TIMCAL
GRAPHITE & CARBON

TIMREX®

Graphites and Cokes for friction materials

a member of IMERYS

Who are we?

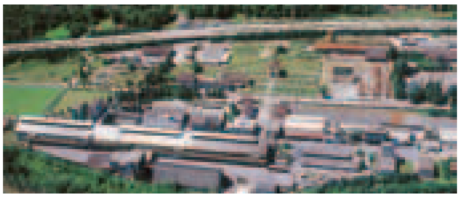
TIMCAL Group has a strong tradition and history in graphite manufacturing. Its first manufacturing operation was founded in 1908. Today, TIMCAL Group facilities produce and market a large variety of synthetic and natural graphite powders and dispersions of consistent high quality. Adhering to a philosophy of Total Quality Management and continuous process improvement, all TIMCAL manufacturing plants comply with ISO 9001-2000.

TIMCAL is committed to produce highly specialized graphite and carbon materials for today's and tomorrow's friction materials industries.

TIMCAL has an international presence with facilities and commercial offices located in the key markets around the Globe. The Group's industrial and commercial activities are implemented by an experienced multi-national team of nearly 300 employees from seven countries on three continents.

TIMCAL Group is a member of IMERYS, a world leader in adding value to minerals.

TIMREX® Graphites combine technical and economic advantages: their optimal price/performance ratio helps maintaing a high quality level in the finished part while, at the same time, reducing manufacturing costs.



Bodio, Switzerland

Willebroek, Belgium

Lac des Îles, Canada

Terrebonne, Canada

Changzhou, China

Fuji, Japan

About friction materials

Rapid developments over the past few years within the automotive industry have resulted in a growing demand for high-quality friction materials.

The main requirement to be met by a brake lining is, besides a high level of energy absorption, a high brake efficiency within a wide temperature range. Comfort aspects, life-time, and absence of noise are factors which also demand important consideration.

These requirements are fulfilled by means of high performace brake pads in which carbon powders such as graphite and coke play a key role.

The extreme consistency of TIMREX® Carbons provides the predictable properties that makes development and production very efficient.

This documentation is intended to help our customers make the best possible selection from the wide range of TIMREX® Graphite and Coke materials available for use in their high performance friction applications.

Graphite and Coke Powders for Brake Linings and Clutch Facings

The Market

Brake Linings and Brake Pads
• Non- metallic organic brake pads (NAO)
• Resin-bonded metallic pads (semimetallic)
• Low-metallic organic brake pads
• Sintermetallic materials for aircrafts, high speed trains, heavy duty machines
• CFC- and C/C-materials as well as brake pads for C/C-brake discs *(CFC: Carbon fiber composites; C/C: Carbon composites)*
• Linings for drum brakes
• Organic brake pads for trains
Clutch Facings for Dry and Wet Applications
• Sintered metallic clutch facings
• Organic-bonded paper- and fiber clutch facings

TIMREX® Graphites and Cokes with a common keyword: consistency

TIMREX® Primary Synthetic Graphite

TIMREX® Primary Synthetic Graphites are produced in a unique highly controlled graphitization process wich assures narrow specifications and unequalled consistent quality due to: monitoring of all production and processing stages, strict final inspection, and clearly defined development processes.

TIMREX® Primary Synthetic Graphites show unique properties thanks to the combination of a consistent purity, perfect crystalline structure and well defined texture.

TIMREX® Natural Flake Graphite

TIMREX® Natural Flake Graphite is produced in a wide range of products distinguished by particle size distribution, chemistry and carbon content. Timcal mines the graphite from its own source in Lac-des-Îles, Quebec, Canada. This unique "close-to-customer" location guarantees very fast and reliable deliveries.

All TIMREX® "Naturals" are thoroughly controlled in our laboratories to ensure quality, consistency and above all, total customer satisfaction.

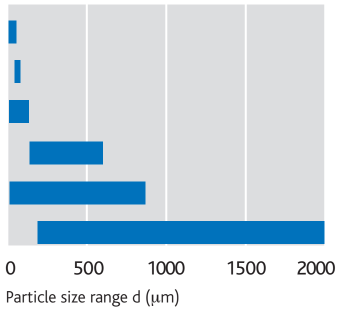
TIMREX® Coke

TIMREX® Petroleum Coke is calcined at appropriate temperature with low ash and sulfur content, well defined texture and consistent particle size distribution.

TIMREX® Carbons for Friction Materials

Typical values

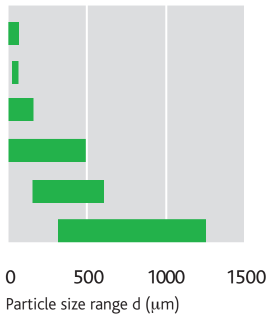
T Graphite



	Ash (%)	Moisture (%)	Crystallite height Lc (nm)	Tap density (g/cm^3)	DBP absorbtion (Dibutylphthalate) (g/100g)
T 75	0.07	0.1	> 100	0.21*	103
T 15-75	0.03	0.02	> 100	0.33*	70
T 150	0.09	0.05	> 100	0.51	59
T150-600	0.09	0.05	> 100	0.59	23
T 800	0.08	0.05	> 100	0.64	33
T 200-2000	0.08	0.03	> 100	0.73	21

* Scott density

KS Graphite



	Ash (%)	Moisture (%)	Crystallite height Lc (nm)	Tap density (g/cm^3)	DBP absorbtion (Dibutylphthalate) (g/100g)
KS 75	0.07	0.1	> 100	0.24*	98
KS 5-75TT	0.04	0.02	> 100	0.41*	45
KS 150	0.06	0.05	> 100	0.60	52
KS 500	0.06	0.04	> 100	0.80	25
KS 150-600SP	0.06	0.04	> 100	0.77	17
KS 300-1250	0.06	0.04	> 100	0.72	14

