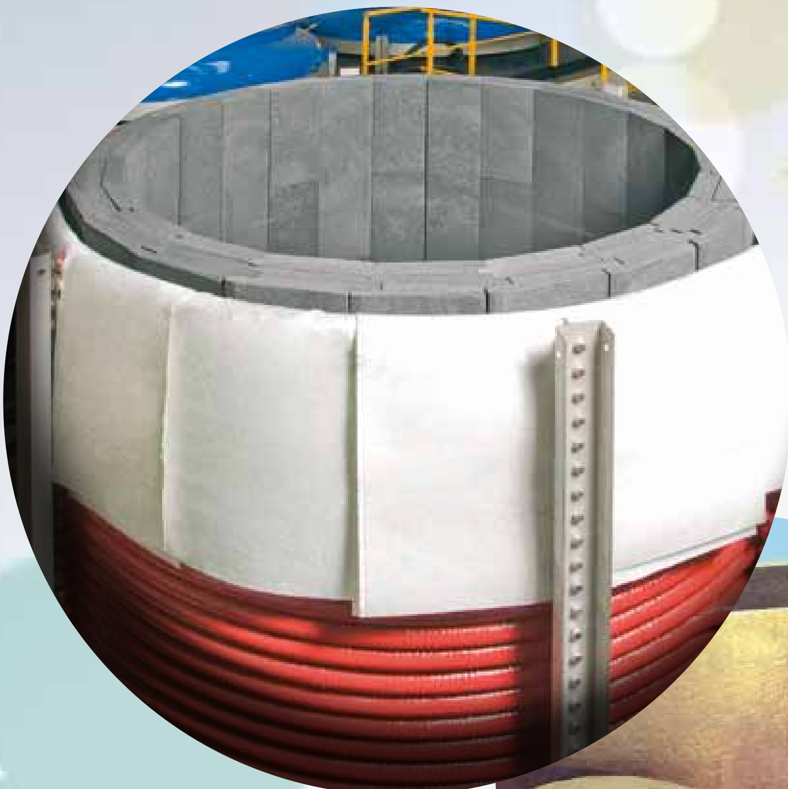
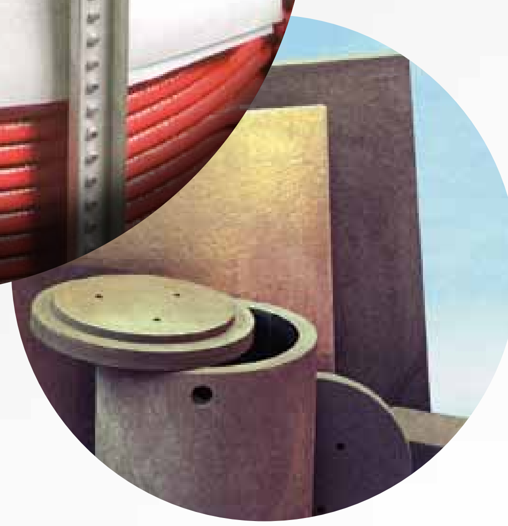
TECHNICAL GUIDE

CALCARB®
RIGID CARBON THERMAL INSULATION

OPTIMIZE THE THERMAL EFFICIENCY OF YOUR PROCESS WITH CALCARB® SOLUTIONS





MERSEN

GLOBAL SOLUTIONS FOR OUR MARKETS

Mersen's expertise is demonstrated in the energy efficiency and thermal control of numerous high temperature industrial processes. Its range of thermal insulation materials includes a variety of rigid and flexible materials.
CALCARB® CBCF is made up from short cut carbon fibres, interconnected in a matrix produced by the carbonisation of phenolic resin.

MAIN APPLICATIONS

CALCARB®CBCF insulation enables the perfect protection and regulation for very high temperature furnaces from 1000°C up to 3000°C.

