Institute Of Refractories Engineers

Bricks and Shapes

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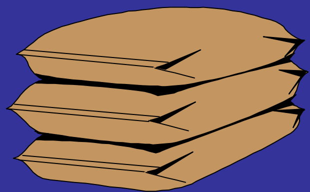
The Forms of Refractory Materials

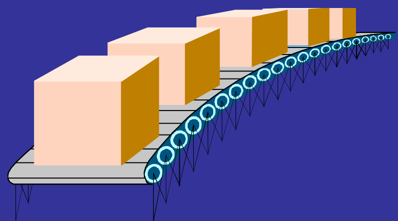
Pressed/Formed Bricks

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

Monolithics

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





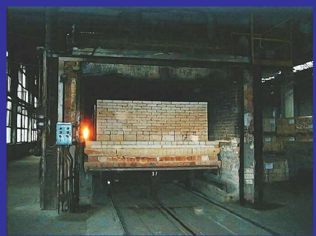
Types of Material

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

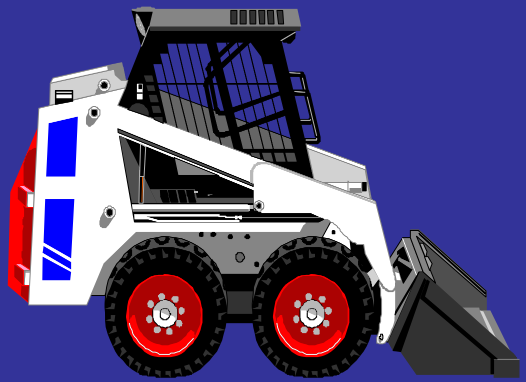
The Production of Bricks

Process raw material → Dry and Crush → Screen and Recycle → Batch to formulation

Form (Press/Ram) → Dry/Cure → Dry & Fire → Finish+Inspect +Pack



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.

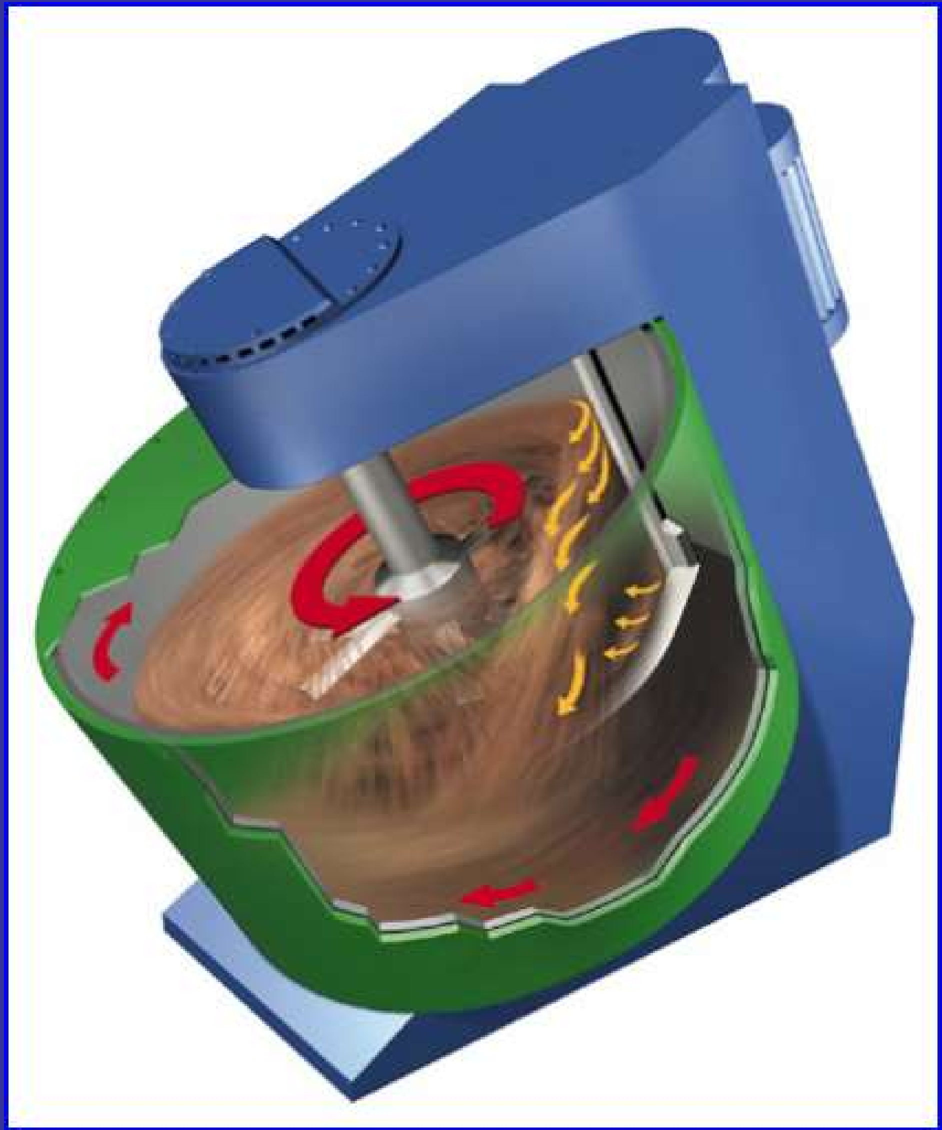
Ingredients, both solid and liquid, are added in controlled sequence and controlled proportions.

