



TECHNOLOGY
AHEAD

ALUMINIUM INDUSTRY



ALUMINIUM INDUSTRY AND TYPES OF EQUIPMENT

The cycle of aluminium metal processing is complex and made by various types of furnaces which melt, treat, refine, remelt and reprocess aluminium products, semi-finished products and scrap in many steps.



The primary aluminium production industry extracts metallic aluminium from minerals. Afterwards aluminium is reprocessed by different factories, which use several type of furnaces for the production of aluminium products or semi-finished products. It is in these remelting stages that modern refractory products are mainly used, while the primary aluminium production relies on refractory bricks.

Seven Refractories can offer solutions for the entire aluminium industry. Products for primary aluminium are mainly shaped products such as fireclay bricks, insulating bricks and alumina bricks, which can be supplied by Seven Refractories in case of need, but are not mentioned in this brochure, which focuses on monolithic products.

Segment	Description	Products	Type of furnace
Primary Aluminium	Reduction of Al_2O_3 to metallic aluminium by consuming graphite anodes and electricity	Liquid aluminium	Cell pot; Anode baking furnace; Transfer ladles
Casthouse	Casting of the molten primary aluminium in semi-finished products	Ingots, bars, slabs, shapes	Reverb. holding furnace; Electrical heating holding furnace; Road transfer ladle; Dross rotary furnace
Alloys Casthouse	Alloying, refining, transformation in alloy semi finished products or finished products	Cast, extruded or rolled ingots, bars, slabs, shapes	Melting/holding furnace; Electrical heating holding furnace; Shaft furnace; Road transfer ladle; Dross rotary furnace
Recycling	Remelting of aluminium scrap into semi-finished products	Ingots, bars, slabs, shapes	Melting/holding furnace; Shaft furnace; Coreless induction furnace; Dross rotary furnace
Foundry	Melting of aluminium semi finished products and casting into finished products	Castings	Coreless induction furnace; Channel furnace; Low pressure casting furnace

Types of production methods in the aluminium industry

REFRACTORIES FOR ALUMINIUM

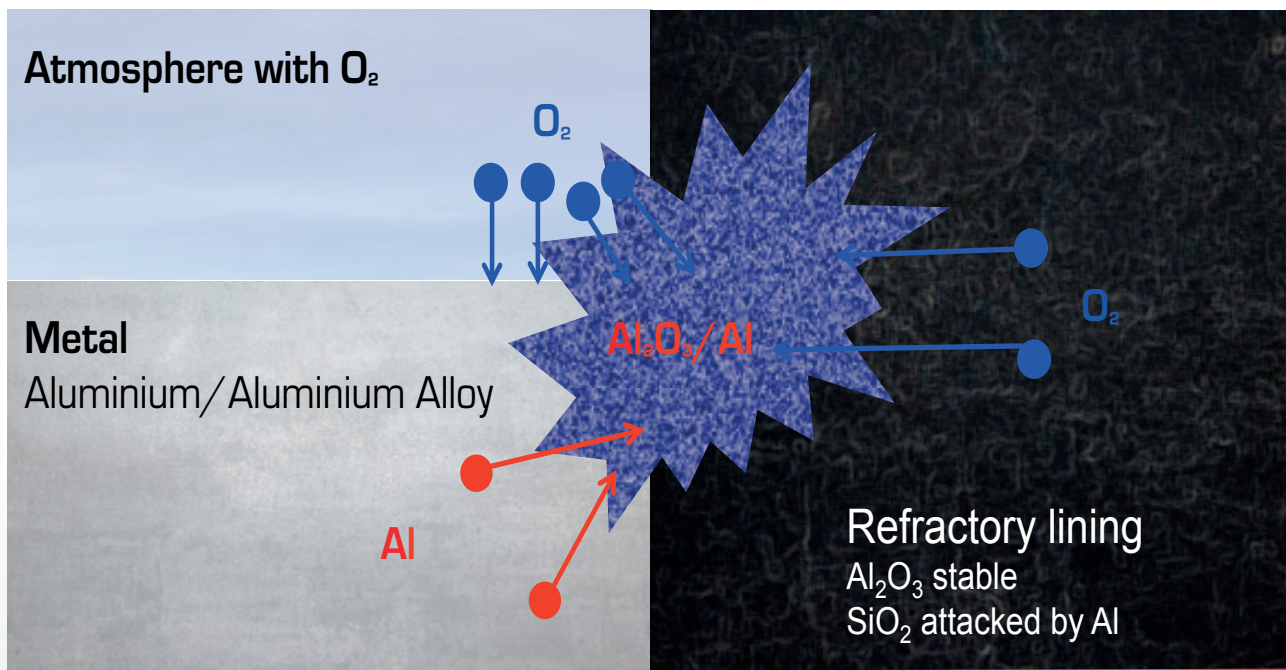
Aluminium has a strong affinity for oxygen, which leads to different mechanisms of oxidation of molten aluminium alloys. The bath surface passivation stops the process at the interface with the furnace atmosphere, but the reaction can proceed at the surface of refractory or in its burden layers. This results in the development of corundum, which can be prevented by the targeted usage of modern refractories.



There are two areas where corundum may be formed:

1. At the bath surface because of direct oxidation:
$$4 \text{ Al (melt)} + 3 \text{ O}_2 \rightarrow 2 \text{ Al}_2\text{O}_3$$
2. In the refractory starting from the liquid contact surface (under the bath level), because of the higher affinity to oxygen of metallic aluminium diffused from the bath into refractory according to the reaction:
$$4 \text{ Al (diff)} + 3 \text{ SiO}_2 \rightarrow 2 \text{ Al}_2\text{O}_3 + 3 \text{ Si}$$

The 2 mechanisms can interact and catalyse each other.



“Corundum formation” occurs at the interphase of refractory lining and liquid aluminium. It consists of a composite rich in aluminium/aluminium oxide, which grows by oxido-reduction.