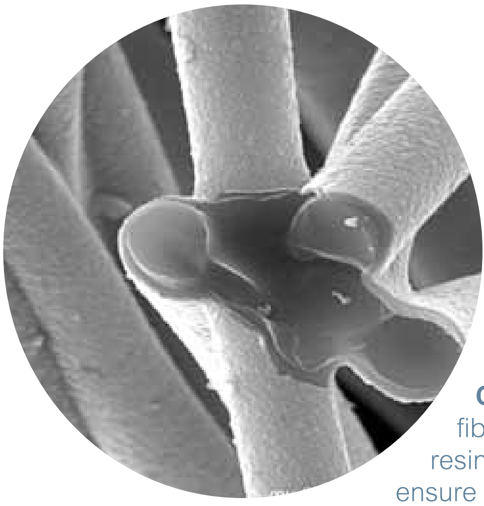
Main applications are :

- Heat treatment in controlled atmosphere:
- CVD furnaces
- Crystal growing industry (Semicon, solar...)
- Optical fibre
- Turbine blade casting
- SiC wafer manufacturing up to 2400-2500°C

MERSEN'S COMPLETE SOLUTION FOR HIGH-TEMPERATURE PROCESSES.

As an expert in composite or graphite refractory materials and high-temperature insulation, Mersen sells "machined to design" solutions, with turnkey services capability

TECHNICAL BENEFITS



CALCARB® strong reputation of reliability and efficiency, combined with mentioned benefits, is making it the preferred insulation material among experienced thermal process engineers.

SUITABLE FOR PERFECTLY PURE PROCESS CONDITIONS

CALCARB® CBCF is a short fibre insulation originating from rayon. These fibres are interconnected in a matrix produced by the carbonisation of phenolic resin. The material is then vacuum-treated at temperatures above 2,000°C to ensure **its temperature stability and the absence of outgassing**.

As a benchmark, the material contains no more than **500 ppm of impurities. Impurity levels below 20 ppm** can be achieved through a purification process.

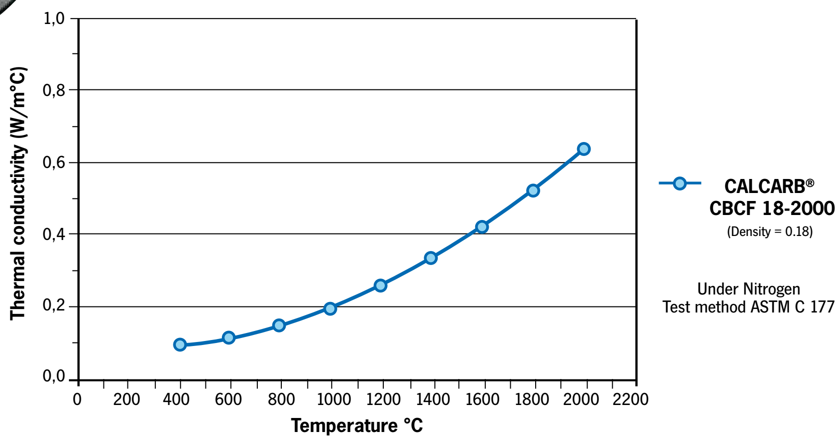
STRUCTURED FOR EXTREME INSULATION PERFORMANCE

The short-cut fibre structure of **CALCARB® CBCF** provides the best thermal insulation properties at a high temperature, making it the material of choice among our customers concerned about the **energy efficiency** of their process.

Density and grade differences are used to modulate the material's thermal characteristics:

CALCARB® CBCF 14VF-2000 for unparalleled insulation performance

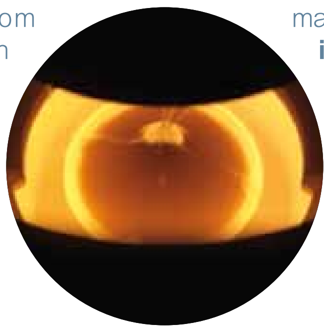
CALCARB® CBCF 18-2000 or CBCF 25-2000 for modulating between insulation and gas permeability.



PRECISION MACHINED TO DESIGN HOT ZONE

Whereas insulation made from long fibre structures can delaminate during machining processes, **CALCARB®** rigid insulation can be easily machined with conventional means.

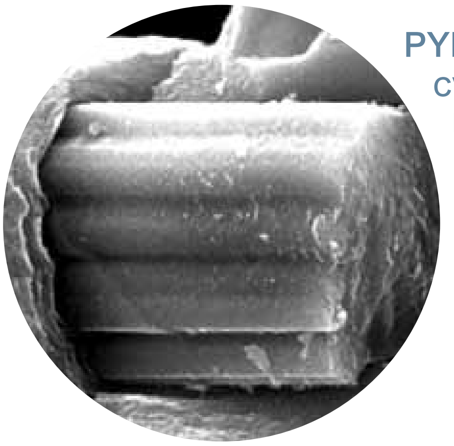
The material's homogeneity, combined with its ability to be machined into **very complex and intricate shapes**, enables precise **thermal gradient control** in high temperature processes.



