Sealing applications

MARKETS

Mersen is one of the oldest manufacturers of flexible graphite in the world. Papyex® quality is demanded, through technical specifications, by many end users engaged in the chemical, nuclear, aeronautical, refining sectors, etc.

Through Papyex®, Mersen guarantees for its partners, experts in sealing products, reliability, service and performance, in particular in terms of resistance to oxidation.

STATIC GASKETS

Papyex®, by virtue of its chemical, physical and mechanical characteristics, is an excellent material for flange gaskets.

Papyex® flange gaskets have the following advantages:

• Excellent properties for use under pressure and temperature.
• Insensitivity to thermal shocks.
• No ageing: neither shrinkage, nor hardening, nor hot creep.
• Practically unlimited chemical resistance.
• Non-polluting (asbestos-free).
• Easy to cut and shape.

The main fields of use are: chemical and petro-chemical industries, refineries, and the energy, engineering and automotive sectors.

Spiral wound gasket
DYNAMIC GASKETS

Seals produced from Papyex® are self-lubricating. They resist high temperatures, high pressures and chemical agents. Regular inspection and periodic replacements are not necessary.

Papyex® is a flexible, pure, homogeneous material without binder or asbestos. It is characterised by its qualities of thermal conductivity, elastic recovery, capacity for compacting, friction even when dry, and chemical iner- tness.

Papyex® seals, by virtue of the absence of ageing and relaxation, avoid retightening and eliminate wear on rods and shafts.

Papyex® is used as a stuffing-box material for valves, pumps, mixers and stirrers in the chemical, refrigeration, oil, petrochemical and food industries.

This material guarantees long service life: a Papyex® seal means 35,000 operations, and several years of use without leakage and without maintenance.
MERSEN IN FURNACE INDUSTRIES

- Heat-treatment furnaces under vacuum or controlled atmosphere.
- Furnaces for passing through controlled atmosphere.
- Vacuum brazing furnaces.

Mersen offers a complete range of high-performance materials for industrial furnaces:

- **Calcarb®**: rigid carbon felt insulation.
- Graphite for refractory application
- Carbon/carbon composite.
- **Papyex®**: flexible graphite.

Associated with other Mersen’s materials Papyex® has become the essential material for overcoming numerous technical difficulties at the best cost for industrial furnace users.

**WHY PAPYEX® IN FURNACES?**

- **As a screen**: thanks to its reflecting capacity, it reduces energy loss. The anisotropy of its thermal conductivity ensures a better homogenisation of the temperature in the chamber.
- **As a thermal insulation element**: it can be used alone, in multiple screens, or in addition to commonplace insulating materials: carbon felt, rigid felt, graphite foam.
- **As a sealing material**: in plants functioning at high temperatures and in a corrosive environment, it is impermeable to hot gas and can be used as a static gasket or impervious packing.

**ASSEMBLIES WITH INSULATORS**

Papyex® is used in combination with insulators for limiting hot spots and for its heat-reflecting capacity. The assemblies can be produced on rigid insulators such as Calcarb® or on flexible felt. To make these assemblies, Mersen uses an adhesive that withstands very high temperatures.

**RESISTANCE TO THERMAL SHOCKS**

During a rapid rise in temperature, the gases contained in Papyex® may cause blisters on the surface of the material. To avoid this inconvenience, Papyex® FHT is first treated at high temperature, which eliminates this risk. Moreover, on request, the surface of Papyex® can be perforated to facilitate degassing.
Other applications

ELECTRICAL RESISTANCE IN FURNACES
Thanks to its flexibility and fineness, Papyex® can be cut easily, thereby making it possible to manufacture curved resistors that adapt to non-standard laboratory equipment.

PROTECTIVE INTERFACE
- For metal casting, Papyex® provides protection for graphite moulds and ingot moulds preventing the sticking of certain metals and alloys; it prevents a rapid deterioration of expensive equipment and facilitates mould stripping.
- In the glass industry, Papyex® is not wet by molten or viscous glass.
- In hot compression operations and in particular in the case of sintering, the thinnest Papyex® makes it possible to produce inserts that facilitate mould stripping and better temperature distribution.
- In soldering or brazing, in particular in the case of work on delicate assemblies, Papyex® is used to protect against splashing of adjacent areas that would risk being damaged.
- In producing ingots, Papyex® is used for protecting the graphite equipment from reactions with the silicon. For this type of application, Papyex® can be purified (less than 5 ppm).