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

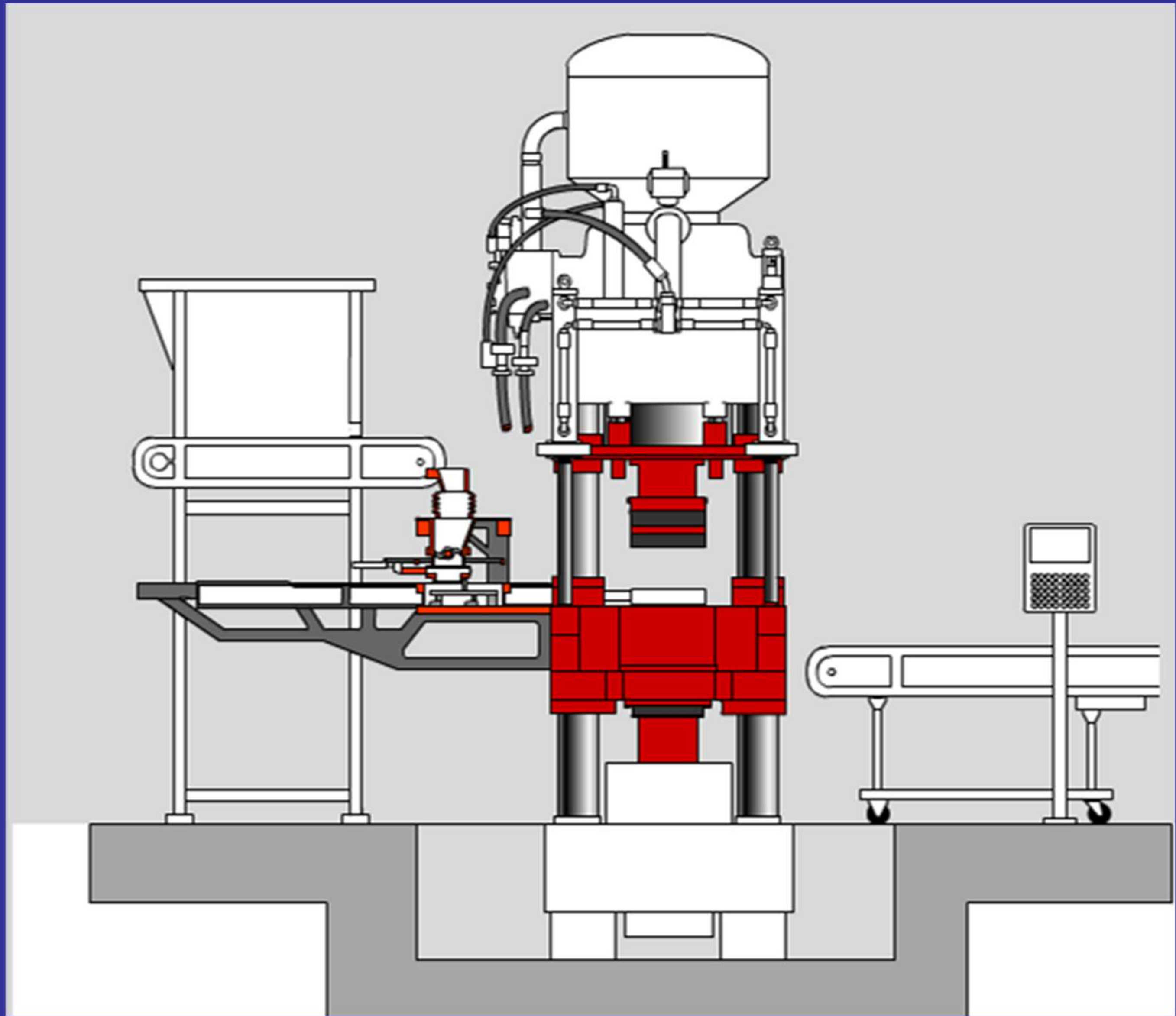


The Production of Bricks

Pressing

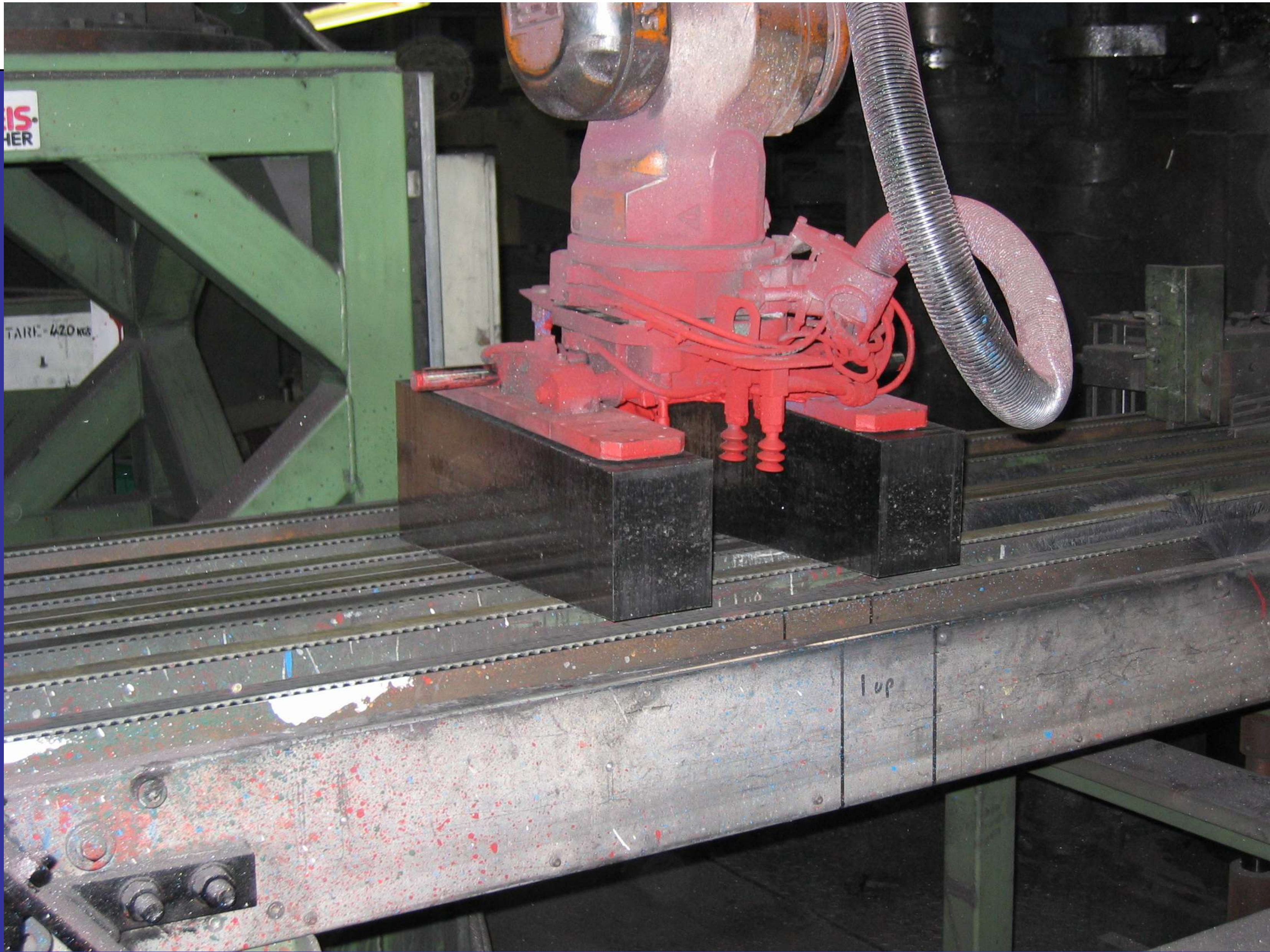
Most bricks are machine pressed.
Presses can be automated hydraulic, manual hydraulic, mechanical, impact or friction types. The presses operate over a wide range of forming pressures, making bricks from one to four at a time, frequently with robotic pick-up. Very sophisticated control systems can be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

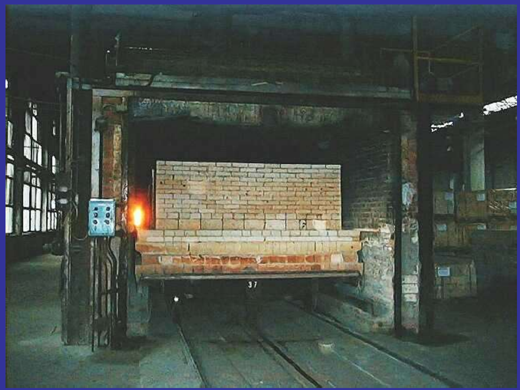
The Production of Bricks

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.

