RHI MAGNESITA

## RHIM's solutions for the Glass Industry

# Melter Crown

Standard Silica & No Lime Silica

Honeycomb shape

ε-solution

RHIM Insulation Concept

# Heating Up Efficiency, Cooling Down Emission:
# Shaping a Sustainable Path for the Glass Industry

RHIM is committed to helping our glass industry customers in reducing CO2 emissions and enhancing furnace efficiency. We achieve this by offering high-performance products and carefully evaluated lining concept for each part of the furnace

In the next slides, we will introduce RHIM's Solutions for the Melter Crown of the furnace, which are designed to decrease consumption, extend the furnace's lifespan, and ensure superior glass quality.

Our objective is to help you achieve Net Zero goals.

If you require further clarifications or additional information, our experts are at your service.

# Melter Crown

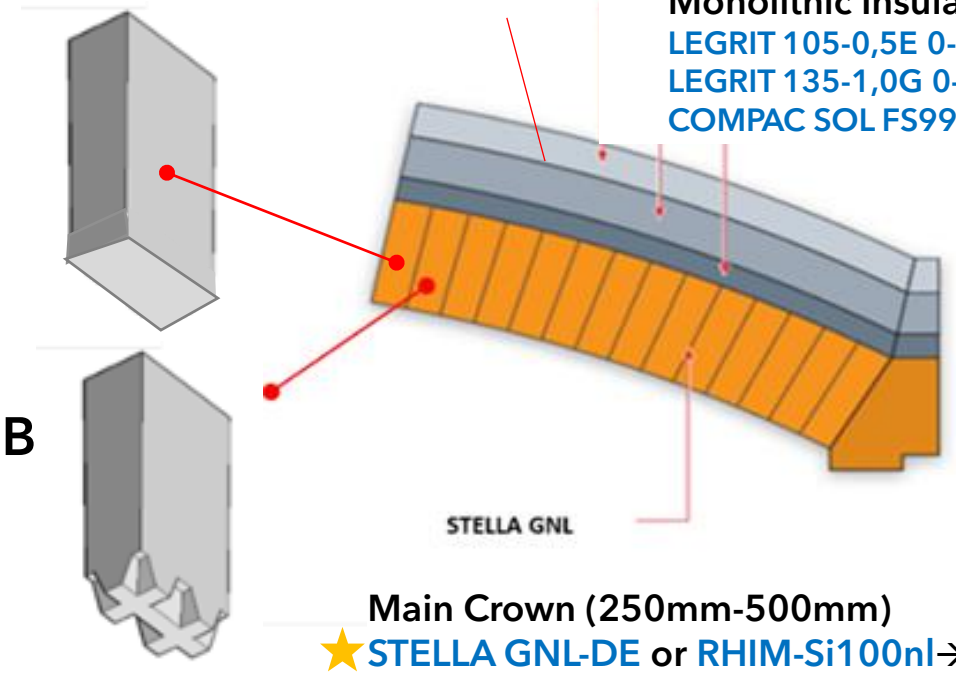
## Proposed Linings

**Standard Insulating Bricks**
Finishing Layer: STELLIT GH 0-1-DE (30mm)
RHIM-LiSi06
RHIM-LiSi08
RHIM-LiSi10

**Monolithic Insulation**
LEGRIT 105-0,5E 0-2 (100mm)
LEGRIT 135-1,0G 0-6-DE (135-175mm)
COMPAC SOL FS99G-3-DE (100-150mm)

Standard Shape
+ε Solution

★ HONEYCOMB Shape
+ε Solution




**Neutral Layer**
Mandatory between Silica crown and AZS wall
ZETTRAL 65GS
RHIM-ZS65c

**Main Crown (250mm-500mm)**
★ STELLA GNL-DE or RHIM-Si100nl → For oxyfuel or high stress furnaces
STELLA GGS-DE, RHIM-Si96 or RHIM-Si96ε → For standard furnaces
STELLA GG-IN
Mortar: STELLAMUR GLS 0-0,3-DE or RHIM MtSi97

★ Highest Performances Solution

# Silica Grades for the Melter Crown

## Properties Comparison

Silica is the most used material for furnace crowns due to its exceptional properties and cost-effectiveness.
RHIM offers various grades of silica:

- Standard Silica for general applications
- No Lime Silica for the most demanding conditions and aggressive combustion environments.

