RHI MAGNESITA

RHIM's Solutions for the Glass Industry

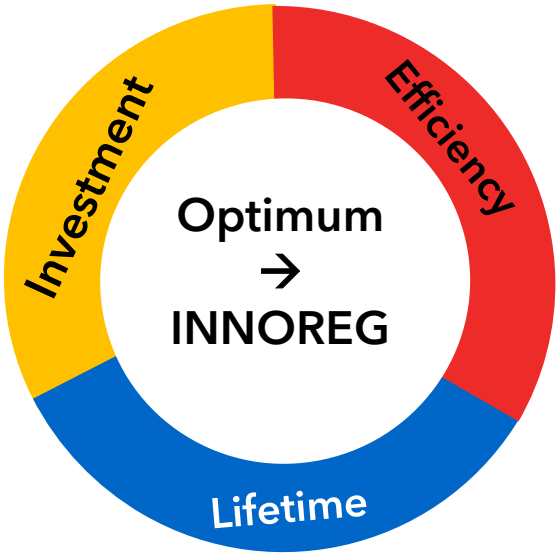
Chimney Blocks - Most Advantageous checker system in the market

September 2024

Regenerator Efficiency

As low as possible and it is influenced by:

- checker work design (flue size → total weight)
- size of regenerator
- material selection (quality and grade of product)



As long as possible and it is influenced by:

- checker work design (flue size & checker shape)
- Low aging effects
- size of regenerator
- material selection (quality and grade)
- Corrosion Resistance and high stability

-Operation & Maintenance

As high as possible and is influenced by:

- Regenerators section and volume
- Checker Shape
  - Specific Heat Exchange Area
  - Turbulence
  - Clogging Potential
  - Homogeneous Distribution of Gases
  - Thermal conductivity and Heat capacity of the selected material
- Stable during the complete campaign
- Air Infiltration
- Clean Checkers
  - Operation & Maintenance (clean checkers – no clogging due to condensation or collapse)

Chimney Blocks

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The most efficient Checker System, a cutting-edge solution that enhances the reliability and performance of modern regenerators

- Chimney blocks are the most widely spread checker system available in the market since they offer high efficiency, stability, durability and customization options.

- As part of our INNOREG - Innovative Regenerator – chimney blocks play a significant role in enhancing the heat recovery process, making them valuable contributors to energy efficiency in the glass manufacturing process.

- Chimney blocks are forming the checker work within regenerators.
  When selecting optimized checker shapes and materials according to the operating conditions, chimney blocks enable the most efficient heat storage and transfer.

The unique features of chimney blocks provide several advantages over other checker settings commonly used in heat recovery systems.

1 Enhanced heat transfer - Shapes

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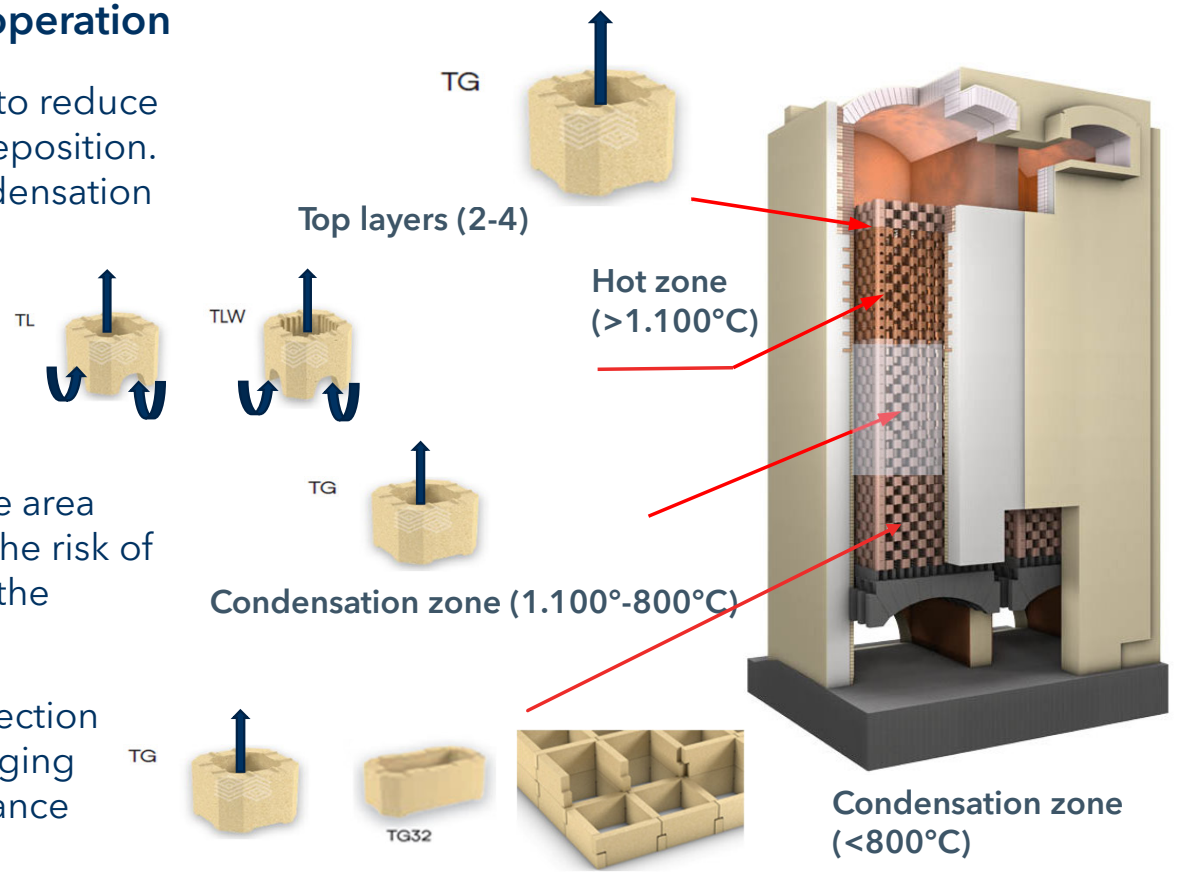
Chimney blocks are specifically designed to optimize heat transfer efficiency within the regenerator. The selection of the specific shapes within our portfolio permits to maintain high levels of heat transfer efficiency while assuring a continuous operation

TG shapes ensure a low turbulent flow to reduce the risk of carry-over or condensates deposition. Suitable for the top layers and the condensation zone.

