Broad Base. Best Solutions.

SGL GROUP
THE CARBON COMPANY

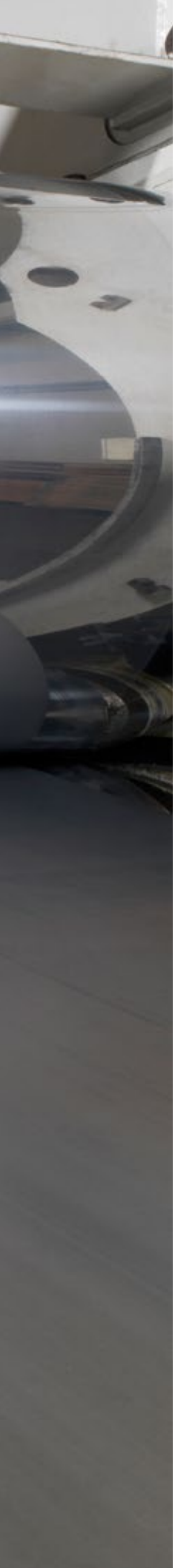
GRAPHITE MATERIALS AND SYSTEMS

Specialty Graphites for the Chemical and Petrochemical Industries

Specialty Graphite and Process Solutions – made by SGL Group.

- Advanced material, equipment, and process solutions
- Engineered for customers from more than 35 industries
- Tailor-made from the most comprehensive product portfolio
- In-depth production and material knowledge
- Consistent high quality, performance, and service
- Attractive total cost of ownership

Broad Base. Best Solutions.



Advanced solutions enable our customers to get ahead.

SGL Group offers advanced solutions – even for challenging applications. We understand the specific requirements of our customers and combine in-depth production, material, and engineering knowledge with the most comprehensive specialty graphite portfolio. This makes us the partner of choice to leading companies in many different industries.

Exceptional resistance to heat and corrosion, high purity and mechanical strength are just a few of the outstanding properties which our materials offer. Specialty graphite products from SGL Group achieve optimal results where other materials fail. No matter what your specific requirements might be, we will identify the best solution from the most comprehensive range of specialty graphites.

- Fine grain graphite: isostatic, vibration-molded, die-molded, extruded
- Expanded natural graphite
- Carbon fiber-reinforced carbon (C/C)
- Soft and rigid graphite felts
- Silicon carbide-coated graphite materials

Additionally we use other materials like PTFE, silicon carbide, and specialty metals.

With our portfolio and technical know-how spanning more than 35 different industries, we engineer tailor-made solutions in close partnership with our customers.

← SIGRAFLEX graphite foil production

SGL Group covers the entire value chain of specialty graphite production, including raw material processing, semi-finished product manufacture, precision machining, purification, and coating. When it comes to engineering of equipment and process solutions our service range makes the difference: We offer mechanical and process design, production, assembly, commissioning, and service – all from a one-stop shop.

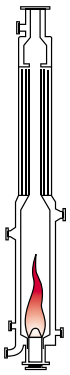
This is how we control and ensure the consistent high quality, reliability, and performance of our products – and enable our customers to become more competitive. Challenge us. We are there for you worldwide.

Specialty graphite solutions for the chemical and petrochemical industries

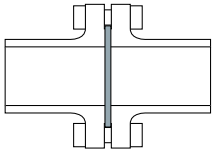
Innovative specialty graphite solutions are indispensible for the intricate processes in the chemical and petrochemical industries. Our expertise in materials and applications and the wide range of products and services we offer make us a sought-after partner of leading companies.

Specialty graphites – made by SGL Group.

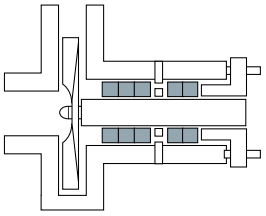
Solutions for the chemical and petrochemical industries.



HCl synthesis



Botted flange connections
Bolted joints



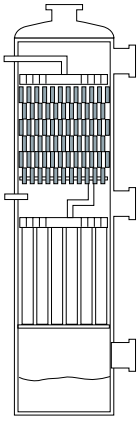
Process pumps

Typical applications	Synthesis, processing and recycling of HCl Production of VCM, ECH, MDI/TDI, phosphoric acid, and sulfuric acid Steel pickling	EN/ANSI flanges Flanges and joints Non-metallic flat gaskets Kammprofile Corrugated, double jacketed gaskets and spiralwound gaskets, Mixers and vessels Ball valve seals	Process pumps Radial blowers Braided compression packings Special and mechanical seals
Materials made of carbon and graphite	Isostatic, extruded and vibration molded carbon and graphite	SIGRAFLEX® flexible graphite SIGRAFINE® die-molded carbon and graphite	SIGRAFLEX® flexible graphite SIGRAFLEX® yarns
Products of the SGL Group	Heat exchanger Columns and reactors Piping, expansion joints Pumps Process solutions	Graphite foils Reinforced and unreinforced graphite laminated sheets	Yarns Graphite foils Seal rings

More information can be found at
www.sgl-processtechnology.com

Materials that are extremely strong and resistant, such as those used for gaskets, are of utmost importance in the chemical and petrochemical industries and play an essential role in ensuring personal safety and environmental protection, system availability, efficient processes and product quality. The objective is to provide a product which is ideally suited to the operating conditions and media used in each specific case.

SGL Group offers you everything from under one roof: material of the highest quality and expertise in technical applications to ensure the best solution.

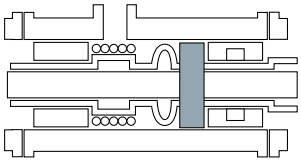


Columns

Support grids
Non-metallic gaskets
Kammprofile, corrugated and spiralwound gaskets

SIGRATHERM®
carbon and graphite felts
SIGRABOND®
carbon fiber-reinforced carbon

Rigid graphite felts
Grid
Graphite foils
Reinforced laminated graphite sheets



Rotating equipment

Vacuum pumps
Rotary joints
Compressors
Turbines
Blowers
Flow meters

SIGRAFINE®
die-molded,
isostatic carbon
and graphite

Seal rings
Bearings
Piston and guide rings
Metal sleeved rings
Control rings

The consistently high quality of our materials and products increases the reliability and service life of plants and systems and minimizes fugitive emissions and downtime, thus reducing the total costs of operation. In addition, we assist companies and their customers as well as operators of plants in continuously optimizing their processes and results. This includes compliance with statutory requirements, such as the "Technical Guidelines on Air Quality Control" (TA Luft), SCAQMD (South coast air quality management district) and stricter limit values for fugitive emissions. Our SIGRAFLEX sealing materials pass these requirements with the greatest of ease.

+ **SIGRAFINE® is the new brand name** for our fine-grain graphites, previously known under the names RINGSDORFF®, SIGRAFORM®, SIGRAMENT® and CRYSTA-SIL®.

Partnerships with refineries all over the world

The refinery business calls for sealing materials with guaranteed dependability including maximum oxidation resistance, even in extreme-temperature applications SIGRAFLEX APX2 foil oxidizes much more slowly than comparable products, even at 593 °C (1099 °F) and significantly extends gasket service life, increases process reliability and reduces costs on the long term.

This is just one example of an application-specific optimized solution from the SGL Group.

SIGRAFLEX®
for sealing applications

Our SIGRAFLEX product portfolio is one of the largest on the market.
Our materials meet virtually all technical requirements of the international chemical and petrochemical industries. Seals made of SIGRAFLEX foil and reinforced sheets offer major advantages, such as:

- **Higher long-term sealing standards**
- **Enhanced process reliability and material dependability**
- **Compliance with statutory requirements for fugitive emission levels**
- **Lower maintenance expenses thanks to the sealing materials' long service life**

SIGRAFLEX® foils made of flexible graphite

Secure sealing – even under the toughest conditions.

Our SIGRAFLEX products made of expanded flexible graphite have proven their long-term reliability under extreme operating conditions over the course of many years. SIGRAFLEX is resistant to most chemical media and sets itself apart from other asbestos substitutes thanks to the long-term stability of its sealing properties – even at temperatures of up to approx. 550 °C (1022 °F).