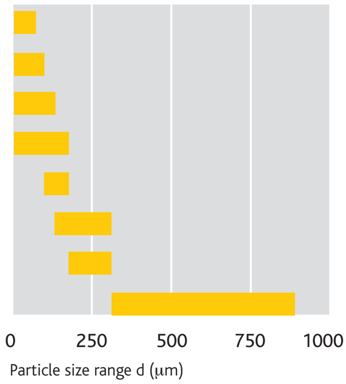
* Scott density

Particle shape	Advantages and applications	
angular flakes, microporous 	Suitable especially for organic bonded clutch facings (paper, fiber) and organic brake linings (semimetallic, non-metallic, low-metallic).	• Good lubrication properties • Reduction of the friction level and smoothing of the friction coefficient • Good thermal conductivity • Reduction of hot spots and difference thickness vibration (DTV) by spring back and good thermal conductivity • High effectivness of wear-reduction at relatively low graphite concentrations • Good damping behaviour due to internal lubricity and micropores - noise reduction • Good wettability with organic binders and high adhesion strength between binder and graphite particle
irregular spheroids 	Suitable especially for sintered metallic clutch facings and brake pads.	• Good lubrication properties • Good transfer film formation • Smoothing of the friction coefficient at the required level • Good thermal conductivity • Reduction of hot spots and DTV • Good mixability with metal powders • Sufficient mechanical strength of sintered parts even at medium density - no lamination

TIMREX® Carbons for Friction Materials

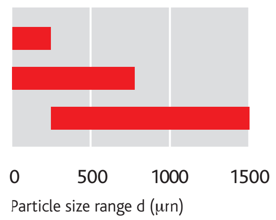
Typical values

Natural Flake Graphite



	Ash (%)	Moisture (%)	Crystallite height Lc (nm)	Tap density (g/cm³)	DBP absorbtion (Dibutylphthalate) (g/100g)
GA 95/75	< 5	< 0.5	> 350	0.52	91
-150 mesh FR	< 7	< 0.5	> 350	0.65	41
-100 mesh FR	< 7	< 0.5	> 350	0.75	42
- 80 mesh FR	< 7	< 0.5	> 350	0.69	37
80 x 150 mesh FR	< 7	< 0.5	> 350	0.74	16
50 x 100 mesh FR	< 7	< 0.5	> 350	0.78	11
50 x 80 mesh FR	< 7	< 0.5	> 350	0.82	10
20 x 50 mesh FR	< 7	< 0.5	> 350	0.77	10

Coke



	Ash (%)	Moisture (%)	Crystallite height Lc (nm)	Tap density (g/cm³)	DBP absorbtion (Dibutylphthalate) (g/100g)
FC 250	0.07	0.02	~2.5	0.91	6.0
FC 800	0.07	0.02	~2.5	1.00	6.0
FC 250-1500	0.07	0.02	~2.5	0.90	5.6

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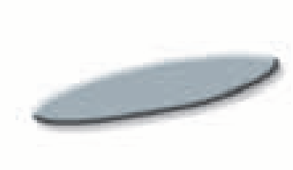
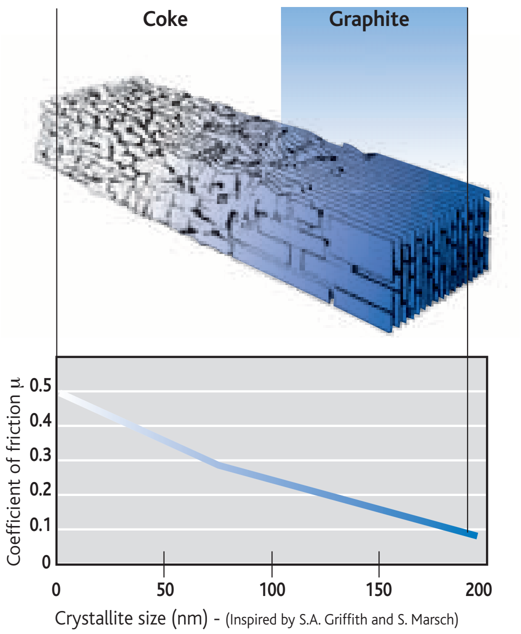
Particle shape	Advantages and applications	
flakes 	Suitable for all organic bonded friction materials, especially for linings in drum brakes as well as in brake pads for trains.	• Good transfer film formation • Good thermal conductivity • Excellent lubricating properties
irregular 	Suitable for all kind of sintered and organic bonded friction materials.	• Low wear of counterpart due to low ash content • Stable friction coefficient, non-fading • High thermal stability • Reduction of noise, especially medium and high frequency sounds

Powder Properties

Graphite and coke and their role in friction materials

TIMCAL Group is in the position to provide analytical and test results for graphite and coke powders and the corresponding graphite compacts. Based on this information, conclusions can be drawn from the properties of the final products and vice versa.



Powder properties

Purity
- Ash content
- Moisture
- Trace elements

Crystalline structure
- Crystallinity

Texture
- BET surface area
- Xylene density
- Scott density
- Oil absorption

Particle size
- Particle size distribution
- Laser diffraction, sieving methods

Other properties
- Thermal conductivity
- Mechanical properties
- Damping behaviour

Production of our model brake linings

- **Mixing**
- **Compacting**
- **Sintering, Curing**

Application properties of model brake linings

- **Wear of disc**
- **Wear of linings**
- **Disc temperature**
- **Lining temperature**
- **Coefficient of friction**
- **Fading behaviour**
- **Noise**
- **Compressibility**

In the following pages there are some of the results of experimental work carried out on TIMREX® Graphite and Coke at our Technical Centre.

