GEZOLAN

FURTHER THAN YOU THINK

Granulogy: Success based on knowledge of rubber.


EPDM granules of the highest quality for sports and recreational surfaces.

Introduction

Some time ago, we were presented with the challenge of making our knowledge about rubber mixtures easier to understand for non-professionals who want to learn more about how EPDM and other elastomers are developed and produced and what their special characteristics are.

This task has proven to be very difficult. As various experts of Gezolan and scientists from our sister companies in the Kraiburg Group became involved, the challenge appeared to be come even greater.

The project lasted significantly longer than expected. Combining know-how gathered over more than 40 years and then concentrating it into a few pages for an audience of interested parties is a very stimulating, yet difficult task.

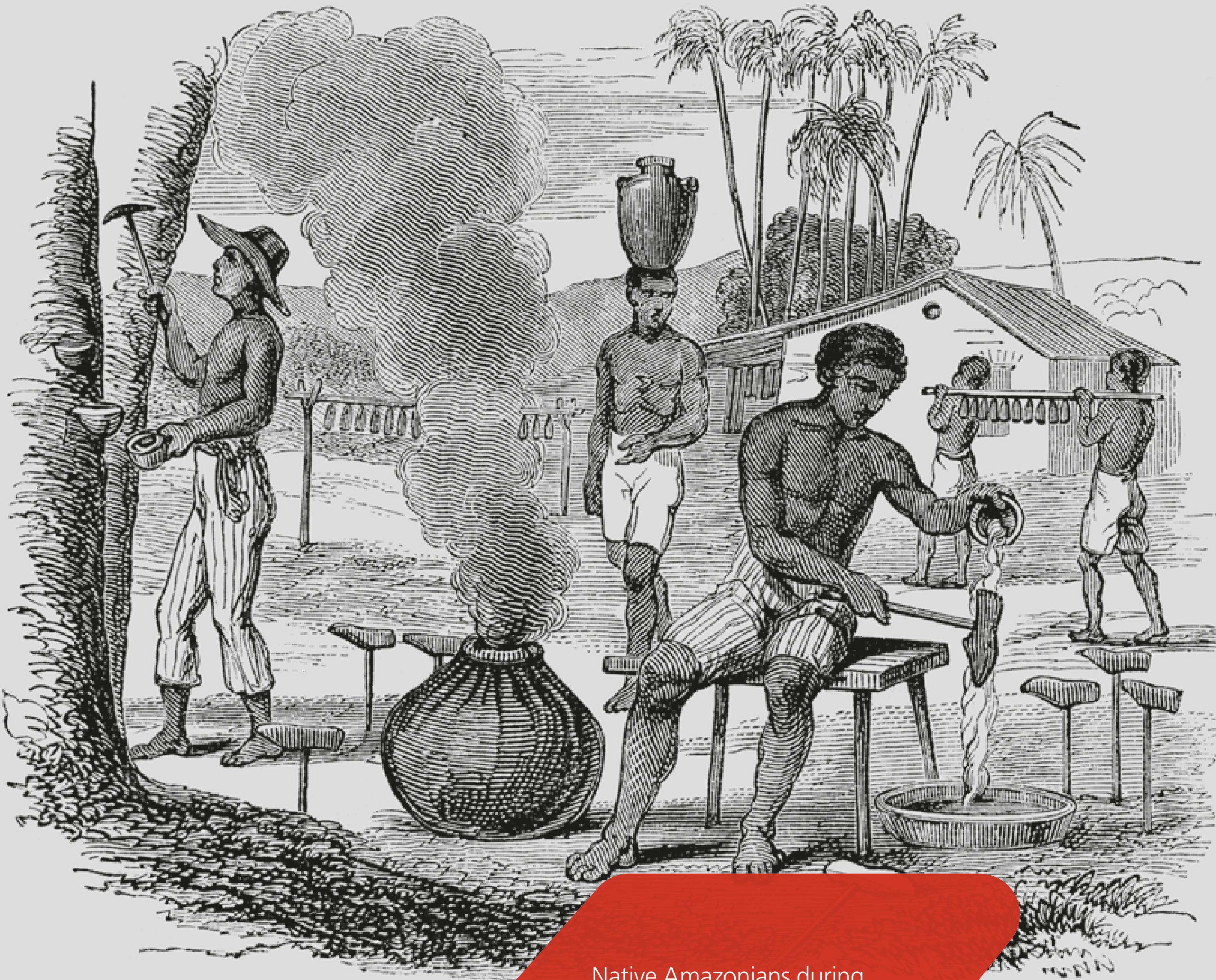
Thanks to the engineering skills and intuition of my predecessor, and thanks to the know-how and support of Kraiburg Holding, a new, ground-breaking continuous production process was developed. This patented technology is now in its third generation and remains equalled within our sector.

