



# Institute Of Refractories Engineers

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## Refractory Bricks



# The Forms of Refractory Materials

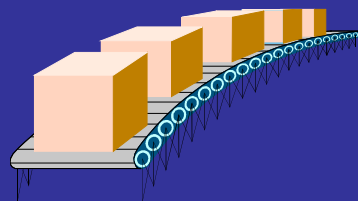
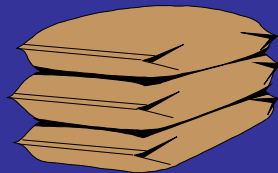
## Pressed/Formed Bricks

- high temperature fired Dense
- high temperature fired Insulating
- low temperature cured
- precast
- chemically bonded
- resin bonded



## Monolithics

- mortars
- castables
- mouldables
- rammables
- plastics
- dry vibratables



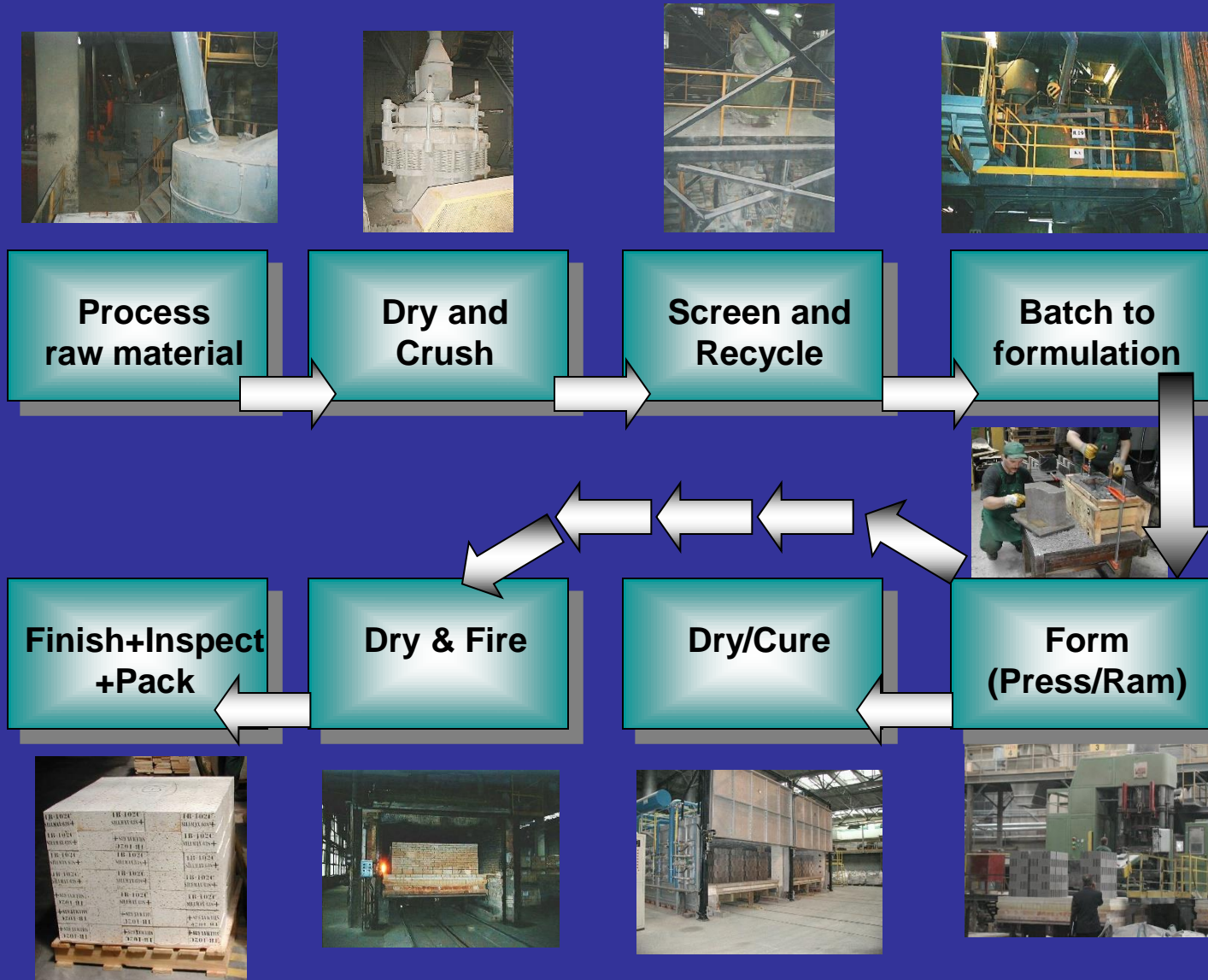


# Types of Material

- Fired
  - Ceramic Bond
  - Firing Temperature typically  $>1200^{\circ}\text{C}$
  - Usually no changes during heating up.
- Unfired
  - Chemical Bond or Carbon Bond
  - Heat treatment typically  $<600^{\circ}\text{C}$
  - Changes in properties on first heating
- Pre-cast and Pre-rammed
  - Complex Shapes Possible
  - Controlled Dry-out
  - Optimum Casting Conditions

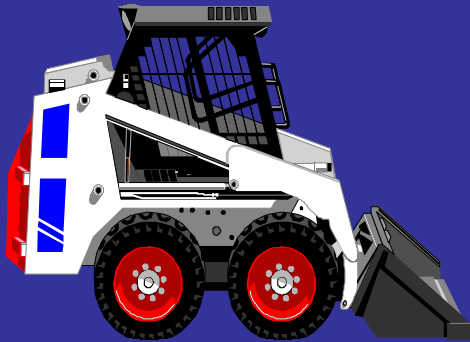


# The Production of Bricks





# The Production of Bricks



**Process  
raw material**



**Dry and  
Crush**



**Screen and  
Recycle**

Raw materials can be bought ex quarry or in processed form.  
They are purchased to tight specifications, often on long term supply contracts, from established and approved suppliers.  
Security of supply is an important consideration.  
Test certificates are required and quality verification tests are performed on the received materials to verify quality.  
Visual inspection is also necessary to confirm that the material has not been contaminated during transit.



# The Production of Bricks



**Dry and  
Crush**



**Screen and  
Recycle**



**Ball Mill**



**Batch to  
formulation**

Raw materials are processed by drying, crushing, screening and milling to produce a wide range of size fractions from millimetre to micron sizes.

Air swept ball mills produce the very fine flour grades.

High purity materials are pre-processed and pre-blends may be purchased.





# Batching





# The Production of Bricks

**Batch to  
formulation**



Raw materials are combined to tried and tested recipes.

Ingredients, both solid and liquid, are added in controlled sequence and controlled proportions.

Ingredients are added which give 'green' strength - these provide some strength to the brick after drying.

