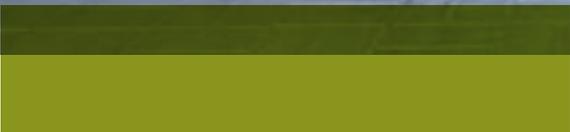
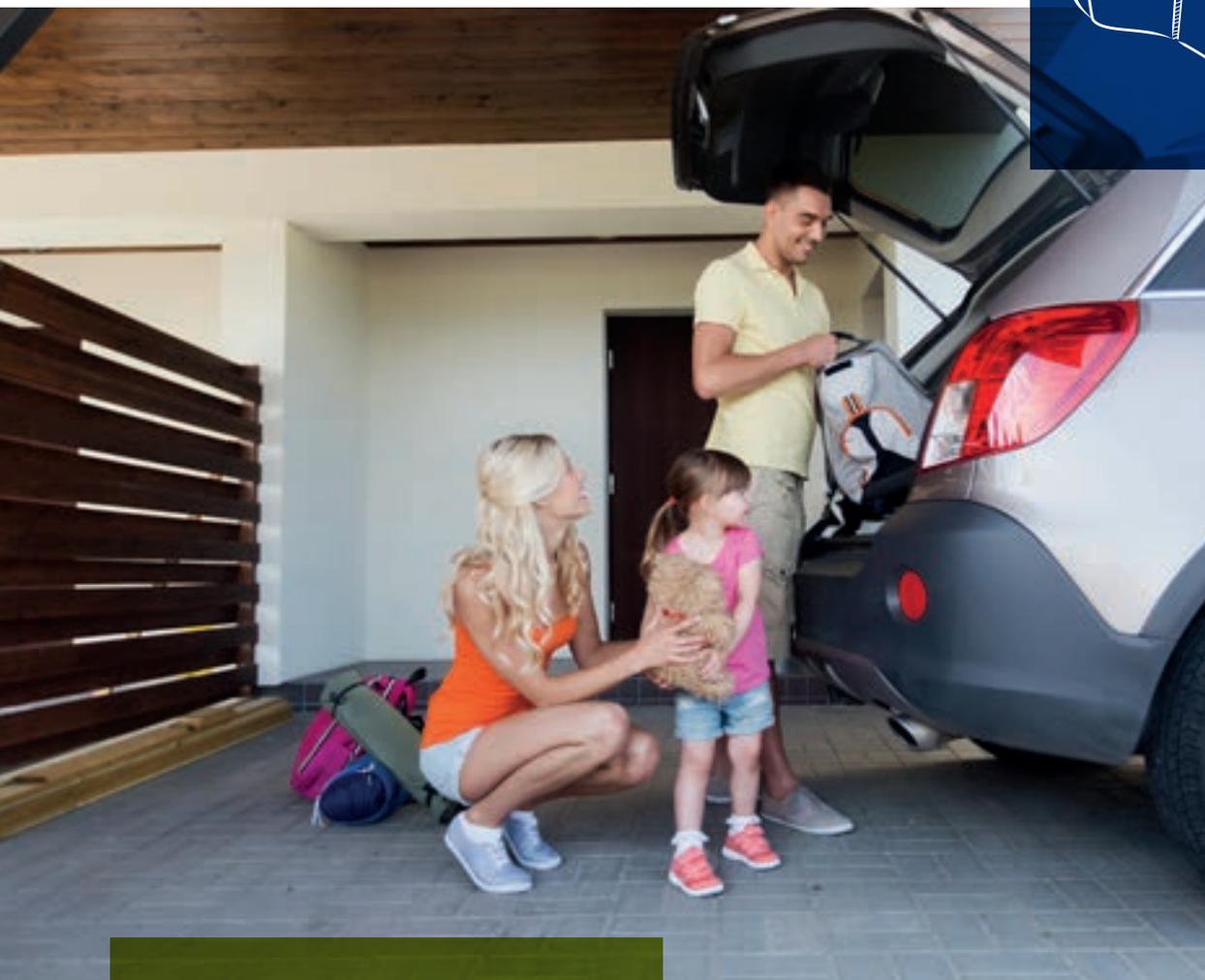


# Friction Applications

Innovative fibre solutions for safe and comfortable braking performance



# Welcome to ROCKWOOL

## Our purpose

**Release the natural power of stone to enrich modern living**

**At the ROCKWOOL Group, we are committed to enriching the lives of everyone who comes into contact with our solutions.**

Our expertise is perfectly suited to tackle many of today's biggest sustainability and development challenges, from energy consumption and noise pollution to fire resilience, water scarcity and flooding.

