Institute Of Refractories Engineers

Introduction To Refractories

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Introduction:
What is a refractory?

Definition: Refractory Material

"A material which is non-metallic, inorganic and does not soften at temperatures below 1500°C."

Introduction:
What does a refractory do?

Put simply:

‘Contain or work within high temperature environments’

To do this a refractory must be able to withstand :

- **high temperatures**
- **variable temperatures**
- **chemical attack by gases**
- **chemical attack by liquids**
- **physical stresses**
- **mechanical wear**

(both separately and in combination)

Introduction: Refractories applications

- Refractory materials are extremely important and affect the operation and costs of any plant in which they are employed.
- The steel industry is the largest consumer of refractories both in this country and worldwide.
- Approximately 2/3 of all refractories are used in the steel industry.
- Other major usage areas for Refractories:

What are refractories made from?

‘Refractory Materials’!

Refractories are usually metal oxides

(or combinations of them)

manufactured from naturally occurring

raw materials or, less frequently,

from synthetically produced

raw materials.

Which metal oxides?

- Importantly - oxides which have high melting temperatures (or on carbon/carbides).
- Pure materials are rarely if ever used because of their high cost and properties that are not appropriate for meeting the conditions in a steelmaking environment.
- The melting temperature of some pure oxides are far in excess of those encountered in the intended applications.

- Silica	SiO_2	1726°C
- Alumina	Al_2O_3	2054°C
- Magnesia	MgO	2800°C
- Zirconia	ZrO_2	2700°C
- Mulite	$Al_6Si_2O_{13}$	1828°C
- Spinel	$MgAl_2O_4$	2135°C
- Lime	CaO	2600°C

However, the melting temperature is generally decreased by impurities in the same way as salt decreases the melting point of ice.

Types of refractories: Chemistry

Classification of Refractories: Chemistry

Acid	Neutral	Basic
Silica	Alumina	Magnesia
Mulite	Bauxite	Doloma
Fireclay	Zirconia	Magnesia-Chrome
Andalusite	(Carbon)	Magnesia-Carbon

Acidic or Siliceous Slags.

Basic or Limey Slags.

Types of refractories: Form

Classification of Refractories: Form

- Shaped:
  - Bricks
  - Blocks
  - Holloware
  - Precast
- Un-Shaped: (Monolithics)
  - Castables
  - Rammables
  - Mouldables
  - Mortars

Shaped Refractory Products

- Delivered to end-user in the ‘final form’
- Main Advantage:
  - Material properties are independent of installation quality (but design integrity isn’t!)
- Main Disadvantages:
  - Size/shape limitations
  - Installation can be lengthy and require high levels of skill

Shaped Refractory Products - Examples

BOS Vessel Bricks:
Double tapered magnesia - carbon brick installation in a radial ‘knuckle’ design 325T BOS vessel

RH Degasser Snorkel Bricks:
Individual fired Magnesia – chrome bricks in a pre-assembled unit for installation in a RH vacuum degasser snorkel

RH Degasser Pre-Cast Snorkels:
Pre-Cast refractory concrete units in which the brick assemblies are supported and protected

Shaped Refractory Products - Examples

Steel ladle wellblock:
Pre-cast and fired alumina – spinel block used in the control of steel flow during the steel casting process

EAF Delta Section:
Pre-cast and high temp dried high alumina delta used in the EAF Roof

Iron Ladle pre-cast bottom:
Pre-cast and dried alumino-silicate section used in working lining of a 300T iron ladle