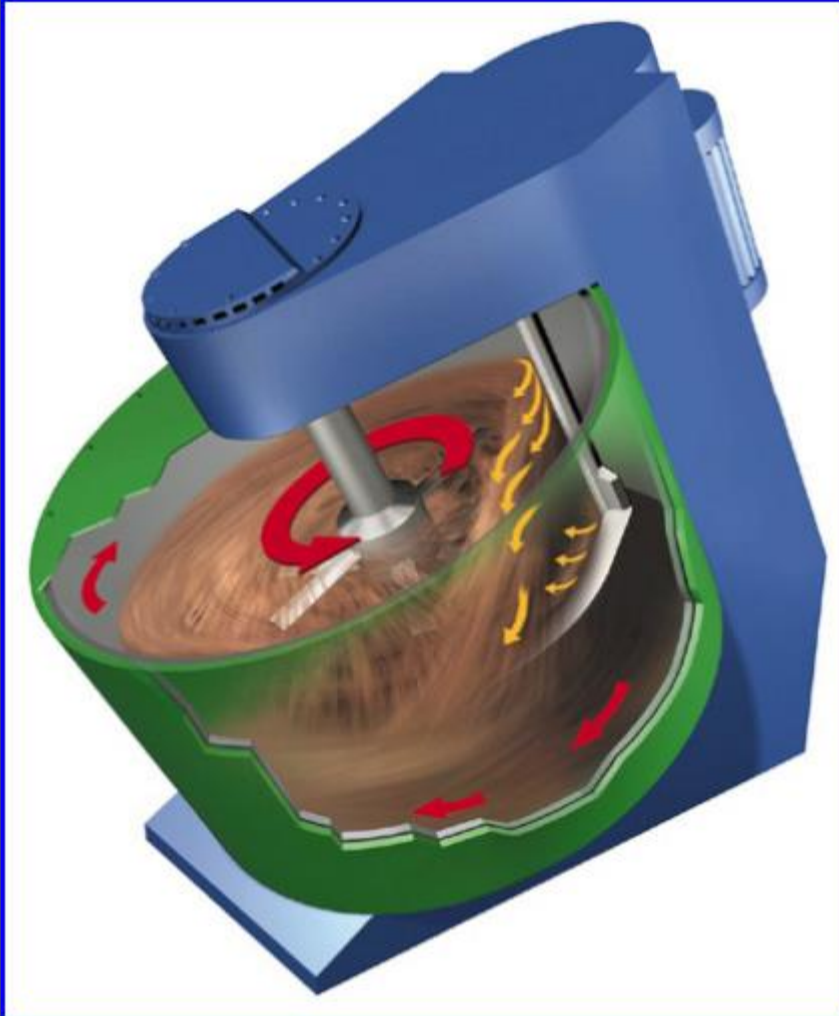
Ingredients are designed to react during the curing/firing process to give the desired physical and hot strength properties to the fired product.

Mixing time is important. Mixes are approved before further processing.





# Mixing





# The Production of Bricks

## Pressing



**Most bricks are machine pressed.**

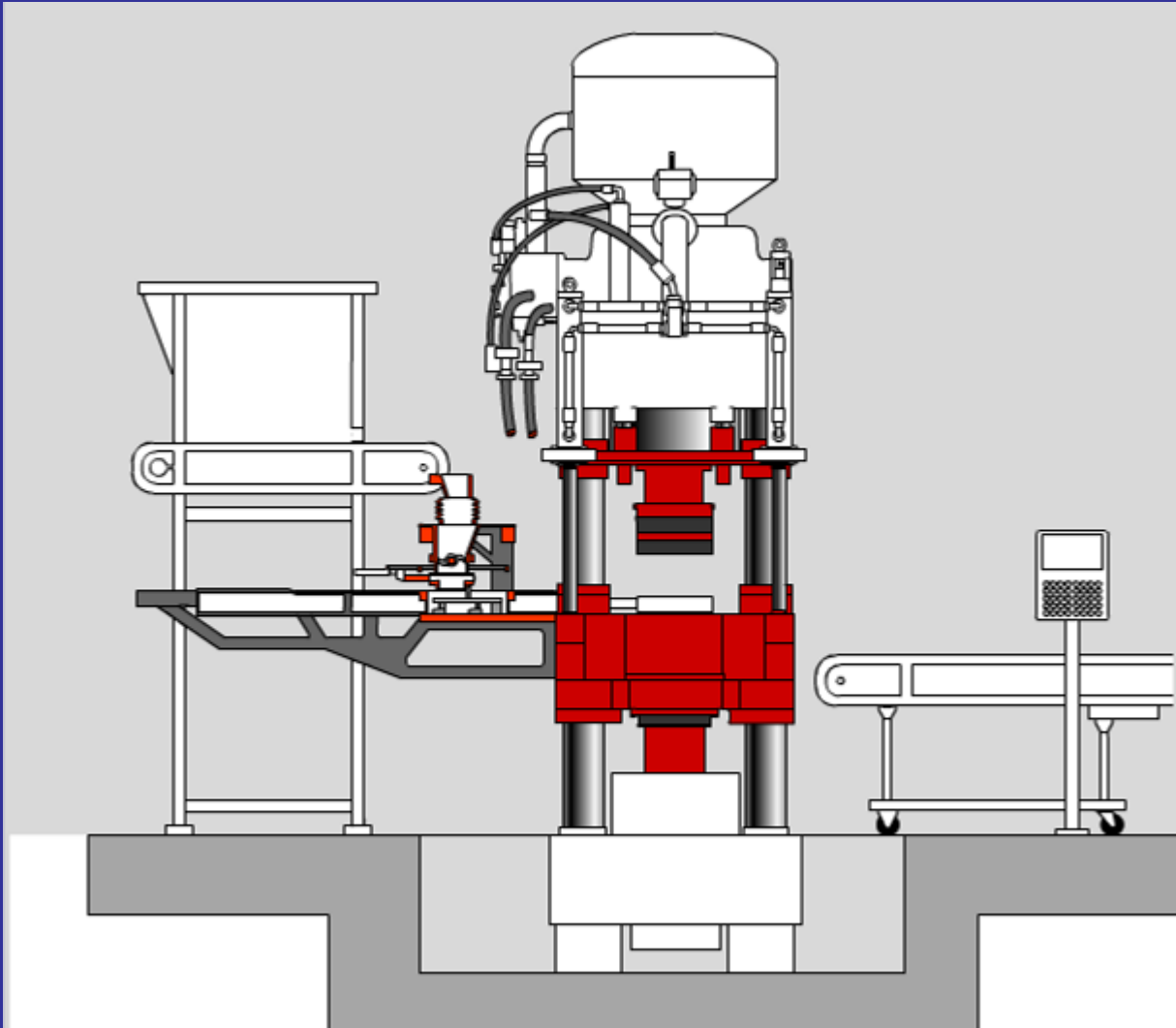
**Presses can be automated hydraulic, manual hydraulic, mechanical, impact or friction types. The presses operate over a wide range of forming pressures, making bricks from one to four at a time, frequently with robotic pick-up. Very sophisticated control systems can be applied to adjust and maintain pressed brick dimensions.**

