Profile

New Bharat Refractories Limited was set up in the year 1960 and has been serving the metal and coal industries throughout India.

We are manufacturers of :

- Standard & Custom sized all types of Fire Clay and High Alumina Bricks
- Acid Resistant and Acid Proof Bricks up to 2% A. P.
- High Alumina Refractory upto 70% Alumina
- Coke Oven Refractories
- Mortars
- Castables
- Ramming Mass
- High Alumina Cement

These confirm to various Indian quality standards such as confirmation to IS:6; IS:8; IS:1523-72 ; IS:1522 ; IS:1524 ; IS:1525 ; IS:1529 ; IS:1571 ; IS:4564; IS:6727; IS:4860 which comply with international standards as well. Our plant is located in Bharechnagar (Jharkhand) which is also a location site for other refractory manufacturers cause of availability of the finest clay and other minerals in the country. With modern manufacturing technology and practices, we have accredit in supply of quality refractory to Steel Authority of India Limited, the largest Government held Steel Association in India and TISCO, the largest private steel manufacturer in India. We have undertaken turnkey consultation and supply of refractory for various Sponge Iron, Coke Oven, Pig Iron and the Iron and Steel Foundry industries.

Some of our esteemed clients are as under :

- SAIL / Bhilai Steel Plant
- SAIL / Rourkela Steel Plant
- SAIL/ Bokaro Steel Plant
- The Indian Iron and Steel Co.
- Tata Iron and Steel Co. Ltd.
- Associated Cement Co. Ltd.
- Nippon Dendro Ispat
- Indo-Asahi Glass Co. Ltd.

The company has recently set up two divisions for diversified interests in

- **M/s New Bharat Refractories (Cement Division)**
  A 100 TPD cement manufacturing unit in Bharechnagar, Jharkhand.

- **M/s New Bharat Refractories (Coke Division)**
  A 150 TPD Coke Oven (Pusher Type) plant in Bharechnagar, Jharkhand.

Services

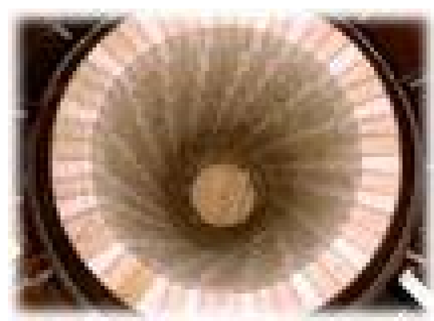
Designing

We undertake turnkey refractory management jobs which stat from product designing as per machinery and raw material suitability. Our team of experts estimate the quality and quantity of refractories (shaped and unshaped) required for projects. We also provide turnkey consultancy for refractory specific projects like coke oven, acid tanks, chimney, etc.

Manufacturing

As per designs laid down by the customer or our design team, we provide for manufacturing of items at our works in Ramgarh cantt., Jharkhand. The plant is well equipped with varied refractory manufacturing like Magnasite, Graphite, Bauxite, Fire Clay, Silica, Chrome etc., based bricks and castables.

Installation



We undertake turnkey installation of refractory jobs for new and replacement jobs. We have a dedicated team of professionals catering to refractory installation as per design. We also assist in secondary designing of refractory installations and replacement. We have accredited in completing more than 100 such projects like coke oven, mini-blast furnaces, acid proofing and acid tanks, chimney work in power plants and coke oven, etc.

Product Servicing and Replacement

We undertake performance guarantee supply against some items and provide for product after sales service and replacement. Performance guarantee of products enables customers to achieve pin-point accurate calculation of production and quality.

Clients

TATA TATA STEEL	सेल SAIL	बी एच ई एल BHEL
ACC	भारतीय रेल INDIAN RAILWAYS	VIZAG STEEL Pride of Steel
HINDALCO ADITYA BIRLA GROUP	Reliance Petroleum Limited	एनटीपीसी NTPC
PARTNERS IN PROGRESS THE ANDHRA SUGARS LIMITED	IISCO	CCI Cement Corporation of India Limited (A Govt. Of India Enterprise)
MECON मेकॉन ISO 9001 Company	Central Coalfields Limited A Mini Ratna Company	इंडियनऑयल IndianOil
SIMPLEX	ESSAR	L&T

List of Products

Industry	Area of Application	Products
Steel	**Blast Furnace**	• Carbon Blocks • Wall Bricks – Fireclay, High alumina and Silicon Carbide • Tap Hole Refractories – Bauxite and Silimanite •
	Cast House	• Alumina Bricks • Alumina and Silicon Carbide Castable
	Hot Stove	• Bricks based on Fireclay, High alumina and Silica • Checker Bricks
	Torpedo Ladle	• Bricks based on Alumina, Graphite and Silicon Carbide
	L D Converter	• Bricks based on Dolomite and Magnasite
	Electric Arc Furnace	• High alumina bricks (delta region) • MgO-C Brick • Magnesite brick • Magnesia ramming Mix • Al_2O_3-SiC-C Bricks in Tapping Sprout • Magnesite • Tuyere • Sleeve refractory • Tapping tube Refractory
	Ladle – Slag Zone	• Carbon Bricks for Teeming Ladle
	Ladle – Metal Zone	• Bricks based on Magnesia Carbon
	Ladle – Bottom Zone	• Bricks based on High alumina, Zircon and Magnesia Carbon
	RH & DH Degasser	• Bricks based on Mag-chrome direct bonded, Mag-chrome semi re-bonded • Alumina Spinel Castable
	VOD	• Bricks based on Mag-chrome direct bonded, Mag-chrome semi re-bonded • Alumina Spinel Castable
	AOD	• Bricks based on Mag-chrome direct bonded, Mag-chrome semi re-bonded • Dolomite
	Continuous Casting	• TD lining bricks • Flow control • Casting • Wear lining Stopper • Slide Gate • Ladle Shroud • Submerged entry nozzle

Cement	**Kiln and Cooler**	• Magnesia – alumina spinal bricks • Dolomite with zirconia's • Mag-dolo with zirconia's • Direct bonded mag-chrome bricks • 70% Al_2O_3 bricks • Insulation Bricks
Aluminum	**Roraty Kiln / Calciner** **Electrolytic Pot Cell** **Cathode/Anode Baking Ring Furnace** **Melting and holding Furnace**	• Fireclay Bricks • High Alumina Bricks • HA Ramming Mass • Low Cement castable • Unit cast Insulating Bricks • Silica Insulating Bricks • Fireclay Insulation Bricks • Mineral Wool • Basic Bricks • Carbon Bricks
Copper	**Rotary dryer combustion chamber** **Anode casting spoon lining** **Boilers** **Induction furnaces** **Heat treatment furnaces.** **Rotary fired furnaces Electric arc furnaces,** **Flash smelting furnaces** **Scrubber** **Refining sulphuric acid plant**	• High alumina refractories • Fireclay refractories • Silica refractories • Magnetite bricks • Magnetite chrome and • Insulating refractories • Carbon paste • Acid resistant bricks
Zinc & Lead	**Waelz kiln, clinker kiln** **Cupellation furnaces** **Blast furnace** **IF Kettles,** **Boilers, roaster, etc.** **Waelz kiln and clinker kiln** **Boil;ers, Waelz kiln Clinker feed chute,** **Scrubber** **Drying tower, acid mixing tower, absorption tower**	• Alumino-Silicate Bricks • Basic Insulation Bricks • Carbon bricks • Acid Resistant Bricks • High Alumina, Fireclay and Monolithics Bricks • Monolithices (Castable)
Coke Oven	**Oven Roof, Wall, Flue, Wall Heads, Regenerator**	• Bricks based on Alumina • Shaped and Unshaped Refractories • Castables
Glass	**Glass Slumping** **Kiln formed glass** **Glass Blowing**	• High temperature castables to 1800 C Ceramic fibre products • Insulating fire bricks • Fused cast (AZS Alumina Zircon Silica) items • High alumina fire bricks and mortar

Carbon Blocks

Following characteristics of carbon blocks are desirable for its usage in furnace bottom and hearth:

a) Solubility resistance to hot metal
b) Penetration prevention of molten substances such as hot metal, etc.
c) Superior thermal stress resistance
d) High thermal conductivity
e) Good spalling resistance.

Keeping the above in view, new carbon blocks have been developed for improved characteristics such as:

i) Prevention of matrix solution by adding alumina and by adding silicon
ii) Improvement of pore size distribution by improved forming method
iii) Improvement of deformability and thermal conductivity by using a lot of natural graphite.

TYPICAL, PROPERTIES OF CARBON & GRPHITE BLOCKS USED IN BLAST FURNACES

Characteristies	Indian Blast Furnaces		
Bulk density g/cm^3 **True density, g/cm^3** **Fixed Carbon, wt. %**	1.62 2.18 99.8	1.62 1.99 8.3	1.56 1.93 96
Total porosity, % **Mean pore diameter, μm** **Air permeability, m^2**	26 3 250	19 0.3 4	19 6 150
Cold crushing strength, MPa **Modulus of rupture, MPa**	21-22 10	44 12	38 12
Co-eff of thermal Expansion, $10^{-6/0}$K	5.4	3.4	3.3
Thermal conductivity, W/m^{0}K **At 20^{0}C** **At 200^{0}C** **At 400^{0}C** **At 600^{0}C** **At 800^{0}C**	 130 115 90 80 70		
Alkali resistance ASTM	U	U/LC	LC
Blast furnace application	Lower Heath Bottom	Bottom and side wall	Bottom and side wall

Note: Alkali resistance: LC (Lightly cracked), U (Unaffected)

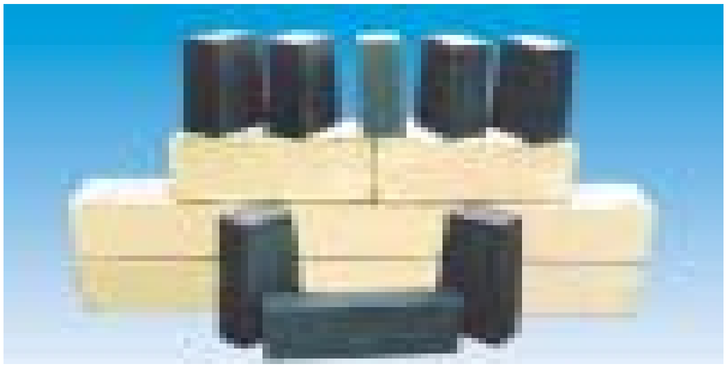
Furnace Wall Bricks

Down movement of ore and coke is hindered due to the uneven surface of the upper stack bricks and the mixed layers of ores. Coke that is formed adjacent to the bricks. This has a bad influence upon the blast furnace operation resulting in an increase in thermal load and acceleration of wear of bricks. The counter measures to these phenomena have been carried out at the time of construction by the following methods:

- Use of bricks having high spalling resistance (refer Table 3.03 for characteristics)
- Castable gunning repair
- Setting up of water cooled hardwires
- Installation of pre-cast panel etc.