TL,TLW shapes with increased heat exchange area promote a high turbulent flow to improve the heat exchange. Suitable for the hot zone.

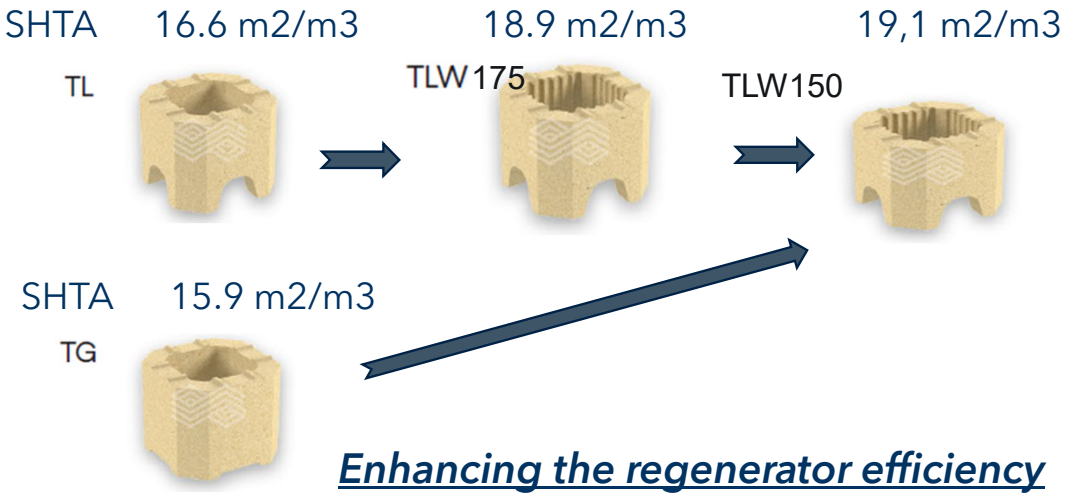
TG shapes with improved heat exchange area promote a low turbulent flow to reduce the risk of carry-over or condensates deposition in the condensation zone**.**

LCP and **TG32** shapes to create a larger flue cross section at the regenerator bottom to reduce the risk of clogging due to solid condensates and facilitate the maintenance

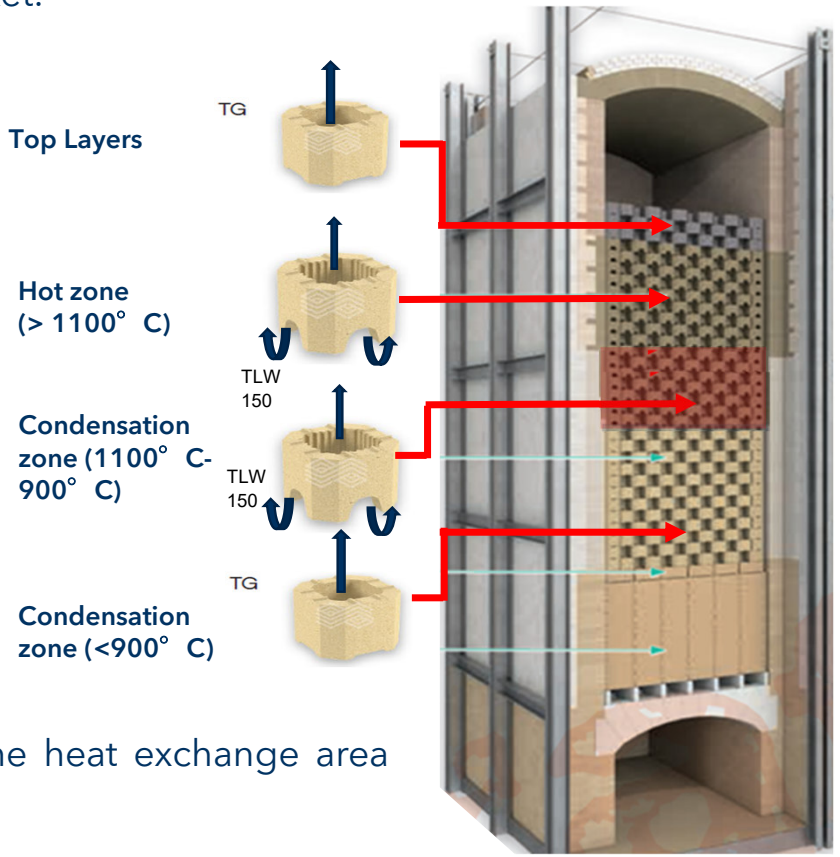


High Efficiency Shapes

TLW, introduced in 2018, is now RHI Magnesita´s standard shape for the hot zone, achieving the highest efficiencies among the checker settings available in the market.