← SIGRAFLEX HOCHDRUCK

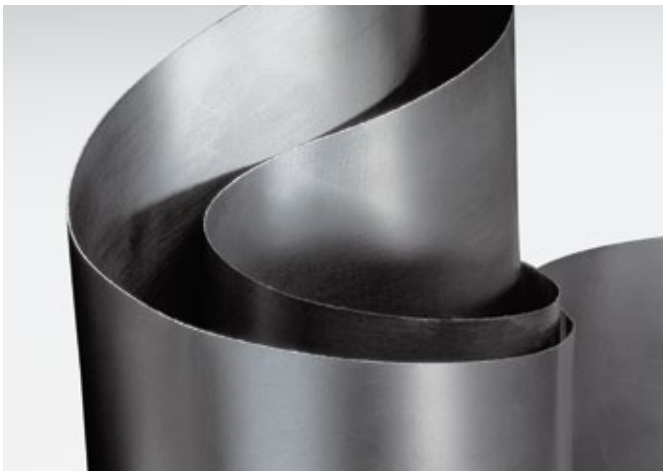
SIGRAFLEX® graphite foil and sheets

		Foil		Reinforced sheets											
Applications	**Products**	**Slides**	**STANDARD**	**ECONOMY**	**UNIVERSAL**	**UNIVERSAL Pro**	**SELECT**	**HOCHDRUCK**	**HOCHDRUCK Pro**	**APX2 HOCHDRUCK**	**MF**	**EMAIL**	**SIGRASEAL**	**BSSC**	**BTCSS**
Gaskets	Grooved and corrugated ring gaskets	●	○												
	Spiral-wound and jacketed gaskets	●													
	Stuffing box packings	●													
	PTFE envelope gaskets											●			
	Gaskets for pumps and valve bodies		○	●	○	○		●	●	●			○	●	○
	One-piece gaskets up to outside diameters of 1500 mm (59.1")				●	●		●	●	●		●	●	●	●
Flange sealing	Flanges with sealing strips		○	●	●	●	●	●	●	●	●		●	●	●
	Flanges in groove and spring design/ sealed joints under high stress							●	○	●					
	Unstable flanges with low gasket stress			●							●				
	Vessel and equipment flanges		○		●	●		●	●	●	●		○	●	●
	Emergency repairs and complex dimensions		●	○				●	●	●				●	
Operations under pressure	Internal pressure up to 40 bar		●	●										●	
	Internal pressures from vacuum up to 100 bar				●	●	●				●		○		○
	Internal pressures from vacuum up to 250 bar							●	●	●					
Operating temperatures	–200 °C to 300 °C (–328 °F to 572 °F)	●	●	●	●	●	●	●	●	●	●		●	●	●
	–200 °C to ~550 °C [1] (–328 °F to ~1022 °F)	●	●	●	●	●	●	●	●	●			○		○
Impermeability	Maximum requirements according to the emission protection regulation "Technical Guidelines on Air Quality Control" (TA Luft)					●	●	○	●		●	●			

○ Suitable ● Recommended

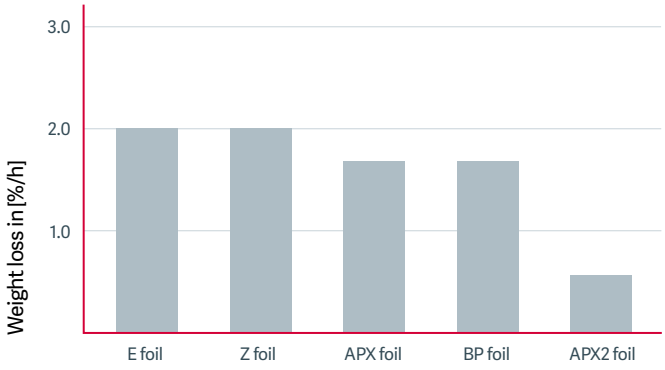
[1] In consideration of chemical resistance. We will be glad to provide specific recommendations for operating temperatures of over 450 °C (842 °F).

SIGRAFLEX® graphite foils



↑SIGRAFLEX foil

Relative weight loss of SIGRAFLEX graphite foils at 670 °C/1238 °F



SIGRAFLEX flexible graphite foil stands out thanks to its exceptional resistance to extreme temperatures. It is the first choice for sealing applications for long-term use at high temperatures – particularly in the petrochemical industry.

Our SIGRAFLEX APX2, BP, APX, Z and E foils feature outstanding oxidation resistance in comparison with other industrial graphite foils, making them ideal for high-temperature processes. As a general rule, the lower the material's weight loss, the better it will perform on the long term. SIGRAFLEX APX2 foil generally only loses 0.6 % of its weight at 670 °C (1238 °F) – while conventional industrial foils may lose up to 40 %.

Material data for our SIGRAFLEX® graphite foils with oxidation protection

Typical properties	Units	APX2	BP	APX	E
Thickness	mm	0.25 – 1.52	0.20 – 3.05	0.35 – 1.0	0.35 – 1.0
	in	0.008 – 0.06	0.008 – 0.12	0.014 – 0.079	0.014 – 0.039
Width	mm	1016 – 1524	1016 – 1524	500/1000/1500	500/1000/1500
	in	40 – 60	40 – 60	19.7/39.4/59.1	19.7/39.4/59.1
Purity	%	≥ 98	≥ 98	≥ 98	≥ 99
Ash content	%	≤ 2	≤ 2	≤ 2	≤ 1
Density (graphite)	g/cm³	1.12	0.7 – 1.43	0.7 – 1.3	0.7 – 1.3
Sulfur content	ppm	< 300	< 500	< 300	< 300
Chloride content	ppm	≤ 25	≤ 50	≤ 25	≤ 10

↑ Various products made of SIGRAFLEX foil

SIGRAFLEX is elastic and malleable, and its superior sealing properties make it exceptionally dependable.
SIGRAFLEX is a soft material which is easily compressible, but exhibits little elastic deformation or springback. This makes the material easily adaptable to any sealing surface it is applied to – even under difficult conditions, such as very rough surfaces.

The material properties are stable for the long term, and SIGRAFLEX retains its sealing effect when the surface pressure reduces during operation – a major advantage over other materials.

Material data for our SIGRAFLEX® graphite foils in industrial quality

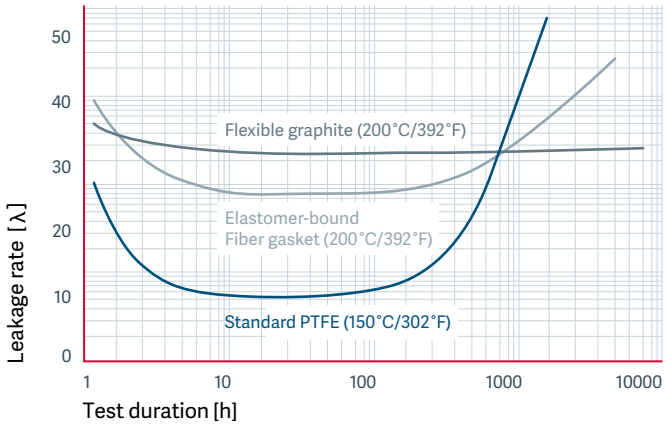
Typical properties	Units	C	B
Thickness	mm	0.35 – 3.0	0.2 – 3.05
	in	0.014 – 0.04	0.008 – 0.12
Width	mm	500/1000/1500	1016 – 1524
	in	19.7/39.4/59.1	40 – 60
Purity	%	≥ 98	≥ 98
Ash content	%	≤ 2	≤ 2
Density (graphite)	g/cm³	0.7 – 1.3	0.7 – 1.43
Sulfur content	ppm	< 300	< 1000
Chloride content	ppm	≤ 25	≤ 50

Fouling has a significant effect on leakage rates and resistance to corrosion and extreme temperatures when graphite gaskets are applied to steel flanges.

Our high-purity foils perform with long-term stability and reliability – since 1972.

An ash content of lower than 0.15 % makes SIGRAFLEX foils the first choice – even under the strictest requirements, such as those in sensitive processes in power plants. In comparison with other sealing materials, the leakage rate of our high-purity foils remains consistent, even under long-term use.

