

INVISIBLE PARTNER  
ZINC KEEPS THE BOUNCE IN RUBBER



**Zinc** Protects!



**INVISIBLE** in the finished product, zinc has long been an essential ingredient in rubber ever since the early days of rubber compounding. Zinc helps make better rubber in a variety of ways, but is best known as an activator during the vulcanising process.

## Colourful History

The history of rubber is a colourful story. The Indians of Central and South America knew rubber as early as the 11th century, but it was only in the 18th century that samples reached Europe. The English word "Rubber" was invented in 1770 by a British chemist, Joseph Priestley. One of the first uses of the substance was discovered in 1818 by a British student named James Syme, who used it to waterproof cloth to make the first raincoats, a process that was patented in 1823 by Charles Macintosh. In 1839, an American named Charles Goodyear discovered vulcanisation, when he accidentally dropped a mixture of rubber and sulphur into a fire. As he retrieved the material, he found that it was no longer sticky and instead of being brittle, snapped back to its original shape. Goodyear coined the word "vulcanisation" to describe the process of heating rubber in the presence of sulphur.

The first patent for a pneumatic tyre was granted in 1882 to John Boyd Dunlop. Zinc oxide was mainly used as a reinforcing agent until 1912, when it was replaced by carbon black, although zinc oxide continued to play a role in optimising the reinforcement process. Growing demand for tyres began to deplete natural rubber supplies and in response, rubber plantations were cultivated in India and Malaya.

## Rise of the Rubber Industry

The synthetic rubber industry was born in the United States during World War II, where production increased from 8,000 metric tons in 1941 to over 1 million metric tons in 1944. Following the war, other countries developed

their own synthetic rubber factories to avoid having to rely on overseas rubber supplies. As a result, world consumption of natural and synthetic rubber increased from less than 4 million metric tons in 1960 to more than 18 million metric tons today. The automotive industry uses about 75% of this volume, for tyres and vehicle components.

## Essential Role of Zinc

In its raw state rubber consists of long, randomly linked hydrocarbon chains that can slide past each other. Raw rubber is therefore plastic, weak and permanently deformable. The purpose of vulcanisation is to chemically link the rubber chains together by "crosslinks" to form a three-dimensional network. Although the process has become far more sophisticated since Goodyear's discovery in 1839, sulphur is still the principal agent. Other agents, notably peroxides and sulphur donors, may be used, but the bulk of natural and synthetic rubber is vulcanised with sulphur. Vulcanisation is activated by zinc oxide and stearic acid and the process is "accelerated" by the addition of small quantities of sulphur-based chemicals, which not only speed up the process, but also influence the properties of the vulcanisate, especially its resistance to ageing.

Researchers in the rubber industry continue to seek new ways to make specific processes more efficient, less costly, and more environmentally friendly. New additives, processes, rubber compounds, and technological applications are constantly being developed. Vulcanisation nevertheless remains a key process in rubber production and for over a hundred years, zinc oxide has served the rubber industry as the most cost-efficient process activator for vulcanising sulphur-cured natural and synthetic rubbers. Zinc oxide belongs to the class of chemical agents called "activators" which are used in the rubber industry to increase the efficiency of another class of ingredients, the "accelerators". By speeding up the vulcanising reaction, zinc oxide became an essential

additive that enabled faster rubber tyre production and thereby lowered the overall cost of automobiles and trucks.

Zinc oxide has many other beneficial effects on rubber, besides helping to optimise the vulcanization process. Adding zinc oxide has long been recognized as a means to protect rubber from thermal effects caused by internal friction. Zinc oxide acts as a "heat sink" which accepts frictional energy without a large increase in internal temperature. Furthermore, zinc oxide's high thermal conductivity helps dissipate local heat concentrations that might otherwise affect the properties of the rubber. The thermal properties of zinc oxide are particularly beneficial in applications such as rubber vibration mounts where loading and cyclic stresses would otherwise generate heat and degrade the rubber. Zinc oxide is also needed for bonding rubber to the steel cord of tyres and for bonding between metal and rubber in technical goods.

Zinc oxide improves not only the properties of vulcanised rubber but also assists the processing of uncured rubber in the factory. Zinc oxide is added to rubber formulations to decrease shrinkage of moulded rubber products and maintain the cleanliness of moulds. This aids productivity by increasing the number of moulding cycles that can be achieved between cleaning.

