SAINT-GOBAIN PERFORMANCE CERAMICS & REFRACTORIES

WASTE TO ENERGY

PERFORMANCE REFRACTORY SOLUTIONS FOR WASTE THERMAL TREATMENT
Saint-Gobain Performance Ceramics & Refractories leads the industry in design, development and production of engineered ceramics and refractory products for extreme operating conditions and high temperature applications. Every product and material is designed to maximize performance and durability while minimizing environmental impact.

We strive to deliver value through our global technical expertise in material science, manufacturing technology, design engineering and the long-term partnerships we form with our customers. Our employees are committed to delivering the best solutions and services to meet the unique material and engineering needs of our customers.

Our ability to deliver custom-made solutions for every application is further enhanced by our R&D centers, manufacturing plants, sales and application engineering specialists who are positioned strategically across the globe.

TOGETHER, WE MAKE THE MATERIAL DIFFERENCE.
Excellent refractory materials, products and systems are our strengths and if you are looking for solutions for waste-to-energy facilities, then we are the specialists. Our products comply with the highest economic and environmental requirements and are known to provide a high level of performance under the most demanding conditions. All well-known installation companies in this field are ranked among our partners.

It is our know-how and experience resulting from over 100 years development and production of refractory products that makes the difference. Silicon carbide with its excellent properties is an important base material that was discovered in our laboratories. As the world’s largest manufacturer, no other company knows this material better than Saint-Gobain.
INDIVIDUAL SOLUTIONS FOR REFRACTORY

TAKING A STEP FORWARD WITH R&D

Worldwide, we support three R&D centers which work on the development of new and continuous improvement of existing ceramic products. As a result, we develop innovative bonded and monolithic refractory products with outstanding oxidation resistance and excellent thermal and mechanical properties, tailored to meet their respective application requirements.

OUR PRODUCTION - QUALITY BY EXPERIENCE

We can fulfill the highest quality standards for our products. Here, concern for worker safety and the environment play an important role in product development and manufacturing. Our manufacturing operations rely on decades of experience with refractory forming techniques and high temperature firing processes. Sophisticated manufacturing make it possible to produce complex components and systems. Due to high production capacity through our worldwide network of, we are able to accommodate demand schedules for large projects.
OUR CONSULTING - NOTHING IS LEFT TO CHANCE

The starting point of each venture is an individual consultation with our customer. Their needs and expectations as well as the existing technical and economic resources are carefully examined. Our experienced engineers and technicians find answers, analyse the operating conditions and give advice on the selection from the different qualities. Our worldwide sales team works closely together to offer a fast, personal service.

OUR EXPERIENCE - OUR EXPERTISE

Excellent refractory materials and system concepts support the efficient operation of waste to energy facilities. Due to our extensive worldwide experience, we have the expertise to find the best technical and design solutions for various types of waste conversion systems. We can provide thermal and mechanical design and modeling to fit system requirements. We work worldwide with leading installation companies that stock and install our products, while providing technical installation support, where needed.
UNIQUE TUBE
PROTECTION SYSTEMS

TAKing A Step FORWARD WITH R&D

Saint-Gobain protection systems are extremely tough and highly efficient. They are optimized for each application from technical and economic points of view. The requirements are diverse: maximum protection for the tube walls against corrosion and erosion, optimal thermal conductivity, long lifetime, together with a safe and simple installation, keeping downtime and repairs to a minimum.

APPLICATION & PRODUCTS

1. **Charge Zone**
   - Alumina brick / Refrax® 20 Brick

2. **Inlet Roof**
   - Refrax® ProGun 80 / ProGun 70
   - Refrax® ProPlast 80 : ProGun 70
   - T-Clip PRO tile System

3. **Combustion Area**
   - T-Clip PRO tile system in
   - Refrax® PLUS Or
   - Refrax® TOP

4. **Grate Lining**
   - Special bricks in Refrax® PLUS Or Refrax® TOP

5. **Burner Outlet**
   - Alumina ramming - Alfrax AFR 700
   - SiC ramming - Refrax® ProRam 80 / ProRam 70

6. **1st Pass**
   - T-Clip PRO tile system in
   - Refrax® PLUS Or
   - Refrax® TOP