Enhancing the regenerator efficiency



Increasing the heat exchange area increases the efficiency
Passing from TL to TLW175 in the hot zone has proven this theory

Consequently, passing from TLW175 to TLW150 further increases the heat exchange area and the additional openings improve the gas distribution

Passing from TG shapes to TLW shapes also in the upper condensation zone is an additional option depending on the operating conditions

2 Homogeneous distribution of the waste gases and combustion air in the regenerators

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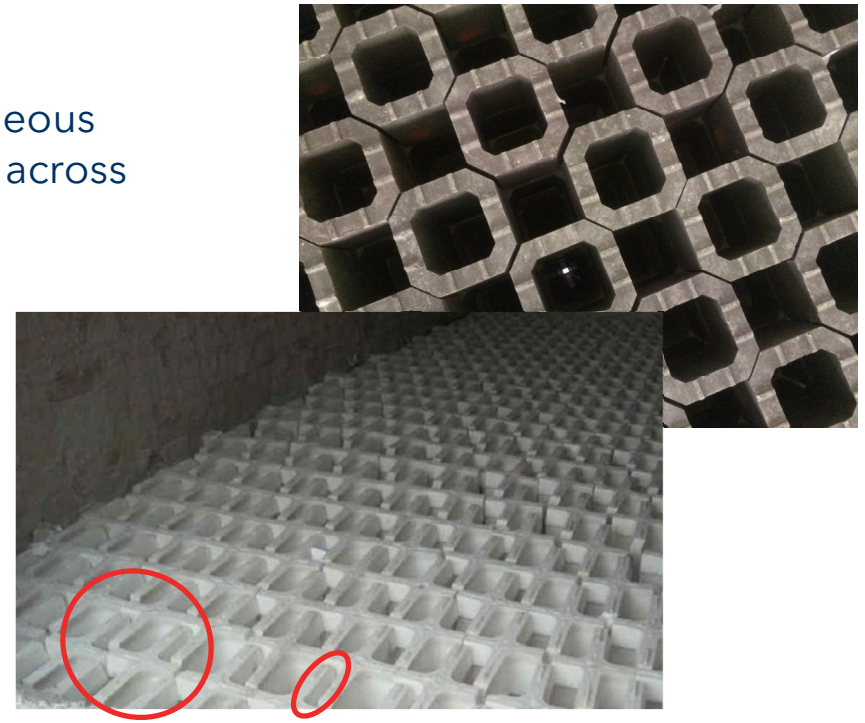
One of the chimney blocks main features is the typical channel shape that maintains a regular flue cross section in the final installation setting

A regular flue size is a pre-condition to guarantee a homogeneous flow distribution and homogeneous temperature distribution across the regenerator cross section

Irregular flue dimensions will promote preferential flows across the regenerator area: smaller flues will lead to a higher pressure drop. Consequently, the checkers will see different flow volumes creating a non-homogeneous temperature distribution with higher risks for clogging in the colder zones.
A non-homogeneous temperature distribution will impact negatively the final efficiency



„Glass Furnaces' Regenerator Performance and Optimization For Energy Saving" by Sebastienne Bourdonnais, AFGM Bali September 17th, 2013

A regular flue size distribution is a pre-condition to achieve the highest efficiencies and a stable regenerator operation

Homogeneous heat distribution
in the regenerators

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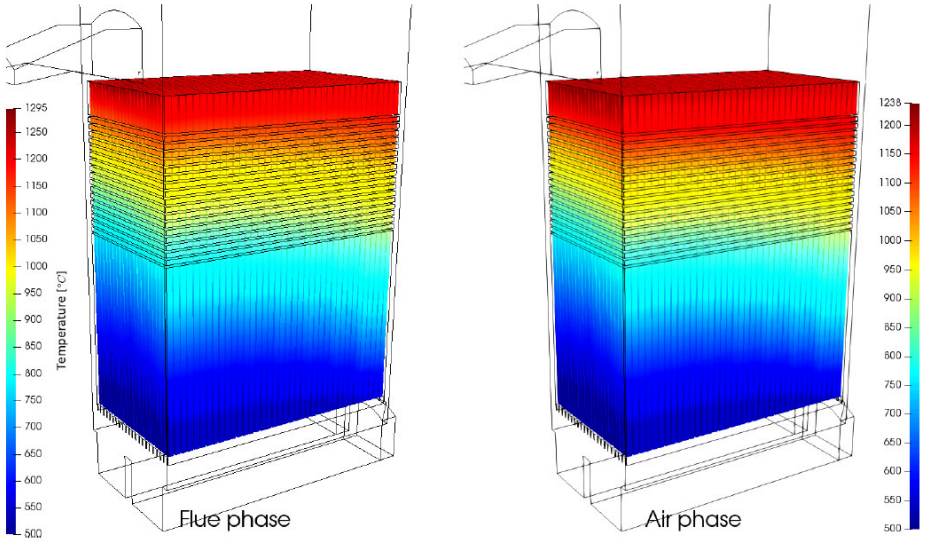
The open design of TL, TLW chimney blocks allows homogeneous flue gas distribution in the regenerator chamber.
This leads to a homogeneous temperature distribution, so that the complete checker work contributes to the heat exchange.



CFD modeling based on data collected at customer site. Waste gases and combustion air flows, temperatures, pressures, etc. were collected at different spots of the regenerators and used to simulate the regenerator operation.

The collected data showed a homogeneous distribution of the flows across the regenerator section. The calculated efficiency > 90% (with our TL shapes) confirmed that the system collects and utilizes efficiently the available thermal energy, contributing to reduce the energy consumption and increase the chimney blocks lifetime