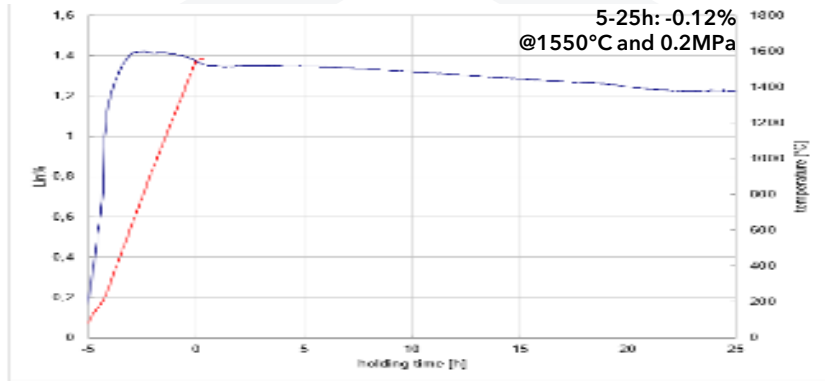
| Characteristic | Standard Silica | | | No lime Silica | |
|---|---|---|---|---|---|
| | STELLA GG-IN | STELLA GGS-DE | RHIM Si96 (ε) | STELLA GNL-DE | RHIM-Si100nl (ε) |
| $SiO_2$ | 95,5 % | 96,0 % | 96,0 % | 98,5 % | 99% |
| CaO | 2,6% | 2,5 % | 2,7% | < 0,05 % | 0,1% |
| $Al_2O_3$ | 0,4% | 0,4% | 0,5 % | 0,1% | 0,1% |
| $Fe_2O_3$ | 0,6% | 0,5% | 0,5 % | 0,1% | 0,1% |
| Residual quartz | < 0,7% | < 0.4 % | < 0,5% | < 0.4 % | |
| Bulk Density | 1,8 g/cm³ | 1,84 g/cm³ | 1,82 g/cm³ | 1,90 g/cm³ | 1,90 g/cm³ |
| Apparent Porosity | 20,5 Vol.% | 20,0 Vol.% | 21% | 16 Vol.% | 17 Vol.% |
| Cold Crushing Strength | 40 N/mm² | 40 N/mm² | 40 N/mm² | 45 N/mm² | 40 N/mm² |
| RUL $T_{0.5}$ | 1650°C | 1660 °C | 1675°C | 1690°C | 1690°C |
| Thermal Expansion | 1,5% | 1,3% | 1,35% | 0,85% | 1,3% |
| Creep (5-25h 0,2 Mpa) | -0.1% @1550°C | -0.1% @1550°C | -0,1% @1550°C | 0% @1600°C | 0% @1600°C |

