FINAL
+ADVANCED MATERIALS

TECHNICAL DATA SHEET

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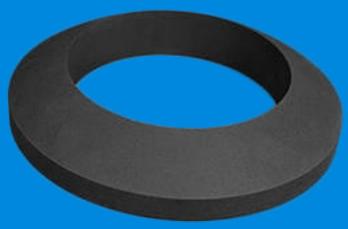

6MG.001
Graphite

Summary

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Overview

Graphite is made of elementary carbon (C), with an hexagonal crystalline structure. It is composed with graphene layers that give it anisotropic physical properties. Graphite products are appreciated because of their resistance to high temperatures and their thermal and electrical conductivity. This soft and flexible material is characterized by a black or grey-black color.

Graphite is found at natural state in form of flakes in the sediments, of veins or amorphous. Graphite synthesis enables to obtain purer qualities, perfect for technical components.

Applications

- Lubricant
- Electronical and semi-conductor pieces
- Trim for brakes and clutches
- Motor pieces
- Sealing joints
- Paints and coatings
- Stable components for nuclear and armament
- Fuel cells

Machining

We certify a machining quality according to ISO 9001:

- Rectification (plane, cylindrical, turning)
- Miling
- Driling
- Machining and driling by ultrasounds
- Polishing (plane and cylindrical)
- Tapping, threading, running-in

info@final-materials.com

Advantages

- Auto-lubricant
- Easy to machinate
- Good thermal shocks resistance
- No adhesion to glass
- Avoid mechanical tensions in glass and scratches on hot glass
- Better resistance to deterioration
- Low friction coefficient
- High thermal conductivity
- Inert
- Thermal dissipation
- Electrical conductor
- Excellent chemical resistance
- Excellent corrosion resistance

Products

Machinable graphite

Machinable blocs of graphite are made from extrusion, vibro-molding or isostatic pressing. In this last case, the standard surface obtained after machinating has a Ra of 0.6 µm.

Machinable graphite pieces resist to thermal applications without being deformed, explode or shrink. They enable to control heat loss and optimize thermal conduction. And are adapted to highly corrosive environments.

Machinable graphite enable to machinate components for plastic processing, glassware, metallurgy or furnaces coating.

Range

Range	Production	Notes
HLM	extruded	Standard grain
HLR	extruded	Lower quality than HLM Higher porosity
ET-10	isostatic	High purity Oxidizing resistant
R7340	isostatic	Standard isostatic grade
R7340P30	isostatic	Same as R7340 Higher porosity Ashes rate < 30 ppm
R4550	isostatic	Thin grain Very good mechanical resistance
R6650	isostatic	Higher than R4550

R6650P5	isostatic	Same as R6650 Very high purity Ashes rate < 5 ppm
R6710	isostatic	Ultra thin grain Excellent mechanical resistance
R6710P5	isostatic	Same as R6710 Very high purity Ashes rate < 5 ppm For semi-conductor

Technical data

Properties	Unit	Extrusion		Isostatic pressing				
Item N°		HLM		R4550	R6650	R6710	R7340	ET-10
Direction according to the length of the grain		//	⊥	// and ⊥	// and ⊥	// and ⊥	// and ⊥	/
Density	**g/cm³**	1.7		1.83	1.84	1.88	1.72	1.75
Maximal size of the grains	**mm**	0.8		0.01	0.007	0.003	0.015	/
Open porosities	**%**	17		10	10	10	15	15
Dielectric resistance	**Ω.m**	$7{,}3.10^{-6}$	$9{,}4.10^{-6}$	13.10^{-6}	14.10^{-6}	13.10^{-6}	12.10^{-6}	14.10^{-6}
Young modulus	**GPa**	10	9	11.5	12.5	13.5	10.5	10.8
Bending resistance (4 points)	**MPa**	18	17	60	65	85	45	58.8
Resistance to compression	**MPa**	39	35	125	150	170	90	98
Traction resistance	**MPa**	13	12	/	/	/	/	34,3
Hardness		/		Rockwell B 95	Rockwell B 95	Rockwell B 110	Rockwell B 80	Shore D 50
Linear dilatation (20/200 °C)	**$10^{-6}.K^{-1}$**	2,1	3,1	4	3,9	4	2,9	3,8
Thermal conductivity	**$W.m^{-1}.K^{-1}$**	180	140	100	90	100	90	104,4
Ashes rate	**ppm**	800		20	/	/	200	32

Dimensions

HLR is only used for very large pieces and is available on request.

