



TECHNICAL GUIDE

PAPYEX®  
FLEXIBLE  
GRAPHITE



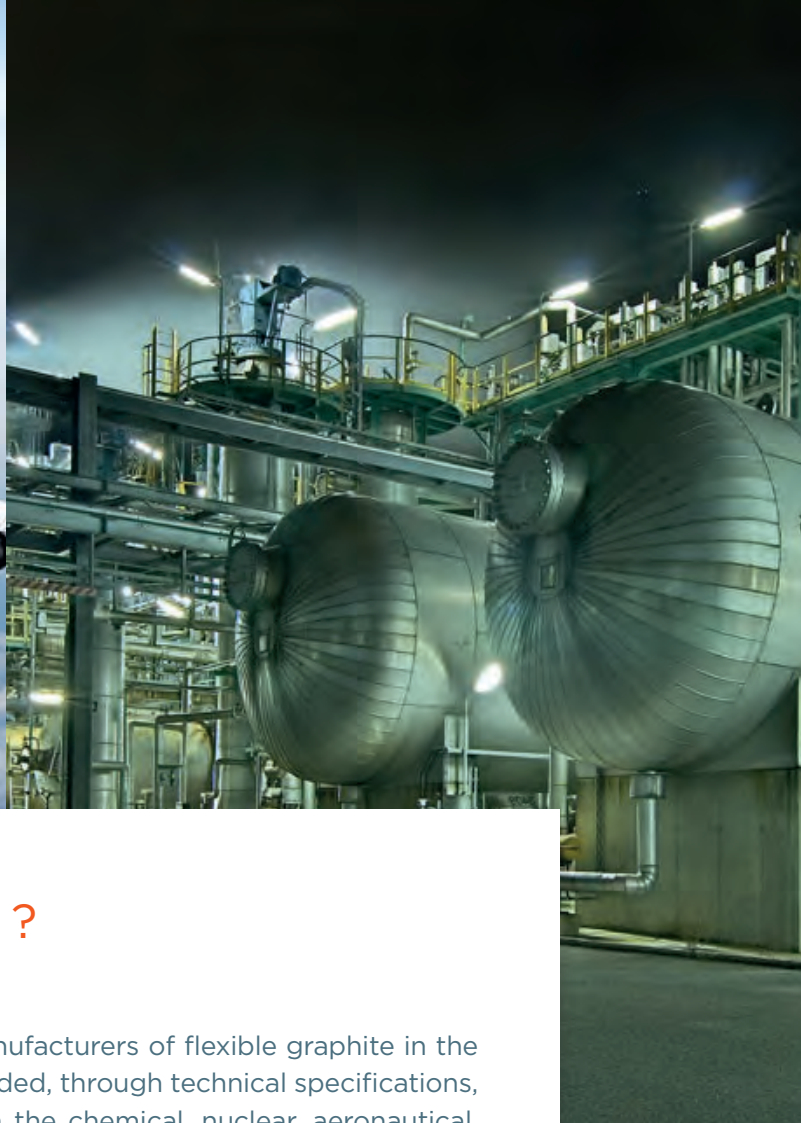
GRAPHITE FOILS  
FOR SEALING  
APPLICATIONS



# SUMMARY



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## WHY MERSEN?

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

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



# 01

## SEALING APPLICATIONS

### + 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 petrochemical industries, refineries, 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 inertness.

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.

### DIE FORMED RINGS



# 02

## THERMAL APPLICATIONS

### 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 and soft felt carbon 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 POPYEX® 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