Our range of products reflects the diversity of the world's needs, supporting our stakeholders in reducing their own carbon footprint along the way.

Stone wool is a versatile material and forms the basis of all our businesses. With approx. 11,000 passionate colleagues in 39 countries, we are the world leader in stone wool solutions, from building insulation to acoustic ceilings, external cladding systems to horticultural solutions, engineered fibres for industrial use to insulation for the process industry and marine & offshore.



Firesafe insulation for all types of buildings and installations



Engineered stone wool solutions for global industries



Precision growing for the horticultural industry



Exterior cladding for buildings



Acoustic ceiling and wall solutions



# 39

countries in which we operate

# 11,000+

Employees worldwide

# 45

Manufacturing facilities

# This is Lapinus

**Lapinus is the world leader in precision-engineered stone wool solutions. We develop and supply versatile and innovative products that help global industries to improve quality of life.**

Our products are used in a wide range of applications, including friction, water management, tracks, coatings, gaskets and fences.

With more than a quarter-century of expertise and experience, we work closely with customers to adapt to their ever-changing needs, from water management to fire safety, vibration isolation to noise and dust emission reduction.

Made from 100% stone, our sustainable products contribute to shaping a better world for today and tomorrow.

Lapinus is part of the ROCKWOOL Group.

 **Friction**  
Innovative fibre solutions for safe and comfortable braking performance

 **Tracks**  
Vibration control solutions for pleasant rail-side living conditions

 **Water management**  
Natural solutions for sustaining water resilience

 **Fences**  
Noise fences for quiet and peaceful living environment

 **Coatings**  
High performing mineral fibres for durable and fire protective coatings

 **Gaskets**  
Thermal resistant mineral fibres for high performance sealing solutions



### Release the natural power of stone to enrich modern living

At Lapinus, we are dedicated to provide solutions that will enable everybody to improve the future. Within the global industry we identify trends and challenges driving the development of tomorrow's products. Using our knowledge of stone wool we design solutions that have a positive impact on safety, emissions, noise, vibration, water management and will improve the quality of life. By developing and sharing our own knowledge and expertise we contribute to solving the challenges of our customers.



### Our contribution to a sustainable future.



#### Ensure safety

All Lapinus products are made from natural stone and are biosoluble. They are safe for humans and the environment.



#### Reduce fine dust emissions

Friction formulations reducing wear of car brakes contribute to a reduction of fine dust emissions.



#### Control vibration

Rail tracks with reduced ground-borne vibrations have a positive influence on a comfortable living environment.



#### Reduce noise

Car brakes that produce less noise and fences that reduce ambient noise result in a healthier society.



#### Manage water

Water management systems that actively regulate water contribute to a resilient infrastructure and sustainable modern living.



#### Disseminate knowledge

We generate knowledge and share it with our stakeholders to help solve their challenges.

To address the global challenges, the UN has identified **17 UN Sustainable Development Goals**:



As part of the ROCKWOOL Group, we actively contribute towards achieving **10** of the 17 goals.