R7340is the only grade available that can be directly extruded in bars with standard diameters. The product doesn't need any remachining.

- Length 300 m
- Following diameters:
  Ø 3,2 - Ø 4,8 - Ø 6,4 - Ø 7,9 - Ø 9,5 - Ø 12,7 - Ø 13,8 - Ø 16 - Ø 19 mm

Example of applications: blown glass

Mold in graphite is used for casting and glass-blowing:

- Gripping supports and inserts
- Support, guide boards
- Wheels and caster wheels of transfer
- Fusion crucible
- Pressing tools
- Furnace insulators

Coatings and impregnations:

Coatings and impregnations allow the modifications of the graphite characteristics. They are only available for isostatic fine-grained graphite (< 10 µm).

Composition	Application	Results	Constraint
Pyrolytic carbon	CVD*	Smooth and dense surface Porosities deleted Chemical resistance Thermal resistance	Width from 2 to 30 µm
Silicon carbide	CVD*	Sealing Hardness Better resistance to oxidizing	Width from 75 to 125 µm
PTFE	-	Better resistance to acids Porosities deleted	-
Methacrylic resin	-	Sealing	-
Antimony	-	Better resistance to deterioration	Only for the Carbo-graphite

*Chemical vapor deposition process, under high temperature and high pressure

Pyrolytic carbon (amorphous carbon) coating is composed by 99.9995 % of elemental carbon and is almost without any organic or metallic impurities. It prevents the formation of silicon carbide on contact with silicon and is resistant to almost all acids, including hydrofluoric acid. It doesn't chip off and doesn't split on thermal choc. It can be used on temperatures up to 550 °C in presence of oxygen and up to 2.500 °C under vacuum or inert atmosphere. It is particularly adapted for solar and semi-conductor applications.

Carbo-graphite

Carbo-graphite is a material with a fine to very fine granulometry composed by amorphous carbon and graphite. This material can have a strong anisotropy because of axial shaping process.

Carbo-graphite products are made to achieve advantageous tribological characteristics and resist to corrosion. Those properties can be strengthened with resins, phosphates or metals impregnation.

Applications

- Sealing rings
- Joints
- Bearing

Technical data

Properties	Unit	EK24	EK2240	EK305
Impregnation		No impregnation	Phenolic resin	Antimony
Density	**g/cm^3**	1,70	1,8	2,55
Bending resistance	**MPa**	60	70	80
Compression resistance	**MPa**	180	200	290
Young modulus	**GPa**	18	19	21
Hardness	**Rockwell B**	105	110	115
Thermal conductivity	**$Wm^{-1}.K^{-1}$**	14	15	33
Linear dilatation (from 20 to 200 °C)	**$10^{-6}.K^{-1}$**	4,1	5,0	6,0
Temperature stability	**°C**	350	200	500

Cotronics graphite adhesives

Resbond™ 931 - Adhesive and coating 99 % graphite; 3,000 °C

Resbond™ 931 adhesive is a bonding pure graphite at 99 %. It can be used only to bond graphite or carbon components.

Because of the composition of Resbond™ 931 product, it is necessary to use a specific packaging for hazard transports.

