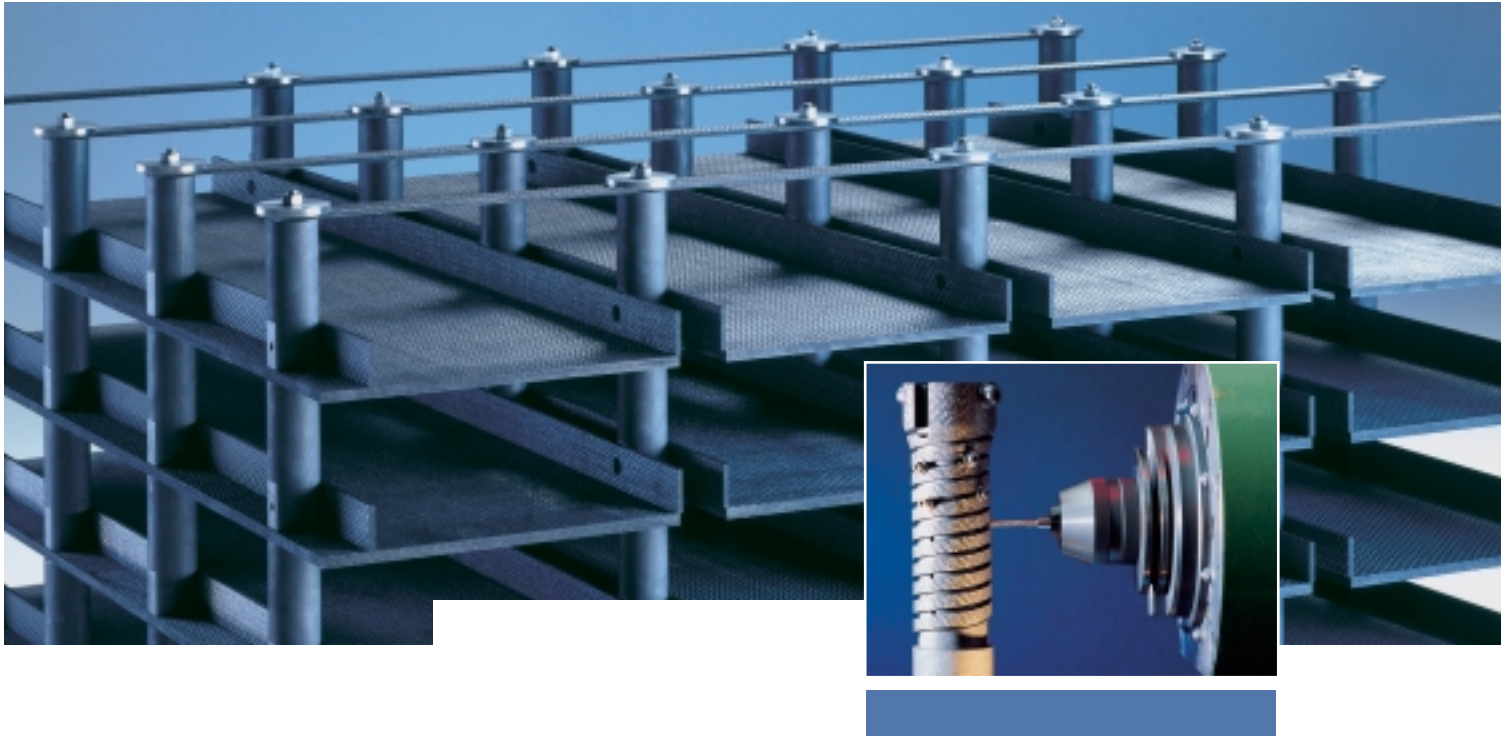


Charging Systems and Heating Elements

in carbon fiber-reinforced carbon



SGL CARBON GROUP

Graphite Specialties

® SIGRABOND charging systems for high-temperature processes

Profitable investments

Problems frequently associated with the use of metals in high-temperature technology can be avoided by using SIGRABOND carbon fiber-reinforced carbon components. They are notable mainly for their:

- shape retention under heat
- increase in strength under heat
- absence of embrittlement
- low weight
- low heat absorption.

