SAFRAN IS A LEADING INTERNATIONAL HIGH-TECHNOLOGY GROUP WITH THREE CORE BUSINESSES: AEROSPACE; DEFENCE; AND SECURITY. OPERATING IN SEVERAL COUNTRIES, SAFRAN EMPLOYS MORE THAN 55,000 PEOPLE WORLDWIDE.

For more than 40 years, Snecma Propulsion Solide, a SAFRAN subsidiary, has developed and manufactured a broad range of high-temperature composite materials for the aerospace, energy, automotive and other industries.

Sepcarb® is our high-performance 3D carbon/carbon composite material. Sepcarb® tooling is used for high-temperature processing of aerospace and automotive components. Over 500 tons of Sepcarb® are produced annually in our European and North American plants.

Sepcarb® is the ideal tooling material for brazing, annealing, carburizing and quenching of high-performance metals in vacuum or inert atmosphere furnaces.

Snecma Propulsion Solide is your partner in the design and fabrication of tooling and equipment for high-temperature applications. Choose Sepcarb® to improve your productivity.
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THERMAL SOLUTIONS

The exceptional characteristics of Sepcarb® carbon/carbon composite make it the ideal material for tooling used in heat treatment, low-pressure carburizing, annealing and brazing applications of metals. Sepcarb® significantly outperforms graphite and refractory alloys in these very demanding thermal processes.

> SEPCARB® EQUIPMENT PROVIDES THESE MAJOR BENEFITS:

- Higher-efficiency and more secure processing
- Reduction of rejected parts and production quality improvements
- No tooling deformation, allowing robotic automation
- Zero creep, providing extended service life
- High temperature capability, allowing higher processing temperatures and shorter cycle times
- Reduced maintenance costs
- High resistance to fatigue and to mechanical and thermal shock
- Low mass for easier handling
- Low thermal inertia, reducing power consumption and cycle duration, and decreasing production costs
- High resistance to corrosive chemicals
- Large range of dimensions available

One-piece plate Ø 2200 mm / 86°
TECHNOLOGY

Sepcarb® is a composite of carbon fibers and a carbon matrix which bonds the fibers together and distributes the load evenly. Both the carbon fibers and the carbon matrix are resistant to extremely high temperatures. The precise distribution and combination of these components provides Sepcarb® with exceptional lightness, outstanding resistance to thermal shock, and stability of mechanical properties at temperatures up to 2700°C. The result is perfectly consistent operational behavior, unmatched reliability and extended service life. These properties make Sepcarb® the ideal tooling material for a very wide range of applications.

In contrast with 2-dimensional (2D) carbon/carbon products, Sepcarb® H01 is highly delamination-resistant. This results from its patented 3D architecture, combined with the chemical vapor infiltration (CVI) process used in its manufacture.

The CVI process enables the formation of an extremely pure and homogeneous carbon matrix within the fiber architecture. This process yields an optimal matrix-to-fiber cohesion, providing excellent mechanical properties and thermal stability. Materials and parts are manufactured using proven industrial processes. Manufacturing capabilities exceed 2 meters x 3 meters (80” x 120”). A wide variety of geometries can be fabricated including (but not limited to) plates, cylinders, tubes, discs, cones and beams, as well as complex shapes with thicknesses of less than one millimeter to several centimeters.

With an average density of 1.5, Sepcarb® is the ideal material for heat treatment fixturing to be used in vacuum and inert atmosphere furnaces operating up to 1300°C (2370° F) or higher.
PROPERTIES

> The main properties of Sepcarb® include its exceptionally low density, outstanding resistance to thermal shock and corrosion, stability of mechanical properties at temperatures up to 2700°C (4890°F), high resistance to fatigue and total absence of creep.

> The following tables compare the mechanical properties of Sepcarb® with those of graphite and refractory alloy.