Several factors can affect the two mechanisms mentioned above, some belong to the operative conditions and the type of alloy, and some are related to the refractory:

1. Operative conditions that can affect the corundum formation:

- Alloying elements (especially magnesium, but also silicon, alkali etc.) can lead to the de-passivation (sometimes catastrophic) of the liquid bath surface
- Fluxes, mainly salts, can influence the kinetic of oxidation and slow down the conversion of metallic aluminium to Al_2O_3 (corundum), but they can also attack the refractory
- Temperature; especially above the bath, it can reach to much higher level than the melting point in case of quick melting operations
- Furnace type, as presented in the following chapters



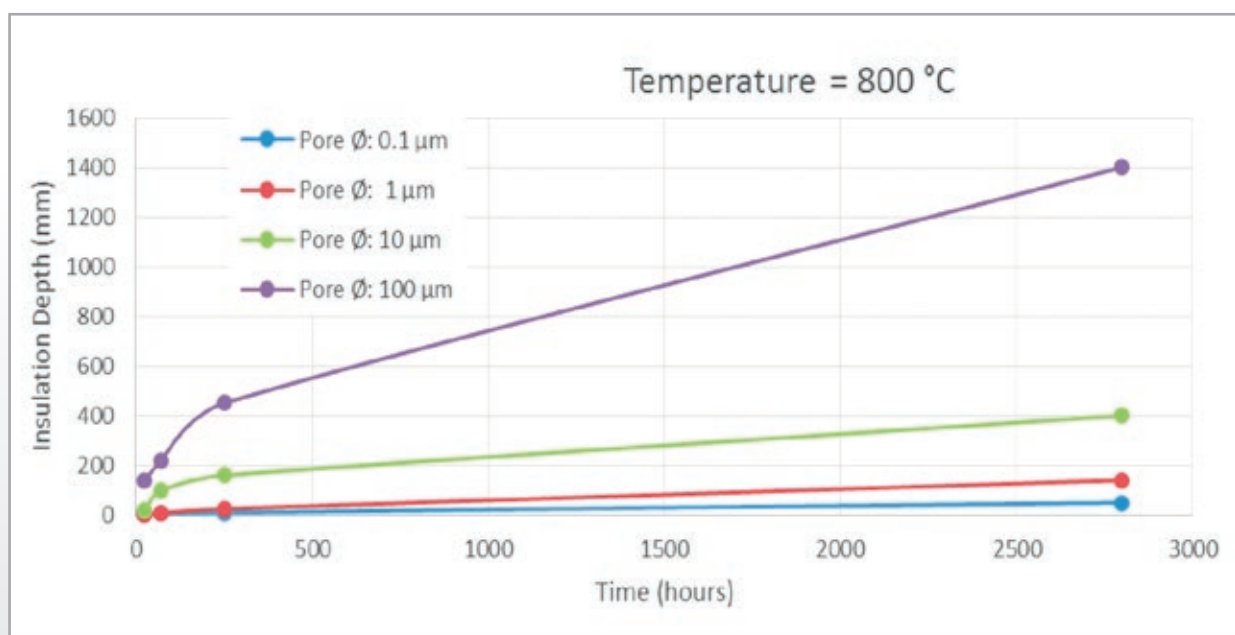
2. Refractory elements that can affect the corundum formation:

- Type of aggregate
- Type of installation
- Matrix of refractory (very important)



3. There are some ways in how refractories can be modified to withstand aluminium attack as explained above, mainly they are based on:

- Reduction of chemical components with affinity to oxygen lower than aluminium
- Optimization of porosity (see picture below)
- Reduction of the wettability of molten aluminium on the refractory surface
- Combination of the items above



