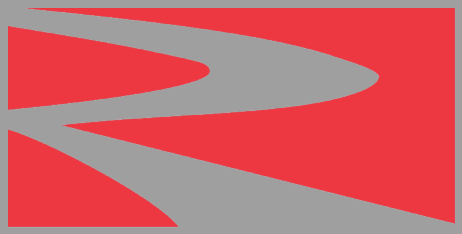
Copper Industry



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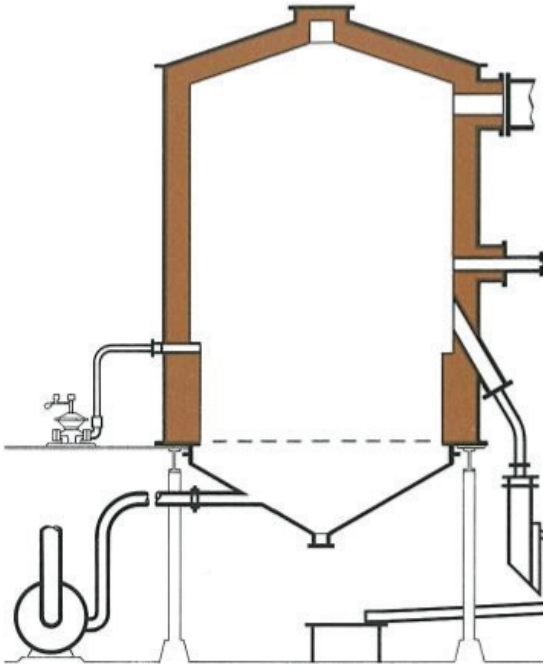
Copper Industry
Products

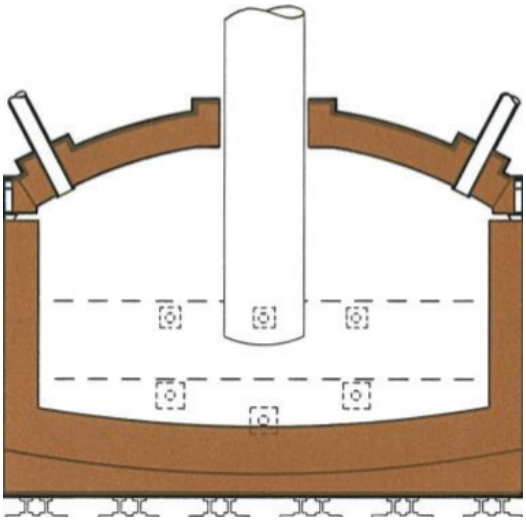
Copper Ore Roasters



The low temperature non-slagging condition of roasting makes this particular process adaptable to the use of monolithic refractories. Environment demands require refractory properties of moderate to high strengths, good erosion resistance to airborne and moving bed abrasive materials, and resistance to sulfurous gasses. Monolithic materials meet these requirements, reduce inventories of special shapes and cut installation and repair times.

Typical applications include cast hearths in multi-hearth roasters, gunned sidewall and domed linings of fluidized bed roasters. **Pacocast 28LI** is suggested for monolithic linings of fluidized bed roasters. We recommend these materials for both new construction and maintenance. For sidewall and dome installations where brick are preferred, we recommend **Super Duty Patriot** brick or **Rescal 70D**.

Electric Smelting Furnaces



The thermal environment of this furnace is much less severe than the conventional reverberatory furnace. Heat is essentially contained below the slag, making the upper portion of the furnace similar in environment to the roaster. Refractory properties needed for this upper area are moderate to high strength with long term stability in the low temperature SO2 environment. **Super Duty Patriot** brick are recommended for green feed furnaces. Furnaces receiving roaster concentrate may require 50% to 60% MgO-Cr brick such as **Nucon 60.**

The slag and matte contact area of the lower sidewalls has an environment similar to the conventional reverb. The wear mechanism is by slag and matte penetration and subsequent spalling of the altered refractory. Products for this application need to have low porosity, low permeability and resistance to chemical corrosion. These properties are found in direct-bonded, fused Mag-Chrome grain **Krilex 621-2 or GR-FG 100.**

