# **DIABON®**

Graphite Plate, Block and Shell and Tube Heat Exchangers

# **Process Technology**



Broad Base. Best Solutions.



# SGL Group – The Carbon Company



We are SGL Group – The Carbon Company – one of the worldwide leading manufacturers of carbon-based products. We have an in-depth materials, production, applications and engineering expertise, a comprehensive graphite and carbon fiber-based product portfolio, and an integrated value chain from carbon fibers to composites.

> We operate close to our customers through a global sales network and state-of-the-art production sites in Europe, North America and Asia. With this Broad Base, we offer Best Solutions to our customers with the help of our Company philosophy of SGL Excellence.

# Process Technology Perfection in Graphite, Silicon Carbide and PTFE

Our Business Line Process Technology is focused on supporting the technical processes of our globally operating customers in the chemical industry, metal manufacturing and environmental protection technology. A maximum degree of know-how and expertise in corrosion protection, a global presence and full-package systems from a single source: that's what our customers need – and get from us:

- Long-standing experience and a high level of expertise in process technology
- Comprehensive process, material and design know-how on resinimpregnated graphite and Poly-Tetra-Fluoro-Ethylene (PTFE)
- Closeness to customers: cost-effective manufacturing to international and local standards at our production sites in Europe, America and Asia, and worldwide customer service
- ► A consistently high standard of quality

Our comprehensive range of products and services extends from process equipment and components made from DIABON® graphite and POLYFLURON® virginal, paste-extruded PTFE, through LICUFLON® skived PTFE sheet-lined steel equipment, FLURO-FLEX® bellows, FLUROPIPE® pipe systems, FLUROSIC® silicon carbide heat exchangers and DIABON® graphite or exotic metal pumps, to the planning and assembly of complex systems.



#### Contents

Heat Exchanger	4	DIABON <sup>®</sup> Block Heat Exchangers	12
Technical specifications	5	DIABON® Block Heat Interchanger	14
DIABON <sup>®</sup> graphite	6	DIABON® Shell and Tube Heat Exchangers	15
DIABON® Heat Exchangers	8	Customer Service	18
DIABON® Plate Heat Exchangers	9	Quality Management	19

# Heat Transfer Our In-House Expertise

Heat Transfers are used in a variety of applications. They enable the heat energy transfer between hot and cold fluids (liquids or gases) through a heat transfer surface. The cold and hot fluids flow simultaneuously while heat energy is transferred through a separating wall. The fluids might be pure components or mixtures of components. The process might involve partial or complete phase changes (evaporation, condensation or crystallization). The heat transfer takes place through the graphite wall by conduction. Fortunately, DIABON has an outstanding thermal conductivity thus enabling us to offer very compact solutions.

> SGL Group has been designing graphite heat exchangers for ultracorrosive applications for more than 50 years. We understand heat transfer and know how to offer the most adapted solution to each complex process specification. Our team of highly-skilled process engineers selects, based on customers' specifications:

- ► Fluids' properties
- Mass flows
- Inlet and outlet temperatures
- Fouling on process and sevice sides
- Maximum allowable pressure drops
- Presence on inerts

The most suitable type of heat exchanger:

- Flow arrangement
- Number of passes
- Number of plates, blocks or tubes
- ► Length
- Shell diameter
- Number of baffles
- ► Baffle cut

Our DIABON impregnated graphite heat exchanger product line includes a complete spectrum of plate and frame, block and shell and tube heat exchangers. Our totally modular designs enable us to offer customer specific heat transfer solutions at reasonnable costs.

# **Technical Specifications**

# Customized Heat Exchanger Design

The design calculation for DIABON graphite heat exchangers are carried out by our experienced application engineers. Heat and mass transfers are modeled using ASPEN+. The thermal calculations are performed with a validated program developped by ourselves or with the help of internationally proven and recognized software such as:

- ► ASPEN+
- ► HTRI
- Alfa Laval CAS





Screen shot of an HTRI design calculation



Screen shot of an ANSYS FEM calculation

Screen shot of an ASPEN+



Screen shot of CAS design calculation

For the most complex services and designs, we use ANSYS a finite element method calculation software to check the behavious of our process equipment under the toughest mechanical and thermal constraints.