Comparison of leakage rates



↑ ***Change in leakage rates*** *of various sealing materials in long-term trials, measured on a DN 40 PN 40 flange in accordance with DIN 28090-1 and -2. Due to the warm flow characteristics of PTFE, the test temperature for this material was set at only 150 °C (302 °F).*

↑ ***Packing ring made of SIGRAFLEX foil***

↑ ***Flange*** *with SIGRAFLEX flat gasket*

Material data for our high-purity SIGRAFLEX® graphite foils

Typical properties	Units	N	Z	ZX	S	HP	UHP
Thickness	mm	0.2–1.52	0.15–3.0	0.37	0.2–1.52	0.2–1.52	0.51–2.54
	in	0.008–0.06	0.006–0.079	0.015	0.008–0.06	0.008–0.06	0.02–0.1
Width	mm	1016–1524	500/1000/1500	500	1016–1524	1016–1524	1016–1524
	in	40–60	19.7/39.4/59.1	19.7	40–60	40–60	40–60
Purity	%	≥ 99.5	≥ 99.85	approx. 98	> 99	≥ 99.85	≥ 99.99
Ash content	%	≤ 0.5	≤ 0.15	approx. 2	< 1	≤ 0.15	≤ 0.01
Density (graphite)	g/cm³	0.7–1.12	0.7–1.3	1.0	1.12	1.12	1.12
Sulfur content	ppm	< 300	< 300	< 300	< 300	< 300	< 30
Chloride content	ppm	≤ 50	≤ 10	≤ 20	≤ 10	≤ 2	≤ 1

Production and properties

We guarantee the high quality and purity of our SIGRAFLEX products by using carefully selected raw materials and highly effective mechanical, thermal and chemical cleansing procedures.

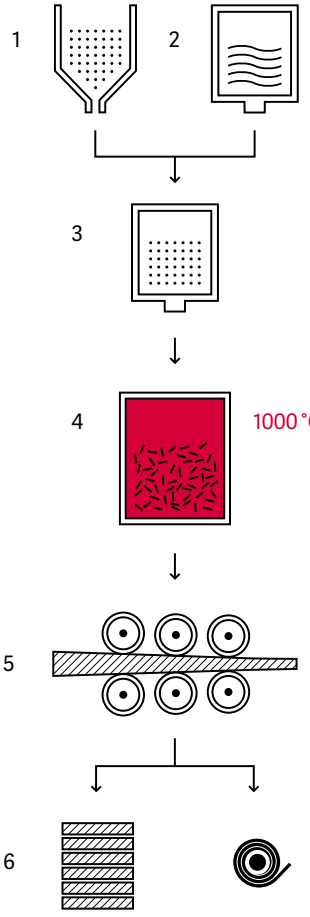
The graphite intercalation compounds produced undergo a process of thermal expansion. The expanded graphite is then compressed into foils and sheets without the use of binders or fillers.

The resulting alignment of the graphite particles and their planar structures produces a high degree of directional dependence (anisotropy).

Characteristic properties of SIGRAFLEX products

- Minimal gas and liquid permeability
- High resistance to radiation, thermal shock
- Resistance to nearly all chemical media
- Resistant to aging and embrittlement
- High load bearing capacity
- No cold or warm flow up to the maximum permissible surface pressure
- Stability of compressibility and recovery over a wide range of temperatures
- Can be used at temperatures from –250 °C (–418 °F) to approx 3000 °C (5432 °F) depending on operating conditions:
  – up to 800 °C (1472 °F) in an inert environment (limited by metal inserts)
  – up to 400–600 °C (752–1112 °F) in air (on consultation)
- Pronounced anisotropy (directional dependency) of many properties, such as electrical and thermal conductivity
- Soft, flexible and workable (easy to cut and punch)
- Environmentally friendly and harmless to the health

Overview of the production process

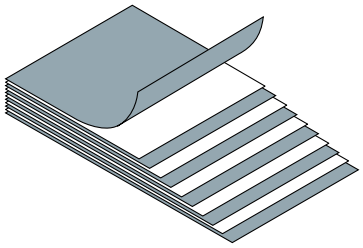


1 Natural graphite
2 Intercalation
3 Graphite salt
4 Thermal expansion
5 Calendering
6 Sheets and foils

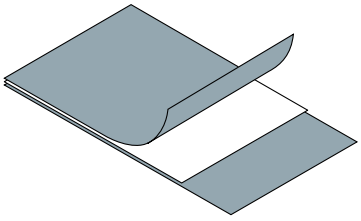
SIGRAFLEX® reinforced graphite sheets

We offer metal-reinforced graphite sheets in many different configurations. The following illustrate the various sheet structures.

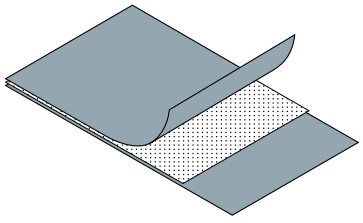
SIGRAFLEX HOCHDRUCK
Multilayer composite of stainless steel foil/graphite, adhesive-free, impregnated
SIGRAFLEX HOCHDRUCK Pro also suitable for TA Luft applications
With APX2 foil for high-temperature applications



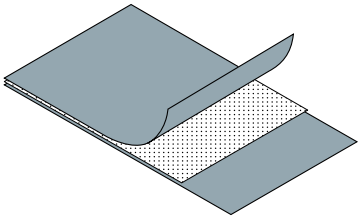
SIGRAFLEX ECONOMY
SIGRAFLEX BSSC
Reinforced with bonded stainless steel foil



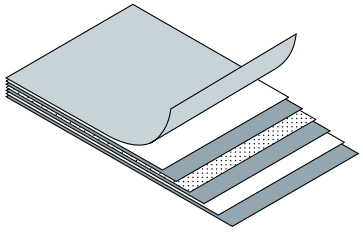
SIGRAFLEX UNIVERSAL
Perforated sheet metal reinforcement, impregnated
SIGRAFLEX UNIVERSAL Pro also suitable for TA Luft applications



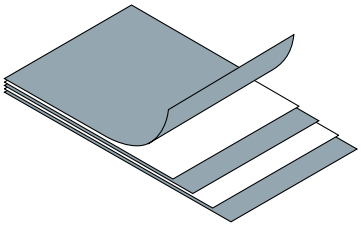
SIGRAFLEX BTCSS
SIGRASEAL
Perforated sheet metal reinforcement, adhesive-free



SIGRAFLEX MF
Adhesive-free composite made of graphite, stainless steel and PTFE; maximum requirements for leak-tightness (TA Luft), reliability, chemical-resistance and process hygiene



SIGRAFLEX SELECT
Stainless steel foil reinforcement, adhesive-free; impregnated
Gasket with inner eyelet for TA Luft applications



We have an extensive product portfolio of unreinforced, sheet metal reinforced and/or impregnated graphite sheets. SIGRAFLEX graphite sheets can be reinforced with materials such as perforated sheet metal or stainless steel foil. Special impregnation improves the sheets with greater strength and gas tightness and provides exceptionally scratch-resistant, non-stick properties.

↓ SIGRAFLEX UNIVERSAL

Typical material data for our SIGRAFLEX® reinforced graphite sheets

	Units	HOCHDRUCK Pro	APX2 HOCHDRUCK	MF	UNIVERSAL Pro	SELECT [1]
Number of inserts	**Number**	**1–7**	**1–5**	**3–7**	**1–2**	**2**
Metal reinforcement: Stainless steel sheet 316 (L)	mm	0.05	0.05	0.05		0.05
	in	0.002	0.002	0.002		0.002
Metal reinforcement: Perforated stainless steel sheet 316 (L)	mm			0.1	0.1	
	in			0.004	0.004	
bonded/adhesive-free		adhesive-free	adhesive-free	adhesive-free	adhesive-free	adhesive-free
Thickness	mm	1.0–4.0	1.0–3.0	2.0/3.0	1.6/2.0/3.0	1.6
	in	0.004–0.157	0.004–0.118	0.079–0.118	0.063/0.079/0.118	0.063
Width	mm	1000/1500	1500	1000	1000/1500	
	in	39.4/59.1	59.1	39.4	39.4/59.1	
Length	mm	1000/1500	1500	1000	1000/1500	
	in	39.4/59.1	59.1	39.4	39.4/59.1	
Purity	%	≥ 99.85	≥ 98	≥ 99.85	≥ 98	≥ 98
Ash content	%	≤ 0.15	≤ 2.0	≤ 0.15	≤ 2.0	≤ 2.0
Density (graphite)	g/cm³	1.1	1.1	1.1	1.0	1.0
Chloride content	ppm	≤ 10	≤ 25	≤ 10	≤ 25	≤ 25

[1] Sold in gasket form

Corrosion on static and dynamic sealed joints results in addition expenses for the operator and jeopardizes plants' safety, reliability and service life.

Our reinforced SIGRAFLEX graphite sheets prove highly resistant to corrosion.
The right selection of SIGRAFLEX materials can significantly reduce corrosion at sealed joints. Examples include:

- the use of flexible graphite gaskets which only contain negligible amounts of critical chloride, fluoride and sulfur contamination
- the selection of a sealing material with sufficient compressibility of over 15 % to prevent gaps from forming in the sealing joint.