Our highly motivated team has brought Gezolan AG to the very pinnacle of our sector. Technological leadership, innovations and added value are concepts that are deeply rooted in the company culture of Gezolan.

I would like to thank the generation that made the realisation of this dream a possibility, as well as my current colleagues, whose commitment and desire for success are second to none.

I am proud to be able to offer you this compendium of information and I hope it will contribute to your success. I hope that you find the reading to be interesting and enjoyable.

Josep Roger, CEO



Native Amazonians during
the rubber harvest at
a caoutchouc plantation.

The history of caoutchouc

It took hundreds of years for caoutchouc and its synthetic successors to conquer the world. Known in Europe since the time of Columbus and the discovery of the Americas, it took two drastic events to pave the path for rubber. Goodyear is the name of an important pioneer and is still a well-known product.

The history of modern polymers began long ago and it took many years of research and development to arrive at the current state of technology.

The first reports of the indigenous peoples of the Amazon and their use of rubber first appear in the history books at the time of Christopher Columbus and the conquest of the Americas. It is known, among other things, that the natives played with a rubber-like ball made from dried milk from a tree.

It was not until nearly three hundred years later, in 1736, that Frenchman Charles Le Condamine sent a package with caoutchouc to Paris from the Amazon. Le Condamine was on an expedition and provided the first detailed report on the use of the material by the indigenous people. One of his fellow countrymen, François Fresneau, spend the following years on location researching and documenting caoutchouc and sent numerous reports back to Europe. He discovered that latex milk is soluble in turpentine, which first made transport over great distances possible. From that point on, a new age in caoutchouc production began.

A pioneering and still important event in the history of caoutchouc processing is the invention of vulcanisation by Charles Goodyear in 1839. This process makes it possible to convert plastic caoutchouc, which has very low heat and ageing resistance, into elastic rubber.

Charles Goodyear, founder of vulcanisation in 1839

One of the main milestones in the modern chemistry of polymers was achieved during the World War II. There was an extremely high demand for rubber products at the time, which caused a considerable shortage in their availability. As a result, there was a strong motivation among the various international forces to conduct uninterrupted research. The earlier discovery that the characteristics of caoutchouc – or natural rubber – can be modified by cross-linking latex with some chemical products established a new direction in research. The aim is to create long molecular chains by beginning with specifically chosen monomers. This makes it possible to cross the elastic properties of natural caoutchouc with alternative raw materials. The result is the discovery of modern polymers, which initially included elastomers and thermoplastics, with the later addition of thermoplastic elastomers.

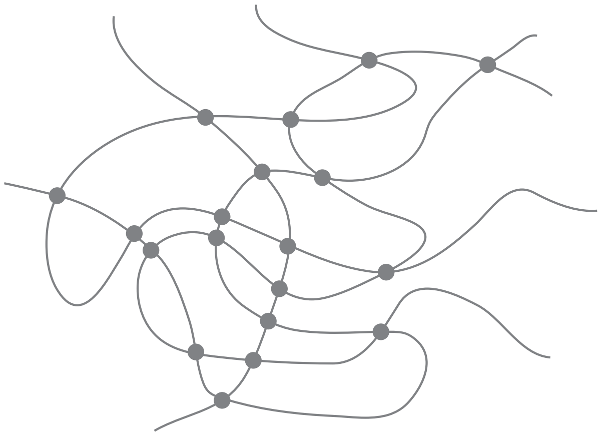
The milk (latex) of the caoutchouc tree is the basis for production of natural caoutchouc.

The basic raw material

Synthetic caoutchouc, the synthetic alternative to natural caoutchouc, excels over its natural forefather with its specific characteristics. The base product of these new elastomers is special fractions of crude oil. The material is distinguished by high elasticity, flexibility and resistance to heat, ozone and oxidation. There are basically two different elastomers that are important for modern production of granules. They differ primarily in their behaviour when heated.