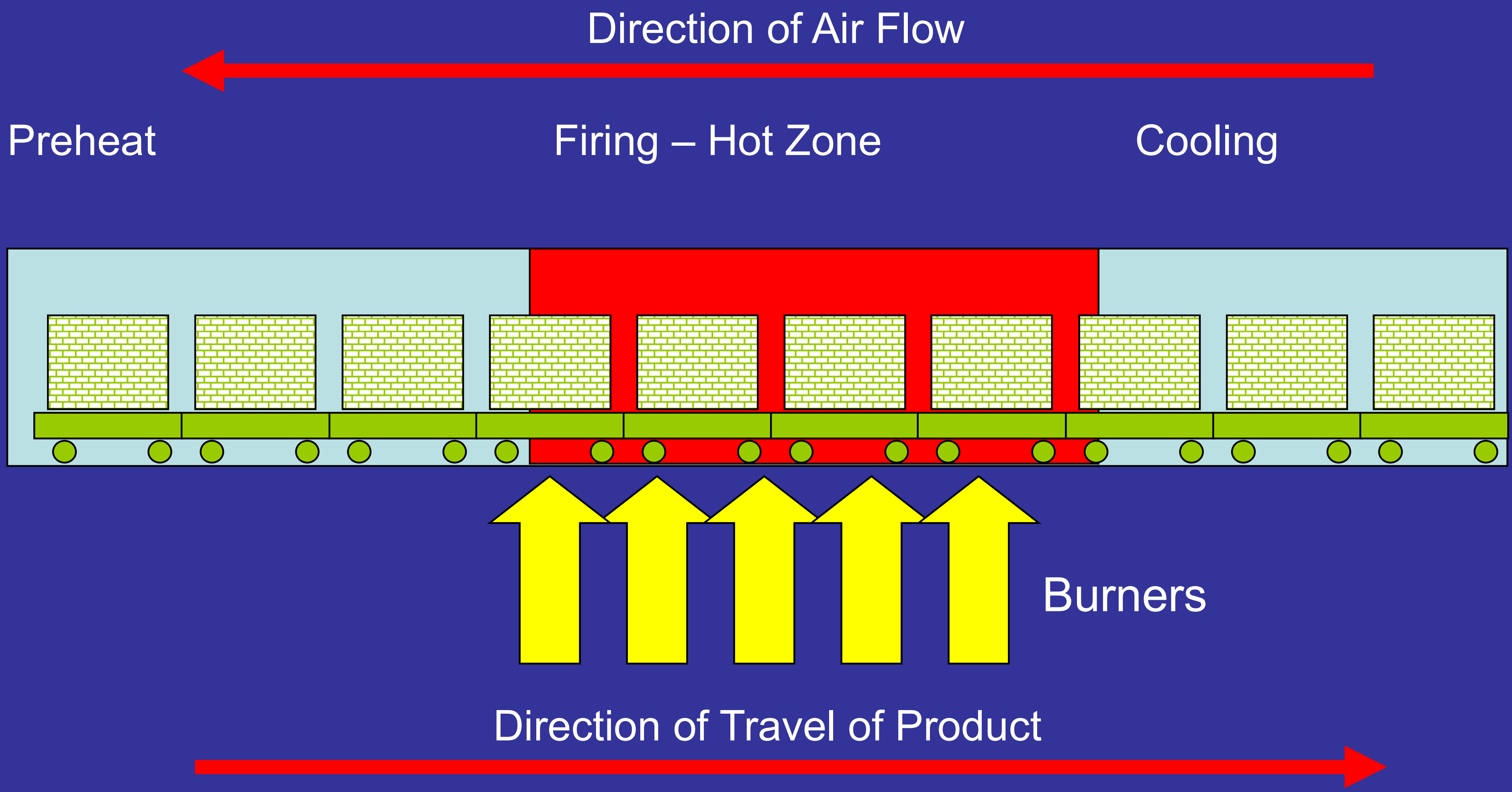
Residence time can be 6-15 days, even longer for silica bricks, with a total firing time, inclusive of the important controlled cooling period, of 7 - 28 days.

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

Firing – Batch Kiln

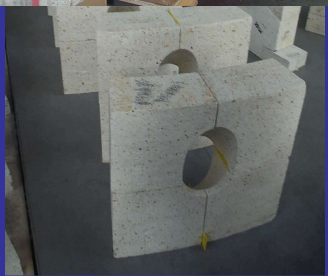
Firing – Tunnel Kiln

Firing – Tunnel Kiln



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

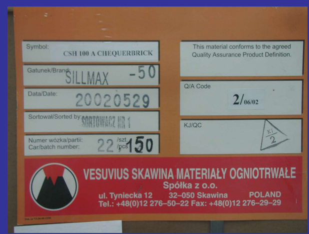
Supplementary Physical Properties
- Creep Resistance
- Refractoriness under load
- Abrasion resistance
- Thermal Shock Resistance
- Thermal Expansion
- Thermal Conductivity
- Hot Modulus of rupture

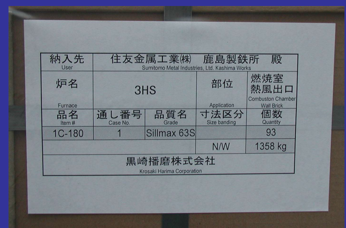
Control Properties
- Apparent Porosity
- Bulk Density
- Cold Crushing Strength

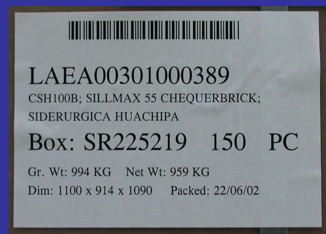
Chemical Analysis

The Production of Bricks

Marking and Packing







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.

Their may be a balance between :

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

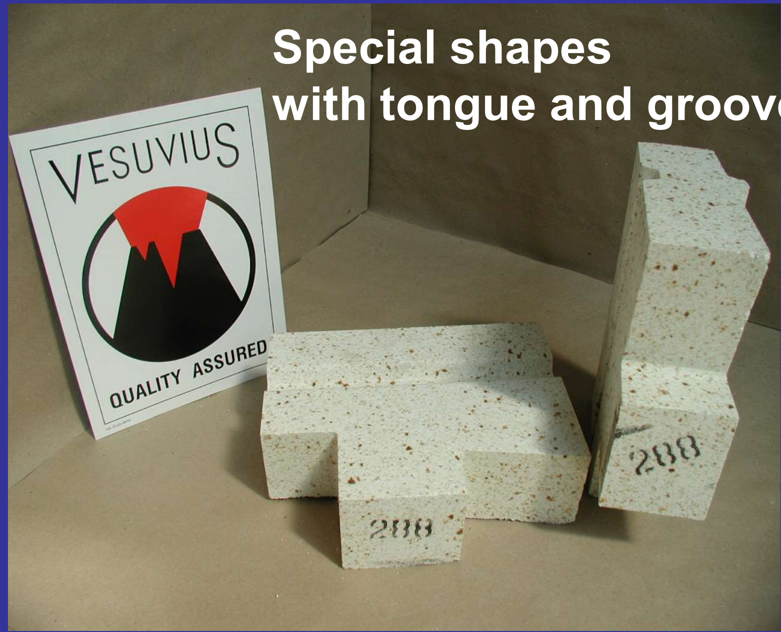
The Application of Refractories

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.

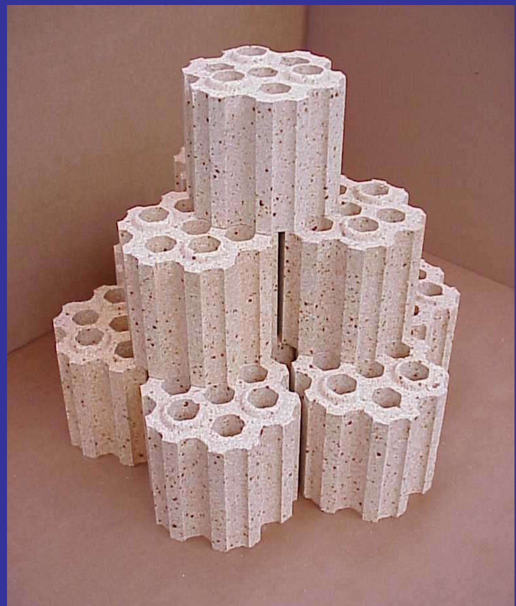
Bricks come in all shapes and sizes

Standard shapes



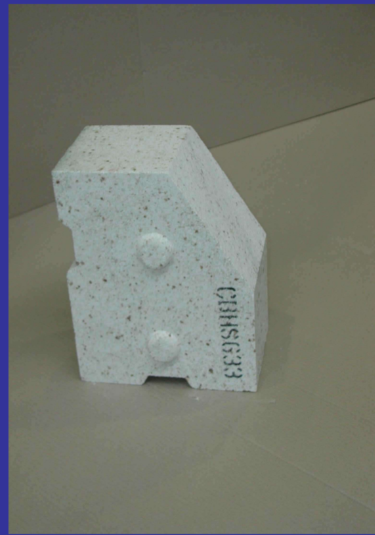
Special shapes
with tongue and groove

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.