We have practical knowledge and offer tailor-made solutions – no matter what the individual application may be.

↑ SIGRAFLEX BTCSS and BSSC

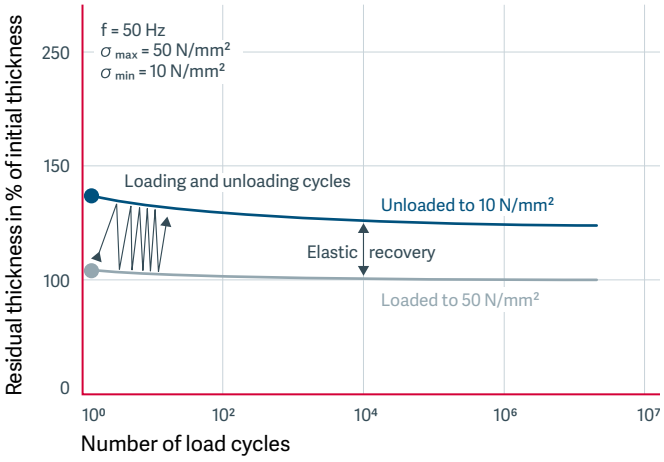
Typical material data for our SIGRAFLEX® reinforced bonded graphite sheets

	Units	ECONOMY [1]	BSSC	BTCSS	BMY
Number of inserts	**Number**	**1–2**	**1**	**1**	
Metal reinforcement: Stainless steel sheet 316 (L)	mm	0.05	0.05		
	in	0.002	0.002		
Metal reinforcement: Perforated stainless steel sheet 316 (L)	mm			0.1	
	in			0.0004	
Polyester film	mm				0.127
	in				0.005
bonded/adhesive-free		bonded	bonded	bonded	bonded
Thickness	mm	0.55–3.0	0.76–3.05	0.762–3.048	0.38–3.05
	in	0.022–0.118	0.03–0.12	0.03–0.12	0.015–0.12
Width	mm	1000	1016/1524	1016/1524	1016/1524
	in	40	40/60	40/60	40/60
Length	mm	1000	1016/1524	1016/1524	1016/1524
	in	40	40/60	40/60	40/60
Purity	%	≥ 98	≥ 98	≥ 98	≥ 98
Ash content	%	≤ 2	≤ 2	≤ 2	≤ 2
Density (graphite)	g/cm³	1.0	1.12	1.12	1.11
Chloride content	ppm	≤ 25	≤ 50	≤ 50	≤ 50

[1] Thickness 1 mm (0.0004"): available in rolls

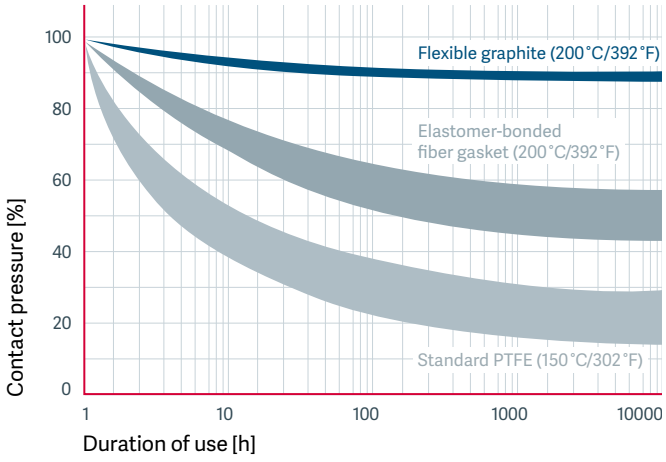
Performance under oscillating loads

Long-term stable elastic recovery with SIGRAFLEX UNIVERSAL



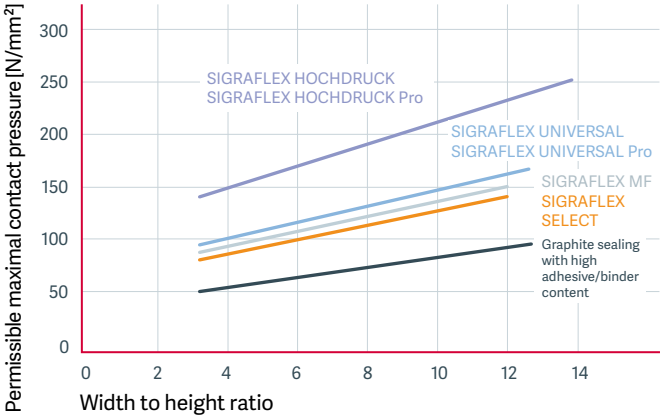
↑ SIGRAFLEX proves exceptionally stable in oscillating drive assemblies. *This can be seen in the following example: SIGRAFLEX UNIVERSAL is compressed to about 60 % of its initial thickness by a surface pressure 50 N/mm². After this prestressing, the material is subjected to oscillating loads of 10 and 50 N/mm². The material retains its elastic recovery – even after 10⁷ load cycles, it displays only a slight degree of settling.*

Consistently high residual contact pressure with flexible graphite



↑ A long-term trial *measured the change in surface pressure of various sealing materials on a DN 40 PN 40 flange (in accordance with DIN 28090-1). Due to the warm flow characteristics of PTFE, the test temperature for this material was set at only 150 °C (302 °F). Even after being subjected to roughly one year of loading, the flexible graphite retains a great deal of surface pressure.*

Maximum permissible contact pressure for gaskets made of reinforced SIGRAFLEX graphite sheets with a thickness of 2 mm (0.08")[1)]



[1)] Measured at 300 °C/572 °F (according to DIN 28090-1)

Additional information on our SIGRAFLEX sealing materials can be found under "Download Center" on our homepage.
www.sglgroup.com/sigraflex-downloads

Chemical resistance

SIGRAFLEX natural graphite products are resistant to most chemical media, even at high temperatures.

Unreinforced SIGRAFLEX is resistant to inorganic and organic acids and bases, solvents, waxes and oils. Exceptions include highly oxidizing molten salts and extremely highly oxidizing agents, such as highly concentrated nitric acid, highly concentrated sulfuric acid (oleum), nitrosulfuric and chloric acid.

All chemical media which are listed without concentration and temperature in the table below are at a concentration 100 % and a temperature corresponding to their respective boiling or melting point.

Chemical resistance of SIGRAFLEX® FOIL (pure graphite) [3]

Alcohols
Ethyl alcohol ●
Glycol ●
Isopropyl alcohol ●
Methyl alcohol ●

Aldehydes
Acetaldehyde ●
Benzaldehyde ●
Formaldehyde ●

Ethers
Diethyl ether ●
Dioxane ●
Diphenylether ●
Methyl ethyl ether ●

Esters
Acrylic ester ●
Amyl acetate ●
Ethyl butyl ester ●

Ketones
Acetone ●
Ethyl methyl ketone ●
Methyl isobutyl ketone ●

Hydrocarbons
Benzene ●
Ethylene ●
Isooctane ●
Propane ●
Propylene ●
Styrol ●
Xylol ●

Halogenated hydrocarbons
Chlorobenzene ●
Chloroform ●
Frigene ●
Carbon tetrachloride ●

Organic acids
Acrylic acids ●
Formic acid ●
Acetic acid ●
Hexachlorphenyl acetic acid ●
Maleic acid ●
Monochloroacetic acid ●
Phenylacetic acid ●
Phthalic acid ●
Stearic acid ●
Sulfonic acid ●
Trichloroaceticacid ●
Tartaric acid ●

Amines
Aniline ●
Diethylamine ●
Ethanol-triethylamine ●

Other organic media
Acrylonitrile ●
Dimethyl sulfoxide ●
Epichlorohydrin ●
Mercaptan ●
Nitrobenzene ●
Phenol ●
Carbon disulfide ●
Silicone ●
Siloxane ●
Thionyl chloride ●

Technical mixtures
Gasoline ●
Hydraulic oils ●
Kerosene ●
Paint thinner ●
Motor oils ●
Transformer oil ●
Heat-transfer oils ●

Alkalis
Ammonia solution ●
Caustic potash ●
Potassium hydroxide up to 400 °C ●
Sodium hydroxide up to 400 °C ●
Caustic soda ●

Aqueous salt solutions
Borates ●
Bromides ●
Chlorides ●
Chromates, concentr. 20 % ●
Fluorides ●
Iodides ●
Carbonates ●
Nitrates ●
Nitrites ●
Phosphates ●
Sulfates ●