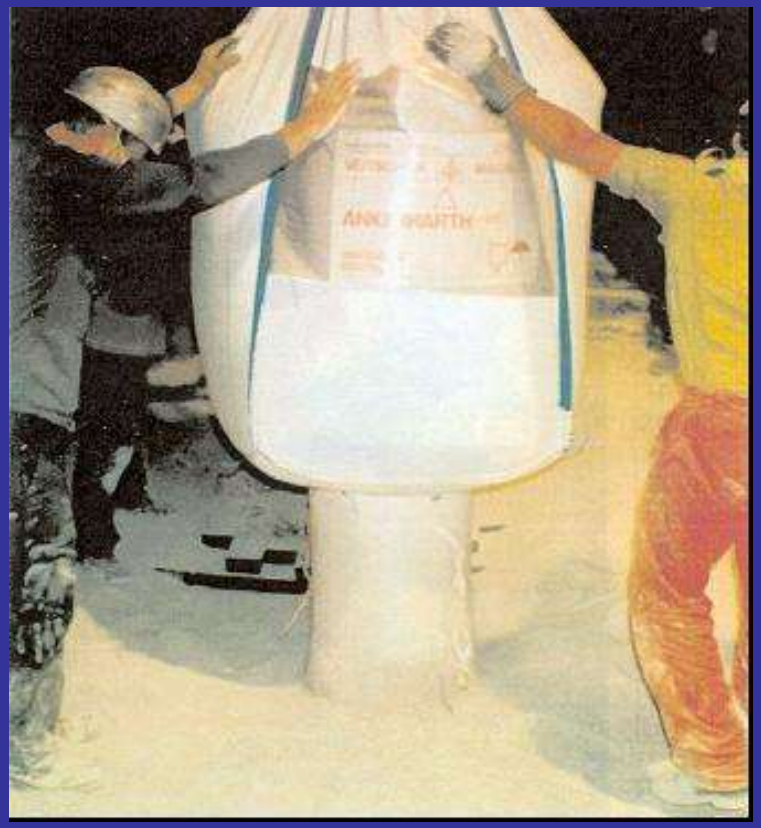
Un-Shaped Refractory Products

- Delivered to end-user in Bags/Buckets/Hoppers
- Material may be ‘ready to use’ or require mixing with a bond-activator/carrier
- Main Advantages:
  - Can be used to fill complex volumes
  - Less skill to install (arguable)
  - Faster to install
- Main Disadvantages:
  - Drying/preheat times
  - Final properties heavily dependent on the quality of installation