15F8M
EBT/C-140

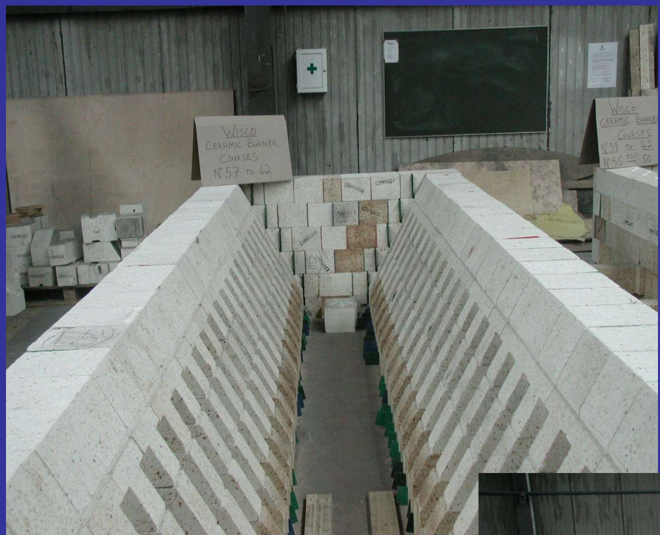
Bricks come in all shapes and sizes

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

A suspended flat arch made from
precast and fired special shapes.

Bricks come in all shapes and sizes

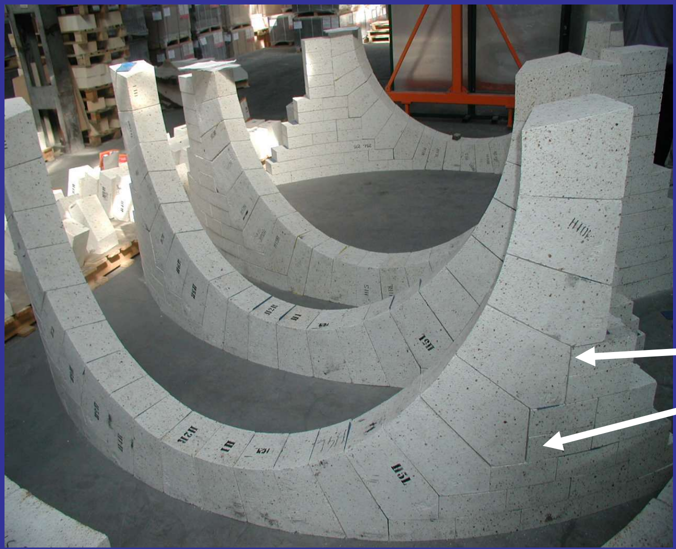
Bricks and blocks
where the jigsaw
must be built
and measured.



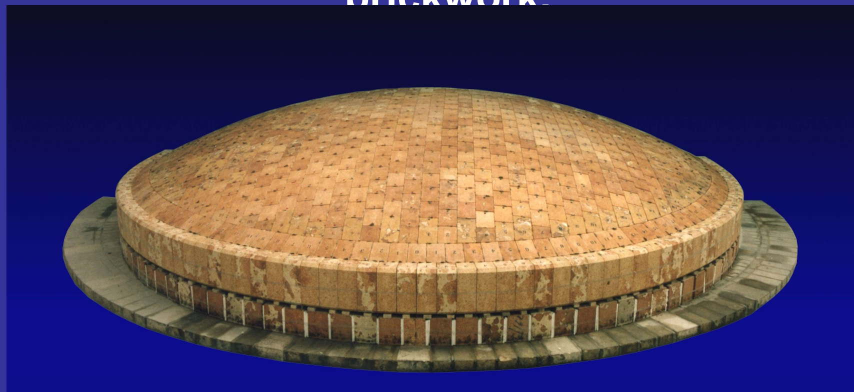
A ceramic burner
for a hot blast stove
designed to allow gas
mixing through the
burner slots