Oxidizing molten salts
Potassium chlorate ■
Potassium nitrate ■
Sodium peroxide ■

Non-oxidizing molten salts
Borate, soda
Potash ●
Calcium chloride ●
Potassium hydrogen sulfate ●

Molten metals
Aluminum ●
Lead ●
Iron ■
Gold ●
Potassium Up to 350 °C ●
Copper ●
Magnesium ●
Mercury ●
Silver ●
Wood's metal ●
Zinc ●
Tin ●

Acids
Boric acid ●
Bromic acid ●
Chromic-sulfuric acid up to 20 % ●
Hydrofluoric acid ●
Aqua regia ■
Nitrating acid ■
Oleum ■
Perchloric acid up to 20 % ●
Phosphoric acid ●
Nitric acid up to 65 % ●
Nitric acid > 65 % ■
Hydrochloric acid ●
Sulfuric acid up to 70 % ●
Sulfuric acid 70 – 100 % up to 100 °C ●
Sulfurous acid ●

Gases/vapors
Ammonia ●
Bromine ■
Hydrogen bromide ●
Chlorine, wet at > 30 °C ■
Chlorine, dry ●
Chlorine dioxide ■
Hydrogen chloride ●
Fluorine ▲
Hydrogen fluoride ●
Carbon dioxide up to approx. 600 °C ●
Carbon monoxide ●
Air, approx. 400 °C and up please consult ●
Phosgene ●
Oxygen up to approx. 300 °C ▲
Sulfur dioxide ●
Sulfur hexafluoride ●
Sulfur trioxide ■
Hydrogen sulfide ●
Nitrogen ●
Nitrogen dioxide up to approx. 600 °C [2] ●
Nitrogen monoxide [2] ●

Other inorganic media
Bleaching lye ●
Hydrazine ●
Sulfur ●

● resistant
■ non-resistant
▲ conditionally resistant
[1] without oxygen entering
[2] dry gases only
[3] Specifications on the chemical resistance of our reinforced SIGRAFLEX sealing materials can be found in our technical information on "SIGRAFLEX Sealing Materials – Resistance to Chemical Media."

Certified safety

↑ These are only a few examples of the many standards SIGRAFLEX meets:
TA Luft certificate, fire safety certificate according to API 607, blow-out resistance, BAM approval, DVGW certificate according to DIN 3535-6

SGL Group's graphite materials and products are tested, standardized and safe. They meet a wide range of global standards and regulations.
We face the challenges which regulatory legislation can pose and demonstrate the high performance of our products on a regular basis. For years, our materials have been routinely evaluated according to the rules and standards of many different countries worldwide. And the wide variety of certificates, certifications and approvals received confirm:
Our SIGRAFLEX products comply with national and international standards and thus provide our customers with a maximum level of safety.

SIGRAFLEX®
yarns for the chemical and petrochemical industries

Our product portfolio covers a wide variety of SIGRAFLEX carbon and graphite packing yarns which provide many advantages:

- **Good thermal conductivity**
- **Outstanding chemical and thermal resistance**
- **High degree of purity**
- **Good mechanical strength**
- **High compressibility and flexibility**
- **Extended service life and reduced packing maintenance expenses**

SIGRAFLEX® carbon and graphite packing yarns

High thermal conductivity, enhanced oxidation protection and chemical resistance.

SIGRAFLEX carbon and graphite packing yarns are used worldwide in high-temperature and high-pressure braided packing applications.

They provide outstanding handling for the braiding process as well as increased corrosion protection, and allow a variety of layers and coatings to be applied.

↑ Packing rings made of yarns

← SIGRAFLEX packing yarns

Packing yarns and possible coatings

Product characteristics	PAN	PAN SB	Rayon	FG
Purity in %	94–99	94–99	> 99	> 98
Tex [1]	200–3200	167–1500	600 & 1200	6500 & 7300
g/m Denier	0.2–3.2 1800–28800	0.167–1.5 1503–13500	0.6 and 1.2 5400 and 10800	7.3/6.5
Tensile strength	very high	high	moderate	very high

All packing yarns can be coated with Teflon, graphite and/or a combination of PTFE and graphite.

Material data for our SIGRAFLEX® yarns

Typical properties	Units	GMCP21 G8 Continuous wound and graphitized packing yarns	LCC21/42 Continuous wound and carbonized packing yarns	CSP9TG18 Staple fiber, carbonized packing yarns	BFI3/5 Braidable foil yarn with Inconel® reinforcement, binder-free
Precursor		high-purity PAN	PAN	PAN	FG
Coating		Graphite	Graphite, PTFE	Graphite, PTFE	none
Purity	%	≥ 99	≥ 94	≥ 94	≥ 98
Ash content	%	≤ 0.5	≤ 1	≤ 1	≤ 2
Tensile strength	kg	≥ 45	≥ 45	≥ 45	≥ 45
Specific weight		1.78	1.75	1.75	
Yarn weight	g/m	0.82	1.4/2.8	1.9	6.3/7.3
Twist	TPI	1.2		1.3	
	TPM	47		51	
Number of plies				9	
Moisture content	%	≤ 1	≤ 1	≤ 1	≤ 1
Finish content	%	8	43	20	
Available twists		S, Z	S, Z	S, Z	
Inconel® content	%				30
Weight loss under heat 593 °C (1099.4 °F) 24 hours (API 622)	%				≤ 5

[1] Mass of yarns in grams per 1000 m length

SIGRAFINE®
specifically for dynamic sealing applications

SIGRAFINE components from SGL Group open up many possibilities and offer the following exciting properties:

- **Very good sliding characteristics for higher energy efficiency**
- **Exceptional mechanical strength**
- **High corrosion resistance**
- **Extended service life resulting in lower maintenance costs**
- **Great resistance to high temperatures and thermal shock**
- **Good thermal conductivity**

Materials made of SIGRAFINE® fine-grain graphite

Resistance to chemicals and high temperatures, high long-term stability.

↑ Metal-sleeved rings for sealing in screw compressors

← Seal rings made of die-molded carbon

Carbon and graphite materials are put to a wide range of uses in the chemical industry thanks to their exceptional sealing properties. Many processes involve the pumping, stirring and transporting corrosive, toxic or explosive media. The pumps used have rotating shafts with axial seal rings which must dependably keep out gases or fluids with low hydrodynamic lubricity.

High resistance to chemicals make specialty graphites the first choice in many applications. They cannot be dissolved or melted and are resistant to virtually all media such as bases and most acids. We apply our decades of experience in the industry and well-founded knowledge of technical applications to assist our customers with innovative, often tailor-made solutions – even in small production runs.

SIGRAFINE® products for specific applications

Applications	Products	EK20 [1]	EK23 [1]	EK24 [1]	EK40 [1]	EK60	V1626
Process pumps	Seal rings	•	•	•	•		
	Segmented packings			•	•		
	Bearings	•	•	•	•		
	Guide rings			•	•		
Vacuum pumps	Vanes					•	•
Flow meters	Bearings	•		•	•		
Pipelines	Ball valve seal rings	•		○	•		
Compressors	Metal-sleeved rings	○		○	•		
	Piston and guide rings	•		•	•		
	Seal rings	•		•	•		
Rotary joints	Seal rings	•		•	•		
Turbines	Seal rings	○		•	•		
	Guide rings			•	•		
Blowers	Segmented packings	•		•	•		
Block heat and power plants	Pistons and piston rings			•	•		
	Segmented packings			•	•		
Mobile range extenders	Vanes			•			
	Seal rings			•	•		

○ suitable • recommended [1] All materials are available in metal and plastic-impregnated form for even better performance properties.

SGL Group offers fine-grain graphite materials for pump and sealing applications: die-molded, isostatic, synthetic resin-bonded.

The base materials used are either graphite or carbon graphite, depending on the specific application. These also come with special impregnations such as antimony, bronze or synthetic resin.

Overview of our range

EK20: Carbon graphite with good failsafe running properties. Usable for machined plain bearings in wet running.

EK23: Carbon graphite pressed to size with good failsafe running properties. Usable for machined plain bearings in wet and dry running. Our pressed to size (PTS) technology enables us to adapt parts with an outer diameter of max. 80 mm (3.15") to match their final form by up to nearly 100 %, which minimizes – or completely eliminates – the need for follow-up machining work.

EK24: Carbon graphite with very good failsafe running properties. Exceptionally well suited for dry-running use and use in media with poor lubricating properties.

EK40: Graphite for dry running plain bearings.