**Popyex®** is used in combination with insulators for limiting hot spots and for its heat-reflecting capacity.

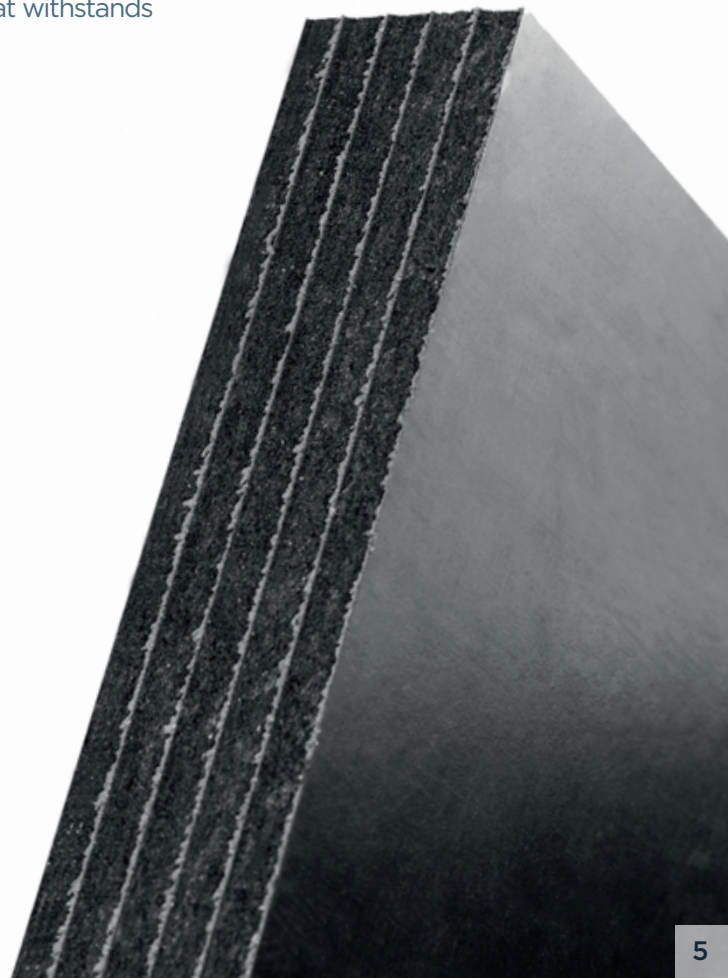
The assemblies can be produced on rigid insulators such as **Calcarb®** or on flexible felt.

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 **Popyex®** may cause blisters on the surface of the material. To avoid this inconvenience, **Popyex®** FHT is first treated at high temperature, which eliminates this risk.

Moreover, on request, the surface of **Popyex®** can be perforated to facilitate degassing.