Together with our group, we are **committed** to the **sustainable goals by 2030**:

#### Health, Safety and Wellbeing:

- Driving a zero accident culture

**10%** reduction in LTI per year   **0** fatalities per year

#### CO<sub>2</sub> Emissions and Energy:

- Reduce CO<sub>2</sub> from factories (t CO<sub>2</sub>/t Wool)

**10%** by 2022 ↓   **20%** by 2030 ↓↓

- Improve energy efficiency in own (non-renovated) building stock kWh/m<sup>2</sup>

**35%** Savings by 2022 ↑   **75%** Savings by 2030 ↑↑

#### Water Management:

- Reduce water consumption in factories (m<sup>3</sup>/t Wool)

**10%** ↓ by 2022   **20%** ↓ by 2030

#### Circular Economy:

- Increase the number of countries where we offer reclaiming of products from the market

**15** ↑ countries by 2022   **30** ↑ countries by 2030

- Reduce landfill waste

**40%** ↓ by 2022   **85%** ↓ by 2030

# Global trends and challenges

Discover the future for friction industry

## Comfort

Evidence shows that 40% of European citizens experience annoyance from traffic noise<sup>1</sup>. Brake noise is a contributor to this, making it a key focus for the friction industry. Bringing comfort by continuously improving noise performance, without compromising friction performance, is one of the main tasks for brake producers.



## Non-exhaust PM Emissions

While exhaust emissions are reducing significantly thanks to stricter regulations, non-exhaust emissions have become the main source of traffic particulate matter (PM) emissions. These account for over 90% of PM<sub>10</sub> and 85% of PM<sub>2.5</sub> emissions from traffic<sup>2</sup>. Up to 55% of non-exhaust traffic related PM<sub>10</sub> emissions in urban environments is caused by brake wear<sup>3</sup>.

## Electrification

The tightening regulations on CO<sub>2</sub> emissions and usage of fossil fuels have boosted the popularity of electric vehicles. In 2030, the share of electrified vehicles is expected to rise up to 50 percent of new-vehicle sales<sup>4</sup>.





## Health & Safety

With an increasing focus on health and safety, compounders are facing limitations on the use of traditional raw materials (e.g. copper). Innovative solutions are needed to make sure the friction material can still perform well even under extreme braking conditions.



## Global platforms

The 'global platform' concept calls for one brake solution with the best possible combination of performance and comfort.



# Rise to friction challenges

## Lapinus for friction

At Lapinus, we offer premium quality mineral fibres and strong technical support for the friction industry. We go beyond being raw material supplier by researching the functionalities of our products together with other materials in the friction matrix. Rise to global challenges for friction, our team has continuously driven innovation for better solutions together with our customers. Rooted in sustainability, our highly biosoluble products contribute to shaping a better world for today and tomorrow.



## Why Lapinus

### Thought Leader



- 80 years of experience in stone wool production
- 25 years of expertise in precision-engineered mineral fibres
- Proven knowledge on friction applications

### Innovative



- Continuous product & service innovation
- Dedicated application development center for friction
- 10% of profit invested in R&D

### Sustainable



- Sustainable products (certified biosoluble)
- Improve safety, comfort and well-being
- Contribute to a circular economy

### Reliable



- Consistent & high product quality
- Flexible and hassle-free logistics
- Recognised as A-rated supplier
- Business stability (Part of the ROCKWOOL Group)