In the lower part of stack, thermal stress is the main cause of wear in addition to chemical corrosion by alkali, Non-oxide Refractories has an advantage to fight the Refractories has an advantage to fight and situation and Si_3N_4 bonded SiC has been found superior in cooling efficiency and thermal stress wear resistance compared with fireclay and high alumina Refractories.

Characteristics	Fireclay bricks	High Alumina Bricks		Silicon Carbide Bricks	
		Type - 1	Type – 2	Type - 1	Type - 2
1. Chemical analysis					
Al_2O_3, %, min	44	62-64	72	-	-
Fe_2O_3. % max	1.5	1.6-1.9	1.2	-	-
Sic, %	-	-	-	77	94
SIALON + Si_3N_4	-	-	-	20	-
2. Bilk density, g/cm^3	2.35	2.45	2.50	2.70	2.75
3. Apparent porosity, %	13	13	16	15	11
4. MOR at room tem., Moa	15	20	20	47	44
5. Cold crushing strength MPa	80	50-80	70	140	140
6. Thermal expansion at 1000^{0}C, %	0.6	0.4	0.40	0.5	0.4
7. Thermal conductivity, W/m^{0}K	1.85	2.3	2.3	18	28
8. Permanent linear change, %	± (1500 ^{0}C, 5 hrs.)	± (1500 ^{0}C, 5 hrs.)	± (1500 ^{0}C, 5 hrs.)	± -	± -
9. PCE, OC	34	37	37	-	-
10. RUL, ta, ^{0}C	1500	1550	1550	-	-



Tap Hole Refractories

In the tap hole area, the structural design to prevent gas leakage from the brick joints is very important, in addition to the wear pattern of Refractories.

Properties required for tap hole bricks include slag resistance, spalling resistance, hot metal abrasion include slag resistance.

The example of Al_2O_3-SiC-C bricks being used as a substitute for silliminite bricks has been reported recently and it showed over two times as much residual thickness as compared to conventional materials

In addition, mud material, which is the packing material of tap hole, is demanded having characteristics such as sinterbility, corrosion resistance, fluidity, easy-packing and easy-opening etc. A change from the SiO2-SiC-C system to the Al_2O_3-SiC-Si_3N_4-C system has been attempted to improve slag corrosion resistance corresponding to high productivity. And recently, the tar bond system has been converted to the resin bond system mainly to make sure of the tap hole depth and the tapping time in practical use.

Characteristics

Properties required for tap hole bricks include slag resistance, spalling resistance, hot metal abrasion include slag resistance.

Cast House Bricks

The tapping trough of the cast house consists of the main iron trough, branch hot metal troughs, tilting runners, etc. In Japan, de-siliconisation treatment was carried out in the main trough since 1980. Recently it has been performed in the tilting runner, resulting in great demand for materials.

Wear pattern and mechanism

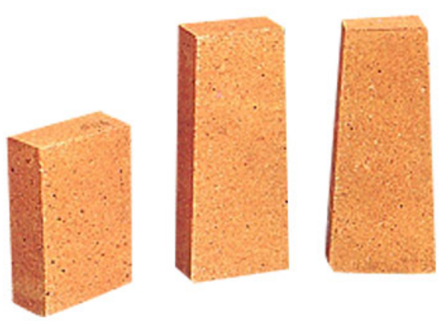
Al_2O_3-SiC-C castables are most commonly used as the trough materials. It is thought that the direct wear is caused by the mechanical abrasion of hot metal & slag and the dissolution into hot metal & slag. Consequently, the formation rate of the de-carbonisation layer at the hot face determines the wear rate. These composite oxides seem to be locally worn by the Marangoni effect and wettability around the boundary between slag and hot metal.

Refractories

From the results of continuous trial and error, Al_2O_3-SiC-C castables have been found most suitable. Workability, homogeneous texture, slag corrosion resistance, strength, hot volume stability and spelling resistance are generally considered as its required properties

Characteristics

Properties	A	B	C
Chemical composition, %			
Al_2O_3	78.70	58.35	72.84
SiC	10.06	30.24	13.80
Bulk density, g/cm^3			
At 110 ^{0}C, 24 h	3.00	2.92	2.91
At 1450 ^{0}C, 3h	2.95	2.86	2.89
Cold crushing strength, MPa			
At 110 ^{0}C, 24 h	43.8	41.4	59.3
At 1450 ^{0}C, 3h	44.6	52.6	-
MOR MPa			
At 110 ^{0}C, 24 h	7.83	8.50	4.28
At 1000 ^{0}C, 3h	7.4	7.12	-
At 1450 ^{0}C, 3h	7.29	6.60	-
Hot MOR (1450 ^{0}C, 3h) MPa	2.44	1.17	3.15
Permanent Linear change (1450 ^{0}C, 3h) %	-0.10	+0.04	+0.48
Water addition, %	4.5	5.0	5.0



Hot Stove Bricks

The air blown into a blast furnace is preheated in a hot stove to reduce the fuel cost. Hot stoves are generally a cylindrical shaft kiln with a dome on top. They consist of a combustion chamber and a regenerator, and are classified as internal of external combustion types, based on their arrangement. The regenerator is filled with heat exchange Refractories, called checker bricks.

Various Refractories, such as fireclay, high alumina and silica are selected on the basis of temperature, load, temperature change, atmosphere (dust) of the various regions, are used in hot stoves. The compressive creep characteristics are the most important characteristics of the stove Refractories.

High alumina bricks have been used for the lowest region to prevent lower temperature spalling, cause by the presence of cristobalite in the brick structure.

Characteristics

Characteristics	Fireclay	High Alumina		Silica
		Type - I	Type – II	
Chemical analysis **Al_2O_3, %** **SiO_2, %** **Fe_2O_3, %**	 41-43 53-55 1-2	 56-58 40-41 1-2	 70-72 - 1-2	 1.0-1.5 94-65 1.0-1.5
PCE, (SK)	34	37	38	32
Apparent porosity, %	16-18	12-14	15-19	20-23
Apparent specific gravity, g/cm^3	-	-	-	2.3-2.33
Bulk density, g/cm^2	2.2-2.25	2.45	2.45-2.55	-
Cold crushing strength MPa	45-50	45-75	49-98	34-69
Permanent linear change (1500^0C, 2 hrs.), %	0.1	0.1	0	0
RUL, ta, ^0C	1460-1520	1580	1650	1600-1620
Creep test 50 h (^0C) **MPa** **(%)**	1150 0.294 0.14	1300 0.19 0.37	1400 0.196 0.51	1450 0.196 0.21
Thermal expansion at 1000^0C, %	0.6	0.52	0.52	1.18
Spelling test at 135^0C heat (1h) and air cooling (30 min)	10 Cycles No crack	10 Cycles No crack	10 Cycles No crack	- -

Torpedo Ladle Bricks

In the past hot metal ladle cars were used to transport hot metal from the blast furnaces to the steel making furnaces and hot metal mixers were used for storage of hot metal. As blast furnaces and converters have become larger and more efficient, the use of torpedo cars has increased as it prevents heat loss from hot metal and the cost of construction as well as maintenance is comparatively low

The torpedo car was originally used for transportation and storage of hot metal. But now hot metal pre-treatment (i.e. desiliconisation, desulphurization and dephosphorisation) has been separated from decarburization processing (done in a converter) and it is done in the torpedo car.

Based on the need for corrosion resistance against FeO, Na_2O and CaF_2, Al_2O_3-SiC-C bricks have been developed comprising of alumina as the main aggregate, graphite which provides resistance to spalling and slag penetration and SiC which protects graphite from oxidizing.

Characteristics

Properties	Metal contact	Slag line	Ceiling	Impact Zone
Chemical composition, %				
Al_2O	86	73	75	66
SiO_2	5	2	1	0.5
SiC	7	7	5	9
Residual Carbon	16	16	16	20
Apparent porosity, %	7	8	7	7
Bulk density, g/cm^3	2.89	2.89	3.02	2.85
Cold crushing strength, MPa	52	30	47	47
Modulus of rupture at room tem. MPa	12	10	12	11

LD Converter Bricks

Converters are classified into three types, based on the difference in oxygen delivery and the stirring methods, namely to blow, bottom blow and combined blowing.

Initially when the LD converter was introduced, tar bonded dolomite bricks were used in the lining. However, due to their low durability tar bonded dolomite bricks were superceded by pitch bonded dolomite bricks, pitch bonded and tar impregnated magenesite bricks, Later on, magnesia carbon bricks which were developed for the hot spot region for electric are furnace linings, were applied in a bottom blown converter with good success because of its superior property of spallig resistance and corrosion resistance. Ultimately, it became the main refractory used in the converter linning.

Since then, various innovations have been made to prolong the life of MgO-C bricks, by way of tar impregnation treatment, firing in a reducing atmosphere, using fused magnesia aggregate (MgO), adding metallic powder (Al and Al-Mg alloy) to prevent oxidation and increasing the strength of the brick, etc. In this way the development of various new versions of the bricks has been taken up in the various part of the world.

At the same time, lining design have been improved, using bricks of different thickness and qualities in different regions, based on difference in the lining wear. As a typical example, in the less affected side wall areas, MgO-C bricks with sintered MfO aggregate are used. In the trunnion and slag line areas, where there is severc chemical corrosion, high grade MgO-C bricks with fused magnesia and highly pure graphite are used. In the tuyere and tap hole, there is not only slag corrosion byt also thermal shock damage and abrasion. In this area, high grade MfO-C bricks with metal powder and additives are being used because of its ability to improve the high temperature strength and oxidation resistance.