Graphite Properties:

Density and internal porosity

Measuring method

The density of carbon particles is usually measured pycnometrically by the xylene method.

Conclusion

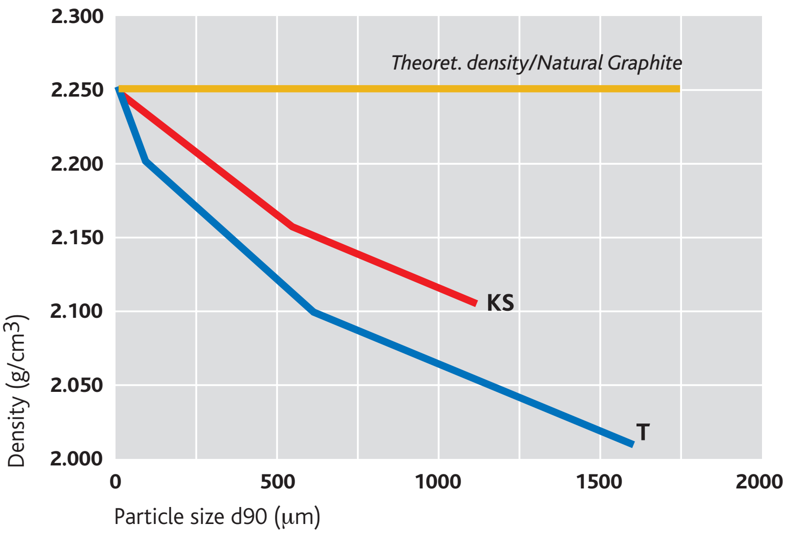
Graphite has a theoretical density of 2.26 g/cm³, and calcined petroleum coke about 2.05 g/cm³ whereas tap densities are relatively low therefore high volume concentrations can be achieved using graphite and coke even in relatively low quantities.

With TIMREX® Graphite powders, theoretical density - excluding internal closed pores - is achieved in the fine powders.
As particle size increases, particle density drops - an effect of internal closed porosity. Micro- and mesopores in the range of <100 nm are mainly involved.

The following effects are thus available to the user:

- rough particle surface - good anchoring in the binding matrix.
- the required volume concentrations are achieved with lower mass concentrations.
- closed micro/meso porosity and surface porosity increase the dissipation of sound waves at interfaces - improving damping behaviour.

Particle density of TIMREX® Graphites at different particle sizes



Graphite Properties:

Damping behaviour

TIMREX® Graphites as fillers demonstrate excellent vibration damping properties. The loss factor is generally used to define the damping properties of a material or damping system. The loss factor is measured on steel plated rods coated with graphite-resin mixtures (80 parts per hundred resin [phr]) using the Oberst bending vibration test.

For TIMREX® Graphites, loss factors of 0.07 to 0.08 were measured in the tests.
These values are approximately 6 times greater than those for unfilled, coated steel plate rods. The effect is caused by friction between grains of graphite and resin within the graphite crystallite, and grain-boundary diffusion (see also porosity).

TIMREX® Graphites contribute towards vibration damping in brake linings, and thus help to reduce noise.

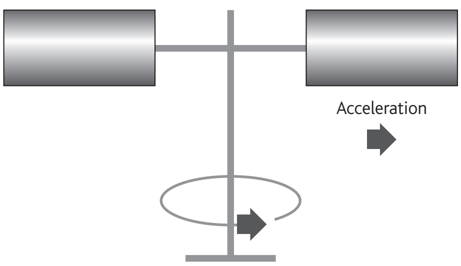
Graphite Properties:
Oil absorption (DBP)

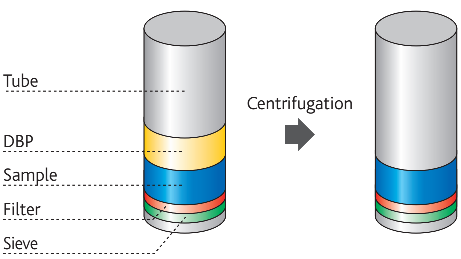
Measuring oil absorption to define the characteristic features of carbon blacks is a normal standard procedure. Use of this method on other powders and fillers has shown that oil or dibutylphthalate (DBP) absorption values are helpful to determine binder consumption in filled materials (filled plastics, resin-bonded carbon brushes and organically-bonded friction modifiers).

Measuring method

The oil absorption test is a special centrifugation method showing high reproducibility, developed by TIMCAL.

A special centrifuge tube is filled with 0.5 g of TIMREX® graphite powder and then covered with dibuthylphthalate (DBP). After centrifuging for 90 minutes at a relative acceleration of 453 g, the tube is weighed and the oil absorption of 100 g of powder is calculated (based upon the weight increase of the 0.5 g sample).