**Moulds can be of hardened steel or tungsten carbide**

**Pressed bricks are set onto drier cars or kiln cars.**



# Hydraulic Press





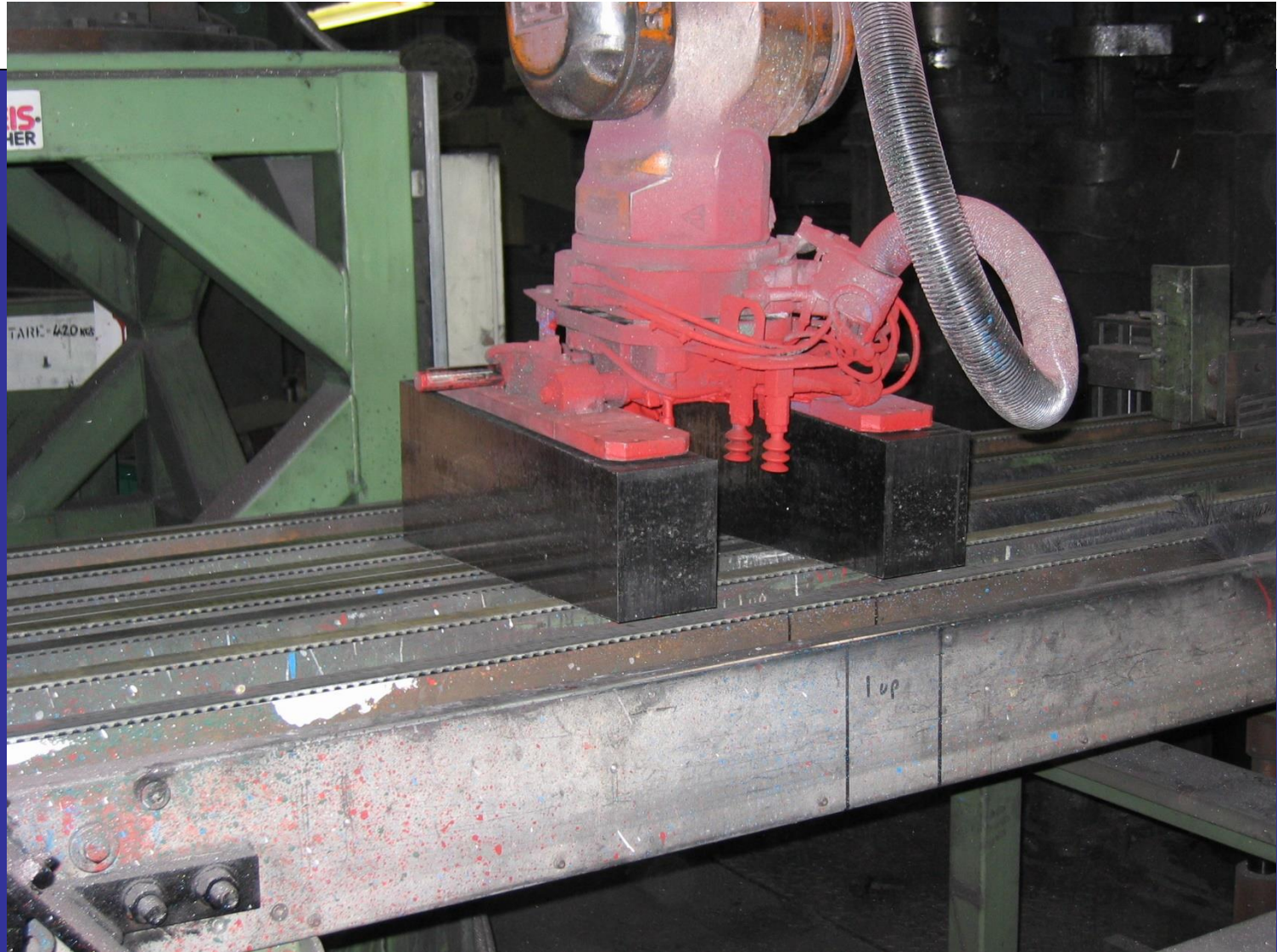
# Hydraulic Press







# Press Robotics







# Friction Screw Press





# The Production of Bricks

## Hand Forming



Some bricks are not able to be machine pressed. This is most commonly because of shape complexity but low quantity items may follow this route to avoid the high cost of press moulds.

Pneumatic rammers are used on mixes formulated for hand forming.

The technique of hand moulding is an acquired skill and there are procedures to be followed to ensure a high quality product.

Controlled drying is applied to bulky shapes.

It is also possible to cast and fire special shapes.





# The Production of Bricks

**Drying/  
Curing**



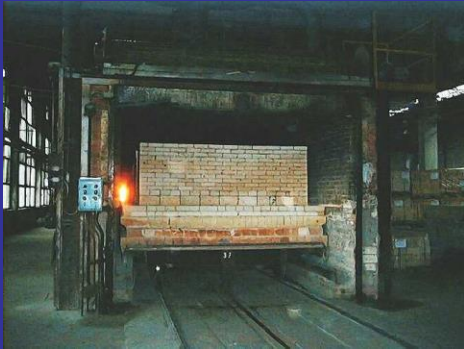
Drying is the first operation in the tempering process and is critical. In some cases the drying process is undertaken in the entry part of the tunnel kiln where low temperatures and humidity can be controlled. Bricks are dried according to their shape and size to avoid undue stresses which can generate or develop faults in the subsequent firing process.

Batch dryers are used for chemically bonded or resin bonded bricks and this completes the production operation for these brick qualities.



# The Production of Bricks

## Firing



**Firing is the main operation in the tempering process.**

**Bricks are fired in tunnel or batch kilns to controlled rates, temperatures and atmospheres. Often the first part of the kiln is the “drier”.**

**Typically the temperatures range from 1200°C (for firebrick) to 1700°C for high alumina and magnesite bricks.**

**Residence time can be 6-15 days, even longer for silica bricks, with a total firing time, inclusive of the important controlled cooling period, of 7 - 28 days.**

**Shape and size dictate the brick position and the setting density.**



## Firing – Batch Kiln







## Firing – Tunnel Kiln





# Firing – Tunnel Kiln

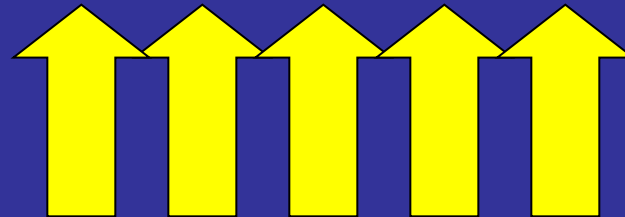
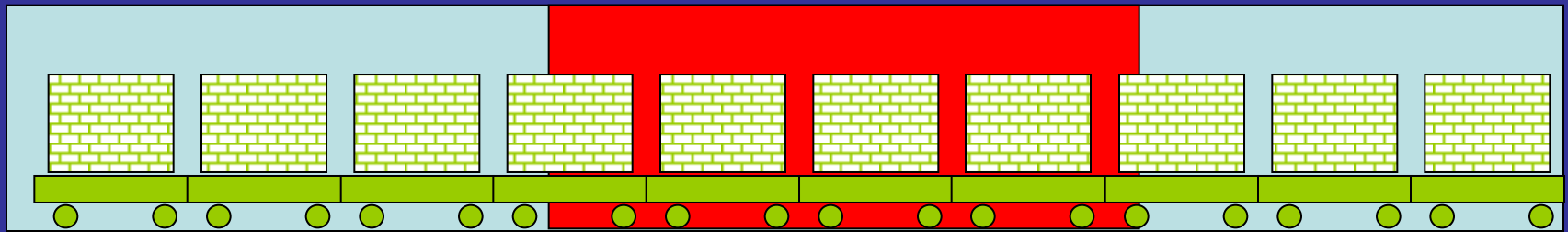
Direction of Air Flow