# Silica Grades For the Crown

## Creep in Compression

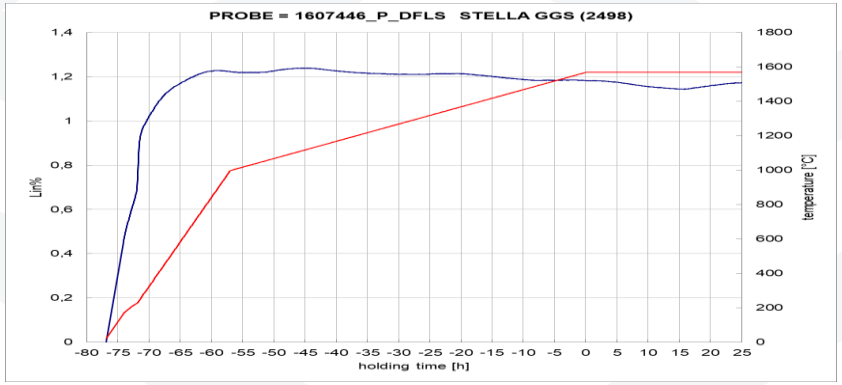
### Stella GG-IN

5-25h: -0.12%
@1550°C and 0.2MPa



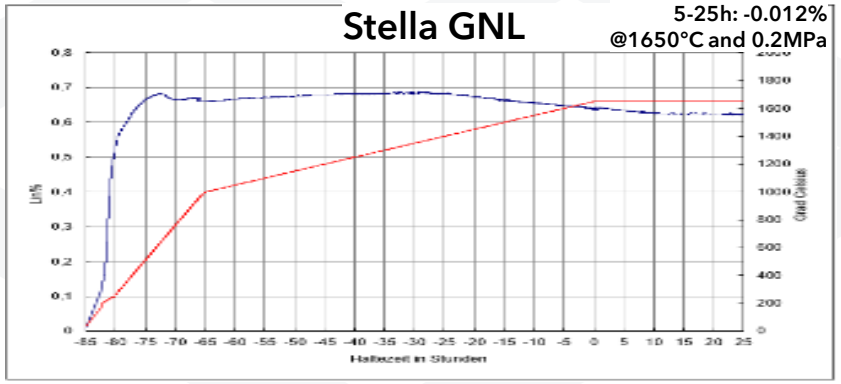

### Stella GGS

5-25h: -0.1%
@1550°C and 0.2MPa



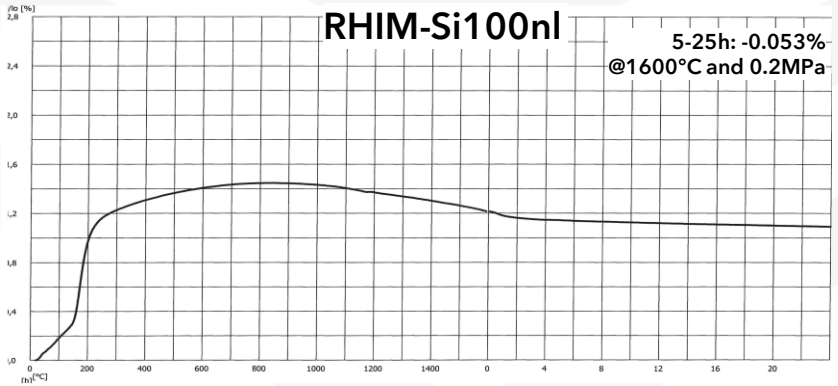

### Stella GNL

5-25h: -0.012%
@1650°C and 0.2MPa




### RHIM-Si100nl

5-25h: -0.053%
@1600°C and 0.2MPa



# For the Toughest Conditions:

## No Lime Silica

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# No Lime Silica

## STELLA GNL and RHIM-Si100nl

No-lime silica is used where the conditions inside the furnace are highly demanding.

Some exemple of installations are:

- Oxy-Fuel melters
- Hybrid furnace
- High wear zones
- Defect sensitive locations

In this conditions NO LIME SILICA show a very low level of $Na_2O$ infiltration and consequently a longer life and a lower maintenance rate during the entire campaign.

*Stella GNL before start-up*

*Stella GNL after 10years campaign in an oxyfuel furnace*

# No Lime Silica
# Multiple Benefits

Stella GNL after 10years in an oxyfuel furnace

Very high corrosion resistance especially against alkaly:
- Longer lifetime
- Lower maintenance costs
- High insulation potential

Wide range of working conditions:
- Low temperature
- High Temperature
- Oxyfuel Firing (including H2 firing)

Lower thermal Expansion:
- Less expansion joints
- Less open joints between the bricks during heat-up

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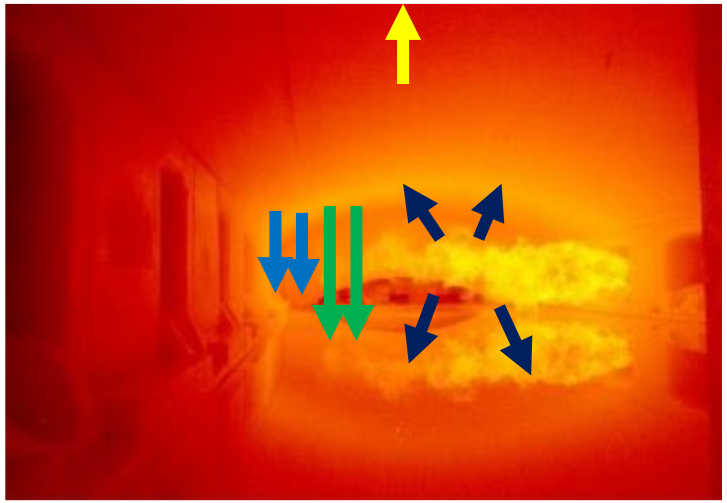
# Enhanced Heat Trasfer