↑ PTS pressed bearings

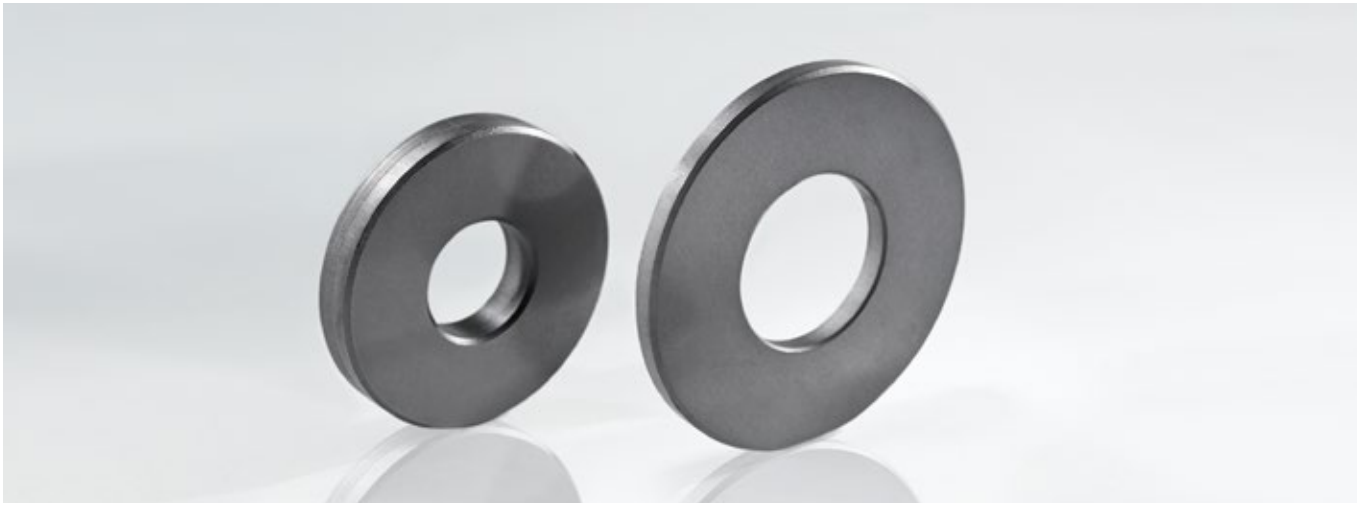
***↑ Carbon seal ring** made with PTS technology*

Material data for our SIGRAFINE® fine-grain graphites

		Carbon graphites [1]				Graphites		Synthetic resin-bound graphite
Typical properties	**Units**	**EK20**	**EK2230**	**EK2239**	**EK24**	**EK40**	**V1626**	**EK60**
Impregnation		–	Synthetic resin	–	–	–	Salt	–
Density	g/cm³	1.70	1.85	1.80	1.70	1.70	1.85	1.73
Flexural strength	MPa	55	60	55	60	35	58	80
Young's modulus	GPa	22.0	22.0	20.0	18.0	10.0	13.0	22.0
Rockwell Hardness B	HR5/100	105	110	105	105	95	90	80
Thermal expansion in 20–200°C (68–392 °F) oxidizing atmosphere	10^{-6} K^{-1}	3.0	6.5	4.5	4.1	4.5	4.0	11.0
	°C (°F)	350 (662)	200 (392)	350 (662)	350 (662)	500 (932)	600 (1112)	180 (356)

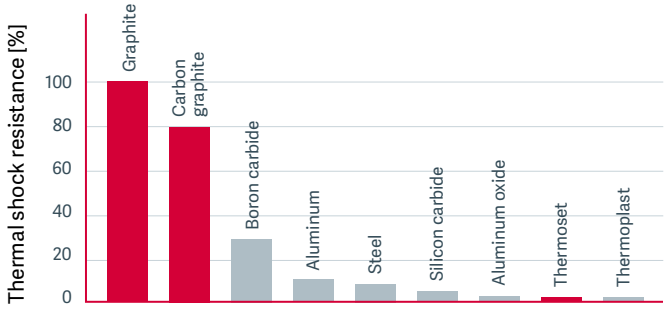
[1] a pitch-bonded, carbonized material with high graphite filler content

Characteristic properties



↑ Axial bearings

Thermal shock resistance of various materials

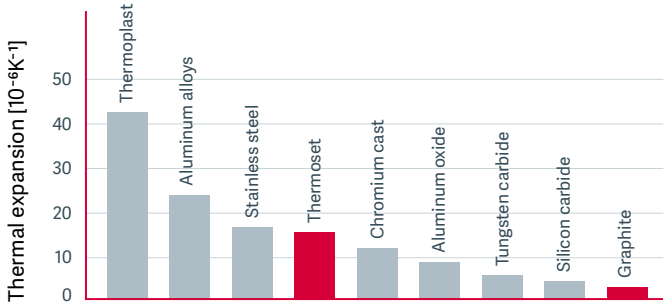


Our SIGRAFINE dynamic sealing elements prove their outstanding properties particularly well under extreme conditions. SIGRAFINE makes a major contribution to process reliability thanks to its great resistance to high temperatures and thermal shock.

← Graphite has the highest thermal shock resistance of any material. *Comparison with other materials points to graphite's clear superiority in terms of its durability under fluctuating temperatures. Resistance to thermal shock depends on thermal conductivity.*

$$\delta = \frac{\text{Strength x thermal conductivity}}{\text{Coeff. of thermal expansion x Young's modulus}}$$

Coefficient of thermal expansion of various materials



← Variable thermal expansion coefficient of various materials. *Combining materials with the same or similar thermal expansion coefficient provides good physical compatibility. The expansion coefficient can be adjusted through the selection of recipe components.*

Die-molded materials made of SIGRAFINE exhibit exceptional wear resistant properties.

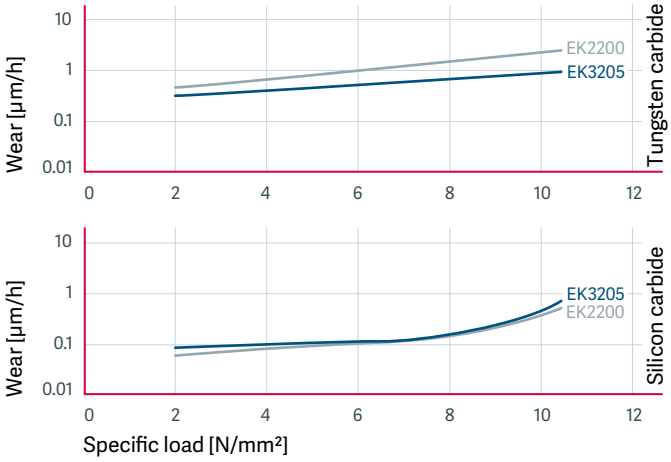
There are many different factors which generally influence wear behavior, such as the following:

- Combination of materials
- Sliding velocity
- Stress
- Surface finish of the contact surfaces
- Solid impurities in the medium to be sealed
- Operating conditions.

This means that the tribological system must be seen as a whole in order to find the best material solution.

We assist our customers with our long-standing experience in application and our extensive knowledge on materials.

Wear behavior depending on counterfaces

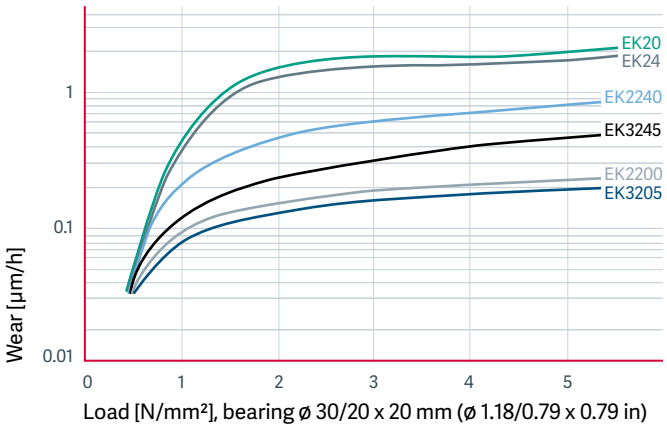


↑ Friction and wear depend on the counterface materials, environmental influences and stress profile. *In this case: Wear behavior of EK2200 and EK3205 for counterfaces made of carbidic materials, a constant sliding velocity of 9 m/s (29.5 ft/s) and increasing stress. Medium: demineralized water.*