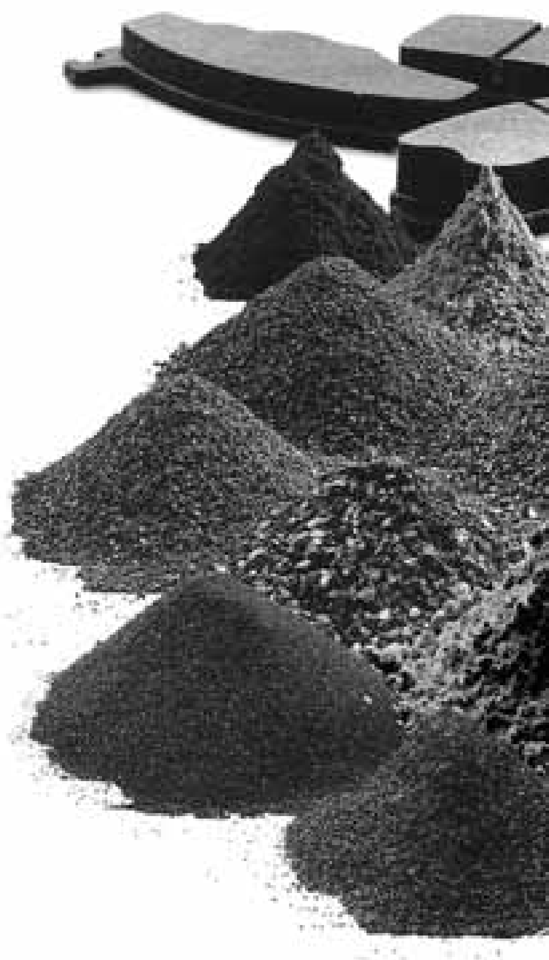
Conclusion

Absorption depends on particle size, bulk density, specific surface area, crystallinity and the wettability of the surface. The proportion of fines in the graphite powders has a particularly marked effect on absorption. By reducing the amount of fines, DBP absorption, and hence binding agent consumption, drops substantially (KS 5-75TT, KS 150-600SP, T 150-600 and 50x100 mesh FR).

Graphite	DBP-Absorption (g/100g)
KS 5-75TT	45
KS 150-600SP	17
T 150-600	23
50x100 mesh FR	11
FC 250-1500	6

DBP-Absorption of graphite powders - especially powders with reduced fines

The use of these graphite powders in lining compounds, gives the user greater freedom when formulating the mixture, and frequently permits an increase in the concentration of fine-grained additives (e.g. oxides, sulfides). Alternatively, the proportion of binding agent can be reduced which generally leads to a lower tendency towards fading.



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Graphite Properties:

Thermal conductivity

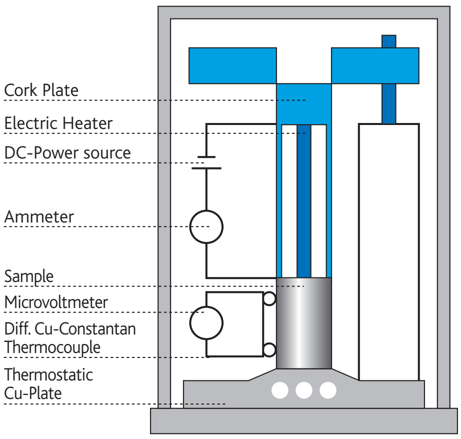
Measuring method

The thermal conductivity is measured on a cylindrical hipped sample of TIMREX® Graphite.

The powders are compacted without binder, machined and equipped with thermocouples. The samples have a diameter of 6 to 8 mm and a length of 20 mm.

The graphite samples are pressed to consistent density to reduce the influence of the density over the thermal conductivity.

The measurement is carried out by using stationary Kohlrausch method as shown below.



Hipped sample of TIMREX® Graphite (HIP, 350 Mpa, 1900°C) with thermocouples

Conclusion

The thermal conductivity of graphites depends upon their crystallinity (crystallite size, c/2) and particle size.

The thermal conductivity of the coarse graphites used mainly in friction linings is virtually independent of grain size. The primary synthetic TIMREX® KS and T Graphites, show a 20-30 % higher thermal conductivity than secondary synthetic graphites.

Good thermal conductivity coupled with a high specific thermal capacity of approx. 0.5 J/(g.K) in the range of 20°C to 100°C, and rising thermal capacities in higher temperature ranges (0.99 J/(g.K) at 200°C) produces a series of interesting advantages to the user:

- a more homogenous temperature distribution in the brake lining, thereby minimizing tension cracks.
- the reduction of hot spots and hot bands in discs and linings, which is coupled with reduced thermo-elastic instability (TEI).
- the friction coefficient is less dependent upon temperature, thus reducing juddering, and in turn noise and shearing stress in the lining.
- the materials are subject to lower local temperatures, leading to a reduction in wear caused by burn-off or welding.

The thermal conductivity of KS and T graphites represents a good compromise between contradictory requirements such as:

- high thermal conductivity to compensate for temperature differences in the friction zone.
- low thermal conductivity to protect the braking fluid from thermal overload.

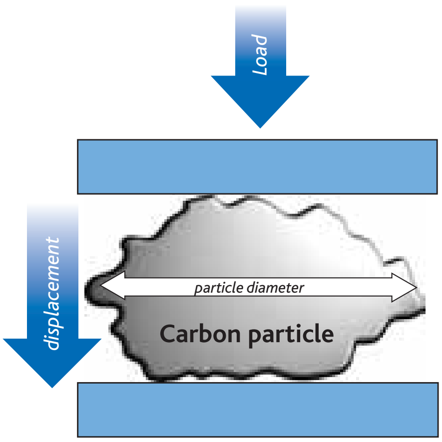
Graphite	Thermal conductivity λ W/(m.K)
Natural	190
KS	140
T	130
Scrap	110
Coke	12

Typical data of thermal conductivity of graphite powders pressed to density ≈2.2 g/cm³, 25°C

Graphite Properties:

Spring back and elasticity of single particles

The force-displacement behaviour of single carbon particles describes qualitatively the mechanical properties of the particles as particle strength, brittleness and elasticity and gives an idea about deformation mechanism, wear and wear mechanism in the friction process.



Measuring method

Testing of single carbon particles is carried out in compression mode by axial loading of particles between parallel plates in the range of 0-100 mN, 0-1000 mN respectively.

