Mersen

Expertise, our source of energy

HIGH-PERFORMANCE CARBON INSULATION SOLUTIONS FOR HIGH TEMPERATURE FURNACES

Calcarb®

Grafshield™ GRI™

Summary

ZOOM

Convection, conduction and radiation

Thermal insulation efficiency centres around 3 key factors. Convection at lower temperatures, conduction along fibre length and radiation dispersion across the carbon fibre pores at the higher temperatures. By controlling both the fibre direction and the material porosity the temperature performance of the insulation can be optimised.

Best in class performance

The unique manufacturing process used to produce Mersen insulation ensures that the fibre structure is positioned at 90 degrees to the thermal source thus providing the market leading product for low thermal conductivity requirements.

Unlimited solutions by Mersen

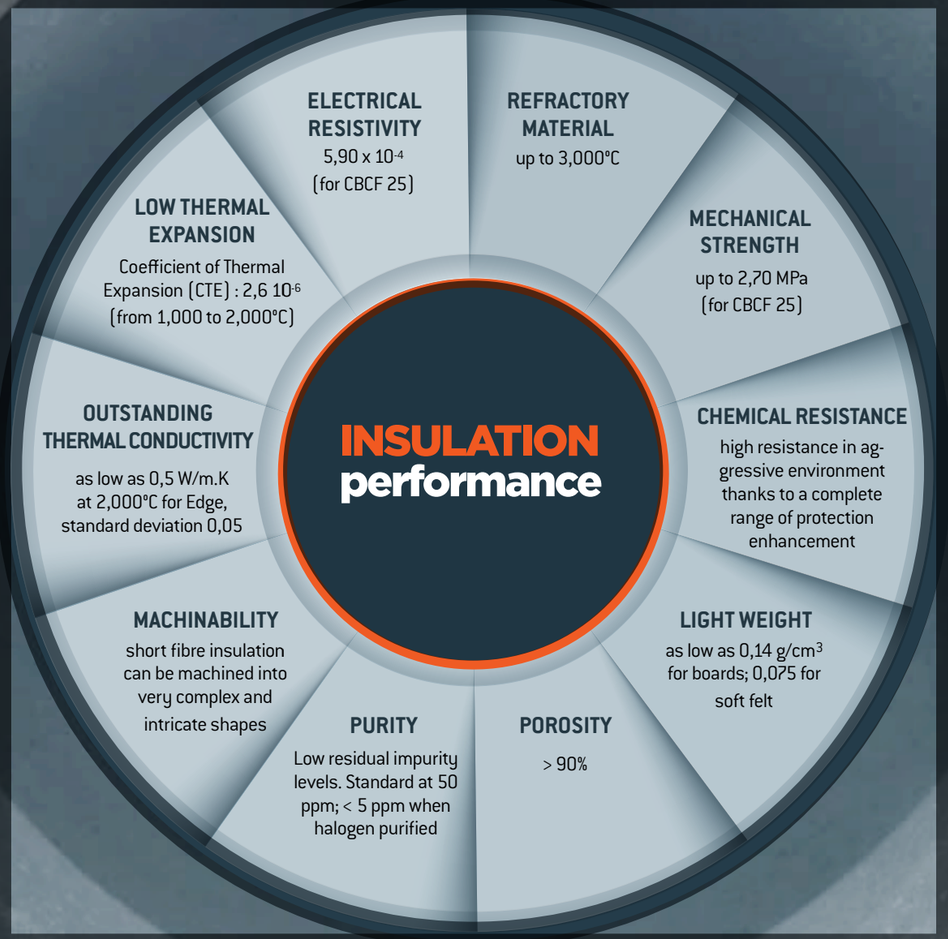
Running temperature, heating and cooling cycles, process duration, chemical reactions and operator experience will impact the selection of the right insulation.

Combining soft or rigid insulation with layers of carbon/carbon composites for strength and rigidity; flexible graphite sheets for heat reflection and gas impermeability creates a series of materials that can be customized to provide solutions to even the toughest heat-barrier problems.

MERSEN CARBON INSULATION

Solutions for high temperature furnaces

Mersen insulation enables the perfect protection and regulation for very high-temperature furnaces from 1,000°C up to 3,000°C. As an expert in carbon/carbon composites, graphite refractory materials and high-temperature insulation, Mersen sells “machined to design” solutions, giving turnkey service capabilities.