Homogeneous heat distribution
in the regenerators

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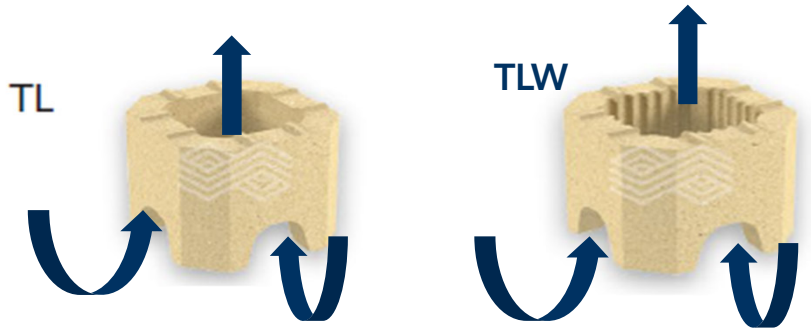
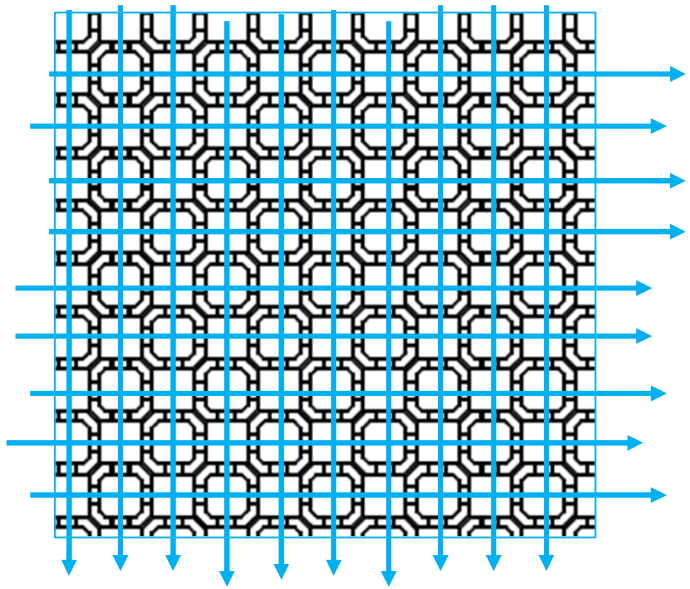
The mouse holes of TL, TLW chimney blocks enable a wide gases circulation across the regenerator section leading to a homogeneous temperature distribution and the complete checker work contributes to the heat exchange.





Homogeneous heat distribution
in the regenerators

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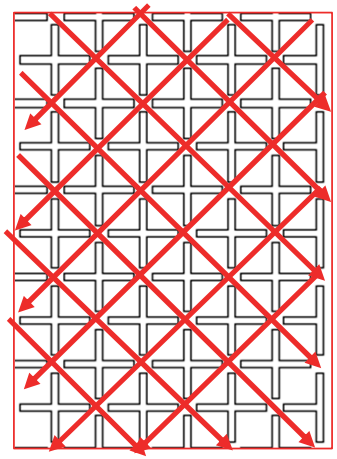
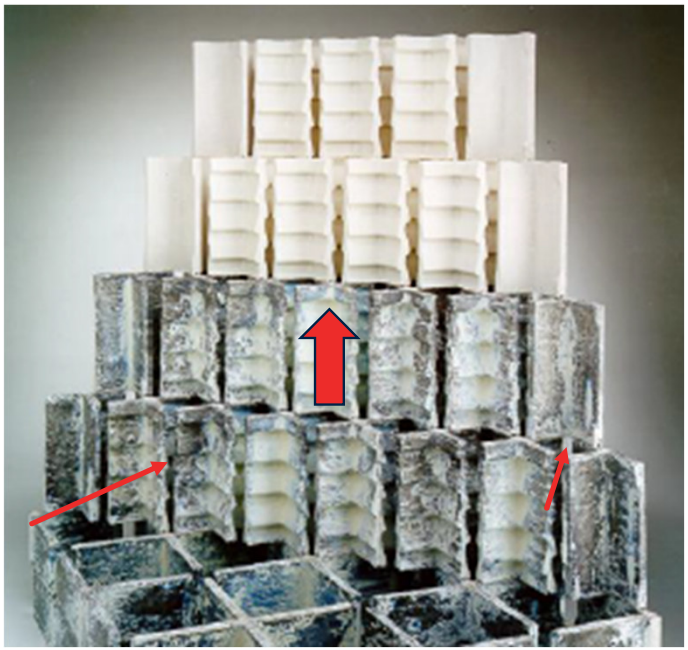
Limited and less efficient gases flow circulation in the cruciforms



Considering the same flue opening e.g. 140 x 140 mm, the flue gases cross circulation is less distributed



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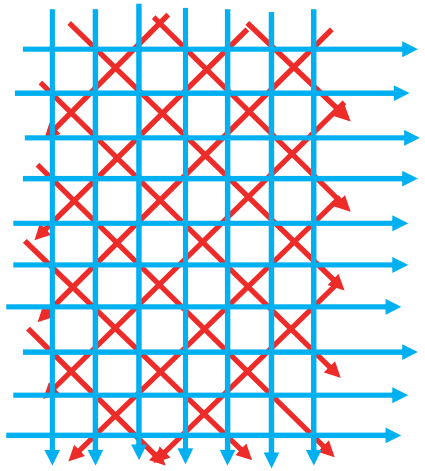

Comparison of the distribution of the gases over the regenerator cross section in case of opening e.g. 140 x 140 mm

Chimney Blocks

Cruciforms

3 Lowest aging effect

in the chimney blocks setting

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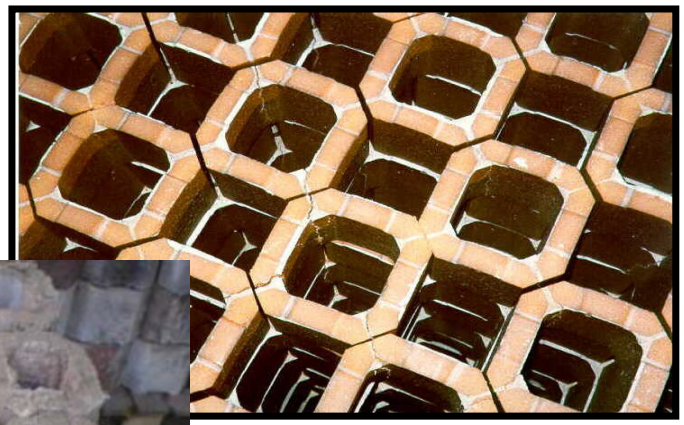
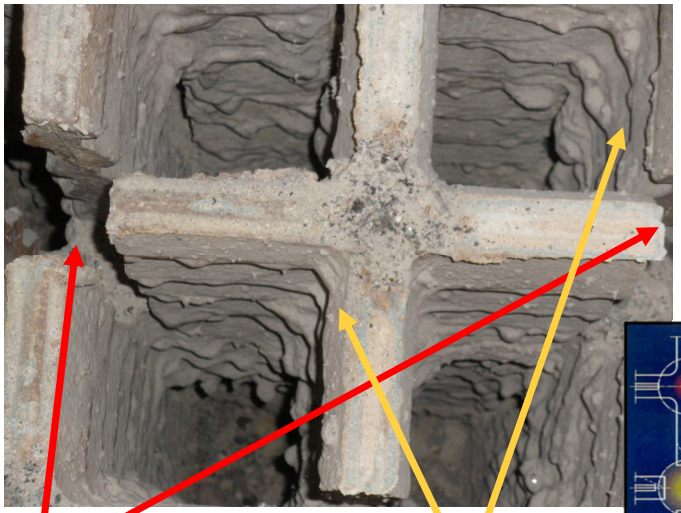
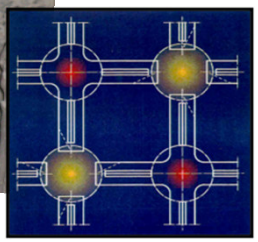
The regular flue size distribution of the chimney blocks enables a clean and long-lasting operation due to the reduced risk of clogging. Additionally, the bonded material is glassy phase free, preventing dust and condensates from sticking on the surface and reducing the heat exchange coefficient