Normally, elastomers are thermally stable polymers. The long polymer chains are linked during the hardening process. The molecular structure of elastomers can be described as a structure of ‘spaghetti with meatballs’, wherein the meatballs represent the links. The elasticity is based on the agility of the chains to change in position and distribute tension. The covalent bond ensures that the elastomer returns to its original position as soon as tension is no longer applied. Elastomers are extremely flexible and can be stretched by 5 % to 700 %, depending on the specific type of material.

Special fractions of crude oil are the base product for elastomers



The molecular structure of elastomers can be described as a structure of 'spaghetti with meatballs', wherein the meatballs represent the links.

Thermally stable elastomers, such as EPDM have outstanding resilience and are highly resistant to atmospheric influences.

With its specific properties synthetic caoutchouc is superior to natural caoutchouc.

The elastomers can be classified as follows according to their behaviour at high temperatures:
Thermoplastic elastomers These elastomers become soft and formable as the temperature increases, although their properties do not change if they have been melted and formed repeatedly. This category includes styrol thermoplastics such as SBS and SEBS, olefins (TPO), vulcanised thermoplastics (TPV) and thermoplastic polyurethane (TPU).

Thermally stable elastomers These elastomers do not change in form and retain their strength. The majority of elastomers, including EPDM, are part of this group.
EPDM (ethylene, propylene, diene, monomer (M-class)) is an elastomer with excellent resistance to abrasion and wear. It also has very good properties as electrical insulation, such as very good resistance to atmospheric influences, media containing acids and alkali and especially chemical products. However, it is susceptible to attacks from oils and petroleum.

Caoutchouc mixtures such as those based on EPDM are produced from formulations that include a multitude of organic and inorganic components. Between 20 and 30 components can be used in a formulation. The diversity with which its properties can be changed through various combinations is one of the most noteworthy features of rubber technology. In general, a typical formation consists of an elastomer base, reinforcing agent, additives to promote the process, counteract decomposition and promote the vulcanisation system.

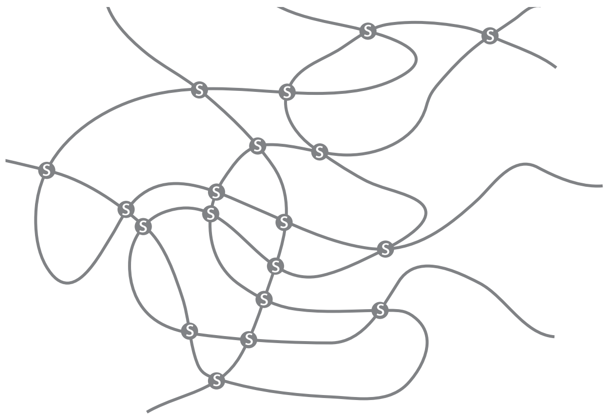
Vulcanisation and cross-linking

The vulcanisation stage is required to change the plastic caoutchouc to an elastic and thermoplastic state. The loose, disorderly molecular chains are cross-linked during the process with sulphur or peroxide. These links ensure that the molecular chains return to their original position after force is applied.

The vulcanising agents are used to delay or accelerate the cross-linking system. These are chemical substances that form a three-dimensional network and establish links between the segments of the chain due to reaction with the rubber molecules. This process is known as vulcanisation, hardening, cross-linking or linkage. The tensile force, hardness and resistance to wear are increased with vulcanisation and the elongation, permanent compression and solubility are reduced as a result. Resistance to tension and elongation at break show are optimised thanks to the changes that arise due to the degree of cross-linking.

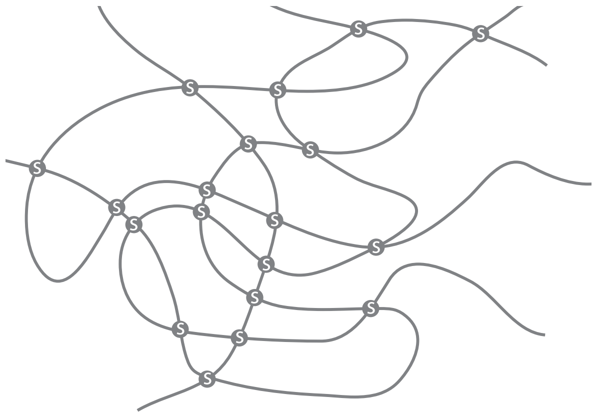
A vulcanisation system with sulphur is the most frequently used vulcanising agent for the production of rubber. Sulphur is insoluble in rubber, which makes it migrated to the surface before the vulcanisation. It is inexpensive, has very low toxicity and is also compatible with other additives.