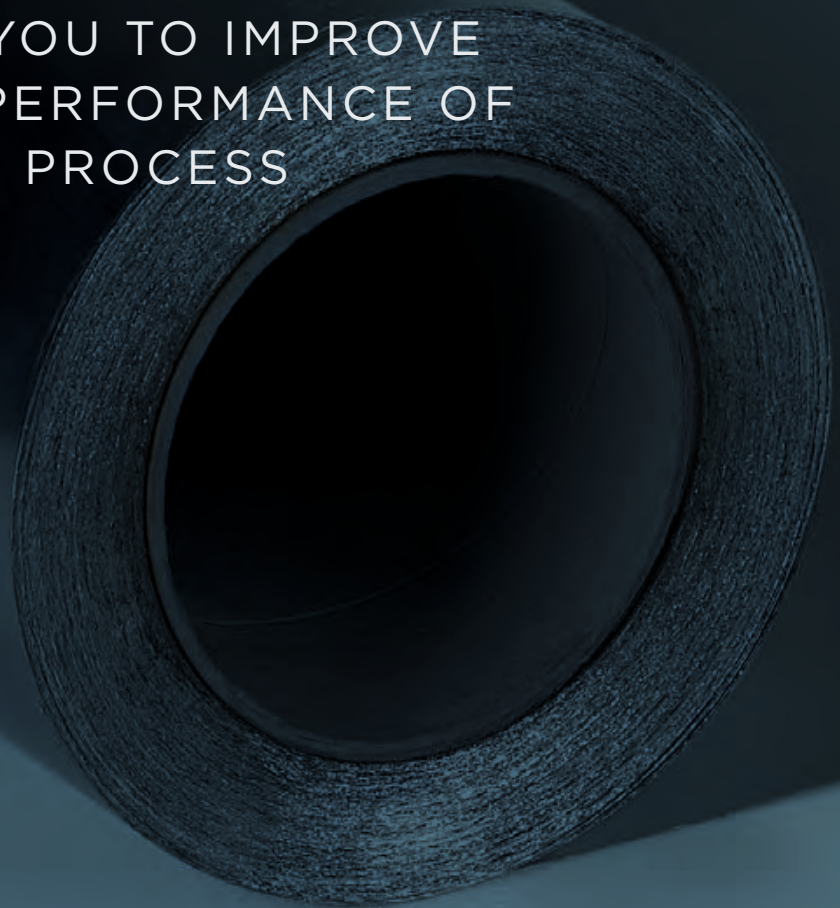


# 03

## OTHER APPLICATIONS



THE RIGHT SOLUTION  
FOR YOU TO IMPROVE  
THE PERFORMANCE OF  
YOUR PROCESS





## 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



### IN THE GLASS INDUSTRY

Papyex® is not wet by molten or viscous glass.



### IN SPARK PLASMA SINTERING (SPS)

in hot compression operations and in particular in the case of spark plasma sintering (SPS), the thinnest Papyex® makes it possible to produce inserts that facilitate mould stripping and better temperature distribution.



### IN SOLDERING OR BRAZING

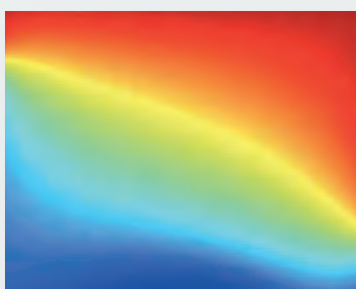
in particular in the case of work on delicate assemblies, Papyex® is used to protect against splashing of adjacent areas that would risk being damaged.



### 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

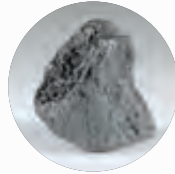


The conductivity of Papyex® in the plane of the sheet increases greatly with an increase in density (see graph page 11). This material can then be used for dissipating heat with equivalent performances than conductive metals such as copper. In electronics, it thus serves as a thermal interface and heat sink. Its lightness and reasonable cost, makes it competitive compared to other solutions.

# 04

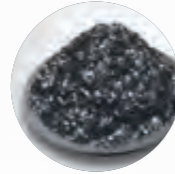
## MANUFACTURE FROM ROUGH MATERIAL TO FINISHED PRODUCTS

### 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.

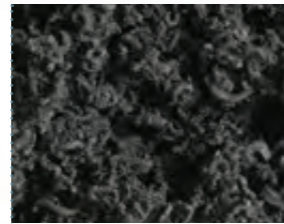
### EXPANDABLE GRAPHITE



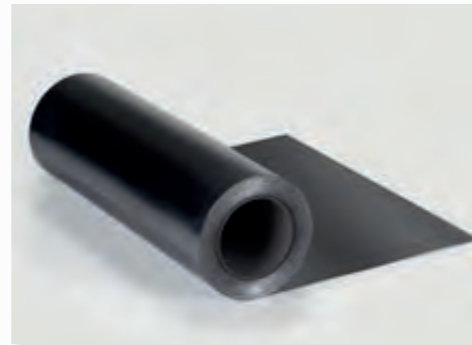
Graphite has the property of forming lamellar compounds by the insertion of atoms or molecules in its structure. This property is used for manufacturing expandable graphite by acid insertion. The inserted compound reacts to a thermal shock at very high temperature: the insertion element vaporises and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



