylsiloxanes and additives	Gray-white liquid of high viscosity	Very good slip of bladders; excellent air bleed and bladder release; short drying time and low consumption	50		X	XX	X	XX
<b>Rhenodiv® BP-9094/I</b>	Aqueous suspension of inorganic pigments, silicone polymers and emulsifiers	Gray liquid of medium viscosity	Easy molding and demolding; novel formulation with favorable effects on inner liner splice; long bladder life	43		X	XX	X	XX
<b>Rhenodiv® BP-9095</b>	Aqueous emulsion of reactive silicone polymers and emulsifiers	Gray liquid of medium viscosity	High lubricity for easy molding and demolding; long bladder life	8		X	XX	XX	X
<b>Rhenodiv® BP-9096</b>	Aqueous suspension of inorganic pigments, silicone polymers and emulsifiers	Gray liquid of medium viscosity	High lubricity for easy molding and demolding; long bladder life	45		X	XX	X	XX
<b>Rhenodiv® BP-9500</b>	Unfilled, silicone-free product based on glycol and vegetable oils	Translucent yellow liquid	Inside lube, especially designed for run-on-flat, sealant, and noise-reduced tires; can be washed with water	100		X	XX	XX	X

\* not available in EMEA

### Tire systems: multiple-release inside tire paints

Unlike single-release inside tire lubes, semi-permanent inside tire paints allow for multiple curing cycles per single application of the release agent. Depending on the respective application, this is facilitating processes in the plant. **Rhenodiv® SP** grades allow to spray 1 out of 6 up to 1 out of 15 tires.



Article	Chemical composition	Appearance, supply form	Characteristics	Solid content %	Reactive H <sub>2</sub>	Frcq. of appl.	PCR, LCV, Moto	TBR	OTR, AGV
<b>Rhenodiv® SP-107*</b>	Water-based emulsion of reactive silicones	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	8	X	1/6	XX	X	X
<b>Rhenodiv® SP-110*</b>	Water-based emulsion of reactive silicones	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	9	X	1/6	XX	X	X
<b>Rhenodiv® SP-289</b>	Aqueous formulation of cross-linkable silicone polymers	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	50	X	1/15	XX	XX	X
<b>Rhenodiv® SP-1003</b>	Silicone emulsion	Milky white liquid	Water-based multiple release inside lube	8	X	1/3	XX	XX	X
<b>Rhenodiv® SP-1010</b>				12	X	1/10	XX	XX	X
<b>Rhenodiv® SP-1020</b>				17.5	X	1/20	XX	XX	X
<b>Rhenodiv® SP-2891</b>	Aqueous formulation of cross-linkable silicone polymers	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	29	X	1/6	XX	X	X
<b>Rhenodiv® SP-2892</b>	Aqueous formulation of cross-linkable silicone polymers	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	46	X	1/10	XX	XX	X
<b>Rhenodiv® SP-2893</b>	Aqueous formulation of cross-linkable silicone polymers	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	50	X	1/15	XX	XX	X
<b>Rhenodiv® SP-950*</b>	Water-based emulsion of reactive silicone polymers	Milky white liquid	Semi-permanent inside tire lube for multiple release of tires	29	X	1/10	XX	X	X

\* not available in EMEA

### Tire systems: bladder coatings

Besides single-release and semi-permanent release agents Rhein Chemie promotes the use of bladder coatings for multiple releases of tires. With **Rhenodiv® BC** grades it is feasible to cure up to 100 tires before a renewal of the coating is necessary. For best results **Rhenodiv®** bladder coatings contain reactive silicones.