Loose molecular chains that are disorderly intertwined.



Molecular chains linked with sulphur.

After tensile force is applied, the molecular chains remain offset and the thermoplastic does not return to its former position.



The three-dimensional cross-linking keeps the molecular chains together; after force is applied, the elastomer draws back together to its original form.

A vulcanisation system with peroxide is the most common system among sulphur-free systems. It is generally used for rubbers with an elastomer base that does not contain any double linkages in its molecular structure and thus cannot be vulcanised with sulphur, because an alternative vulcanisation process that is capable of reacting with only one linkage is required. Although the formulations based on vulcanisation with peroxide have good thermal ageing and flexibility properties, precautions must be taken during the handling and storage, because it involves substances with risks that can generate an unpleasant odour. It also involves substances that react with other components, which is why the use of antioxidants is limited.

The vulcanisation must take place without oxygen, because with the presence of oxygen the transfer radical of the rubber chain oxides and the degradation process begins.

Sulphur is the most widely used cross-linking agent for vulcanisation.

The process

In formulations with partially up to thirty different components, the focus is on the correct mixture and distribution of ingredients.

The **mixture** of individual components and simultaneous distribution – dispersion – in the polymer matrix is a significant stage in the production of rubber and the manufacture of TPE / TPV mixtures.

In the rubber industry the mixture, the compound, is usually produced discontinuously in so-called internal mixers after a precisely defined mixing procedure. TPE / TPV are normally mixed continuously in extruders and auger mixers. This process is also applied for the production of compounds in the rubber industry in isolated cases. Continuous mixing in extruders for the production, such as the process used at Gezolan, is advantageous, because the granules can be produced immediately after exiting the extruder.

The cross-linking – vulcanisation – takes place in a second stage or, in continuous production,

immediately after exiting the extruder. The vulcanisation processing time is controlled and the process temperature is regulated to 150 to 220 °C. The cross-linking of TPV usually takes place in situ – i.e. during the mixing process or with addition of pre-cross-linked polymers.

Depending on the technology that is used, the **granulation** takes place in an additional step or the granules after extrusion and subsequently vulcanised are produced in the desired grain size in the granulating plant. The fine dust arising in the process and / or the rubber dust can be added to the respective base compound for the next production without a reduction in quality.

Mixture of individual components → Vulcanisation at 150 to 220 °C → Granulation in the desired grain size

Granulation to the desired grain size.

Which elastic granules are used for today’s sports facilities?

The use of ground coverings for sport is divided into four major categories: Granules made of recycled tyres (wrongly referred to as SBR granules), granules made from recycled rubber, EPDM granules and TPE / TPV granules.

The granules that originate from recycled tyres or other types of rubbers are not addressed in this document, because they have a pre-existing formulation and have not been created specifically to fulfil the required function of a synthetic ground covering for sporting activities, although these products are commonly used for this type of application with the benefits and risks that their use entails.

	EPDM	TPE / TPV
Resistance to mineral oil	poor	poor
Elasticity	satisfactory	poor
Ozone resistance	excellent	excellent
UV resistance	satisfactory	satisfactory
Mechanical strength	satisfactory	poor
Compression	satisfactory	poor
Acid resistance	excellent	excellent
Hydrolysis resistant	excellent	excellent
Quality	CONSTANT	CONSTANT
Heat resistance + °C	130 °C	
Cold resistance – °C	50 °C	
Pollutant content	DEEP	DEEP
Colours	ARBITRARY	ARBITRARY

excellent satisfactory poor

Are conventional thermoplastic granules suitable for use in synthetic surfaces and artificial turf?

Rubber, such as EPDM granules, and TPE or TPV granules can be tailored by the manufacturer, i.e. adapted, formulated and produced to suit the respective application.

The elastic behaviour of polymers depends heavily on the molecular structure. The macromolecules of thermoplastics, thermoplastic elastomers and – with the exception of natural caoutchouc – all types of caoutchouc, including EPDM, are manufactured synthetically. The original product is special fractions of crude oil (mineral oil). With the polymerisation of monomers, the molecular structure and distribution of components is determined with copolymers or terpolymers.