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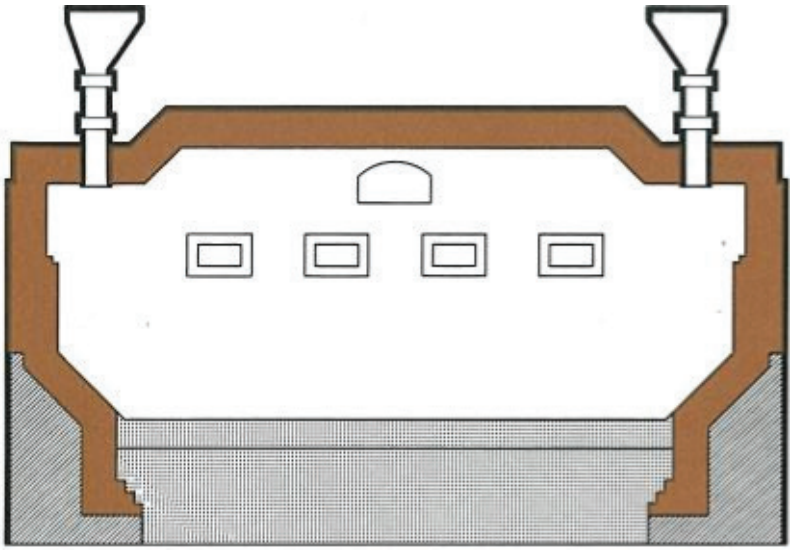
Reverberatory Smelting Furnaces



The thermal and chemical environments of this type furnace vary greatly within each unit. As a result, refractory requirements also vary.

Upper endwall, sidewall and arch areas are subjected to both intermediate and high temperatures and low chemical corrosion attack by SO2 gas. Normally, refractory deterioration is caused by long term recrystallization, growth and spalling owing to the thermal condition. High thermal and low chemical corrosive environments of upper sidewalls and arches permit the use of a range of direct-bonded magnesia chrome brick with 50-70% MgO such as **Nucon 60.** Direct-bonded materials have superior strength and thermal stability.

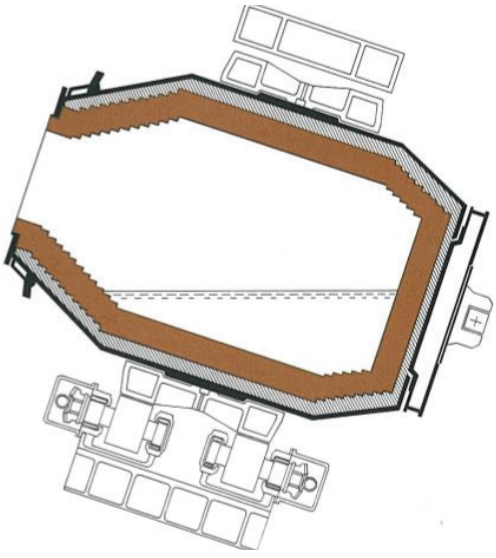
Lower endwalls and sidewalls not protected by concentrate feed are subjected to chemical corrosion by slag and matte. Wear is normally caused by slag or matte penetration and chemical corrosion. Penetration of the refractory and the resultant alteration process also causes spalling and loss of structural stability caused by growth of the refractory. Refractories in this environment must be corrosion resistant and offer properties of low porosity and permeability to resist penetration and alteration. Direct-bonded, fused mag-chrome grain compositions such as **Krilex 621-2 and GR-FG 100** meet these requirements. Special application products such as tap hole blocks, arch patching tile, and maintenance mixes are also available for these applications.

Top Blown Rotary Converters (TBRC)

The TBRC process generates one of the most severe erosion environments of any copper furnace. The process subjects refractory linings to continuous washing by both slag and matte. Changing atmospheric environments of lance injected air and fuel affect linings too. Because of batch operation, thermal shock is a factor as well.

The TBRC may be divided into two zones of wear. The lower sidewall and bottom portions of the vessel are the most severe. Not only is this area subjected to continuous wash by slag and matte, it is also under the highest hydrostatic pressure of the bath. Also the lance injection of air or oxygen-enriched air is directed at the lower portion of the vessel. The major cause of refractory wear in the lower portion of the vessel is by chemical corrosion and chemical reaction induced spalling. Wear is less severe in upper portion of the vessel. Slag and matte wash are present too at a lesser hydrostatic loading.

TBRC continued on next page.