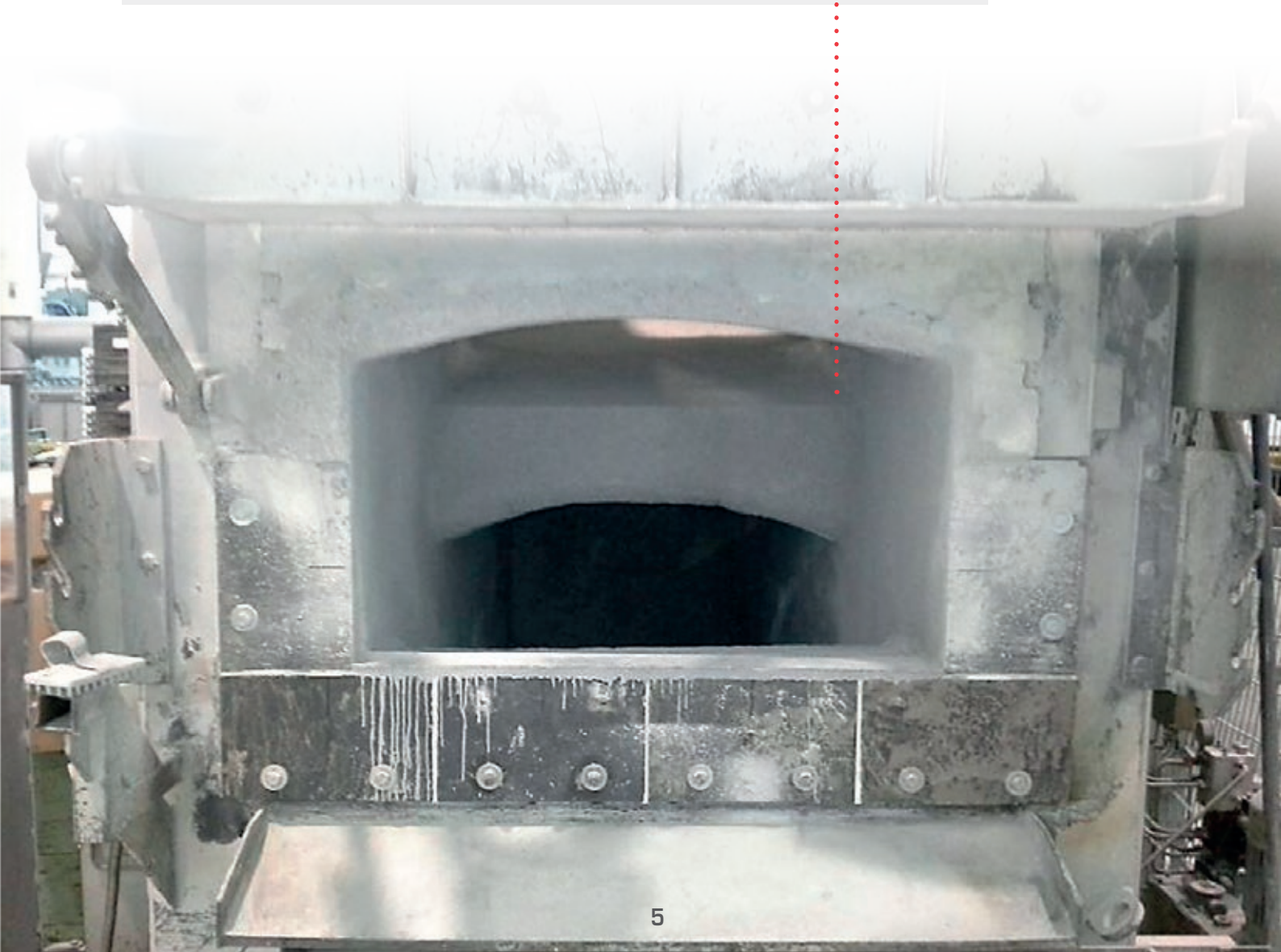
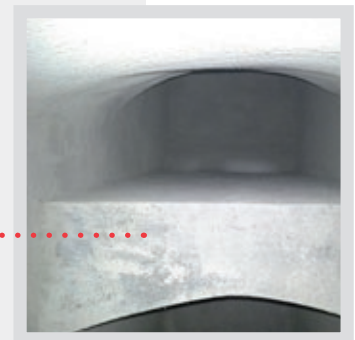
Penetration of aluminium and effect of the diameter of pores.
(from Refractory Application and News Vol. 8 n. 1, pg. 32)

Seven Refractories' product range contains the right blend of additives to ensure the mechanisms discussed above are working correctly.

Seven Refractories can support aluminium plants and furnace makers with the choice of the right products, with precise instructions how to realize linings and to reduce the corundum formation or other problematic issues.

Other typical issues for refractories applied in aluminium furnaces are:

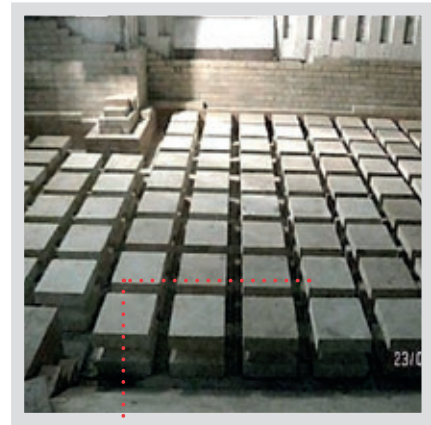
- **Mechanical issues:** related to the furnace loading and the removal of slag
- **Thermal shocks:** especially in areas near burners and above the bath end in case of quick heating and cooling
- **Design:** proper design will ensure that linings are sound, not penetrated by metallic liquid and that the metallic shell is not overheated. Seven Refractories offers its clients the technical consulting and project management expertise to avoid design problems.



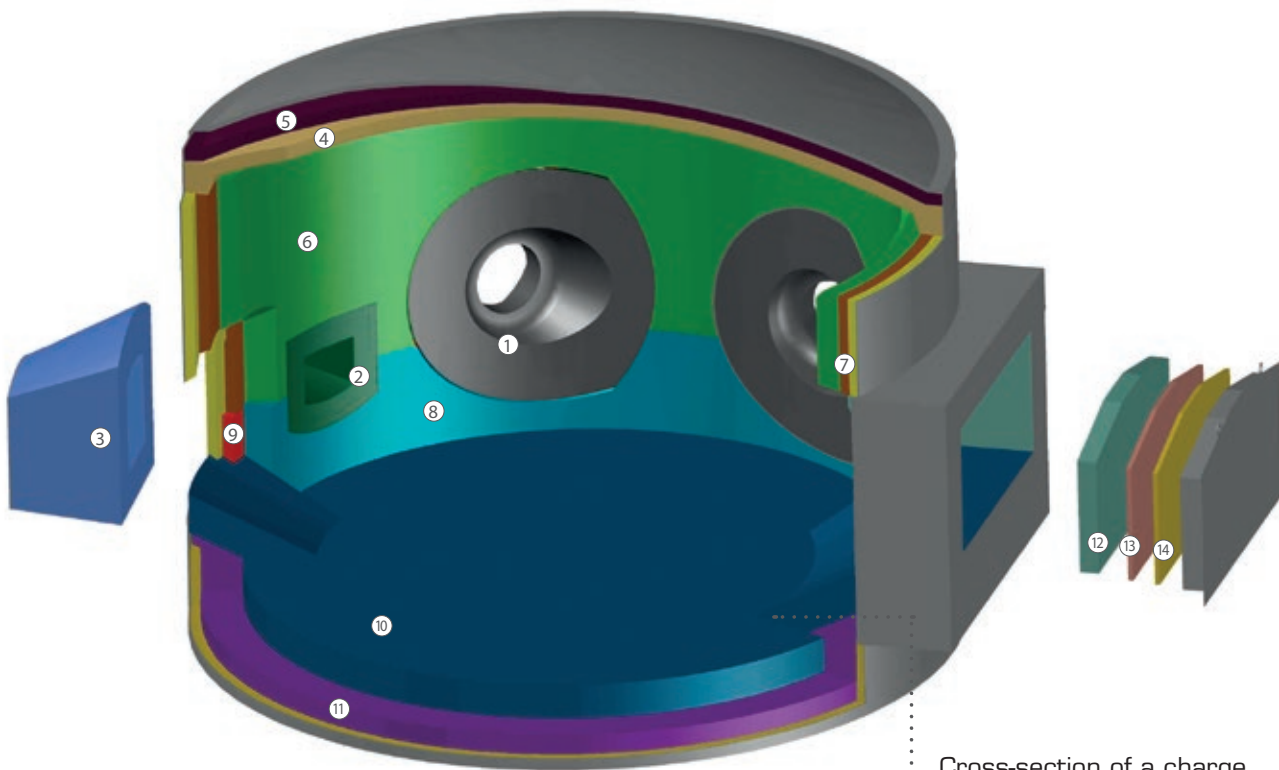
1. Round top charge melting and holding furnace