Anker DG1:
7 years of operation in an end fired container tank



Rubinal EZ :
14 years of operation in a float tank





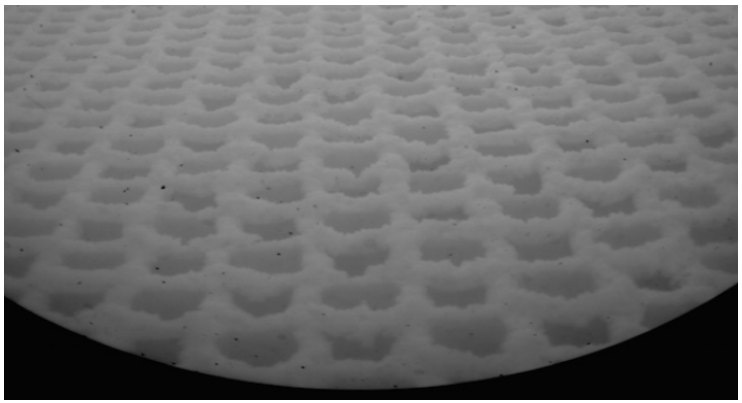
Cruciforms : due to the flow interruption fast clogging of the small areas near the edges: no gases circulation is possible

Cruciforms : the exudation of the glassy phase included in the AZS promotes a fast gluing of dust and condensates on the brick surface reducing dramatically the heat exchange coefficient in a short time

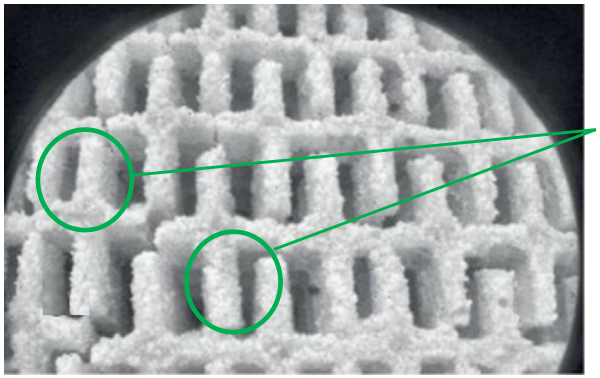
Lowest aging effect

chimney blocks for regenerators top layers

- The top layers of the checker work are facing batch and cullet carry over; this can easily lead to clogging in this area.
- In case of cleaner conditions, smaller flue sizes in the top layers can be applied (e.g. TG120 can be used in the last chambers of cross fired regenerators). In such cases, the risk of clogging is significantly lower compared to type 8 shapes from cruciforms



Chimney blocks TG after 7 years
wide free channel area despite carry over deposits



Single channels almost closed resulting in inhomogeneous gas flue sections distribution and less efficiency

S. Schaller et al., Glass Int. Sep. 2020 p. 57
Cruciform bricks X8 after 6 years

4 Highest corrosion resistance

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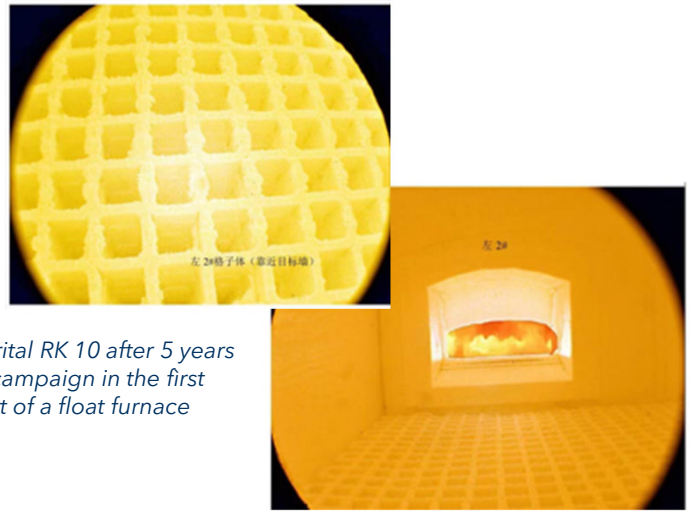
Chimney blocks are selected in a wide range of high-quality refractory materials depending on the thermal, chemical, and mechanical stresses of the application zone.

