Heat Exchangers and Components in Graphite and Silicon Carbide
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Overview on Products and Applications          | 18-19|
For more than 45 years GAB Neumann have designed and manufactured heat exchangers, equipment and components for applications in the chemical, pharmaceutical, steel coating and environmental industries.

Providing the highest quality and maintaining a strong customer focus are the foundation of our organisation. This is demonstrated by the longevity of more than 18,000 units that have been delivered to a loyal customer base. Our staff are our key, they are highly skilled, well experienced and dedicated, ensuring the success of our products and our company.

Across the world, our staff and agents develop solutions with our clients for their specific applications to optimise overall performance and cost.

Our experienced staff assist in thermal and physical sizing of units using customised software (e.g. finite element analysis) which is translated into the automated manufacturing process to ensure continuity throughout the chain.

In addition to our products we offer the respective maintenance services. These activities include chemical cleaning services of process equipment and plants in various materials of construction of various manufacturers.
The critical success factors for high quality graphite processing are: an homogeneous texture, a uniform grain structure, a perfect graphite impregnation process and consistent mechanical and thermal processing. Providing these, ensures that our products meet the most demanding requirements (e.g. cGMP capabilities).

Graphite is characterised by its wide ranging and high level of corrosion resistance. It resists nearly all acids, solvents, chlorides and other halogen compounds as well as their corresponding alloys.

Graphite’s thermal conductivity is much greater than most comparable corrosion resistant materials.

A very low tendency to foul compliments and helps to qualify the material for use in onerous applications.

Comparison of the thermal conductivity of various corrosion resistant materials used in the chemical processing industry

A comparison of the adhesion angle as an indicator for the adherence tendency of various corrosion resistant materials

Duties as extreme as quenching flue gas at 1,300°C can be accommodated with graphite as it is capable of withstanding wall temperatures within the range of -60°C to +200°C.

Diverse processes can be accommodated with the large available pressure envelope -1 bar to +16 bar.

Different raw material manufacturing processes provide for differing graphite grades, i.e. mechanical strengths, allowable operating temperatures and chemical resistance.
Due to its hardness, its resistance against abrasion, its thermal properties and the universal corrosion resistance, silicon carbide is an excellent material for the design of heat exchangers and other process equipment. Regarding its complete lack of ductility and other mechanical treatment, it is very different from any metallic materials.

Crucial to the application of the pressureless and directly sintered silicon carbide (SSiC) employed in GAB Neumann products is its excellent chemical and abrasion resistance.

Silicon carbide shows a very high purity and consequently does not cause any product contamination. For use in ultra pure processes, e.g., in the manufacturing of electronic chemicals, SSiC is cleaned by a special cleaning agent before use. This enables the material for use in ppt applications.

The ceramic also offers excellent properties with respect to thermal shock. The allowable short-term temperature gradient exceeds 200 K. This ensures highest operational safety of heat exchangers and condensers especially at start up and shutdown procedures.

To comply with the different challenges of diverse applications, GAB Neumann developed three heat exchanger designs:

- CORRESIC® Shell and Tube Heat Exchangers
- CORRESIC® Block Heat Exchangers
- CORRESIC® Annular-groove Heat Exchangers

The specific characteristics of the different designs result in diverse benefits as per the respective application. This ensures best performance throughout all thermal processes.
The Designs

Key design and one focus of the GAB Neumann product portfolio is the annular-groove heat exchanger design.

This unique design developed by GAB Neumann enables us to adapt the heat exchanger to the specific needs of the customer’s operating requirements. The geometry and design provides high turbulence, resulting in low fouling, automatic cleaning and high heat transfer. Potential leak paths and cross contamination is minimised by eliminating or reducing gasketed joints.

Block and shell & tube heat exchangers complete the various modifications of the annular-groove heat exchanger design. This portfolio enables us to cover the complete range of thermal processes perfectly.

Broad design portfolio to cover all thermal applications perfectly
Unique design
Highly turbulent forced flow provides excellent automatic cleaning
Minimum fouling and high thermal conductivity provides best heat transfer
Leak paths minimised with no or few gaskets
The combination of the designs developed and the two high performance materials impregnated graphite and silicon carbide result in heat exchangers that are applied successfully in both, mono and multi purpose plants. According the specific thermal processes the optimal design and the suitable material can be chosen.

Depending on the application, for example, best thermal performance at small overall size, product purity, cGMP compliance in API synthesis units or other specific process conditions are crucial to the best choice.

In any case, this broad portfolio ensures best operational safety, highest equipment reliability at competitive prices and low operating and maintenance cost.