# **Resin-Impregnated DIABON® Graphite** Characteristic Features and Applications

Carbon and graphite are outstandingly corrosion resistant. Therefore, they are attacked only by strongly electronegative elements such as oxygen at temperatures above 500°C and elemental halogens. The corrosion resistance is essentially determined by the behavior of the synthetic resin. If in doubt, corrosion tests can be carried out with standardized material specimens. Analysis of the results in our laboratories then shows whether the material is suitable for the application.



Micrograph of DIABON® NS1

### DIABON® NS1

#### **Properties**

DIABON NS1 is an impervious synthetic resin-impregnated fine grain graphite with a homogeneous material structure and a uniform pore distribution. Its maxium allowable material temperature is 200°C.

#### **Applications**

Tube sheets, plates, blocks and tubes for heat exchangers.



Micrograph of DIABON® NS2

### DIABON® NS2

#### **Properties**

DIABON NS2 is a material for superior demands. It is characterized by higher strength and lower sensitivity to swelling than DIABON NS1 graphite. Its maxium allowable material temperature is 200°C.

#### **Applications**

Tube sheets, plates, blocks and tubes for heat exchangers in case of higher mechanical stresses and/or extremely corrsive media and solvents.



Micrograph of DIABON® F100

### DIABON® F100

#### **Properties**

Fluoroplastic-bonded, nonporous fine-grain graphite with an extremely homogeneous material structure. The plastic is finely dispersed between the grains of graphite. DIABON F100 graphite plates have an anti-adhesive, non-porous surface. The fluoroplastic encapsulated graphite has an outstanding corrosion resistance in oxidizing media such as mixtures of HNO3 and HF. DIABON F100 maxium allowable material temperature with liquids is 140°C.

#### **Applications**

Plates for plate heat exchangers.

# **Carbon Fiber-Reinforced Components**

**Increased Reliability** 

With the carbon fiber reinforcement of components (DIABON HF), SGL Group has found a way to significantly increase the operational reliability of graphite components. Highly pretensioned carbon fibers are wrapped around the DIABON components. Carbon fiber's high modulus of elasticity ensures a permanent tension even under sharply fluctuating load – no fatigue is experienced.

Due to the carbon fiber's negative coefficient of thermal expansion (volume increase in diameter), the tension on the reinforcement is further increased when the temperature rises. As a result, the bursting pressure and maximum leakage resistance pressure are improved at higher temperatures than room temperature. The reinforcement with carbon fiber markedly improves the mechanical properties of all graphite components.

#### Properties of graphite tubes with carbon fiber reinforcement

#### Increased bursting pressure

The tube becomes more resistant to steam hammer and pressure surges. Its bursting pressure at room temperature is more than doubled.

#### Resistance of a cracked tube to leakage

Should a longitudinal crack occur in a DIABON HF tube as a result of overstressing, the tube will not allow any major leakage. In all instances, the reinforcement prevents any spalling from the tube and a consequent escape of product in large quantities. Usually the equipment can continue to operate without interruption until the next planned shutdown.



Carbon fiber-reinforced HF tubes



Carbon fiber-reinforced HF tube sheet

Comparison of tube properties						
Property		Unit	DIABON NS1	DIABON HF1	DIABON NS2	DIABON HF2
Flexural strength, longit	udinal		>52	>52	>52	>52
Bursting pressure	at 20°C	bar	80	110	80	110
	at 50°C	bar	75	120	75	120
Resistance to pressure s	urges	relative %	100	250	100	250
Leakage pressure		bar gauge	0	2 - 5	0	2 - 5
Thermal conductivity		W/m·K	>60	>50	>60	>50
Maximum allowable ter	nperature	°C	200	200	200	200
Pore volume before imp	regnation	% vol	18 - 22	18 - 22	12 - 15	12 - 15
Av. pore Ø before impre	egnation	μm	2 - 3	2 - 3	1 - 2	1 - 2

# DIABON® Heat Exchangers Complete Product Spectrum

Our DIABON heat exchanger product range includes plate and frame, block and shell and tube heat exchangers. This product spektrum – the largest on its kind in the industry – enables us to offer the most adapted solution to any kind of heat transfer in ultracorrosive applications. As a rule of thumb, plate and frame heat exchangers are mainly used for liquid/liquid heat interchange, block heat exchangers are used for all kinds of applications from small to large flow rates and shell and tube heat exchangers are used for all kinds of applications from medium to very large flow rates.