Characteristics

Properties	Side Wall	Tuyere	Tap hole
MgO, % **Residual Carbon, %**	78 18	76.6 20.8	79.7 17.2
Bulk density, g/cm^3 **Apparent porosity, %** **Cold crushing strength, MPa**	2.89 3.2 35.4	2.85 3.0 47	2.89 1.1 61.2
Hot modulus of rupture at 1400^{0}C, 3 hrs, MPa	11.0	15.0	16.9

EAF Roof Bricks

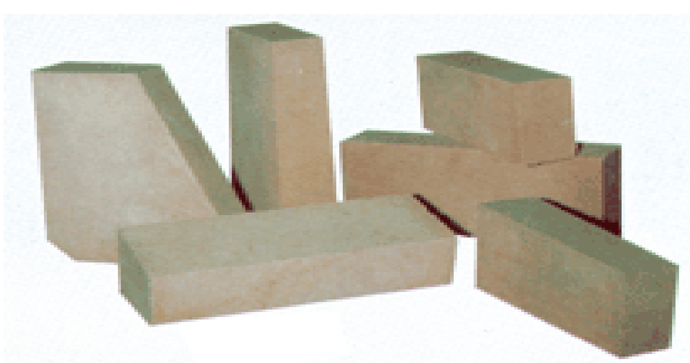
The basis for increased production of steel is related to a stabilized supply of scrap and advancement of EAF technology, including Refractories technology.

There are two main types of EAF, namely, Conventional alternating current (AC) furnaces and direct current (DC) furnaces and the later are characterized by less fluctuation of power and cheaper electrode cost.

Formerly, in the peripheral parts of the roof, silica brick or metal-cased unfired mag-chrome bricks were widely used, while the central part of the roof (delta region) and around the electrodes was lined with high alumina ramming masses. The delta region was generally lined with chrome containing high alumina precast blocks. With the introduction of water cooling system, the area of use of Refractories is limited to only around the electrodes and the type of Refractories include high alumina Refractories with 85% Al_2O_3 content.

Characteristics

Part	Refractory Type	Chemical composition (%)						AO (%)	BD (g/cm^3)	CCS (MPa)
		Cao	Al_2O_3	SiO_2	MgO	SiC	C			
Roof	**High alumina (delta region)**	1.3	86.2	96	-	-	-	18.3	2.86	53
Wall	**MgO-C Brick**	1.1	0.1	0.8	74.8	-	19.5	3.4	2.84	33
	Magnesite brick	1.2	1.1	2.1	94.3	-	-	3.5	2.92	73
Hearth	**Magnesia ramming Mix**	1.4	0.1	1.2	96.3	-	-	-	-	-
Tapping spout	**Al_2O_3-SiC-C**	-	78.0	3.0	-	15.0	3.0	12.5	3.05	50
Repair material	**Magnesite**	1.6	1.5	6.8	87.4	-	-	-	2.43	15
Bottom blowing	**Tuyere**	1.1	91.0	1.5	-	-	-	13.7	3.20	55
	Sleeve refractory	-	0.2	0.5	74.9	-	17.9	3.1	2.88	48
EBT	**Tapping tube Refractory**	-	-	-	77.3	-	15.3	3.1	2.86	38

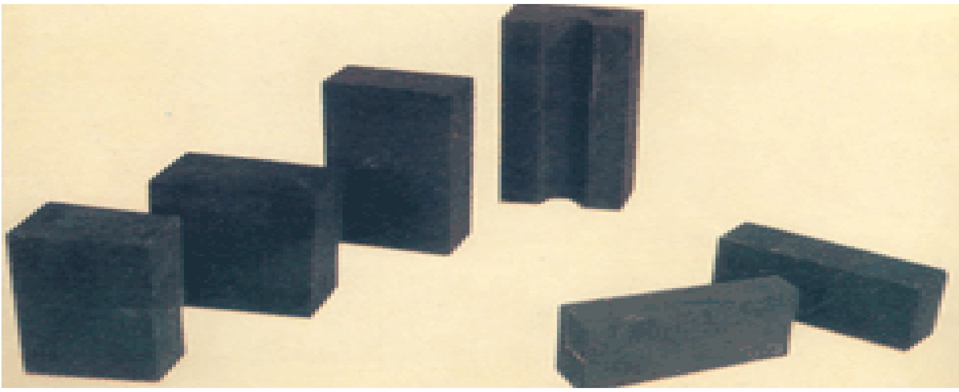


EAF Hearth Bricks

The hearth is generally lined with fired magnesia bricks below, and magnesia ramming mass on it. As for the ramming materials, there are wet and dry types, and the later I mainly used due to its ease of installation and drying. In some cases, in DC electric furnaces, or bottom gas blowing operations, magnesia-carbon bricks are installed instead of rammed magnesia to get improved life and less maintenance of the hearth.

Characteristics

Part	Refractory Type	Chemical composition (%)						AO (%)	BD (g/cm^3)	CCS (MPa)
		Cao	Al_2O_3	SiO_2	MgO	SiC	C			
Roof	High alumina (delta region)	1.3	86.2	96	-	-	-	18.3	2.86	53
Wall	MgO-C Brick	1.1	0.1	0.8	74.8	-	19.5	3.4	2.84	33
	Magnesite brick	1.2	1.1	2.1	94.3	-	-	3.5	2.92	73
Hearth	Magnesia ramming Mix	1.4	0.1	1.2	96.3	-	-	-	-	-
Tapping spout	Al_2O_3-SiC-C	-	78.0	3.0	-	15.0	3.0	12.5	3.05	50
Repair material	Magnesite	1.6	1.5	6.8	87.4	-	-	-	2.43	15
Bottom blowing	Tuyere	1.1	91.0	1.5	-	-	-	13.7	3.20	55
	Sleeve refractory	-	0.2	0.5	74.9	-	17.9	3.1	2.88	48
EBT	Tapping tube Refractory	-	-	-	77.3	-	15.3	3.1	2.86	38

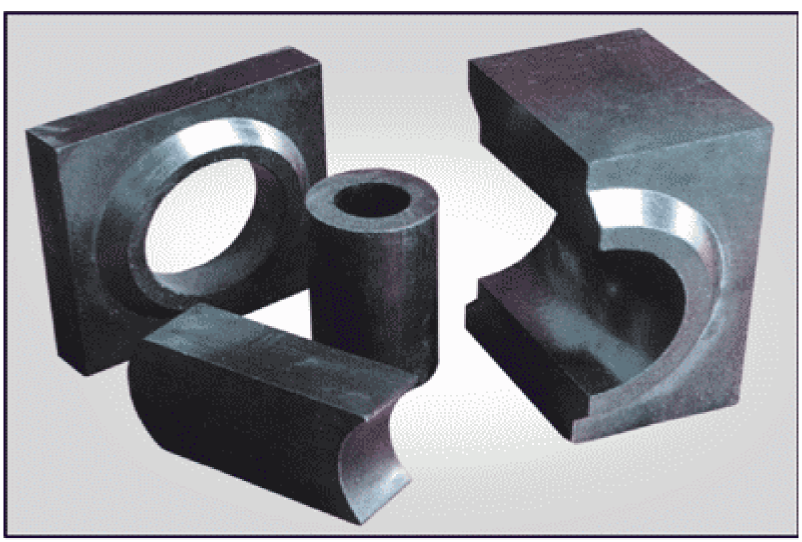


EAF Tapping Spout Bricks

The principal requirements, for the spout Refractories are abrasion resistance, spalling resistance, and non-wetting by molten steel. The main materials used at present are alumina-SiC, high alumina and others. High durability is required because the enlargement of the inner diameter of the tube brick greatly affects the tapping time, slag-stopping capability, etc. Furthermore to avoid tapping problems with clogging stan due to a vitrification reaction with Refractories, magnesia carbon and alumina-magnesia carbon bricks are mainly used.

Characteristics

Part	Refractory Type	Chemical composition (%)						AO (%)	BD (g/cm^{3})	CCS (MPa)
		Cao	Al_2O_3	SiO_2	MgO	SiC	C			
Roof	High alumina (delta region)	1.3	86.2	96	-	-	-	18.3	2.86	53
Wall	MgO-C Brick	1.1	0.1	0.8	74.8	-	19.5	3.4	2.84	33
	Magnesite brick	1.2	1.1	2.1	94.3	-	-	3.5	2.92	73
Hearth	Magnesia ramming Mix	1.4	0.1	1.2	96.3	-	-	-	-	-
Tapping spout	Al_2O_3-SiC-C	-	78.0	3.0	-	15.0	3.0	12.5	3.05	50
Repair material	Magnesite	1.6	1.5	6.8	87.4	-	-	-	2.43	15
Bottom blowing	Tuyere	1.1	91.0	1.5	-	-	-	13.7	3.20	55
	Sleeve refractory	-	0.2	0.5	74.9	-	17.9	3.1	2.88	48
EBT	Tapping tube Refractory	-	-	-	77.3	-	15.3	3.1	2.86	38



Slag Zone Bricks for Ladle

The following factors are considered to be most influencing ones for the lining life of steel ladles:

- Slag basicity and fluidity of molten steel
- Long holding time of high temp. molten steel
- Stirring action of molten steel
- Thermal spalling from tem. Fluctuation
- Ladle handling method
- Ladle structural deign
- Process constraints
- Tap conditions
- Lining/repairing method, etc.

Lining of steel teeming ladle is divided into several zones including slag zone metal zone and bottom zone. The required characteristics of Refractories for each zone are as under

ZONE in steel ladle	Basic slag resistance	Abrasion resistance	Spalling resistance	Hot strength	Type of bricks used
Slag Zone	0	X	0	0	Mgo-C
Metal zone	X	X	$	$	AMC / MgO-C
Bottom zone	X	0	$	0	High alumina/Zircon/ MgO-C

0-Most important, $-Important, X-Moderate

The area most severely corroded is the slag zone. The reasons for corrosion are chemical reaction with metal & slag, erosion by stirring, oxidation at high temperature and thermal spalling due to temperature changes. At the earlier stage, mag-chrome brick was used but it was not very successful for achieving higher life because these bricks used to wear out very fast in high basicity slag. Later on, magnesia rich spinel bricks were used in the area and performance was satisfactory but to get higher life above 80 heats with one repair, magnesia carbon (MgO-C) bricks is found most suitable.

Characteristics

TYPICAL CHARACTERISTICS OF MAGNESIA CARBON BRICKS FOR STEEL TEEMING LADLE

Properties	Type
AP (%)	4-6
BD (gm/cm^3)	2.90-2.92
CCS	400-600
MOR	150-250
Thermal shock resistance at 1300 ^{0}C (Water quenching)	Good
Type of magnesia used	Fused & sinter quality
Type of carbon used	High purity graphite
MgO (%) in RM used	97-98
C (%)	10-12
Anti oxidant (%)	2

Metal Zone Bricks for Ladle

The following factors are considered to be most influencing ones for the lining life of steel ladles:

- Slag basicity and fluidity of molten steel
- Long holding time of high temp. molten steel
- Stirring action of molten steel
- Thermal spalling from tem. Fluctuation
- Ladle handling method
- Ladle structural deign
- Process constraints
- Tap conditions
- Lining/repairing method, etc.