**Technically perfect**
- Use in single or multipurpose plants
- High thermal performance
- Small overall size
- cGMP-compliant / qualified for API-production
- Long lifetime

**Economically outstanding**
- Low cost price
- Short delivery time
- Low operating expenses
Annular-groove Condenser NB/HB/KB

- Condensers for highly corrosive applications with high heat transfer
- Corrosion resistant on both service and product side
- Vertical or horizontal installation
- Dephlegmation applications possible
- Carbon fibre reinforcement (optional)
- Detachable header and bottom for mechanical cleaning of product side (optional)

Applications (examples)
- Condensing of chlorinated solvents and acidic chlorides in pharmaceutical, agrochemical or dyestuff industries
- Condensing vapours in inorganic processes (e.g. sulphur-acidic vapours, hydrochloridic vapours)

Special Features
- Both flow cross-sections are variable, thus resulting in high heat transfer rates and self-cleaning
- No gaskets and therefore no risk of leakage
- No critical swelling stress caused by the use of organic solvents

Benefits
- High operational safety
- High operational availability
- Minimised maintenance needs
- Small heat transfer area requirements
- Small space needs

Annular-groove Column Heat Exchanger G1

- Heat exchanger for highly corrosive applications
- For direct vertical installation in columns
- Corrosion resistant both on the service and product side
- cGMP design (optional)

Applications (examples)
- Use as a dephlegmator in the partial condensation of solvents
- Heat input into a column (e.g. as an evaporator “Robert” type)
- Application as a head condenser in a column with reflux separator

Special Features
- Direct access to product grooves
- Extremely small overall height

Benefits
- Easy to clean on the product side
- Small required space in column
cGMP-Annular-groove Condenser
NB/GMP / HB/GMP

- Condenser for cGMP applications (e.g. in pharmaceuticals synthesis)
- For highly corrosive applications at a high thermal efficiency
- Corrosion resistant both, service and product side
- Vertical or horizontal installation
- For applications where FDA or other special food processing requirements need to be met
- Carbon fibre reinforcement (optional)

Applications (examples)
- Condensing of solvents in synthesis plants, especially in multi-purpose plants in the pharmaceutical and speciality chemical industry
- Condensing duties within the production of APIs (active pharmaceutical ingredients)
- Use within the production of food and food ingredients (i.e. flavours and fragrances)

Annular-groove Vent Condenser GN/GH

- Condenser for highly corrosive applications
- Corrosion resistant both, service and product side
- Vertical or horizontal installation
- Dephlegmation applications possible
- Inclusion of demister possible
- Carbon fibre reinforcement (optional)

Applications (examples)
- Vent cooling of exhaust gas or vent condensing of corrosive vapours, e.g. for complying with VOC regulations (volatile organic compounds)
- Condensing and separation of corrosive vapours at the inlet or outlet of vacuum pumps

Special Features
- Detachable header and bottom
- Rotating cleaning device (PTFE)
- No gaps, crevices and dead corners
- Bonded construction without gaskets between product and service media
- Inspection glass

Benefits
- Cleaning in Place (CIP) and mechanical cleaning possible
- Completely drainable
- In situ inspection with access for endoscopes and swab testing
- No batch or cross-contamination
- No black particles due to special mechanical processing and cleaning
Annular-groove Heat Exchanger RA/WA

- Heat exchanger for heating or cooling of highly corrosive media
- Corrosion resistant one side: RA series
- Corrosion resistant both sides: WA series
- Wavy groove design (optional)
- Carbon fibre reinforcement (optional)

Applications (examples)
- Heating or cooling of hydrochloric or sulphuric acids and solvents
- Heat transfer between two corrosive media
- Use as feed preheater for sump of column

Special Features
- Both flow cross-sections are variable, thus resulting in high heat transfer rates and self-cleaning
- No gaskets and therefore no risk of leakage
- Small overall height

Benefits
- Excellent heat transfer performance
- Self-cleaning
- No cross-contamination
- Low maintenance cost
- High plant availability

Annular-groove Dilution Cooler RA-K

- Dilution and cooling unit for the dilution of sulphuric acid
- Separate inlets for concentrated acid and dilution water
- Inlet of acid through PTFE tube
- Carbon fibre reinforcement (optional)

Applications (examples)
- Production of battery acid
- Dilution of concentrated acids in chemical production plants or fertiliser production
- Sulphate production for water treatment

Special Features
- Dilution and cooling combined in one unit
- Dilution directly in the cooled segments
- Continuous dilution and mixing process

Benefits
- Achieving final dilution and final temperature in one single process
- High efficiency
Annular-groove Evaporator UB/FB

- Evaporator with forced or thermosiphon circulation: UB series
- Falling film evaporator with special distribution disc design: FB series
- Corrosion resistant both, service and product side
- Carbon fibre reinforcement (standard)
- Detachable header and bottom for mechanical cleaning of product side (optional)
- cGMP design (optional)