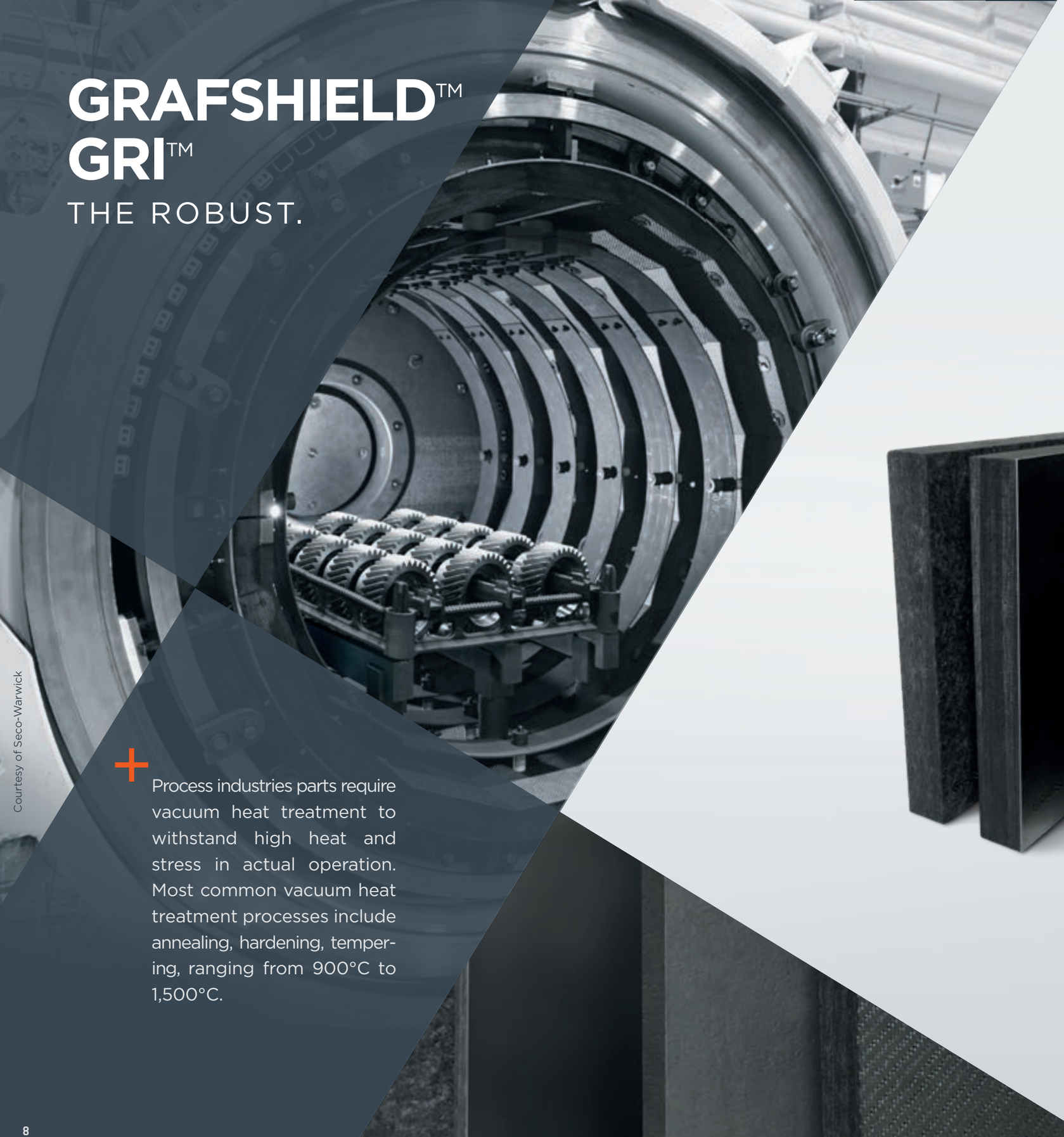


YOUR BENEFITS

- Mersen is the producer of carbon insulation materials combining constant quality with tight material tolerances
- Complete insulation range offering specific solutions to your process
- Global sales network in more than 35 countries is a strong asset to serve our customers in their projects

GRAFSHIELD™ GRI™

THE ROBUST.



Courtesy of Seco-Warwick

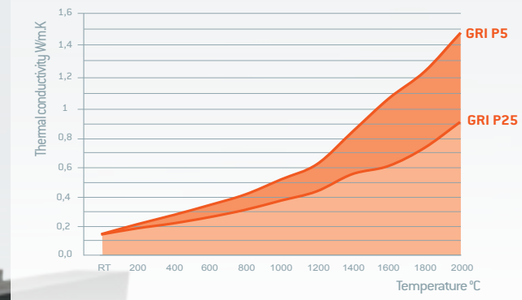
+ Process industries parts require vacuum heat treatment to withstand high heat and stress in actual operation. Most common vacuum heat treatment processes include annealing, hardening, tempering, ranging from 900°C to 1,500°C.