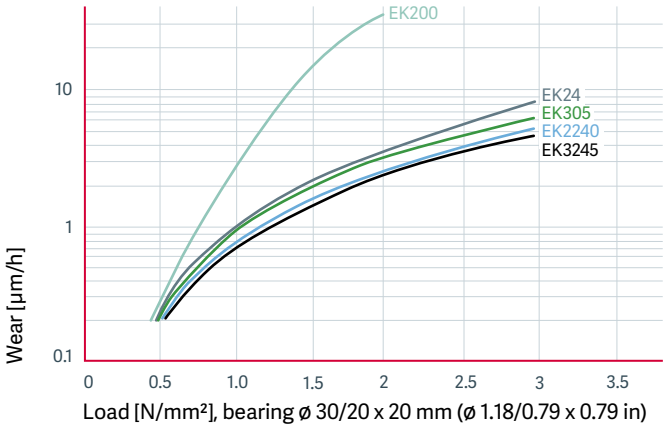
↓ Wear behaviour *of machined plain bearings of various brands of carbon at a constant sliding velocity of 1 m/s (3.3 ft/s) and increasing specific stress in wet and dry running.*

EK2240 = EK24 synthetic resin-impregnated
EK3245 = EK24 antimony-impregnated
EK2200 = EK20 synthetic resin-impregnated
EK3205 = EK20 antimony-impregnated

Wear behavior: wet running



Wear behavior: dry running

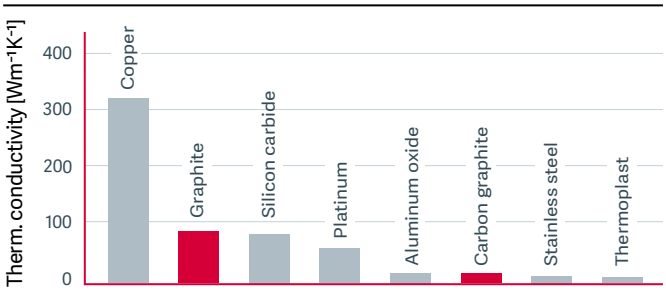


↑ ***Spherical bearings***

Materials made of SIGRAFINE also boast impressive thermal conductivity.

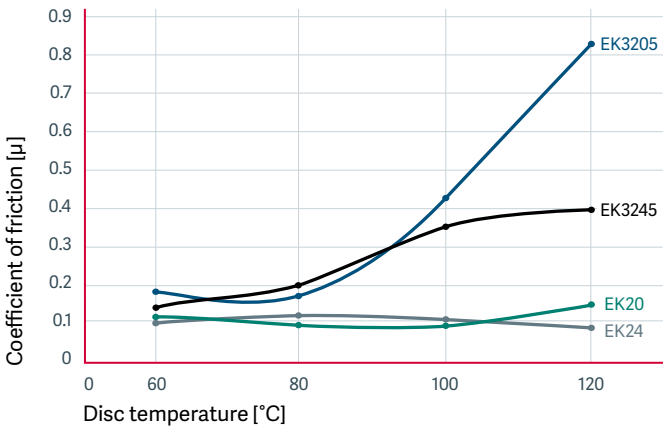
In fact, SIGRAFINE is many times more heat conductive than its surrounding components and prevents systems from overheating and wear.

Thermal conductivity of various materials

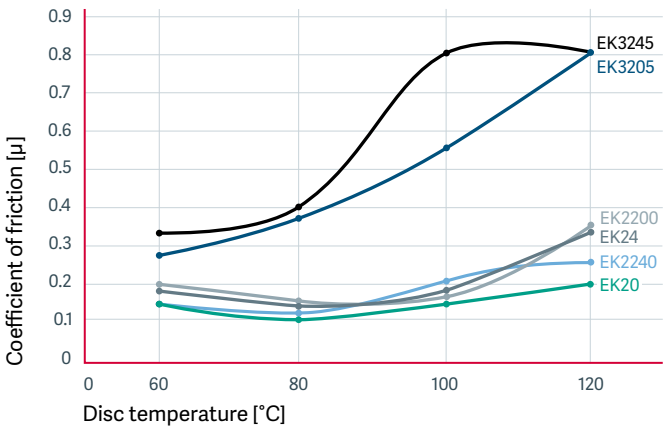


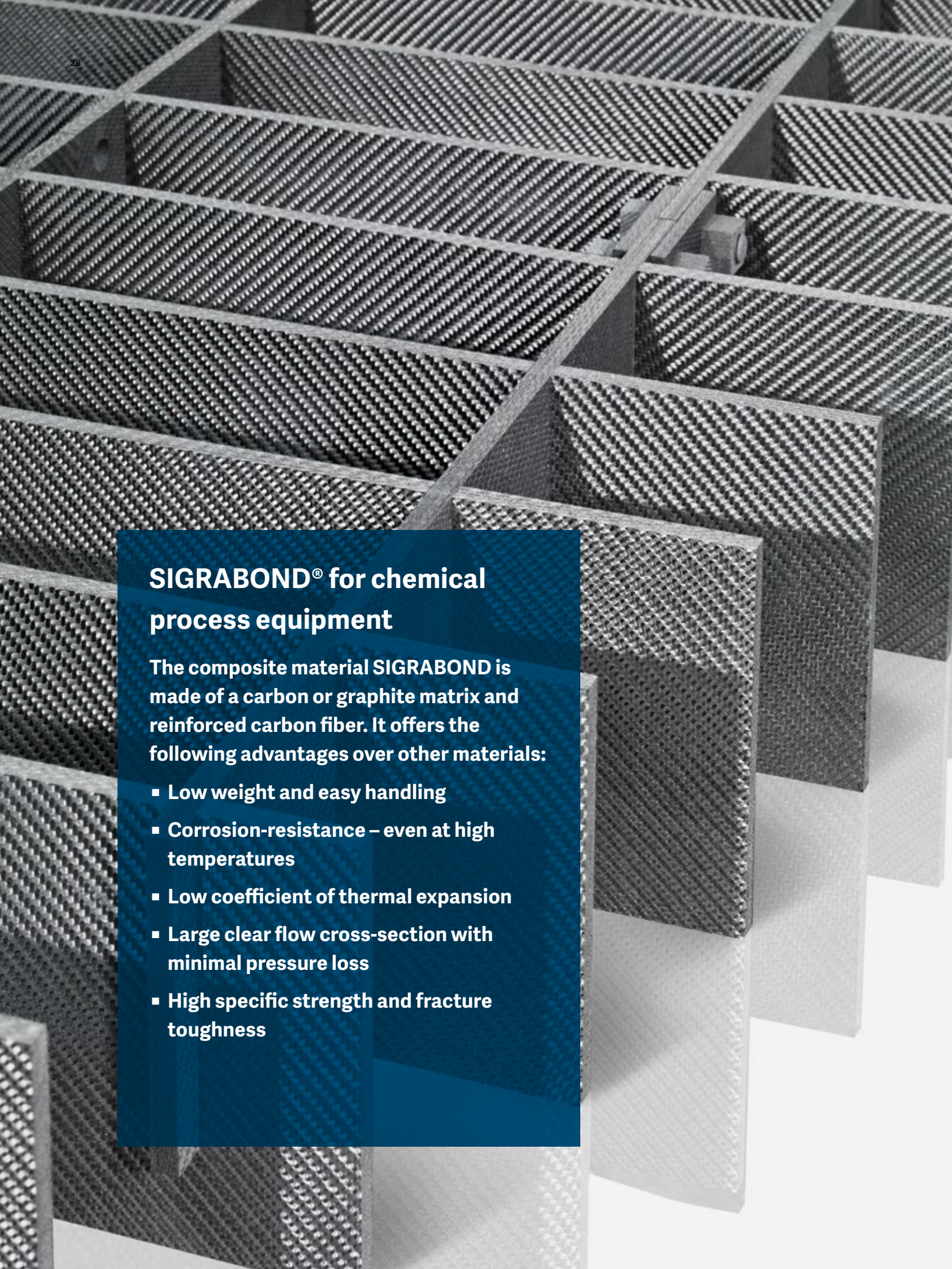
↓ ↘ ***The coefficients of friction*** *were determined in a pin-on-disc test at 11 m/s (36.1 ft/s), a relative air humidity between 36 % and 43 % and a heated disc.*

SiC discs (Ra ≈ 0.2)



Gray cast iron 20 (Ra ≈ 0.3)