Bricks come in all shapes and sizes

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



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



Pre-assembly of a full furnace roof

Bricks come in all shapes and sizes

The Application of Refractories

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

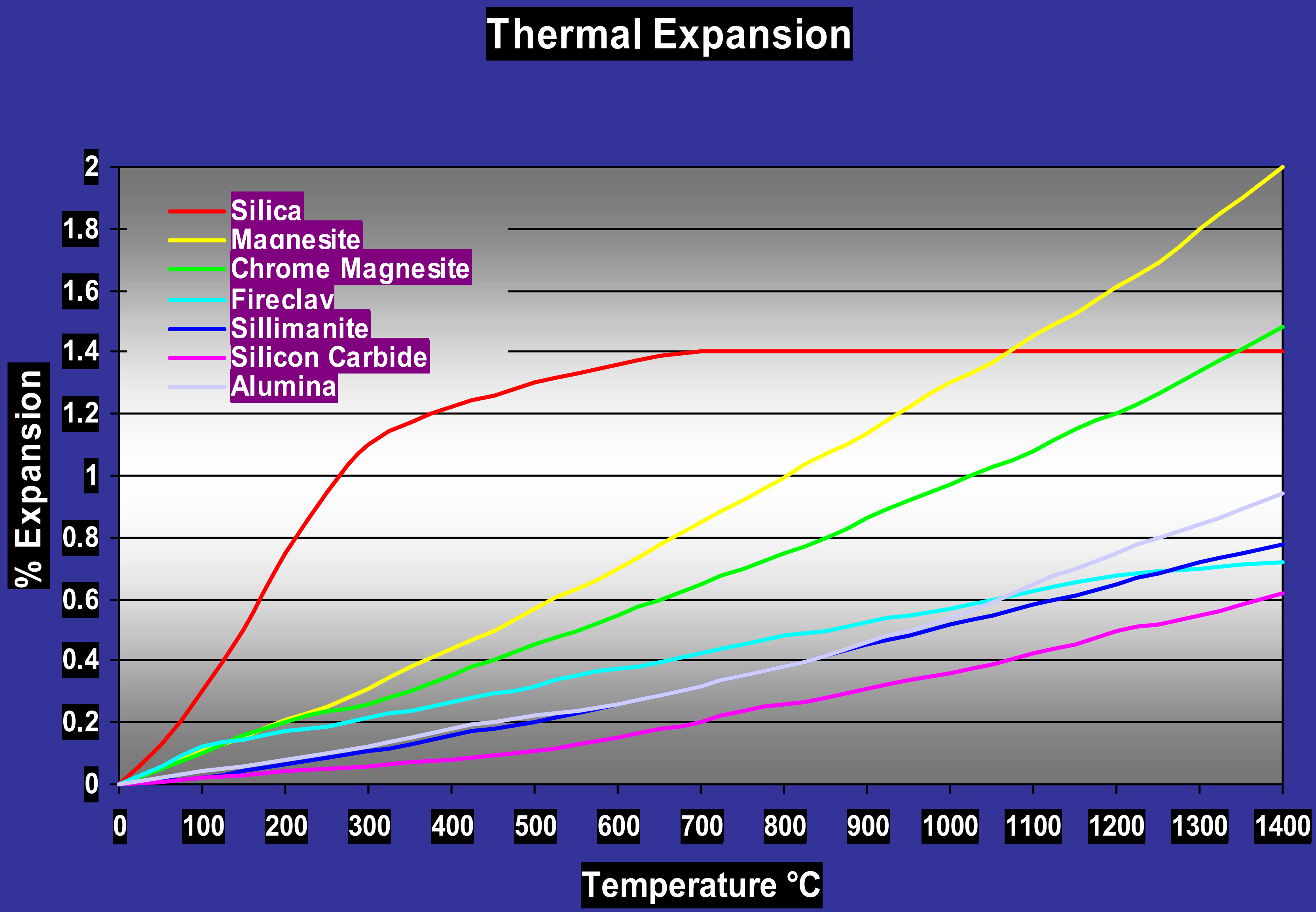
The Application of Refractories

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



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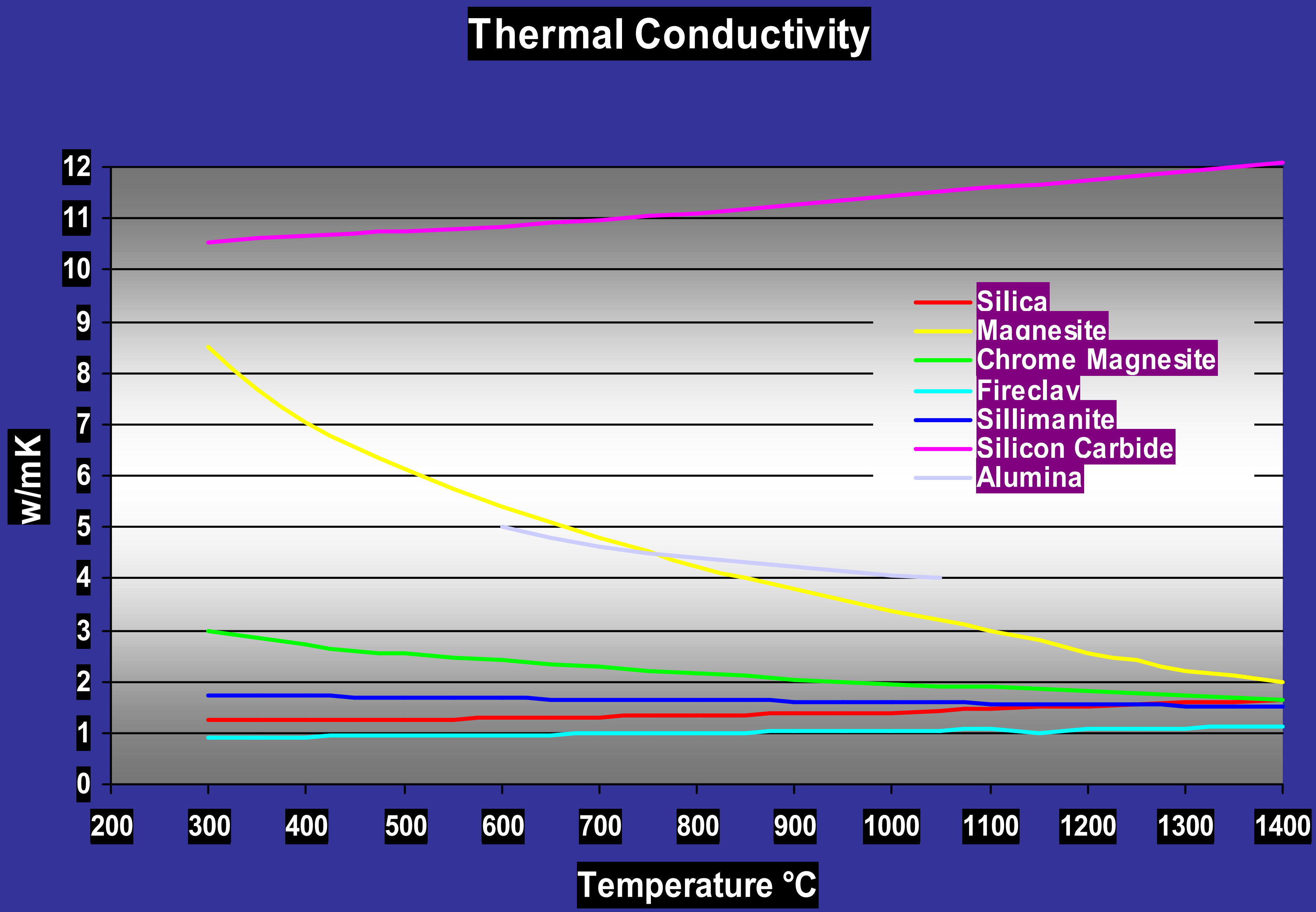
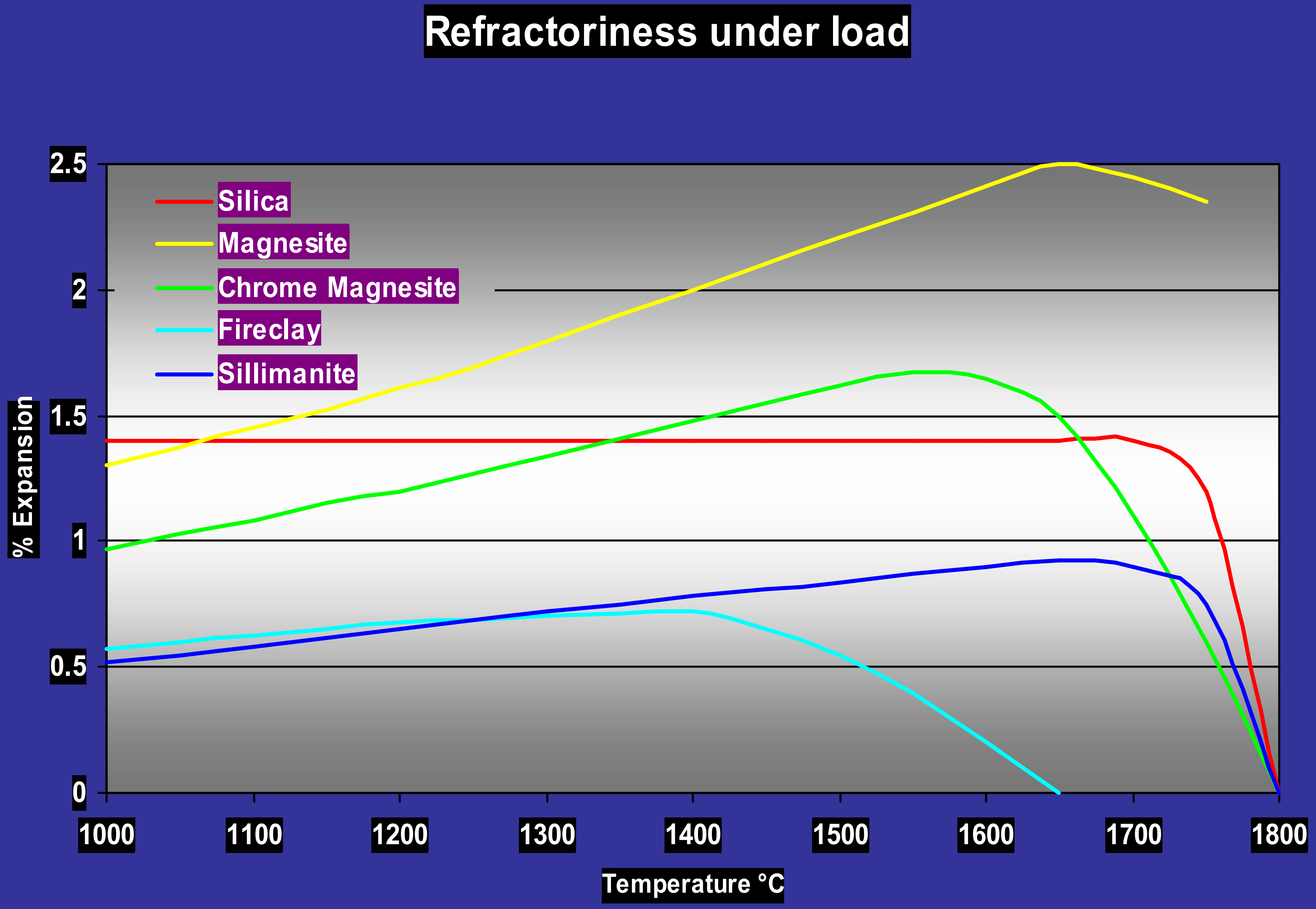


Properties to be considered



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/repaired ?