EXPANDABLE GRAPHITE



EXPANDED GRAPHITE

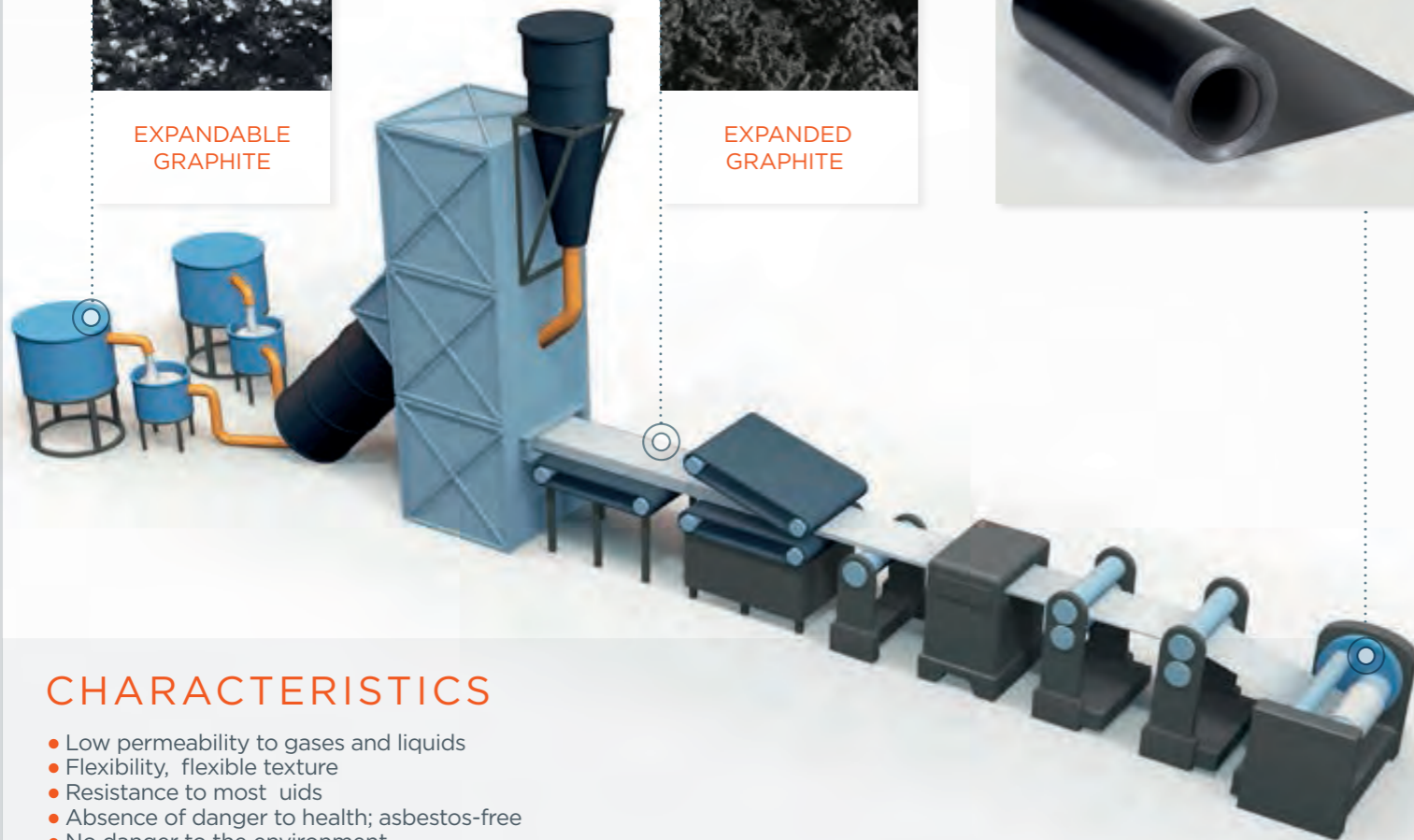


### PAPYEX® ROLL

Standard width:  
500, 1 000, 1 500 mm

Standard density:  
0,7g / cm<sup>3</sup> to 1,1g / cm<sup>3</sup>

Standard thickness:  
0,2 to 1,5 mm in roll form  
up to 10 mm in plate form



## 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

### PAPYEX® TAPE SLIT FROM A ROLL

Minimum width: 4,5 mm



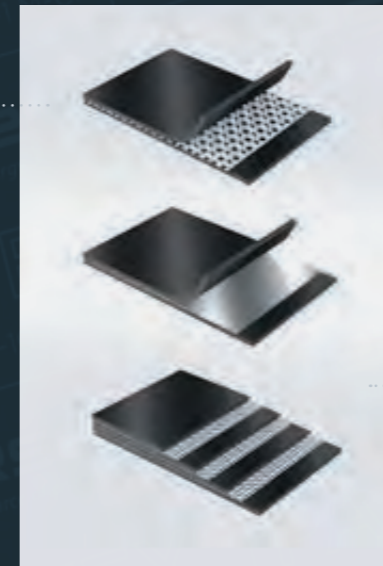
### SPIRAL WOUND GASKET

Co-winding of Papyex® and steel



### GRAPHITE RINGS

with or without metal insert obtained by compressing Papyex® tapes



### REINFORCED SHEETS ASSEMBLED

by gluing or clinched with tanged inserts

### FLAT GASKET

cut by punch, water jet, oscillating blade



### PAPYEX® HP

multi-reinforcement gasket easy to cut by conventional means



# 05

## PAPYEX® GRADES

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.

### FLEXIBLE GRAPHITE MEETING SEALING REQUIREMENTS

	CHEMICAL, PETROCHEMICAL INDUSTRIES				AUTOMOTIVE	
	I600		I980		A960	
	Low oxidation rate		Standard purity		Low purity	
	specification	typical value	specification	typical value	specification	typical value
Carbon rate	> 99%	99,40%	> 98%	99,25%	> 96%	98,45%
Ash content	< 1%	0,60%	< 2%	0,75%	< 4%	2%
Sulfur content	< 700 ppm	500 ppm	< 1400 ppm	< 700 ppm	1400 ppm	1000 ppm
Total chlorine content	< 50 ppm	25 ppm	< 50 ppm	25 ppm	80 ppm	50 ppm