Lining of steel teeming ladle is divided into several zones including slag zone metal zone and bottom zone. The required characteristics of Refractories for each zone are as under

ZONE in steel ladle	Basic slag resistance	Abrasion resistance	Spalling resistance	Hot strength	Type of bricks used
Slag Zone	0	X	0	0	Mgo-C
Metal zone	X	X	$	$	AMC / MgO-C
Bottom zone	X	0	$	0	High alumina/Zircon/ MgO-C

0-Most important, $-Important, X-Moderate

For metal zone, high alumina bricks were widely used. However, it has many problems such as structural spalling by slag penetration, damage to joints by slag & metal and shrinking after 25-30 campaigns. Alumina-magnesia spinal bricks show batter performance than high alumina brick in this area due to high corrosion resistance, slag resistance and tight brick joints. Recently, Alumina-magnesia graphite (AMG) bricks are used successfully. The opening at the brick joints is overcome by combining MgO in Al_2O_3-C bricks to provide a controlled/gradual continuous expansion of brick by spinal formation. With this combination, the joints will bot open during thermal cycling of the ladle, thus reducing pre-mature wear at the joints and avoiding steel & slag penetration to the cold end and consequently unexpected ladle break through MgO addition also improves corrosion resistance. However, excessive addition of MgO causes excessive expansion of the bricks, which may cause peeling.

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF MAC BRICKS

Characteristics	Type-I	Type-II
Bonding	Resin	Resin
Carbon contents (%)	6-8	3-5
AP (%)	8-10	4-6
BD (gm/cm^3)	2.8-2.9	2.9-3.0
CCS (kg/cm^2)	400-500	500-600
MOR at RT (kg/cm^2)	100-150	100-200
Chemistry (%)		
Al_2O_3	60	80
Fe_2O_3	1.5	1.0
MgO	18	10

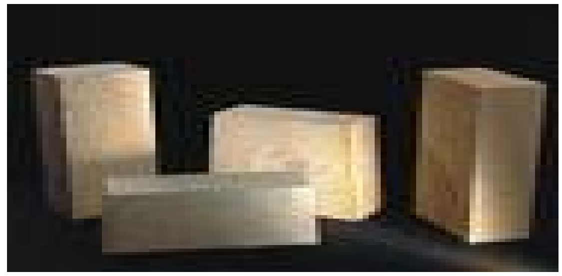
TYPICAL CHARACTERISTICS OF MgO-C (MC) BRICKS

Properties	Value
AP (%)	5-8
BD (gm/cm^3)	2.85-2.88
CCS (kg/cm^2)	300-500
MOR (kg/cm^2)	100-200
Thermal shock résistance at 1300 ^{0}C/ water quenching	Good

Bottom Zone Bricks for Ladle

The following factors are considered to be most influencing ones for the lining life of steel ladles:

- Slag basicity and fluidity of molten steel
- Long holding time of high temp. molten steel
- Stirring action of molten steel
- Thermal spalling from tem. Fluctuation
- Ladle handling method
- Ladle structural deign
- Process constraints
- Tap conditions
- Lining/repairing method, etc.



Lining of steel teeming ladle is divided into several zones including slag zone metal zone and bottom zone. The required characteristics of Refractories for each zone are as under

ZONE in steel ladle	Basic slag resistance	Abrasion resistance	Spalling resistance	Hot strength	Type of bricks used
Slag Zone	O	X	O	O	Mgo-C
Metal zone	X	X	$	$	AMC / MgO-C
Bottom zone	X	O	$	O	High alumina/Zircon/ MgO-C

O-Most important, $-Important, X-Moderate

In the wear lining for bottom zone, several types of bricks from zircon to high alumina burnt bricks had been used but the performance was not found to be satisfactory due to the following:

- Structural spalling caused by slag penetration
- Mechanical spalling
- Wear in brick joints
- Heavy erosion in striker pad area
- Abrasion by molten metal.

TYPICAL CHARACTERISTICS OF BOTTM REFRACTORIES FOR STEEL LADLES

Characteristics	MgO-C	Zircon	High Alumina
AP (%) max	3-4	18	20
BD (gm/cm^3)min	2.98-3.00	3.3	2.8
CCS (kg/cm^2) min	600-700	600	500
MOR at RT (kg/cm^2)	200-300	-	-
RUL, ta, ^{0}C,min (at 2 kg/cm^2 load)	-	1400	1500
PLC at 1600^{0}C/2 hrs. max	-	+0.5	+1.5
Refractoriness, ^{0}C	-	1800	1820
Chemical composition (%)			
Al_2O_3	-	8	85
ZrO_2	-	56	-
FeO^3	-	0.5	1.5
Thermal shock resistance at 1300^{0}C/water quenching	Very Good	Very Good	Very Good

RH & DH Degasser Bricks

The RH (Ruharstahl-Heraus) and DH (Dortmund-Horde) are typical examples of the sucking type degasser.

The RH is a principal facility to refine ultra low carbon steel, and in many cases OB (Oxygen blowing) equipment is attached to accelerate decarburization. OB operation is done through tuyeres installed in the side wall of the RH vessel, or through a lance inserted from the upper part of the vessel, In the operation some RH processes, chemical composition is adjusted by adding alloy, slag refining is done by adding flux and temperature is compensated with combination of OB and add metallic Al. the RH refractory lining commonly consists of magnesia chrome brick of direct bonded type.

Adjustment of the chemical composition of steel, by addition of alloy, is done in the DH as well. Concerning the refractory lining, magnesia-chrome bricks of semi-rebounded or rebounded type are generally used.

TYPICAL CHARACTERISTICS OF REFRACTRORIES USED IN RH, VOD & LF

Refining process	RH			VOD		LF	
Material Characteristics	Mag-chrome direct bonded			Mag-chrome direct bonded	Mag-chrome semi re-bonded	MgO-C	Alumina Spinel Catable
	I	II	III				
Bulk density, (g/cm^3	3.1	3.2	3.2	3.1	3.3	2.9	3.0
Apparent porosity, (%)	16	16	16	16	13	3	13
Cold crushing strength (MPa)	53	88	49	58	109	46	42
Hot modulus of rupture at 1500^{0}C, (MPa)	4	10	6	10 (1450 ^{0}C)	12	16 (1450 ^{0}C)	-
Chemical composition, (%)							
SiO_2	2	2	2	2	1	-	-
Al_2O_3	9	11	5	11	6	-	91
Cr_2O_3	10	20	31	19	21	-	-
Fe_2O_3	4	8	7	6	7	-	-
CaO	<1	<1	<1	<1	<1	-	-
MgO	74	58	54	60	64	80	-
C	-	-	-	-	-	17	-

VOD Bricks

As refining facilities in which molten steel in a ladle is treated in a vacuum chamber, the VOD (Vacuum Oxygen De-carburization) is a typical one. In the VOD process, decarburization of special steel and refining, which are difficult in air are done along with adjustment of chemical composition by addition of alloy, temperature compensation and slag refining? In combination with argon bubbling from a porous plug in the ladle bottom, which stirs the molten steel, decarburization is performed by blowing oxygen onto the surface with a lance above the ladle.

The typical refractory lining in a VOD is magnesia-chrome brick of direct bonded or semi-rebounded type. Dolomite brick is also used in some cases.

LF

A ladle furnace (LF) is a secondary refining facility; which does not involve vacuum treatment. The refractory lining in LF ladles, is commonly MgO-C bricks in the slag line and alumina castables in the side walls.

TYPICAL CHARACTERISTICS OF REFRACTRORIES USED IN RH, VOD & LF

Refining process	RH			VOD		LF	
Material Characteristies	Mag-chrome direct bonded			Mag-chrome direct bonded	Mag-chrome semi re-bonded	MgO-C	Alumina Spinel Catable
	I	II	III				
Bulk density, (g/cm^3	3.1	3.2	3.2	3.1	3.3	2.9	3.0
Apparent porosity, (%)	16	16	16	16	13	3	13
Cold crushing strength (MPa)	53	88	49	58	109	46	42
Hot modulus of rupture at 1500^{0}C, (MPa)	4	10	6	10 (1450 ^{0}C)	12	16 (1450 ^{0}C)	-
Chemical composition, (%)							
SiO_2							
Al_2O_3	2	2	2	2	1	-	-
Cr_2O_3	9	11	5	11	6	-	91
Fe_2O_3	10	20	31	19	21	-	-
CaO	4	8	7	6	7	-	-
MgO	<1	<1	<1	<1	<1	-	-
C	74	58	54	60	64	80	-
	-	-	-	-	-	17	-

AOD Bricks

AOD (Argon Oxygen Decarburization) is principally used to refine stainless steel and its configuration and function are similar to converter in plain steel refining.

Molten steel made by EAF is charged into the vessel, oxygen & argon are blown in from tuyeres at the lowermost level of the side wall and decarburization is conducted without chromium oxidation. The common AOD lining are magnesia-chrome brick of semi-rebounded or direct bonded type or dolomite brick.

The typical characteristics of various types of Refractories used in RH, VOD & LF are indicated in Table 3.13 and those used in AOD are indicated in Table 3.14.

TYPICAL CHARACTERISTICS OF REFRACTORIES USED IN AOD

Material Characteristics	Magnesia Chrome Semi-rebonded/ direct bonded	Dolomite (burnt)
Bulk density, (g/cm^3	3.3	3.0
Apparent porosity, (%)	12	13
Cold crushing strength (MPa)	130	93
Hot modulus of rupture at 1500^{0}C, (MPa)	16	-
Chemical composition, (%)		
SiO_2		
Al_2O_3	1	1
Cr_2O_3	4	<1
Fe_2O_3	20	-
CaO	4	1
MgO	<1	12
C	70	85

Continuous Casting Refractories

Continuous casting is a process in which molten steel shoes chemical composition has been adjusted by secondary refining is solidified in water cooled copper mould.

i) Tundish Refractories

Tundish linings generally include a back-up safety lining and wear (service lining. The wear lining has commonly been burnt alumina bricks but in recent year there has been increasing use of low cement high alumina castable.

ii) Flow Control

Flow control Refractories include two systems viz a sliding nozzle or sliding gate system and a stopper system. These systems are used to regulate the flow of molten steel from ladle to tundish and from tundish to mould respectively.

iii) Pouring refractories

There are two types of pouring refractories viz. the long shround nozzle (ladle shroud) for pouring molten steel from ladle to tundish, and the submerged entry nozzle (immersion nozzle) from the tundish to mould. Both of these applications require corrosion and thermal shock resistance. In the early years of continuous casting, fused silica material was used but at present alumina graphite is the typical material for submerged nozzle. In the submerged entry nozzle there is an internal fitted nozzle with slits for orgon gas bubbling as a way of preventing alumina inclusion in molten steel from causing build-up and nozzle clogging. On the exterior of the submerged entry nozzle at the slag line an insert of zirconia-graphite is included in the alumina-graphite body, to provide added corrosion resistance.