7. **Superheater**
   - Special tubes shields in super cast Refrax® and super Refrax® 20
   - using Carbofrax® 3445AT mortar

8. **Header/Collector**
   - Refrax® ProGun 80 Or
   - Refrax® ProPlast 60 / ProPlast 70

9. **Ash Hopper**
   - Alfrax CK abrasion resistant trowel mix
   - Or Refrax® ProCast 70

Repairs / Patching in tube areas 3,4,6,8
Refrax® ProGun 80 / ProGun 70 - suitable for troweling & casting
as Refrax® ProPlast 60 / ProPlast 70 - Plastic / Ram mix
MATERIAL OXIDATION

As the major enemy of silicon carbide within the WTE market, ASTM oxidation test is necessary for all typical SiC products of Saint-Gobain, especially in the case of Refrax® TOP (as shown in the graph below). Oxide or silicate bonded SiC will have a much higher level of oxidation and expansion of tiles (see typical oxide 1 & oxide 2 levels). We have the lowest level of oxidation and the longest life in the demanding conditions of WTE plants.

Test: ASTM C 683 – steam at 1000°C for 500 h

CONTENT OF THE FOLLOWING PAGES

• T-Clip PRO System
• T-Clip System
• 45° System
• CFB System
• Belly Brick System
T-Clip PRO SYSTEM

THE T-CLIP PRO SYSTEMS
An optimized backfilled tile design offering optimum protection

APPLICATION
Can be used in all installation systems, for vertical boiler tube walls, e.g. the side walls, back and front walls, as well as the slanted tube walls on the ceiling, like inlet ceiling, burn out and boiler ceilings.

BENEFITS
- Quick and precisely defined installation
- Increased tile flexibility
- Reduced tension
- Oxidation & corrosion & high mechanical load resistance
- Excellent thermal conductivity
- Best price - performance ratio on the market
- Available for all tube diameters and spacings
MATERIAL COMBINATIONS CALCULATIONS

SURFACE TEMPERATURE HEAT LOSS PER m²

<table>
<thead>
<tr>
<th>TILE COMBINATION</th>
<th>BACKFILLING MIX</th>
<th>Inside °C</th>
<th>Outside °C</th>
<th>W/m²</th>
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<tbody>
<tr>
<td>1 Refrax® PRO</td>
<td>Refrax® PLUSflow</td>
<td>419.0</td>
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<tr>
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<td>23868</td>
</tr>
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</table>

Following specifications apply to all calculations:
Ambient temperature inside 1000 °C, outside 260 °C.
Heat transfer coefficient inside 105 W/m²K, outside 10000 W/m²K.
Material thickness for steel, tile, mix and build-up see tables and diagrams on the following pages. Calculation point: Soffit.

T-Clip PRO SYSTEM

SYSTEMS FITTINGS

Anchorage to the tube wall: Threaded bolts with round washers made from heat-resistant steel with bitumen or wax coating (alternative with plastic caps).

Backfilling mix: Offers added protection against flue gases and reduces the anchor corrosion. Refrax® PLUSflow with higher thermal conductivity. The self-flowing and self-compacting SiC concrete is formulated to fill a defined gap between the tile and the tube wall.
This ensures optimal contact to the wall and offers added protection against flue gases.

Note:
The tube walls in the ceiling area can be backfilled if the angles are not smaller than 15° otherwise the self-flowing SiC concrete would not fill the hollow spaces. If the angle is smaller than 15°, the tiles have to be laid using SiC mortar, Refrax® PROMor.
Ceramic fibre mats or fibre paper to compensate for potential expansion.

ASSOCIATE THIS UNIQUE SYSTEM TO THE BEST PERFORMING MATERIALS

Refrax® PLUS: Highly performing patented material to address harsher conditions with enhanced resistance to steam and chemical attack, thanks to significant improvements in material formulation.

Refrax® TOP: Outstanding material that provides superior performance to improve the life-time for special applications or in areas where ash or slag adhesion is a problem.

We can also supply our Refrax® PRO: Reliable, proven and quality material in standard condition areas.