Traditional large round top charge furnaces, typically built in big sizes, are widely used in large casthouses and applied for all types of alloy. Advanced refractories can support the production process by maintaining controlled temperatures within the furnace and by reducing the heat losses.

This type of furnace was originally developed with a full brick lining; modern refractory technologies have shown the benefits of monolithic linings for this equipment.



Hearth construction



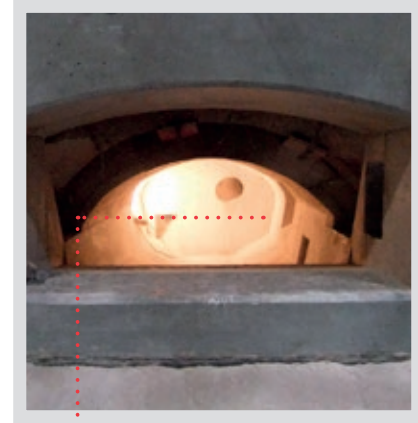
Cross-section of a charge round top melting furnace

Color	Zones	Material type	Attention to
①	Burner	low cement, no cement castable, plastic, gunning mix	thermal shock, temperature
②	Inlet	medium, low cement castable	strength, abrasion, resistance against Al
③	Spout working lining	medium, low cement castable	strength, abrasion, resistance against Al
④	Roof working lining	low cement castable, gunning mix	thermal shock
⑤	Roof insulation	LW insulating castable	thermal conductivity, density
⑥	Upper wall working lining	low cement castable, plastic, gunning mix	thermal shock
⑦	Upper wall safety/insulation lining	LW, MW insulating castable	thermal conductivity, strength
⑧	Lower wall working lining	low cement castable, plastic	resistance against Al, strength, abrasion
⑨	Lower wall safety/insulation lining	low cement castable, MW castable	thermal conductivity, resistance against Al
⑩	Bath working lining	low cement castable	resistance against Al, strength
⑪	Bath safety/insulation lining	low cement castable, MW castable	thermal conductivity, strength
⑫	Door working lining	medium, low cement castable	density, strength, resistance against Al
⑬	Door safety/insulation lining	LW insulating castable, insulating boards	density, thermal conductivity
⑭	Insulation second layer	insulating boards	thermal conductivity

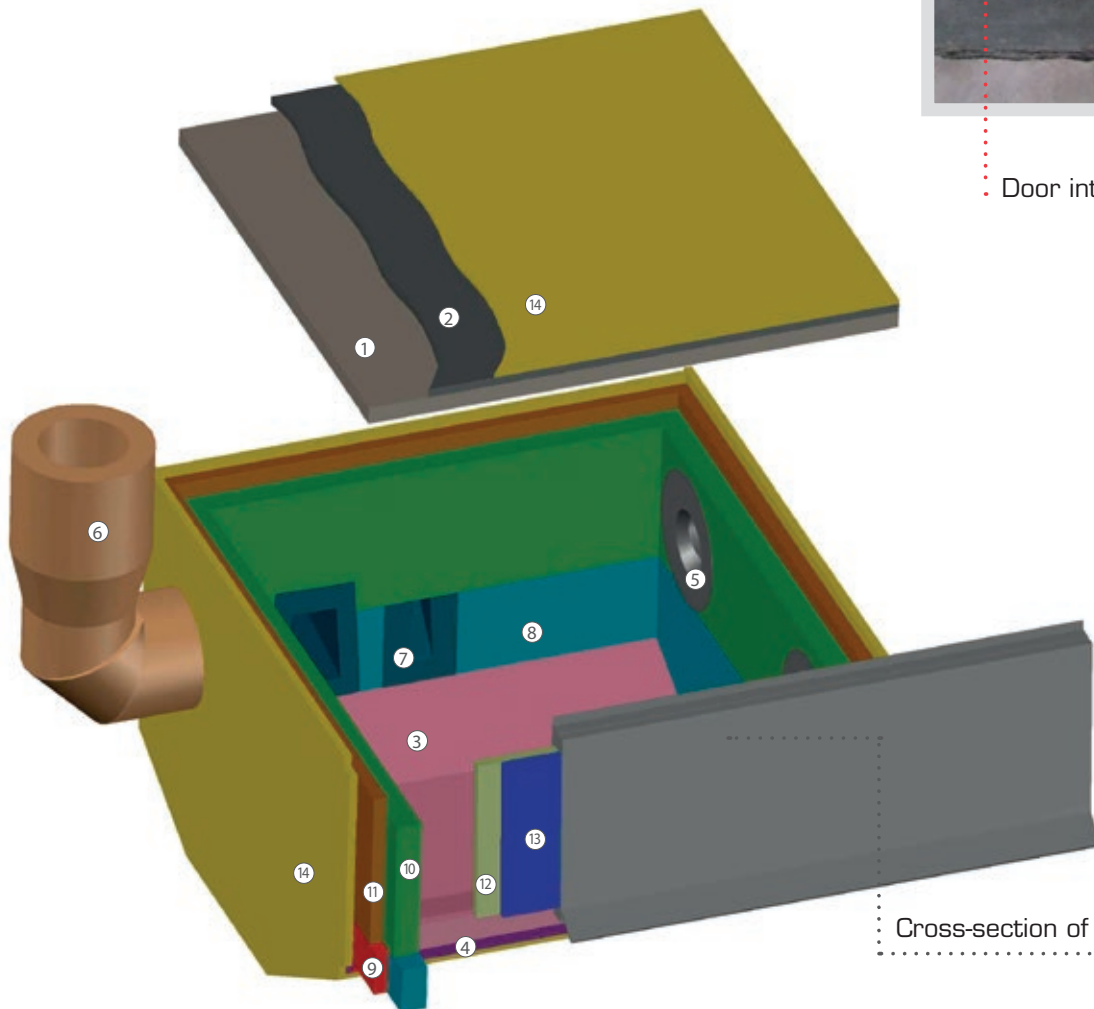
See used Seven products for this furnace in the combined table after chapter Tilting furnace.