## Honeycomb Shapes

## ε-Solution

# Design to Enhace Heat Trasfer

## Honeycomb, ε-Solution and Improved Insulation

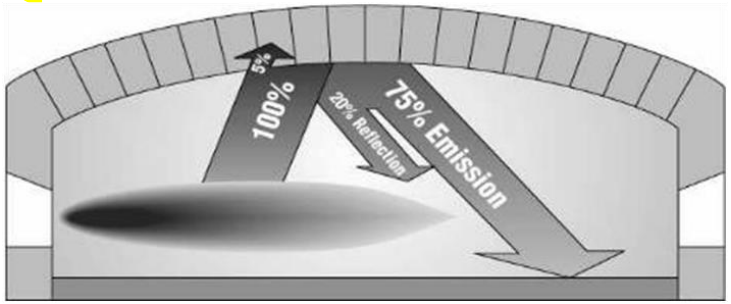


Heat From the flame that heat the glass and the crown

Heat from the flame Reflected by the crown

Heat from the crown by emission

Heat Loss




The crown play a crucial role in the heat transfer process inside the furnace.

If we consider a crown madee with flat wedges, part of the heat radiated from the flames goes directly to the glass while the rest is received by the superstructure and the crown.

The heat received by the refractories can be transferred in different directions and ways:

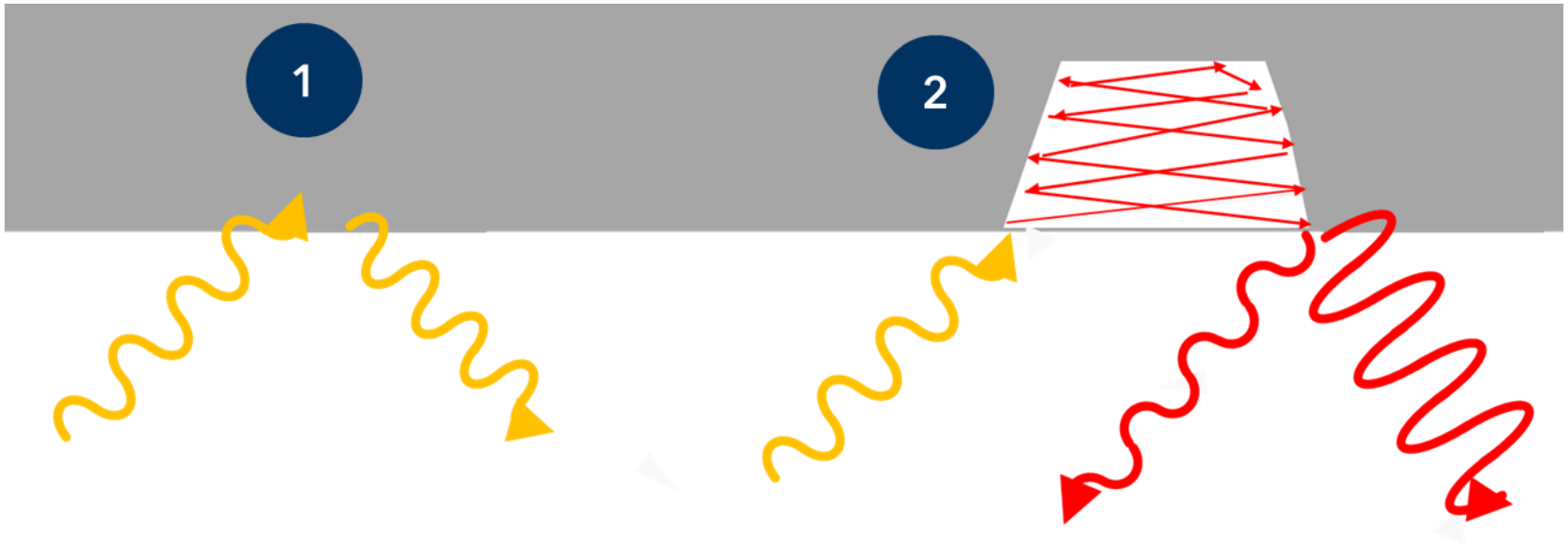
- A significant part (20%) is reflected at the same wavelength of the flame and then partially absorbed by the waste gases.
- The majority (75%) is radiated toward the bath at different wavelengths.
- A small part (5%) is transferred outside the furnace as heat loss.