TYPICAL CHARACTERISTICS OF REFRACTORIES FOR CONTINUOIUS CASTING

Material Characteristics	TD lining bricks		Flow control			Casting		
	Permanent lining	Wear lining	Stopper		Slide Gate	Ladle Shroud	Submerged entry nozzle	
			Head	Sleeve			Body	Slag Bond
Chemical composition, (%)								
Al_2O_3	15.0	70.0	60.0	17.0	74.0	38.0	60.0	-
SiO_2	83.0	26.0	-	80.0	10.0	24.0	5.0	11.0
Fe_2O_3	1.0	1.4	-	-	-	-	-	-
ZrO_2	-	-	-	-	-	-	-	63.0
CaO		-	-	-	-	-	-	3.0
Residual carbon		-	28.0	-	12.0	36.0	31.0	22.0
Bulk density (g/cm^2)	2.10	2.70	2.52	2.15	2.77	2.20	2.37	3.18
Cold crushing strength (MPa)	25	55	38	30	120	29	31	34
Modulus of rupture at RT (MPa)	-	-	17	-	21	11	13	11

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Refractories for Cement Industry

Burning zone and transition zone are the most critical zones of the cement rotary kiln where actual firing of the charge and clinker formation takes place. Consequently, both chemical and thermo-mechanical conditions are very severe here. The primary criteria for Refractories to be used in these zones are that they should have higher tendency to form a stable coating of clinker which enhance the life of the refractory by protecting it against the mechanical abrasion and chemical action of the clinker. The usage of high alumina Refractories in this zone is diminishing with the advent of large diameter rotary kilns with pre-heaters and pre-calcinators due to increased thermal as well as mechanical load.

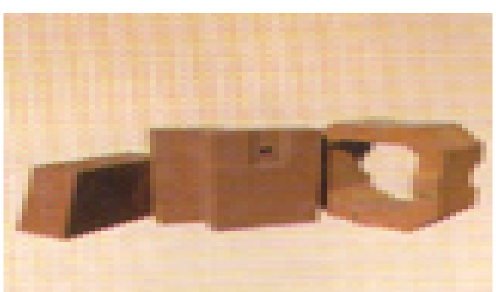
This eventually calls for the thermally efficient refractory lining in the rotary kiln. Keeping pace with the improved cement manufacturing technology has been increasingly specialized to offer the opimum possible solution to the cement manufacturers for increasing the life of Refractories lining. Further environmental considerations and disposal regulations in many countries have made the limitation in selection of Refractories for lining the rotary kilns. Super duty basic bricks of direct bonded mag-chrome and mag alumina quality are gradually substituting the presently used high alumina bricks.

Magnesia Spinal Brick

Magnesia Spinal bricks are found to the superior to mag-chrome bricks with regard to flexibility under pressure, resistance to thermal shocks, alkali and Redox stressing, they are used in marginal areas of sintering zone and transition zone with increased lifetime of about 20%. In the outlet side, the durability is improved by up to 40% in the marginal area.

Due to absence of any iron oxide/chromium oxide, Redox problems are not experienced. Further there is a decrease in the influence of silicate infiltration and slag attack. Premature wear is caused by alkali salts and thermal overloading. Hence, need is felt to develop improved quality magnesia spinel bricks to achieve greater resistance to salt attack and higher thermal rating.

REFRACTORY APPLICATION TREND IN CEMNT ROTARY KILNS IN BURNING AND TRANSITION ZONES

Burning Zone 	**Magnesia – alumina spinal bricks** **Dolomite with zirconia's** **Mag-dolo with zirconia's** **Direct bonded mag-chrome bricks** **70% Al_2O_3 bricks**
Transition Zone 	**70% Al_2O_3 bricks** **Mag-chrome bricks (Direct bonded)** **Magnesia-alumina spinal bricks**

Properties	Cement kilns	
	I	II
Chemical composition, (%) SiO_2 Al_2O_3 Cr_2O_3 Fe_2O_3 CaO MgO	 1.5 1-3 3-5 6-8 2.5 82-86	 ~ 0.5 9-12 - ~ 0.5 ~ 1.0 85-89
Apparent Porosity, %	18	16-18
Bulk density (g/cm^3)	2.95	2.85-3.00
Cold Crushing Strength (MPa)	50	50
Hot Modulus of Rupture at 1400^0 C (MPa)	-	-
Refractoriness Under Load Ta (^{0}C) Te (^{0}C)	 1650 1700	 > 1700 > 1700
PCE, OC	> 42	> 42
Thermal Shock (Cycles)	80	100
Thermal Conductivity (kCal/m hr ^{0}C) At 300^0C At 700^0C At 1000^0C	 4.0 3.0 2.8	 4.0 3.0 2.8

Properties	High Lumina Bricks	Fireclay	Insulation Bricks
Chemical composition, (%) Al_2O_3 Fe_2O_3	 > 70 < 205	 32-40 3-3.5	 22-26 ~ 2.5
Bulk density (g/cm^3)	~ 2.75	2.2 – 2.3	1.6 – 1.75
Apparent Porosity, %	< 22	21 - 23	25 – 35
CCS, MPa	> 60	30-35	20
Refractoriness Under Load Ta (^{0}C) Te (^{0}C	 > 1450 -	 1350-1400 -	 1350 1450
PCE, OC	36	-	28
Thermal conductivity –kCal/mhr ^{0}C	> 35	20-25	50
Thermal Conductivity (kCal/m hr ^{0}C) At 300^0C At 700^0C At 1000^0C	 1.9 1.9 2.0	 1.3 1.4 1.5	 0.5 0.6 0.6

Bricks for Aluminum Industry

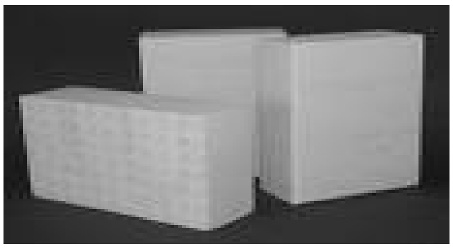
Aluminum has gained a lot of importance in the field of metals in the recent past. India blessed with a huge reserve of bauxite, the basic raw materials for the production of aluminum, has rightly focused her attention on the development of aluminum industry in the country.

In alumina and aluminum industries, Refractories are used mostly in furnaces like rotary calciners, carbon cathode/anode baking furnaces, electrolytic pot cell, melting furnace, holding furnace, pre-heating and annealing furnaces.

Roraty Kiln / Calciner

The rotary calciner condition (1150^{0}C – 1650^{0}C), lining design (monolithic/refractory shapes) and refractory applications vary depending on the product type and kilns. To meet the critical operational conditions and to the at par with the best achieved performance and refectory consumption (1.25kg/t) overseas, specific qualities of Refractories are desired. The major problems faced with indigenous Refractories used in alumina calciners are high shall temperature and low abrasion resistance. Low cement/Ultra low cement constable (80 – 90% Al_2O_3) and refractory shapes of tailored properties are essential for overcoming these operational problems and achieving improved performance.

Electrolytic Pot Cell



Several courses of fireclay bricks are used in an electrolytic pot cell. Molten aluminum is an active reducing agent, which reacts with free silicon in refractory brick producing silicon as impurity in the metal. Similarly, free ferric oxide reacts with molten aluminum with a yield of iron.

Cathode/Anode Baking Ring Furnace

This furnace is a large structure, mostly built underground, on a floating foundation. It consists of several pits or cells. Several type of fireclay and insulation Refractories are used in these furnaces. High grog super duty bricks are mostly used in the flue duct. In back up walls and head walls, high duty and medium duty bricks depending on service conditions are being used. The furnace temperature varies from 1300^{0}C to 1500^{0}C.

Melting and holding Furnace

Refractories used for melting and holding furnaces should have properties like abrasion resistance, resistance dusting, resistance to thermal and mechanical shock, resistance to attack by aluminum and its alloys and chemical inertness to gasses and solid fluxes, non-wetting by aluminum.

Basically PCE, RUL and PLC are the main properties of Refractories to maintain stability of the furnace lining which is purely related to temperature, firing rate, fluctuations of temperature, etc.

Recent trend of improvement

The Refractories earlier used were produced from bauxite and kainite. At present, the basic ingredient has changed to calcined alumina, fused alumina and tabular alumina. These developments have taken place to suit the requirements of properties in Refractories. In addition, various types of binders have been developed to obtain improved properties. The most remarkable one is the phosphate binder.

The high quality aluminum products call for future requirement of Refractories, which do not contaminate the aluminum during refining and casting.