2. Tilting furnace

Mostly built for holding purposes this type of furnace is a buffer between the melting furnace and the casting line, it is able to consistently deliver molten metal to the caster. The size can range from few to more than 100 t of molten metal, refractories must therefore be versatile and match the engineering requirements.



Door into a tilting furnace



Cross-section of a tilting furnace

Color	Zones	Material type	Attention to
①	Roof working lining	low cement castable, gunning mix	thermal shock
②	Roof insulation	LW insulating castable	thermal conductivity, density
③	Bath working lining	low cement castable	resistance against Al, strength
④	Bath safety/insulation lining	low cement castable, MW castable	thermal conductivity, strength
⑤	Burner	low cement, no cement castable, plastic, gunning mix	thermal shock, temperature
⑥	Chimney	MW insulating castable	thermal conductivity, density
⑦	Spout	medium, no cement castable	strength, abrasion, resistance against Al
⑧	Lower wall working lining	no cement castable, plastic	resistance against Al, strength, abrasion
⑨	Lower wall safety/insulation lining	low cement castable, MW castable	thermal conductivity, resistance against Al
⑩	Upper wall working lining	low cement castable, plastic, gunning mix	thermal shock
⑪	Upper wall safety/insulation lining	LW, MW insulating castable	thermal conductivity, strength
⑫	Door working lining	medium, low cement castable	density, strength, resistance against Al
⑬	Door safety/insulation lining	LW insulating castable, insulating boards	density, thermal conductivity
⑭	Insulation second layer	insulating boards	thermal conductivity

See used Seven products >>>

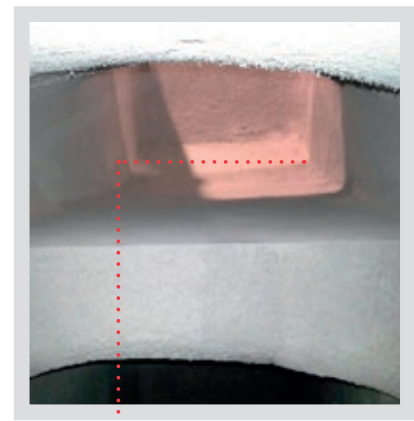
Seven products	Application areas
Seven Cast A 80 RX	bath working lining, spout
Seven Cast A 80 RB	bath working lining, spout, inlet
Seven Cast A 70 NH	bath working lining
Seven Cast A 84 NX	bath working lining
Seven Cast A 82 RX	spout, inlet
Seven Cast A 42 RM 4	door working lining, lower wall safety lining, bath safety lining
Seven Cast A 60 RH	upper wall working lining
Seven Cast A 60 NH ZR	upper wall working lining
Seven Cast A 53 RM	roof, door working lining, lower wall safety lining
Seven Gun A 75 RB	wall, door working lining, repairs
Seven Gun A 35 RM 4	door working lining
Seven Cast A 90 CR	burner, spout, lower wall working lining
Seven Cast 75 CX 01V	spout, walls working lining, repair
Seven Cast 59 ND	burner, Roof, upper wall working lining
Seven Plast 85 CX -3	burner, lower wall working lining, spout
Seven Plast 70 AKX	burner, Roof
Seven Cast 75 RX 4	lower wall safety lining
Seven Cast 50 NM	roof
Seven Gun 55 RM	roof
Sevenlite 1050 P	roof insulation
Sevenlite 1100 P	roof insulation, upper wall insulation
Sevenlite 1200 P	roof insulation, upper wall insulation
Sevenlite 1300 P	lower wall safety lining
Insulating boards (ceramic fiber, calcium silicate)	second layer insulation