High-velocity gas

At a pressure of 20 bar, a quenching gas such as nitrogen has a weight of 51 kg/m³! Mersen heat treatment experts can help you to identify the right insulation grade for high-velocity gas quenching.

THERMAL CONDUCTIVITY

GRAFSHIELD™ GRI™ P5 & P25



WHAT THE APPLICATION(S) REQUIRES:

- High resistance to oxidation
- Ease of installation
- Lightweight
- Robust boards with good mechanical strengths
- Appropriate Thermal Conductivity for fast heating up and cooling down cycles
- Extended lifetime
- Competitive solution

GRAFSHIELD GRI P5 AND GRAFSHIELD GRI P25

- Outstanding oxidation resistance properties
- High tensile strength for an improved resistance to gas quenching
- Insulation board reinforcement with a carbon-carbon composite layer to strengthen its mechanical properties
- Grafshield GRI P5 Thermal Conductivity at 1,000°C is 0,467; GRI P25 Thermal Conductivity at 1,000°C is 0,327 for fast heating up and cooling down cycles

CALCARB® LF7

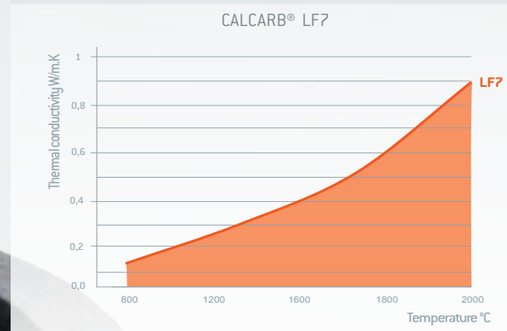
THE VERSATILE.

Calcarb® LF7 insulation is made from Long Fibre carbonised rayon precursor. This material has been designed for high temperature induction and resistance furnaces to operate in inert gas or vacuum atmosphere.
Calcarb® LF7 has low impurity levels and has very low gas evolution due to its high temperature treatment.
Long usage experienced in high pressure quench furnaces.

In the aerospace industry, stress reduction on metal parts to enhance component strength and fatigue life is critical to ensure components stand up to the extreme demands.

Mersen has a vast expertise in providing solutions for the heat treatment of advanced materials for high-tech industries, power generation and aerospace.

THERMAL CONDUCTIVITY



WHAT THE APPLICATION(S) REQUIRES:

- Tight control of temperature uniformity during the process with complex treatment cycles
- Provide critical heating and cooling rates necessary for optimum component performance
- Material performance at a running temperature in the range of 1,500°C to 2,300°C
- Clean process to avoid contamination
- Energy savings

CALCARB® LF7

- Rigidised long fibre material
- Extraordinary temperature stress resistance
- Thermal conductivity at 1,600°C is 0,571 for a good thermal uniformity for the process
- Enhanced LF7 specifications possibilities for an extended lifetime, oxidation resistance and clean process.
- Halogen Purification (HP) possible to avoid process contamination
- Capable of complex machining

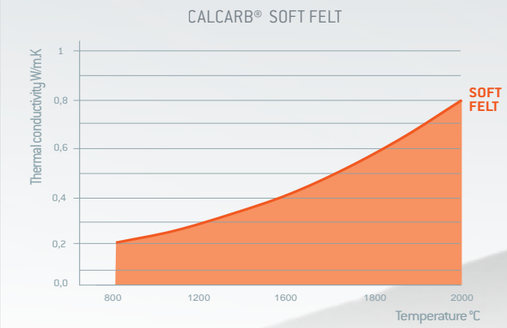
CALCARB® SOFT FELT

EASY & AGILE.

Calcarb® Soft Felt is an insulation made from carbonised rayon precursor and designed for high temperature induction and resistance furnaces to operate in inert gas or vacuum atmosphere.
Graphitized grade is the best choice for higher purity environments due to its low impurity level and very low gas evolution as a result of higher processing temperature to a minimum 2,000°C.

Calcarb® Soft Felt is an easy to use top performance insulation material, capable of running temperature in excess of 2,400°C. Creating the desired wall thickness is a simple matter of layering the soft felt to the final thickness. Its soft texture allows for easy bending around corners or a radius.