Spring back measurements of compacted powders give also an idea about the elastic properties of the graphite (see also our brochure TIMREX® Graphites for Carbon Brushes and Carbon Parts).

Results

The graph shows typical load-displacement-curves of TIMREX® T, KS and Natural Graphite up to higher loads. The results correlate with the results at low load presented in the table.

TIMREX® Graphites show high plastic and elastic deformation properties. The high plastic particle deformation causes smooth friction surfaces to form on the brake lining and disc. At the same time the formation of a stable, dense and smooth transfer film is also promoted.

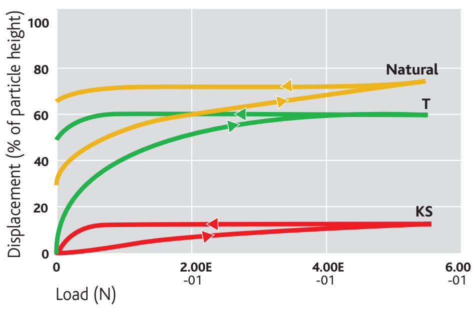
The relatively high elasticity reduces the risk of fatigue failure at the edges of the particles; it also reduces dust formation and wear in the lining.

Moreover, the elasticity of the graphite particles contributes towards the elasticity of the entire lining. It helps to smooth out rough spots on the surfaces, and increases the effective contact surface between friction partners. Wear caused by surface rough spots and noise caused by difference thickness vibration (DTV) are reduced.

T Graphites are particularly suitable for organically-bonded brake linings (NAO) and KS Graphites for sintermetallic linings.

In their mechanical properties, secondary synthetic graphites more closely resemble cokes than graphites. Because of their low plastic deformation, they have a lower tendency to the transfer film formation. Lower elasticity could cause particle failure and higher wear.

TIMREX® Cokes are characterized by a high level of grain stability. Their elasticity, which is relatively high for cokes, reduces dust and hence wear and noise. By contrast, gas and metallurgical coal cokes, which are very brittle, tend to produce dust in the friction process which leads to increased wear and is linked to noise in the quiet zone.



Load - displacement - response (hysteresis) for TIMREX® Graphite particles (typical curves) reported up to high loads.

Carbon	plastic deformation (%)	elastic deformation (%)	plastic+elastic deformation (%)
T graphite	2.6	1.1	3.7
KS graphite	1.4	1.4	2.8
Scrap	0.47	0.22	0.69
TIMREX® Coke	0.21	0.1	0.31
Natural Graphite FR	5.2	1.2	6.4

Deformation of single carbon particles at low pressures (15 N/cm²) and low displacements from load displacement hysteretic measurements (in % of the particle height).

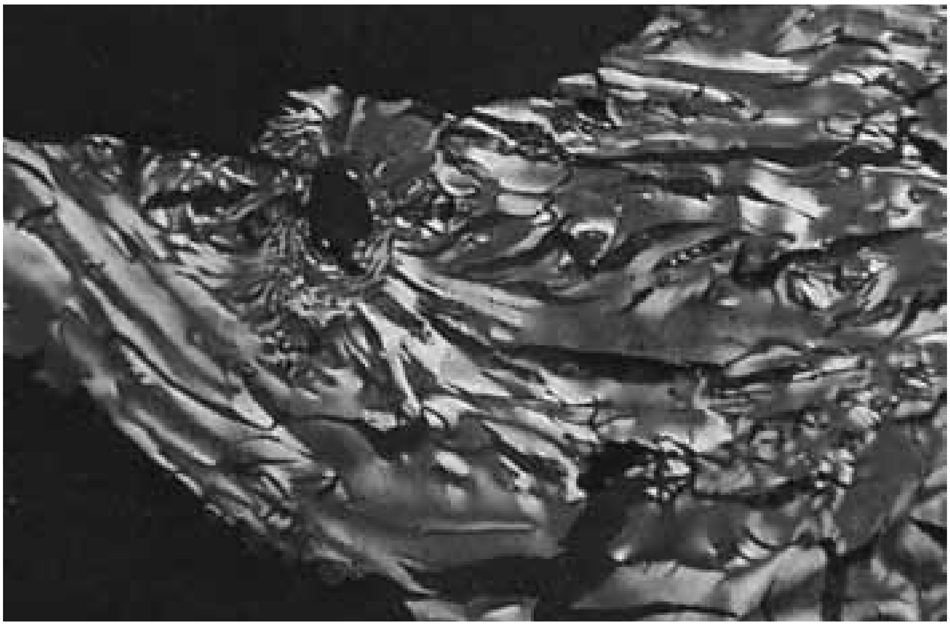
Coke Properties:

Coke structure

The structure of coke is determined by oil quality, the coking technology used and the duration and temperature of the calcination phase. TIMREX® Cokes have excellent textures with anisotropic flow and mosaic structures to ensure a high level of grain stability and a relatively high elasticity.

The figure shows a polished section in polarized light in which these structures are clearly visible.

The visible, slit pores are usually open pores and ensure that the grain is firmly anchored in the binding matrix.



Structure of TIMREX® Coke

Coke properties

TIMREX® Cokes are characterised by low and constant ash content (approx. 0,07%), low sulfur content (approx. 1%) and the absence of volatile substances.

• The low ash content accounts for the low rate of wear of brake linings with TIMREX® Cokes; no scoring can occur on the brake disc.

• Because of the high calcination temperature, these cokes do not contain any volatile hydrocarbons. The presence of volatile substances frequently leads to the formation of cracks in brake linings at high temperatures.