Mass loss (500°C / 24h)	< 0,5%	0,10%	< 4%	1,50%	< 10%	5%
Mass loss (670°C / 4h)	< 4%/h	3%	-	-	-	-
Maximum operating temperature to air	550 °C		450 °C		450 °C	
Maximum operating temperature under an inert atmosphere	2700 °C		2700 °C		2700 °C	

### GENERAL PROPERTIES

	specification	typical value
Tensile strength (D=1g/cm³)	> 4 Mpa	4,5Mpa
Compressibility	45% to 52%	45% to 52%
Elastic recovery	10% to 15%	10% to 15%
Area weight distribution (g/m²)	+/- 5%	3,50%

### PHYSICAL PROPERTIES

	unit	in plane	through thickness
Permeability	cm².s⁻¹.atm⁻¹	-	10⁻⁵
Shore hardness	C²	25	25
Coefficient of thermal expansion	10⁻⁶.°C⁻¹	zero	25 to 28
	10⁻⁶.°F⁻¹	zero	14 to 15
Electrical resistivity	Ωcm	0,001	0,05
	Ωinch	0.0004	0.02
Emissivity coefficient at 400°C	-	0,4	0,4
Emissivity coefficient at 1.000°C	-	0,6	0,6

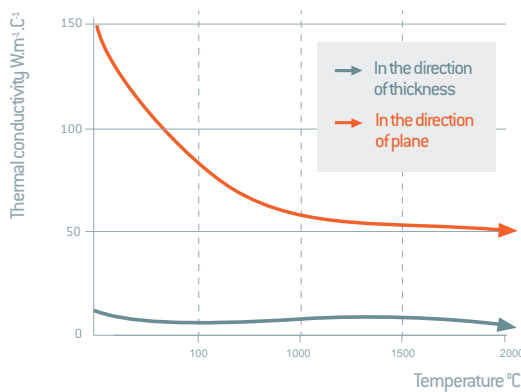
Data herein contained are provided for general information purpose only and are not binding. Mersen shall have no liability whatsoever with respect to information contained herein. Duplication, reproduction or translation of any information contained herein, in whole or in part, is strictly prohibited without prior written consent of Mersen. Our materials are in conformity with the RoHS-Directive (Restriction of the use of certain Hazardous Substances).

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.