Un-Shaped Refractory Products - Examples

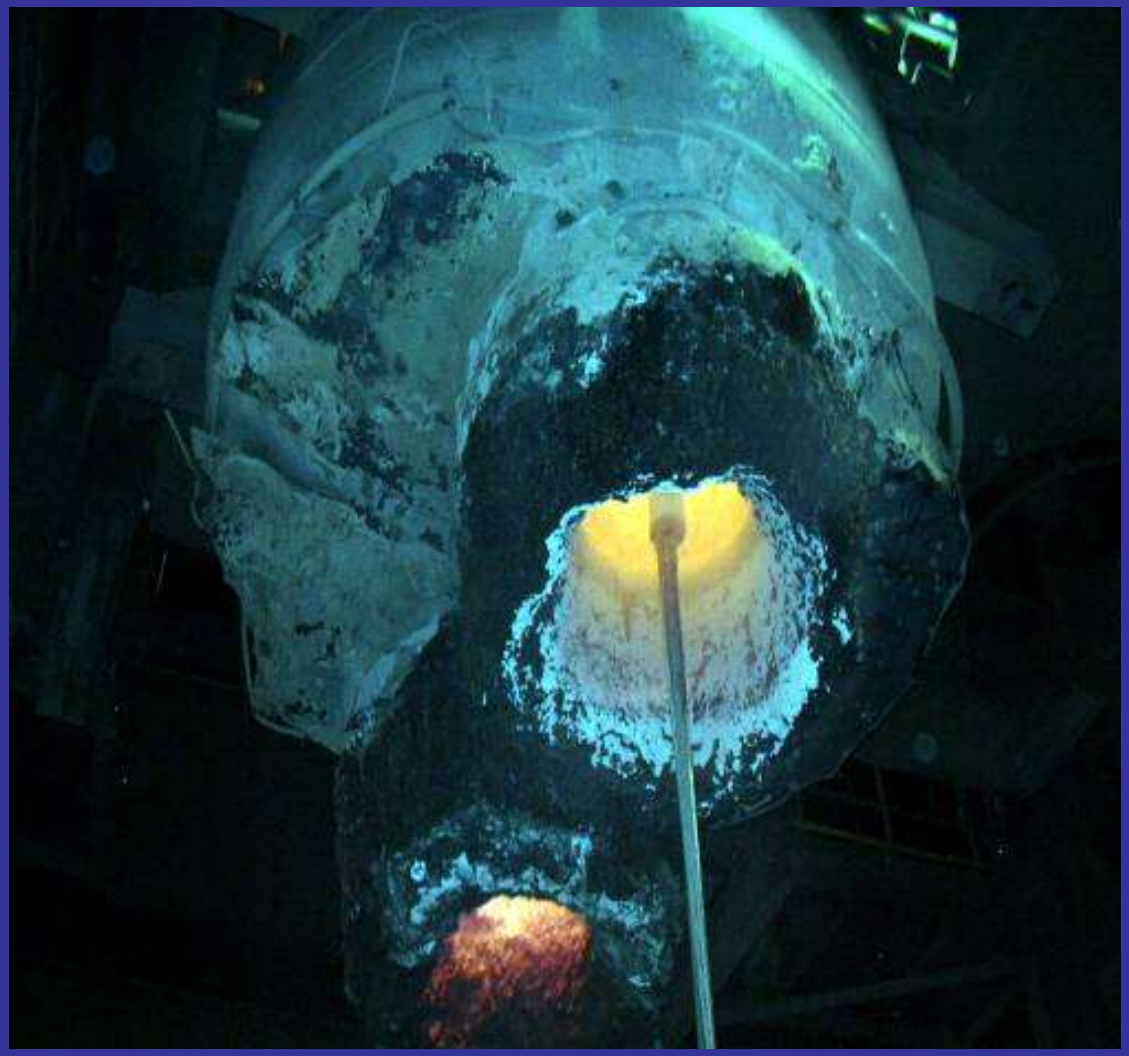
300T Steel ladle top:
A combination of 2 alumino-silicate shotcrete materials and a basic (magnesia based) spray are used in this 6T ladle top installation

Un-Shaped Refractory Products - Examples



Electric Hearth Furnace Hearth:
Use of dry rammable basic material to construct or repair the hearth.
Material is poured from a big bag, distributed manually into place and then consolidated using vibration skeds (think of installing block paving!)

Un-Shaped Refractory Products - Examples



RH Degasser snorkel :
Use of alumina-spinel shotcrete material to repair the internal brickwork lining of the snorkel. This is done in the ‘hot’ condition to allow the RH degasser to continue in operation with minimum downtime, thereby maximising unit availability and productivity.

Basic Properties of Refractories

We need to know the basic properties of refractories in order to determine their 'fitness' for the intended application.

Properties can be grouped as:

- **Physical:** Affect how quickly the material 'physically wears'
  - Things such as density, cold strength (compressive and tensile), porosity, hot strength, flexibility etc.
- **Thermal:** Determines how the material performs under thermal loading (eg. While heating up or at temperature)
  - Things such as expansion coefficient, conductivity, high temperature strength/flexibility, specific heat capacity, refractoriness etc.
- **Chemical:** Determines the resistance to attacking chemicals or 'corrosion'
  - Things such as basicity/acidity, carbon level etc.