As a result, SIGRABOND carbon fiber-reinforced carbon charging systems offer the following advantages:

- long service life
- excellent energy efficiency
- suitability for larger batches or reduced processing times
- optimum conditions for process automation
- greatly reduced deformation of workpieces, so less need for oversizing and subsequent machining.

These useful properties make for substantial cost savings by improving the economic efficiency of the operating sequence. This ensures that the cost of SIGRABOND charging systems is rapidly recovered.

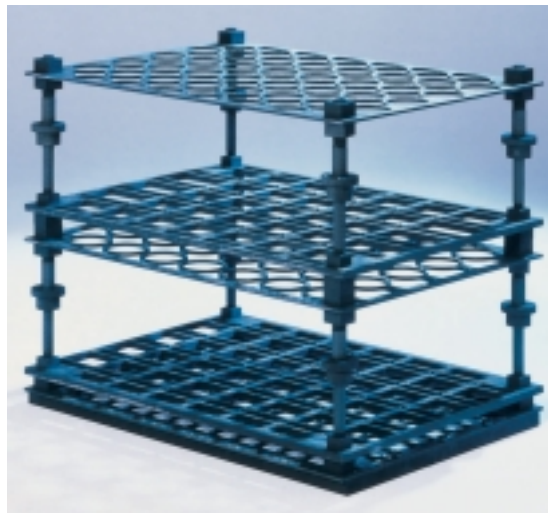
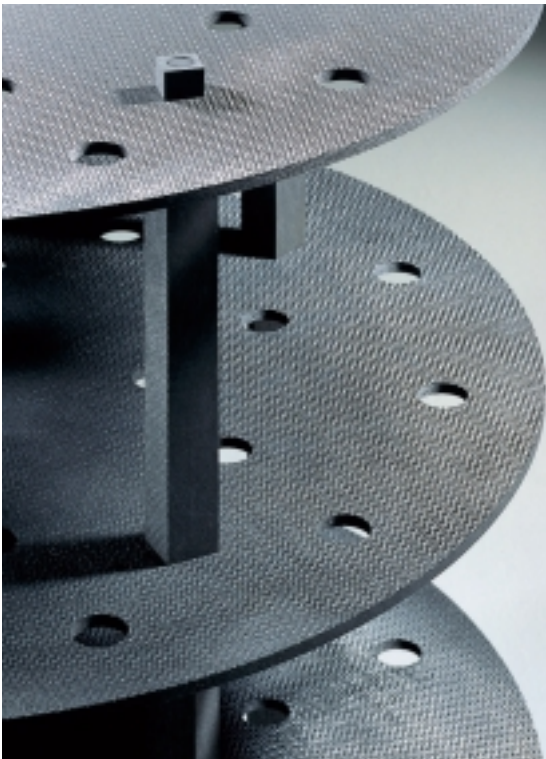
Relevant properties

The above advantages over steel, molybdenum or nickel-chromium alloy systems are the combined result of the following material properties:

- high thermal stability
- low density
- low thermal expansion.

This means the relatively high specific heat capacity of SIGRABOND material is more than compensated for.

The following table compares the parameters of SIGRABOND 1501 G and a high-performance nickel-chromium alloy.



Parameter	Unit	NiCr	SIGRABOND 1501 G
σ_b	MPa	50	300
ρ	g/cm ³	8.1	1.5
c_p	J / g · K	0.5	1.8
$\sigma_b / \rho \cdot c_p$	K	12	111

where:

σ_b : three-point flexural strength at 1000°C

ρ : density

c_p : specific heat capacity at 1000°C

The $\sigma_b / \rho \cdot c_p$ ratio against temperature expresses the relationship between thermal stability and heat absorption. The higher the ratio, the more suitable is the material for use in mechanically stressed components in high-temperature processes.