Thermoplastics, TP, usually having long-chained, linear and non-cross-linked macromolecules, generally have a low elasticity within a limited temperature range in comparison with elastomers and TPE / TPV. They are thermally formable and soften at higher temperatures, which means they are not suitable for use in synthetic surfaces and artificial turf.

Thermoplastic elastomers, TPE or TPV, are only permanently elastic within a limited temperature range – although it is wider than that of TP. The elasticity is usually lower due to the lower number of chemical cross-linking points with TPV, or the purely physical cross-linking with TPE.

Elastic polymers, such as **caoutchouc,** are usually characterised by claw-like, crystalline or amorphously structured molecular chains. With a cross-linking of macromolecules that can be carried out with **caoutchouc,** the shift and flow under the influence of heat.

The chemical, wide-meshed **cross-linking** of caoutchouc with sulphur or peroxide, usually at temperatures of at least 150 °C, the **vulcanisation,** produces a thermally stable product that is also permanently elastic – **rubber** or **elastomer.** The sporting and protective properties are maintained to the greatest possible extent in the temperature range to be expected.

Vulcanising agents are used to enable the cross-linking system

The high-performance EPDM
surface complies with
all existing national and
international standards.

EPDM rubber granules

EPDM is the predestined elastomer for all outdoor applications and is the first choice for use in sports facilities.

The saturated ethylene-propylene polymethylene main chain of the polymer (no double bond susceptible to ozone and oxygen) assures very good resistance to weathering and ageing. Even unprotected, this is better than typical tyre rubber mixtures having elastomers with reactive double bonds in the main chain and which, without appropriate stabilisation with antioxidants and antiozonants, can only withstand use outdoors at higher temperatures for a short time without a loss of function.

The thermally stable properties are only achieved by means of cross-linking with sulphur or peroxide. As is the case with all elastomers, the correct selection and quantity of fillers, softeners, UV stabilisers, cross-linking system and polymers will significantly change and optimise the properties. For instance, EPDM polymerisation can vary according to ethylene or propylene content, the type and quantity of diene and in molecular structure and thus have different basic properties.

Forty years of know-how for the GEZOFLEX product group (main application for athletics, multi-purpose fields and children's fall protection) and extensive experience for GEZOFILL (scatter granules for artificial turf) have enabled the high quality level of GEZOLAN EPDM rubber granules. Experience, continuous adjustment to increasing demands (KVP), select raw materials, the modern, computer-controlled continuous production and consistent process and quality monitoring (ISO 9001 since 2003) guarantee the quality of GEZOLAN EPDM rubber granules that our customers value.

The granules of both product groups can be dyed according to customer wishes. There are currently 21 different colours available to choose from. The colour consistency after UV weathering is tested and monitored outdoors and in our laboratory (with xenon and QUV testing).

Colour granules heat up significantly less in solar radiation than black recycled tyre rubber granules. The existing national and international regulations and standards are fulfilled without limitation by the GEZOFLEX products for synthetic surfaces and GEZOFILL for artificial turf.

Our EPDM rubber granules are cross-linked with sulphur like the elastomers in tyres. The cross-linking system for GEZOLAN EPDM granules is precisely attuned to existing environmental requirements. For instance, the zinc content was reduced to level that is unusually low for the rubber industry. The softener used by GEZOLAN is aroma-free and, in contrast to the aromatic or naphtenic softeners used in tyre mixtures, have the lowest PAK content, at a level that is irrelevant for the environment. A strict consideration of environmental requirements also applies for the other ingredients.

Granule manufacturers carried out cross-linking of EPDM granules with peroxide instead of sulphur. The purpose was to facilitate compliance with environmental requirements. Unfortunately, presumably due to incomplete cross-linking, adhesion and clumping of the artificial turf filler granules occurred after only a short period of use, which is the equivalent of a total loss of function. This resulted in a general uncertainty of the use of EPDM granules in the market.

With a correctly adjusted cross-linking system and sufficient cross-linking conditions (time and temperature), however, our experience has shown that sulphur cross-linked and peroxide cross-linked EPDM rubber granules are suitable for practical use in compliance with environmental requirements.

With the use of microporous GEZOLAN EPDM granules, the functional properties for sport and protection can be further optimised. The reduced density or volume increase achieved in the process means less material is needed by the user and thus a lower price.