THERMAL CONDUCTIVITY



CALCARB® SOFT FELT

- High temperature resistance
- High purity as low as 5 ppm
- No electrostatic charging
- Low heat capacity allows rapid heating and cooling cycles
- Low thermal conductivity
- Highly flexible - not fragile
- Easy bending around corners or a radius
- Can be custom cut and delivered in a perfectly flat shape if the application requires it

CALCARB® CBCF

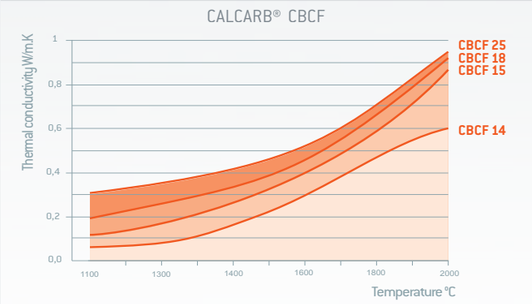
THE ORIGINAL. OUTSTANDING.

Calcarb® CBCF (Carbon Bonded Carbon Fibre) is a short fibre insulation originating from rayon. CBCF is formed from a slurry of carbon fibre and resin, which is molded into either a board, a cylinder or a disk form, to produce a 2D planar-random structure composite.

CBCF fibres are made from Rayon

This is the the least thermally conductive of all carbon material types; suppressing the physical transfer of energy. CBCF has a homogeneous structure with an even distribution of micro-pores, suppressing the transfer of radiant energy. CBCF exists in various densities, from 0,14 (CBCF 14) to 0,25 g/cm³ (CBCF 25).

THERMAL CONDUCTIVITY



WHAT THE APPLICATION(S) REQUIRES:

- High process temperature requires dimensionally stable insulation material
- Insulation solution has to withstand agressive / corrosive environment generated by high process temperatures and the process conditions
- High temperature uniformity within the hot zone for improved quality

CALCARB® CBCF

- 100% rayon-based fiber precursor for a high thermal efficiency
- Low CTE for stable dimensions during the process
- Short fibre structure makes it the perfect material to be machined for intricate design
- Additional product enhancement available for improved resistance to corrosive environment
- Minimize energy consumption and cost
- Maximize furnace performance and longevity
- High purity and high thermal resistance
- Low ash & sulphur content - purification possible as low as < 5 ppm
- Carbon Content ≥ 99%
- Possibility to have “ready to install” solutions for improved furnace availability

CALCARB® HYBRID

THE SOLUTION PROVIDER.

Mersen has developed a solution which combines 2 or more materials and utilises the best of each of their properties in a synergistic manner.

+

The higher the temperature gradient, the higher the thermal stress inside the material, as per standard thermal stress equation:

$\sigma = E*\alpha*(Thf-Tcf) = E*\alpha*\Delta T$

Calcarb® Hybrid is an extraordinary solution developed by Mersen to get rid off thermal stress and potential cracking when thicker insulation is required.

[HYBRID]

Combines the least thermally conductive of all carbon material types, suppressing the physical transfer of energy. CBCF has a homogenous structure with an even distribution of micro-pores which suppresses the transfer of radiant energy.

Soft felt insulation is cemented to the CBCF material to minimise any hot spots and give a homogeneous thermal profile throughout.

WHAT THE APPLICATION(S) REQUIRES:

- High temperature uniformity within the hot zone for improved quality
- Insulation solution has to withstand agressive / corrosive environement generated by high running temperatures and the process itself (residual SiO2; Silicon,...)
- Dimensionally stable insulation material in high running temperature
- Energy consumption cost control

CALCARB® HYBRID

- Standalone insulation hot zone unit : fast replacement and down time reduction, equates to Cost Of Ownership benefits
- Calcarb® Hybrid conception minimises hot spots with a superior homogeneous thermal profile
- High purity
- High performance at 2,400°C
- Extended lifetime

CALCARB® EDGE

THE ULTRA PERFORMER.

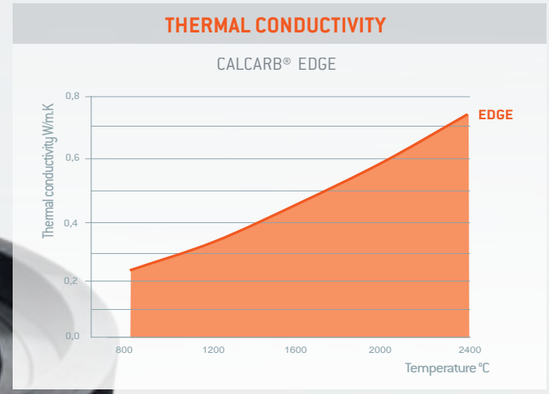
CBCF from 100% rayon, provides lowest Thermal Conductivity for process temperature above 1,800°C.