# Where our mineral fibres are applied

The application areas of our solutions



## Automotive

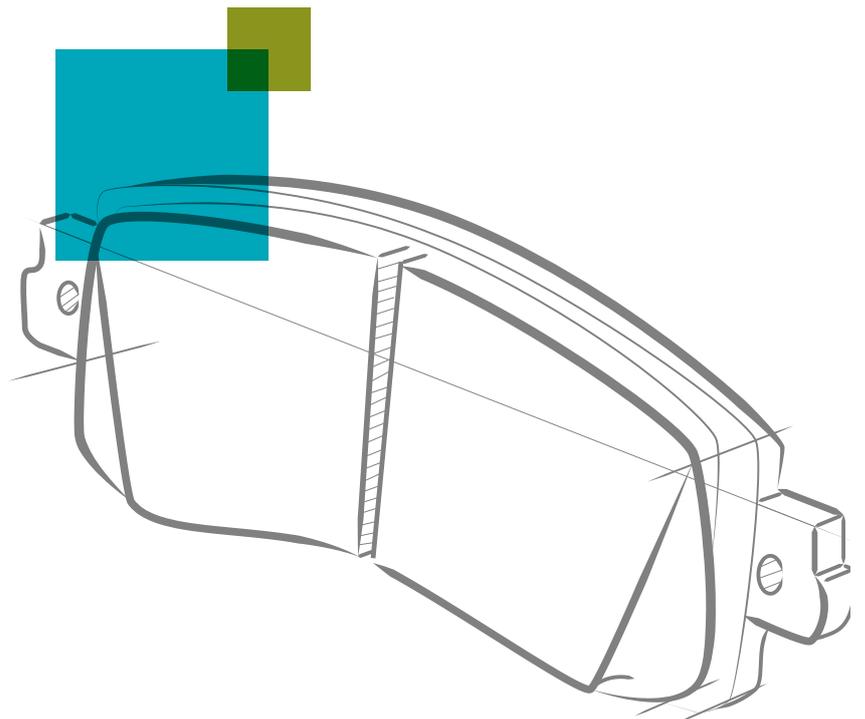
It is without doubt that brake systems are among the most important safety components in passenger cars and commercial vehicles. They must be able to stop under any circumstance. For this reason, it is crucial to have a friction material which can function under extreme conditions. For many years our mineral fibres have been used in automotive friction materials (disc pads and linings) to improve comfort, safety and durability.

## Railway

With an increased focus on comfort and noise, the railway industry globally is moving from cast iron blocks to composite friction materials. Our mineral fibres are used widely in these composites, which allow the friction material (railway blocks and pads) to perform under extreme braking conditions.

## Industrial applications

Industrial equipment, such as windmills and elevators, are equipped with various brake systems for safe operation. Our mineral fibres are used in industrial friction materials to increase efficiency, lower the cost of ownership and minimize downtime.



# Why mineral fibres for friction

The benefits of using our mineral fibres



The performance of friction materials depends on the synergy between all raw materials.

Our mineral fibres contribute to the mechanical and tribological performance of brakes.



**Increasing comfort by reducing noise (NVH)**



**Improving durability and decreasing fine dust emissions by decreasing wear**



**Enhancing safety by stabilising friction level**



# How mineral fibres work

## The working mechanisms of our mineral fibres

Braking is the result of a surface interaction between brake disc and friction material. The performance of the brake system is influenced by the formulation of the friction material. A typical friction material consists of 10 - 20 raw materials. Each raw material has a unique chemistry, size and shape and therefore a unique functionality. Finding the right balance between these functionalities is crucial in the development of friction formulations. Each raw material, including mineral fibres, has a specific function. The main purpose of mineral fibres is to facilitate other raw materials to work properly under any braking condition. They can also be engineered for different contributions to friction formulations from a tribologic point of view. The final performance of the friction material always depends on the synergy between all raw materials.



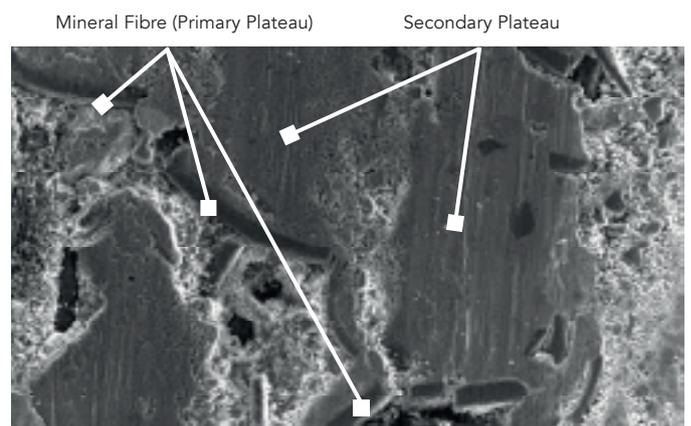
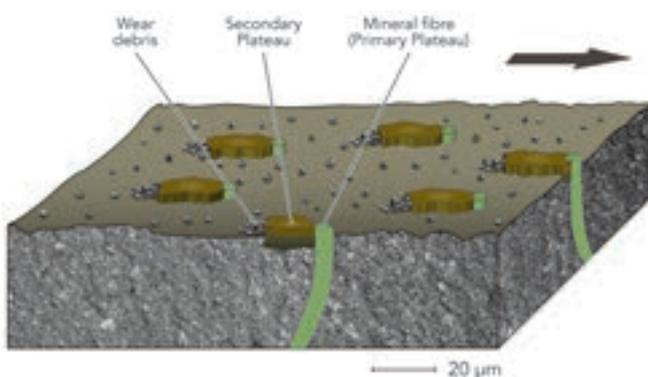
### Anchoring Effect