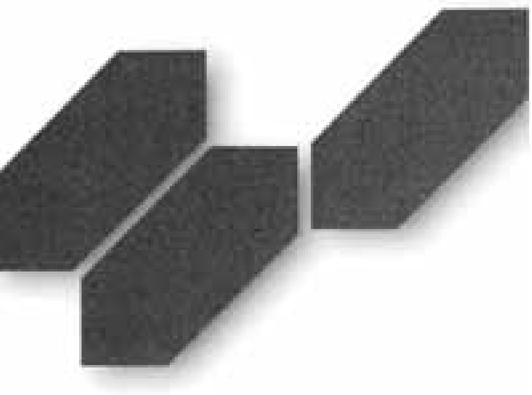
• TIMREX® Cokes are low in dust, owing to their grain fractions and the milling/screening processes used. They are therefore easy and clean to process.

• To guarantee good wetting properties and adhesion to the binding resin, no dust-binding agents are used during production.

Application properties of model brake linings

Graphite and coke in sintermetallic friction materials

Sintermetallic friction materials are used predominantly in braking systems for heavy construction machines, in clutch linings, and in some high-speed applications; high-speed trains and a series of motorcycles with higher performances are also fitted with sintermetallic brake linings.
TIMREX® Cokes, and especially TIMREX® Graphites play a particularly important role as friction modifiers in Fe and Cu alloy materials.



Method

The following results were obtained with sintered cylindrical model linings (d=37mm, h=18mm) on a friction test piece and a gyrating mass dynamometer.

Technical data of the friction test piece:	
Speed:	constant = 42 km/h
Contact pressure:	67 N/cm^2
Technical data of the dynamometer:	
Simulated moment of inertia range:	4 - 80 kg/m^2
Initial speed:	33 - 111 km/h
Contact pressures:	30, 60, 82 N/cm^2

Graphite

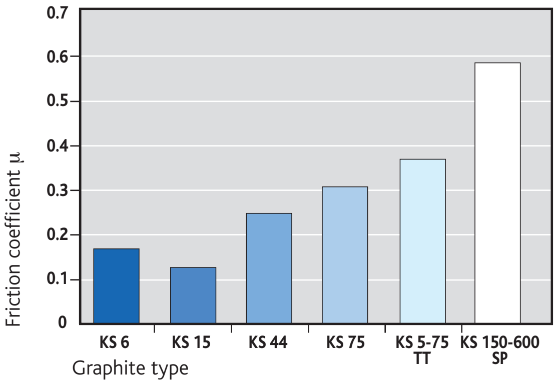
Graphite is the main additive in many Cu friction materials - the proportions by volume used are frequently up to 30%. Other additives are oxides such as Al_2O_3, SiO_2, carbides such as SiC or chromium carbides and cokes. The friction behaviour of the lining is essentially dependent upon the type of graphite used, the grain size and the concentration.

Application properties of model brake linings

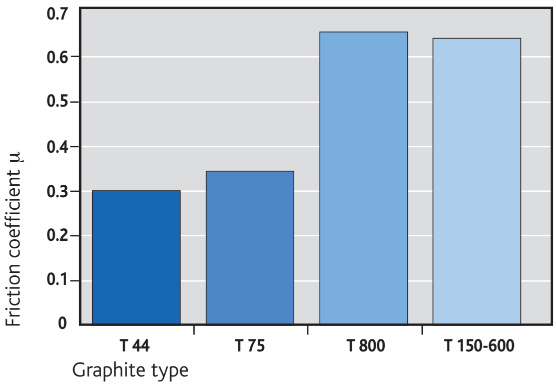
Graphite and coke in sintermetallic friction materials

Results and Conclusions

Both for KS and T graphites, a rise in the friction coefficient commensurate with the graphite grain size was ascertained. In particular, a reduced proportion of fine grains in the graphite grain band (KS 5-75TT, KS 150-600SP) led to an increase in the friction coefficient with simultaneous reduction of abrasion of the lining. A frequent, undesirable side-effect, however, is an expansion of the friction coefficient range (minimum µ - maximum µ). By adding a tiny quantity of fine graphite powder the properties of the friction lining can be optimised.

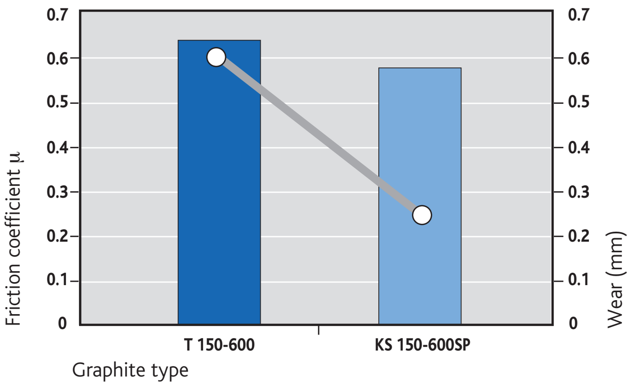


Friction coefficient of sintered Cu-C -brake pads with 10% TIMREX® KS Graphite as a function of the particle size
Sinterconditions: 850°C, 3 h
Sinterdensity: 55% of the theoret. density



Friction coefficient of sintered Cu-C -brake pads with 10% TIMREX® T Graphite as a function of the particle size
Sinterconditions: 850°C, 3 h
Sinterdensity: 55% of the theoret. density

Where grain sizes were identical, the T graphites were generally observed to have higher friction coefficients than model linings with KS graphites. The higher friction coefficients of T graphite linings cause greater wear of the linings, however.