COMPARATIVE TABLE OF SPECIFIC ULTIMATE STRENGTH (ULTIMATE STRENGTH / DENSITY)

<table>
<thead>
<tr>
<th>Property</th>
<th>Sepcarb®</th>
<th>Graphite ATJ</th>
<th>ASTM A297-HT</th>
<th>Inconel 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>25</td>
<td>1000</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>Tensile strength</td>
<td>σt,r (MPa)</td>
<td>100</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Et,r (%)</td>
<td>0.6</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Eo (GPa)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Interlaminar shear strength</td>
<td>Tr (MPa)</td>
<td>22</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>V (%)</td>
<td>1.3</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>G (GPa)</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

> The properties of standard-grade Sepcarb® 3D carbon/carbon material are provided below as indicative values.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value (MPa)</th>
<th>Value (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile strength</td>
<td>σt,r (MPa)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Et,r (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eo (GPa)</td>
<td></td>
</tr>
<tr>
<td>Interlaminar shear strength</td>
<td>Tr (MPa)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G (GPa)</td>
<td></td>
</tr>
<tr>
<td>Thermal expansion</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>Heat capacity</td>
<td>(J.Kg⁻¹.K⁻¹)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The above values are indicative and may vary depending on the specific composition and manufacturing process of the Sepcarb® material.
## Benefits

The following table provides a qualitative comparison of SepCarb® carbon/carbon, graphite, and refractory alloy. In addition to usage guidelines, the table illustrates the benefits and advantages of carbon/carbon.

<table>
<thead>
<tr>
<th></th>
<th>SepCarb® carbon/carbon</th>
<th>Graphite</th>
<th>Refractory metal</th>
<th>Carbon/carbon benefit</th>
</tr>
</thead>
</table>
| **Weight**       | Density 1.5            | Density 1.8    | Density 5 to 10 times higher than c/c | - Easy handling,  
- Increased worker safety,  
- Easier storage,  
- Lighter loads yield reduced maintenance costs, less down-time. |
| **Thermal resistance** | Excellent            | Excellent (but mechanical strength is 4 times less than c/c) | Performance characteristics reduced at 1000°C (1832°F); completely lost above 1100°C (2012°F) | Permits a lighter, more robust design. |
| **Creep**        | Excellent              | Excellent     | Poor             | No deformation – permits robotic automation of loading / unloading.                     |
| **Thermal shock resistance** | Excellent          | Fair          | Poor             | Stands up to shorter heat/quench cycles; increases productivity.                        |
| **Mechanical shock resistance** | Very Good            | Very Poor     | Excellent        | Due to its composite make-up, c/c is not brittle (as are graphite and ceramic). It is therefore very suitable for intensive use. |
| **Energy saving** | Excellent              | Fair          | Poor             | Carbon/carbon fixturing has much less thermal inertia than graphite and metal. Up to 3 times less energy is required for heating. Heating and cooling cycles are shortened. |
| **Safety**       | Excellent              | Fair to Poor   | Fair to Poor     | Lighter carbon/carbon fixturing makes handling easier, faster and safer.               |
| **Protecting the environment** | Excellent            | Poor          | Poor             | Less energy used = reduced environmental impact.                                       |
Additional applications, designs, geometry and dimensions upon request
CARBURIZING FIXTURES

600 x 450 x 600 mm³
24" x 18" x 24"

900 x 600 x 600 mm³
36" x 24" x 24"

Ø 500 mm - H 900 mm
Ø 20" - H 36"

Ø 500 mm - H 900 mm
Ø 20" - H 36"

400 x 200 x200 mm³
16" x 8" x 8"

Additional designs, geometry and dimensions upon request
SEPCARB® THERMAL PRODUCTS

3D CARBON/CARBON COMPOSITE

FURNACES BASES

Ø 600 mm / 24”

Ø 600 mm / 24”

Ø 1200 mm / 47”

Additional designs, geometry and dimensions upon request

SPECIALIZED HARDWARE

Temperature Uniformity Survey (TUS) fixture

Ø 1500 mm - H 1500 mm
 Ø 60” - H 60”

Spring shapers

Bolts & nuts

Additional applications, designs, geometry and dimensions upon request
DISCLAIMERS

1 - BROCHURE CONTENTS DISCLAIMER

All information in this brochure is based on Snecma Propulsion Solide data that were currently available at the time of production. The brochure provides general information on Snecma Propulsion Solide products and product applications.

The product data given in this brochure are typical values and are not guaranteed.

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