HEAT DISSIPATION PRODUCT
The conductivity of Papyex® in the plane of the sheet increases greatly with an increase in density (see graph page 9). This material can then be used for dissipating heat with performances equivalent to conductive metals such as copper. In electronics, it thus serves as a thermal interface and heat sink. Its lightness and reasonable cost, makes it competitive compared to other solutions.
NATURAL GRAPHITE
Flexible graphite is manufactured from purified natural graphite crystallites. The best graphite ores are mainly extracted in China, Canada, India and Madagascar. In order to obtain good-quality flexible graphite, it is necessary to select ores having crystallites with dimensions greater than 180 µm.

EXPANDABLE GRAPHITE
Graphite has the property of forming lamellar compounds by the insertion of atoms or molecules in its structure. This property is used for manufacturing expandable graphite by acid insertion. The inserted compound reacts to a thermal shock at very high temperature: the insertion element vaporises and expands each graphite crystallite.

Characteristics
- Low permeability to gases and liquids
- Flexibility, flexible texture
- Resistance to most fluids
- Absence of danger to health; asbestos-free
- No danger to the environment
- Suitable for use at temperatures varying from -250°C to 450°C in air and up to 3000°C in inert atmosphere
- Absence of binders causing neither ageing nor crumbling
- Long-term compressibility stability over a wide range of temperatures
- High elastic recovery
- Anisotropic electrical and thermal conductivity
- Resistance to radiation
- Very good resistance to thermal shock
- Facilitates cutting by punch
Sealing products

Papyex® roll
- **Standard width:** 500, 1,000, 1,500 mm.
- **Standard density:** 0.7 g/cm³ to 1.1 g/cm³.
- **Standard thickness:** 0.2 to 1.5 mm in roll form, up to 10 mm in plate form.

Papyex® tape slit from a roll. **Minimum width:** 4.5 mm.

Spiral wound gasket: Co-winding of Papyex® and steel.

Graphite rings with or without metal insert obtained by compressing Papyex® tapes.

Flat gasket cut by punch, water jet, oscillating blade.

Papyex® HP: multi-reinforcement gasket easy to cut by conventional means.

Reinforced sheets assembled by gluing or clinched with tanged inserts.
For more than 30 years, Mersen has been rigorously selecting and processing the best natural graphite ores in order to guarantee its clients compliance with the strictest standards for industrial, nuclear and automotive sealing. The wide range of Papyex® grades can meet the most advanced requirements for chemical purity in order to minimise risks of corrosion and extend its use beyond 450°C. Specific anti-corrosion and anti-oxidation treatments further extend its use under extreme conditions.

<table>
<thead>
<tr>
<th>Chemical, petrochemical industries</th>
<th>Automotive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I900</strong></td>
<td><strong>A960</strong></td>
</tr>
<tr>
<td><strong>Low oxidation rate</strong></td>
<td><strong>Low purity</strong></td>
</tr>
<tr>
<td>specification</td>
<td>typical value</td>
</tr>
<tr>
<td>Carbon rate</td>
<td>&gt; 99%</td>
</tr>
<tr>
<td>Ash content</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Inhibitor rate</td>
<td>-</td>
</tr>
<tr>
<td>Sulfur content</td>
<td>&lt; 700 ppm</td>
</tr>
<tr>
<td>Total chlorine content</td>
<td>&lt; 50 ppm</td>
</tr>
<tr>
<td>Mass loss (500°C / 24h)</td>
<td>&lt; 0.5%</td>
</tr>
<tr>
<td>Mass loss (670°C / 4h)</td>
<td>&lt; 4%/h</td>
</tr>
<tr>
<td><strong>Maximum operating temperature:</strong></td>
<td></td>
</tr>
<tr>
<td>• to air</td>
<td>550 °C</td>
</tr>
<tr>
<td>• under an inert atmosphere</td>
<td>2.700 °C</td>
</tr>
</tbody>
</table>

**General properties**

<table>
<thead>
<tr>
<th>specification</th>
<th>typical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (D=1g / cm²)</td>
<td>&gt; 4 Mpa</td>
</tr>
<tr>
<td>Compressibility</td>
<td>45% to 52%</td>
</tr>
<tr>
<td>Elastic recovery</td>
<td>10% to 15%</td>
</tr>
<tr>
<td>Area weight distribution (g / m²)</td>
<td>+ / -5%</td>
</tr>
</tbody>
</table>