Friction coefficient and wear of sintered Cu-C -brake pads with 10% TIMREX® KS 150-600SP and T 150-600 Graphite
Sinterconditions: 850°C, 3 h
Sinterdensity: 55% of the theoret. density

Application properties of model brake linings

Graphite and coke in sintermetallic friction materials

One reason for the different levels of wear and tear of sinter linings with T and KS graphites lies in the varying shapes of the graphite particles. The more flaky T graphite particles tend to align vertically to the direction of pressure during the compression process. This leads to lamination of the grain and anisotropic mechanical stability after sintering. Under heavy stress in the friction process, shearing forces can lead to greater wear and tear of the lining.

KS graphites do not tend to align themselves in any particular direction during the compression process because their particles are irregularly shaped, and their textures are more homogenous after sintering.

Use of less fine-grained graphites also helps to reduce wear and tear: Cu particles are usually enveloped by any fine graphite particles present in the mixing process. The graphite-coated Cu surfaces are then no longer available in the sinter process for the formation of sinter contacts, leading to a reduction in grain stability and to increased wear and tear in the friction process.

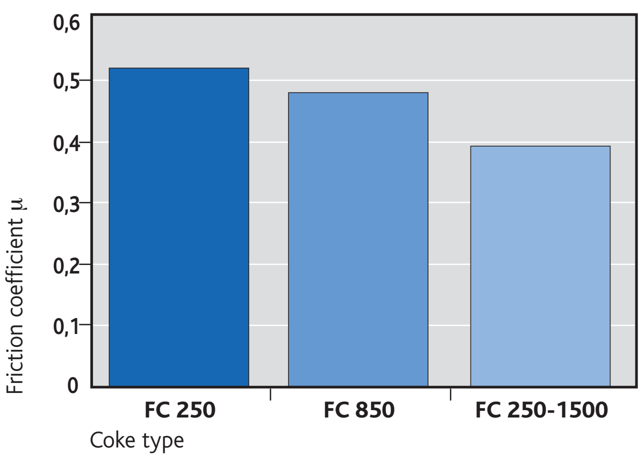
Largely isotropic and undisturbed Cu sinter textures are obtained by using KS graphites with a reduced proportion of fine grains.

KS 150-600SP and KS 5-75TT graphite powders are predestinated for sintered brake linings based on Cu. KS 75 is particularly suitable for large surface clutch linings with low surface compression.

Coke results

Cokes may be added in a concentration range of 5-10% of the powder mixture to regulate the friction coefficient. As the grain size and concentration of the coke increase, so the friction coefficient is reduced.

Abrasion of the lining is reduced when used in combination with graphite powders.



Friction coefficient of sintered Cu-C -brake pads with 10% TIMREX® Coke
Sinterconditions: 850°C, 3 h
Sinterdensity: 53% of the theoret. density

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Application properties of model brake linings

Graphite and coke in organic bonded friction materials

Graphite

Graphite powders are used as solid lubricants, and should fulfill the following principle functions:

- Set the required friction coefficient in a range from 0.38 to 0.45.
- Level off the friction curve.
- Reduce wear and tear on disc and lining.

The suitability of a raw material for a specific brake lining can only be clearly established in a dynamometer test and by vehicle road tests. However, tests using model linings on friction testbeds can frequently give an indication of the tribological behaviour of graphites, and can be an aid to formulation.

Method

Formulation of test samples

Test samples				
	Concentration (mass%)			
Additive	formul. 1	formul. 2	formul. 3	formul. 4
Graphite	80	40	20	10
Baryte	0	40	60	70
Alumina	16	16	16	16
Phenolic resin	4	4	4	4
	diameter: 14.3 mm height: 4 mm			

Investigated graphite powders

Parameter	Natural graphite 1	T 800	Natural graphite 2	T 200-2000
Ash (%)	5.2	0.1	1.8	0.05
Particle size (µm)	0-300 fine flakes	0-700	500-2000 grains	200-2000

Test equipment:

Standard F.A.S.T. Machine
Sliding speed: 7 m/s
Sliding time: 90 min
Procedure: Heavy duty brake

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Application properties of model brake linings

Graphite and coke in organic bonded friction materials

Result and conclusion

As graphite concentration decreases, the friction coefficient rises and finally reaches a constant value at 20% graphite. Fine-grained, flaky, nat. graphite 1, is an exception with a further increase at 10% of graphite. Friction coefficient fluctuations are largely constant for all graphite concentrations, and increase marginally at 10%. The start-up period to steady conditions decreases with reducing graphite concentration.

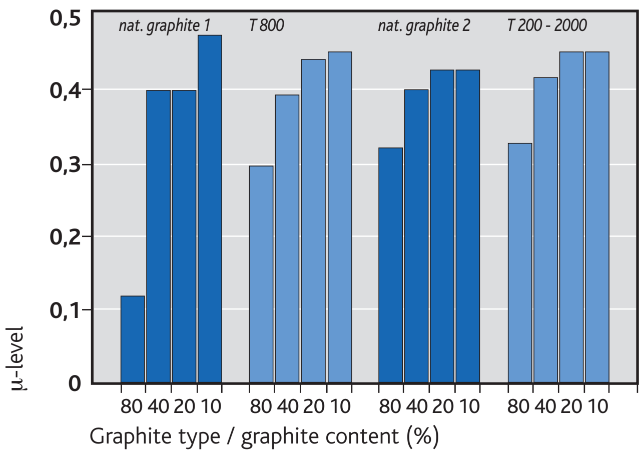
The test material with 10% T 200-2000 does not appear to have an instable start-up period, and reaches the required friction level immediately with the least friction coefficient fluctuations.