DIABON<sup>®</sup> plate and frame heat exchanger



DIABON® block heat exchanger



DIABON<sup>®</sup> shell and tube heat exchanger

#### Processes

- ► Cooling
- ► Heating
- ► Interchange
- ► Condensation
- Absorbtion
- Evaporation

#### **Fields of applications**

- Hydrochloric acid (HCl)
- ► Sulfuric acid (H<sub>2</sub>SO<sub>4</sub>)
- Hydrofluoric acid (HF)
- Phosphoric acid (H<sub>3</sub>PO<sub>4</sub>)
- Other organic or inorganic media

#### **Advantages**

- Outstanding corrosion resistance
- Modular Heavy-duty designs
- Possibility to have corrosive fluids on both sides
- High overall heat transfer efficiency
- ► Heat transfer surface areas up to 2000 m<sup>2</sup>
- Very small to very large duties possible

# **DIABON®** Plate Heat Exchangers

Compact and Ultra-Efficient

#### Compact and innovative design

In close collaboration with Alfa Laval Thermal (based in Lund, Sweden), we have developed a plate and frame heat exchanger in DIABON graphite. This represents an innovative solution for a compact heat exchanger. It combines the universal corrosion resistance of graphite with the high efficiency and full modularity of plate heat exchangers.

#### **Problem-free servicing**

Servicing of DIABON plate heat exchangers is simple and can be easily carried out on site – by your personnel. In addition, our specialists are always at your disposal to give training or to carry out installation or repair works. We also supply spare quickly from stock.

#### Specific advantages of our DIABON plate heat exchangers

- The corrugated design of the plates induces a very high overall heat transfer coefficient
- Ourplateheatexchangers are suitable for corrosive media on both service and product sides
- The compact construction results in a very low space requirement
- Real counter-current flow allows optimum utilization of the temperature differential
- By simply changing the number of plates, our heat exchangers are adaptable to any conditions
- Different plate corrugation patterns and singleor multiple-pass arrangement allow great flexibility in the use of our heat exchangers
- High-turbulence corrugation patterns minimize the tendency to fouling
- The film-type PTFE plate gaskets mean that the heat exchangers are corrosion-resistant in various environments, including the gaskets
- Our large stockholding capacity makes for short delivery times for complete heat exchangers and spare parts.



DIABON<sup>®</sup> F100 graphite plate pack and LICUFLON<sup>®</sup> PTFE lined steel frame plate

## **DIABON®** Plate Heat Exchangers Design

Modularity at its Best



- 1 Frame plate (steel)
- 2 Pressure plate (steel)
- 3 Support column
- 4 Guide bars
- 5 Corrugated plates (DIABON<sup>®</sup> graphite)
- 6 End plates (DIABON<sup>®</sup> graphite)
- 7 LICUFLON® PTFE linings
- 8 Graphite gaskets
- 9 Tie rod
- 10 Compression spring
- 11 Centering disks

The plate pack is secured between two thick steel plates, one fixed and the other movable, by means of tie rods. It is held in line by an upper and a lower stainless steel bar, which are securely fixed to the frame plate. The rear ends of the two guide bars are fixed to a support column. By this means, the pressure plate can be moved freely after releasing the tie rods. This allows unhindered access to the graphite plates without having to move the exchanger out of its installed position or disconnect it from the pipe connections. A further advantage of this design is that the difference in the coefficients of expansion of steel and graphite are compensated for by means of compression springs.