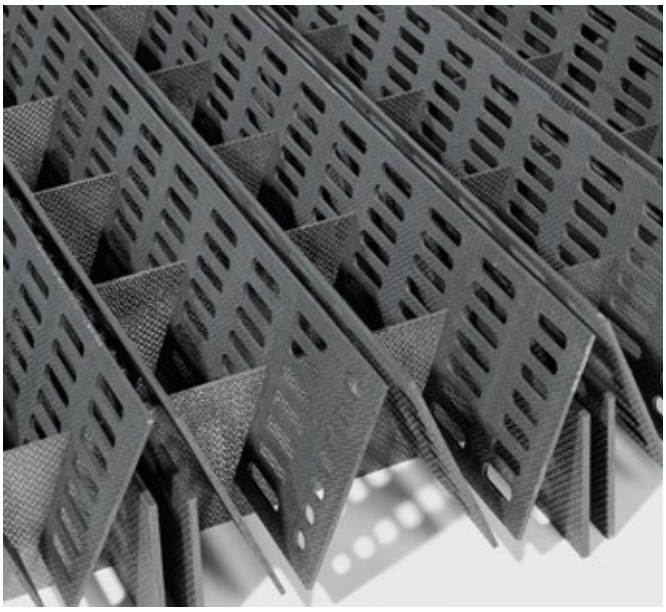
SIGRABOND® for chemical process equipment

The composite material SIGRABOND is made of a carbon or graphite matrix and reinforced carbon fiber. It offers the following advantages over other materials:

- **Low weight and easy handling**
- **Corrosion-resistance – even at high temperatures**
- **Low coefficient of thermal expansion**
- **Large clear flow cross-section with minimal pressure loss**
- **High specific strength and fracture toughness**

SIGRABOND® carbon fiber-reinforced carbon and graphite

Lightweight, stiff, temperature and corrosion resistant.



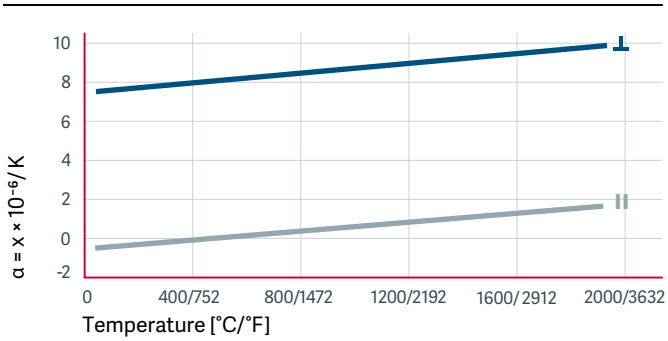
←↑↗ Column support grid made of SIGRABOND

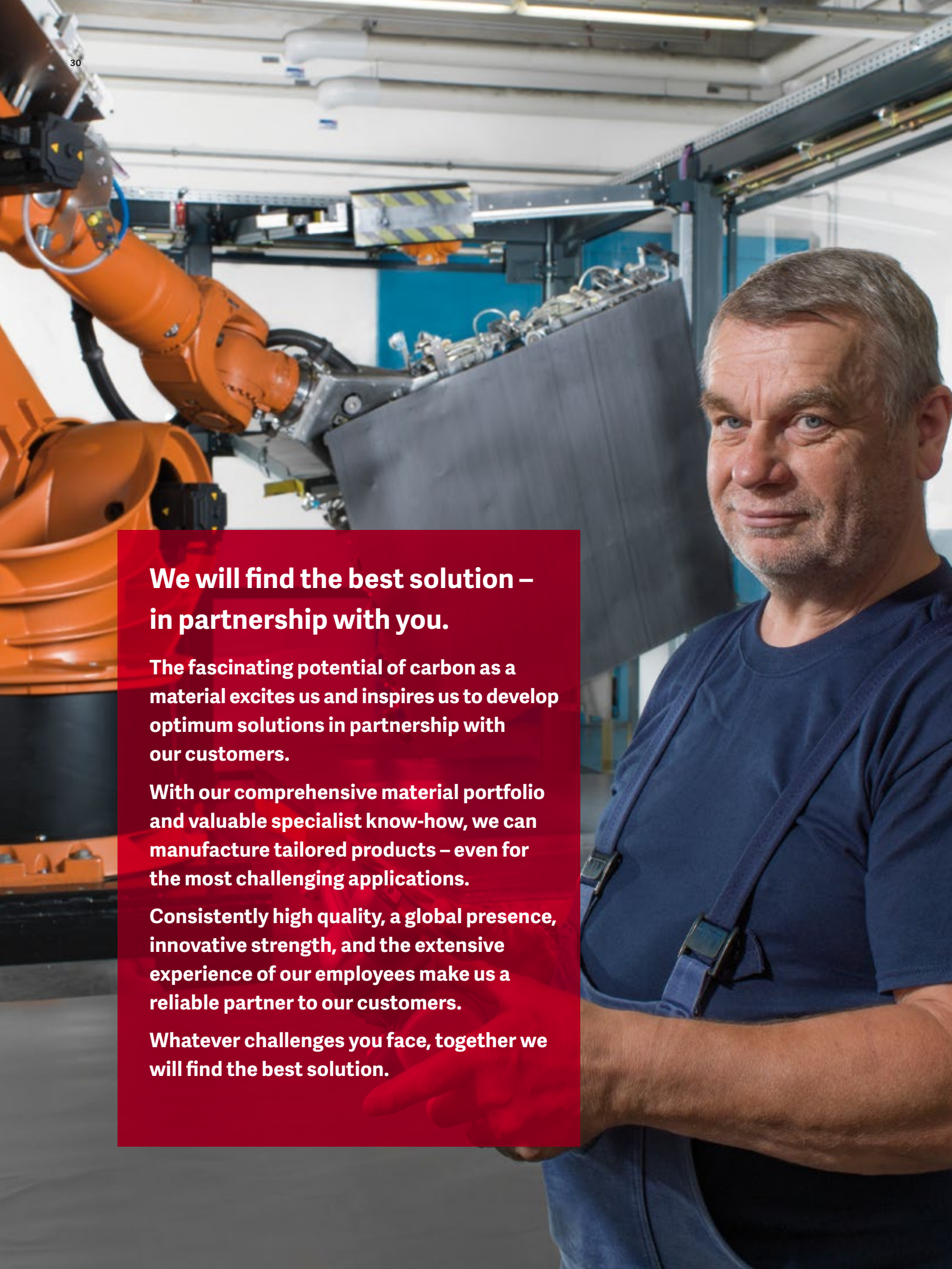
SIGRABOND is extremely compact and proves high stability despite its low weight – even at low component thicknesses. Supporting grids for structured packings made of SIGRABOND allow for large distillation columns in elegant designs. Moreover, they are very easy to disassemble, and maintenance work can be carried out through manholes. And don't forget SIGRABOND's high resistance to thermal shock – a major advantage over most ceramic and metallic materials.

Material data for our SIGRABOND® Performance carbon fiber-reinforced carbon

Typical properties	Units	Service
Density	g/m³	1.45
Flexural strength	MPa	200
Flexural elasticity modulus	GPa	70
Interlaminar shear strength (ILSS)	MPa	8
Ash	ppm	1000
Purified types	ppm	< 10
Max. application temperature	°C (°F)	2000 (3600) under inert gas 2000 (3600) in vacuum up to 350 (662) under oxygen

Coefficient of thermal expansion SIGRABOND Performance





We will find the best solution – in partnership with you.

The fascinating potential of carbon as a material excites us and inspires us to develop optimum solutions in partnership with our customers.

With our comprehensive material portfolio and valuable specialist know-how, we can manufacture tailored products – even for the most challenging applications.

Consistently high quality, a global presence, innovative strength, and the extensive experience of our employees make us a reliable partner to our customers.

Whatever challenges you face, together we will find the best solution.

SGL Group – The Carbon Company. A leading global manufacturer of carbon-based products.

- *Unique product portfolio*
- *Innovative technologies and solutions*
- *Production sites close to sales markets*
- *Technology & Innovation Center in Germany with international networks*

← Production of SIGRAFLEX graphite sheets

We have wide-ranging expertise in raw materials, advanced manufacturing processes, and long-standing application and engineering know-how. We have a comprehensive portfolio of carbon, graphite, and carbon fiber products and our integrated value chain covers everything from carbon fibers to composites. With a global sales and distribution network and modern production sites in Europe, North America, and Asia, we are close to our customers throughout the world.

We use this broad base to offer our customers the best solutions possible. That's how we live up our claim: **Broad Base. Best Solutions.** This claim is also upheld by our corporate SGL Excellence philosophy of continuous improvement.

More information can be found by visiting:
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