STEADY STATE HEAT TRANSFER CALCULATIONS THROUGH PLANE WALL

T-CLIP PRO - DIFFERENT MATERIAL COMBINATIONS

<table>
<thead>
<tr>
<th>MATERIAL COMBINATIONS</th>
<th>CALCULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SURFACE TEMPERATURE</td>
</tr>
<tr>
<td>TILE BACKFILLING MIX</td>
<td>Inside °C</td>
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<tr>
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<tr>
<td>with ash build-up</td>
<td>775.1</td>
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<tr>
<td>2 Refrax® PLUS</td>
<td>432.0</td>
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<tr>
<td>with ash build-up</td>
<td>777.4</td>
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<tr>
<td>3 Refrax® TOP</td>
<td>404.9</td>
</tr>
<tr>
<td>with ash build-up</td>
<td>772.7</td>
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</table>
### DETAILS FOR THE MATERIAL COMBINATION 3

#### WALL LAYERS FROM INSIDE TO OUTSIDE - WITHOUT BUILD-UP

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>mm</th>
<th>W/mK</th>
<th>Mean temperature</th>
<th>Interface temperature</th>
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#### WALL LAYERS FROM INSIDE TO OUTSIDE - WITH BUILD-UP

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>mm</th>
<th>W/mK</th>
<th>Mean temperature</th>
<th>Interface temperature</th>
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<td>40.00</td>
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<td>265.4</td>
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<td></td>
<td>54.0</td>
<td></td>
<td></td>
<td>262.4</td>
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</tbody>
</table>

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**Heat Transfer Calculations**

The thermal conductivity values used in these calculations are average values, recognizing that thermal conductivity can have a range of values according to testing procedure and material and manufacturing variations. Therefore, the calculations represent an approximation of heat transfer characteristics and should be used accordingly, without a guarantee of results. Also, metallic anchors (hangers), joints between tiles and unusual buildup of ash deposits or any other factors which would change the tubewall design assumptions in the heat transfer models are not included in the calculations.
THE T-CLIP SYSTEM
Patented backfilling design for reliable protection

APPLICATION
Can be used in all installation systems, for vertical boiler tube walls, e.g. the side walls, back and front walls, as well as the slanted tube walls on the ceiling, like inlet ceiling, burn out and boiler ceilings.

BENEFITS
- Quick and clean installation
- Universally applicable
- Excellent heat conductivity
- Protection (oxidation & corrosion & high mechanical stress resistance)
- Very good price - performance ratio on the market
MATERIAL COMBINATIONS CALCULATIONS

SURFACE TEMPERATURE HEAT LOSS PER m²

<table>
<thead>
<tr>
<th>TILE</th>
<th>BACKFILLING MIX</th>
<th>Inside °C</th>
<th>Outside °C</th>
<th>W/m²</th>
</tr>
</thead>
<tbody>
<tr>
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<td>with ash build-up</td>
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<td>771.1</td>
<td>262.4</td>
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</table>

Following specifications apply to all calculations:
Ambient temperature inside 1000 °C, outside 260 °C.
Heat transfer coefficient inside 105 W/m²K, outside 10000 W/m²K.
Material thickness for steel, tile, mix and build-up see tables and diagrams on the following pages. Calculation point: Soffit.

SYSTEMS FITTINGS

Anchorage to the tube wall: Threaded bolts with round washers made from heat-resistant steel with bitumen or wax coating (alternative with plastic caps).

Backfilling mix: Offers added protection against flue gases and reduces the anchor corrosion. Refrax® PLUSflow with higher thermal conductivity. The self-flowing and selfcompacting SiC concrete is formulated to fill a defined gap between the tile and the tube wall.

This ensures optimal contact to the wall and offers added protection against flue gases.

Note:
The tube walls in the ceiling area can be backfilled if the angles are not smaller than 15° otherwise the self-flowing SiC concrete would not fill the hollow spaces. If the angle is smaller than 15°, the tiles have to be laid using SiC mortar, Refrax® PROFom.

Ceramic fibre mats or fibre paper to compensate for potential expansion.