Applications (examples)
- Evaporating organic media in continuous and batch processes (e.g. distillation, fractionation)
- Concentration of diluted sulphuric or hydrochloric acids
- Desorption of hydrochloric acid

Conti-Reactor

- Mixing, heating and cooling of two or more process media reacting exothermically or endothermically within one continuous process
- Multiple heating and cooling circuits possible
- Maximum dwell time / reaction time depending on size of unit and volume flow (e.g. 15 min at 0.7 m³/hr)
- All circuits are corrosion resistant

Applications (examples)
- Synthesis of active ingredients in agro-chemical industry by three separate, individually controlled steps
- Continuous chlorination (Cl₂+HCl+Educt)
**Annular-groove Absorber**

- For absorbing HCl and other halogenated hydrogen based gases
- Use in scrubbing applications
- Co or counter current flow options
- Design for small, medium and large inert gas content
- Capacity for 40 kg/hr to 2,000 kg/hr HCl gas at 100 % concentration

**Applications (examples)**
- Production of high purity hydrochloric acid

**Special Features**
- Cross sectional flow corresponding to decreasing gas volume
- High mass transfer
- Robust construction

**Benefits**
- Wide load area at highest absorption
- High performance
- Great operational safety

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**Block Heat Exchanger GE/GZ**

- All-purpose unit for cooling, heating, condensing and evaporating duties
- Vertical or horizontal installation

**Applications (examples)**
- Heating pickling baths in steel industry
- Cooling of galvanising baths in steel finishing processes
- Condensing and cooling of hydrochloric acid in adiabatic absorption operations
- Evaporation of organic solvents

**Special Features**
- Single or double-row borings at the product side
- Robust construction
- Modular design
- Easy to disassemble

**Benefits**
- Large transfer areas and comparatively low pressure drop on the product side
- High operational safety
- Mechanical cleanability
Quench

- Quench with spray lances
- For gases up to 15,000 m³/hr volumetric flow
- For gases up to 1,300°C inlet temperature
- Suitable for gases with halogens (e.g. Cl₂, Br₂) and NOₓ

Applications (examples)
- Quenching of exhaust gas containing HCl, HBr and Cl₂ within organic polymer production
- Quenching in ore refining processes with approx. 15 kg/hr of solids content
- Quenching of CFC vent gas containing PTFE dust

Special Features
- Two or more spray lances
- Excellent cooling due to continuous water film on wall surfaces and the cooling grooves in the wall

Benefits
- Suitable even with large gas volume variations
- Treatment of highly oxidising gases
- Very low maintenance and operational cost

Columns and Column Internals

Based on customer’s drawings and requirements we manufacture
- distribution trays
- sieve trays
- bubble-cap plates
- cascades
- supporting trays
- hold-down plates

On request, or if necessary we perform strength calculations (e.g. finite element analysis).

Applications (examples)
- Column header with inlet pipe and distribution tray (Ø500 mm)
- Distributor for column (Ø400 mm)

Columns and Vessels
- up to DN 800

Internals for vessels up to DN 800

Strength calculations (e.g. finite element analysis)
Other Components

Based on customer’s drawings and requirements we manufacture

- jet nozzles
- steam and water jets
- thermowells
- wiper blades (for thin film evaporators)
- inlet pipes for liquids, gases and vapours
- heating / cooling candles

On request, or if necessary, we perform strength calculations (e.g. finite element analysis).

Applications (examples)

- jet nozzles for corrosion resistant vacuum jet pump (e.g. Ø38 x 125 mm)
- overflow cartridge for distribution tray (e.g. Ø92 x 115 mm)

Wide range of applications
Strength calculations (e.g. finite element analysis)
Silicon Carbide Shell & Tube Heat Exchanger SR

- CORRESIC® silicon carbide shell & tube heat exchanger with universally corrosion resistant tube material silicon carbide (SSiC) with very high thermal conductivity
- Resistant against all brines, acids, solvents and halogenes
- Leakage free tube sheet system (patent pending)
- MOC selection according application (carbon steel, stainless steel, glass lined steel, PTFE lined steel (for headers))
- Various installation modes possible (vertical, horizontal, inclined)

Applications (examples)
- Liquid/liquid heat exchange at all acids, brines and organic solvents, e.g. mixed acid, sulphuric acid, nitric acid
- Condensation processes
- Condenser skids containing main and vent condenser and condensate cooler
- Cooling of humid gases containing elementary halogenes
- Acid concentration processes

Special Features
- Highest corrosion resistance
- Optimised sealing system (double sealing FKM / FFKM)
- Leakage control system (optionally)
- Improved ratio transfer area / shell volume
- Excellent thermal conductivity
- Abrasion resistance
- Both sides are corrosion resistant