During braking, high shear forces are exerted on the surface of the friction material. This results in wear debris. Mineral fibres show a strong Anchoring Effect in the upper layer of the friction material. They withstand the high temperatures in the sliding surface and are in direct contact with the disc, forming a Primary Plateau. In front of the fibres, the wear debris agglomerates and forms a Secondary Plateau. This is called the Anchoring Effect<sup>5</sup>. The interaction between the Primary and Secondary plateau with the disc surface generates a Third Body Layer that is responsible for the good braking performance.

The number and size of the Primary and Secondary Plateaus have an impact on the Third Body Layer.

Smaller fibre diameters result in more fibres per weight. This way, the Anchoring Effect can be enhanced at similar fibre loadings.

The Anchoring Effect has a positive influence on the friction level: more anchoring points means a bigger contact area, resulting in enhanced friction level. If managed properly in the formulation, the advantage of having many secondary plateaus results in a less abrasive formulation and a reduction of wear and vibrations. The best Anchoring effect is achieved by using short fibres that are optimally distributed in the friction matrix.



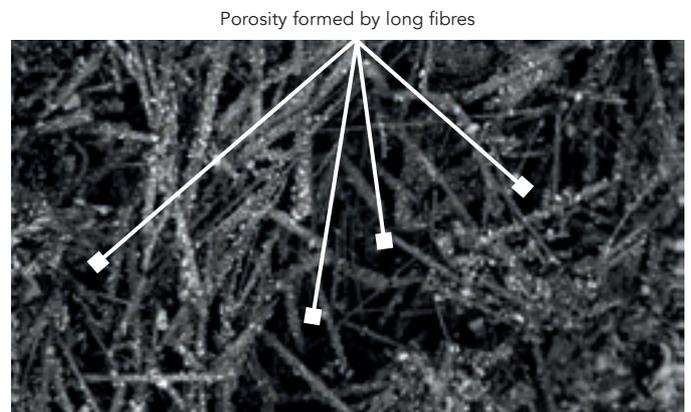
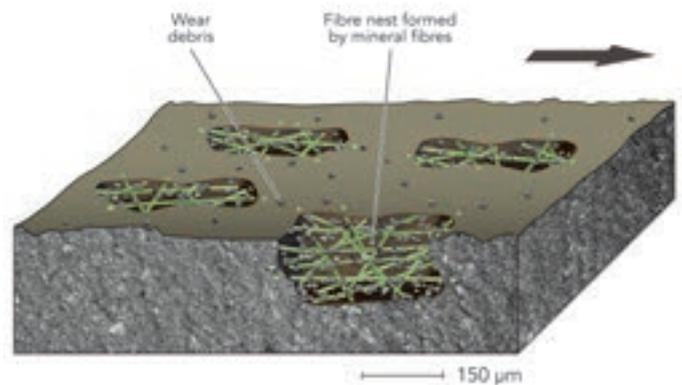


## Reservoir Effect

Long mineral fibres can form fibre nests, introducing voids into the friction matrix. When the voids reach the external surface of the brake pad and enter into contact with the disc during the braking event, wear debris is generated and accumulated inside the voids. These voids act as a reservoir for wear debris. This has a number of consequences:

1. Wear debris does not become immediately released powder (dust).
2. Wear debris changes the surface of the friction material by forming spots of debris similar to the secondary plateaus but thicker. These thicker spots of debris increase the contact area between disc and friction materials, increasing friction stability.
3. The voids act as damping spots which reduce the occurrence of noise.