Top layers available in:

DURITAL RK10TS Resistant to the harshest conditions (silica , raw materials and cullet carryover and V_2O_5 attack from fuel oil)
DURITAL AZ58TS Chrome free alternative
DURITAL K99 Extra Resistant to lime attack from dust
RUBINAL VZ resistant to sand carryover and to V_2O_5 attack (fuel oil)



Durital RK 10 after 5 years of campaign in the first port of a float furnace

β'''-Al2O3 cruciforms		
	new	corroded
MgO	5.31	**12.1**
SiO2	0.46	**4.02**
Al2O3	89.8	72.7
ZrO2	0.38	0.68
Na2O	3.73	**0.2**
K2O	<0.02	<0.02
CaO	0.09	**9.19**

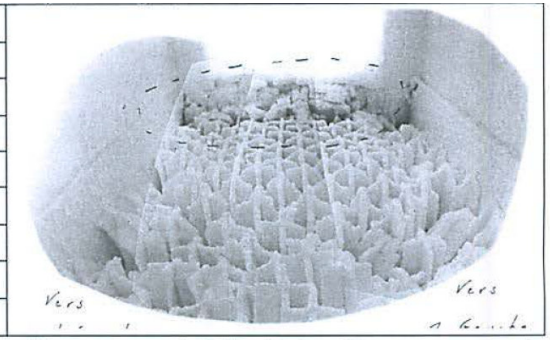


Figure 1: chemistry and state of β-Al2O3 cruciforms corroded by high silica carry-over in combination with high temperature

Beta Alumina has a poor resistance to silica carryover attack in combination with high temperatures

„Environmental impact for regenerators materials selection in soda-lime flat glass furnaces" by Jean-Pierre Meynckens, Benoit Cherdon Advanced Materials Research 2008-04-08 ,39-40, pp 619-624

Highest corrosion resistance

RHI MAGNESITA

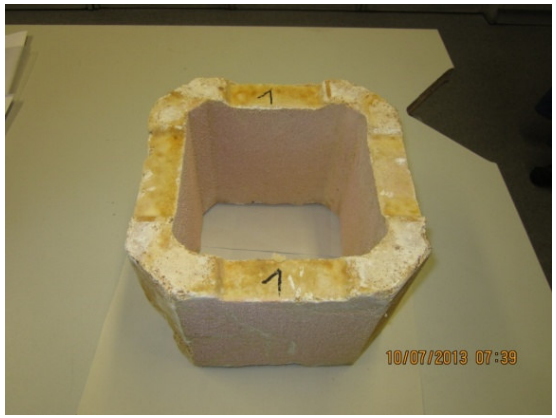
Hot Zone layers

ANKER DG1 with a MgO-MgO direct bonding
RUBINAL VZ suitable for fuel oil

Condensation zone layers

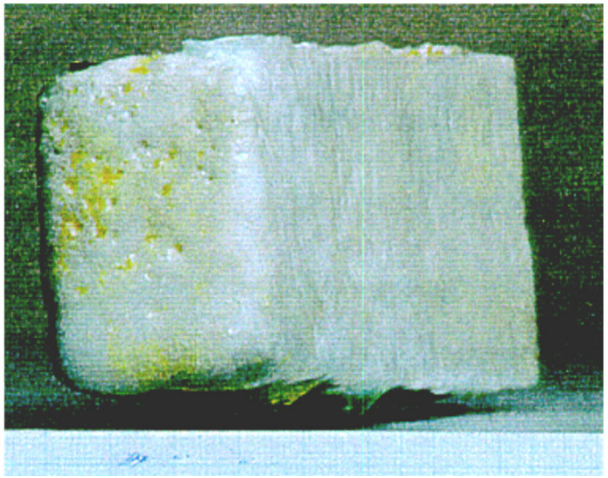
RUBINAL EZ MgO protected from forsterite and ZrO_2
RUBINAL ESP MgO protected from spinel

ANKER DG1 is resistant to alkali attack in the condensation zone, in reducing conditions



Rubinal EZ: no gluing and no corrosion after 7 years

Under reducing conditions
Alkalines attack both Beta alumina and f.c. AZS with corresponding nepheline formation and fast brick corrosion



5 Highest stability of the chimney blocks setting

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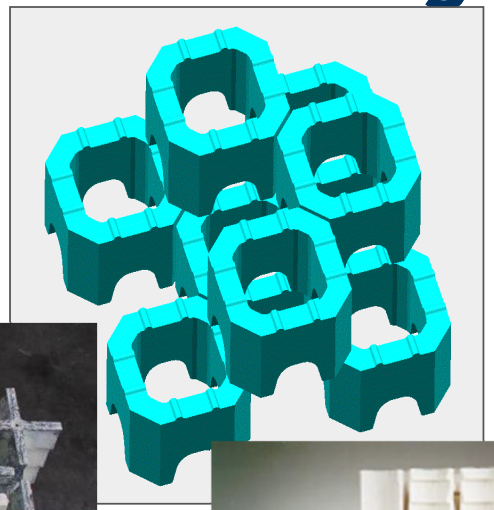
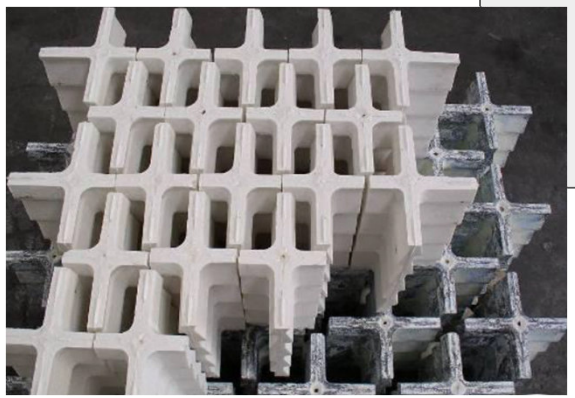
Chimney blocks

One chimney block is in contact with 12 'neighbours':
Sitting on four blocks,
Four neighbour blocks in the same layer and topped by four blocks.