Article	Chemical composition	Appearance, supply form	Characteristics	Solid content %	Reactive H <sub>2</sub>	Reactive H <sub>2</sub> -free
<b>Rhenodiv® BC-638-1</b>	Reactive silicone polymers dissolved in a hydrocarbon solvent	Whitish, cloudy solution	Bladder coating	16		X
<b>Rhenodiv® BC-700/2</b>	Water-based emulsion of reactive silicon polymer	White, cloudy suspension	Bladder coating	11	X	
<b>Rhenodiv® BC-700/3</b>	Water-based emulsion of reactive silicon polymer	White, cloudy suspension	Bladder coating	15	X	
<b>Rhenodiv® BC-730**</b>	Water-based emulsion of reactive silicon polymer	White, cloudy suspension	Bladder coating	3	X	
<b>Rhenodiv® BC-750**</b>	Water-based emulsion of reactive silicon polymer	White, cloudy suspension	Bladder coating	5	X	
<b>Rhenodiv® BC-770**</b>	Water-based emulsion of reactive silicon polymer	White, cloudy suspension	Bladder coating	5	X	
<b>Rhenodiv® BC-792</b>	Water-based emulsion of reactive silicon polymer	White, cloudy suspension	Bladder coating	18	X	
<b>Rhenodiv® BC-1700</b>	Silicone emulsion	Milky white liquid	Water-based release treatment for new bladders free of VOC	28.5	X	

\*\* only available in APAC



### Tire systems: Aqueous Outside tire Paints

Outside tire paints are a proven means for the removal of blemish on the outside surface of tires. All **Rhenodiv® OP** grades are water-based and free of VOC.

Article	Chemical composition	Appearance, supply form	Characteristics	Solid content %
<b>Rhenodiv® OP-600*</b>	SBR compound with mineral filler	Black liquid	Outside anti-blemish paint	18
<b>Rhenodiv® OP-720*</b>	SBR compound with mineral filler	Black liquid	Outside anti-blemish paint	42
<b>Rhenodiv® OP-787*</b>	SBR compound with mineral filler	Black liquid	Outside anti-blemish paint	24
<b>Rhenodiv® OP-9150-2A**</b>	Aqueous suspension of fillers and bonding agents	White low-viscosity suspension	High-adhesion water-based green tire outside paint	12
<b>Rhenodiv® OP-9160</b>	Aqueous suspension of fillers and bonding agents	Gray-black low-viscosity dispersion	Transparent water-based green tire outside paint	14
<b>Rhenodiv® OP-9208</b>	Aqueous suspension of fillers and bonding agents	Black low-viscosity suspension	High-adhesion water-based green tire outside paint	17
<b>Rhenodiv® OP-9218**</b>	Aqueous suspension of fillers and bonding agents	Black low-viscosity suspension	High-adhesion water-based green tire outside paint	11
<b>Rhenodiv® OP-9430</b>	SBR compound with mineral filler	Black liquid	Outside anti-blemish paint	25
<b>Rhenodiv® OP-98</b>	SBR compound with mineral filler	Black liquid	Water-based, non-flammable blemish removal agent	12