This is called the Reservoir Effect<sup>6</sup>.



The Reservoir Effect has a positive influence on friction level stability, wear and noise reduction.



## Bonding

Adding fibres into a composite increases the strength of the material. In order to optimise the bonding strength between the fibre and the matrix, it is important to make sure that the binders used in the matrix can chemically attach to the fibres.

By surface-treating mineral fibres with coupling agents, optimal chemical bonding can be achieved.

Different surface treatments must be used for different binding systems. For phenolic resin-based formulations, amino-silane coupling agents are good compatibilisers.



## Damping

Noise is a result of vibration propagation. To reduce the propagation of vibration, friction formulations must contain materials with damping properties or they should be able to generate frequencies outside the audible range or beneath the critical noise decibel level.

Mineral fibres can contribute in two ways to reduce the propagation of vibrations:

1. Reducing the generation of vibrations with long fibres through the Reservoir Effect
2. Mineral fibres coated with rubber contribute to the damping properties of the friction material

Both mechanisms result in an improved NVH performance.



## Surface Reinforcement

Mineral fibres allow all the functionalities needed in friction materials to be maintained under heavy loads of pressure, temperature and mechanical stress.

There are two key ways in which mineral fibres can improve disc pad surface reinforcement by:

1. Working as an anchor to keep all the functions working on the surface;
2. Generating porosities that accumulate other raw materials in the surface, allowing them to work for a longer period of time.





## Porosity Contribution

Porosity can be generated during processing of the friction material with the use of crosslinking gases. This porosity is generally present in the phenolic matrix.

It can also be generated with the use of raw materials: they can create porous structures or can create structures where voids are generated. Porosity affects thermal conductivity, damping properties, friction, wear and squeal.

Fibre length, fibre coating, shot content and fibre diameter are relevant parameters contributing to the generation of porosity.



## Abrasiveness

Any material having hardness higher than the hardness of the disc is considered to be an abrasive in friction formulations. By varying the ratio of materials with high and low hardness in a friction formulation, abrasiveness can be tuned to the level required for the application.

Abrasiveness of the friction composite can be used to control friction level, disc wear and pad wear.

The hardness of mineral fibres can be controlled by changing the chemical composition and the shot content.

## Application Development Center

Being part of world's biggest stone wool producer allows us to engineer mineral fibres for different contributions in friction formulations depending on customer needs.

Using a friction pilot plant (including NVH Dyno and Krauss machine), we are able to present very detailed information which allows our customer to select the material which is the most complimentary for their formulation.

Our people have the ambition to continuously increase their knowledge on all relevant aspects of friction materials. We actively participating in all mayor friction related forums. By talking to our customers we continually look for future demands. We identify global trends and challenges, driving our developments for tomorrows' friction solutions.



# What mineral fibres are

The unique features of our mineral fibres

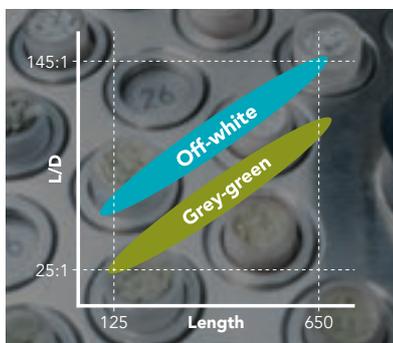
## Safe, inorganic fibres

The starting point for mineral fibres is stone wool. This means that the fibres are actually made of natural stone. It makes them strong, versatile, temperature resistant and completely safe for humans and the environment. There are two distinct product lines. One product line has grey-green fibres, the other is off-white. Both product lines have unique properties, making them suitable for different applications.

## Features of mineral fibres

### High fibre aspect ratio

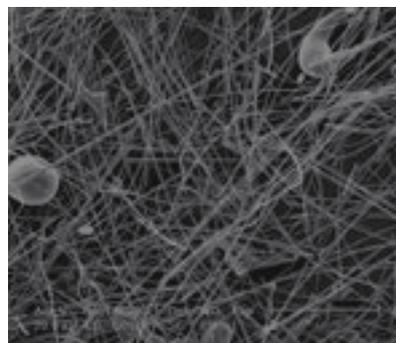
Increased dimensional stability



Our fibres have a high aspect ratio for increased dimensional stability. We produce fibres with L/D ratios from 25:1, up to 145:1.