**Physical properties**

<table>
<thead>
<tr>
<th>unit</th>
<th>in plane</th>
<th>through thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeability</td>
<td>cm².s⁻¹.atm⁻¹</td>
<td>-</td>
</tr>
<tr>
<td>Shore hardness</td>
<td>C²</td>
<td>25</td>
</tr>
<tr>
<td>Coefficient of thermal expansion</td>
<td>10⁻⁴. °C⁻¹</td>
<td>zero</td>
</tr>
<tr>
<td>Electrical resistivity</td>
<td>Ω.cm</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Ω.inch</td>
<td>0.0004</td>
</tr>
<tr>
<td>Emissivity coefficient</td>
<td>at 400°C</td>
<td>-</td>
</tr>
<tr>
<td>at 1 000°C</td>
<td>-</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Flexible graphite meeting sealing requirements

<table>
<thead>
<tr>
<th>Specification</th>
<th>Typical value</th>
<th>Specification</th>
<th>Typical value</th>
<th>Specification</th>
<th>Typical value</th>
<th>Specification</th>
<th>Typical value</th>
<th>Specification</th>
<th>Typical value</th>
<th>Specification</th>
<th>Typical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon rate</td>
<td>&gt; 99.85%</td>
<td>&gt; 99.5%</td>
<td>&gt; 96%</td>
<td>&gt; 95%</td>
<td>&gt; 93.5%</td>
<td>&gt; 92%</td>
<td>&gt; 90%</td>
<td>&gt; 88%</td>
<td>&gt; 86%</td>
<td>&gt; 84%</td>
<td>&gt; 82%</td>
</tr>
<tr>
<td>Ash content</td>
<td>&lt; 0.15%</td>
<td>&lt; 0.10%</td>
<td>&lt; 0.5%</td>
<td>&lt; 0.45%</td>
<td>&lt; 0.5%</td>
<td>&lt; 0.2%</td>
<td>&lt; 0.15%</td>
<td>&lt; 0.15%</td>
<td>&lt; 0.15%</td>
<td>&lt; 0.15%</td>
<td>&lt; 0.15%</td>
</tr>
<tr>
<td>Inhibitor rate</td>
<td>-</td>
<td>-</td>
<td>2% to 6%</td>
<td>3%</td>
<td>2% to 6%</td>
<td>3%</td>
<td>1% to 3%</td>
<td>1.35%</td>
<td>1% to 3%</td>
<td>1.35%</td>
<td>1% to 3%</td>
</tr>
<tr>
<td>Sulfur content</td>
<td>&lt; 600 ppm</td>
<td>500 ppm</td>
<td>&lt; 450 ppm</td>
<td>400 ppm</td>
<td>&lt; 300 ppm</td>
<td>250 ppm</td>
<td>&lt; 200 ppm</td>
<td>180 ppm</td>
<td>&lt; 150 ppm</td>
<td>&lt; 100 ppm</td>
<td>&lt; 50 ppm</td>
</tr>
<tr>
<td>Total chlorine content</td>
<td>&lt; 30 ppm</td>
<td>20 ppm</td>
<td>&lt; 30 ppm</td>
<td>20 ppm</td>
<td>&lt; 30 ppm</td>
<td>20 ppm</td>
<td>&lt; 30 ppm</td>
<td>20 ppm</td>
<td>&lt; 30 ppm</td>
<td>20 ppm</td>
<td>&lt; 30 ppm</td>
</tr>
<tr>
<td>Leachable chlorine content</td>
<td>&lt; 20 ppm</td>
<td>10 ppm</td>
<td>-</td>
<td>-</td>
<td>&lt; 30 ppm</td>
<td>20 ppm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Halogen content (F, Br, I)</td>
<td>-</td>
<td>&lt; 50 ppm</td>
<td>30 ppm</td>
<td>&lt; 50 ppm</td>
<td>30 ppm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mass loss (500°C / 24h)</td>
<td>&lt; 1%</td>
<td>0.50%</td>
<td>1%</td>
<td>1%</td>
<td>&lt; 1%</td>
<td>0.60%</td>
<td>-</td>
<td>&lt; 0.50%</td>
<td>0.10%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Maximum operating temperature:

- To air
  - 500°C
  - 500°C
  - 500°C
  - 500°C
  - 450°C
  - 550°C

- Under an inert atmosphere
  - 2.700°C
  - 2.700°C
  - 2.700°C
  - 2.700°C
  - 2.700°C
  - 2.700°C