Maximum permissible service data						
Property	Unit	DIABON F100	DIABON NS1/NS2			
Maximum service pressure	bar	7	7			
Maximum service temperature	°C	140	200			
Maximum heat exchange area	m <sup>2</sup>	52	29			
Maximum plate / heat exchanger		130	96			
Plate thickness	mm	8	10			

To protect the frame/pressure plates and the nozzles against corrosion, we use LICUFLON PTFE linings.

The sealing system of the DIABON plate heat exchanger has very special advantages. A soft PTFE seal is applied to the 20 mm wide sealing strips of the graphite plates and compressed to a film thickness of about 0.15 mm when tightening up the plate pack.

DIABON plate heat exchangers allow real counter-current flow thus meaning a extremely high efficiency.

The design of the DIABON graphite plate heat exchanger allows straight counter-current flow

# **DIABON® Block Heat Exchangers**

Flexibility by Essence

DIABON graphite block heat exchangers are flexible in use. They are suitable for all heat exchange and mass transfer processes involving corrosive media. SGL Group's block heat exchangers are used in all branches of the organic and inorganic chemical industry. Our range of DIABON block heat exchangers includes cylindrical, cubic and monoblock heat exchangers.

They are suitable for corrosive media on both service and process sides depending on the design. They are easy to service (easy cleaning and block replacement).



- 1 DIABON<sup>®</sup> cubic block
- 2 DIABON<sup>®</sup> header
- 3 Shell
- 4 Compression springs
- 5 Baffles

## Cylindrical block design: Series CK

DIABON block heat exchangers of this design consist of graphite blocks that incorporate horizontal and vertical passages. The blocks are stacked on a baseplate with corrosion-resistant gaskets between each.

A steel shell fits over the block column and is bolted to the baseplate. The block column is secured by a top pressure plate bolted to the steel shell. The joint between the steel shell and top header is sealed with an O-ring to allow free movement of the shell. The difference in thermal expansion between graphite and steel is compensated by helical compression springs.

As a rule, the corrosive medium flows through the vertical passages of the DIABON blocks. Fluid enters the heat exchanger through a DIABON header, flows through all the blocks and is collected on the opposite side in another DIABON header before leaving the equipment.

The service medium, usually in the shell space, passes through the horizontal passages of the DIABON blocks. A baffle cage optimizes the flow through the horizontal passages on the service side. When two corrosive fluids are involved, a suitable anti-corrosion coating or lining can be offered on the shell side (e.g. in rubber, PTFE, special metal).

#### Specific advantages of the cylindrical block design

- Monolithic blocks
- Multipasses arrangements
- Graphite header for gas-liquid separation (optional)

### Cubic block design: Series EC and NEC

DIABON block heat exchangers of this design consist of graphite cubic blocks that incorporate horizontal and vertical passages. The blocks are stacked on a baseplate with corrosion-resistant gaskets between each. The block column is secured between a top and a bottom steel pressure plates.

The difference in thermal expansion between graphite and steel is compensated for helical compression springs.

As a rule, the corrosive medium flows through the vertical passages of the DIABON blocks. Fluid enters the heat exchanger through a DIABON header, flows through all the blocks and is collected on the opposite side in another DIABON header before leaving the equipment.

The service medium passes through the horizontal passages of the DIABON<sup>®</sup> cubic blocks. When two corrosive fluids are involved, a suitable anti-corrosion coating or lining can be offered in the lateral plates (e.g. in rubber, PTFE, special metal).

#### Specific advantages of the cubic block design

- Easy servicing and repair
- ► No risk of cross-contamination



DIABON<sup>®</sup> cubic block heat exchanger

- 1 DIABON® cubic block
- 2 DIABON® header
- 3 Pressure plate
- 4 Compression springs
- 5 Lateral plates

Maximum permissible service data						
Property	Unit	СК	EC	NEC		
Max. standard service pressure	bar	7	5	7		
Maximum service temperature	°C	200	200	200		
Maximum heat exchange area	m <sup>2</sup>	850	0.5 - 259	0.8 - 145		
Block no. / heat exchanger		15	12	12		
Product passage diameter	mm	8, 16	10, 12, 18, 20	10		

## **DIABON® Block Heat Interchanger**

Efficience in Heat Recovering

### Monoblock: Series KU

Our KU monoblock design is used successfully between two ultracorrosive media. This monoblock heat exchanger series is made from a single monolithic DIABON graphite block that includes integrated baffles on the product and service sides produced by milling. The graphite block is sealed on four faces with LICUFLON PTFE lined steel plates that are braced together.