**By increasing the insulation and the emissivity of the material is possible to reduce the thermal loss and increase the heat transferred to the melt.**

# Higher Emissivity

## With Corrugated Shapes

1 Reflection on a straight surface: Incoming wavelength is equal to the Outgoing waivelength. This radiation is partially adsorbed by the flames and waste gases.

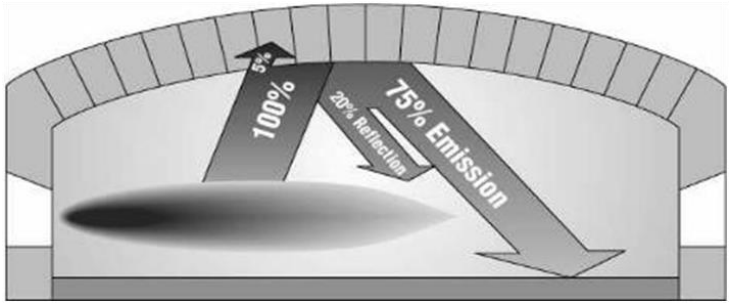



2 In the honeycomb structure, the incoming beam undergoes multiple reflections, absorptions, and re-emissions, resulting in the transformation of the initial wavelength into a range of wavelengths, while the total energy remains conserved. This energy is not adsorbed by the flames or waste gases, but goes directly to the glass.

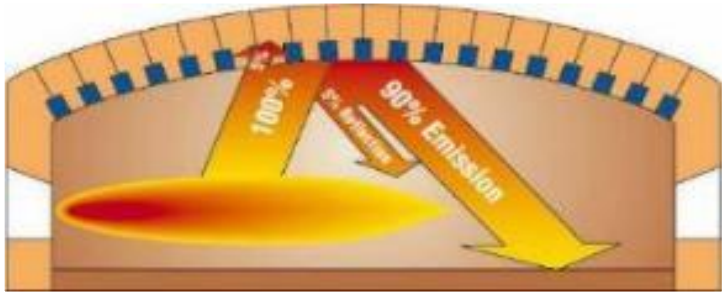
# Honeycomb Shape

## Increased Emissivity with Higher Inner Surface

One way to increase the emissivity of the crown is by increasing the inner surface area of the crown introducing corrugate shapes



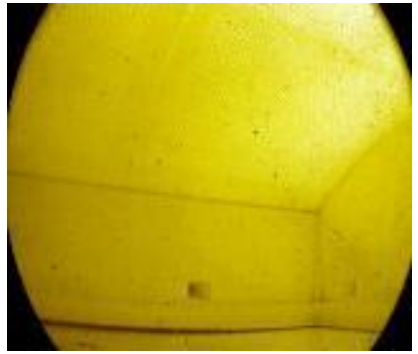

Without Honeycomb




With Honey comb

## Honeycomb Shape

+15% Emitted Energy



The higher emissivity leads to better efficiency of the furnace up to 4%

With the following advantages

| Lower Fuel Consumption | Higher Pull | Higher Glass Quality | Lower Operating Temperature |
|---|---|---|---|