ASSOCIATE THIS UNIQUE SYSTEM TO THE BEST PERFORMING MATERIALS

Refrax® PLUS: Highly perfoming patented material to address harsher conditions with enhanced resistance to steam and chemical attack, thanks to significant improvements in material formulation.

Refrax® TOP: Outstanding material that provides superior performance to improve the life-time for special applications or in areas where ash or slag adhesion is a problem.

We can also supply our Refrax® PRO: Reliable, proven and quality material in standard condition areas.

STEADY STATE HEAT TRANSFER CALCULATIONS THROUGH PLANE WALL

<table>
<thead>
<tr>
<th>MATERIAL COMBINATIONS</th>
<th>T-CLIP - DIFFERENT MATERIAL COMBINATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TILE</td>
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<tr>
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<tr>
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<td>Refrax® PLUSflow</td>
</tr>
<tr>
<td>with ash build-up</td>
<td></td>
</tr>
<tr>
<td>2 Refrax® TOP</td>
<td>Refrax® PLUSflow</td>
</tr>
<tr>
<td>with ash build-up</td>
<td></td>
</tr>
<tr>
<td>2 Refrax® TOP</td>
<td>Refrax® PLUSflow</td>
</tr>
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</table>
## DETAILS FOR THE MATERIAL COMBINATION 3

### WALL LAYERS FROM INSIDE TO OUTSIDE - WITHOUT BUILD-UP

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>mm</th>
<th>W/mK</th>
<th>Mean temperature</th>
<th>Interface temperature</th>
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<tr>
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<tr>
<td>Steel</td>
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<td>40.00</td>
<td>270</td>
<td>274.3</td>
</tr>
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</table>

### WALL LAYERS FROM INSIDE TO OUTSIDE - WITH BUILD-UP

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<thead>
<tr>
<th>MATERIAL</th>
<th>mm</th>
<th>W/mK</th>
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<th>Interface temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash build-up</td>
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<td>527</td>
<td>771.1</td>
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<td>Refrax® TOP</td>
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<td>311.3</td>
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<tr>
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<td>7.200</td>
<td>277</td>
<td>288.8</td>
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<tr>
<td>Steel</td>
<td>5.0</td>
<td>40.00</td>
<td>264</td>
<td>265.4</td>
</tr>
</tbody>
</table>

**Heat Transfer Calculations**

The thermal conductivity values used in these calculations are average values, recognizing that thermal conductivity can have a range of values according to testing procedure and material and manufacturing variations. Therefore, the calculations represent an approximation of heat transfer characteristics and should be used accordingly, without a guarantee of results. Also, metallic anchors (hangers), joints between tiles and unusual buildup of ash deposits or any other factors which would change the tubewall design assumptions in the heat transfer models are not included in the calculations.
THE 45° SYSTEM (OPTIMIZED)

Mortared system

APPLICATION

Can be used in all installation systems, for vertical boiler tube walls, e.g. the side walls, back and front walls, as well as the slanted tube walls on the ceiling, like inlet ceiling, burn out and boiler ceilings.

BENEFITS

- Good thermal conductivity and quicker cooling effect
- Simple and quick replacement
- High durability
**SYSTEMS FITTINGS**

Anchorage to the tube wall: 45° anchors made from heat-resistant steel covered with bitumen or wax coating.

Mortar: Refrax® PROmor, a chemical-ceramic bonded, thick refractory mortar with the best possible cohesion. This ensures optimal contact to the wall and offers added protection against flue gases.

Plastic fibre compound (alternatively ceramic fibre mat) to fill in the anchorage and assure flexibility of the tiles and to file the joint and compensate for potential expansion.

**ASSOCIATE THIS UNIQUE SYSTEM TO THE BEST PERFORMING MATERIALS**

Refrax® PLUS: Highly performing patented material to address harsher conditions with enhanced resistance to steam and chemical attack, thanks to significant improvements in material formulation.

Refrax® TOP: Outstanding material that provides superior performance to improve the life-time for special applications or in areas where ash or slag adhesion is a problem.

We can also supply our Refrax® PRO: Reliable, proven and quality material in standard condition areas.