1 DIABON<sup>®</sup> monolythic block 2 Lateral plates 3 LICUFLON<sup>®</sup> PTFE liner 4 PTFE gasket 5 Pressure plate

# Specific advantages of the monoblock design

- Suitable for processes with low temperature differential and/or temperature cross
- Suitable for corrosive fluids on both sides

Maximum permissible service data				
Property	Unit	KU		
Max. standard service pressure	bar	7		
Maximum service temperature	°C	200		
Maximum heat exchange area	m²	100		
Block no. / heat exchanger		1		
Product passage diameter	mm	8, 16		

# **DIABON® Shell and Tube Heat Exchangers**

Flexible and Heavy-duty Design

DIABON shell and tube heat exchangers are constructed from the following components:

- ► Two tube sheets with or without carbon fiber reinforcement – one fixed and the other floating, relative to the shell
- Baffle cages with DIABON baffles
- Headers made from DIABON NS1/NS2 graphite or other materials. Depending on the application, the header in contact with the floating tube sheet is braced against the tube sheet by a dual clamping tie rod system
- Shell made from steel, with anticorrosion lining on request, or from other materials
- Partition plates in the headers allow several passes through the tube bundle, when required in the process



DIABON® tube bundels

#### Specific advantages of our DIABON shell and tube heat exchangers

- ► Very large flow rates possible
- Multi-pass design possible
- ► Low pressure drop

# **DIABON® Shell and Tube Heat Exchangers**

Meeting Your Largest Expectations

#### **Corrosion resistance**

The basic materials for our shell and tube heat exchangers, DIABON NS1 and DIABON NS2 process equipment graphite, are resistant to virtually all organic and inorganic media. For heat exchange between two corrosive media, we supply special designs on request with a suitable anticorrosion lining or coating of the steel shell (rubber, PTFE, enamel, etc.)

#### O-ring seal

Our long experience has shown that O-ring seals offer substantial advantages over stuffing box packings:

- Extremely low coefficients of friction
- Low sealing forces required
- Corrosion resistance
- Ease of adjustment
- ► Ease of replacement
- ► Long service life
- Low servicing cost



1 DIABON® tubes 2 Fixed DIABON® tube sheet 3 Floating DIABON® tube sheet 4 DIABON® baffles 5 DIABON® headers 6 Steel shell 7 Pressure plate 8 Tie rod

9 Compression spring

#### **Pressures and temperatures**

A maximum permissible material temperature of 200 °C has been certified for DIABON NS1 and NS2 tubes by the South German Technical Supervisory Board (TÜV). Moreover, strength certification up to G32-0-200 (32 N/mm<sup>2</sup> with 0 ‰ strength decrease up to 200 °C) can be given for the tubes. The standard design allows for optional pressures of up to 6 bar gauge for both service and product sides. Special designs for higher pressures up to 16 bar gauge on the service side and up to 12 bar gauge on the product side can be supplied on request.



DIABON® shell and tube heat exchanger

#### Training

Servicing of our DIABON shell and tube heat exchangers is simple and can be carried out on site by your own personnel. On request, we put your technical personnel through our training courses. This enables repairs and overhauls to be carried out even more quickly and economically. In addition, our specialists are always at your service – whatever your problem. We also supply spare parts quickly and easily.



Carbon fiber-reinforced HF tubes

Maximum permissible service data					
Tube diameter in/out [mm]	Unit	15/26	22/32	25/37	37/50
Max. standard service pressure	bar	6	6	6	6
Maximum service temperature	°C	200	200	200	200
Maximum heat exchange area	m <sup>2</sup>	1646	1446	1302	1030
Maximum number of tubes		2725	1945	1519	889
Maximum shell diameter	mm	1945	1945	1945	1945

### **Customer Service**

With a full Package of Benefits



Individual tube testing on a shell and tube heat exchanger

Our continuing partnership with customers is based on the excellent services and system solutions we provide. These are a key part of our commitment.