The example shows that the dimensions of SIGRABOND support fixtures can be greatly reduced in comparison with those of metal fixtures. This makes for extremely lightweight charging systems that combine high strength and efficiency.

Not only does this facilitate handling; the saving in mass can also be utilized to increase the charge volume. As a result, SIGRABOND charging systems create an opportunity for cost savings due to their far higher cost-efficiency in heat treatment processes.

Another advantage of SIGRABOND is its resistance to embrittlement in high-temperature processes. This considerably lengthens the service life of support fixtures.

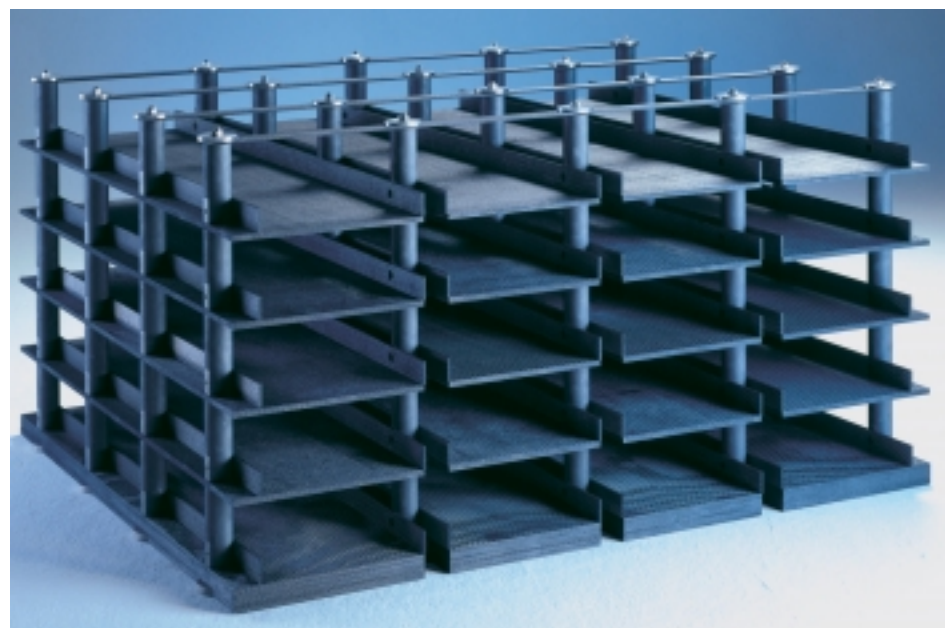
Owing to their complete absence of deformation, SIGRABOND charging systems can be reliably integrated into automated operating sequences.

Package solutions

SIGRABOND charging equipment is ideally suited to processes such as hardening, sintering or brazing in vacuum or protective gas furnaces.

® **SIGRABOND**
charging systems for high-temperature processes

The package solutions we offer are tailored to our customers' specific requirements and extend from structural design to commissioning of systems.



® SIGRABOND charging systems for high-temperature processes

We optimize the design of SIGRABOND charging systems for the application concerned in terms of required tier structure and workpiece arrangement.

This design work also involves combining SIGRABOND carbon fiber-reinforced carbon with other materials such as graphite, metals or ceramics as required.