**STEADY STATE HEAT TRANSFER CALCULATIONS THROUGH PLANE WALL**

<table>
<thead>
<tr>
<th>MATERIAL COMBINATIONS</th>
<th>CALCULATIONS</th>
<th>SURFACE TEMPERATURE</th>
<th>HEAT LOSS PER m²</th>
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<tbody>
<tr>
<td>Tile</td>
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<td>2 Refrax® PLUS</td>
<td>Refrax® PLUSflow</td>
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<td>266.4</td>
</tr>
<tr>
<td>with ash build-up</td>
<td></td>
<td>769.9</td>
<td>262.4</td>
</tr>
<tr>
<td>2 Refrax® TOP</td>
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<td>266.6</td>
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<td>with ash build-up</td>
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<td>262.4</td>
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<tr>
<td>with ash build-up</td>
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<td>771.1</td>
<td>262.4</td>
</tr>
</tbody>
</table>

Following specifications apply to all calculations:
- Ambient temperature inside 1000 °C, outside 260°C.
- Heat transfer coefficient inside 105 W/m²K, outside 10000 W/m²K.
- Material thickness for steel, tile, mix and build-up see tables and diagrams on the following pages. Calculation point: Soffit.
### Heat Transfer Calculations

The thermal conductivity values used in these calculations are average values, recognizing that thermal conductivity can have a range of values according to testing procedure and material and manufacturing variations. Therefore, the calculations represent an approximation of heat transfer characteristics and should be used accordingly, without a guarantee of results. Also, metallic anchors (hangers), joints between tiles and unusual buildup of ash deposits or any other factors which would change the tubewall design assumptions in the heat transfer models are not included in the calculations.
THE CFB SYSTEM

Tile protection system for CFB (circulated fluidized bed) plants

**APPLICATION**

Suitable for CFB plants with tube walls in the combustion ceiling / freeboard area, especially for intensive abrasion, corrosive load and heat transfer areas.

**BENEFITS**

- High abrasion resistance of tile and joint
- Good thermal conductivity
- Protection of the anchor system (abrasion & corrosion resistance )
- No plastic fibre compound for the joint of the tiles is necessary
SYSTEMS FITTINGS

Anchorage to the tube wall: Pin, disc and screw nut made of heat-resistance steel covered with bitumen for fastening to the tube wall and closure plug in SiC or equivalent.

Mortar: Refrax® PROmor, a specially developed ceramic-bonded SiC refractory mortar with excellent adhesion behavior and high thermal conductivity.

Ceramic fiber stripe to minimize the stress between the tiles.

ASSOCIATE THIS UNIQUE SYSTEM TO THE BEST PERFORMING MATERIALS

Refrax® TOP: Outstanding material that provides superior performance to improve the life-time for special applications or in areas where ash or slag adhesion is a problem.

STEADY STATE HEAT TRANSFER CALCULATIONS THROUGH PLANE WALL

<table>
<thead>
<tr>
<th>MATERIAL COMBINATIONS</th>
<th>SURFACE TEMPERATURE</th>
<th>HEAT LOSS PER m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>TILE</td>
<td>BACKFILLING MIX</td>
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<tr>
<td>1 Refrax® TOP</td>
<td>Refrax® PROmor</td>
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</tr>
<tr>
<td>with ash build-up</td>
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<td>Outside °C</td>
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</table>

Following specifications apply to all calculations:
Ambient temperature inside 1000 °C, outside 260°C.
Heat transfer coefficient inside 105 W/m²K, outside 10000 W/m²K.
Material thickness for steel, tile, mix and build-up see tables and diagrams on the following pages. Calculation point: Soffit.
Heat Transfer Calculations

The thermal conductivity values used in these calculations are average values, recognizing that thermal conductivity can have a range of values according to testing procedure and material and manufacturing variations. Therefore, the calculations represent an approximation of heat transfer characteristics and should be used accordingly, without a guarantee of results. Also, metallic anchors (hangers), joints between tiles and unusual buildup of ash deposits or any other factors which would change the tubewall design assumptions in the heat transfer models are not included in the calculations.
BELLY BRICK SYSTEM

THE BELLY BRICK SYSTEM
Simple and safe protection for single tube walls

**MATERIAL**

- **Bricks:** Refrax® PRO, Refrax® PLUS and Refrax® TOP
- **Installation:** without metallic fittings
- **Mortar:** Refrax® PROmor, a chemical-ceramic bonded, thick refractory mortar with best cohesion to the tiles
- **Backfilling mix:** Refrax® PLUSflow
- **Ceramic fibre mat or paper to compensate for any expansion**

**APPLICATION**

Protection of single tube walls in high temperature areas and in the main combustion zone.