Properties

- Temperature stability: 3,000 °C
- Resistant to liquid metals, at oxidizing and reducing atmospheres, and at many solvents and chemical products
- No contamination of furnaces atmosphere
- Electrical conductor
- Traction resistance

Example: a bonding graphite-graphite with Resbond™ 931 ensures a traction resistance of 17.5 MPa

Applications

- Repairs of broken or cracked graphite pieces: crucibles, boards fixation, induction furnace
- Casing bonding in felt, wool or graphite paper

Implementation

- Mix the graphite powder with its activator.
- Curing at 100 °C minimum to obtain a bonding 100 % graphite
- Curing in 16 hours at 130 °C

Ceramic-filled graphite adhesive, 1,370 °C

The adhesive Resbond™ 931C is a one-component adhesive filled with graphite and ceramic powder. It is used for bonding between graphite and an other material, and as a graphite coating on metallic, glass ceramic or other non porous surface.

Properties

- One-component filled with ceramic
- Temperature stability: 1,370 °C
- 99 % pure graphite
- Good electrical conductor
- Excellent resistance to different chemical and solvent agents
- Oxidizing resistant

Applications

- Bonding between graphite and other material
- Graphite coating on a metallic, glass, ceramic or non porous surfaces

Implementation

- Mix to obtain a smooth paste
- Curing in 24 hours at room temperature

Activator binder 931T

The binder 931T is an advantageous source of finely divided graphite. It is used to laminate porous surfaces of graphite pieces to increase the abrasion resistance.

Applications

- Sealing agent

Implementation

- Saturate the surfaces to be treated
- Curing at 130 °C
- Superposition of dried layers possible

Graphite

Technical data

Properties	Unit	931	931C
UN No		UN2874	-
Continuous temperature stability	°C	3,000	1,370
Number of components		2	1
Consistency		Paste	Paste
Filler		Graphite-Ceramic	
Compressive strength at 20 °C	MPa	20.7	29
Flexural strength at 20 °C	MPa	10.3	12.4
Thermal conductivity	$W.m^{-1}.K^{-1}$	8.64	5.76
Thermal Expansion	$10^{-6}.K^{-1}$	7.4	7.4
Dielectric Strength		Relative conductor*	
Resistivity		Relative conductor*	
Mix ratio	Powder - Binder	100 - 35	-
Cure at room temperature		-	24 h
Fast Cure		4 h at 100 °C	-
Post-Cure	°C	16 h at 130 °C	2 h at 93 °C

*The presence of graphite in the powder affects its insulating properties but is not sufficient to carry an electric current.

Security

Because of the composition of Resbond™ 931 product, it is necessary to use a specific packaging for hazard transports.

Graphite Aerosol

Graphite aerosol enables lubrication of metal, plastic or grease-free rubber pieces. Its binder allows to fix, on different materials, a graphite powder film with a very thin granulometry almost without overthickness.

Caution, this graphite aerosol is an electrical conductor.

Applications

- Dry/Cure lubrication for all materials
- Anti-seizing for all materials
- Demolding

Conditioning

- Aerosol 650/400 ml.

Graphite

Technical data

Properties	Unit	013-0001
UN No		UN 1950
Aspect		Liquid, black
Solid content	%	25
Density	g/m³	0.87
Average granulometry	µm	2
Flash point	°C	< 21
Temperature stability	°C	-15 to +1,500

Instructions for use

- Use on clean and degreased surfaces.
- Shake the aerosol before use.
- Spray approximatively at 20 cm from the surfaces to be treated.
- Let dry a few minutes.

Graphite Suspension

Graphite suspensions are used to lubricate metal, plastic or rubber grease-free pieces. Their binder enables to fix, on these different materials, a film of graphite powder of very fine granulometry almost without overthickness.

Caution, those graphite suspensions are electrical conductors.

Applications

- Cure lubricating agent for all materials
- Anti-seize
- Demolding agent

Technical data

Properties	Unit	013-0002	013-0003
Solvent		ethanol	water
Aspect		Black liquid	
Solid content	%	25	15
Density at 20 °C	g/m³	0.9	1.08 ± 0.01
Viscosity	mPa.s	-	600
Average granulometry D50	µm	2,2	± 10
Flash point	°C	16	0
Temperature stability	°C	Between -15 to +1,500	

Dimensions

		013-0002	013-0003
Conditioning		Contact us	Container of 30 L Barrel of 200 L Other: contact us

Implementation

- Clean surfaces to be coated, remove melting or welding spatter.
- Spray or apply with a brush.
- Apply in thin layers.
    - If the film is too thick, it may break.
    - It is recommended to overlay several thin cured layers.