All items of SGL Group's DIABON process equipment are quality products manufactured in our own plants from high-grade materials using the latest technologies. If a product still fails to meet your requirements, SGL Group's world - wide network of service centers will be on hand to help. We see every problem as a fresh opportunity. Give us the chance to prove it.

#### Spare parts and repairs

SGL Group's responsibility for its products doesn't end when customers take delivery of DIABON equipment. In fact, we give our customers systematic support all the time it's in use. This support is a key part of our customer service.

The long service life of our graphite equipment depends crucially on its high quality and the servicing and/or cleaning it gets when in contact with highly corrosive and contaminated media.

# Quality Management by Process Technology

As a manufacturer of carbon and graphite products, process equipment and systems for the chemical industry and environmental protection technology, SGL Group maintains a targeted quality management system designed to attain and meet the product quality standards demanded by customers. The quality management system of SGL Group meets the requirements of DIN EN ISO 9001:2000 and Pressure Equipment Directive 97/23/EC Annex III, Module H/H1 and has been certified by the approved authorities. In process equipment construction, Quality Management is responsible for the testing and approval of semi-finished graphite products, impregnation resin, cement components, outsourced parts, process equipment and components.





Heat exchanger during pressure testing

Synthetic resin impregnation, cementing and assembly are all subject to continuous monitoring. Appropriate marking of the semi-finished graphite products before and after synthetic resin impregnation, during machining and thereafter until assembly of the complete equipment provides comprehensive evidence of the semi-finished products employed.

Consequently, they meet the tracability requirement of specification AD 2000-Merkblatt N2 for pressure vessels made from electro-graphite. The conditions for synthetic resin impregnation of the semi-finished graphite products and those for cementing of the components are stipulated, monitored and checked.

#### **Process Technology Brochures**

- Process Technology We Combat Corrosion from Process Equipment and Components to Complex Systems
- DIABON<sup>®</sup> Graphite for Engineered Process Equipment
- > DIABON® Graphite Plate, Block and Shell and Tube Heat Exchangers
- DIABON<sup>®</sup> Economizers for Heat Recovery
- ► DIABON<sup>®</sup> and LICUFLON<sup>®</sup> Columns and Column Internals
- DIABON<sup>®</sup> Hydrogen Chloride Synthesis Plants
- DIABON<sup>®</sup> and Exotic Metal Pumps
- DIABON<sup>®</sup> Safety Discs
- Systems Solutions for Corrosive Processes
- ► ECOPOR<sup>®</sup> Porous Reactors
- ► FLUROFLEX® POLYFLURON® PTFE Bellows, DIN/ASME
- ► FLUROPIPE<sup>®</sup> ANJA Safety Tapes
- ► FLUROPIPE® POLYFLURON® PTFE-Lined Steel Pipes and Fittings, DIN
- FLUROPIPE® POLYFLURON® PTFE-Lined Steel Pipes and Fittings, ASME
- ► FLUROPIPE® POLYFLURON® PTFE-Lined Dip Pipes, DIN/ASME
- ► FLUROSIC<sup>®</sup> Silicon Carbide Plate Heat Exchangers
- ► FLUROSIC<sup>®</sup> Silicon Carbide Shell and Tube Heat Exchangers

® registered trademark of SGL Group companie

#### 07 2009/1 E Printed in Germany

The data contained herein represent the current state of our product knowledge and are intended to provide general information on our products and their application spectra. In view of the variety and large number of application possibilities, these data should be regarded merely as general information that gives no guarantee of any specific properties and/or suitability of those products for any particular application. Consequently, when ordering a product, please contact us for specific information on the properties required for the application concerned. On request, our technical service will supply a profile of characteristics for your specific application requirements without delay.

#### Process Technology SGL CARBON GmbH

Werner-von-Siemens-Straße 18 86405 Meitingen/Germany Phone +49 8271 83-1564 Fax +49 8271 83-2101 pt@sglcarbon.de

www.sglgroup.com

