EREDI SCABINI NEWS

Since 1945, the refractory specialist at your disposal.

An ongoing story of success…

Eredi Scabini has been on the refractories market for almost 75 years, during which time it has grown constantly, to become what it is today: a company Italian by birth but international by vocation, which has always believed in the importance of good business practice to offer products and services of quality, with ever-improving performances and more and more advanced technologies, with the aim of achieving growth not only for itself but above all for its customers.

To enable all this to come about, the company's organisation has also undergone major changes over time: as production has increased in terms of both quantities and number of types, the company has expanded its premises to accommodate the new equipment and the new staff required.

The latest expansion took place in the first half of this year, when the company purchased another 5,000 sqm of factory buildings next door to its headquarters.

Today, Eredi Scabini has a total operating area of about 30,000 sqm, on two separate sites. The plants are close together and are both strategically located in the Milan hinterland.

The complex includes 3 different monolithics and preformed production plants, also recently expanded with 2 new high-temperature furnaces of impressive capacity; several warehouses for raw materials and products in transit, and a brand new centre entirely dedicated to the experimentation and design phase, which precedes and accompanies the birth of the products and solutions offered to customers: the ATC - Advanced Technology Centre, opened at the end of 2018.

The new ATC houses professionals of vast experience, including engineers, chemists and designers, who cooperate and exchange ideas on a daily basis in a well organised process, to create products and services of excellence. It is equipped with state-of-the-art technological tools including Wavelength Dispersive X-Ray Fluorescence spectrometers, Electric Fusion Machine for preparation of beads (XRF analysis), compression and flexural strength test presses also for large-sized pre-forms, equipment for analysis of apparent density and porosity, pH, viscosity and much more.

Eredi Scabini is a sound, prosperous business, with a solid past and excellent future prospects, thanks to its innate ability to evolve and keep constantly up to date.

Eredi Scabini headquarters

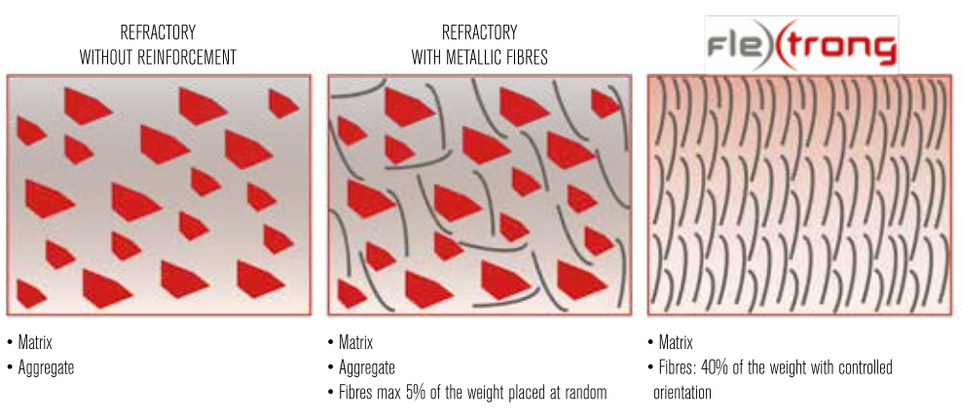
Flextrong®: unity is strength!

Flextrong is a line of Eredi Scabini products developed and launched relatively recently. However, thanks to its distinctive characteristics it has rapidly achieved success, becoming one of the product families most widely used in situations requiring high levels of performance and/or involving particularly tough conditions. Today Flextrong® is the exclusive Eredi Scabini product family with countless applications for steel, iron and steel, aluminium, copper and cement.

What makes Flextrong® so special?

First and foremost, we need to know that Flextrong® is not a ceramic product but is a composite. Composites are characterized by the combination of at least two different, physically separate substances, with different properties. The combination thus produced has new physical and chemical properties not provided by its individual constituent materials. One excellent example of a composite material is reinforced concrete, where concrete and steel maintain their individual identities but combine to generate a product with unique characteristics: the rebars mainly withstand the tensile loads, while the concrete is more resistant to the compressive loads.

The individual constituent parts of the composite are the MATRIX and the REINFORCEMENT. In Flextrong the matrix consists of a CERAMIC material, while the reinforcement is in METAL. Flextrong® is therefore a fibre-reinforced composite material. The matrix is initially in the viscous fluid state in order to fill all the spaces and bond perfectly with the fibres, then hardens to protect the fibres from physical and chemical attacks. The job of the fibres, on the other hand, is to give the composite strength and resistance to mechanical stresses.