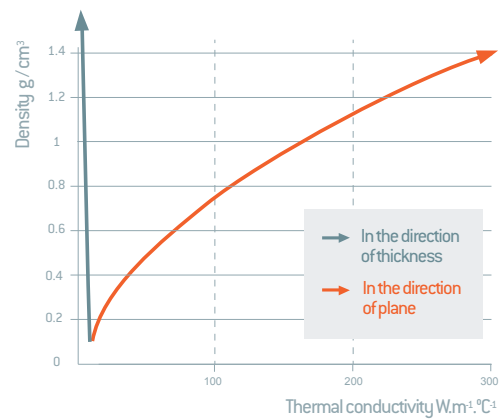
## FLEXIBLE GRAPHITE MEETING SEALING REQUIREMENTS

NUCLEAR								
N9985		NS200		N998		NP998		
The highest purity without additive		Very low sulfur		High purity without additive		High purity with oxidation inhibitor		
	specification	typical value	specification	typical value	specification	typical value	specification	typical value
Carbon rate	> 99,85%	99,90%	> 99,5%	99,55%	> 99,8%	99,85%	> 95%	98,50%
Ash content	< 0,15%	0,10%	< 0,5%	0,45%	< 0,2%	0,15%	< 0,2%	0,15%
Inhibitor rate	-	-	-	-	-	-	1% to 3%	1,35%
Sulfur content	< 600 ppm	500 ppm	< 200 ppm	120 ppm	< 600 ppm	450 ppm	< 600 ppm	450 ppm
Total chlorine content	< 30 ppm	20 ppm	< 30 ppm	20 ppm	< 30 ppm	20 ppm	< 30 ppm	20 ppm
Leachable chlorine content	< 20 ppm	10 ppm	-	-	< 30 ppm	20 ppm	-	-
Halogen content (F, Br, I)	-	-	< 50 ppm	30 ppm	-	-	-	-
Mass loss (500°C / 24h)	< 1%	0,50%	1%	1%	< 1%	0,60%	< 0,50%	0,10%

### THERMAL CONDUCTIVITY ACCORDING TO TEMPERATURE






### THERMAL CONDUCTIVITY ACCORDING TO DENSITY

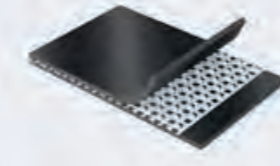
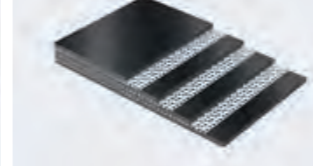


dous Substances in electrical and electronic equipment). Besides Mersen guarantees the application of the European Community REACH-Regulation (Registration, Evaluation, Authorization and Restriction of Chemical substances) to all its plants located in Europe. We are constantly involved in engineering and development. Accordingly, Mersen reserves the right to modify, at any time, the technology and product specifications contained herein.

# 06

## TECHNICAL DATA OF PAPYEX® SHEETS

PAPYEX® SR	PAPYEX® RI	PAPYEX® RN
		
Flexible graphite sheet without reinforcement.	Flexible graphite sheet reinforced with a 50 µm glued flat stainless steel insert. It is used in flange connections for chemical, petrochemical industries.	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	PAPYEX® HP
	
Flexible graphite sheet reinforced with a tanged 100 µm stainless steel insert, without adhesive. Suitable for manufacturing pipe gaskets & reactor seals in chemical and petrochemical industries.	Multi-reinforced flexible graphite sheet designed to resist very high pressures and mechanical stresses even the highest temperatures. Suitable for high pressure steam in generator, pump seals and high pressure vessels.

	Unit/standard
Sheet size	m
Insert material	DIN /ASTM
Insert thickness	µm
Nomenclature	DIN 28 091-4
Flexible graphite density	g/cm³ +/-10%
Standard thicknesses	mm +/-10%
Amount of inserts	nb
Gas permeability (helium)	cm³ /min
Specific leakage rate L	mg/s/m
σ <sub>vo</sub>	N/mm²
σ <sub>Bo</sub> at 300°C Standard thicknesses	N/mm²
"Anti-sticking" treatment	
Tightness	
<b>Gasket coefficient (bD=20 mm) :</b>	
σ <sub>w</sub> DIN E 2505	N/mm²
m DIN E 2505	DIN coeficient
m coefficient ASTM	
y coefficient ASTM	psi
<b>Mechanical tests:</b>	
EN 13555 - Gasket width 20 mm	°C
Q <sub>smax</sub>	N/mm²
POr (50 Mpa)	
Compressibility ASTM F36A-66	%
Elastic recovery ASTM F36A-66	%
Residual stress DIN 52913, 16h/300°C	N/mm²