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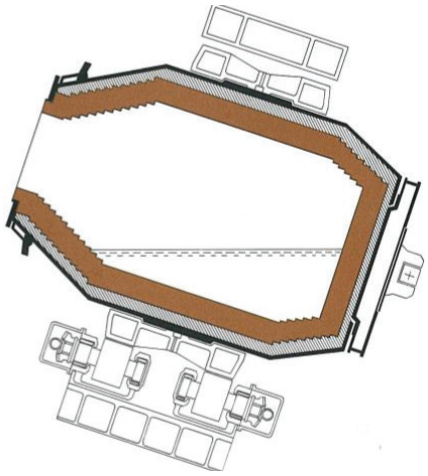
Products

Top Blown Rotary Converters (TBRC)

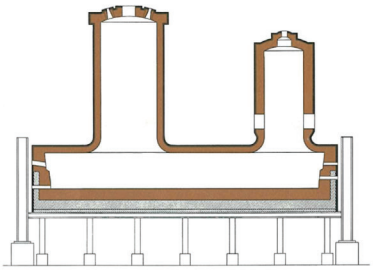


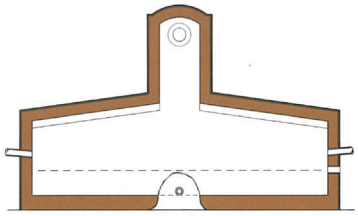
Desired refractory properties for the highly corrosive environment are low porosity, low permeability and chemical stability. Refractories with these properties are direct bonded fused magnesia chrome grains with 50-60% MgO products. Recommended products of this type are **Krilex 621-2, GR-FG 100, and Nucon 60.**

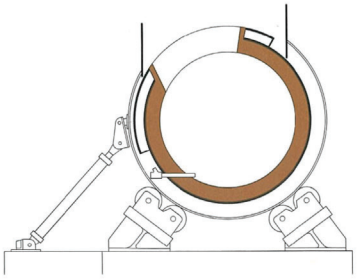
Desired refractories for the upper portion of the vessel are good corrosion resistant, conventional direct-bonded 60% MgO brick. **Nucon 60 and Krilex 621-2** have these properties.

Refractory zoning is recommended in the TBRC, both in lining thickness and composition. Thicker and higher performance refractory linings are needed in the lower sidewall and bottom areas, whereas thinner linings can be used in the upper sidewall and cone areas.

Flash and Continuous Smelting Furnaces







Usually, thermal and chemical corrosive environments of flash and continuous smelting furnaces are more severe than conventional furnaces. Acceleration of the smelting process by flash burning or by injection of air or oxygen-enriched air above or into the bath increases both the intensity of the smelting and the refractory attack thermally, chemically and mechanically. Increased turbulence and the lack of sidewall protection by cold charge also subjects the refractory lining to more intense wear mechanisms. Zoning of refractories by both thickness and quality is very beneficial in these varied processes. Generally sidewall and slag line corrosion is more severe than conventional smelting.

Normally these types of processes require higher quality refractories. The intense wear mechanism in these types of environments is normally chemical corrosion and chemical reaction induced spalling. Desired refractory properties are low porosity, low permeability, high strength and chemical stability. Ideally, the chemical corrosive action should be limited to and minimized at the refractory hot face by using products that are chemically inert and impervious to the slag.

These properties are available in direct-bonded, fused mag-chrome grain 50-60% MgO type basic brick. Direct-bonding assures good high temperature strength. fused mag-chrome grain reduces chemical attack, and low porosity minimizes slag and matte penetration. Fused mag-chrome grain products are of the highest purity and lowest porosity available today. Recommended products are **GR-FG 100, and Krilex 621-2.**