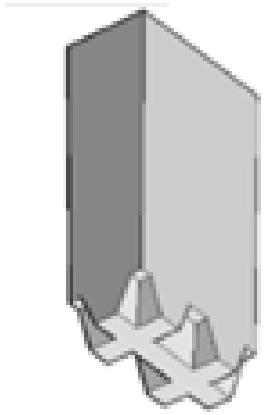
# Epsilon Solution

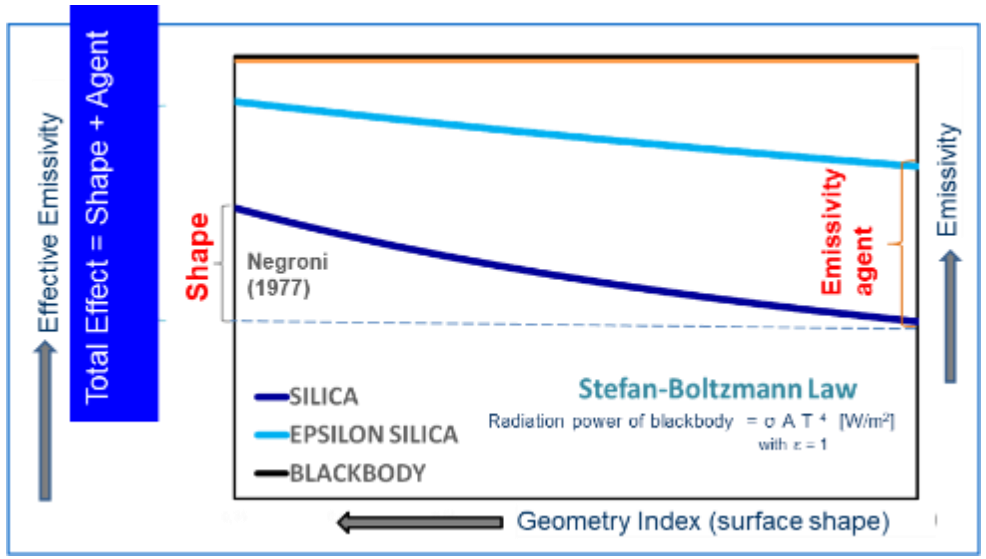
## Increased Emissivity with Emissive Agent Addition

In addition to Honeycomb shapes, Epsilon Solution can enhance the heat transfer through radiation into the glass melt.
The silica wedges are added with an emissive agent that will increase the emissivity (ε) of your furnace crown and thus contribute significantly to both energy savings and the reduction of emissions.

The effect of the added emissivity agent can reach up to 1.5%.

Epsilon Solution can be combined with Honeycomb shapes leading to the most efficient crown on the market.





# Honeycomb Shape
# ε-Solution
# Multiple Benefits

- Decrease of Energy Consumption from 4% to 8%
- Higher Glass Quality due to shorter melting time and longer fining that leads to better homogeneity
- Possibility to increase the melting rate up to 15%
- or decrease the superstructure tempeture by 70°C
- Extension of the lifetime of the furnace

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# Reduced Heat-loss
# Improved Insulation
# Monolithic Concept

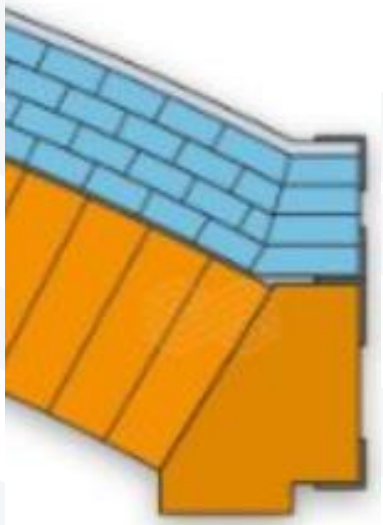
# Insulation Concepts

## Standard Bricks

All the insulations concept must be very carefully designed to minimize the heat-loss and, at the same time, ensure a correct temperature profile inside the wedges.

Standard Bricks are the most used insulating materials for crown and RHI Magnesita propose a large portfolio of different linings based on the needs:

Our Proposal for an efficient furnace is a concept based on 4 brick layers*:



1 Layer (30mm) STELLIT GH 0-1-DE
3 Layer (64mm/L) RHIM-LiSi-06
1 Layer (64mm/L) RHIM-LiSi-08 or RHIM-LiSi-10

Thickness and number of layers can be modify based on the specific needs.
We can provide heat-loss calculation on different scenarios

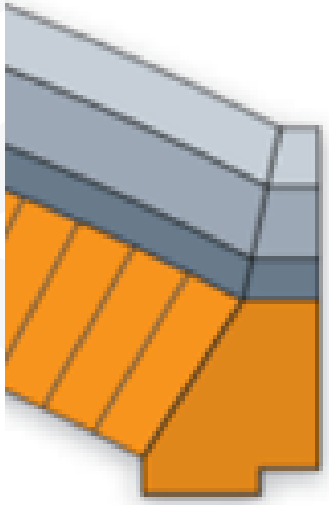
# Insulation Concepts

## Monolithic

All the insulations concept must be very carefully designed to minimize the heat-loss and, at the same time, ensure a correct temperature profile inside the wedges.

Monolithic Insulation is the most performant due to the sealing capacity of the monolithic layer and lower thermal loss. With a monolithic insulation you have the possibility to reduce the capex and maintenance costs. Monolithic insulation can be installed also on damaged crown to extend the lifetime.