This property is one of the main contribution to CALCARB's established reputation, for instance in the new generation of crystal pullers.

EXTENDED SERVICE LIFE, EVEN IN THE MOST AGGRESSIVE ENVIRONMENTS

Mersen has developed a complete range of processes designed to reinforce the resistance of CALCARB® CBCF in aggressive environments.



PYROCARBON PROTECTION

CVI-pyrocarbon layer to Fibre – :

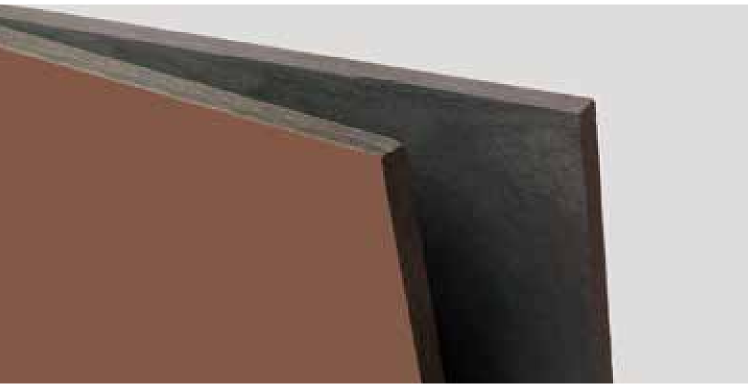
Embedding core fibres into 99.99% pure carbon, the infiltration provides protection in harsh environments with a greater than 50% extended life over standard material.

Calcoat CVD : a pyrocarbon outer layer :

The pyrocarbon outer layer acts as a protection without changing thermal characteristics.

It is a dense erosion resistance coating applied by CVD process.

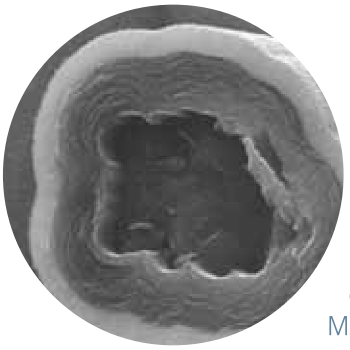
Being applied to all finished surfaces of machined parts, it offers beyond the erosion protection, a barrier against impregnation from process vapours.



CALCOAT AND CALFOIL EXTERNAL PROTECTION

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

Calfoil is a high purity graphite foil protection that inhibits also dusting, enabling a better temperature uniformity along plane of foil.



INNOVATIVE SILICON CARBIDE PROTECTION

In some specific conditions, like hydrogenated atmosphere over 1000°C, carbon fibres are corroded by the medium. As insulation parts are often the critical part of such process, the silicon carbide infiltration provides an unparralled advantage. Mersen unique expertise in this field can help to reduce maintenance downtime of your process by extending the insulation service life.

PRODUCT'S STANDARD DIMENSIONS

Material Boards and Disks

Board size	Board thickness	Standard density	Disks size
48 x 42 inches / 1219 x 1067 mm	Up to 8.5 inches / 216 mm	VF : 0.16 g/cc +/- 0.03 g/cc	Φ 25 up to 73 inches
52 x 48 inches / 1320 x 1219 mm		Standard : 0.18 g/cc +/- 0.03 g/cc	Φ 635 up to 1854 mm
52,5 x 52,5 inches / 1333 x 1333 mm		Dense 0.25 g/cc +/- 0.03 g/cc	**Disk thickness**
60 x 40 inches / 1524 x 1016 mm			Φ 25 inches Max thickness is 16 inches
60 x 60 inches / 1524 x 1524 mm			Φ 69 inches Max thickness is 10 inches

Material Cylinder up to 1400 mm

Internal Diameter	Max height	Max wall thickness	Standard density
Φ 65 up to 400 mm (+/- 0.5 mm)	350 mm	40 mm	VF : 0.14 g/cc +/- 0.03 g/cc
Φ 400 up to 1100 mm (+/- 0.75 mm)	500 mm	55 mm from Φ > 600 mm	Standard : 0.15 g/cc +/- 0.03 g/cc
Φ 1100 up to 1400 mm (+/-0.75 mm)	880 mm	55 mm	Dense 0.18 g/cc +/- 0.03 g/cc

The fibre orientation is perpendicular to this axis and random on height.