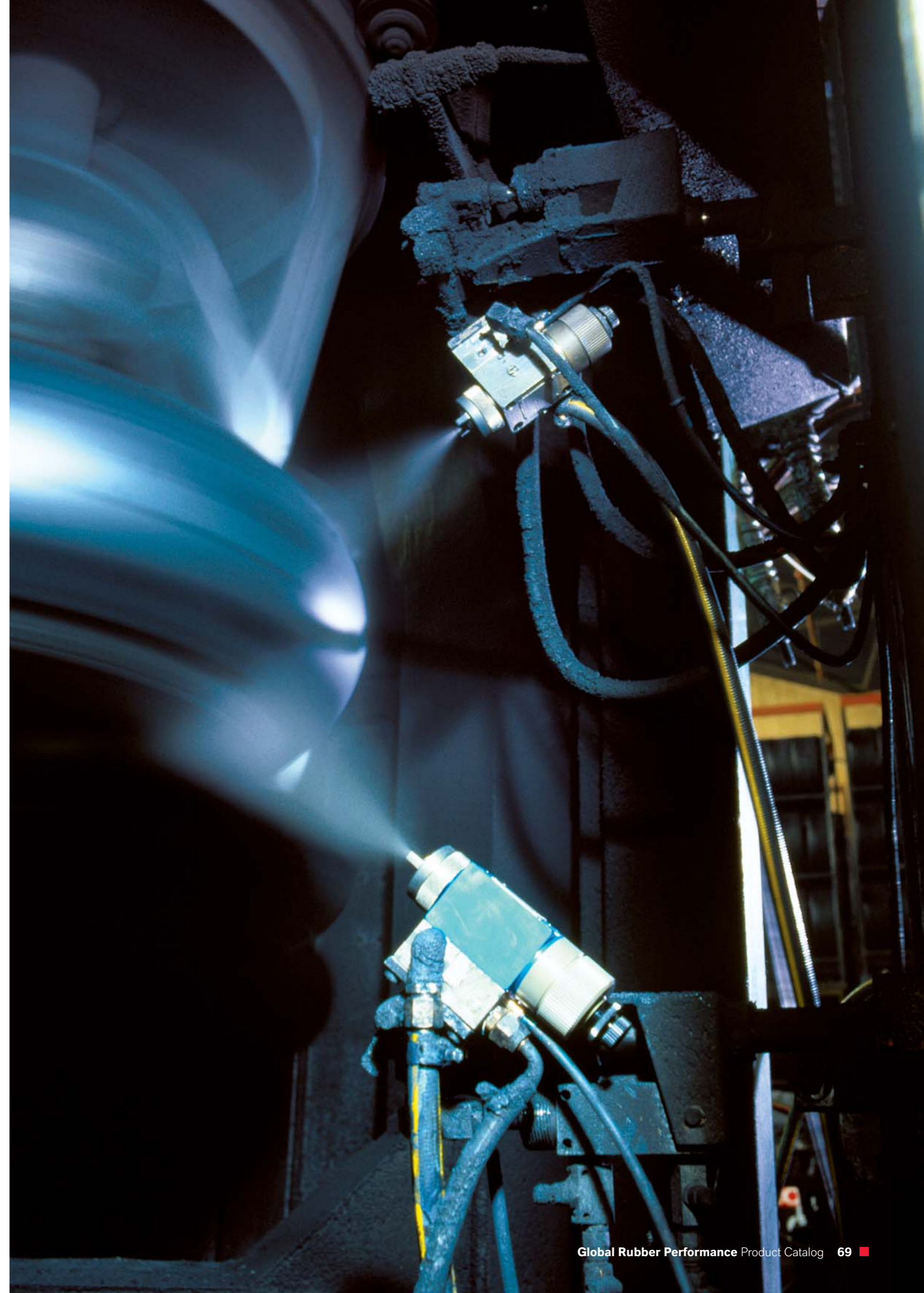
\* not available in EMEA / \*\* only available in APAC

### Tire systems: Finishing and Protection Paints

Tire finishing and protection paints are ready-to-use outside tire paints for cosmetic repairs of cured tires (non-glossy). All **Rhenodiv® FP** grades are water-based and free of VOC.

Article	Chemical composition	Appearance, supply form	Characteristics	Solid content %	PCR, LCV, Moto
<b>Rhenodiv® FP-26</b>	Water-soluble polymer, pigment	Blue liquid	Water-removable paint to provide protection on white tire sidewalls and other cured rubber surfaces	18	X
<b>Rhenodiv® FP-41</b>	Mixture of SBR latex with mineral fillers and carbon black	Black liquid	Non-glossy outside tire paint for masking small touch-up buffings or for repairs on cured tires	25	X
<b>Rhenodiv® FP-444</b>	Water-based dispersion of polymers, fillers and pigments	Black liquid	Rhenodiv® FP-444 provides tires with a finish closely matching the appearance of new tires	28	X
<b>Rhenodiv® FP-45</b>	Water-based dispersion of polymers, fillers and pigments	Black liquid	Paint for masking of minor cosmetic, touch-up buffing or repairs on cure tires, compatible with any type of rubber compound, excellent fixing and covering properties	25	X
<b>Rhenodiv® FP-61</b>	Water-based dispersion of polymers, fillers and pigments	Black liquid	Paint for masking of minor cosmetic, touch-up buffing or repairs on cure tires, compatible with any type of rubber compound, excellent fixing and covering properties	20	X
<b>Rhenodiv® FP-900C**</b>	Preparation of polymers with mineral fillers and carbon black	Black liquid	Water-based, ready-to-use outside tire paint for masking small touch-up buffings or for repairs to cured tires	25	X