Wear characteristics vary considerably for natural graphites and TIMREX® T 800 and T 200-2000 graphites. With TIMREX® Graphite friction materials, wear reduces at lower graphite concentrations, but tends to increase with natural graphites. In the concentration range of around 10%, which is of interest to the user, TIMREX® Graphite friction materials demonstrate less wear.

We therefore recommend the T 800 and T 200-2000 coarse graphites for use in organically bonded brake linings.

T 150-600 is particularly suited to achieving specific grain densities. By reducing the proportion of fine grain in the graphite powder, extra space is available between the coarse graphite particles so that other fine fillers such as oxides, sulfides, baryte or cokes can be added.

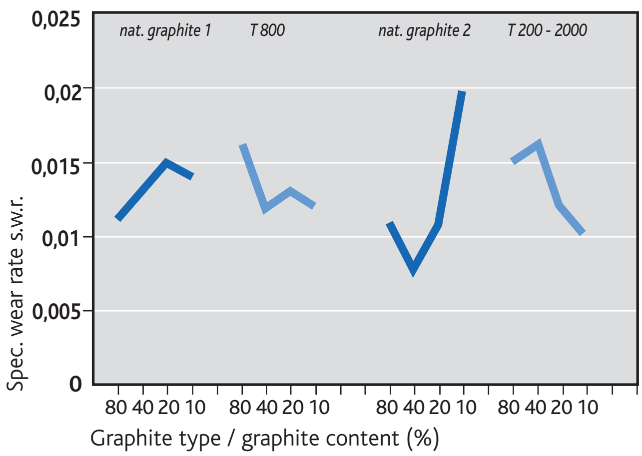
Friction coefficient



Friction level of test samples as a function of graphite type and graphite concentration after the period of bedding, friction load: 15 lbs

Courtesy: ITT Automotive

Wear



S.W.R. of test samples as a function of graphite type and graphite concentration.

Courtesy: ITT Automotive

TIMCAL
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Application properties of model brake linings

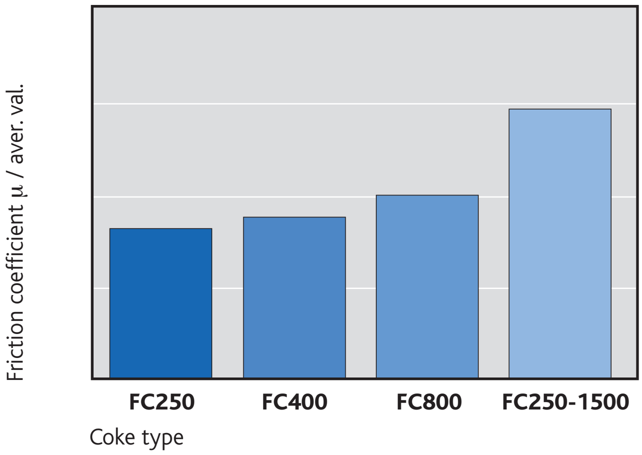
Graphite and coke in organic bonded friction materials

TIMREX® Graphite has found its place in the field of friction materials as a reliable, high quality product. Many problems can be solved thanks to the broad range of TIMREX® Graphites. Our specialists will be glad to help you in the selection of the most suitable product for your application.

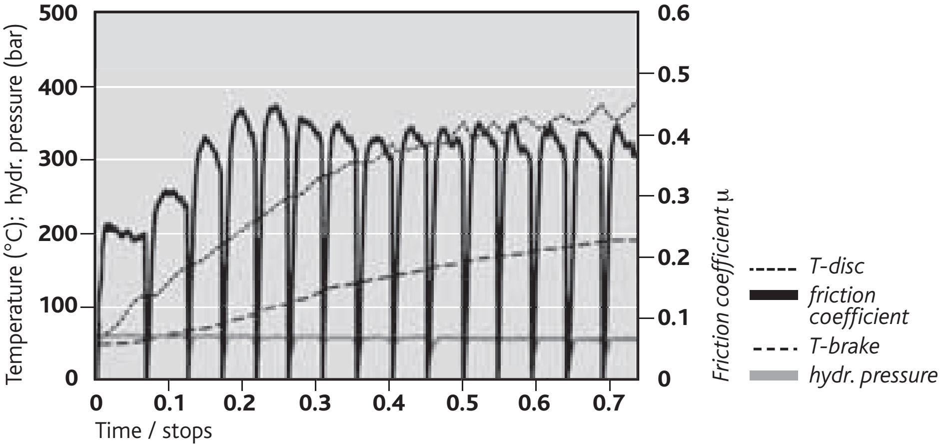
Coke

Coke powders are used as friction modifiers, and should fulfill the following principle functions:

- **Reduce weight by using a filler with low specific weight.**
- **Set the required total concentration of carbon by volume (graphite and coke).**
- **Reduce fading.**
- **Reduce wear and tear of the lining.**



Average friction coefficient of TIMREX® Cokes in model brake pads (90% coke, 10% phenolic resin, compacting pressure: 200 bar, curing temperature: 160°C)



Fading behaviour of FC 250-1500 in model brake pads (90% coke, 10% phenolic resin, compacting pressure: 200 bar curing temperature: 160 °C)

TIMREX® Cokes are characterised by a high friction coefficient and low wear - especially by contrast with other petroleum and metallurgical coal cokes. The friction coefficient of the brake lining can be influenced by the grain size of the TIMREX® Coke. A constant friction coefficient throughout a wide temperature range, and excellent fading behaviour during successive stop brake applications is of importance to the user.

Method

Test samples	
Model brake pads	
Formulation	90% coke, 10% Phenolic resin
Thickness	12 mm
Surface area	35 cm²

Test equipment:

Dynamometer
Special TIMCAL procedure
(modified VW-Audi test)

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Leading the way.

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