technical data				technical data											
1x1/1,5x1,5				1x1/1,5x1,5						0,5x1/1x1/1,5x1,5					
without insert				1.4401 /SS316 (flat)						Nickel					
-				50						13					
GR-10				GR-10-0-1 K-Cr						GR-10-I K-Ni					
0,7 to 1,3				0,7 or 1						1					
1,0	1,5	2,0	3,0	0,75	1,0	1,5	2,0	3,0	0,4	0,8	1,0	1,5	2,0	3,0	
0				1						1 or 2					
< 0,30	< 0,60	< 0,80	< 0,85	< 0,60						< 0,85					
< 0,05	< 0,08	< 0,1	< 0,15	< 0,06						< 0,1					
160	140	120	100	100						110					
140	120	100	80	70						90					
Option available				No						No					
20				10						10					
1,3				1,3						1,3					
2				2						2,5					
1500				900						1000					
40-50				40-50						40-50					
10-15				10-15						10-15					
>47				>45						>45					

technical data				technical data					
1x1/1,5x1,5				1x1/1,5x1,5					
1.4401 /SS316 (perforated)				1.4401 /SS316 (L) (tanged)					
100				50					
GR-10-0-1 M-Cr				GR-11-I-3-Cr					
1				1,1					
1,0	1,5	2,0	3,0	1,1	1,5	2,0	3,0	4,0	
1				1 or 2					
< 0,60	< 0,60	< 0,80	< 1,0						
< 0,06	< 0,06	< 0,08	< 0,1						
180	160	140	120						
160	140	120	100						
Option available				yes					
				Ta-Luft certification, optional					
20				20					
1,3				1,3					
3	2,5			2,5					
9000	4000			3000					
				20°C		300°C		400°C	
				> 220		> 220		200	
				0,99		0,94		0,92	
30-35				30-40					
15-20				4-5					
> 48	> 48	> 48	> 45	> 48					

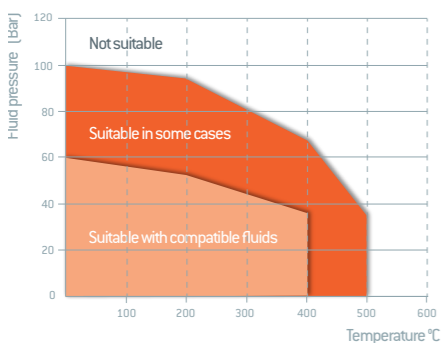
**+** IN PARTNERSHIP WITH SPECIALISTS IN STATIC SEALING, MERSEN HAS DEVELOPED A COMPLETE RANGE OF FLEXIBLE GRAPHITE SHEETS ALLOWING CUSTOMERS TO CUT FLAT GASKETS FOR THEIR SPECIFIC APPLICATIONS.

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.

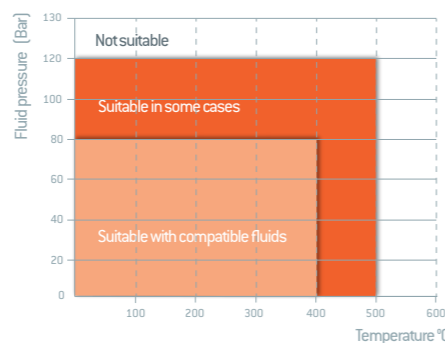
**+** ANTI-STICKING COATING FOR FACILITATING GASKET REMOVAL

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.