Copper Industry
Products

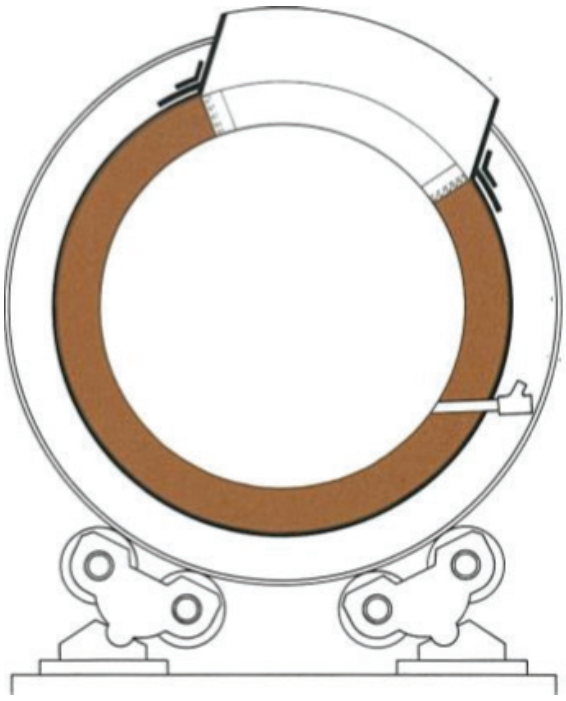
Copper Converters

The environment for refractories in copper converters is one of intermediate to high temperature thermal cycling and an atmosphere that varies from reducing to oxidizing (redox). The environment also contains a very corrosive slag of iron oxide and silica whose corrosiveness is accelerated by the turbulence of the blowing. Copper oxide is very corrosive especially in the cuprous form (Cu2O). It attacks all the refractory oxides to form low melting compounds. It is also subject to redox conditions oxidizing to CuO or reducing to copper metal.

Essentially, converter refractory environments can be divided into two parts. Most severe is that associated with the turbulence of the tuyere line area. Normally this area starts slightly below the tuyere line and goes up the back wall to the mouth area. In some converters adjacent areas of the endwall have this same environment. These areas of highly turbulent slag and matte are subject to chemical corrosion of the refractory hot face and spalling caused by penetration and alteration of the refractory. The remaining portion of the vessel has a less severe environment of intermediate to high temperature, some wash or splash, and SO2 gas contact.

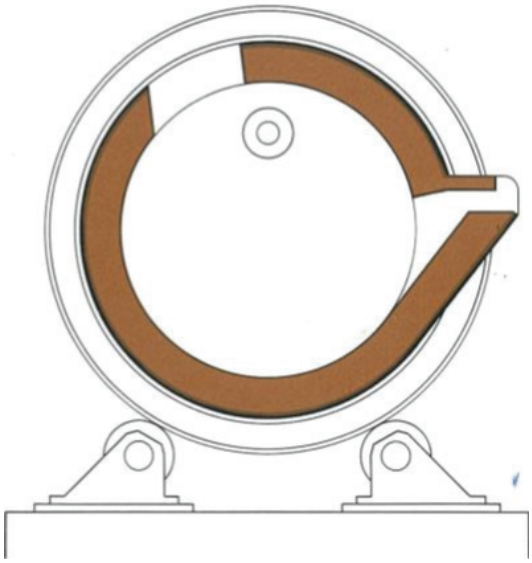
Refractories for these two areas differ. The high intensity wear area of the tuyere line and associated areas requires a corrosion resistant product with low porosity and permeability. These properties are best supplied by high purity direct-bonded 50-60% MgO products made from fused mag-chrome grain, such as **Guidon LS, and Krilex 621-2.** Conventional direct-bonded or regular burned products are sufficient for the remaining portion of the barrel. Recommended products of this type are **Nucon 60 or NR 1202**.

Hot and cold maintenance by gunning is successfully used in the tuyere line, barrel and mouth areas. Cold or hot gunning with **Permacast FG-GM** is recommended to maintain the mouth and mouth arch. Collar pulling damage is minimized by providing a parting plane and a refractory coating.



Copper Industry
Products

Refining Furnaces



The cylindrical anode furnace has a refractory environment of low severity in both temperature and chemical corrosiveness. Refractories in this type of furnace normally last for long periods of time with very little maintenance. Maintenance is normally limited to the burner and tuyere block areas. The refining and heating processes of this vessel require high quality refractories to achieve long service life. Insulation requires better working refractories and improves the thermal efficiency of such vessels.

The environment is one of intermediate to high temperature with minimal slag contact. The lining, however, is subjected to turbulence of poling or blowing by reducing gasses. Typically, wear is due to chemically induced spalling. The desired refractory properties are low porosity, low permeability and medium resistance to chemical corrosion. Refractories of this type are conventional direct-bonded **Nucon 60** or for improved performance fused mag-chrome grain grain products such as **Krilex 621-2.** These refractories are designed for continuous operation at temperatures with minimal penetration and reaction.

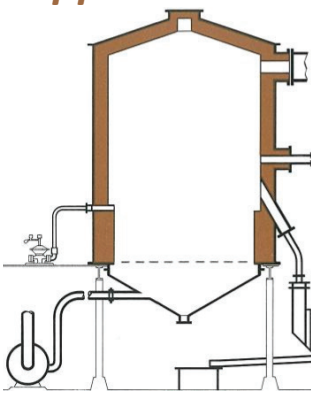
In the upper sidewall and arch areas cyclic temperatures and atmospheric conditions can cause refractory volume changes which in turn upset the stability of the refractory sidewall and arch. Direct-bonded refractories such as **Nucon 60** are stable in this environment.