Other settings

One block is in contact with 8 'neighbours':
Sitting on 4 blocks and topped by 4 blocks (distance depends on the flue size)



„Glass Furnaces' Regenerator Performance and Optimization For Energy Saving" by Sebastienne Bourdonnais, AFGM Bali September 17th, 2013

In the transition from type 6 to type 3/type 4 and from Type 4 to Type 8 the bricks are supported only on two «wings»; the remaining two «wings» are not supported and they are hanging on the air

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Highest stability of the chimney blocks setting

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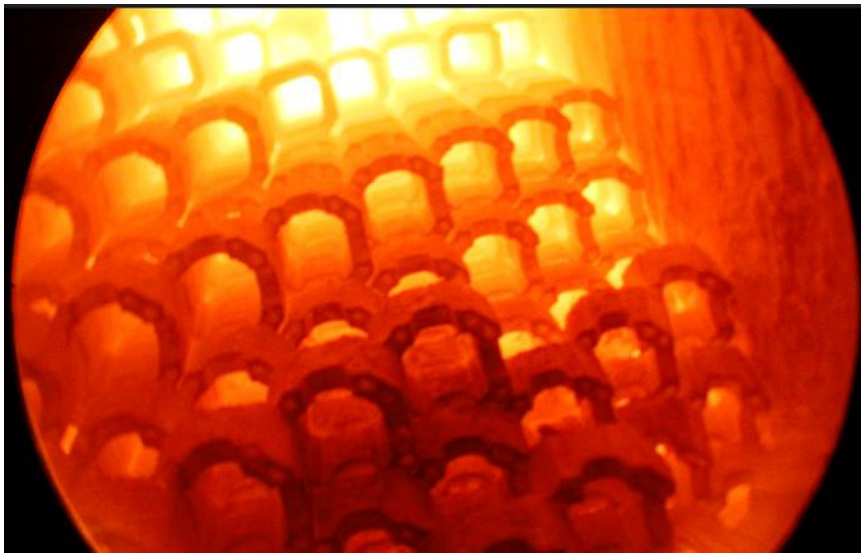
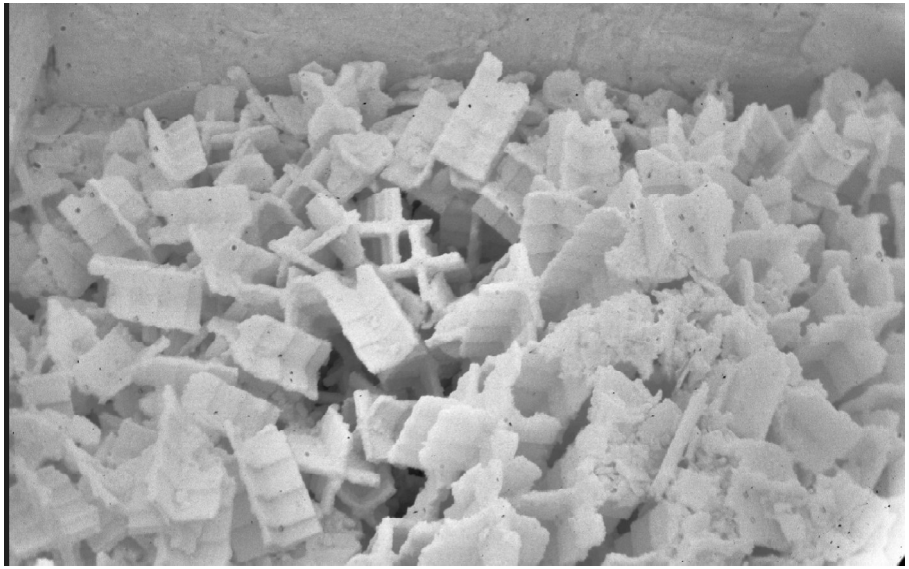
In case of a partial collaps in a chimney block checkerwork, the chimney blocks wedge together and form a bridge preventing further sagging of the construction.
→ The regenerator remains in operation



Looking upwards from the regenerator bottom: after collapse of transition tile, the chimney blocks have built a bridge!

When collapsing, the single cruciform bricks are not hold by the surrounding bricks, so wedging in the original position is not possible.



6 Easiest maintenance of the flue channels

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- **Stability** is the pre-condition to an easy access to the checker package and cleaning.
  Stability will prevent also a serious collapse keeping clear the flue channel
- **No Exudation** reduces the risk of clogging
- **Low Corrosion** reduces the risk of collapse

These features result in the easiest maintenance of the flue channels with less efforts from the operators

Benefits of Increasing the Regenerator´s Efficiency

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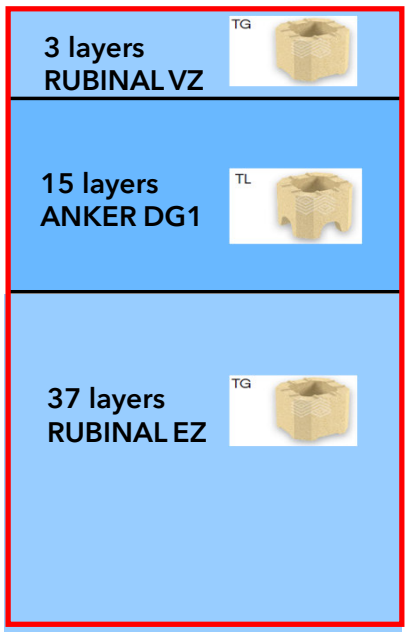
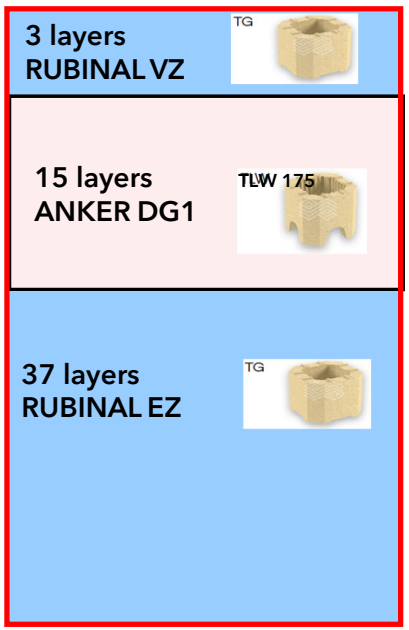
- The figures given below are a real case example.