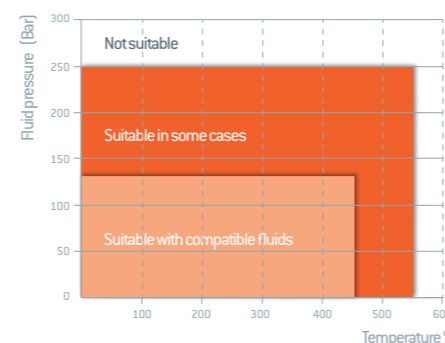
PAPYEX® RI / PAPYEX® RN PRESSURE / TEMPERATURE



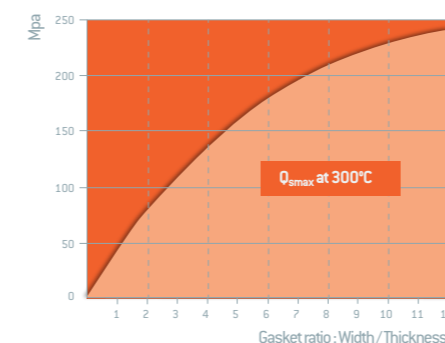
PAPYEX® PI PRESSURE / TEMPERATURE



PAPYEX® HP PRESSURE / TEMPERATURE



PAPYEX® HP MAXIMAL SEAT PRESSURE ON THE GASKET



### 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 1500 x 2000 mm.



GLOBAL EXPERT IN ELECTRICAL  
POWER AND ADVANCED MATERIALS

#### EUROPE

##### FRANCE

Mersen France Gennevilliers S.A.S  
BP148 - 41 rue Jean-Jaurès  
F-92231 Gennevilliers  
tel. : +33 (0)1 41 85 45 87

##### GREAT BRITAIN

Mersen UK Portslade Ltd  
Boltby Way  
Durham Lane Industrial Park  
Eaglescliffe  
Stockton on Tees  
TS16 0RH  
tel: +44 (0)1642 790100

##### GERMANY

Mersen Deutschland Suhl GmbH  
Dröhbergstr. 1,  
98527 SUHL  
Germany  
tel. : +49 03681-35320-0

##### NETHERLANDS

Mersen Benelux B.V.  
Mercuriusweg 4-6  
3113 AR (SCHIEDAM)  
Netherlands  
tel. : +311 0298 3030

#### ASIA

##### CHINA

Mersen Chongqing Co., Ltd  
No. 2 Yunsong Road, Economic Development Park,  
North New District  
401122 Chongqing  
P.R. of China  
tel. : +86-236-730-8668

##### CHINA

Mersen Kunshan Co., Ltd  
Eastside of Taihu Rd.  
Kunshan Development Zone  
Kunshan 215334  
Jiangsu Province  
P.R. of China  
tel. : +86-400-162-8288

##### KOREA

Mersen Korea Co., Ltd. -  
Ssangam Branch  
2001-1, Ssangam-ri,  
336-865 SSANG-AM  
Eumbong-myeon, Asan,  
Chungnam, Korea  
tel. : + 82-41-547-0135-6

#### NORTH AMERICA

##### USA

Mersen USA St Marys-PA Corp  
215 Stackpole Street  
St Marys PA 15857 - USA  
tel. : +1 814 781 1234

##### USA

Mersen USA Bay City - MI LLC  
900 Harrison Street  
Bay City MI 48708 - USA  
tel. : +1 989 894 2911

#### SOUTH-AMERICA

##### BRAZIL

Mersen do Brasil, Ltda.  
Av. Jabaquara, 3060 - 5 andar- Cj. 502.  
Bairro Mirandópolis - São Paulo - SP  
CEP: 04046-500  
tel. : +55 11 2348-2360

##### MEXICO

Mersen México Monterrey, S. de R.L. de C.V.  
Temis No. 703,  
Col. Arboledas de Santa Cruz  
Guadalupe. N.L., Mexico  
C.P. 67196  
tel. : +52 81 81272800

MERSEN LOCAL  
PAPYEX® EXPERTS  
ALSO IN OUR SITES IN

SOUTH-AMERICA:  
Colombia, Argentina, Chile

EMEA:  
Spain, Italy, Turkey,  
Switzerland, South-Africa

ASIA:  
Thailand, India, Australia,  
Japan

WWW.MERSEN.COM

PAPYEX@MERSEN.COM