+

The increased reliability, higher operating temperature, increased efficiency, reduced size, higher voltage capabilities of SiC make it highly desirable in the electric vehicle and renewable energy industries. Mersen has developed a specific insulation material with exceptional performance.

SIC crystal growth is the most difficult step in the material value chain

Silicon Carbide crystal growth is highly challenging. **Calcarb® EDGE** has unique properties that allow a precise control of the temperature process that can take up to 14 days at 2,400°C !



WHAT THE APPLICATION(S) REQUIRES:

- High temperature uniformity within the sublimation zone and for system to system.
- Insulation solution has to withstand very high operating temperatures and maximise the insulation lifetime
- Dimensionally stable insulation material in high running temperature
- Energy consumption cost control due to low Thermal Conductivity

CALCARB® EDGE

- Unique Cylinder within Cylinder (CwC) construction gives optimal cost of ownership to the customer
- Our unique process and material combination provides a narrow Standard Deviation on thermal and mechanical properties tolerance.
- Allow precise process control at high temperature (2,400°C)

SOLUTIONS FOR SQUARE AND ROUND HOT ZONES

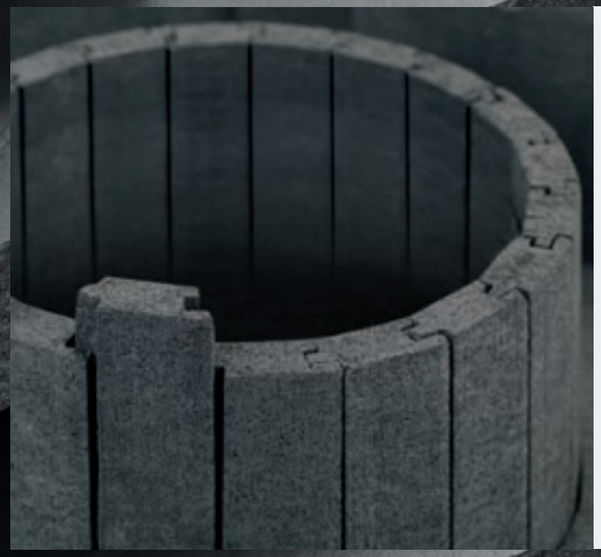
SQUARED CONSTRUCTION SOLUTIONS

Calcarb® CBCF and Grafshield boards can be can be machined to both squared and cylindrical hot zone shapes.

CYLINDER SHAPE SOLUTIONS

Mersen is able to engineer ready to use cylinders based on your process requirement and performance expectations in CBCF, CBCF + Soft felt or Grafshield GRI configurations.
Foil and coating possible on both sides and in intermediate layer.

- Machined to size and customer designs
- Uniform insulation properties
- Foil and coatings on request for improved performance and life time
- From 65 mm to 1600 diameter



CYLINDER CONSTRUCTION SOLUTIONS

Insulation cylinders can either be made as a a solid vacuum formed cylinder or as a series of barrel staves.

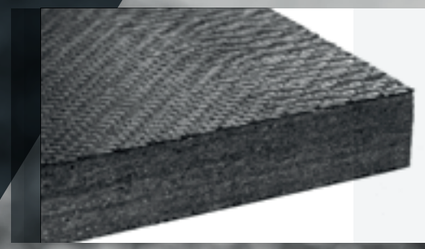
- Machined ready to assemble for an easy setting
- Foil and coatings on request for improved performance and life time
- Up to 2,400 mm diameter - 200 mm thick

DISK SHAPE SOLUTIONS

Disks can be machined up to 1854 mm diameter and 254 mm thickness.

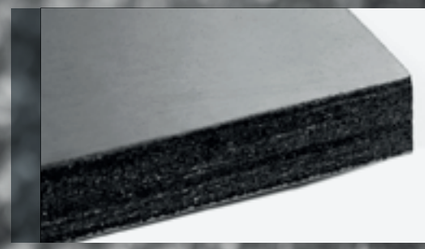
+ ENHANCED SOLUTIONS

MERSEN HAS DEVELOPPED A COMPLETE RANGE OF PROCESSES DESIGNED TO REINFORCE THE RESISTANCE OF THE INSULATION IN AGRESSIVE ENVIRONMENTS



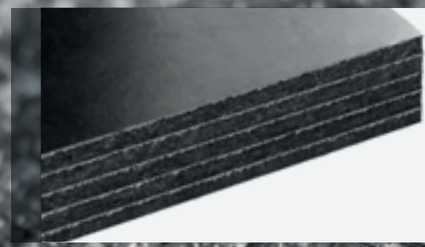
WEAR PROTECT

is a combination of bonded graphite foil and CFC cloth material. This combination provides temperature uniformity across the foil plane, reduces erosion from high velocity gas flows and protects the insulation material from incurring mechanical damage during customer process runs.