Customer data (furnace conditions)

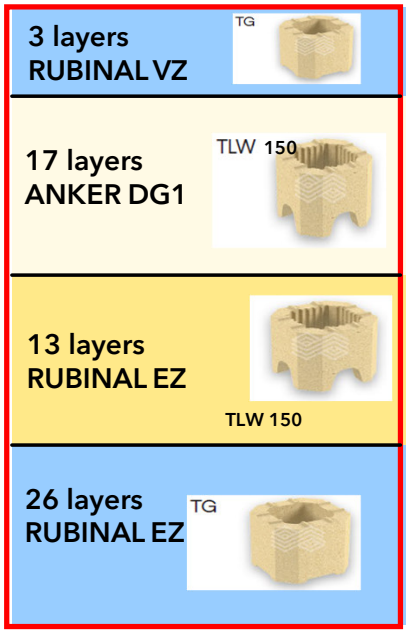
Furnace area	128,8 sqm
Regenerator depth	6590 mm
Regenerator width	4790 mm
Checker Height	9625 mm
Air Temp below rider arches	150°C
Temp Flue gases top checkers	1450°C
Reversal time	20 min
Fuel consumption (NG)	1365 Nm^3/h
Furnace melting rate	450 tpd
Cullet ratio	70%
Batch Humidity	5%
Batch preheating	NO
O_2 excess in the waste gases	2%
Electric boosting	3600 KW



Base Case



CASE 1 - TLW



CASE 2 – TLW D1 + TLW EZ

Benefits of Increasing the Regenerator´s Efficiency

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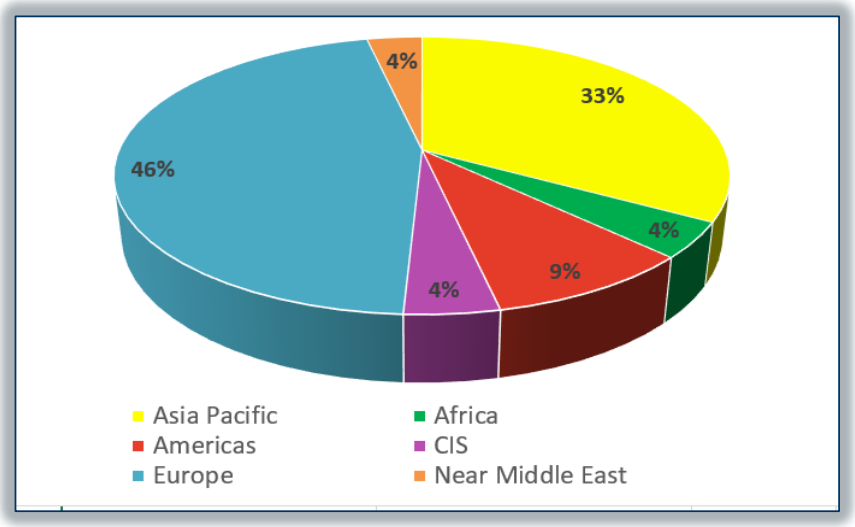
CHECKER CONFIG	EFF	PREHEAT AIR TEMP	FUEL CONS	ΔCO_2	Savings €*
BASE CASE TG 14/175 TL14/175 TG 14/175	88.5%	1301°C	1365 Nm3/h	23.473 T/Y	-
CASE 1 TG14/175 TLW14/175 TG 14/175	89.3%	1310°C	1358 Nm3/h -61.320Nm3/Y	-120 T/y	31.200 €
CASE 2 TG14/175 TLW14/150 TLW14/150 TG14/175	91,0%	1333°C	1339 Nm3/h -227.760 Nm3/Y	-447 T/y	115.900 €

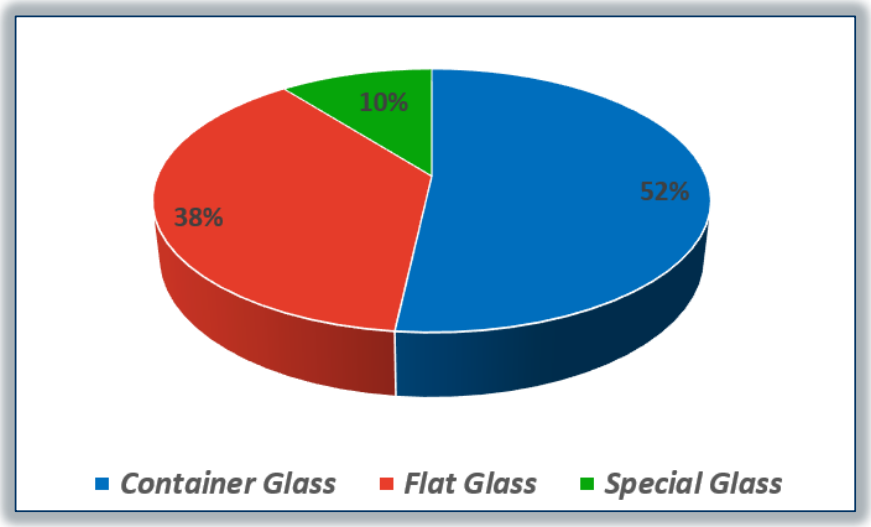
*Cost of CO2 EU= 70 €/t Cost of NG EU= 0,352€/stcm (June 2024)

World-wide experience

Chimney block success story since 1984

Over the last 20 years on average 70 furnaces per year equipped with chimney blocks





40.000 to of chimney blocks sold per year over the last 20 years

The glass industry is trusting

Chimney block checker works

RHI MAGNESITA

All major glass producers have installed chimney blocks

St. Gobain Isover

St. Gobain Glass

Yioula

Heinz Glas

Euroglas

Verallia

Vidrala

Consol Glass

Owens Illinois

Wiegand

PQ

Gerresheimer

BA Vidros

Guardian

Ardagh

AGC

NSG/Pilkington

St. Gobain Desjonquères

Libbey

Stölzle

PPG

… and many others

RHI MAGNESITA

Thank you for your attention

Get in Touch

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