Storage

- Keep the product in its original closed packaging in a closed dry premises at a temperature between +5 °C and +30 °C.
- Shelf life: 12 months at 20 °C, in its original closed packaging.
- Protect from freezing.

Graphite Powder

Our sieved graphite powder is made from our machinable graphite scrapers. Because of its revaluation, the impurities rate is about 200 ppm max. Five standard siftings are available, from 50 to 315 µm.

Applications:

- Filler for the thermal conductivity improvement
- Material of thermal interface
- Additives for epoxy molding components
- Filling for thermal dissipaters
- Filler for the electrical conductivity improvement

Technical data

Item N°	Sifting in µm
113-0025	315 to 500
113-0024	200 to 315
113-0023	100 to 200
113-0022	50 to 100
113-0021	0 to 50

A tailor-made sifting or unscreened bulk fill are also available.

Dimensions:

- Minimum conditioning: bottle of 1 L
- Minimum to order: 2 L

Smooth carbon and graphite felts

Smooth carbon and graphite felts are available in 6 and 12 mm thicknesses, respectively in widths of 1,200 and 1,370 mm. Widths and customized forms are available on request.

Advantages

- Lower thermal conductivity
- High specific heat for fast heating or cooling of the furnace
- Stable at 350 °C under air, vacuum or inert atmosphere at 1,000 °C for carbon and 2,000 °C for graphite
- Easy to machinate, can be cut with scissors or a cutter
- Isn't wet by molten metals
- High purity, contains very little sulfide or ashes
- Doesn't fill static electricity
- Good resistivity, in an induction furnace the pairing occurs only above 12 kHz

Applications

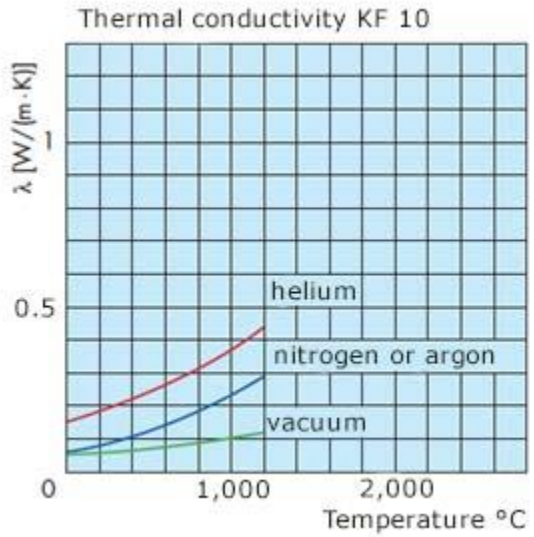
- Thermal insulation for vacuum or inert gas furnaces
- Degassing, brazing, sintering and annealing furnace for metals
- Induction furnace (better performance than ceramic felt)
- Filters for hot or corrosive liquids and gases and molten metals
- Support for welding or stirring