### Precision shot control

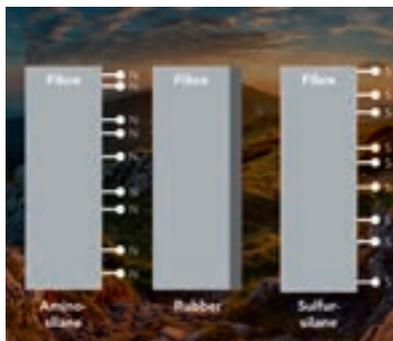
Non-fibrous particles



The nature of the production process means that for every fibre, there is a small non-fibrous particle called "shot". In our production process, we can reduce the shot-content and keep it stable at a level as low as 0.1 %.

### Surface treatment

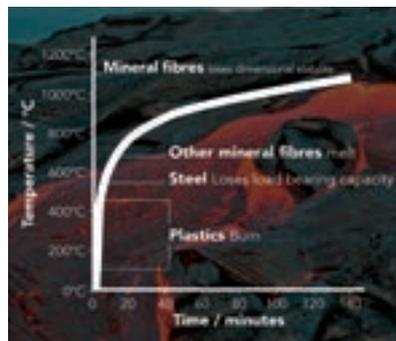
Compatible to different binder systems



We are able to put a variety of surface treatments on the fibres. This can be an adhesion promotor, surfactant, or even a rubber layer. With the different surface modifiers, we can engineer the fibres for a range of binder systems and applications.

### High temperature resistance

We keep cool when things get hot



All Lapinus products can withstand high temperatures up to 1000 °C. It is non-flammable and doesn't produce significant toxic smoke.