The properties of Refractories are very important in aluminum industries, especially where the liquid aluminum is handled. The aluminum industry is rally looking for refractory having the following properties:

i)	**Chemical composition**	: 85% Al_2O_3 (Phosphate bonded) having Fe_2O_3 content of 0.5 to 0.8% and silica content of 5 to 8%
ii)	**Cold crushing strength**	: 1000 kg/cm^3
iii)	**MOR at room temp**	: 300 kg/cm^2
iv)	**Porosity**	: 12%
v)	**PCE, OC min**	: 38
vi)	**RUL, ta, min**	: 1600 ^0C
vii)	**Thermal conductivity**	: 1.4 k Cal/mhr ^0C
viii)	**Thermal shock resistance**	: 30 cycles
ix)	**Bulk density, min**	: 2.85 g/cm^3
x)	**Cup test**	: must pass 72 hrs test
xi)	**Size tolerances**	: ± 1% or ± 1.5mm whichever is greater

QUALITY OF ALUMINO-SILICATE REFRACTORIES FOR ALUMINUM & ALUMINA PLANNTS IN INDIA

Properties	Fireclay Bricks		High Alumina Bricks		HA Ramming Mass	Low Cement castable	
	Type -I	Type-II	Type-I	Type-II		Type-I	Type-II
Al_2O_3 %	40	32-35	58-60	85	80	70	94
Fe_2O_3 %, Max	2.5	2	2	0.8	-	1.5	0.3
SiO_2 %	-	-	-	10	-	-	-
P_2O_5	-	-	-	1.5-5.0	-	-	-
Type seting	-	-	-	-	Chemical	-	-
Bulk density, g/cm^2, Min	2.0	-	2.9	2.9	2	2.7	3.1
Apparent Porosity, %	20	18	25	17-21	-	-	-
RUL, at deg. C, min	1450	1450	1500	1550	-	-	-
CCS, kg/cm^2	300	300	350	700-900	250-500(1450 deg. C)	750	1050 (800 deg.C)
PLC, %	± 0.4 at 1450 deg.C 5hrs	± 0.5 at 1450 deg.C 2hrs	± 2.5 at 1350 deg.C 2hrs	± 0.5 at 1450 deg.C 6hrs	-	± 0.3 at 1150 deg.C 3hrs	± 0.2 at 1800 deg.C 3hrs
PCE, OC	33	31	36	36	-	36	40
MOR at RT, kg/cm^2	-	-	-	200-300	-	45	-
HMOR, kg/cm^2	-	-	-	50-70 (1350 deg. C 0.5 hrs)	-	144 (1450 deg. C 2hrs)	-
Cup test at 850 deg. C with Al lloys.	-	-	-	72 hrs	-	-	-
Service temp. deg. C	-	-	-	1500	-	1300	-

QUALITY OF INSULATION AND OTHER REFRACTORIES FOR ALUMINUM & ALUMINA PLANTS IN INDIA

Properties	Unit cast Insulating Bricks	Silica Insulating Bricks	Fireclay Insulation Bricks			Mineral Wool	Basic Bricks	Carbon Bricks
	Type - I	Type - II	Type-I	Type-II	Type- III			
Al_2O_3, %	-	-	25-30	30	30-33	-	-	-
Ash Content, %	-	-	-	-	-	-	-	-
CaO, %	-	-	-	-	-	-	2.5 max	5
SiO_2,%	-	70.00	-	-	-	-	6.5 max	-
MgO, %	-	-	-	-	-	-	85 min	-
Bulk Density, cm^2, max	0.64	0.75	0.63	0.70	1.00	0.20	-	1.54
Apparent Porosity, % min	68	65-70	75	70	60	-	24 max	15
RUL, ta.deg. C	-	-	-	-	-	-	1550 min	-
CCS kf/cm^2	8-9	7-15	4-8	10	15-20	-	350 min	300

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Refractories for Copper Industry

Refractories used for copper industries are with regard to smelting furnaces, converter, refining furnaces and electrolytic cell

The major locations of use are indicated below:

1.	**High alumina refractories**	Rotary dryer combustion chamber super heater combustion chamber, holding furnace, electric furnace, pan heater, boiler, heat treatment furnaces, etc.
2.	**Fireclay refractories**	Anode casting spoon lining, heat treatment furnaces, boilers, induction furnaces, launders and back lining in all furnaces.
3.	**Silica refractories**	Heat treatment furnaces.
4.	**Magnetite bricks**	Rotary fired furnaces, electric arc furnaces, electric arc furnace in wire bar casting plant.
5.	**Magnetite chrome and**	Flash smelting furnaces, converter, chrome mag bricks slag cleaning furnace, casting cover and oxidation cover in anode furnaces.
6.	**Insulating refractories**	Backup lining of flash smelting furnaces, electric arc furnaces, dryer combustion chamber, sulphating pan heater, selenium furnaces, holding furnaces, etc.
7.	**Carbon paste**	Scrubber
8.	**Acid resistant bricks**	Refining sulphuric acid plant, evaporator basement, floor, acid tank, etc.

Copper industries are facing serious difficulties in obtaining suitable basic refractories for flash smelting furnaces specially the portion, which is below the metal level. Therefore, the refractory performance for this furnace plays a vital role.

New Bharat Refractories Ltd

- 50 years in adding Strength to Steel -

QUALITY OF REFRACTORIES FOR COPPER PLANTS BASIC AND SILICA

Properties	Basic					Silica
	Magnesite Bricks	Mag-chrome/ chrome mag Bricks		Ramming Mass	Mortar	
Chemical Composition		Type-I	Type-II			
MgO, %	85-90	68-74	32.5	91	33.5	-
Cr_2O_3, %	-	9-13	40	1.5	22	-
Fe_2O_3,%	0.3	5	15	-	-	-
Fe_2O_3,%	4.5	1	9	-	-	1.5
SiO_2,%	3.4	2.5	2.5	-	-	94
CaO, %	1.1	0.8	0.7	-	-	-
Physical properties						
Bulk Density, g/cm^3	2.85-3.00	3.00-3.15	3.2	-	-	2.1
Apparent Porosity, %	14-18	14-18	19-23	-	-	25
Refractoriness deg, C	-	> 1855	> 1855	-	-	1683
Refractoriness under load, ta. Deg, C	1550	1550-1700	1650	-	-	1670
Cold crushing Strength. Kg/cm^3	350-600	350-600	500-700	-	-	250
Permanent Linear Change, %	-	-0.5 (1600 deg.C 2hrs)	-0.5 (1600 deg.C 2hrs)	-	-	+1.0 (1450 deg.C)
Specific gravity	-	-	-	-	-	-

QUALITY OF REFRACTORIEWS FOR COPPER PLANTS
ALUMINO-SILICATE, INSULATION AND ACID RESISTANT BRICKS

Properties	High Alumina	Fireclay				Acid resistant Bricks
		Type-I	Type-II	Monol-ithics	Insulat-ing	
Chemical Composition						
Fe_2O_3, % Max	1	2.5	2.5	1.5-2.0	-	-
Fe_2O_3, % Min	58-60	40	30	40-55	35	-
Physical properties						
Bulk Density, g/cm^3	2.2	2.0	2.0	2.0	0.7-0.8	1.9
Apparent Porosity, %	23	28	25	-	65	3-6
Refractoriness deg, C	1804	1717	1665	1665-1763	1665	1605
Refractoriness under load, ta. Deg, C	1560	1400	1350	-	-	-
Cold crushing Strength. Kg/cm^3	350	175	200	-	10-15	500
Permanent Linear Change, %	+ 0.5 at 1450 deg, C +	+ 1.0 at 1450 deg, C +	+ 0.5 at 1450 deg, C	-	-	500
Thermal Conductivity, kCal/mhrdeg.C	-	-	-	-	0.30	-
Resistance to acid, %	-	-	-	-	-	99

New Bharat Refractories Ltd.

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Refractories for Lead & Zinc Industry

Zinc

Zinc ore usually consists of sulphide minerals, which can not be directly reduced. Instead, the ores must first be calcined to convert the sulphide minerals into an oxide form, which then can be reduced by smelting. Smelting is roughly classified into two methods, the dry method and the wet method. In the dry method the oxide ore is miced with coke and heated to 1200 – 1300^{0}C. to generate zinc vapour. The vapour than passes into a condenser where it cools and condenses. In the wet method, the roasted ore is treated with sulphuric acid and the resulting solution is then electrolyzed.

Lead

The process of "roasting ⇒ sintering ⇒ blast furnace ⇒ electrolytic refining" which is known as "blast furnace method" is generally applied for lead smelting. Lead sulphide concentrates (Pb 65 – 70 wt %) are converted into oxide form by roasting. After roasting, the lead oxide together with coke and fluxes such as limestone are reduced in a blast furnace to form crude metallic lead (Pb 97 wt %).

The profile of blast furnace for lead smelting is similar to the copper smelting process. The refractories include high alumina refractories (60-72 % Al_2O_3), fireclay high grog, mag-chrome & chrome-mag bricks, carbon bricks, acid resistant bricks, insulationg refractories and monolithic (both alumino – silicate and basic).

The major locations of use are as follows:

	Refractories	Location
1.	**High aluimina refractories (60-70% Al_2O_3) including bricks, ramming masses, castables**	Waelz kiln, clinker kiln Cupellation furnaces, retorts settlers, etc.
2.	**Fireclay high grog quality bricks**	Blast furnace
3.	**Fireclay other quality bricks and monolithics**	IF Kettles, refineries, Boilers, roaster, etc.
4.	**Mag-chrome and chrome-mag**	Waelz kiln and clinker kiln
5.	**Insulation Refractories**	Boil;ers, Waelz kiln Clinker feed chute, Kettle refining, DL maching, ignition hood, induction furnace, etc.
6.	**Carbon bricks and pastes**	Scrubber
7.	**Acid resistant bricks**	Drying tower, acid mixing tower, absorption tower (leaching, electrolysis & acid plant.

QUALITY OF REFRACTORIES USED IN ZINC & LEAD MANUFACTURING PLANTS

Table: 3.23

Properties	Alumino-Silicate					Basic		Insulation			Carbon bricks	Acid Resistant Bricks
	High Alumina		Fireclay	Monolithics		Bricks	Monolithics	Type-I	Type-II	Monolithices (Castable)		
	Types - I	Type-II		Type - I	Type - II							
Chemical Composition												
Al_2O_3, % Min	72	60	36	40	60	-	-	40-45	34-37	-	1.8	-
Ash, %	-	-	-	-	-	-	-	-	-	-	6.4	-
Fe_2O_3 % Max	3	2	2	3	-	-	-	-	-	-	-	-
MgO, %	-	-	-	-	-	45-50	20	-	-	-	-	-
Cr_2O_3, %	-	-	-	-	-	22	35	-	-	-	-	-
Physical Properties												
Bulk Density, g/cm^3	2.8	2.3	-	-	-	3.12	-	0.7-0.8	0.9	0.72-0.80	1.56	-
Apparent Porosity, %	18	22	22	-	-	-	-	50-60	70	-	16	-
Refractoriness, deg C, Min	1805	1805	1683	1585	1683	1855	-	-	-	-	-	-
Refractoriness under load ta. Deg. C	1650	1530	1350	-	-	1650	-	-	-	-	-	-
Cold Crushing Strength, kg/cm^2	500	300	300	250	150	300	150-200	20-30	20	4-6	980	500
Premanent Lenear Change, % Max	+0.3 at 1600 deg C 2hjrs	-	-	-	-	-	-	0.5 at 1100 deg.C 2hrs -	-	-1.8 at 1100 deg.C 2hrs	-0.9 at 150 deg.C 2hrs	-
Thermal spalling resistance cycles	+30	-	-	-	-	-	-	0.3	-	-	-	-
Thermal Conductivity at 600 deg.C, kCl/m.hr.deg.C	-	-	-	-	-	-	-	- -	0.3	0.20-0.22	3.7	-
Flextural Strength kg/cm^2, min	-	-	-	-	-	-	-	-	-	-	-	70
Water absorption capacity, %, max	-	-	-	-	-	-	-		-	-	-	4
Resistance to acid %	-	-	-	-	-	-	-		-	-	-	loss>4

Castables & Ramming Mass

Monolithic

Monolithic are joint free refractories and include constable, remming masses, gunning mixes, etc. these are tailor made items and mainly influenced by two factors viz. customer demand and technological advancement in the related fields. The changed pattern of steel technology and increased quality demands of customers have made a significant improvement in the use of monolithic refractories during the last 30 years. Castables are one of the nuclei of such changes in the refractory technology.