Preheat

Firing – Hot Zone

Cooling



Burners

Direction of Travel of Product





# The Production of Bricks

## Inspection and Finishing



**The finished product is not yet finished.**

**Some bricks will go on to be drilled or cut into derivatives.**

**Some bricks will go for size banding.**

**Some bricks will be pre-assembled where the overall assembled dimensions can be verified.**

**All bricks require inspection for size and attributes and samples must be selected to go the laboratory to verify physical and chemical properties.**





# The Production of Bricks

## Testing



LABORATORIUM

### Control Properties

- Apparent Porosity
- Bulk Density
- Cold Crushing Strength

### Chemical Analysis

### Supplementary Physical Properties

- Creep Resistance
- Refractoriness under load
- Abrasion resistance
- Thermal Shock Resistance
- Thermal Expansion
- Thermal Conductivity
- Hot Modulus of rupture



# The Production of Bricks

## Marking and Packing



納入先	住友倉庫工業株式会社 東京製鉄所 炭			
納入先	住友倉庫工業株式会社 東京製鉄所 炭			
炉名	3HS	部位	1号炉室 炭風出口	
品名	通し番号	品質名	寸法区分	積載
1C-150	1	Sillmax 63S	1100 x 914 x 1090	150
東陽商事株式会社			GW	1368 kg

LAEA00301000389
CSH100B; SILLMAX 55 CHEQUERBRICK;
SIDERURGICA HUACHIPA
Box: SR225219 150 PC
Gr. Wt: 994 KG Net Wt: 959 KG
Dim: 1100 x 914 x 1090 Packed: 22/06/02

The final stage of the operation is the marking/labelling of the bricks and the appropriate packing for transit to the final destination.

Bricks may be individually marked or colour coded.

Pallets may have special packaging and/or labelling.

Traceability codes form part of the labelling





# The Application of Refractories



Refractory materials are selected for a particular application in consideration of their properties against the environment that they must survive.

Often there will be more than one option and more than one cost and the final decision will be made in consideration of the life expectancy and the cost effectiveness of the lining configuration.

There may be a balance between :

- long life but expensive
- cheap but short life and increased replacement/repair costs.



# The Application of Refractories

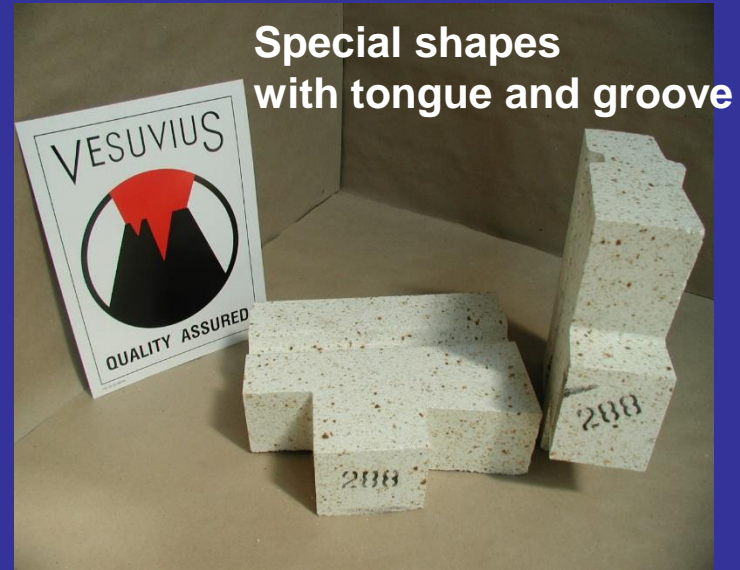


No refractory material is “perfect”.

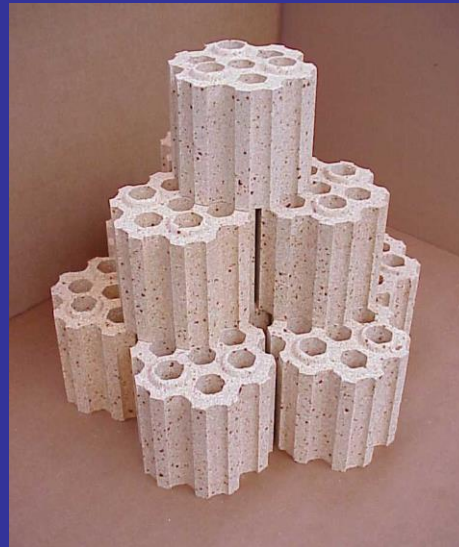
Selection will consider an optimum balance of a combination of the physical and chemical characteristics of the particular products considered for a chosen application.



# Bricks come in all shapes and sizes



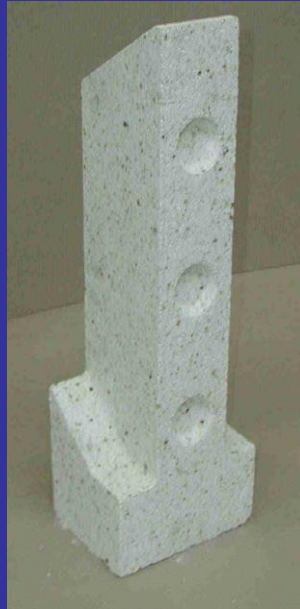
Bricks which are designed to store and release heat in regenerators.





# Bricks come in all shapes and sizes

**Bricks and blocks  
which form part  
of a large  
jigsaw puzzle.**











# Bricks come in all shapes and sizes

Bricks and blocks  
where the jigsaw  
must be built  
and measured.

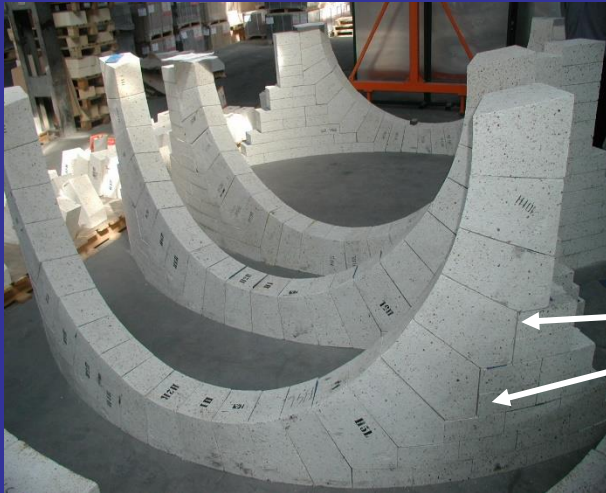


A preassembled snorkel for a steelmaking RH vacuum degasser.