Slag line and below areas require superior refractories to those above, because of the slag and bath contact. Normally the slag line is the most severe of these areas and requires the most chemically resistant brick. This should be a product of low porosity, low permeability and high corrosion resistance. These characteristics are best supplied by direct-bonded fused mag-chrome grain brick of 50-60% MgO such as **Krilex 621-2.** Similar products are used below the slag line at the taphole or if turbulence created by blowing and refining techniques is severe. In less severe conditions conventional direct-bonded brick such as **Nucon 60** are normally sufficient.

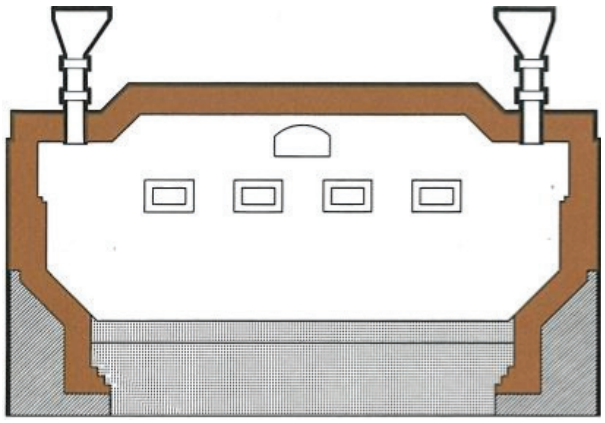
Mouth maintenance by gunning reduces shut downs for brick repairs in the cylindrical anode. **Permacast FG-GM** is recommended because it extends mouth brick life and acts as a parting plane for collar removal.

