A WORLD EXPERT in materials and solutions for high temperature processes

A GLOBAL PLAYER
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- Optical fibre
- Turbine blade casting
- SiC wafer manufacturing up to 2,400-2,500°C

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

**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**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Impurity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-Fired to 2,300°C</td>
<td>&lt;75 ppm</td>
</tr>
<tr>
<td>Hi-Fired to 2,200°C</td>
<td>&lt;500 ppm</td>
</tr>
<tr>
<td>Hi-Fired to 2,000°C</td>
<td>&lt;500 ppm</td>
</tr>
<tr>
<td>Halogen Purified</td>
<td>&lt;5 ppm</td>
</tr>
<tr>
<td>Critical Metallics</td>
<td>&lt;5 ppm</td>
</tr>
</tbody>
</table>

Results of ICP-ETV – Inductively Coupled Plasma Mass Spectroscopy

Results are Based on a 22 Element Table [Contact Mersen Scotland Holytown Ltd for the list 22 of elements].

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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 contributions to CALCARB’s established reputation, for instance in the new generation of crystal pullers.
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 resistant 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 1,000°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 unparalleled 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

<table>
<thead>
<tr>
<th>Board size</th>
<th>Board thickness</th>
<th>Standard density</th>
<th>Disks size</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 x 42 inches / 1,219 x 1,067 mm</td>
<td>Up to 8.5 inches / 216 mm</td>
<td>VF : 0.16 g/cc +/- 0.03 g/cc</td>
<td>⌀ 25 up to 73 inches</td>
</tr>
<tr>
<td>52 x 48 inches / 1,320 x 1,219 mm</td>
<td></td>
<td>Standard : 0.18 g/cc +/- 0.03 g/cc</td>
<td>⌀ 635 up to 1,854 mm</td>
</tr>
<tr>
<td>52.5 x 52.5 inches / 1,333 x 1,333 mm</td>
<td></td>
<td>Dense 0.25 g/cc +/- 0.03 g/cc</td>
<td>Disk thickness</td>
</tr>
<tr>
<td>60 x 40 inches / 1,524 x 1,016 mm</td>
<td></td>
<td></td>
<td>⌀ 25 inches Max thickness is 16 inches</td>
</tr>
<tr>
<td>60 x 60 inches / 1,524 x 1,524 mm</td>
<td></td>
<td></td>
<td>⌀ 69 inches Max thickness is 10 inches</td>
</tr>
</tbody>
</table>

Material Cylinder up to 1,400 mm

<table>
<thead>
<tr>
<th>Internal diameter</th>
<th>Max height</th>
<th>Max wall thickness</th>
<th>Standard density</th>
</tr>
</thead>
<tbody>
<tr>
<td>⌀ 65 up to 400 mm (+/- 0.5 mm)</td>
<td>350 mm</td>
<td>40 mm</td>
<td>VF : 0.14 g/cc +/- 0.03 g/cc</td>
</tr>
<tr>
<td>⌀ 400 up to 1,100 mm (+/- 0.75 mm)</td>
<td>500 mm</td>
<td>55 mm from ⌀ &gt; 600 mm</td>
<td>Standard : 0.15 g/cc +/- 0.03 g/cc</td>
</tr>
<tr>
<td>⌀ 1,100 up to 1,400 mm (+/- 0.75 mm)</td>
<td>880 mm</td>
<td>55 mm</td>
<td>Dense 0.18 g/cc +/- 0.03 g/cc</td>
</tr>
</tbody>
</table>

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

Typical Cylinder Construction

- **Barrel Stave Construction**
  - over ⌀ 1,600 mm

- **CWC**
  - Cylinder Within Cylinder construction
  - Over 55 mm side wall

- **Backing Strip**
  - Of precut single wall cylinder
**Physical Properties**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Board &amp; Cylinder</th>
<th>Standard Density Board</th>
<th>Standard Density Cylinder</th>
<th>Dense Board &amp; Cylinder</th>
<th>High Density Board</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cylinder 0.14 ± 0.03</td>
<td>0.18 ± 0.03</td>
<td>0.15 ± 0.03</td>
<td>0.25 ± 0.04</td>
<td>&gt; 0.30</td>
</tr>
<tr>
<td></td>
<td>Board 0.16 ± 0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compressive Strength MPa</td>
<td></td>
<td>Compressive Strength MPa</td>
<td>Compressive Strength MPa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perpendicular to fibre (z)</td>
<td></td>
<td>Perpendicular to fibre (z)</td>
<td>Perpendicular to fibre (z)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.09</td>
<td>1.10</td>
<td>0.80</td>
<td>2.10</td>
<td>3.20</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>0.76</td>
<td>0.20</td>
<td>1.07</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td>Flexural Strength MPa</td>
<td></td>
<td>Flexural Strength MPa</td>
<td>Flexural Strength MPa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parallel to fibre orientation (xy)</td>
<td></td>
<td>Parallel to fibre orientation (xy)</td>
<td>Parallel to fibre orientation (xy)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.65</td>
<td>1.03</td>
<td>1.50</td>
<td>2.70</td>
<td>2.32</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.15</td>
<td>0.20</td>
<td>0.62</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>Coefficient of Thermal Expansion</td>
<td></td>
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<td>Coefficient of Thermal Expansion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25 to 1,000°C</td>
<td>3.0 ± 0.3 x 10^6</td>
<td>2.6 ± 0.3 x 10^6</td>
<td>2.6 ± 0.3 x 10^6</td>
<td>2.6 ± 0.3 x 10^6</td>
</tr>
<tr>
<td></td>
<td>1,000 to 2,000°C</td>
<td>3.0 ± 0.3 x 10^6</td>
<td>2.6 ± 0.3 x 10^6</td>
<td>2.6 ± 0.3 x 10^6</td>
<td>2.6 ± 0.3 x 10^6</td>
</tr>
<tr>
<td></td>
<td>Specific Surface Area m².g⁻¹</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>18</td>
<td>20</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Electrical Resistivity Ω.m</td>
<td></td>
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<td>Parallel to fibre orientation (xy)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>12.5x10⁻⁴</td>
<td>11.0x10⁴</td>
<td>25.0x10⁻⁴</td>
<td>5.90x10⁴</td>
<td>12.0x10⁻⁴</td>
</tr>
<tr>
<td></td>
<td>52.1x10⁻⁴</td>
<td>40.7x10⁴</td>
<td>74.0x10⁻⁴</td>
<td>15.93x10⁴</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal Conductivity W/m.K</td>
<td></td>
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<tr>
<td></td>
<td>Vac N2 Ar</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0.06 0.11 0.08</td>
<td>0.26 0.48 0.36</td>
<td>0.18 0.35 0.26</td>
<td>0.39 0.70 0.55</td>
<td>1.49 2.77 2.06</td>
</tr>
<tr>
<td></td>
<td>0.16 0.28 0.21</td>
<td>0.41 0.72 0.54</td>
<td>0.31 0.54 0.40</td>
<td>0.57 1.01 0.75</td>
<td>1.65 2.89 2.14</td>
</tr>
<tr>
<td></td>
<td>0.62 0.97 0.76</td>
<td>1.00 1.47 1.16</td>
<td>0.83 1.24 0.98</td>
<td>1.22 1.79 1.38</td>
<td>1.99 3.03 2.32</td>
</tr>
</tbody>
</table>

**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.
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