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 ?

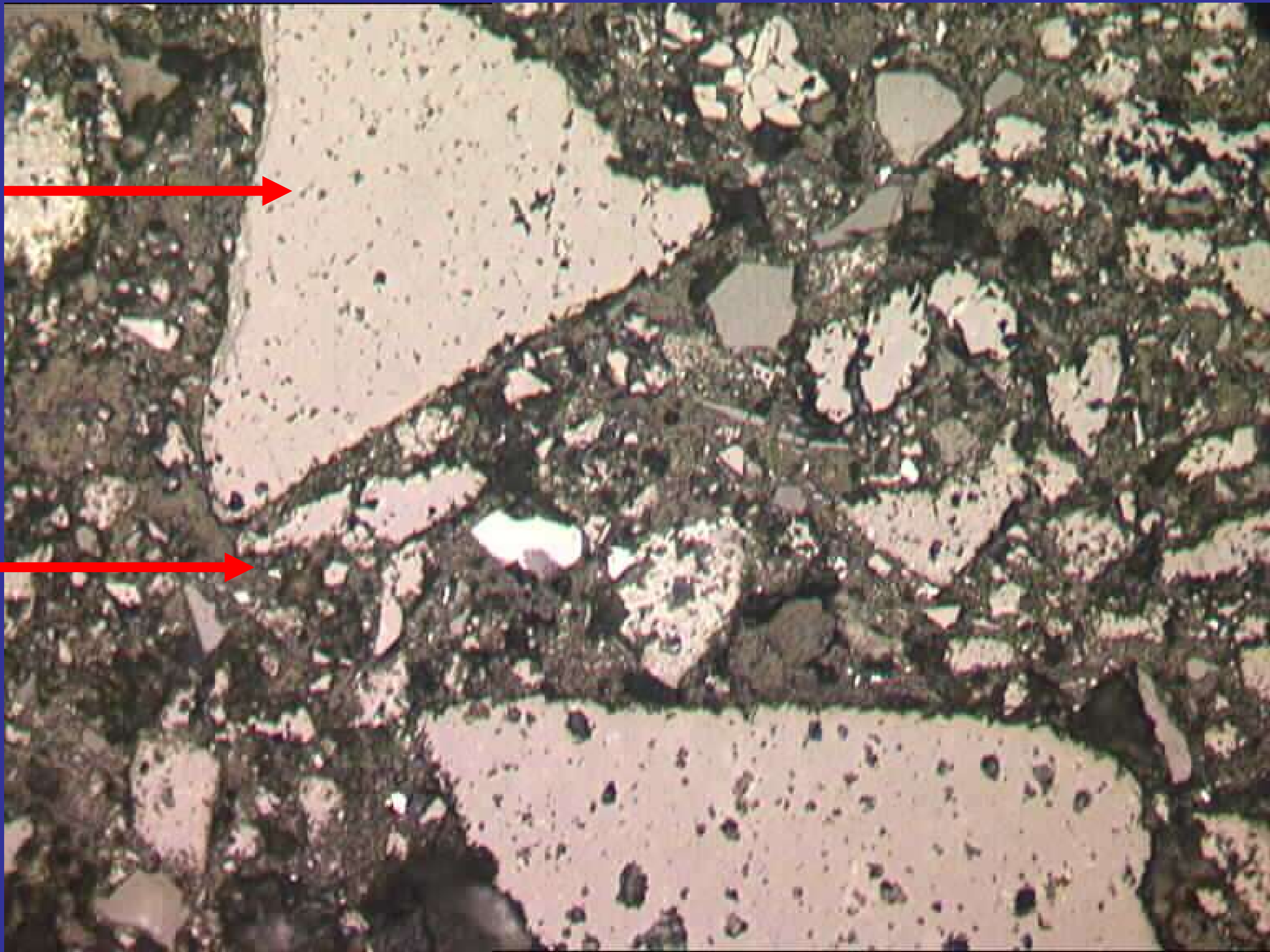
Can the installation be mechanically or chemically damaged before it goes into service ?

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

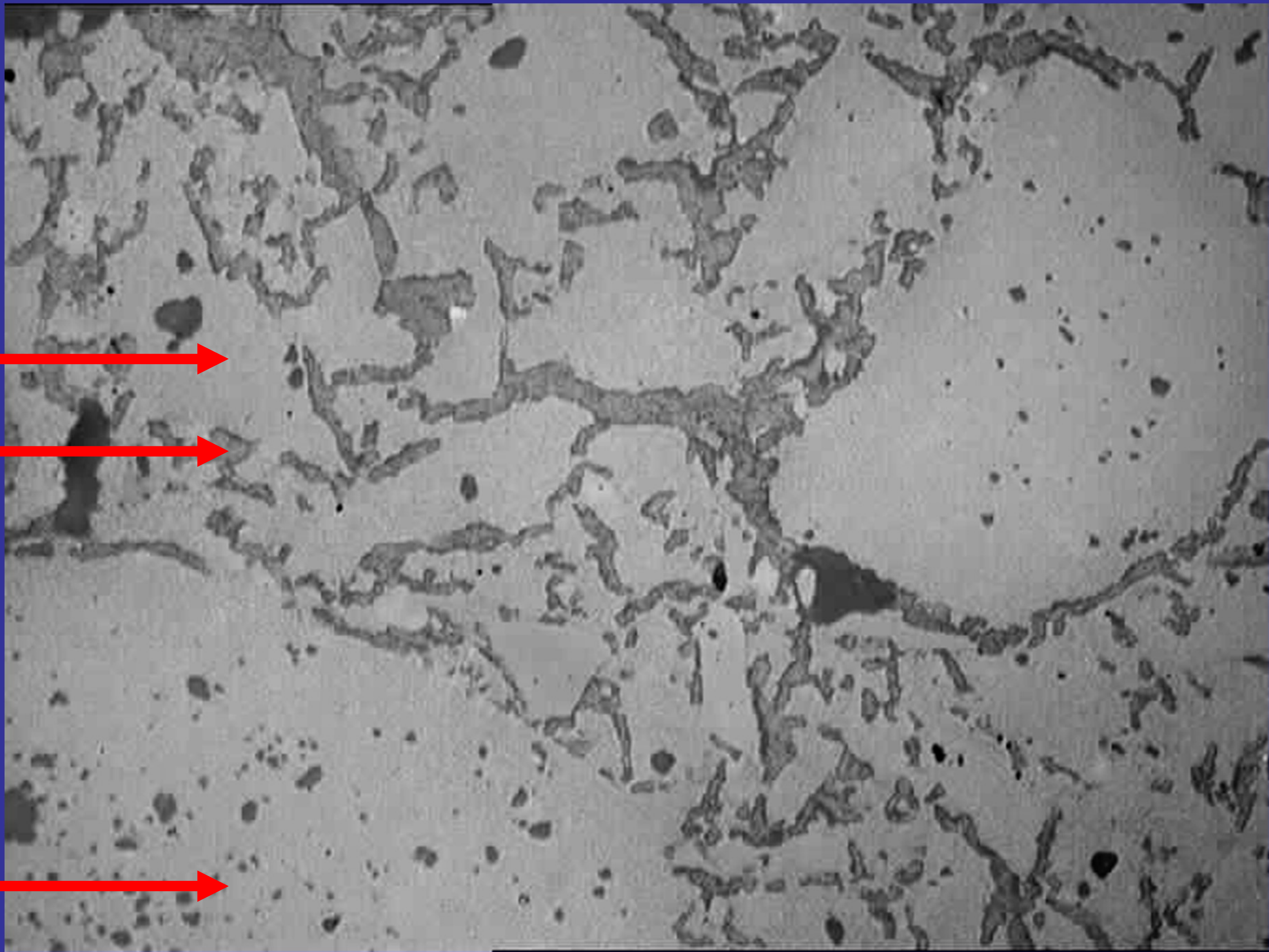
Typical Microstructure – Unfired – Chemical Bond