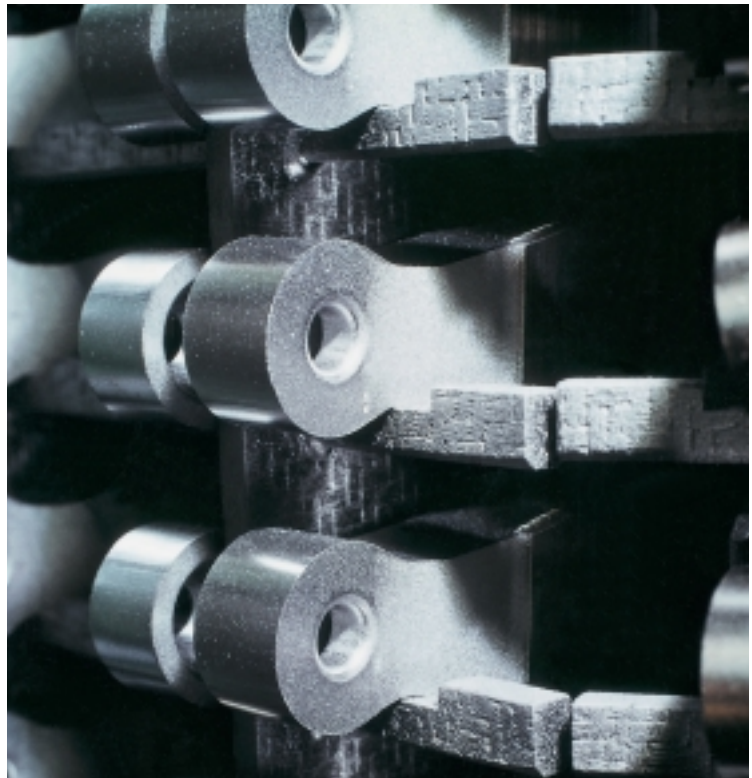
In processes involving oil quenching operations, the materials used must not contain any open pores. SGL Carbon is breaking new ground in its research and development work by combining SIGRABOND with carbon fiber-reinforced silicon carbide (CSiC). The purpose is, firstly, to optimize process suitability and service life, and, secondly, to take full advantage of the favorable thermal and mechanical

properties of fiber-reinforced ceramic materials.

This material combination also helps prevent carburization of the charging material, which otherwise occurs at temperatures above 1050°C and usually causes complications. CSiC is also highly oxidation-resistant up to 1350°C. This new material is undergoing comprehensive research and development work to optimize its use in support fixtures.

We design and manufacture our support fixtures in accordance with the latest technology and exacting quality standards.

This means our SIGRABOND charging systems are guaranteed for many years.



Efficient heating elements

The high thermal stability of carbon fiber-reinforced carbon allows SIGRABOND heating elements to be used in vacuum and protective gas furnaces at temperatures up to more than 2700°C. Unlike graphite, SIGRABOND material offers two major advantages:

- high breaking strength
- low heat absorption.

With its high mechanical strength, SIGRABOND can be used for space-saving, filigrane designs.

SIGRABOND is also suitable for large surface-area systems, which ensure uniform dissipation of heat.

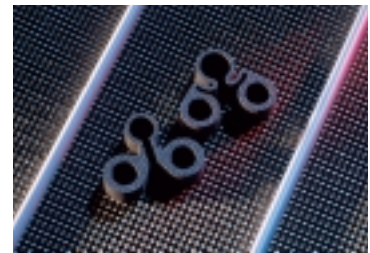
The low thermal mass of the heating elements results in excellent response behavior.

We undertake design and manufacture of SIGRABOND heating elements to our customers' special requirements.

The large variety of possible designs can be seen from the illustrations. We manufacture not only flat, but also cylindrical heating elements with diameters and lengths up to 1600 mm and 2500 mm respectively.

Whatever their design, SIGRABOND heating elements offer long service lives and high operational reliability.

® **SIGRABOND heating elements for high-temperature processes**



® SIGRABOND charging systems and heating elements for high-temperature processes

Expertise in carbon composites

Many years of continued research and development work have paved the way for the economical use of carbon composites in various sectors of industry.

Our process expertise covers the entire range of carbon composites and extends from woven fabrics to prepregs and CFRP components to carbon fiber-reinforced carbon and ceramic materials.

Brochures with full details of these materials and the products made from them are available on request.

This applies in particular to our brochure on the properties, uses and design principles of SIGRABOND carbon fiber-reinforced carbon.

Production at our Meitingen site complies with stringent quality requirements and is accredited to DIN EN ISO 9001 standards.





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