Flextrong® has a ceramic matrix made from a special superfine, high fluidity, microionic set refractory material, which gives the product hardness and refractory properties, while the large quantities of special steel fibres, with controlled orientation, give it ductility.

The combination of these factors creates a product with outstanding thermal shock, impact, fracture and oxidation resistance, even in an oxidising atmosphere.

What's more, since the ceramic matrix acts like a shell, protecting the metal fibres from oxidation and high temperatures, Flextrong® is also widely used in situations in contact with direct flames and molten metals. Mechanical resistance of Flextrong compared to some competitor products. Another factor which has made Flextrong® a widely used product is the ease with which it can be installed, removed and replaced. Flextrong® is designed to simplify its installation, thanks to the use of screws, stud bolts, tie-bolts and eye bolts which are bolted to metal structures.

The case histories offered on the following pages explain how this product is able to guarantee performances immensely superior to those of standard solutions previously used by the same customers.

So enjoy the read but never forget that every situation is unique and unrepeatable, so please get in touch so we can design the ideal refractory solution for you, too.

Preformed are easier said than done!

Eredi Scabini was one of the first, if not the first (or one of the very first) refractory industry companies to believe and invest in the development of the technology for producing preformed shapes, as an alternative to bricks and castables. More than 35 years have now passed since those early days, and time has confirmed the wisdom of the choices made back then: while initially preformed were only used in steel production, for "accessory" components such as the tundish barriers or the burner blocks of heating furnaces, today their use is also widespread in foundries for iron and other metals, even for complete linings. Thanks to its countless benefits, the use of preforms has set new performance benchmarks which have now become essential for competitiveness. At present we have a portfolio of over 100 different preformed solutions, including complete reverberatory furnaces for aluminium, vertical furnaces for copper production, tundish covers, basins and inductors of channel-type induction furnaces, EAF delta section, crucibles for coreless induction furnaces and many more items, through to the complete realisation of the world's largest channel-type furnace, with capacity of 200 tons (some examples of preformed shapes are featured in this Newsletter). We are proud of having believed and invested so much in this project. Over the years, the work that has followed in both production and performance analysis, in the various types of application, has enabled the company to specialise and design new, increasingly sophisticated preformed, larger in size and more important in function. Naturally, none of this would have been possible without the foundation of in-depth knowledge of the raw materials and their behaviours in the most widely different conditions. Because, contrary to what one might think, taking any castable and giving it a shape is not enough to make a good preformed. The castables produced in our plants, in a controlled environment, specifically for preformed shape production, are developed "ad hoc" bearing in mind the geometrical forms and the stresses and temperatures the future preformed will have to withstand as well as the performance levels desired by customers. There is no denying that it has not always been easy, and even today for every new challenge we need to bring into play all the skills and know-how acquired, focusing very closely on every phase of the production process; however, we do not know any other method able to guarantee better results, or any competitors who have achieved results which come even remotely near to our standards. Today, Eredi Scabini is really the only company able to design and produce preformed weighing up to 15 tons, and with amazing performances. The market knows this, and more and more often it is recognising our supremacy by offering us major new challenges.

Cover Tundish

Crucibles CPS®

Inductor IPS

Realization of a complete furnace

Highlights

2lite® insulating foam. Effective, safe innovation.

2lite® is a product line that represents an absolute novelty on the market for insulation products. Developed to create the back-up of preformed linings in a simple, fast and safe way, 2lite® is an insulating nanostructured mixture that expands in situ generating a foam with very low thermal conductivity, high thermal shock resistance and good mechanical strength. 2lite® guarantees maximum safety thanks to the excellent non wetting properties and stability, enabling it to maintain excellent insulating properties and ensure a stable support for the working lining, even in case of contact with molten metal.
Moreover, 2lite® is an ecological product and does not contain ceramic fibres.