\*\* only available in APAC



### Tire systems: Tread Marking Paints

Rhenomark® Tire marking paints are the benchmark in tire marking: ten brilliant colors plus white:

- easy to apply, short drying time
- completely water-based, solvent-free, and free of heavy metals and VOC
- the brilliance of the colors endures curing of the tire and lasts throughout the storage time of the tires



Article	Product subgroup	Chemical composition	Appearance, supply form	Colours	Characteristics	Solid content %
Rhenomark® MP	High-density tire marking paints, no-mold-fouling formulation	Aqueous dispersion of pigments, containing polymers	White medium-viscosity liquid	White, red, green, blue, yellow, brown, orange, purple, pink, lime, gray	High-density water-based tread marking paint, free of VOC, anti-mold-fouling formulation	55
Rhenomark® PI	High-performance tire marking paints	Aqueous dispersion of pigments, containing polymers	Pink medium-viscosity liquid	White, red, green, blue, yellow, brown, orange, purple, pink, lime, gray	Medium-density water-based tread marking paint, free of VOC	50

### Batch-off release agents

Batch-off release agents (anti-tacks) are necessary to safeguard easy separation of uncured rubber sheets. Compounds, milled to sheets after mixing, are dipped in an aqueous anti-tack dispersion of release-active substances. During the so-called batch-off process, the uncured sheets are coated, dried and stacked on pallets. The batch-off release agent needs to provide the stacked sheets with sufficient anti-tack properties lasting over the entire storage time.

Sufficient in this context means that the anti-tack properties of the batch-off release agent have to ensure easy separation of the sheets and safe stacking without slipping of the sheets during transport and likewise storage. Also, the batch-off release agent needs to be fully compatible with the elastomers of the compound during downstream mixing steps.

#### Batch-off release agents: powder and pearls grades

Pre-dispersed batch-off release agents either in liquid or paste form offer the advantage of facilitated handling without dust formation. They can either be applied manually or in a batch-off process.

Product	Chemical composition	Concentration in water [%]	Appearance, supply form	Characteristics
Rhenodiv® BO-3300*	Fatty acid compound, free of silicates and phosphates	1–1.5	White to amber powder	Compound release agent in powder form for batch-off operations
Rhenodiv® BO-3300 pearls	Fatty acid compound, free of silicates and phosphates	1–2	Yellowish pearls	Filler-free anti-tack agent, which provides high temporary tack insulation between green rubber sheets; free of silicone and phosphates
Rhenodiv® BO-3400*	Fatty acid compound, free of silicates and phosphates	1–1.5	White to amber powder	Compound release agent in powder form for batch-off operations; soluble in cold water
Rhenodiv® BO-3700 pearls	Fatty acid compound, free of silicates and phosphates	1–2	Yellowish to light brown pearls	Filler-free anti-tack agent, which provides high temporary tack insulation between green rubber sheets; free of silicone and phosphates; soluble in cold water
Rhenodiv® BO-501-2	Combination of inorganic fillers, synthetic fillers, and surfactants	1.5–3	Grayish powder	Forms a thin, flexible, and non-dusting film on the surface of rubber sheets non-dusty; minimal built-up on equipment
Rhenodiv® BO-505-2	Combination of inorganic fillers, synthetic fillers, and surfactants	1.5–3	Grayish powder	Forms a thin, flexible, and non-dusting film on the surface of rubber sheets non-dusty; minimal built-up on equipment
Rhenodiv® BO-719A**	Combination of inorganic fillers, calcium stearate, and surface active substances	3–4	Gray-beige powder	Forms a thin, flexible film on the surface of uncured rubber sheets providing good release properties without dust formation
Rhenodiv® BO-7665-1A**	Combination of inorganic fillers, calcium stearate, and surface active substances	3–4	Gray-beige powder	Forms a thin, flexible film on the surface of uncured rubber sheets providing good release properties without dust formation
Rhenodiv® BO-7665-1B**	Combination of inorganic fillers, calcium stearate, and surface active substances	3–4	Gray-beige powder	Forms a thin, flexible film on the surface of uncured rubber sheets providing good release properties without dust formation
Rhenodiv® BO-7665-2**	Combination of inorganic fillers, calcium stearate, and surface active substances	3–4	Beige powder	Forms a thin, flexible film on the surface of uncured rubber sheets providing good release properties without dust formation
Rhenodiv® BO-7665-10**	Combination of inorganic fillers, calcium stearate, and surface active substances	3–4	Gray-beige powder	Forms a thin, flexible film on the surface of uncured rubber sheets providing good release properties without dust formation