# Bricks come in all shapes and sizes

Bricks and blocks where the jigsaw must be built and measured.



A precast outlet ring made to join a horizontal cylinder to a vertical cylinder

A brick outlet ring made with steps to mate with courses of standard brickwork.



Pre-assembly of a full furnace roof



# The Application of Refractories

In most cases, refractory materials are installed where they will be used, inside the furnace or application.







# The Application of Refractories

In some cases, refractory materials are installed outside a furnace so that a pre-lined unit can be installed and save valuable and costly turn-round time and lost production.







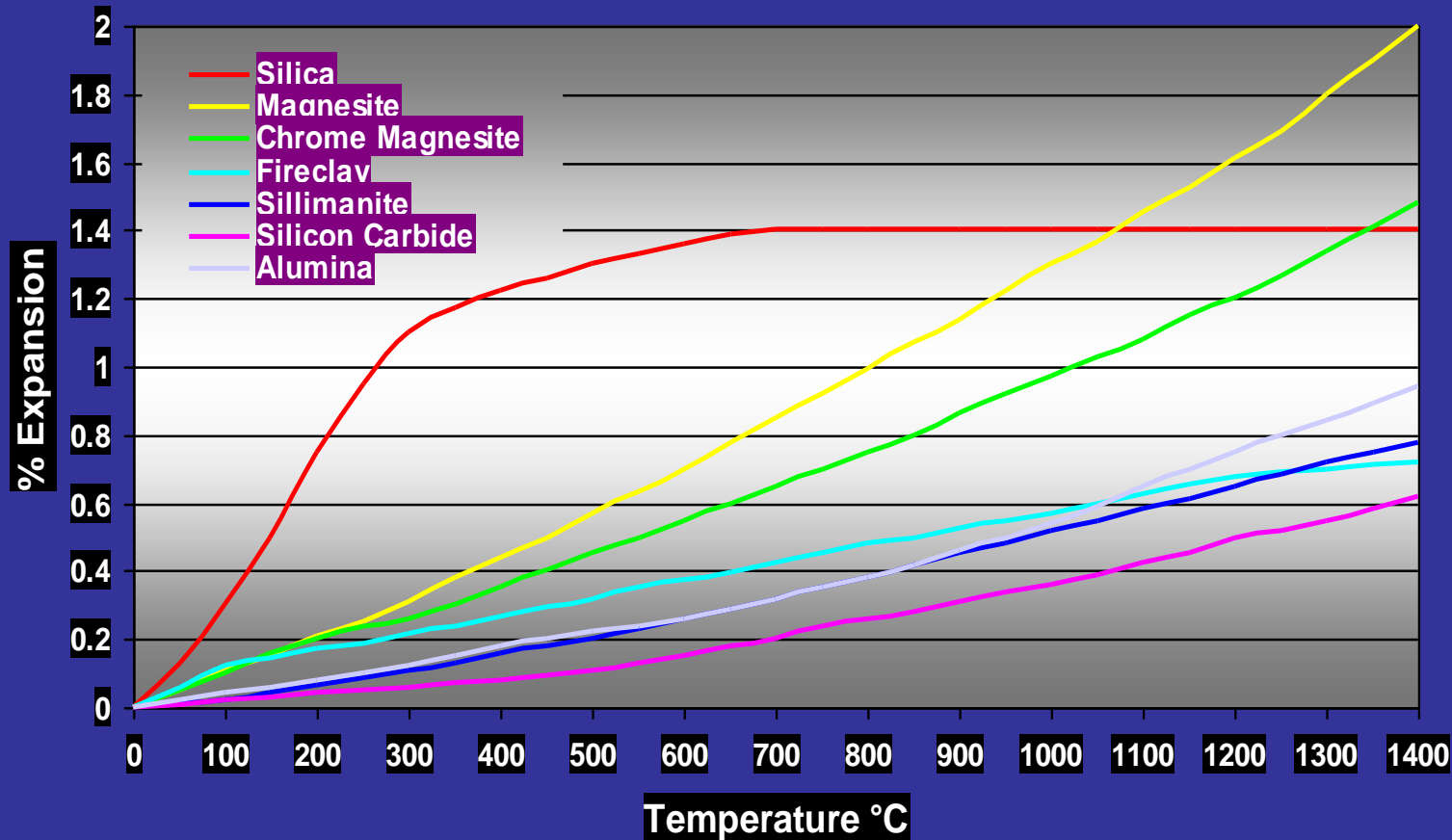
# Properties to be considered

- Chemical Composition
- Resistance to attacking chemicals (slags, fluxes, reactants, etc.) in both liquid and vapour form.
- Resistance to oxidation.
- Resistance to hydration.
- Porosity and water absorption.
- Pore size distribution.
- Gas permeability.
- Density.
- Strength (Compressive and tensile).
- Accuracy of dimensions.
- Accuracy of shape.
- Abrasion resistance.
- Specific heat.
- Thermal Conductivity.
- Electrical resistivity.
- Thermal shock resistance.
- Refractoriness (Melting point).
- Refractoriness under load.
- Creep under compression.
- Hot Modulus of Rupture.
- Young's Modulus (Stress/Strain).
- Thermal expansion.