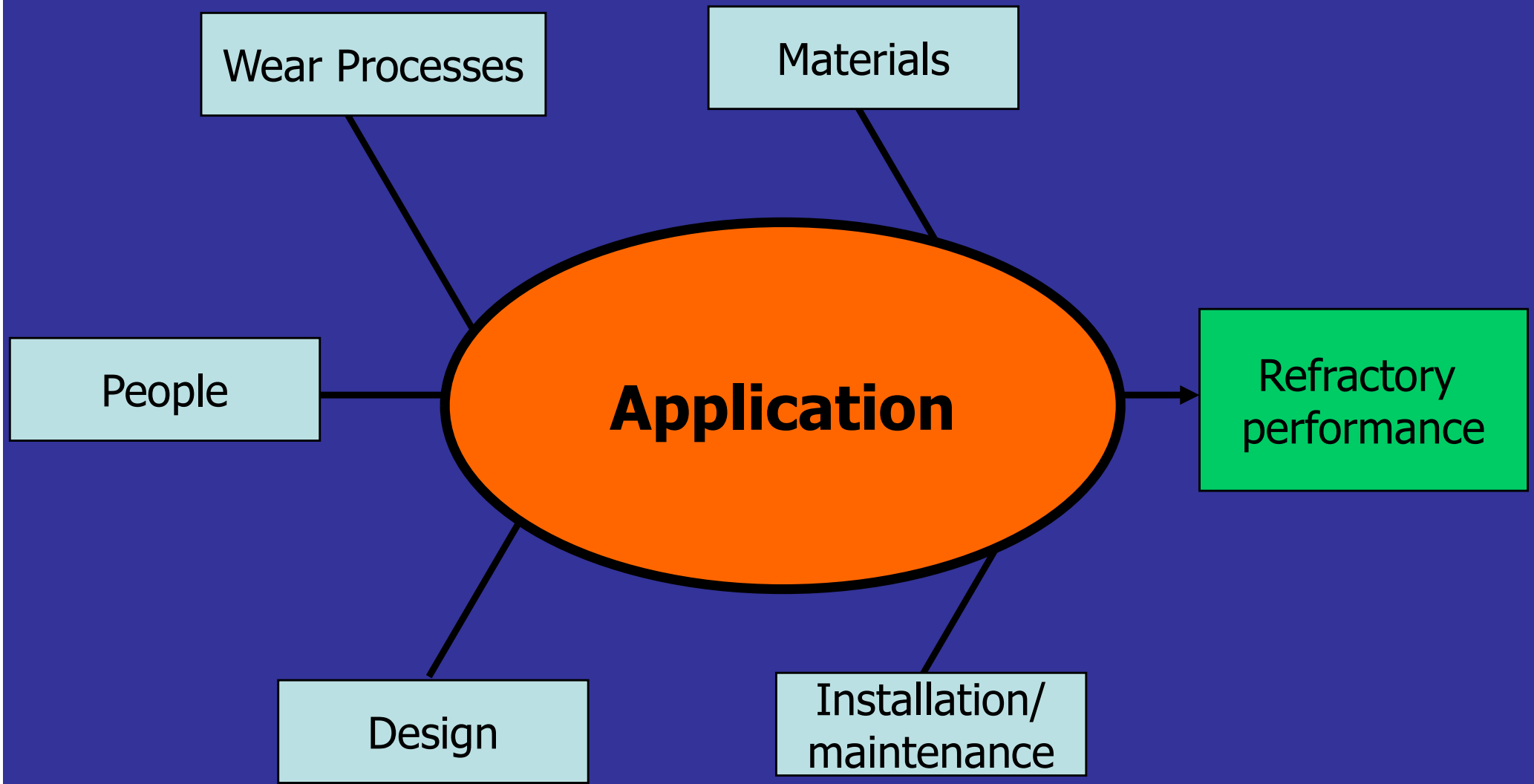
Basic Properties of Refractories

The basic properties of refractories are tested as a means of QUALITY CONTROL to assure customers that a given material meets THE MINIMUM requirements for use in the intended application

Typical Properties measured:

- **Physical:** Bulk density, apparent porosity, cold crushing strength
- **Thermal:** Thermal expansion, permanent linear change (on heating), refractoriness under load, creep
- **Chemical:** Oxide composition, non-oxide composition, volatiles

Why don't refractories last forever?