Tilting furnace

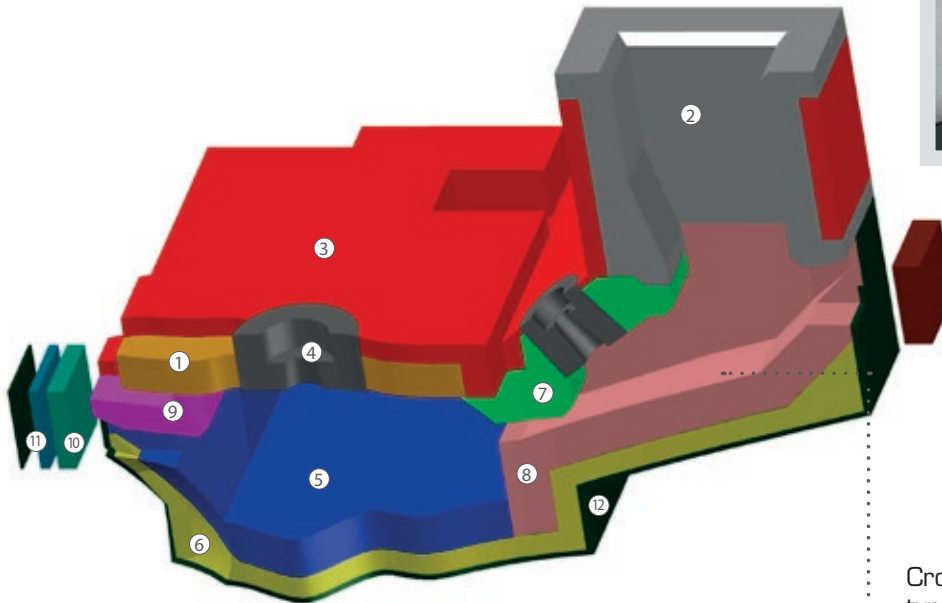


3. Shaft type reverberator furnace

Powered by gas reverberatory heating and typically used for quick melting of scrap, this furnace concept maximizes energy efficiency, lowest emission and compact design. Possible refractory issues can be solved by correct material selection and careful installation and dry out.



Shaft



Cross-section of a shaft type reverberator furnace

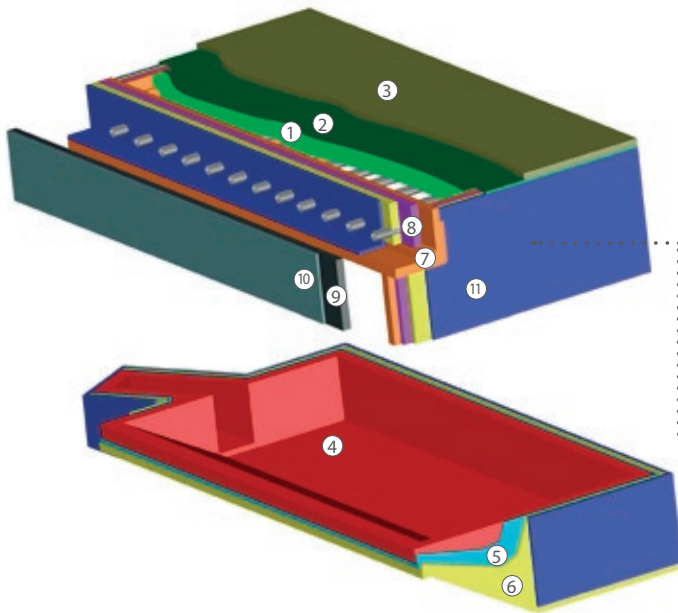
Color	Zones	Material type	Attention to
①	Roof working lining	low cement castable	thermal shock
②	Shaft working lining	medium, low cement castable	thermal shock, strength
③	Roof and shaft insulation	LW insulation castable	thermal conductivity, density
④	Burner	no cement castable, plastic	thermal shock
⑤	Bath working lining	no cement castable	resistance against AI, strength
⑥	Bath insulation/safety lining	medium, low cement castable, MW castable	thermal conductivity, resistance to AI, strength
⑦	Chute roof	low cement castable	thermal shock, strength
⑧	Chute bottom	no cement castable	resistance against AI, strength, abrasion
⑨	Main opening lintel	medium, low cement castable	strength, thermal shock
⑩	Door working lining	medium, low cement castable, MW castable	thermal conductivity, density
⑪	Door insulation/safety lining	LW insulating castable, insulating boards	density, thermal conductivity
⑫	Insulation second layer	insulating boards	thermal conductivity

Seven products	Application areas
Seven Cast A 80 RX	bath working lining, main opening lintel, chute bottom
Seven Cast A 80 RB	bath working lining, chute bottom
Seven Cast A 70 NH	main opening lintel
Seven Cast A 84 NX	bath working lining, chute bottom
Seven Cast A 42 RM 4	door working lining, bath safety lining
Seven Cast A 60 RH	chute and roof
Seven Cast A 90 CR	burner, bath working lining, chute bottom wall lining
Seven Cast 75 CX 01V	bath working lining, repair
Seven Cast 59 ND	burner, roof, shaft working lining
Seven Cast 80 NX	shaft working lining
Seven Plast 70 AKX	burner
Seven Cast 50 NM	roof, shaft working lining
Seven Gun A 75 RB	wall, door working lining
Seven Gun A 35 RM 4	door working lining
Sevenlite 1050 P	roof and shaft insulation
Sevenlite 1200 P	roof and shaft insulation
Sevenlite 1300 P	door, bath insulation/safety lining
Insulating boards (ceramic fiber, calcium silicate)	second layer insulation

4. Electrical heating furnace

This furnace ensures a highly controlled and continuous heating process.

Countries where electrical power is available and cheap still prefer electrical heating supplied by large resistors for the big size melting and holding furnace. Based on the mix of energy sources in the production of electricity, this has the potential for a higher percentage of renewable and environmentally friendly sources of energy.



Resistors in the roof of an electrical heating furnace



Cross-section of an electrical heating holding furnace



Door charging in an electrical heating furnace

Color	Zones	Material type	Attention to
①	Roof working lining	low cement castable, gunning mix	thermal shock
②	Roof insulation	LW insulating castable	thermal conductivity, density
③	Roof insulation second layer	LW insulating castable	thermal conductivity, density
④	Bath working lining	low cement castable	resistance against Al, strength
⑤	Bath safety lining	regular, low cement castable, MW castable	thermal conductivity, strength
⑥	Bath and side wall insulation	LW insulating castable	thermal conductivity
⑦	Side wall working lining	low cement castable, plastic, gunning mix	thermal shock
⑧	Side wall safety lining	medium, low cement castable, MW castable	thermal conductivity, strength
⑨	Door working lining	medium, low cement castable, MW insulating castable	density, strength, resistance against Al
⑩	Door insulation/safety lining	LW insulating castable, insulating boards	density, thermal conductivity
⑪	Insulation second layer	insulating boards	thermal conductivity