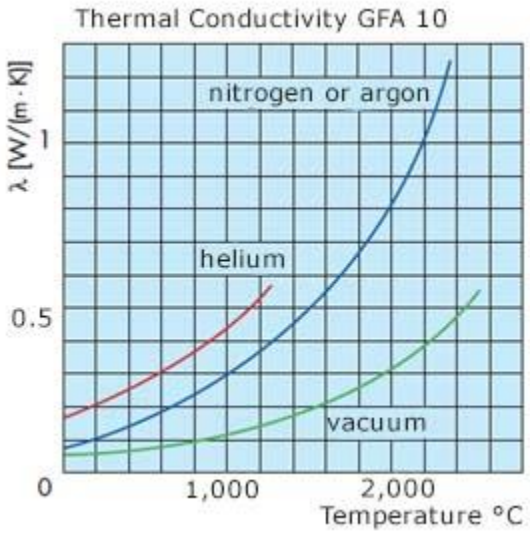
Technical data

Properties		Unit	Smooth carbon felt		Smooth graphite felt	
Item N°			KFA5	KFA10	GFA5	GFA10
Area density		g/m²	550	1,100	500	1,000
Thickness		mm	6	12	6	12
Width		mm	1,200	1,270	1,200	1,270
Length		m	25-30	25-30	25-30	15-30
Ashes rate		%	< 1.7	< 1.7	0.1	0.1
Ashes rate (purified grade)		ppm	/	/	< 20	< 20
Continuous temperature under vacuum or inert atmosphere		°C	1,000	1,000	2,000	2,000
Thermal conductivity	at 200 °C	$Wm^{-1}.K^{-1}$	0.05	0.05	0.03	0.03
	at 600 °C		0.09	0.09	0.17	0.17
	at 1,000 °C		1.6	1.6	0.6	0.6

Other dimensions available on demand. Items GFA5 and GFA10 available for cutting.

Thermal conductivity

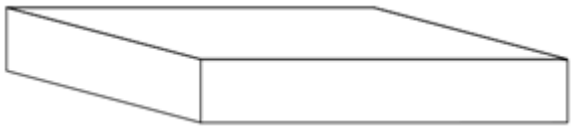
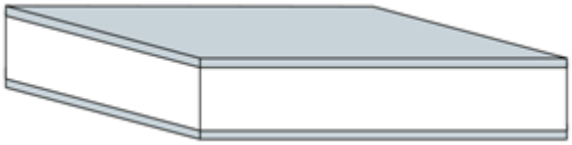




Rigid graphite felt

Rigid graphite felts from the MFA range are made from graphite fibres and carbon binder. Those products are used up to 2,200 °C as insulator or support. They are available: 1,524 x 1,219 x 40 mm. Widths and customized forms are available on request.

The MFA range proposes 4 products:

	**MFA:** hard felt without coating **Application:** insulation
	**MFA-FF:** rigid felt coated with a joint sheet on both sides. **Application:** insulation, radiation reflection on towards the interior of the furnace, protection against erosion, convection barrier
	**MFA CC:** rigid felt coated with a C/C composite on both sides. **Application:** insulation, additional shape retention
	**MFA-FCCF:** rigid felt coated with a C/C composite and a joint sheet on both sides. **Application:** insulation, additional shape retention, reflection of radiation back into the furnace, erosion protection, convection barrier, etc.