The customer whose case history is described here belongs to an international group with 9 production sites in Europe, North America and Asia. It is the world's biggest producer of semi-finished products for the packaging industry (tubes and cans), with output of about 30,000 tonnes/year. The foundry has 2 continuous casting lines.
The customer used to insulate and fix its preformed filter boxes and launders with insulating panels clad with adhesive aluminium sheeting and ceramic fibre cements.
The customer has now been using our 2lite® insulating foam to insulate and fix its preformed filter boxes and launders since 2013, to its great satisfaction. Apart from the easy installation and effective insulation, the customer is also delighted with the reduction in crack formation in the preformed launders: exceptionally fluid, 2lite® fills in every gap and its volumetric stability guarantees the preformed launder excellent support. **REF. N.6**

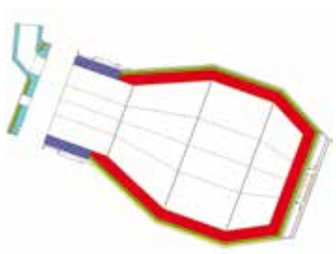
Photo 1 - The product is poured into the gap between the preformed shape and the carpentry or the rest of the insulating lining. The filling is guaranteed by the product fluidity and its 'high' density during the installation

Photo 2 - Expansion of 2lite®

Better performances with Ultrablock® preformed shape for casting launder system.

The customer is a leading Middle Eastern company which produces rolled aluminium products with continuous casting process, with production capacity of about 250,000 tonnes/year in two plants. The holding furnaces are connected to the continuous casting machine by the launders, which convey the molten metal from the furnaces to the degassing unit, the filter box and finally the casting machine itself.
In the past, the launders used to be lined with preforms and insulated by means of two sets of insulating panels; the preform was fitted inside them and secured by flanges at the top. The customer started to use Eredi Scabini preforms for its launders in 2011.
The launders were constructed using Ultrablock®, which has excellent non-wetting properties and equally outstanding resistance to thermal shock, impact, and in particular the abrasive effects of the liquid metal. Moreover, its low apparent porosity makes the launders easier to clean. Thanks to these characteristics, the launder recorded better-than-standard performance (1.5/2 years). In response to these highly satisfactory results, the customer has chosen also to use Ultrablock® preformed linings for the degassing unit and filter box. **REF. N.7**

With Flustone®, lifetime of tilting rotary furnaces lining has increased by +35%.



Flustone is a line of microionic dense castables with excellent flow ability allowing application by self-distribution. They are used mainly for working linings requiring high resistance to abrasion and/or saturation by metals and/or slags. They are self-bonding, allowing linings to be repaired by applying the same product to the worn surface without changing the whole lining.

The customer is an aluminium refiner with production capacity of about 100,000 tonnes a year. Apart from the various melting and holding furnaces, the foundry contains 2 tilting rotary furnaces with capacities of 14 and 20 tonnes. The tilting furnace produces aluminium by melting Al slag and salt (10%) and is charged every 6 hours, with continuous operation for 6 days a week. This causes problems of thermal shock, abrasion and chemical attack. In the past, tilting rotary furnace linings used to be made from Low Cement Castable, which tended to wear very quickly, lasting only 8/12 months in tilting furnace 1 (14 tonnes) and only 6/8 months in tilting furnace 2 (20 tonnes) (Photo 1).
Most of the problems occurred on the charging/pouring door, in the first part of the basin and on the end wall. In our solution the tilting rotary furnaces were lined with Flustone® castable.
The first lining was installed on tilting furnace 1 and lasted 28 months, while the second, installed on tilting furnace 2, was still in service after 25 months (Photo 2). A number of infrared pictures were taken during production and showed very low heat losses (Photo 3). All this foundry's tilting rotary furnaces now have complete Flustone linings.

REF. N.13

Photo 1 - Conventional solution after 4 months' service

Photo 2 - Eredi Scabini solution after 20 months

Photo 3 - Infrared picture of Eredi Scabini solution

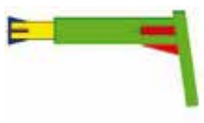
Preassembly of the lining

ABT increase output and reduce problems.

Eredi Scabini has always believed in the development of preformed shapes and its capability for producing them up to 15 tonnes in weight places the company amongst the undisputed world leaders in this market sector. Eredi Scabini's ABT- Advanced Block Technology-solutions are customised preformed furnace lining kits. The kit developed for this customer comprised several products, including Ultrablock®, dense preformed shapes with excellent "non-wetting" properties. The low porosity, controlled pore size and unique bonding system deliver a winning combination against abrasion and chemical attack.