GRAPHITE PAINT

Standard graphite paint that inhibits dusting by sealing all coated surfaces. It offers a limited erosion resistance.

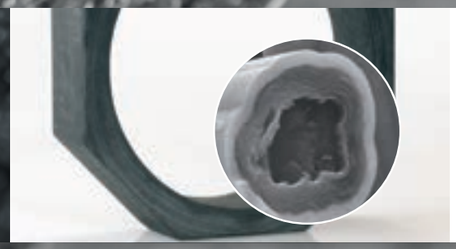


GRAPHITE FOIL

Provides added spill protection and temperature uniformity along plane of foil. Boards can be foiled one side, two sides or all over.

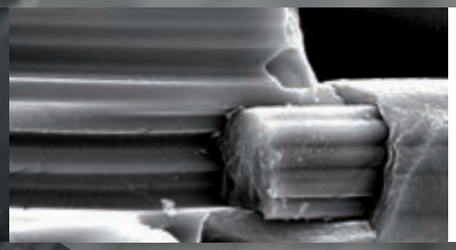
PYROCARBON OUTER LAYER CVD COATING

The pyrocarbon outer layer acts as a protection without changing thermal characteristics. It is a dense erosion resistance coating applied by CVD process. Being applied to all finished surfaces of machined parts, it offers beyond the erosion protection, a barrier against impregnation from process vapors.



SILICON CARBIDE (SIC) PROTECTION

In some specific conditions, like hydrogenated atmosphere over 1,000°C, carbon fibers are corroded by the medium. As insulation parts are often the critical part of such a process, the silicon carbide infiltration provides an unparalleled advantage, helping to extend insulation service life.



PYROCARBON PROTECTION - CVI

Embedding core fibres into 99.99% pure carbon, the infiltration provides protection in harsh environments with a greater than 50% extended life over standard material.

INSULATION SELECTION GUIDELINES

Running temperature, heating and cooling cycles, process duration, chemical reactions and operator experience will impact the selection of the insulation. Our experts are here to help you to select the right solution for you.

	INDICATIVE T° WITH USUAL PRESSURE ON INDUSTRIAL PROCESS (10-2)	CHEMICAL REACTION	CUSTOMER DESIGN HOT ZONE & FURNACE		
			SQUARED BOARD	CYLINDER	BARREL STAVES
POLYSILICON CONVERTERS	900°C	Hydrogen	n/a	Soft felt CBCF (6)	n/a
HEAT TREATMENT SINTERING /BRAZING	1,300°C	None residual oxygen	GRI ; LF7 (1) (2) (3)	n/a	GRI ; CBCF possible
CZ SILICON (PV & ELECTRONICS)	1,500°C	Silicon	n/a	Soft felt (7) CBCF ; LF7 (2) (4) (7) Hybrid (32") (2) (4) (7)	n/a
TURBINE BLADE (DIRECTIONAL SOLIDIFICATION)	1,500°C	None residual oxygen	n/a	LF7 (2) (4) (7) Soft felt CBCF (7)	n/a
HT CVD (SIC EPITAXY)	1,800°C	Silicon	n/a	CBCF (2) (7)	n/a
OPTICAL FIBRE	2,000°C	None residual Si02	n/a	Soft felt ; CBCF ; Hybrid (7)	n/a
SIC CERAMICS	2,100°C	Silicon	LF7 (1) (2) (3) (7)	LF7 ; CBCF (2) (7) Soft felt	LF7 ; CBCF (2) (7) ; EDGE
SAPPHIRE	2,200°C	Oxygen	n/a	LF7 ; CBCF (2) (7) Soft felt	LF7 ; CBCF (2) (7) ; EDGE
SIC MONO-CRYSTAL	2,400°C	Silicon	n/a	CBCF CWC (2) (7) Hybrid (2)	CBCF ; EDGE (2) (7)

(1) WEAR PROTECT - T° up to 1,800-2,000°C max
(2) GRAPHITE PAINT - T° up to 2,400°C but process dependent
(3) GRAPHITE FOIL - T° up to 1,800°C
(4) CVD COATING - T° up to 2,000°C - could go above - process dependent
(5) CVI PYROCARBON - CVI - T° up to 2,000°C - could go above – process dependent
(6) SILICON CARBIDE (SiC) PROTECTION - T° up to 1,500°C
(7) HALOGEN PURIFICATION (HP)