Graphite

Applications

- Thermal Insulation
- Support element
- High temperature furnace component

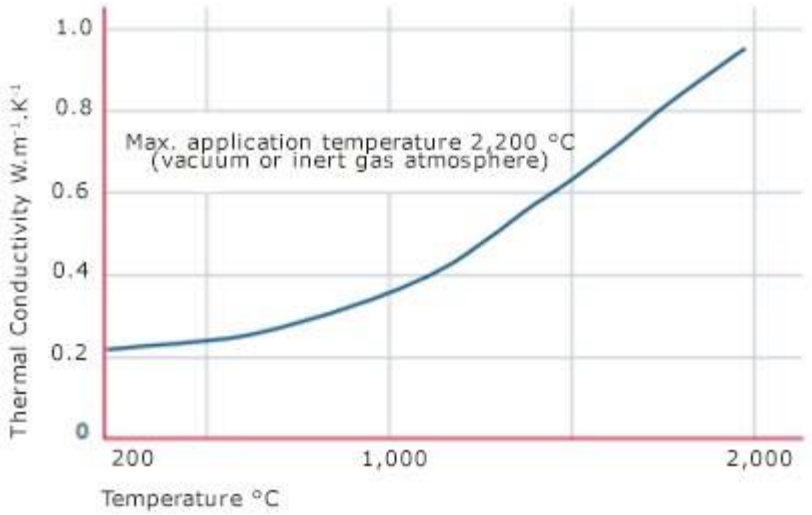
Technical data

Properties		Unit	Rigid felts in graphite
Item N°			MFA
Density		**g/cm³**	0.17
Thickness		**mm**	40
Width		**mm**	1,219
Length		**mm**	1,524
Compression resistance		**MPa**	0.7
Flexural strength		**MPa**	0.8
Ashes rate (purified grade)		**Ppm**	< 20
Continuous temperature under vacuum or inert atmosphere		**°C**	2,000
Thermal conductivity	**at 200 °C**	**$Wm^{-1}.K^{-1}$**	0.2
	at 600 °C		0.35
	at 1,000 °C		0.95

Rigid felt also available with a coating on one or both sides (carbon or graphite strengthening).

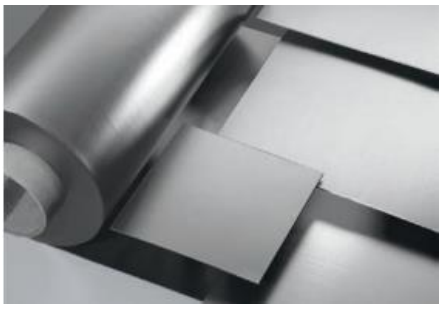
Thermal conductivity of the felt MFA

as a function of temperature in inert atmosphere



Graphite

Sealing sheets



The sealing sheets are made of high quality natural expanded graphite that can withstand very high temperatures. They don't contain any adhesive or binder. Flexible and light, they are easy to manufacture.

Sealing sheets are often used in combination with rigid felts as a single or double-sided coating. They are available in thicknesses of 1 and 2 mm, 1 000 x 1 000 mm².

Applications

- Thermal shield
- Protective coating
- Diffusion barrier
- Non-adhesive protection
- Heating element

Technical data

Properties		Unit	Flexible expanded graphite gasket sheet		
Item N°			105-0201	105-0202	105-0203
Description			Without reinforcement	Stainless steel reinforcement with picks	Multi-layer reinforcement smooth stainless steel sheet
Composition			99% pure graphite		
Color			Black two faces		
Density DIN 3754		g/cm³	1	1	1
Pressure (without temperature association)		Bar	50	120	250
Temperature stability	Peak	°C	3,000	800	800
	Inert fluid oxidizing environment		550	550	550
	Fluid oxidizing		450	450	450
	Minimum		-200	-200	-200
Compressibility ASTMF36/J		%	45	35	40-50
Elastic recovery ASTMF36/J		%	10-15	10-15	10-15
Breaking load DIN 52910		MPa	4.5	25	/
Hot Relaxation DIN 59213 16 h, 300 °C, 50 MPa		MPa	47	48	48
Chloride content		ppm	< 50	< 50	< 50
Gas permeability DIN 3535/6		ml/min	0.6	0.6	0.6
Tightening factor			Y = 10 MPa m = 2	Y = 17 MPa m = 2	Y = 15 MPa m = 3
Norms and agreements			ISO 9002	ISO 9002 S.N.C.F FITT	ISO 9002 S.N.CF

Dimensions

Properties	105-0201	105-0202	105-0203
Standard sizes	1,000 x 1,000 mm 1,500 x 1,500 mm	1,000 x 1,000 mm 1,500 x 1,500 mm	1,000 x 1,000 mm 1,500 x 1,500 mm
Other sizes on request	1,000 x 2,000 mm Roll thickness < 1 mm	1,000 x 2,000 mm	1,000 x 2,000 mm
Standard thicknesses (other on request)	0,3 / 0,5 / 0,8 / 1 / 1,5 / 2 / 2,5 / 3 mm	1 / 1,5 / 2 / 3 mm	1,5 / 2 / 3 mm

Carbon reinforced composites

These composites are characterized by a carbon matrix and a carbon fiber reinforcement. Their manufacture guarantees very high purity: they are obtained by heating at temperatures above 2,000 °C. With this process, their ashes content is generally 600 ppm although it can be reduced to less than 10 ppm by a post-purification treatment.