Benefits
- Compact and cost efficient design
- High operational safety
- Low leakage risk
- No product contamination by particles
Silicon Carbide Block Heat Exchanger SE

- CORRESIC® silicon carbide block heat exchanger with universally corrosion resistant block material silicon carbide (SSiC) with very high thermal conductivity
- Resistant against all brines, acids, solvents and halogenes
- Robust, modular design ensuring long lifetime and low cost maintenance
- Especially applicable for steam heated evaporation or heating processes
- Various installation modes possible (vertical, horizontal, inclined)

Applications (examples)
- Liquid/liquid heat exchange at all acids, brines and organic solvents, e.g. mixed acid, sulphuric acid, nitric acid
- Reboiler evaporation, especially steam heated
- Condensation processes with special need of robustness
- Pickling applications in steel and galvanic industries (heating, cooling, acid regeneration)
- Acid concentration processes

Special Features
- Highest corrosion resistance
- Excellent thermal shock resistance
- Robust and modular design
- Abrasion resistance

Benefits
- Especially applicable in steam heated processes
- No product contamination
- Low maintenance need
- High operational reliability in robust applications
Silicon Carbide Annular-groove Heat Exchanger SB

- CORRESIC® silicon carbide block heat exchanger with universally corrosion resistant block material silicon carbide (SSiC) with very high thermal conductivity
- Resistant against all brines, acids, solvents and halogenes
- Virtually monolithic design with no dead space enabled by Tasic fusing process for long lifetime and easy maintenance
- Especially applicable in multi purpose plants, also in cGMP processes
- Various installation modes possible (vertical, horizontal, inclined)

Applications (examples)
- Condensation of organic solvents in active pharmaceutical ingredients manufacturing (API) even under cGMP regulation
- Heat exchanging processes in crop protection chemical synthesis
- Condensation processes in ultra pure electro chemicals manufacturing
- Applications in manufacturing of flavours and fragrances
- Falling film evaporation in organic synthesis
- Liquid/liquid heat exchange at all acids, brines and organic solvents, e.g. mixed acid, sulphuric acid, nitric acid

Special Features
- Highest corrosion resistance
- Applications in all organic synthesis processes
- Dead space free design ensuring complete drainability and excellent cleanability
- High reliability of sealing system
- Excellent resistance against thermal shock
- Both sides corrosion resistant

Benefits
- 100% GMP/FDA compliant
- No risk of product contamination (MOC, batch, cross)
- Outstanding thermal performance and compact design
- Best operational safety and availability
### Overview on Products and Applications

**Graphite Equipment**

- **Overview** on products and applications
- **Graphite Equipment**

**Condensation**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Partial Condensation**
- Annular-groove Condenser G1
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Vent Condenser GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Cooling of Corrosive Media**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Heating of Corrosive Media**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Heating Exchange of two Corrosive Media**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Dilution Cooling**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Mixing**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Circulating Evaporation**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Falling Film Evaporation**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Absorption**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Other Mass and Heat Transfer Processes**
- Annular-groove Condenser NB/HB/KB
- cGMP Annular-groove Condenser NB/GMP
- Annular-groove Heat Exchanger GN/GB
- Annular-groove Heat Exchanger RA/WA
- Annular-groove Dilution Cooler RA-K
- Annular-groove Evaporator UB/FB
- Conti-Reactor
- Black Heat Exchanger GE/GZ
- Annular-groove Absorber

**Symbols**:
- ● recommended
- ○ suitable

**Please ask us for special designs and applications.**
Overview on Products and Applications
Silicon Carbide Equipment

<table>
<thead>
<tr>
<th>CORRESIC®</th>
<th>Shell &amp; Tube SR</th>
<th>Block SE</th>
<th>Annular-groove SB</th>
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<td>Cooling</td>
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<td>2 corrosive media</td>
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<td>Feed heating</td>
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<td>Circulation evaporation</td>
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<td>Falling film evaporation</td>
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<td>GMP compliant processes</td>
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<td>●</td>
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</tbody>
</table>

● recommended
○ suitable

Please ask us for special designs and applications.
We have successfully delivered to:

- Ajinomoto Omnichem
- BASF
- Bayer
- Clariant
- DSM
- EGIS
- Evonik
- Glaxo SmithKline
- Hindustan Insecticides
- H.C. Starck
- IFF
- ICL (Rotem, Industrial Products)
- Lanxess/Saltigo
- Merck
- Plinke
- Roche
- Sanofi-Aventis/Chinoin
- Symrise
- Syngenta
- Wacker Chemie

Details on corrosion resistance, materials, designs and products can be found in our product information, work standards and SPOTS on the internet.

www.gab-neumann.de

Please ask us for detailed references.