## Zinc's Many Benefits

Other benefits from the presence of zinc oxide include improved tyre wear abrasion performance and protection against UV radiation of rubber products. By absorbing ultraviolet radiation more readily than other materials, zinc oxide prevents UV radiation from penetrating into the body of the rubber compound and thereby helps to extend the life of rubber goods that would otherwise be degraded by UV radiation.

The physical and chemical properties of zinc oxide are determined largely by the method of manufacture. Most of the zinc oxide used today is

produced either by the 'direct' American Process, or the French Process, also known as the 'indirect' process. The 'direct' process was developed to treat oxidised ores or sulphide concentrates but today, this process principally uses residues from the zinc processing industry as its main raw material, thus fostering sound environmental practice. These residues are purified and treated and mixed with carbon in a furnace to form zinc vapour. The zinc gas is then drawn into a combustion chamber where it is oxidised to form pure zinc oxide. French process zinc oxide is made from zinc in metallic form, which has been vaporised and then oxidised in a combustion zone. Primary refined zinc (usually Special High Grade) or recycled zinc metal are used as starting material. A third method of production involves precipitation of zinc carbonate or hydroxide, which is then dried and calcined to remove water and/or carbon dioxide.

The efficiency of zinc oxide during vulcanisation is enhanced by maximising contact between zinc oxide particles and the fluid components of the rubber formulation. The number of points of contact is dependant on the size of the particles, their shape and specific surface area. Efficiency is increased when very small particles with a high surface area are uniformly dispersed throughout the rubber matrix.

Today's tyres are a reliable and safe product. Compared to the old two-ply of a generation ago, they are a high-tech engineering feat. The rubber industry takes pride in its technological achievements. By applying rubber cushioning to railway wheels and tracks, for example, city transportation systems are becoming quieter and smoother. Impact-resistant bumpers, shock-absorbing interiors, and crash-resistant fuel tanks on cars and trucks help prevent highway deaths and injuries. Rubber linings in reservoirs and waste ditches reduce ground and water pollution. Latex is even being used to help stabilize desert soils to make them suitable for agricultural uses. Not to mention the hundreds of everyday items based on rubber that are indispensable to modern society.

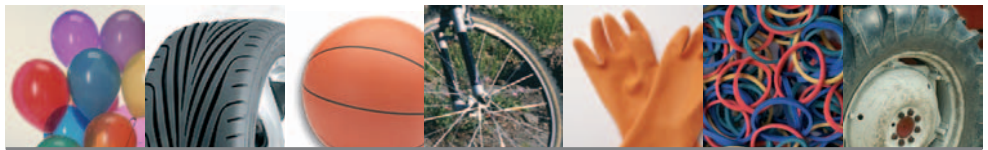
## Less for More

The use of zinc oxide in rubber compounds has evolved too. Today, significantly less zinc oxide is needed to produce high quality rubber. While this is mainly due to the discovery and use of carbon black and the development of tubeless tires, the use of zinc oxide has also been optimised. The combination of application know-how and improved production techniques has enabled zinc oxide to maintain its role as a key functional ingredient in rubber compounds. Today's passenger car tyre typically contains only about 100 grams of zinc oxide.

Consumption of zinc oxide in the United States, Western Europe and Japan is around 580,000 metric tons (1999). In the U.S., the rubber industry is the major market for zinc oxide, accounting for approximately 60% of consumption. Zinc oxide use in tyre applications is expected to increase modestly over the next five years. In Europe, some 40% of zinc oxide is used in rubber production and approximately 50% in Japan.

## Sustainability and Zinc

Zinc is natural, recyclable and inherently part of our environment. It is the 17th most common element in the earth's crust and an essential element for man, animals and plants. Specifying zinc is an environmentally responsible choice, in line with today's need for sustainable materials. Zinc is recyclable and can be recovered from zinc-containing products via an established recycling industry, thus finding its way into new products from the steel, rubber, agricultural and pharmaceutical industries. Recycling of rubber tyres is becoming a reality and presents an opportunity to recover the small quantities of zinc they contain. The technology is presently in its infancy but regulatory pressures on end of life products is likely to advance rubber tyre recycling in coming years.



For more information about zinc and sustainable development, please visit

**[www.zincworld.org](http://www.zincworld.org)**

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