Our Proposal for an efficient furnace is a concept based on 3 monolithic layers*:



LEGRIT 105-0,5E 0-2 (150mm)
LEGRIT 135-1,0G 0-6-DE (135mm)
COMPAC SOL FS99G-3-DE (100mm)

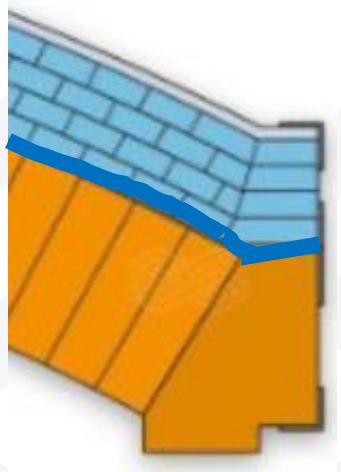
→ Applied by Dry-Gunning after heat-up

Thickness and number of layers can be modify based on the specific needs.
We can provide heat-loss calculation on different scenarios

# Insulation Concepts

## Combined: Monolithic + Bricks

In oxyfuel furnaces the sealing of the crown is crucial, and a monolithic sealing layer must be applied also if a Bricks Insulation concept is used.



1Lx30mm STELLIT GH 0-1-DE
3Lx64mm RHIM-LiSi06
1Lx64mm RHIM-LiSi08

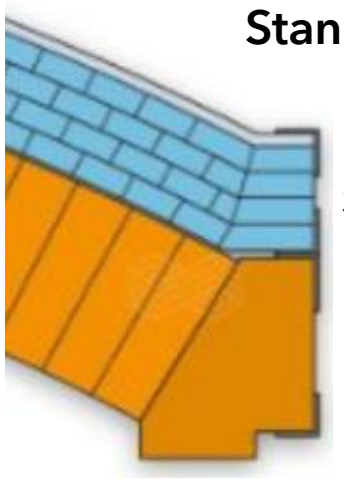
Installed in hot condition after the application of the Sealing Layer

25-50mm COMPAC SOL FS99G-3-DE
COMPAC SOL FS99-3-DE

Applied in hot condition after complete expansion of the crown with dry gunning or casting

# Insulation Concepts

## Standard Bricks vs Monolithic Insulation



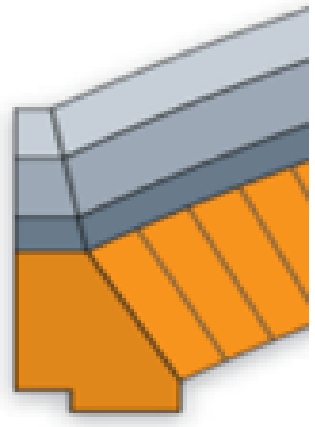
### Standard Bricks

1 Layer (30mm) STELLIT GH 0-1-DE
3 Layer (64mm/L) RHIM-LiSi-06
1 Layer (64mm/L) RHIM-LiSi-08

### Monolithic

LEGRIT 105-0,5E 0-2 (150mm)
LEGRIT 135-1,0G 0-6-DE (135mm)
COMPAC SOL FS99G-3-DE (100mm)

Applied by Dry-Gunning after heat-up



| Option | Description | Heat Loss | Delta CO2 | Delta Energy |
|---|---|---|---|---|
| Market STD | 450mm-Stella GGS<br>64 mm 160 1-L<br>3x64mm 150 0.6-L<br>30 mm STELLIT GH 0-1-DE | 1567 Wh/m2 | 0 | 0 |
| RHIM-High Efficiency Concept | 450mm-Stella GGS<br>64 mm RHIM-LiSi-08 (155 0,85/L)<br>3x64mm RHIM-LiSi-06 (150 0.65-L)<br>30 mm STELLIT GH 0-1-DE | 1323 Wh/m2 | - 42 t/y | - 213 MW/y |
| RHIM-Monolithic High Efficiency | 450mm-Stella GGS<br>150 mm Compac Sol FS99G-3-DE<br>135 mm Legrit 135-1,0G 0-6-DE<br>150 mm Legrit 105-0,5E 0-2AT | 1066 Wh/m2 | - 87 t/y | - 438 MW/y |

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# For More Information

## Get in Touch

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