The customer produces refined aluminium slabs for the internal production of flat products for the food packaging and automotive industries (500,000 tonnes/year). This line for the production of series 5000 Al alloys comprises 2 channel melting furnaces of 45 t each and 1 holding furnace. 4 inductors are installed on each melting furnace.
The project for rebuilding the furnaces with big-blocks arose and was developed in a number of phases in response to the customer's need to use a refractory lining technology capable of achieving the following aims: reduction of furnace downtimes, increase of the two furnaces' capacity, reduction in repair and maintenance costs, reduction of the number of maintenance stoppages, extension of the time interval between two complete reconstructions of the refractory lining, increase in output due to reduction of the number and duration of stoppages plus the increase in the inductor melting capacity. In the original solution, the basin was lined with bricks, the throat with ramming mix and the top cap with low cement castable. Maintenance work was performed frequently and major repairs were needed whenever an inductor was replaced. The first phase of the project began in March 2010. It involved the reconstruction of the throats of one furnace with Eredi Scabini Flustone® castable. In view of the good results achieved, in 2011 the throat of the second furnace and the top cap of both furnaces were rebuilt using the same castable. The rest of the lining was unchanged. Compared to the original solution, even this partial introduction of Eredi Scabini products generated considerable improvements: the throats and top cap required very little maintenance - the lifetime of the throats was doubled (from 18 to 36 months). The definitive project includes the use of Ultrablock® big-blocks for the working lining, combined with a monolithic back-up lining in Flustone® and Cast-Lite™.
The reconstruction of the two furnaces was completed in 40% less time than with the previous solution, drastically reducing the plant downtime. Staff immediately reported that the furnaces were needing less cleaning, since aluminium and slag do not stick to the lining easily. The furnaces' capacity was increased, but even though these modifications reduced the total thickness of the lining, there are no significant increases in the temperature on the steel shell. Simultaneously with the design of the basin, Eredi Scabini also developed a solution for the lining of the inductors which increased their lifetime by 300% compared to the previous lining. **REF. N.14**

Thanks to Flextrong®, skimming and stirring tool performances are greatly multiplied.



The customer is a primary aluminium producer specialized in aluminium alloys production. Flextrong®, Eredi Scabini's preformed ceramic matrix composite, has replaced steel skimming and stirring tools.

Flextrong® skimming tool

The cast house is equipped with several casting lines for ingots and billet production. Serval melting furnaces, with capacity varying from 19 to 30 tons are used to re-melt and alloy the metal.
Skimming and stirring tools, fitted on forklifts, are used in the reverberatory melting furnaces for:
- Stirring the bath to re-melt alloying elements and speed up the re-melting of recycled scrap
- Skimming slag from the surface of the bath
- Cleaning the lining.

Every day, the tool is used 48 times for stirring the bath and skimming the surface. Each stirring cycle lasts from 13 to 20 minutes, depending on the furnace capacity Originally, the tools were made of carbon steel plate (photo 1), and lasted from 1 to 2 days; in the past, the customer also performed tests with special steels, achieving lifetimes of up to 7 days, and more tests with other, competitor composites (photo 2), without ever exceeding a lifetime of 7 days. In 2005 Eredi Scabini supplied the first 2 Flextrong® tools (photo 3), which immediately gave results considerably better than the competitor products.
The company then went on to develop and produce a tool for the customer with connecting arm lined for about 1.5 meters (photo 4), to prevent the latter from being corroded and extend the tool's lifetime. Since 2012 Eredi Scabini has been supplying the customer with skimming tools with arm in Flextrong®, achieving lifetimes of as much as 100 days, and Flextrong® tools without lined arm with lifetimes of up to 35 days. **REF. N.27**

CPS® the exclusive solution for coreless induction furnace linings with no rivals on the market.

The customer is a leading Middle Eastern company which produces rolled aluminium products with continuous casting machinery. Their production capacity is about 250,000 tonnes/year in two plants. CPS® – Crucible Preformed System – is the Eredi Scabini solution for relining coreless induction furnaces with a pre-formed and pre-sintered crucible.

The customer uses a 4-tons coreless induction furnace to re-melt production returns. This furnace is charged with return coils which weigh up to more than 750 kg per coil, so it is constantly subjected to heavy stresses. The customer used to line the coreless induction furnace with a dense refractory castable. After the installation, this solution required curing and then a drying/sintering schedule; a procedure which took 6 or 7 days, during which time the furnace could not be used. This type of lining did not last more than 8/9 months. Since 2010 Eredi Scabini has been supplying this customer with the CPS® solution, which comprises a pre-fired, pre-formed working lining and a dry rammed backup lining. Installation takes less than one day, as does the first heat-up schedule. The customer can therefore start to produce molten aluminium at the end of the second day. The average lifetime of the Eredi Scabini CPS® solution is 12-14 months. Today the customer continues to successfully use our CPS® solution. **REF. N.28**

Crucible installation

Charging / melting

Eredi scabini: No. 1 FOR OEMs TOO!