MERSEN INSULATION ENGINEERED SOLUTIONS

	GRI P5	GRI P25	LONG Fibre LF7	CBCF 14		CBCF 15	
DESIGN AVAILABILITY	BOARD / CYLINDER / DISK / COMPONENTS	BOARD / CYLINDER / DISK / COMPONENTS	BOARD / CYLINDER	BOARD / CYLINDER / DISK / COMPONENTS		CYLINDER	
BULK DENSITY g.cm^3	0,14	0,19	0,14	0,14		0,15	
COMPRESSIVE STRENGTH MPa	1,00	1,00		1,09		0,80	
FLEXURAL STRENGTH MPa	1,01	2,09	0,80	1,65		1,50	
COEFFICIENT OF THERMAL EXPANSION 25° TO 1,000°C	WG : 3,0 X 10^{-6} AG : 3,3 X 10^{-6}	WG : 3,0 X 10^{-6} AG : 3,3 X 10^{-6}	PROVIDED AT REQUEST	3,0 X 10^{-6}		3,0 X 10^{-6}	
1,000° TO 2,000°C	WG : 3,6 X 10^{-6} AG : 4,0 X 10^{-6}	WG : 3,6 X 10^{-6} AG : 4,0 X 10^{-6}	PROVIDED AT REQUEST	2,6 X 10^{-6}		2,6 X 10^{-6}	
SPECIFIC SURFACE AREAS - $m^2.g^{-1}$	PROVIDED AT REQUEST	PROVIDED AT REQUEST	PROVIDED AT REQUEST	22		20	
ELECTRICAL RESISTIVITY PARALLEL TO FIBRE ORIENTATION (xy) µohm.cm	5,3 X 10^{-4}	5,0 X 10^{-4}	PROVIDED AT REQUEST	12,5 X 10^{-4}		25,0 X 10^{-4}	
ELECTRICAL RESISITIVITY PERPENDICULAR TO FIBRE ORIENTATION (z) µohm.cm	3,0 X 10^{-4}	3,3 X 10^{-4}	PROVIDED AT REQUEST	52,1 X 10^{-4}		74,0 X 10^{-4}	
THERMAL CONDUCTIVITY* W/m.K	VACUUM	VACUUM	VACUUM	VACUUM	NITROGEN	VACUUM	NITROGEN
400°C	0,23	0,17	0,16	0,05	0,09	0,11	0,159
800°C	0,37	0,27	0,25	0,12	0,19	0,16	0,237
1,200°C	0,57	0,39	0,39	0,25	0,378	0,29	0,409
1,600°C	1,01	0,56	0,57	0,45	0,579	0,52	0,689
2,000°C	1,45	0,90	0,89	0,61	0,879	0,85	1,041
BOARD SIZE (MAX)	1,250 x 1,500 mm	1,250 x 1,500 mm	1,000 x 1,500 mm	1,500 x 1,500 mm		1,500 x 1,500 mm	
BOARD THICKNESS (MAX)	50 mm	50 mm	1,200 mm	250 mm		250 mm	
DISK DIAMETER	up to 1,250 mm	up to 1,250 mm	N/A	from 635 mm to 1,854 mm		N/A	
DISK THICKNESS [MAX]	50 mm	50 mm	N/A	406 mm		N/A	
CYLINDER OD (MAX)	250 mm	250 mm	Almost unlimited: designed to customer request	1,651 mm		1,100 mm	
CYLINDER HEIGHT(MAX)	1,500 mm	1,500 mm		350 mm		500 mm	
MAX WALL THICKNESS				40 mm		55 mm	
PRODUCT ENHANCEMENT							
SILICON CARBIDE (SIC) PROTECTION	X	X		X		X	
CVI PYROCARBON	X	X		X		X	
CVD COATING	X	X		X		X	
GRAPHITE PAINT COATING	X	X		X		X	
GRAPHITE FOILED	X	X	X	X		X	
WEAR PROTECT	X	X	X	X		X	