Requirements on flame resistance in accordance with EN13501-1 are met without the use of toxic, environmentally harmful halogen or phosphorous compounds.

EPDM granules demonstrate good resistance to water, antifreeze and diluted acids. However, like other granules, they are not resistant to mineral oils and fuels.

The adhesion, cohesive bonding, of GEZOFLEX granules with polyurethane bonding agents has been demonstrated to be very good for GEZOLAN granules due to the formulation of the recipe specifically for this purpose. It is better than the PUR adhesion of tyre granules, which is reduced due to the migration of microcrystalline growth on the granule surface.

EPDM granules are thermally recyclable in bonded and non-bonded form, which means the energy used for the production can be recycled through combustion in incinerators or in the furnaces of the cement industry.

TPE/TPV granules

TPE/TPV granules are mainly used as filler for artificial turf. Due to the difference in quality of various TPE/TPV materials, a differentiation between suitable and unsuitable materials must be made for filler granules. Like EPDM granules, the correct formulation is crucial for long-term suitability in artificial turf – in other words, the choice of polymers, filler material, softeners, UV stabilisers and cross-linking agents (only for TPV granules).

The suitable TPE/TPV granules can have similar basic properties as EPDM granules. Nevertheless, due to the lower cross-linking of polymer chains, **limited performance at higher environmental temperatures** must be taken into consideration.

At **lower temperatures** the reversible **hardening is greater than** that of recycled tyre and EPDM granules.

Like all thermoplastics, **TPE / TPV** are **basically recyclable,** with an expected period of use of more than 10 years. However, a loss in value must be taken into account due to degradation of the polymers. With the use of granules in artificial turf, mixture with sand or protective ingredients is possible, which complicates an original recyclability.

A pattern of characteristics comparable to EPDM granules necessitates a **higher price.**

Also suitable for elastic surfaces: infill granules from Gezolan AG.

Experience, technology and additional expertise

Since 1968 GEZOLAN has gathered extensive experience in the production of EPDM granules for use in sports and recreational applications. The company also benefits from synergies with other companies in the KRAIBURG group, which enables access to technologies associated with rubber compounds, thermoplastics and recycling and production techniques.

Towards the end of the 1980s, we began to question the technology used for the production of rubber compounds. Over the course of innovative development, and with a sizeable economic investment, we made an enormous advancement with the conceptual design of a new production model that would result in the production of an incomparable end product. Today we still enjoy a privileged market position and a level of quality that remains unequalled by any of our competitors.

As the 1990s progressed, new market tendencies opened a new segment. The new generation of artificial turf systems for football required a filler granule that must provide the necessary elastic factor. There currently a wide variety of options for attempting to achieve this function. Based on EPDM granules,

Artistic ambience in St. Gallen: the red square made of EPDM granules.

thermoplastics, organic or hybrid filler materials and recycled products, there is a broad spectrum of solutions available to the customer.

Since this is a market niche, product requirements expand on a day-to-day basis. The rules and requirements stipulated by authorities, concerns relating to the biomechanical aspect, environmental regulations and aspects of recycling all represent very important challenges for the sector in consideration of changing conditions.
In 2001 GEZOLAN launched for first generation of the filler material GEZOFILL. It is specially formulated for this application and has been regularly updated, always on the basis of an EPDM compound. Over the course of time and after evaluation of various options and on the basis of experience that we have gathered, we are absolutely convinced that the EPDM-based components will continue to be the most reliable option for this application and for fulfilment of the expected function.

We were able to formulate a product that provides a reasonable response with respect to the playing characteristics, environmental limitations and ageing properties and simultaneously offers additional characteristics that no other product on the market has been able to match.

Glossary

Elastomers are solid, yet elastic formable plastics. The plastics can be formed elastically with tension and pressure, but then return to their original shape.

Thermoplastic elastomers (TPE) are plastics that behave similarly to traditional elastomers at room temperature, but can deform plastically with the addition of heat.

EPDM (ethylene propylene diene monomer (M-class) rubber) is an elastomer that is highly resistant to weather influences such as UV, ozone, strong acids and bases and high and low temperatures. However, this elastomer has very poor resistance to mineral oil and grease.

Rubber Name for vulcanised, elastic caoutchouc.

Caoutchouc Collective term for elastic polymers from which rubber is produced. Natural and synthetic caoutchouc are differentiated between. Natural caoutchouc is primarily composed of latex from the caoutchouc tree (hevea brasiliensis).