Typical Cylinder Construction

Barrel Stave Construction
over Φ 1600 mm

CWC
Cylinder Within Cylinder construction
Over 55 mm side wall

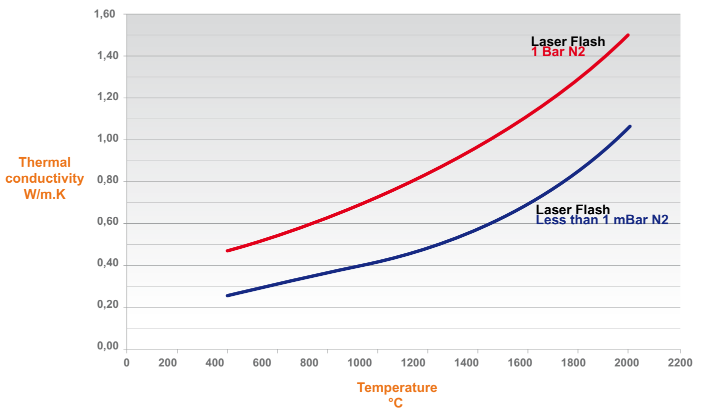
Backing strip
Of precut single wall cylinder

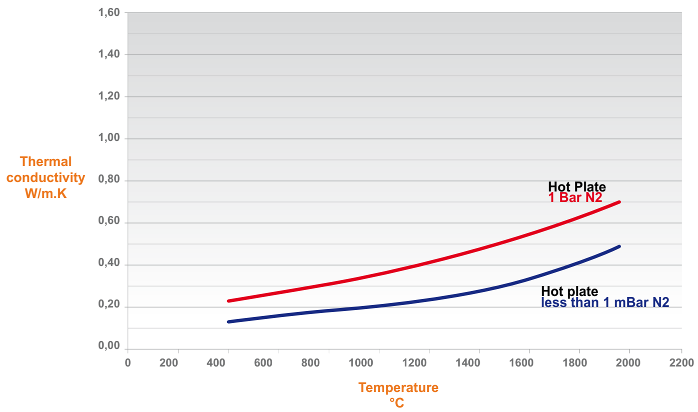
MAIN PROPERTIES

Physical Properties

	VF Board & Cylinder	Standard Density Board	Standard Density Cylinder	Dense Board & Cylinder	High Density Board
Grade	**CBCF 14VF-2000**	**CBCF 18-2000**	**CBCF 15-2000**	**CBCF 25-2000**	**HD**
Bulk Density g/cm³	Cylinder 0.14 ± 0.03 Board 0.16 ± 0.03	0.18 ± 0.03	0.15 ± 0.03	0.25 ± 0.04	> 0.30
Compressive Strength MPa Parallel to fibre orientation (xy) Perpendicular to fibre (z)	1.09 0.23	1.10 0.76	0.80 0.20	2.10 1.07	3.20 2.30
Flexural Strength MPa Parallel to fibre orientation (xy) Perpendicular to fibre (z)	1.65 0.20	1.03 0.15	1.50 0.20	2.70 0.62	2.32 1.45
Coefficient of Thermal Expansion 25 to 1000°C 1000 to 2000°C	$2.9 \pm 0.2 \times 10^{-6}$ $2.2 \pm 0.2 \times 10^{-6}$	$3.0 \pm 0.3 \times 10^{-6}$ $2.6 \pm 0.3 \times 10^{-6}$	$3.0 \pm 0.3 \times 10^{-6}$ $2.6 \pm 0.3 \times 10^{-6}$	$3.0 \pm 0.3 \times 10^{-6}$ $2.6 \pm 0.3 \times 10^{-6}$	$3.0 \pm 0.3 \times 10^{-6}$ $2.6 \pm 0.3 \times 10^{-6}$
Specific Surface Area - $m^2.g^{-1}$	22	18	20	11	17
Electrical Resistivity Ω.m Parallel to fibre orientation (xy) Perpendicular to fibre (z)	12.5×10^{-4} 52.1×10^{-4}	11.0×10^{-4} 40.7×10^{-4}	25.0×10^{-4} 74.0×10^{-4}	5.90×10^{-4} 15.93×10^{-4}	12.0×10^{-4} 4.0×10^{-4}
Thermal Conductivity* W/m/K 500°C 1000°C 2000°C	**Vac N2 Ar** 0.06 0.11 0.08 0.16 0.28 0.21 0.62 0.97 0.76	**Vac N2 Ar** 0.26 0.48 0.36 0.41 0.72 0.54 1.00 1.47 1.16	**Vac N2 Ar** 0.18 0.35 0.26 0.31 0.54 0.40 0.83 1.24 0.98	**Vac N2 Ar** 0.39 0.70 0.55 0.57 1.01 0.75 1.22 1.79 1.38	**Vac N2 Ar** 1.49 2.77 2.06 1.65 2.89 2.14 1.99 3.03 2.32