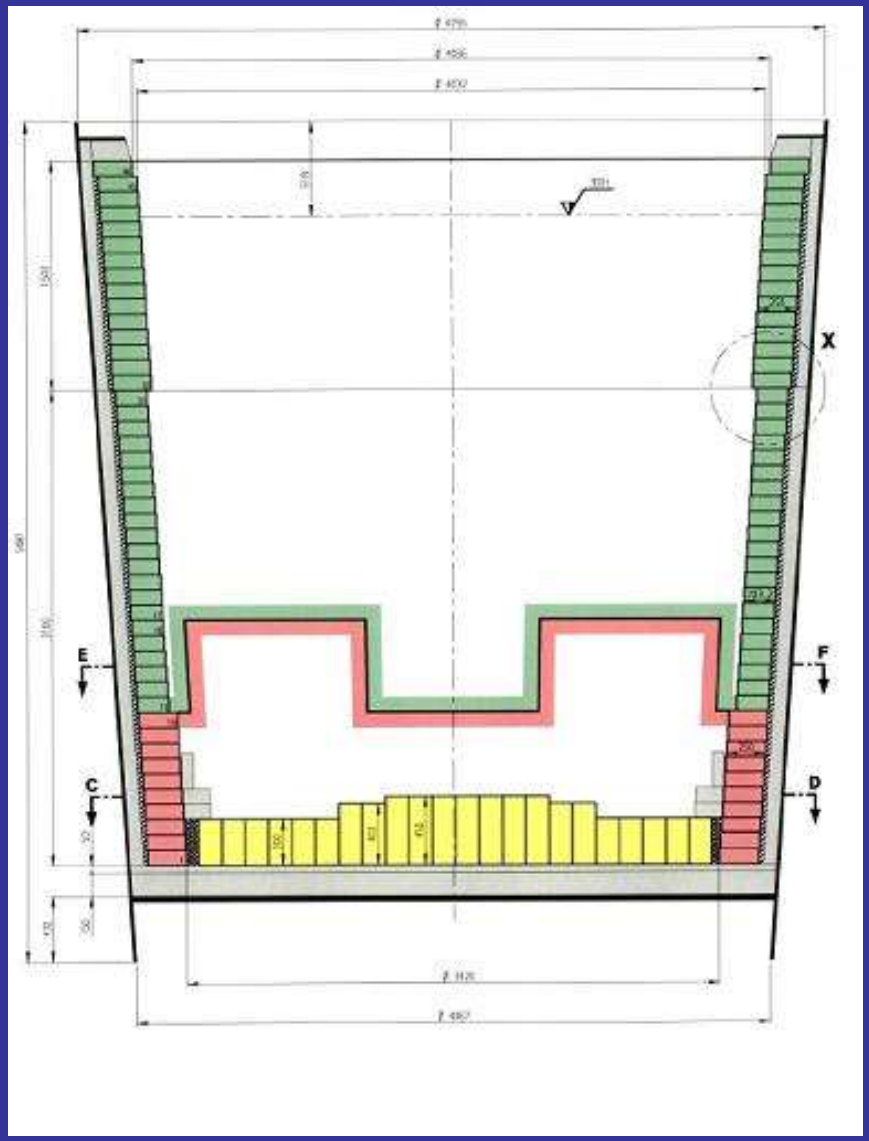
Wear mechanisms – Ladle Example

People

- Correctly or adequately trained in the use of refractories in their application?
  - Need for good thermal maintenance practice
  - Optimisation of industrial process to give best balance of productivity and refractory performance
  - Visual management? When is a lining worn?

Design

- Is the design suitable for the intended application?
- Have the correct materials been specified?
- Are they in the right places to deal with the ‘zonal’ wear mechanisms?
- Is the lining the correct thickness(es)
- Was the job scoped correctly?



Installation and Maintenance

- Are the installers sufficiently skilled to build the intended refractory structure?
- How is the installation supervised and signed off?
- How is refractory maintenance performed?
  - Pre-planned?
  - Emergency?
  - Not at all?

Introduction to Refractories - Summary

- Hopefully you now have more understanding about:
  - What a refractory is
  - What a refractory does
  - Where we use refractories
  - What they are made from
  - Refractory classifications
  - Refractory Properties and…..
  - How we manage to wear them out

Final Comment

Refractories are 'only' facilitators' in that they allow us to carry out processes/operations at high temperatures.

This doesn't mean we don't treat them with respect……

Enjoy the rest of your day.