Copper Industry
Diagrams

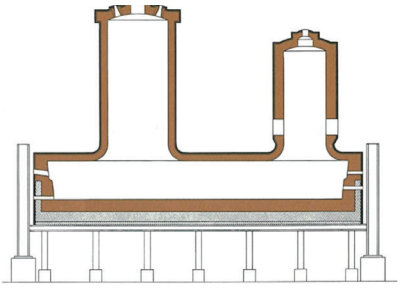
Copper Ore Roasters

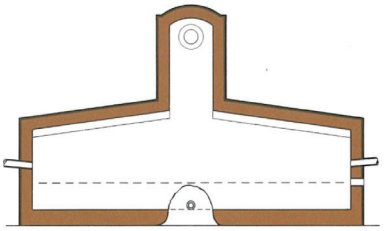


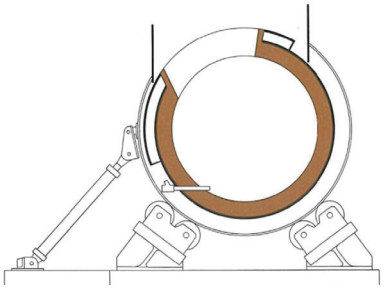
Reverberatory Smelting Furnace



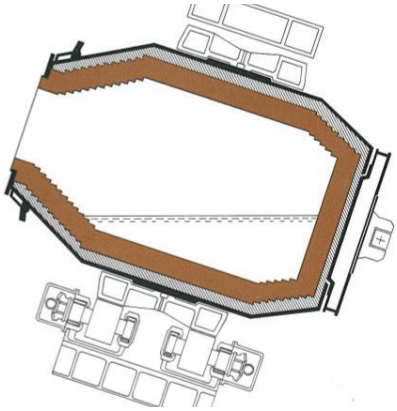
Flash & Continuous Smelting Furnaces



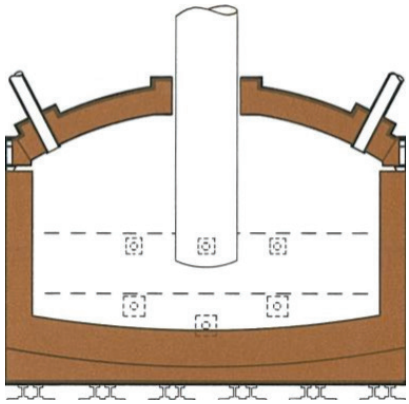




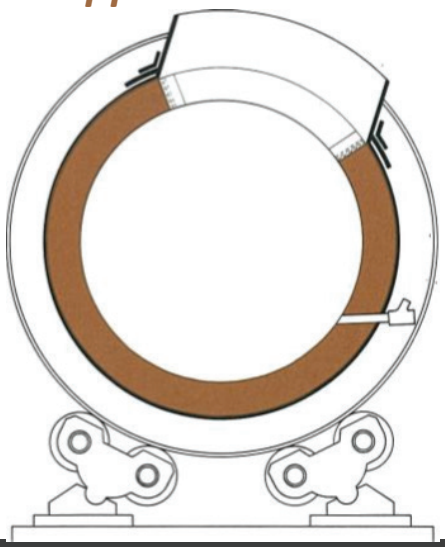
Top Blown Rotary Converter



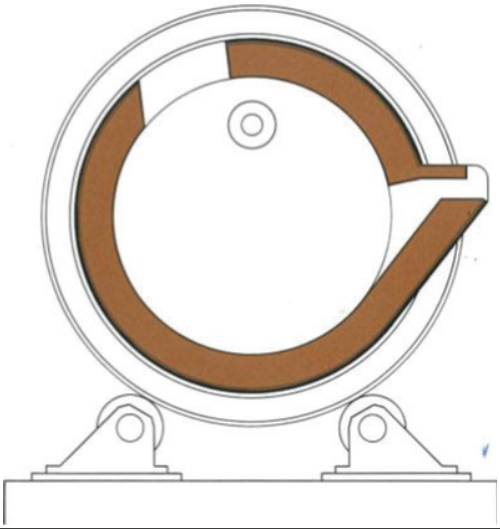
Electric Smelting Furnace



Copper Converters



Refining Furnaces



Recommendations
For Roasting, Smelting & Refining of Copper Sulfide Ores

ENVIRONMENT	WEAR MECHANISM	DESIRED REFRACTORY PROPERTIES	REFRACTORY RECOMMENDATIONS	RESCO PRODUCTS
COPPER ORE ROASTERS				
Low temperature, no slag or matte contact, SO_2 present, contact with moving concentrate	Mechanical erosion and long term structural deterioration	Good low temperature strength and good erosion and abrasion resistance	Volume stable high duty and super duty brick. High strength and good erosion resistant castables	Patriot, Rescal 70D Pacocast 28LI
SMELTING AND REFINING FURNACES				
Arch & Upper Sidewalls - Electric Furnaces				
Low to intermediate temperature, no slag, or matte contact, SO_2 present	Long term structural deterioration	Good low temperature strength and high matrix to aggregate content	Volume stable super duty brick or 40-50% MgO fired or direct-bonded brick	Patriot
Arch & Upper Sidewalls - Fossil Fueled Furnaces				
Intermediate to high temperature, minor chemical corrosion, no slag or matte contact, SO_2 present	Long term thermal alteration resulting in refractory growth and spalling.	Good thermal stability, medium to high strength	40-70% MgO chemically bonded or fired brick and 50-60% MgO direct-bonded brick. Metal encased for basic arch	Nucon 60
Bottom & Lower Sidewalls - Electric & Fossil Fueled Furnaces				
Intermediate temperature, slag and matte contact	Chemical corrosion and chemical reaction induced spalling	Low porosity and permeability medium to high purity, direct bonded matrix	Regular fired 40% MgO, direct-bonded 60% MgO, direct-bonded fused mag-chrome grain 50-60% MgO	Nucon 60, GR-FG 100, and Krilex 621-2
SMELTING AND REFINING FURNACES				
Upper Barrels & End Walls - Not in Continuous Contact with Slag & Matte Wash				
Intermediate to high temperature, slag and matte splash contact	Chemical corrosion and chemical reaction induced spalling	Low porosity and permeability, medium to high purity, fired or direct-bonded	Regular fired 40% MgO, direct-bonded 60% MgO, direct-bonded fused mag-chrome grain 50-60% MgO	Nucon 60, NR 1202 and Krilex 621-1
Lower Barrel Bottom & Tuyere Areas - In Contact with Slag & Matte Wash				
Intermediate to high temperature with turbulent slag and matte redox and thermal cycling	Chemical corrosion accelerated by turbulence of rotation, blowing or refining. Chemical reaction induced spalling	Low porosity and permeability, high purity, chemically stable direct-bonded	Direct-bonded fused mag-chrome grain 50-60% MgO.	Gidon LS, Nucon 60, Krilex 621-2

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