Data herein contained are provided for general information purpose only and are not binding. Mersen shall have no liability whatsoever with respect to information contained herein. Duplication, reproduction or translation of any information contained herein, in whole or in part, is strictly prohibited without prior written consent of Mersen. Our materials are in conformity with the RoHS-Directive (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment). Besides Mersen guarantees the application of the European Community REACH-Regulation (Registration, Evaluation, Authorization and Restriction of Chemical substances) to all its plants located in Europe. We are constantly involved in engineering and development. Accordingly, Mersen reserves the right to modify, at any time, the technology and product specifications contained herein.
IN PARTNERSHIP WITH SPECIALISTS IN STATIC SEALING, MERSEN HAS DEVELOPED A COMPLETE RANGE OF FLEXIBLE GRAPHITE SHEETS ALLOWING CUSTOMERS TO CUT FLAT GASKETS FOR THEIR SPECIFIC APPLICATIONS.

They are available in all grades suited to purity specifications for the chemical, petrochemical, refining, and nuclear or aeronautics industries. Mersen checks the purity of its materials in its analysis and measuring laboratories on a daily basis in order to guarantee its customers compliance with chemical specifications for materials.

ANTI-STICKING COATING FOR FACILITATING GASKET REMOVAL

Mersen has developed a surface impregnation that forms an anti-adhesion coating effective up to 350°C in application. This AS “Anti-Stick” coating meets the technical specifications of leading chemical firms in Germany. It is an option that is particularly recommended for tanged reinforced products.

A UNIQUE SERVICE FOR PROMOTING YOUR BRAND

Mersen - sealing specialists - offers its customers the option of promoting or customizing their own brand, by means of a service marking the sheets by screen printing. We can print your sheets in the colour and model of your choice. The largest format is up to 1.500 x 2.000 mm.

Gasket before assembly

Gasket after removal

Papyex® HP gasket

Non-stick coating TEST

Hot steam:
60 Bar, 280°C
DN80PN100
flange gasket
Assembly stress: 90 MPa
Technical data of Papyex® sheets

**Papyex® SR**
Flexible graphite sheet without reinforcement.

**Papyex® RI**
Flexible graphite sheet reinforced with a 50 µm glued flat stainless steel insert. It is used in flange connections for chemical, petrochemical industries.

**Papyex® RN**
Flexible graphite sheet reinforced with a 13 µm glued flat nickel insert. Easy cutting and resistant to very corrosive fluids, in particular chlorine.

**Papyex® PI**
Flexible graphite sheet reinforced with a tanged 100 µm stainless steel insert, without adhesive. Suitable for manufacturing pipe gaskets & reactors seals in chemical and petrochemical industries.

---

**Sheet size**
- Papyex® SR: 1 x 1 / 1.5 x 1.5
- Papyex® RI: 1 x 1 / 1.5 x 1.5
- Papyex® RN: 0.5 x 1 / 1 x 1 / 1.5 x 1.5
- Papyex® PI: 1 x 1 / 1.5 x 1.5

**Insert material**
- Papyex® SR: DIN / ASTM without insert
- Papyex® RI: 1.4401 / SS316 (flat)
- Papyex® RN: GR-10-O-1 K-Cr
- Papyex® PI: GR-10-O-1 M-Cr

**Insert thickness**
- Papyex® SR: 50 µm
- Papyex® RI: 13
- Papyex® RN: 0.7 or 1
- Papyex® PI: 1

**Flexible graphite density**
- Papyex® SR: 0.7 to 1.3
- Papyex® RI: 0.7
- Papyex® RN: 1
- Papyex® PI: 1

**Standard thicknesses**
- Papyex® SR: 1.5, 2, 3
- Papyex® RI: 1, 1.5, 2, 3, 4, 0.8, 1.0, 1.5, 2.0
- Papyex® RN: 1, 1.5, 2, 3
- Papyex® PI: 1, 1.5, 2, 3

**Gasket coefficient (bD = 20 mm)**
- \( \sigma_{vu} \) DIN E 2505: 20, 10, 10, 20
- \( m \) DIN E 2505: 1.3, 1.3, 1.3, 1.3
- \( y \) coefficient ASTM: 2, 2, 2.5, 2.5
- \( m \) coefficient ASTM: 1.500, 900, 1.000, 3.000
- Residual stress DIN 52913, 16h / 300°C: >47, >47, >47, >47
- Ash content DIN 51903: <2.0, <2.0, <2.0, <2.0
- Sulfur content: <50, <50, <50, <50
- Anti-sticking treatment: Yes, upon request, Yes, upon request, No, Yes, upon request