# Properties to be considered

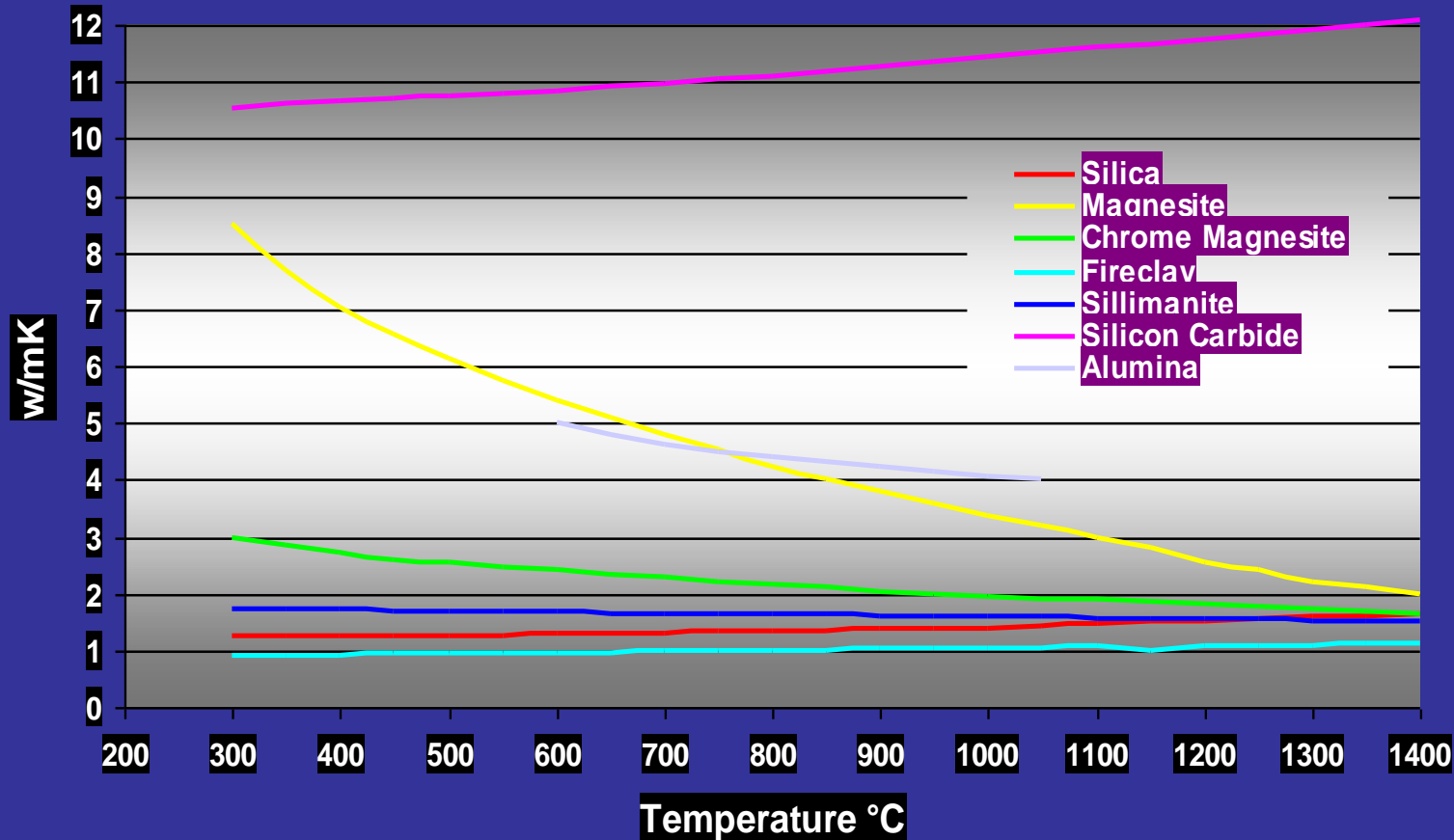
## Thermal Expansion





# Properties to be considered

## Thermal Conductivity

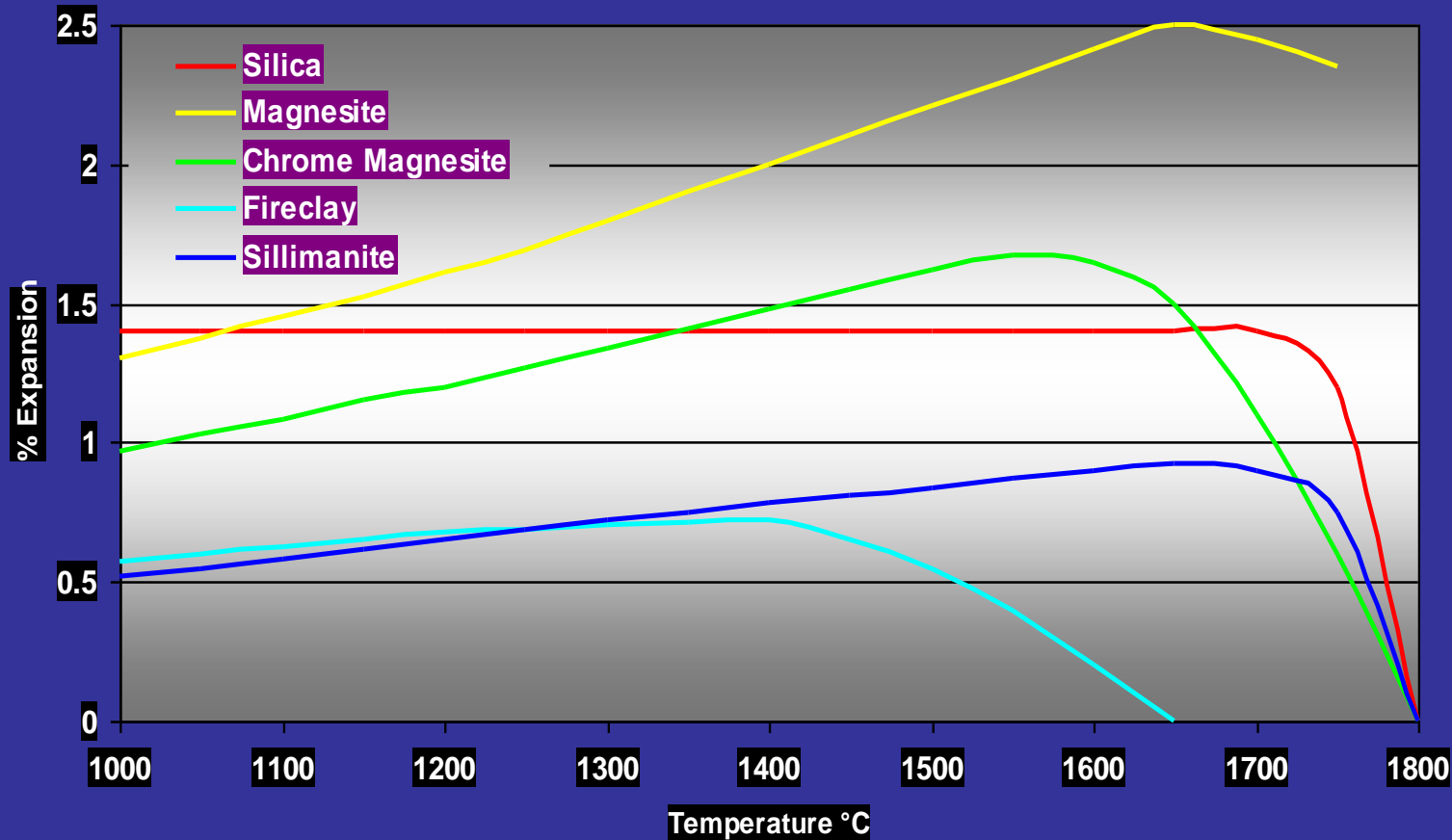






# Properties to be considered

## Refractoriness under load





# The Operating Conditions to be considered

## 1. THERMAL

What is the application and what furnace type applies ?

What is the size of the furnace ?

Which sections are to be relined/repared ?

What temperatures will be encountered ?

How much temperature variation can be expected ?

Will operation be continuous or cyclical ?

Where is heat applied ?

How quickly is the heat applied ?

What restraints apply ?

What restraints should be applied ?

What restraints will be adjusted during commissioning/decommissioning ?

Thermal shock resistance.