Seven products

Seven Cast A 80 RX

Seven Cast A 80 RB

Seven Cast A 84 NX

Seven Cast A 82 RX

Seven Cast A 42 RM 4

Seven Cast A 60 RH

Seven Cast A 53 RM

Seven Cast 40 RM 5, Seven Cast 50 NM, Seven Gun 55 RM

Seven Cast A 1200 LW

Seven Gun A 50 NM

Seven Gun A 35 RM 4

Seven Gun 38 RM 4

Sevenlite 1450 LI P

Sevenlite 1050 P

Sevenlite 1100 P

Sevenlite 1300 P

Insulating boards
(ceramic fiber, calcium silicate)

Seven CAST A 90 CR

Application areas

bath working lining, spout bottom

bath working lining, spout

bath working lining

spout

bath safety lining

side wall working lining, spout roof

roof, door working lining

roof

side wall safety lining

side wall working lining, spout roof

door working lining

bath safety lining

door working lining

roof insulation (first and second layer)

bath insulation, side wall insulation

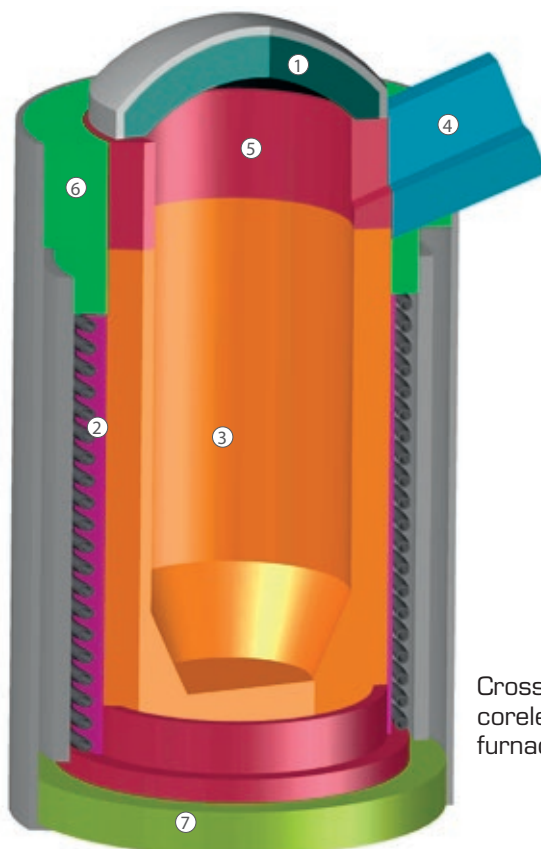
side wall safety lining

second layer insulation, door insulation

spout, bath working lining, repair

5. Channel induction furnace

The coreless induction furnace is especially suitable for the manufacture of high quality alloys. Secondary Aluminium and Aluminium recycling plants rely on this type of furnace as it allows various methods to clean the molten aluminium directly in the furnace.



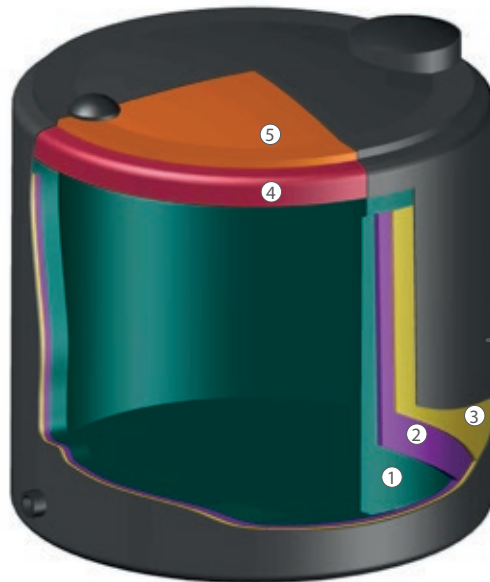
Cross-section of a coreless induction furnace

Color	Zones	Material type	Attention to
①	Cover	regular / low cement castable	thermal shock
②	Coil grout	troweling castable	troweling behaviour
③	Working lining	High alumina dry vibration mix / low cement castable	sintering behaviour; anti wetting to Al
④	Spout	anti wetting vibration / low cement castable or plastic	anti wetting to Al
⑤	Top cap	anti wetting vibration / low cement castable or plastic	anti wetting to Al
⑥	Top rim	vibration / low cement castable or plastic	
⑦	Bottom	regular / low cement castable	

Seven products	Application areas
Seven Dry A 87 CK 01 V	Working lining
Seven Cast A 60 RH	Working lining, top cap, top rim, cover
Seven Plast 85 CX -3	Spout, top rim, top cap
Seven Ram 85 CX	Spout, top rim, top cap, repair
Seven Plast 70 AKX	Cover, top rim
Seven Cast A 1200 LW	Cover
Seven Cast 65 RBB LW	Cover
Seven Trow 80 RX - 05	Coil grout
Seven Trow 95 RW -3	Coil grout
Seven Cast 52 RM CO	Top rim; cover; bottom
Seven Gun 55 RM	Cover

6. Road transfer ladle

Aluminium plants commonly rely on road transfer ladles to transport molten aluminium between their production sites. The refractory lining plays a key role in avoiding heat losses and maintaining an optimal heat curve.