- **Standard:** Standard grade C/C composites are made from woven carbon fabric. They are available as boards and sections. They are ideal for heating elements and furnace walls.
- **Premium:** C/C Premium composites are also made from fabric made from woven carbon. These products are semi-finished, available in very rigid sheets. They are ideal for heating elements and highly stressed components.
- **Performance:** C/C Performance composites are ideal for bases and loading systems.
- **Mechanical:** C/C Premium composites are ideal for locking and fastening systems.

Manufacturing

C/C composites are made from resin and carbon fibers. The molding is done in two steps: the material is first subjected to a plastification and winding process before being pressed and cured. Carbonization and graphitization take place during the heat treatment at 2,000 °C. The obtained pieces are then machined to the desired dimensions.

Applications

C/C composites have a very good flexural strength and are particularly adapted for the following applications:

- Load systems,
- Flat heating elements,
- Screw and bolt components for the aeronautics industry

Technical data

Properties	Unit	Standard	Premium	Performance	Mechanical
Density	g/cm³	1.5	1.6	1.5	1.5
Flexural strength	MPa	150	230	300	100
Young modulus	GPa	60	75	80	28
Traction resistance	MPa	350	400	-	65
Interlaminar shearing strength	MPa	8	11	8	11
Ashes rate	ppm	1,000			
Ashes rate (purified grade)	ppm	< 10			
Max temperature Inert atmosphere or vacuum	°C	2,000			

Sintered glassy carbon

Sintered glassy carbon is an extremely resistant material, perfect for molding crucibles. It resists up to 3,000 °C in inert atmosphere and, unlike the other products, its resistance increases proportionally with the temperature.

Example: sintered glassy carbon is twice resistant at 2,400 °C than at room temperature.

Products don't become fragile at high temperature and resist at repeated cycles of rising temperature and cooling without difficulty.

Sintered glassy carbon crucibles don't present porosity. While using them, they generate a light oxidizing that causes the appearance of a gas on the molten metal. This phenomenon prevents the formation of an oxide layer on the molten metal and guarantees quality.

The flow has a uniform and clear aspect and doesn't wet the surfaces of the crucible. Reduced heating and melting times enable to melt the metal faster and more homogeneous.

Those crucibles are adapted to palladium alloys, noble metals, precious metals, and titanium melting. However, they don't have to be used for steel or ferrous metals alloy melting.

Sintered glassy carbon crucibles have a longer lifetime than conventional ceramic and graphite crucibles. They are compatible with an induction heating.

Graphite

Applications

- Crucibles Molding
  - Cylindrical crucible, conical crucible (large angle), conical crucible (thin angle), crucibles for crystals development, crucible with spout
- Cover manufacturing
- Boat manufacturing
- Evaporating dish manufacturing

Technical data

Properties	Unit	K Grade	G Grade
Density	**g/cm^3**	1.54	1.42
Open porosities	**%**	0	0
Temperature stability vacuum or in inert atmosphere	**°C**	1,000	3,000
Electric resistance	**Ω.m**	50.10^{-2}	45.10^{-2}
Young modulus	**GPa**	35	35
Bending resistance (4 points)	**MPa**	210	260
Compression resistance	**MPa**	580	480
Vickers hardness	**HV**	340	230
Linear dilatation (20/200 °C)	**$10^{-6}.K^{-1}$**	3.5	2.6
Thermal conductivity	**$Wm^{-1}.K^{-1}$**	4.6	6.3

Dimensions

Type	Dimension	Type	Dimension
Rod	Ø 1 to 10 mm	**Tube**	On request
Board	thk. 0,5 to 6 mm	**Powder**	-
Film	thk. 60 to 180 µm	**Crucible**	Tubular, cylindrical, conical

Physical variables included in this documentation are provided by way of indication only and do not, under any circumstances, constitute a contractual undertaking. Please contact our technical service if you require any additional information.