**BENEFITS**

- Simple and safe assembly
- Excellent thermal conductivity
- High corrosion resistance
- Available for all tube diameters and spacings
- High mechanical durability at high T°C

*The choice of the belly brick design depends on the boiler type in which it will be installed.*
EXTREMELY RESISTANT MATERIALS

It is the material that makes the refractory products from Saint-Gobain so exceptional. In order to meet the different thermal and chemical requirements in the boiler of steam generators in the best possible way, Saint-Gobain has developed various silicon carbide (SiC) based materials.

Contents of the following pages:

General Material Properties

The Material REFRAX®:
- Production, properties, types and details regarding the material Refrax® PLUS

The Material CARBAL® 130:
- Properties and types

The Material CARBOFRAX®:
- Properties and types
MATERIALS WITH OUTSTANDING PROPERTIES

In addition to the most important SiC properties, such as:

**Excellent mechanical properties, even in high-temperature areas:**
- Extreme hardness and high wear-resistance
- High thermal shock resistance
- Low thermal expansion

**Very good heat conductivity**

**Corrosion resistance up to highest temperatures**

Saint-Gobain materials have an additional decisive advantage:

**Excellent oxidation resistance.**

Due to the moisture from the wet waste and the operating conditions with high oxygen content, the wall linings made from silicon carbide are detrimentally affected by oxygen, steam or carbon dioxide. Normally this leads to an increase in volume, stress and crack formations in the tube wall protection tiles.

Saint-Gobain qualities Refrax® and Carbofrax® are produced using engineered bond phases that reduce oxidation and the resulting effects to a minimum.

**THE REFRAX® PRODUCT FAMILY**

Under the name Refrax®, Saint-Gobain offers various qualities of nitride bonded SiC (NSiC).

**Production**

A moulded body of SiC granulate and metallic silicon powder is fired in an atmosphere of nitrogen at approximately 1400°C. Thereby the initial metallic silicon changes to the very stable silicon nitride (Si₃N₄). In case of our Refrax® TOP quality, the material is subsequently exposed to an oxidizing atmosphere above 1200°C. During this process a thin oxidation protection layer in the form of a very hard glass layer is formed on the surface of the moulded body.

**BENEFITS**

- Increased durability of the wall linings
- Quick pay-back time
- Reduced maintenance costs
- High energy efficiency
- Minimized unplanned down-time
- Excellent oxidation resistance thanks to its small pore size
- Excellent thermal conductivity
- Low thermal expansion
- High mechanical strength
In order to fulfill all the technical and economical requirements, Saint-Gobain has developed and newly arranged its material portfolio.

**The Refrax® Types**

In order to fulfill all the technical and economical requirements, Saint-Gobain has developed and newly arranged its material portfolio.

**Shaped Products:**

<table>
<thead>
<tr>
<th>Material name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrax® PRO</td>
<td>Tried and tested material with narrow tolerances. Application areas: Standard product for the first pass and the combustion area.</td>
</tr>
<tr>
<td>Refrax® PLUS</td>
<td>Endowed patented premium product for the toughest requirements. Application areas: For all areas; particularly suited for areas exposed to high wear and high stresses and for repairs.</td>
</tr>
<tr>
<td>Refrax® TOP</td>
<td>Doped patented, doubled fired material with glazed surface. Application areas: For all areas; particularly suited for areas exposed to aggressive slags.</td>
</tr>
</tbody>
</table>

**Castable / Mortar:**

<table>
<thead>
<tr>
<th>Material name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Refrax® Plusflow</td>
<td>Backfilling mix with maximised thermal conductivity for T-Clip systems.</td>
</tr>
<tr>
<td>Refrax® PROmor</td>
<td>Mortar for 45° systems, CFB systems and belly bricks.</td>
</tr>
</tbody>
</table>

Sales and R&D departments work hand in hand to offer constantly improved materials.
The bonding phase is more amorphous, with corresponding large surface structure.