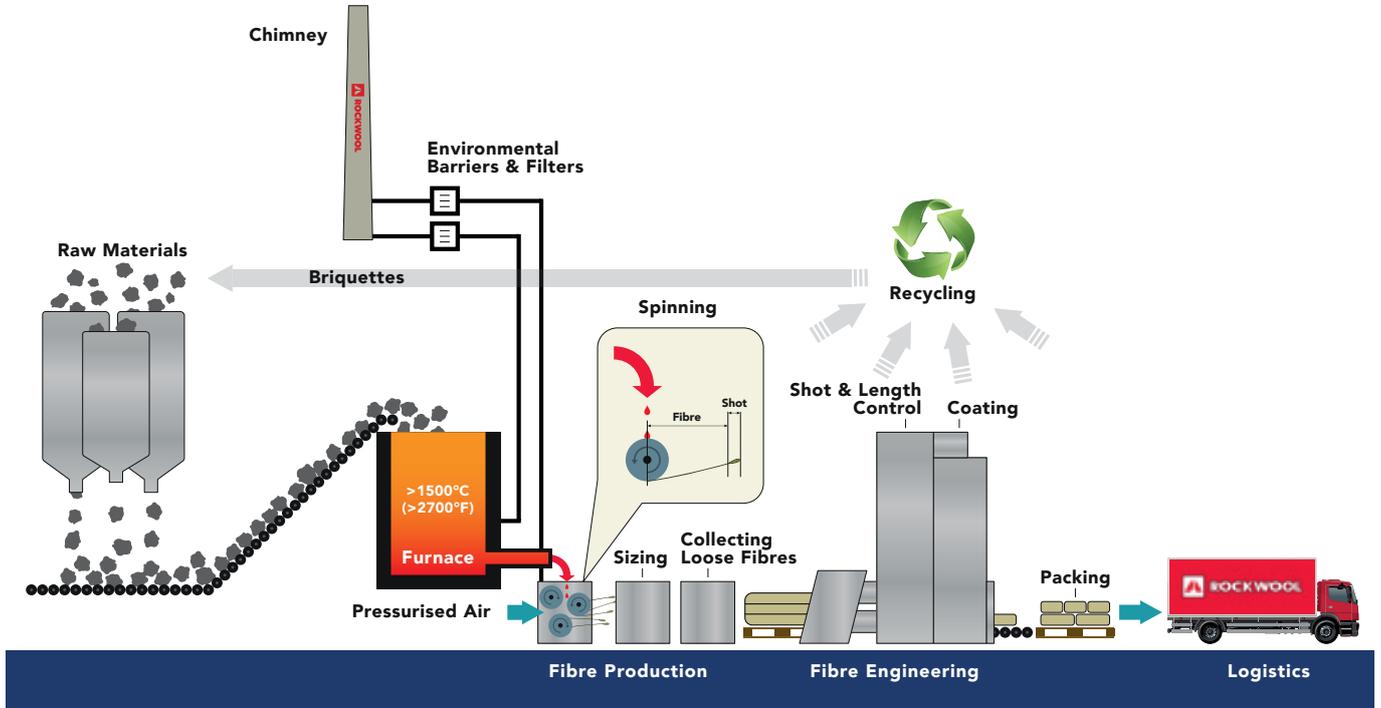
## Classification of mineral fibres



# How mineral fibres are engineered

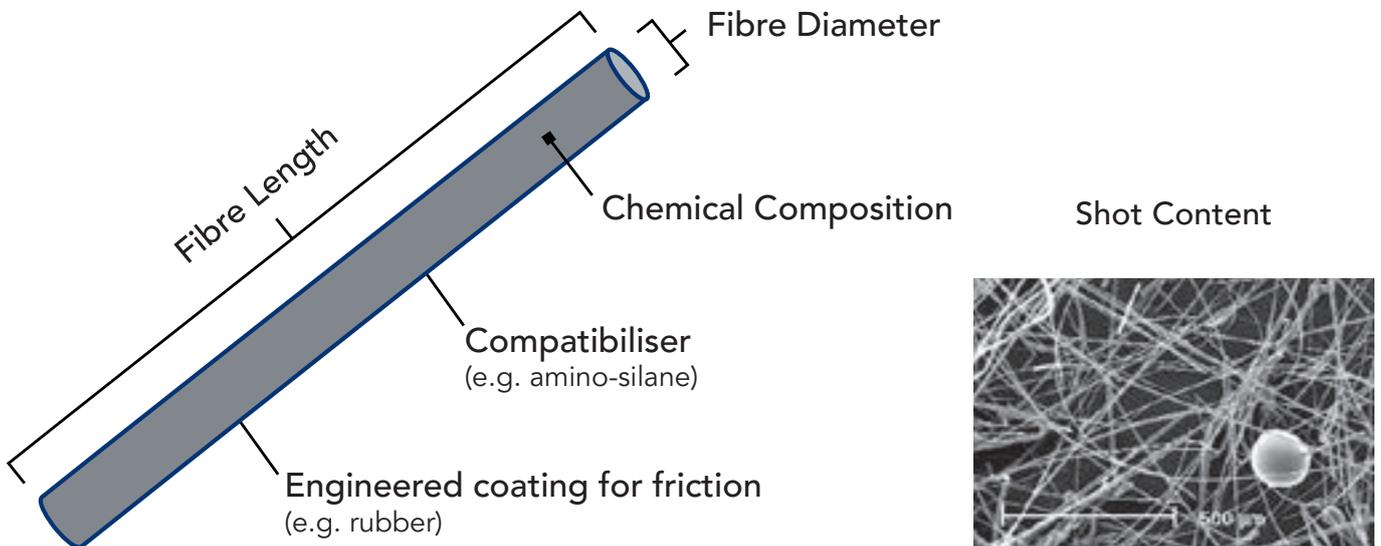
Precision-engineered mineral fibres in Lapinus

## Production process



## Degrees of freedom for mineral fibre engineering

With more than 25 years of expertise in producing mineral fibres for the friction industry, we have developed the technology to adapt the following fibre parameters to meet the differing needs of friction formulations.





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All Lapinus products are biosoluble  
and safe for human and environment