Castable based on high purity periclase has been in the market for over 10 years for application where excellent corrosion resistance to basic slags and compatibility with clean steel is most important. However, its poor physical properties restricted its further growth for many years. To meet the requirement, mag-aluminate spinal containing refractory Castable materials are the latest development in this field

Alumina-magnesia spinal exists as a solid solution and, as a solid solution and, as a result a variety of possible compositions exist with differing alumina to magnesia ratio. For monolithic applications, alumina rich spinals are normally used with alumina to magnesia ratio varying from 70:30 and 90:10.

There are many advantages of introducing the spinal phase into a Castable. Spinel will trap iron and manganese from the slag within its crystal structure. The mechanism tends to block further penetration of the slag into the Castable. Furthermore, the lime in the slag reacts with the alumina in the Castable to form CA_6. Hence, the slag becomes richer in silica. Therefore, its viscosity increases and its penetration into the Castable is slowed down even more.

Another approach is to add alumina and magnesia separately to the Castable. Then spinal will be sintered in situ at about 1400^0C – 1500^0C. two problems have to be resolved to succeed with this type of formulation. The early hydration of magnesia (slicking) has to be prevented and the volume increase that occurs when the spinal is formed during the Castable sintering has to be controlled and compensated. Silica fumes tend to be used quite widely in attempts to prevent magnesia slaking and relieve the stess built up in the Castable when spinal is formed. Silica fumes help in forming lower temperature melting compound which releases space for the spinal expansion.

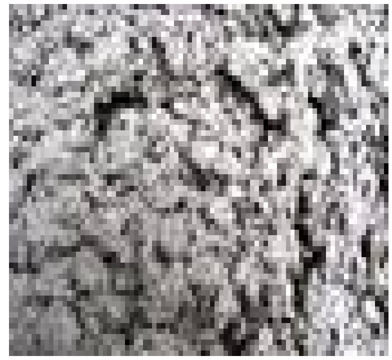
While the "pre-formed spinal" Castable is of a medium cement Castable type, the percentage of calcium aluminates cements varying commonly between 6 to 12%. The "in-situ spinal forming" Castable will be low/ultra low cement Castable types, with about 3% calcium aluminate's cement. Another latest development is in the field of MgO-C castable. The infiltration-inhibiting effect of carbon & favorable corrosion resistance of MgO forms a class of basic castable, which have a high degree of structural homogeneity, high bulk density and excellent strength over the entire temperature range.

CHARACTERISTICS OF SPINEL CASTABLE

Properties	Type-I	Type-II
Physical properties		
BD_2, gm/cm^3		
At 110^{0}C/ 24hrs	2.75	2.95
CCS, kgs/cm^2		
At 110^{0}C/24 hrs	250	200
At 1110^{0}C/3 hrs	350	400
At 1450^{0}C/3 hrs	850	850
PLC, %		
At 1100^{0}C/3 hrs	-0.06	Nil
At 1550^{0}C/3 hrs	-0.06	-0.3
Water required for easting, %	6.5-7	6.5-6.8
Typical Chemical Analysis, %		
Al_2O_3	92	92
SiO_2	1.2	1.5
MgO	5	5

CHARACTERISTICS OF BASIC CASTABLE

Characteristics	Magnesia Castable	Mag-Carbon Castable
Chemical Analysis MgO (min), % Carbon (max), %	 86 -	 80 4
Physical properties Water for Casting (%)	 6.2	 6.5
Bulk Density (g/cm^3) after drying At 110^{0}C	 2.74	 2.65
Cold CCS (kg.cm^2) after drying At 110^{0}C at 1110^{0}C At 1600^{0}C	 650 250 285	 450 200 220
Cold MOR ((kg.cm^2) after drying At 110^{0}C at 1110^{0}C At 1600^{0}C	 125 47 126	 90 30 75
PLC (%) after heating at 1110^{0}C, 2 hrs At 1600^{0}C, 2hrs	 + 0.12 - 0.42	 NIL - 1.0
Hot MOR (kg.cm^2) after heating at 1400^{0}C, 3hrs	 95	 60



CHARACTERISTICS OF RAMMING MASSES

PROPERTIES	TYPES-I	TYPES-II
MgO (min), %	94	96
SiO_2	2.5	1.0
Fe_2O_3	2.0	0.5
Fixed carbon, min, %	4	5
Grading, min	0-5	0-6
Setting	Chemical / Ceramic	Chemical / Ceramic
Application temperature, ^{0}C	1750	1850

Product data for Low Cement Cast able

GRADE	45 %	60 %	70 %	80 %	90 %
Physical Properties					
Refractoriness Orton (°C) min	32 (1720)	36(1800)	36(1800)	37(1825)	37(1825)
Max service Temperature (°C)	1550	1650	1650	1750	1750
Dry Density (gm/cc) min (110°C)	2.35	2.60	2.70	3.00	3.00
Cold Crushing Strength At 110° C At 1500 °C	 650 950	 700 950	 700 950	 700 1000	 700 1100
P. L.. C. % (max.) at 1500 °C	± 1.0	± 1.0	± 1.0	± 0.8	± 0.6
Typical Water mixing requirement for casting %	5	5	5	4	4
Typical Grain Size (mm)	1-5	1-5	1-5	1-5	1-5
Chemical Properties					
Al_2O_3 (%) min	45	60	70	80	90
Fe_2O_3 (%) max	1.0	1.5	1.5	2	2

Product data for General Cast able

GRADE	45 % Normal	50 % Heat C	60 % Heat K	70 % Super	80% Heat M	85% Heat A	90% Heat A
Physical Properties							
Refractoriness Orton (°C) min	1400	1450	1550	1550	1650	1650	1700
Max service Temperature (°C)	1550	1650	1650	1750	1750	1800	1800
Dry Density (kg/m3) min (110°C)	2100	2100	2200	2300	2400	2400	2500
Linear Change % max At 1400 °C for 3 hrs.	± 1.0	± 1.0	± 1.0	± 1.0	± 1.0	± 1.0	± 1.0
Cold Crushing Strength At 110° C At 1500 °C	 250 -	 300 -	 350 -	 350 -	 450 -	 500 -	 550 -
Typical Grain Size (mm)	1-5	1-5	1-5	1-5	1-5	1-5	1-5
Chemical Analysis							
Al_2O_3 (%) min	45	50	60	70	80	85	90
Fe_2O_3 (%) max	1.0	1.5	1.5	2	2	2	2

Product data for Insulating Castable

GRADE	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Physical Properties							
Max service Temperature (°C)	1100	1100	1100	1200	1200	1250	1300
Dry Density (kg/m3) min (110°C)	700	800	900	1000	1100	1200	1300
P. L.. C. % (max.) at 1200 °C	± 1.0	± 1.0	± 1.0	± 0.8	± 0.6	± 0.6	± 0.6
Typical Grain Size (mm)	1-5	1-5	1-5	1-5	1-5	1-5	1-5
Thermal Conductivity (Kilo Cal/m/hr/°C)	0.15	0.25	0.30	0.33	0.40	0.42	0.45
Chemical Analysis							
Fe_2O_3 (%) max	10	8	6	5	4	3	2

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Product data for Air Setting Mortars and Pot Mix

GRADE	30%	35%	40%	45%	50%	60%	70%
Physical Properties							
Max service Temperature (°C)	1450	1500	1500	1550	1600	1650	1650
Typical Grain Size (mm)	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0
Setting Type	Air	Air	Air	Air	Air	Air	Air
Chemical Analysis							
Al2O3 (%) min	30	35	40	45	50	60	70
Fe2O3 (%) max	1.0	1.5	1.5	2.0	2	2.5	2.5

Product data for Fire Clay and High Alumina Mortars

GRADE	30%	40%	50%	60%	70%	80%	90%
Physical Properties							
P C E Orton	30	32	34	35	36	37	38
Max service Temperature (°C)	1300	1350	1400	1450	1500	1550	1600
Typical Grain Size (mm)	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0
Setting Type	Ceramic	Ceramic	Ceramic	Ceramic	Ceramic	Ceramic	Ceramic
Chemical Analysis							
Al2O3 (%) min	30	40	50	60	70	80	90
Fe2O3 (%) max	1.0	1.5	1.5	2.0	2	2.5	2.5

Product data for Fire Clay and High Alumina Ramming Mass

GRADE	30%	40%	50%	60%	70%	80%	90%
Physical Properties							
P C E Orton	30	32	34	35	36	37	38
Max service Temperature (°C)	1300	1350	1400	1450	1500	1550	1600
Typical Grain Size (mm)	0-5	0-5	0-5	0-5	0-5	0-5	0-5
Setting Type	Ceramic/ Chemical	Ceramic/ Chemical	Ceramic/ Chemical	Ceramic/ Chemical	Ceramic/ Chemical	Ceramic/ Chemical	Ceramic/ Chemical
Chemical Analysis							
Al2O3 (%) min	30	40	50	60	70	80	90
Fe2O3 (%) max	1.0	1.5	1.5	2.0	2	2.5	2.5

Mineral Benefication

MgO-based raw materials

The properties of magnesia based refractories are dependent on the quality of magnesia sinter. Grain bulk density, high magnesia content, less porosity are some of the properties of magnesia sinter. Dolomite suitable for brick making containing less than 1% silica is obtained.