	CBCF 18		CBCF 25		EDGE	
DESIGN AVAILABILITY	BOARD / CYLINDER / DISK / COMPONENTS		BOARD / DISK / COMPONENTS		BOARD / CYLINDER	
BULK DENSITY g.cm^3	0,18		0,25		0,13	
COMPRESSIVE STRENGTH MPa	1,10		2,10		1,10	
FLEXURAL STRENGTH MPa	1,03		2,70		1,50	
COEFFICIENT OF THERMAL EXPANSION 25° TO 1,000°C	3,0 X 10^{-6}		3,0 X 10^{-6}		3,0 X 10^{-6}	
1,000° TO 2,000°C	2,6 X 10^{-6}		2,6 X 10^{-6}		2,6 X 10^{-6}	
SPECIFIC SURFACE AREAS - $m^2.g^{-1}$	18		11		PROVIDED AT REQUEST	
ELECTRICAL RESISTIVITY PARALLEL TO FIBRE ORIENTATION (xy) µohm.cm	11,0 X 10^{-4}		5,90 X 10^{-4}		4,4 X 10^{-4}	
ELECTRICAL RESISITIVITY PERPENDICULAR TO FIBRE ORIENTATION (z) µohm.cm	40,7 X 10^{-4}		15,93 X 10^{-4}		3,0 X 10^{-4}	
THERMAL CONDUCTIVITY* W/m.K	VACUUM	NITROGEN	VACUUM	NITROGEN	VACUUM	
400°C	0,17	0,224	0,30	0,325	0,16	
800°C	0,22	0,317	0,38	0,415	0,22	
1,200°C	0,32	0,485	0,48	0,531	0,32	
1,600°C	0,55	0,724	0,64	0,723	0,46	
2,000°C	0,84	1,170	0,92	1,080	0,60	
BOARD SIZE (MAX)	1,500 x 1,500 mm		1,500 x 1,500 mm		1,500 x 1,500 mm	
BOARD THICKNESS (MAX)	250 mm		250 mm		250 mm	
DISK DIAMETER	from 635 mm to 1,854 mm		from 635 mm to 1,854 mm		from 635 to 1854 mm	
DISK THICKNESS [MAX]	406 mm		406 mm		407 mm	
CYLINDER OD (MAX)	1,651 mm		N/A		1651 mm	
CYLINDER HEIGHT(MAX)	880 mm				350 mm	
MAX WALL THICKNESS	55 mm				40 mm	
PRODUCT ENHANCEMENT						
SILICON CARBIDE (SIC) PROTECTION	X		X		X	
CVI PYROCARBON	X		X		X	
CVD COATING	X		X		X	
GRAPHITE PAINT COATING	X		X		X	
GRAPHITE FOILED	X		X		X	
WEAR PROTECT	X		X		X	

	SOFT FELT
BULK DENSITY g.cm^3	0,075 +/- 0,01
FLEXURAL STRENGTH MPa	0,051
MODULUS OF ELASTICITY GPa	0,558
IMPURITY ppm	< 400
ASH CONTENT	< 0,06 %
TEMPERATURE PROCESS [MIN]	2,000°C
CARBON CONTENT (ESTIMATED)	> 99,94 % 1,93 AT 1,000°C
THERMAL CONDUCTIVITY* W/m.K	VACUUM
800°C	0,207
1,000°C	0,257
1,200°C	0,329
1,400°C	0,413
1,600°C	0,524
1,800°C	0,657
2,000°C	0,812
THICKNESSES	6/8/10/12 mm

Declared purity levels reached with Halogen Purification (HP) process.

GUARANTEED 34 ELEMENTS MEASURED	< 20 ppm
TYPICAL 5 METALS MEASURED	< 5 ppm

*Thermal conductivity measured with laser fl ash ; results would be signifi cantly lower with hot plate.

MERSEN
Expertise, our source of energy

GLOBAL EXPERT IN ELECTRICAL POWER AND ADVANCED MATERIALS

AMERICAS

MERSEN USA
Bay City, MI
Greenville, MI
St Marys, PA
Columbia, TN

MERSEN MEXICO
Monterrey

MERSEN ARGENTINA
Buenos Aires

MERSEN CHILE
Santiago

MERSEN COLOMBIA
Bogota

MERSEN BRAZIL
Sao Paulo

EUROPE & AFRICA

MERSEN BENELUX
Schiedam

MERSEN GERMANY
Suhl & Munich

MERSEN FRANCE
Gennevilliers & Bazet

MERSEN IBERICA
Barcelona

MERSEN TURKEY
Gebze

MERSEN ITALY
Milan & Malonno

MERSEN NORDIC
Kista

MERSEN UK
Teesside & Holytown

MERSEN SOUTH AFRICA
Johannesburg

ASIA & OCEANIA

MERSEN CHINA
Chongqing, Kunshan
& Yantai

MERSEN INDIA
Pune & Bangalore

MERSEN JAPAN
Tokyo

MERSEN SOUTH KOREA
Seoul

MERSEN OCEANIA
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