Grain

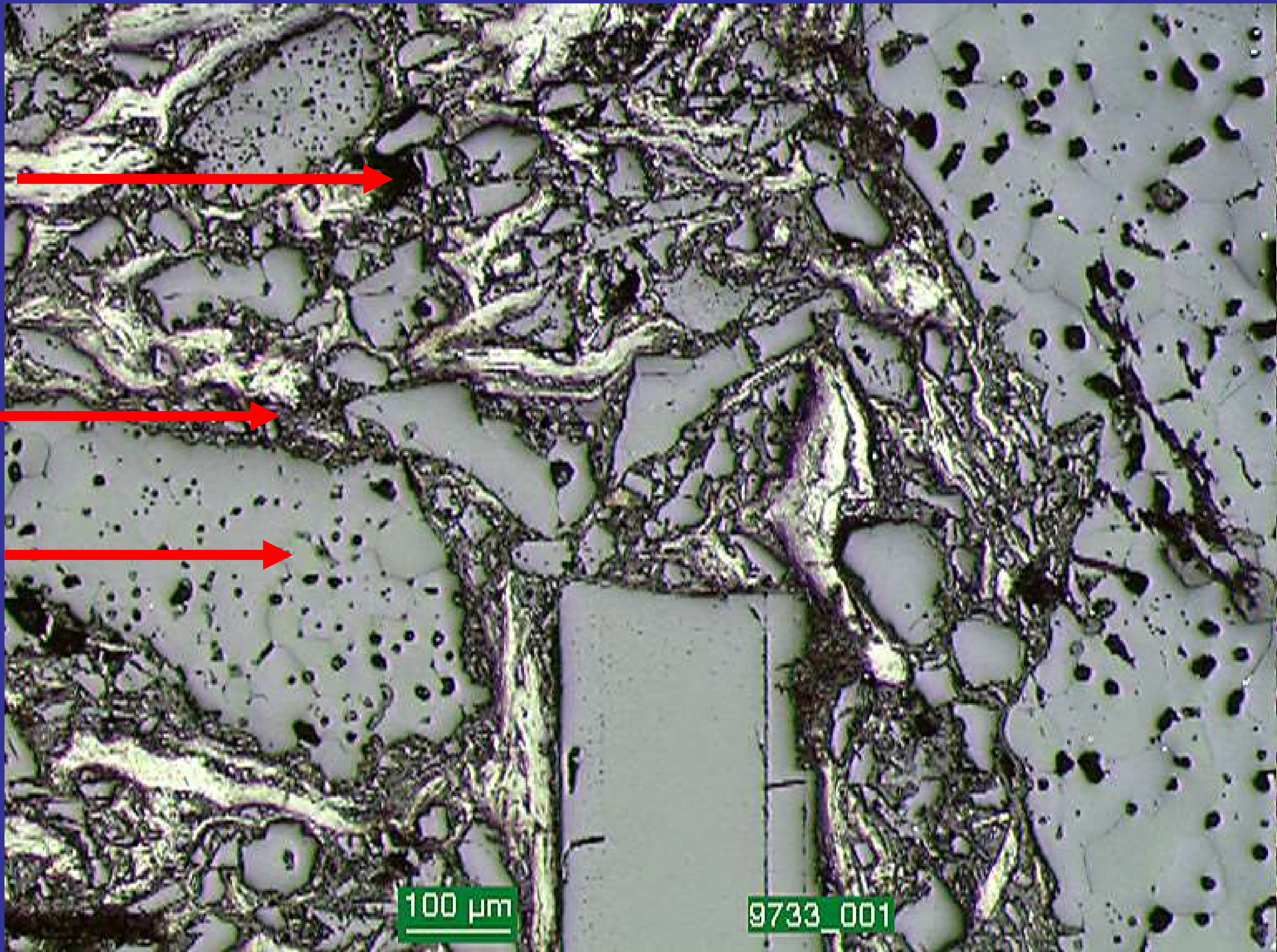
Matrix



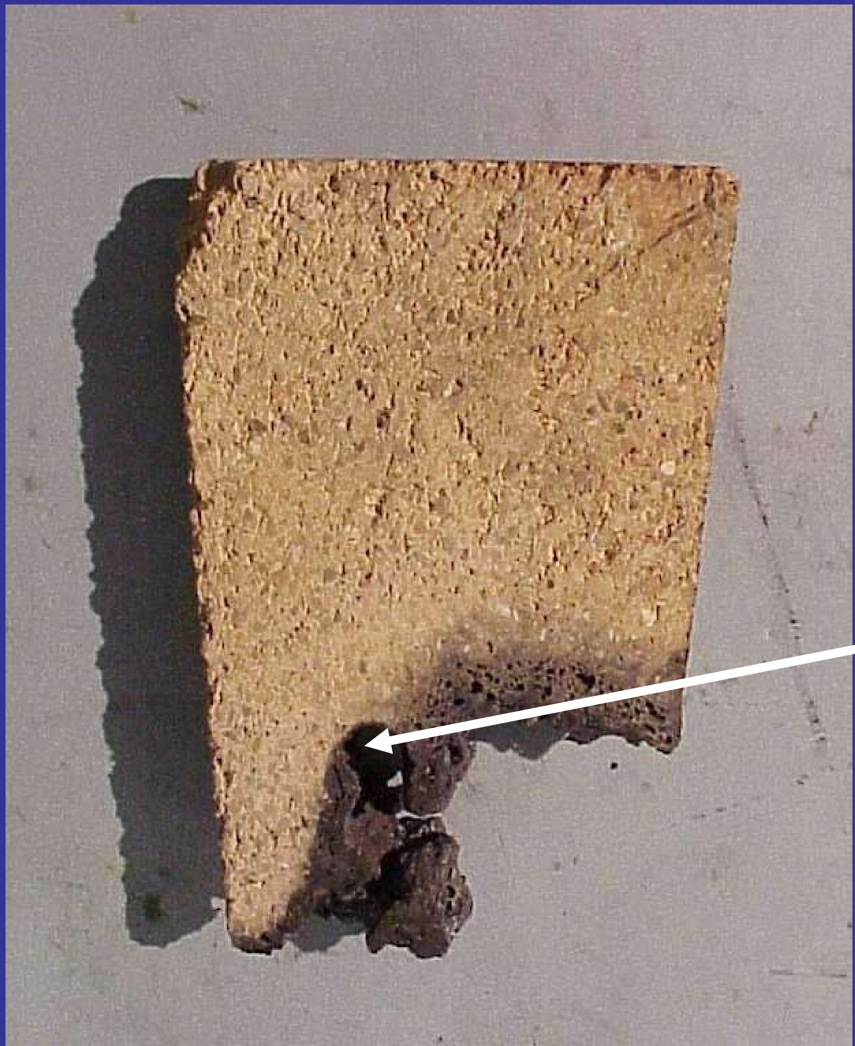
Typical Microstructure - Fired



Typical Microstructure – Unfired – Carbon Bond



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.