Calcarb® CBCF 18-2000 Thermal Conductivity vs Temperature





Laser Flash Diffusivity

ASTM E-1461

A sample of material is heated to the required temperature.

A laser pulse is applied to the front surface of the sample ; and the thermal diffusivity is determined by measurement of the rate and intensity of temperature increase on the back face.

The thermal conductivity is then determined from the sample density, its specific heat value at the required temperature and the determined diffusivity.

Hot Plate

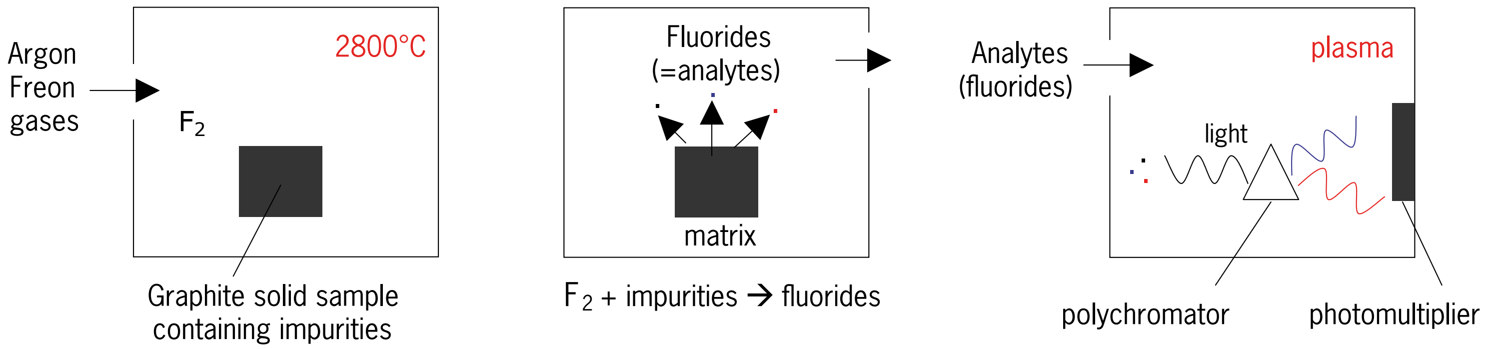
ASTM C-177

A hot-plate is heated to the required temperature. The power to maintain this temperature at equilibrium, with reference to a known cold plate and surface area, gives a measurable thermal energy flux.

Thermal conductivity is measured using the temperature drop across a sample of defined thickness and the measures thermal energy flux of the system when in steady state equilibrium.

MEASURES OF IMPURITY LEVELS

OUR METHOD ETV-ICP-OES



Sampling, loading and heating
Electro Thermal Vaporization

Inductively Coupled Plasma
Optical Emission Spectrometry

KEY ADVANTAGES

- Simple and rapid acquisition: up to 50 samples analysed per day with automatic loading. Suitable for routine analysis.
- Sampling and calibration of graphite possible with existing standards and reference solutions, which is not the case with the GDMS method (Glow Discharge Mass Spectrometry).
- Very low limits of detection for most elements of the periodic classification, 1 - 50 µg/kg = ppb (parts per billion).
- Perfectly adapted to purified graphite, carbon/carbon composite and carbon insulation materials.
- Value-added service for customers.

Our specifications on impurity level

PPM Limit	2000°C	2200°C	2300°C	Halogen Purified
Total on 34 Elements	<150	<75	<40	<20
Al+Cu+Fe +Cr+Ni	<20	<10	<5	<5
Al+Cu+Fe	<5	<3	<2	<2

Results of ICP-ETV – Inductively Coupled Plasma Mass Spectroscopy

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l'adresse créative

MERSEN

Expertise, our source of energy

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.

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