Latex Is a material from different types of plants that is used to produce natural caoutchouc. This term also refers to rubber products that are produced from caoutchouc.

Molecule The smallest unit of a chemical compound of two or more atoms that cannot be divided further without changing its properties.

Monomer Individual module of polymers. Each molecule exists on its own.

Polymer Basis of every plastic. Macromolecules that are formed from numerous equal or similar modules (monomers).

Polymer chain Polymers linked in the shape of a chain.

Vulcanisation Refinement of caoutchouc in which the addition of sulphur or peroxide provides the plastic caoutchouc with elastic properties.

EPDM colour spectrum of Gezolan AG.

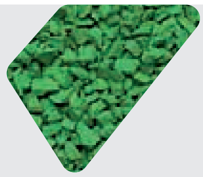
060
WEISS
WHITE
BLANC
BLANCO
RAL 9010

056
EGGSHELL
EGGSHELL
COQUILLE D’OEUF
CÀSCARA DE HUEVO
RAL 1015

066
BEIGE
BEIGE
BEIGE
BEIGE
RAL 1014

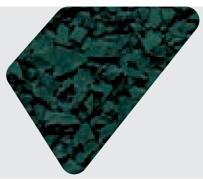
069
GELB
YELLOW
JAUNE
AMARILLO
RAL 1002

089
LEUCHTGELB
BRIGHT YELLOW
JAUNE ILLUMINANT
AMARILLO BRILLANTE
RAL 1012

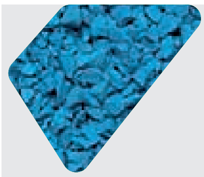


087
LEUCHTGRÜN
BRIGHT GREEN
VERT ILLUMINANT
VERDE BRILLANTE
RAL 6017

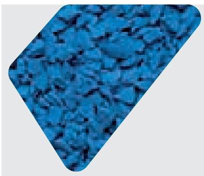
067
GRÜN
GREEN
VERT
VERDE
RAL 6021



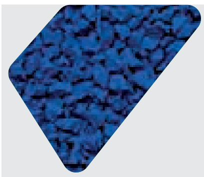
047
DUNKELGRÜN
DARK GREEN
VERT FONCÉ
VERDE OSCURO
RAL 6005



084
LEUCHTBLAU
BRIGHT BLUE
BLEU ILLUMINANT
AZUL BRILLANTE
RAL 5012

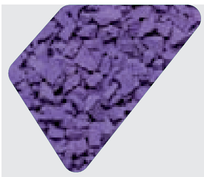


064
BLAU
BLUE
BLEU
AZUL
RAL 5015



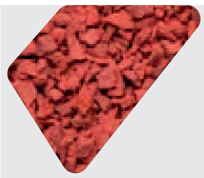
054
DUNKELBLAU
DARK BLUE
BLEU FONCÉ
AZUL OSCURO
RAL 5010

052
PINK
PINK
ROSE
ROSA
RAL 4003



044
LILA
LILAC
LILAS
LILA
RAL 4005

083
LEUCHTORANGE
BRIGHT ORANGE
ORANGE ILLUMINANT
NARANJA BRILLANTE
RAL 2008



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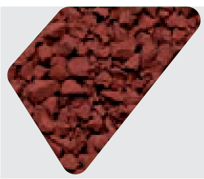
LEUCHTROT
BRIGHT RED
ROUGE ILLUMINANT
ROJO BRILLANTE
RAL 3017

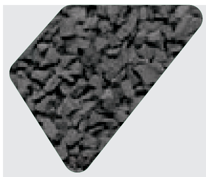


062
ROT
RED
ROUGE
ROJO
RAL 3016

076
BEIGEBRAUN
BEIGE BROWN
MARRON MOYEN
MARRÓN CLARO
RAL 8024

046
BRAUN
BROWN
MARRON
MARRÓN
RAL 8025

065
GRAU
GREY
GRIS
GRIS
RAL 7038



055
MITTELGRAU
MIDDLE GREY
GRIS MOYEN
GRIS MEDIANO
RAL 7037

045
DUNKELGRAU
DARK GREY
GRIS FONCÉ
GRIS OSCURO
RAL 7011

021
SCHWARZ
BLACK
NOIR
NEGRO
RAL 9004

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