Cross-section of a road transfer ladle

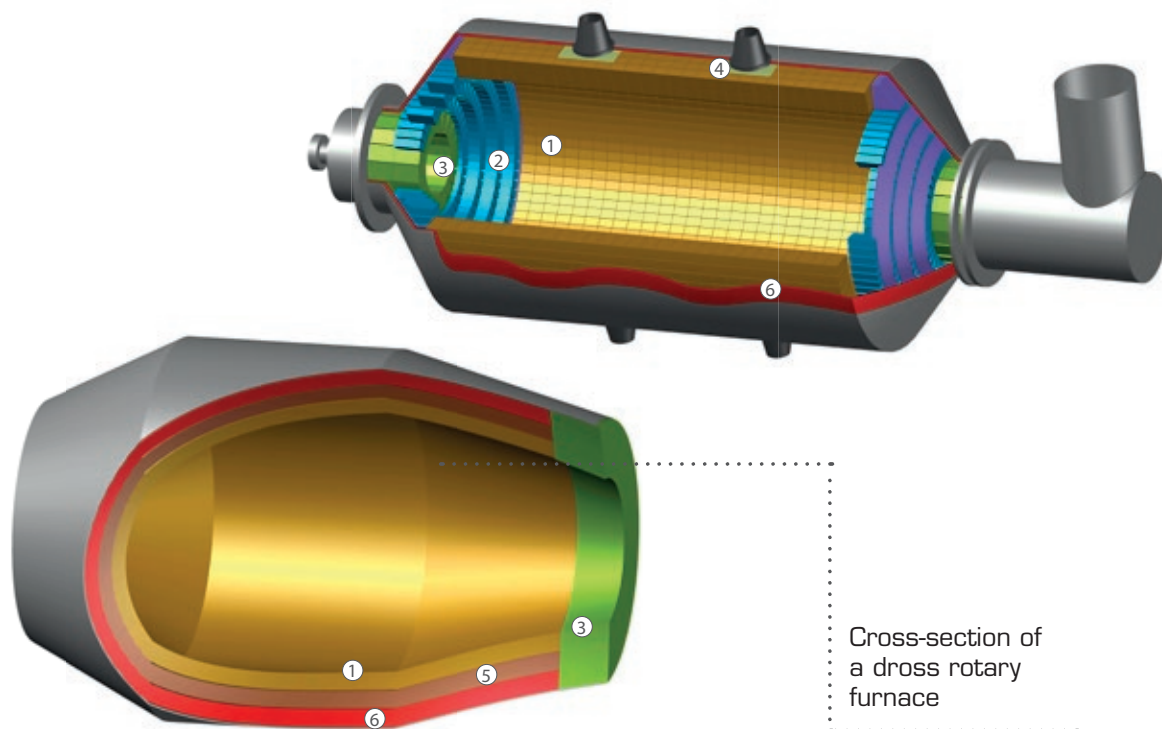
Color	Zones	Material type	Attention to
①	Working lining	low cement or self flowing castable	anti wetting to Al and strength
②	Insulation layer 1	insulating castable	thermal conductivity and strength
③	Insulation layer 2	insulating board	thermal conductivity
④	Cover lining	low or MW insulating castable	thermal conductivity and strength
⑤	Cover insulation	insulating boards	thermal conductivity

Seven products	Application areas
Seven Cast A 60 RH	working lining
Seven Cast A 80 RX	working lining
Seven Cast 1200 LW	working lining + insulating layers, cover
Seven Flow 85 UX	working lining
Seven Flow A 75 NX	working lining
Sevenlite 1200 P	cover lining, insulating layer 1
Sevenlite 1050 P	cover lining, insulating layer 1
Sevenlite 1300 P	cover lining

7. Rotary drum furnace

Fine aluminium scrap and dross from reverberatory furnaces contain a relevant percentage of metal which can be partially recovered when they are re-melted by means of a proper equipment and the right fluxes to prevent the massive oxidation which would result from the big specific surface of these raw lumps.

Rotary drums are an interesting refractory application as the chemistry of dross and the additives can attack linings if they are not properly designed.



Color	Zones	Material type	Attention to
①	Working lining cylinder	low cement castable; dense bricks	low porosity, resistance to Al
②	Working lining cones	low cement castable; dense bricks	low porosity, resistance to Al
③	Rim	low cement castable	low porosity, resistance to Al
④	Nozzles	low cement castable	low porosity, resistance to Al
⑤	Safety lining	medium/low cement castable	conductivity, strength, resistance to Al
⑥	Insulation layer	insulating castable/board	insulation properties

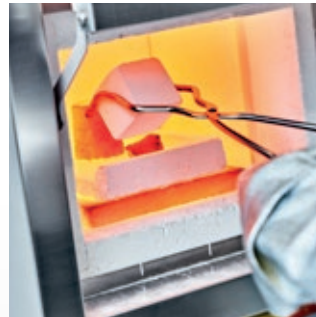
Seven products	Application areas
High Alumina Brick 50	working lining
Bauxite Brick 80	working lining
Seven Cast A 80 RX	working lining, rim
Seven Cast 80 NX	working lining, rim
Seven Cast A 53 RM	safety lining, insulation layer
Sevenlite 1200 P	safety lining
Sevenlite 1050 P	insulation layer
Ceramic fibre board; calcium silicate board	insulation layer

RESEARCH AND SUSTAINABLE DEVELOPMENT

Seven Refractories has incorporated environmental concerns about climate change in its innovative approach to the market; not only in making our factory more electrically independent by using renewable energy sources, but in the entire manufacturing process cycle and quality control.

Respect of the environment is a core value of Seven Refractories.

Selection of the raw materials, dedicated and oriented research, composition architecture and on the field technical experts are the key-points for outstanding efficiency and reliability of the refractory linings, excellent control of the thermal load distribution and low product variability in time.



TESTING



PRODUCTION



SERVICES PROVIDED

- Preliminary study and investigation for the entire project
- Design and architecture including bill of materials and thermal calculation
- Full range of products for lining and maintenance
 - Regular, low, ultra-low and no-cement castable
 - Regular and dense low-cement gunning mix
 - Ramming
 - Shotcreting
 - Self flowing
- Supply of mixers, gunning machines, pumps, etc.
- Training on mixing, gunning and maintenance techniques
- Training on equipment usage
- Supervision and monitoring by experienced technicians
- Global research & development
- Technical advice by experts
- Monitoring and targeting of results



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