Refractoriness (Melting point).

Refractoriness under load.

Creep under compression.

Hot Modulus of Rupture.

Young's Modulus (Stress/Strain).

Thermal expansion.



# The Operating Conditions to be considered

## 2. MECHANICAL

Is the application static ?

What actual movement occurs ?

What contact is made with the furnace lining ?

What internal influences apply (charge, etc.) ?

What is the nature of the contact (gas, particle, solid, liquid) ?

At what speed is contact made ?

What external influences apply (vibration, etc.) ?

Can the furnace deform ?

Density.

Strength (Compressive and tensile).

Elasticity

Accuracy of dimensions.

Accuracy of shape.

Abrasion resistance.





# The Operating Conditions to be considered

## 3. CHEMICAL

What is the chemistry of the environment ?

Which gases, vapours, liquids will be present ?

Will they change/be changed ?

In what quantities ?

At what times, in what frequency ?

How will the environment react with the refractories in theory ?

How will the compounds react with each other ?

What are the products of combustion ?

Will they be changed ?

**Chemical Composition**

**Resistance to attacking chemicals  
(slags, fluxes, reactants, gases etc.)**

**in both liquid and vapour form.**

**Resistance to oxidation.**

**Resistance to hydration.**

**Porosity and water absorption.**

**Pore size distribution.**

**Gas permeability.**



# The Operating Conditions to be considered

## 4. OTHER

What has and has not worked in the past ?

What, if anything, has changed since the last operation/s ?

What restrictions apply to the installation

(access, size of inlet, shell steelwork, opening location etc.) ?

What turn round time is allowed ?

How long will there be between installation and commissioning ?

How will the lining be protected during this period ?

What heat treatment will be given prior to the time lag ?

Will the installation be moved before use ?

Will strict commissioning guidelines be approved and followed ?

What is proven to work in this/similar applications ?

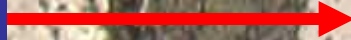
Can the installation be mechanically or chemically damaged before it goes into service ?

Can the installation be mechanically or chemically damaged as it goes into service ?