**Papyex® RI / Papyex® RN - Pressure / temperature**

**Papyex® PI - Pressure / temperature**
The structure patented by Mersen pushes back the boundaries of flexible graphite in the field of sealing:

- Very high pressure.
- No adhesive, simple mechanical assembly for very high temperatures.
- Easy cutting by conventional means by virtue of fine reinforcements.
- Easy dismantling because of the anti-sticking treatment.
High-performance Papyex® HP multi-reinforcement sheet

PAPYEX® HP

Multi-reinforced flexible graphite sheet designed to resist very high pressures and mechanical stresses even at the highest temperatures. Suitable for high pressure steam in generator, pump seals and high pressure vessels.

Unit / standard technical data

<table>
<thead>
<tr>
<th>Sheet size</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insert material</td>
<td>DIN / ASTM</td>
</tr>
<tr>
<td>Insert thickness</td>
<td>µm</td>
</tr>
<tr>
<td>Nomenclature</td>
<td>DIN 28 091-4</td>
</tr>
<tr>
<td>Flexible graphite density</td>
<td>g/cm³ ± 10%</td>
</tr>
<tr>
<td>Standard thicknesses</td>
<td>mm ± 10%</td>
</tr>
<tr>
<td>Amount of inserts</td>
<td>nb</td>
</tr>
<tr>
<td>Anti-sticking treatment</td>
<td>yes</td>
</tr>
</tbody>
</table>

Mechanical tests: EN 13355 - Gasket width 20 mm

| T°C | Qsmax (N/mm²) | PQr (50 Mpa) | Compressibility ASTM F36A-A6 | Elastic recovery ASTM F36A-A6 | Residual stress DIN 52913, 16h / 300°C (N/mm²) |
| 20°C | > 220 | 0.99 | 31-40 | 4-5 | > 48 |
| 300°C | > 220 | 0.94 | 31-40 | 4-5 | 20 |
| 400°C | 200 | 0.92 | |

Gasket coefficient (b0 = 20 mm):

| σb | DIN E 2595 (N/mm²) |
| 20°C | 20 |
| 300°C | 1.3 |
| 400°C | 2.5 |
| 500°C | 3.000 |

Papyex® grades available:

| Ash content DIN 51903 (%) | < 1 |
| Sulfur content ppm | < 700 |
| Chlorine content ppm | < 25 |

Data herein contained are provided for general information purpose only and are not binding. Mersen shall have no liability whatsoever with respect to information contained herein. Duplication, reproduction or translation of any information contained herein, in whole or in part, is strictly prohibited without prior written consent of Mersen. Our materials are in conformity with the RoHS-Directive (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment). Besides Mersen guarantees the application of the European Community REACH-Regulation (Registration, Evaluation, Authorization and Restriction of Chemical substances) to all its plants located in Europe. We are constantly involved in engineering and development. Accordingly, Mersen reserves the right to modify, at any time, the technology and product specifications contained herein.
Main production sites
Industrial or commercial branch

A WORLD EXPERT
in materials and solutions for high temperature processes

A GLOBAL PLAYER
Global expert in materials and solutions for extreme environments as well as in the safety and reliability of electrical equipment Mersen designs innovative solutions to address its clients specific needs to enable them to optimize their manufacturing process in sectors such as energy, transportation, electronics, chemical, pharmaceutical and process industries.

Contact in North America
MERSEN USA BN Corp.
Bay City Branch,
900 Harrison Street
BAY CITY, MI 48708, USA
Tel.: +1 989 894 29 11
Fax: +1 989 895 77 40

Contact in Europe
MERSEN France Gennevilliers S.A.S.
41, rue Jean Jaures - BP 148
F-92231 GENNEVILLIERS CEDEX
FRANCE
Tél.: +33 (0) 1 41 85 43 66/43 93
Fax: +33 (0) 1 41 85 45 88

Contact in Asia
MERSEN Kunshan Co. Ltd.
#29 South Taihu Road,
Kunshan Development Zone,
Kunshan, Jiangsu Province,
215334, PR CHINA
Tel.: +86 512 5763 9808
Fax: +86 512 5763 9811

Papyex@mersen.com
www.mersen.com