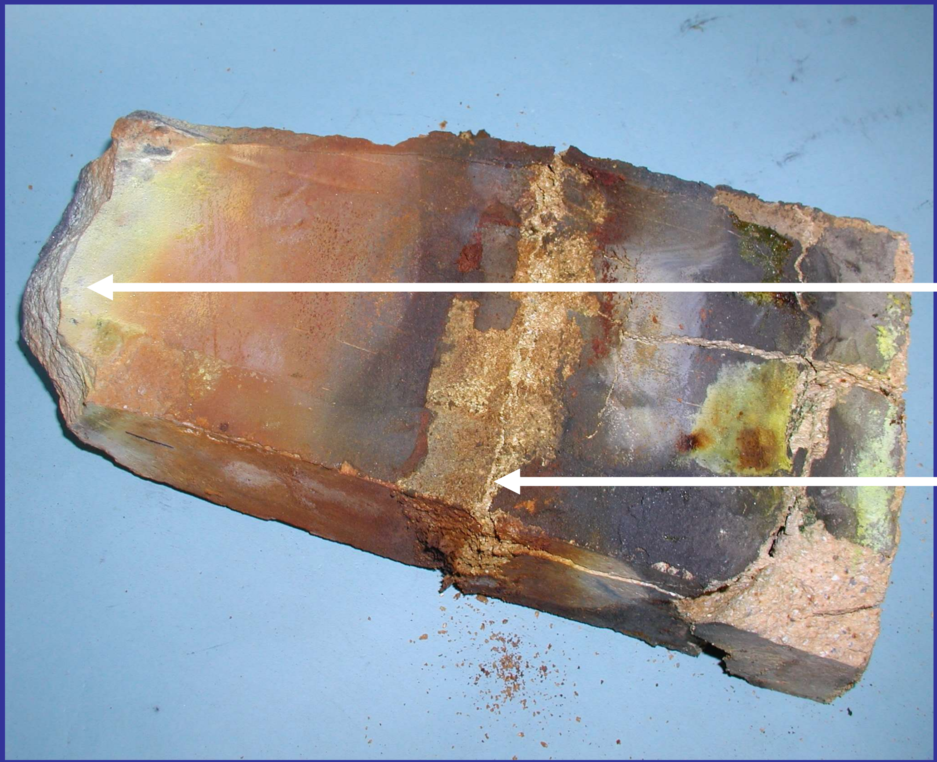
The electric arc tracked into the brick causing concentrated and localised overheating.

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



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

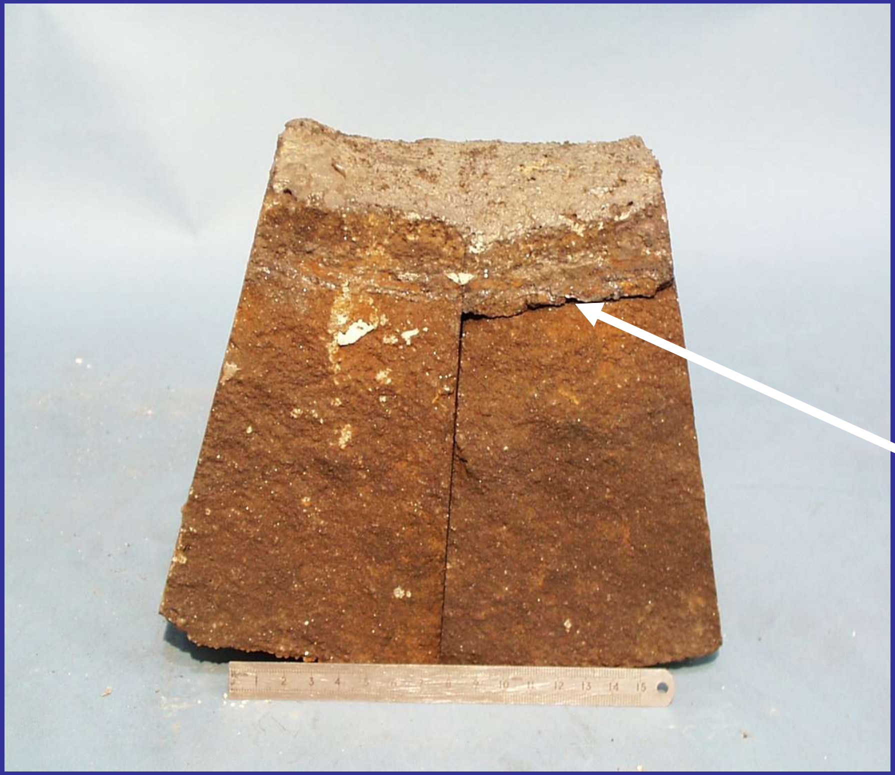
In addition, iron chlorides have penetrated the brick and condensed. Thermal cycling of the impregnated section leads to stresses and cracking of the brick.

The things that happen to refractory bricks

A bricks that has been in
molten aluminium.
Corundum (alumina) is
growing inside the brick
texture
and densifying the
brick texture.

Chemicals are now added to
the
brick to prevent the reaction.

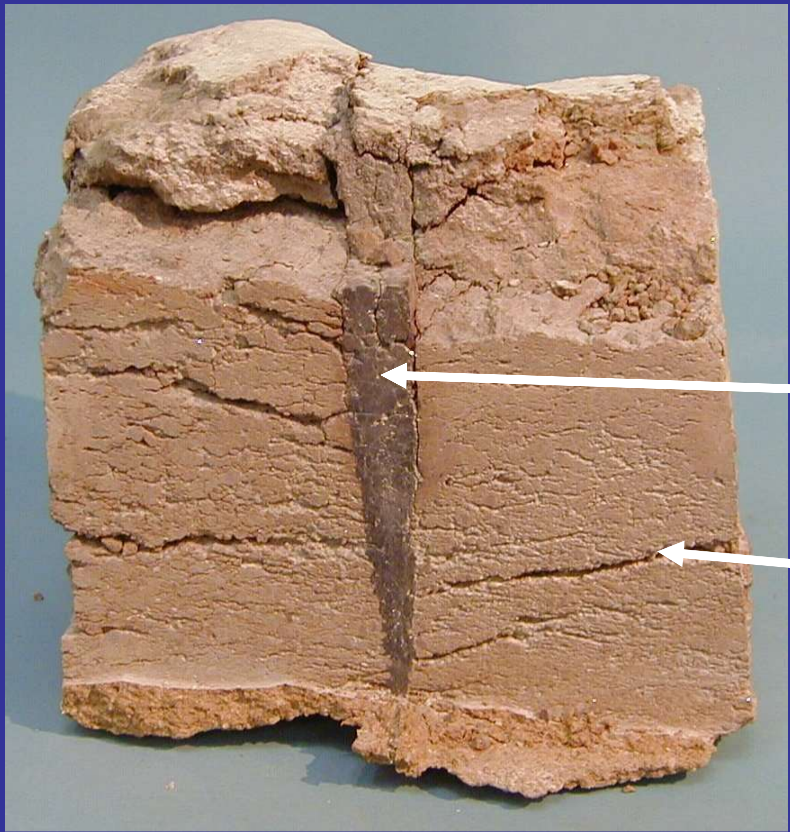
The things that happen to refractory bricks



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



Bricks after service in a cement kiln.

The original lining had slackened and instead of removing and replacing the slack section, a steel wedge had been driven in to tighten the lining.

In later operation the steel had oxidised and expanded and the expansion forces have led to extensive cracking of the bricks in this area.

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

Pre-cast Pieces

Brick and Pre-cast combined

Precast bottoms - Installation

Pre-cast Pieces

ADVANTAGES

- Large Complex Shapes Possible
- Ideal Casting Conditions
- Can be fully pre-dried
- Can Incorporate Other Parts
  - Anchors
  - Purge Elements

DISADVANTAGES

- Handling
- Shell Distortions
- Joints

Thank You For Your Attention