Refrax® PLUS bonding morphology after the corrosion test (1000°C / 500h).

Investigations of the Refrax® PRO and Refrax® PLUS materials after the steam corrosion test have led to the following findings:

- New microstructure with bigger crystals which improves resistance to corrosion and oxidation (due to the reduced surface)
- Low volume expansion, due to the low oxidation. This is very important for the application, since the adjusted expansion joints remain intact and the material can be used for a longer period of time
- Very low increase of volume. The mechanical strength remains constant in contrast to oxide bonded SiC, where the mechanical strength decreases with increasing temperature

Refrax® PRO and Refrax® PLUS bonding morphology after the corrosion test (1000°C / 500h).

Refrax® TOP bonding morphology

As far as Refrax® TOP concerned, thanks to its special material composition and a second firing process, a glazed phase is generated at the surface, which clogs the material porosity and acts as a durable physical barrier to corrosive media. This material is preferred in areas where ash or slag adhesion is a problem.
CARBAL® 130

The Saint-Gobain product Carbal® 130 consists of Al₂O₃ (40%) and high-quality SiC (50%).

This material represents an additional alternative to the nitride-bound qualities for controlling the heat balance in a boiler. In addition, Carbal® 130 is characterized by its significantly lower porosity and the increased cold crushing strength (CCS) compared to SiC - refractory monolithic mixes.

**BENEFITS**

- Excellent oxidation resistance
- Good stress and form stability due to its better surface resistance
- Lower thermal conductivity
- High abrasion resistance due to addition of alumina oxide

**MATERIALS**

<table>
<thead>
<tr>
<th>Material name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbal® 130</td>
<td>Tried and tested SiC (50%) material with addition of alumina (40%). Very good price-performance ratio. Application areas: Special bricks and tiles.</td>
</tr>
</tbody>
</table>
**MATERIALS**

**CARBOFRAX®**

The silicate bonded SiC from Saint-Gobain.

Although Saint-Gobain Refrax® Materials have, to a large extent, replaced this material, Carbofrax® is still successfully used for certain applications, for example in plants with low heating values. It is characterized by its high SiC content (85%), and, in contrast to alternative materials, high thermal conductivity.

**BENEFITS**

- Excellent resistance to corrosion from gases at low T°C, thanks to the glaze on the materials, which acts as protection
- Good fracture toughness at middle T°C. This is thanks to the silicate bonding which makes the material less brittle

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Carbofrax® BASIC</td>
<td>Tried and tested silica bonded material with narrow tolerances. Very good</td>
</tr>
<tr>
<td></td>
<td>cost-performance ratio according to Saint-Gobain quality standards.</td>
</tr>
<tr>
<td></td>
<td>Application areas: Special bricks, and spandrel bricks.</td>
</tr>
</tbody>
</table>
Energy efficiency and environmental protection

30% of the turnover and 40% of the operating profit of the Saint-Gobain group are achieved through solutions, which help save energy, produce clean energy and protect the environment.
The innovation capacity of the company plays a major role here, 20% of all Saint-Gobain products are less than 5 years old.
Together with our subsidiaries, who specialize in high performance ceramics, as well as R&D centres in France and the U.S.A., we have established a leading team of ceramic experts. From the resources, the know-how and the technology within this worldwide network, synergies are created which guarantee expertise and safety even in complex projects.

Focus: Our employees, quality and environmental protection

Our employees and their dedication ensure the success of our products. Their highest priority is always to ensure stringent quality standards while adhering to safety standards of the highest level which are a must within our company. We also feel a responsibility towards the challenges facing the environment. Not only our products, but also our production processes play an active part in protecting the environment. Saint-Gobain has been a member of the United Nations Global Compact since 2003 and has also signed their declaration of management support for human rights.

We have the following certificates:

**Quality:** DIN EN ISO 9001

**Environment:** DIN EN ISO 14001

**Occupational Safety:** OHSAS 18001

**Energy:** ISO 500001
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