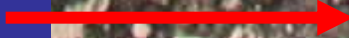


## Typical Microstructure – Unfired – Chemical Bond

Grain



Matrix







## Typical Microstructure - Fired

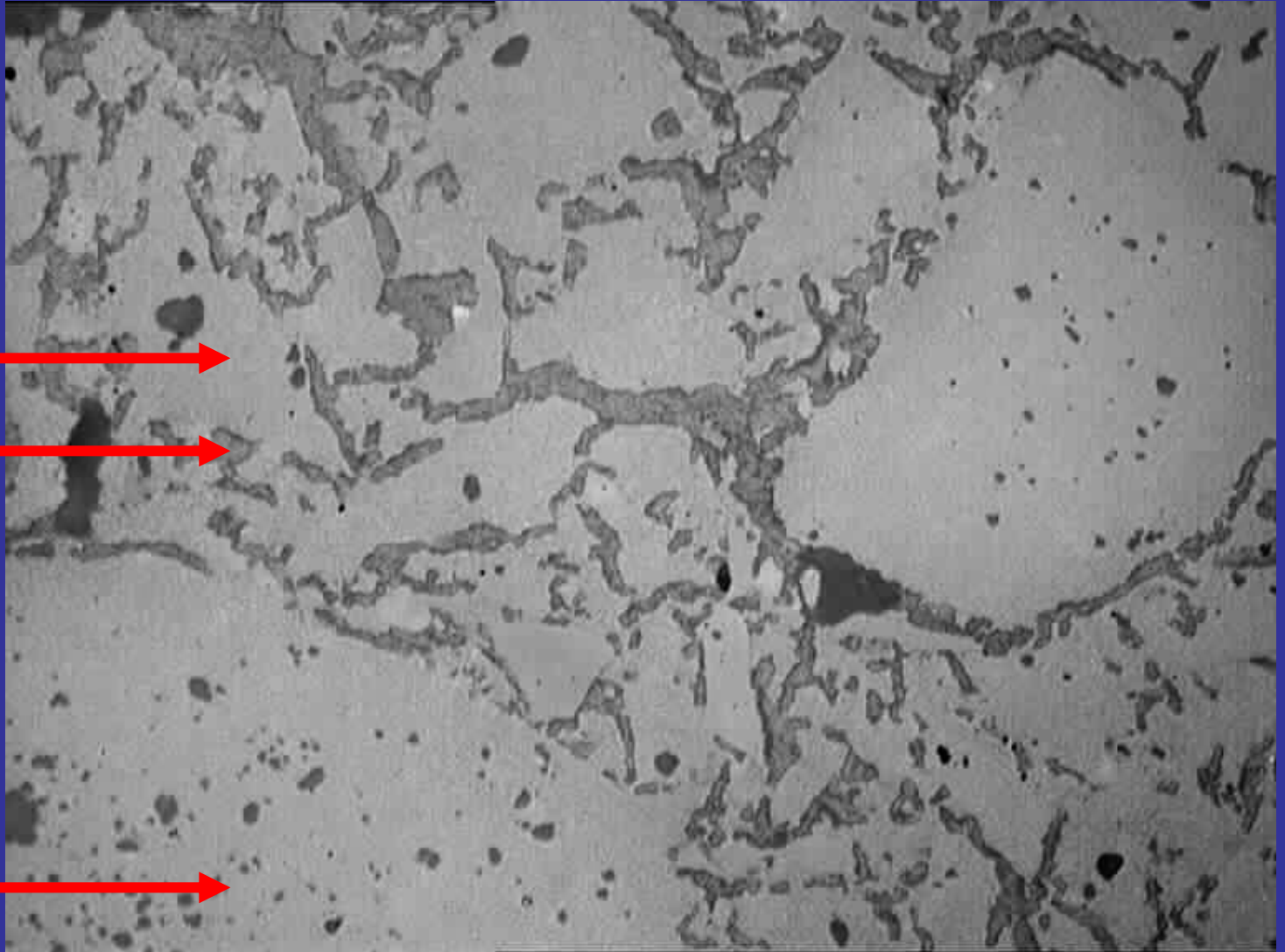
Matrix



Pore



Grain



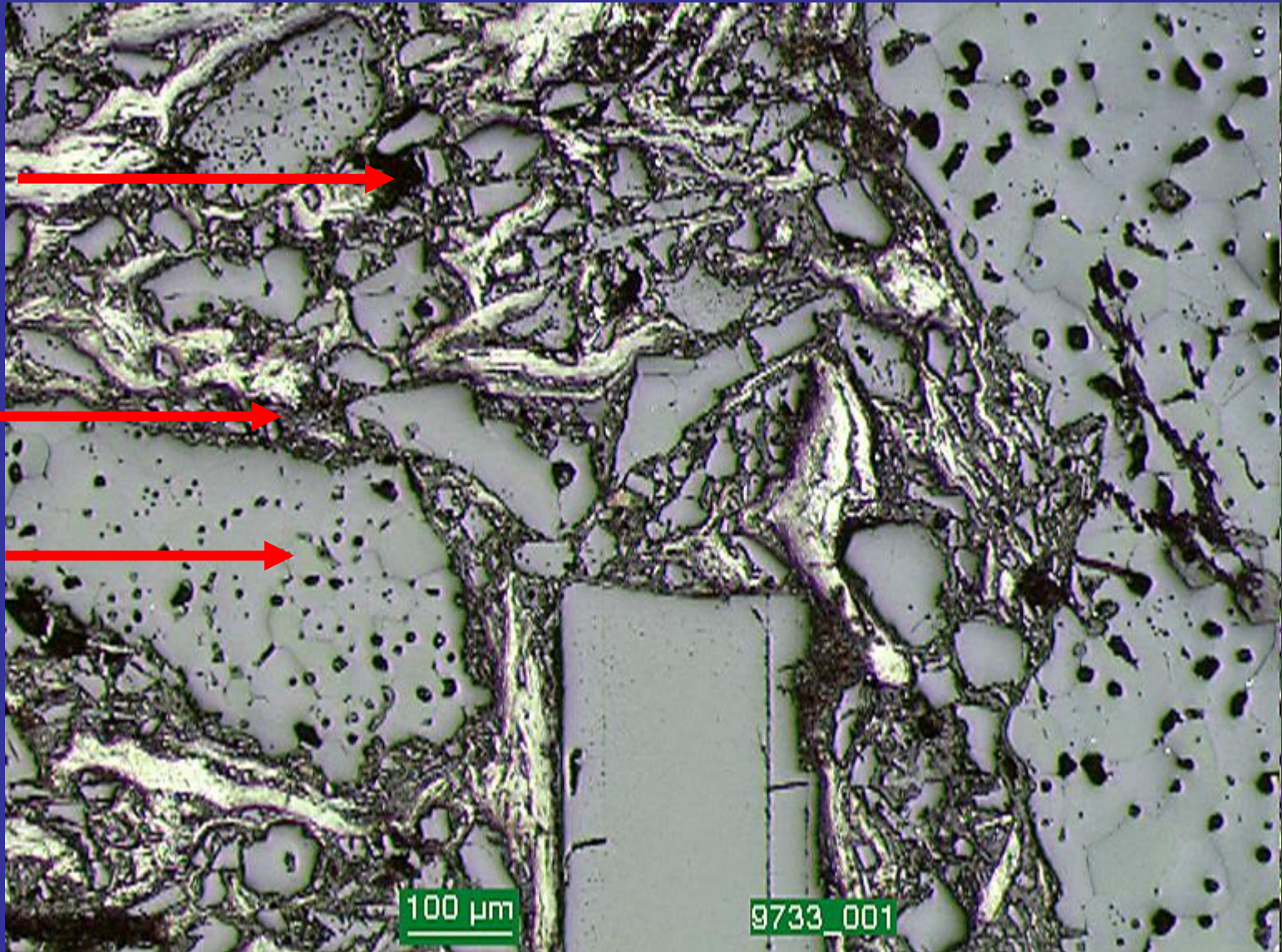


## Typical Microstructure – Unfired – Carbon Bond

Pore

Matrix

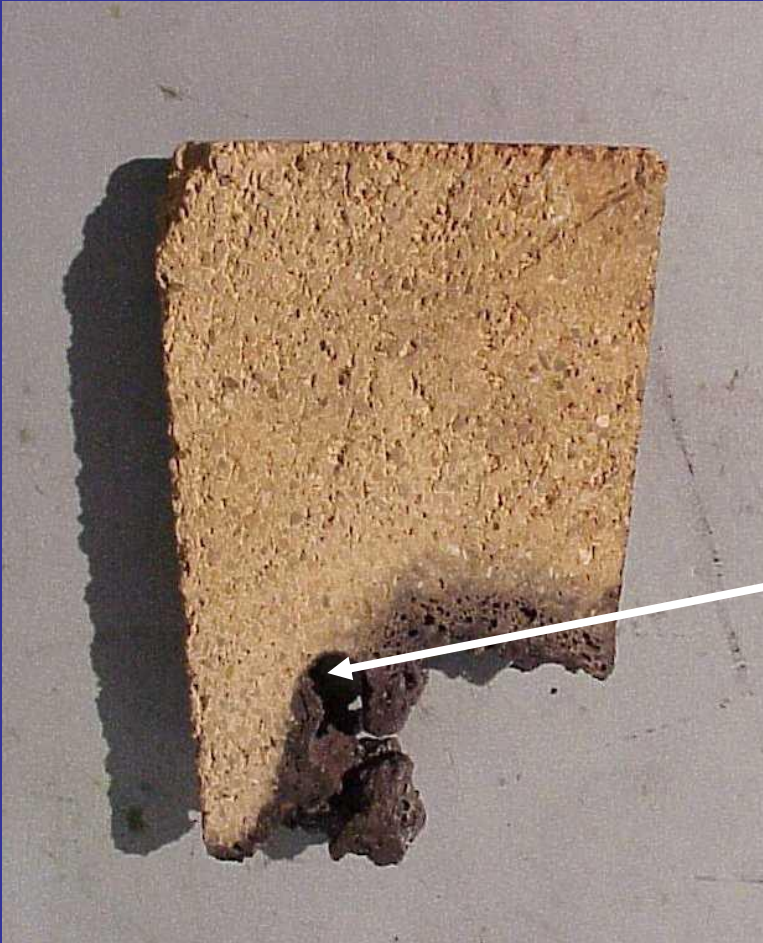
Grain







# The things that happen to refractory bricks



Installed in the roof of an electric arc furnace

Heavy iron rich splatter coated the face of the brick and the brick became electrically conductive.

The electric arc tracked into the brick causing concentrated and localised overheating.





# The things that happen to refractory bricks



A bricks after service in a Chlorinator where chlorine gas has reacted with the alumina content of the brick and left a weakened and friable surface

Gas passing along mortar joints has reacted with the outside faces of the brick.



# The things that happen to refractory bricks



**Basic bricks from a  
combustion chamber.**

**The bricks have densified in  
service and thermal cycling  
has caused the dense hot face  
to slab off.**



# The things that happen to refractory bricks



**Basic Magnesia Chrome bricks in a degasser snorkel.**

**Thermal cycling has lead to thermal expansion related stress development which has given the bricks the characteristic 'cobbled' appearance**



# The things that happen to refractory bricks



**A silica brick from the roof of a glass furnace.**

**The operators thought the furnace had been switched off over the weekend but they left the gas switched on and the burners firing.**

**The roof overheated until it melted and long viscous strings of molten silica dropped from the roof.**





## Disadvantages

- Lead Time
- Installation Time
- Installation Cost
- Skills for installation
- Joints between pieces



## Advantages

- Volume Stable
- No Water – no need to dry out
- Certain Chemical Compositions only possible in brick
  - Carbon Bond
  - CaO containing (eg Doloma)
- Hot Load Capability



Thank You For Your Attention