\* not available in EMEA / \*\* only available in APAC

Rhenodiv® batch-off grades supplied in pearl form are unfilled anti-tack solutions. These grades offer several advantages:

- no dust formation
- pearls loadable by spiral conveyor
- optimal anti-tack characteristics without slip

Rhenodiv® BO-3300 pearls and Rhenodiv® BO-3700 pearls are filler-free, offering the following advantages:

- transparent surface of rubber sheets
- no sedimentation
- clean batch-off equipment
- reduced abrasion of mechanical parts



Rhenodiv® BO-3300 pearls



Rhenodiv® BO-505-2



#### Batch-off release agents: liquid grades

Rhenodiv® BO liquid batch-off release agents are dispersions of fatty acid salts in combination with fillers in water. They are easy to dissolve in water. Rhenodiv® BO liquid grades are applicable for batch-off processes, too.

Product	Chemical composition	Concentration in water [%]	Appearance, supply form	Characteristics
Rhenodiv® BO-1016***	Combination of fatty acid salts, free of silicones and phosphates	5–10	White-yellow dispersion	Batch-off release agent for uncured rubber sheets
Rhenodiv® BO-1019***	Combination of fatty acid salts, free of silicones and phosphates	5–10	White-yellow dispersion	Batch-off release agent for uncured rubber sheets
Rhenodiv® BO-7672-1	Combination of salts of fatty acids and calcium stearate	4–10	White-yellow dispersion	Liquid compound release agent for sheets
Rhenodiv® BO-7672-2	Aqueous solution of a blend of fatty acid salts with water-soluble high-molecular substances	5–10	White to yellow viscous liquid	Liquid compound release agent for uncured rubber sheets
Rhenodiv® BO-LE	Combination of fatty acid salts with high-molecular water-soluble substances	5–20	Yellowish aqueous paste	Forms a thin, stable film on the surface of the rubber compounds
Rhenodiv® BO-LL	Aqueous solution of a blend of fatty acid salts with water-soluble high-molecular substances	5–20	White to yellow viscous liquid	Liquid compound release agent for uncured rubber sheets

\*\*\* only available in Americas

#### Mold, hose and internal release agents

Rhenodiv® SI-V is an aqueous emulsion of medium viscosity silicone oil in combination with other release active substances. Rhenodiv® MR grades are silicone-based mold release agents. Rhenodiv® MR-30/1 is silicone-free.

Compound release agents like Rhenodiv® DALE 667 are used for an easy release of the rubber mix from the internal mixer. Rhenodiv® HR-795 is a multi-purpose release agent used for hoses and latex mattresses.



Product	Chemical composition	Concentration in water [%]	Appearance, supply form	Characteristics
Rhenodiv® SI-V	Aqueous emulsion of a medium viscosity silicone oil and of substances for enhanced release properties	1:1	White turbid liquid	Vulcanizates demolded by use of Rhenodiv® SI-V characterised by high gloss and pleasant haptic
Rhenodiv® MR-60	Aqueous emulsion of reactive silicone polymer and special surfactants	1:5–1:15	White turbid liquid	Demolding agent vulcanizates made of natural and synthetic rubber
Rhenodiv® DALE 667	Combination of fatty acids and synthetic waxes	1–3 phr	White-yellow pellets	Lowers the viscosity compound and exhibits a tendency to migrate to the surface of the uncured rubber compound
Rhenodiv® HR-687-5	Mixture of polyfunctional alcohols	1:2	Yellowish liquid	Liquid hose-release agent facilitating mounting and the removal of the hose on resp. from the mandrel; silicone-free
Rhenodiv® HR-795	Mixture of high-molecular-weight surfactants and polyfunctional alcohols	Hose: '50 Mattresses: '8–10	Light yellow liquid	Hoses, latex mattresses