Bauxite beneficiation

Components, %	Bauxite
Al_2O_3	85.0
SiO_3	4.0
Fe_2O_3.	3.5
TiO_2	4.5
Alkalis	3.0

Kyanite beneficiation

Kyanite is an important refractory mineral for the manufacture of high alumina refractories. Though similar in composition to silliminite, kynaite differs from the physical properties in that, on conversion to mullite by heating, kyanite undergoes volumetric expansion of 16% necessitating its calcinations prior to utilization.

Magnesite beneficiation

Magnesite is used as the principal raw material for the manufacture of basic bricks. As the raw material has to be dead burnt before it is put to use in refractory industry, production of raw magnesite is primarily governed by the requirement for dead burning.

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- 50 years in adding Strength to Steel -

Coke Oven Refractories

A coke oven battery is a complex structure of many different refractories shapes but it can be divided in general in to two sections; the regenerators which are the lower section and the coking and combustion chambers which represent the upper section. The refractories used require good mechanical strength, thermal shock resistance abrasion resistance, volume stability and in the upper section good hot strength. Fireclay and silica are the principal Refractories used with the latter in the upper section. Silica with very carefully controlled granulometry and tridymite and quartz content are essential to withstand the severe operational requirement of the coking and combustion chambers as coke ovens, with the appropriate repairs are expected to have a life of >30 years.

PRODUCT NAME			KA-35-2	KA-40-2
APPLICATION			OVEN ROOF	OVEN WALL HEADS, REGENERATOR, REGENERATOR CHECKERS
CHEMICAL COMPOSITION	Al_2O_3	%	35	40
			1.5	1.5
	Fe_2O_3	%	2.5	2.0
			0.5	0.5
Cold Compressive Strength (KDF)		N/mm^3	30	30
			10	10
			20 MIN	20 min
Apparent Porosity (Po)		%	21.0	24.0
			2.0	2.0
Refractoriness under Load, Ta		° C	1350	1400
			40	40
Creep-in Compression (1050 ° C, 25 hrs, 0.2 MPa)		%		0.25
				0.1

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Acid & Alkali Proof Bricks

Acid & Alkali proof bricks are specially made for regions which require acid and alkali proofing. The acid attack may take place where there is use of sulphur based materials which causes wear of ferrous lining of furnaces and tanks.

Acid & alkali proof bricks have a varied usage in the following industries –

a) Zinc & Lead Industry for galvanizingPower plants for chimney
b) Acid and Slurry tanks
c) Oil Refineries and Distillaries

The specification of acid resistant brick can be based on the requirements set forth in Indian Specification 4860-1968.

Tests	1st Class	2nd Class
Water Absorption	2%	4%
Flexural Strength	100 kg/cm	70 kg/cm
Compression Strength	700 kg/cm	500 kg/cm
Acid Loss	1.5%	4%
Resistance to Wear	2.0 mm	-
Warpage	2.5 mm	2.5 mm
Tolerances – Length	± 3.5 mm	± 3.5 mm
- Width	± 2.0 mm	± 2.0 mm
- Thickness	± 1.0 mm	± 1.0 mm

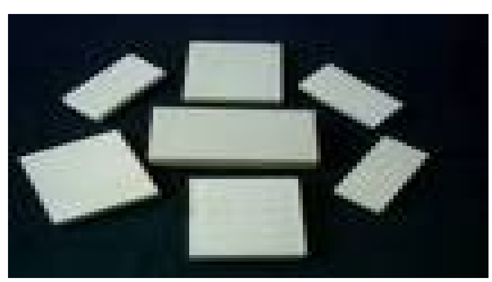
Standard Dimensions

Length	Height	Width
230 mm (9.06 in)	115 mm (4.53 in)	38 mm (1.50 in)
230 mm (9.06 in)	115 mm (4.53 in)	64 mm (2.52 in)
230 mm (9.06 in)	115 mm (4.53 in)	75 mm (2.95 in)

Porosity

The porosity of a brick is a function of the material (fireclay or red shale) and the method of manufacture. A higher porosity implies that it is easier for liquid to penetrate the brick. Thus it is generally desireable to have a brick with the lowest porosity possible to minimize migration of acid through the brick to the shell of the vessel.

There are some cases where higher porosity is desireable such as in high temperature applications. In this situation, brick porosity helps a brick to resist spalling due to thermal shock by allowing it to absorb dimensional changes more easily.



Boiler Bricks

All kinds of boilers require lining of refractory and unshaped products for production. We manufacture shaped and unshaped bricks used in various regions of the boiler.

Item	NBR-70	NBR-80	NBR-90
Al_2O_3 ≥	70	80	85
SiO_2 ≥	25	15	10
Cold crushing strength(MPa) ≥	60	80	100
Bending strength(MPa) ≥	10	12	14
Thermal shock resistance(900) time	20	25	30
Abrasive index(ASWTC-704)	9	8	6
coefficient of heat conductivity W/m.k(under 1000)≤	1.5	1.5	1.5
Working temperature(Max)	1400	1500	1600
Features	High strength in medium temperature Volume stability in high temperature Wearable Anti-corrasion		
Working part	Material returner,wall of economizer,inner wall of mixture room etc.		

Glass Industry Refractory

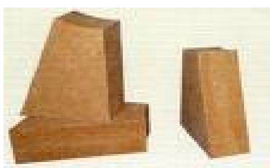
Glass Slumping/Kiln formed glass

Where people are heating glass to a point where, at the right temperature gravity causes the glass to take a new shape we are supplying a full range of products. Forming glass in this way requires a mould to get the glass to form into or to allow the glass to slump to create a smooth concave or convex surface. Glass formed in this way can be used for plates, bowls, windows, furniture, panels and many decorative and artistic items.

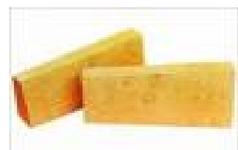
Glass Blowing

Glass is contained in either a crucible or tank furnace and is heated to a molten state for use to make formed objects. Glass made this way requires a furnace for holding and melting the glass, a glory hole for keeping the glass hot and workable and an annealing furnace for tempering the glass. Blown glass can be used for items from bowls and plates, sculptures, artwork to specialised equipment. We can supply material for your tank furnace, glory hole and annealing furnace. Our products include:

- High temperature castables to 1800 C
- Ceramic fibre products
- Insulating fire bricks

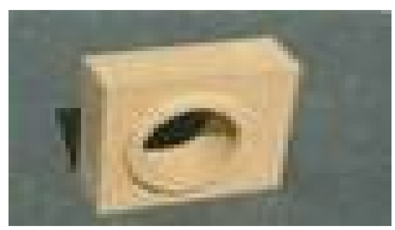


- Fused cast (AZS Alumina Zircon Silica) items



High alumina fire bricks and mortar

Furnace materials and repairs



Product code	AL2O3 %	ZrO2 %	Fe2O3 %	PCE (Orton)	AP %	B.D. gm/cc	C.C.S. kg/cm	R.U.L Ta°C	P.L.C.AR at °C for 2 hrs.
SILL	56	-	1.5	35	23	2.3	400	1480	1500
SILLS	58	-	1.2	36	18	2.35	450	1500	1500
MUL	72	-	0.5	38	22	2.5	600	1600	1600
ZIRMUL	70	18	0.5	-	20	3.1	600	1650	-

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Refractories for Power Industry

Acid & Alkali proof bricks are specially made for regions which require acid and alkali proofing. The acid attack may take place where there is use of sulphur based materials which causes wear of ferrous lining of furnaces and tanks.

Acid & alkali proof bricks have a varied usage in the following industries –

d) Zinc & Lead Industry for galvanizingPower plants for chimney
e) Acid and Slurry tanks
f) Oil Refineries and Distillaries

The specification of acid resistant brick can be based on the requirements set forth in Indian Specification 4860-1968.

Tests	1st Class	2nd Class
Water Absorption	2%	4%
Flexural Strength	100 kg/cm	70 kg/cm
Compression Strength	700 kg/cm	500 kg/cm
Acid Loss	1.5%	4%
Resistance to Wear	2.0 mm	-
Warpage	2.5 mm	2.5 mm
Tolerances – Length	± 3.5 mm	± 3.5 mm
- Width	± 2.0 mm	± 2.0 mm
- Thickness	± 1.0 mm	± 1.0 mm

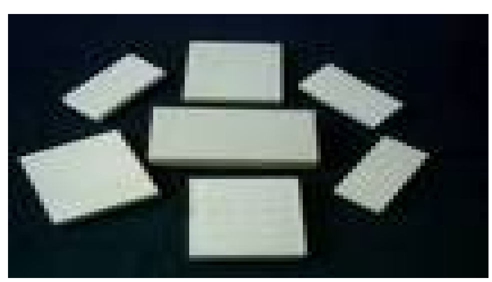
Standard Dimensions

Length	Height	Width
230 mm (9.06 in)	115 mm (4.53 in)	38 mm (1.50 in)
230 mm (9.06 in)	115 mm (4.53 in)	64 mm (2.52 in)
230 mm (9.06 in)	115 mm (4.53 in)	75 mm (2.95 in)

Porosity

The porosity of a brick is a function of the material (fireclay or red shale) and the method of manufacture. A higher porosity implies that it is easier for liquid to penetrate the brick. Thus it is generally desireable to have a brick with the lowest porosity possible to minimize migration of acid through the brick to the shell of the vessel.

There are some cases where higher porosity is desireable such as in high temperature applications. In this situation, brick porosity helps a brick to resist spalling due to thermal shock by allowing it to absorb dimensional changes more easily.



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Sugar & Fertilizer Industry
Product Code :

Root : Glass
Category :

Description

Application

In various regions of glass making furnace

Characteristics

Insulation Bricks

Technical Specification of Insulating Bricks								
Product code	AL2O3 %	Fe2O3 %	PCE Orton	Service Temp °C	BD gm/cc	AP %	CCS kg/cm	Thermal Conductivity at 600°C H/F K. Cal/m/hr°C
LW	30	2	30	1200	1.0-1.1	55	30	0.4
LWS	30	2	30	1200	1.2-1.3	50	70	0.5
CFI	30	2	30	1200	0.7-0.8	65	10	0.3
CFS	30	1.5	30	1200	0.55-0.65	70	8	0.195
HFI	30	2	30	1300	0.8-0.9	60	15	0.35
HFS	35	2	31 1/2	1300	1.0-1.1	60	30	0.4
HFX	40	2	32 1/2	1400	1.0-1.1	55	40	0.45
HF-40	40	1.8	32 1/2	1500	0.9-1.1	60	20	0.26