SPECIALTY CARBONS FOR SINTERED FRICTION MATERIALS

TIMREX® Graphite
TIMREX® C-THERM™ Graphite
TIMREX® Coke

www.imerys-graphite-and-carbon.com
Imerys Graphite & Carbon, member of the Imerys Group, is the reference for innovative capability in the field of carbon-powder-based solutions: natural graphite and synthetic graphite powders, conductive carbon blacks, as well as silicon-carbon composites and water dispersions. High standards in terms of employee health and safety, social behaviour and environmental responsibility are core values of the company, which is capturing opportunities by developing new products and applications, investing in assets & people, and growing its commercial presence worldwide.

Profitable company, part of Imerys, the world leader in mineral-based specialty solutions for industry, listed on the Paris stock exchange.

IMERYS GROUP 2017

FINANCIAL STRENGTH

| WORKFORCE    | 18,300 |
| REVENUE      | 4.6 Bn |
| OPERATING MARGIN | 14.1 % |

RELIABLE PARTNER

INNOVATION STRATEGY
- Focused on the market and the Customer’s needs

SECURITY OF SUPPLY
- 6 Industrial sites

OUR DRIVING FORCE
- Customer Service

RESPONSIBLE GROWTH

COMMITMENT TO
- Green Technology and Sustainable Development

REDUCTION OF
- CO₂ Footprint

ENGAGEMENT WITH
- Local Communities
We at Imerys Graphite & Carbon deliver tailor made solutions for Friction Material applications with superior consistency of key product parameters: Purity, Crystallinity, Particle Size Distribution, and Oversize Control.

- High speed trains
- High-performance motorcycles
- Military Vehicles
- Wind Turbines
- Aircrafts
- Other industrial equipment
- Off-Road Vehicles

Our portfolio of carbon materials and R&D efforts addresses the key requirements of the friction materials industry.

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<th>KEY PERFORMANCE REQUIREMENTS (OF BRAKE PADS)</th>
<th>RELATED GRAPHITE PROPERTIES</th>
<th>RECOMMENDED GRADE</th>
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<td>Consistent compressibility, compaction of powder mix, and processability</td>
<td>low spring back and tailored particle size distribution (PSD)</td>
<td>KC 150-600 20x60 96 FR</td>
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<td>Good Sintering</td>
<td>Tailored PSD and graphite morphology</td>
<td>KC 150-600 KS 500 KS 150-600 20x60 96 FR</td>
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<td>Good Mechanical Properties</td>
<td>tailored PSD</td>
<td>20x60 96 FR KS 150-600 KC 150-600</td>
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<td>Low Swelling</td>
<td>Low thermal spring-back</td>
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<td>Low Wear</td>
<td>High thermal conductivity and tailored PSD</td>
<td>KC 150-600 C-THERM KS 500</td>
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<td>High Brake Energy</td>
<td>High friction coefficient</td>
<td>KS 500 KC 150-600 FC Coke</td>
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Test results presented in this brochure have been obtained in copper-sintered motorbike formulations containing ca. 8 % graphite (in collaboration with SBS Friction A/S)
Compaction of powder mixes generates plastic deformation of particles, with a 'partial recovery of compaction energy' (elastic spring-back). Spring-back can lead to lower density, cracks and increased scrap rate in production.

We offer tailored solutions with consistent compressibility and easy processability. KS synthetic graphite has much higher spring-back compared to natural graphite, while C-THERM and KC have intermediate spring-back values. Spring back strongly depends on particle size and increases with increasing PSD.

Spring-back of powder mix follows the same trends as for pure graphite.

Tailored PSD and morphology allow us to deliver customized solutions to meet your specific needs. Different graphites have various morphology: natural graphite 20x50 is very flaky and anisotropic, whereas KS graphite is more spheroidal and isotropic. KC graphite has intermediate anisotropy.

Metallography of sintered brake pads containing 8% graphite.

The density increase after sintering is higher for coarse graphites, therefore indicating better sintering compared to fine graphites.
MECHANICAL PROPERTIES

The hardness clearly increases with increasing graphite particle size and highest values are obtained with 20x50 and KC150-600. A similar trend is observed for the shear strength. This is due to the bad sintering quality when using fine graphite.

Safe friction materials must be able to maintain thermal stability in the severest of braking conditions in order to prevent the dangerous phenomenon of deformation or cracks in the brake pads and fading. KC graphite is able to maintain low swelling at high temperatures.

THERMAL CONDUCTIVITY AND SWELLING

THERMAL CONDUCTIVITY OF SINTERED BRAKE PADS CONTAINING 8% GRAPHITE

High in-plane thermal conductivity minimizes hot spots and tension cracks.

THERMAL EXPANSION OF SINTERED BRAKE PADS CONTAINING 8% GRAPHITE (DILATOMETER TESTS IN NITROGEN ATMOSPHERE)

Low swelling prevents cracks and deformation in brake pads, even in extreme conditions.
• Brake pad wear increases with decreasing particle size of graphite
• Highest wear is observed with natural graphite

C-THERM is proven to stabilize friction coefficient at high values >0.55 in both hot and cold sections as seen in following graph. Natural graphite 20x50 has overall lower friction coefficient compared to synthetic graphite, especially in the hot section.
TAILORED SOLUTIONS

Carbon based solutions for sintered friction materials:

C-THERM™ 001  [Patent granted]
C-THERM™ 011

Hot-spots reduction
Heavy-duty friction materials

Natural flakes 94 to 96% C, oversize control
Primary Synthetic Graphite
Primary synthetic graphite with higher compressibility
Calcined petroleum coke