The customer is an international corporation specialising in the design and production of industrial furnaces for ferrous and non-ferrous metals. Their range also includes aluminium melting, holding and heat treatment furnaces.

Over time, Eredi Scabini has built up a major partnership with this company, enabling the two firms to work in synergy to provide end customers with a complete, absolutely efficient service, as well as a top-quality product. In this case, Eredi Scabini saw to the lining of a 25 ton reverberatory furnace for melting aluminium, with regenerative burners. The design produced by EREDI SCABINI drew on its experience gained in linings for furnaces of this type during recent years, and involved the use of large preforms for the hearth and ramp and the use of CEMENT-FREE castables for all the other parts of the furnace. This solution was developed to deliver:

- Easier, quicker installation
- Best possible mechanical strength for both the hearth and the ramp, the areas that receive the most punishment from the charge and the electromagnetic stirrer.

As scheduled, the complete lining installation procedure required just eighteen 10-hour shifts. The furnace is still in constant operation with no stoppages. Thanks to the remarkable results achieved, the customer decided to cover the second twin oven with the Eredi Scabini solution.

REF. N.37

Metal structure ready for work to start

Metal structure ready for work to start

Installation of the side walls underneath the bath

Installation of the preformed hearth

Preparing the crown anchor points

Top-bottom side walls and burners. Crown formwork

Completed refractory lining of furnace

Furnace in production

Flextrong® & Flustone® make up a complete lining.

Flextrong® is a preformed ceramic matrix composite reinforced with heat resistant steel. The product has excellent resistance to thermal shock, impact, fracture and oxidation as well as to contact with molten metals. Flextrong® is designed for the installation via bolts and/or welding brackets provided. Flextrong® HT has been specifically developed for applications at high temperatures and in the presence of oxidizing atmospheres.

The customer is an European company which is a leading international producer of rolled products, processing more than 150,000 tons of aluminium a year and exporting to more than 85 countries. It prioritises the constant search for potential improvements to the production process to maintain a high quality standard over time. In this case, the customer was about to completely rebuild a 60 ton reverberatory furnace and stated the need to greatly extend the lifetime of the door frame compared to the conventional types with steel or iron impact plates, to eliminate the flares, the continuous maintenance costs and the rapid wear of the sill and chute due to the charges. The customer also required a high-quality refractory material with strong resistance to aluminium corrosion, highly reliable, stable and with minimal expansion and contraction in the event of furnace shutdown and re-start, not to mention quick to install. One key feature of the design developed by Eredi Scabini is the Flextrong® HT doorframe. The wear linings of the basin, walls, burner blocks and roof were constructed in a variety of products from the Flustone® line of microionic dense castables with high resistance to abrasion and/or saturation by metals and/or slags. More than three years after it was put into service, the plant is still fully operational with only a small amount of scheduled maintenance and just one replacement of the sill and jambs and not of the lintel, which is still intact. Completely satisfied with this solution to all its requirements, the customer is now working in partnership with Eredi Scabini on a continual basis, assigning more complete melting furnace rebuilding projects to our company.

REF. N.49

Furnace during maintenance. Note the serious wear of the metal door frame

Completed lining ready for controlled drying

Construction of the Flextrong® HT doorframe. The sill is in Flextrong® HT AL

Furnace in production 3 years after reconstruction

A mix of products and methods for tower furnaces applied by true specialists.

The company has offered and conducted the in-house development of top quality monolithic refractories since its foundation. The range now comprises hundreds of different formulae, used for the realisation of refractory and insulating linings as required by the characteristics of the project and the customer's specific needs, also using a wide variety of methods. In this case, the preferred option was the Flustone® line, which comprises a vast range of microionic setting dense castables used mainly for the realisation of linings requiring high resistance to abrasion and/or corrosion by metals and/or slag. The Flustone® line is self-bonding, allowing linings to be repaired by applying the same product to the worn surface without changing the whole lining.

The customer is a multinational specialising in the production of aluminium castings, mainly for the automotive industry. The aluminium ingots are melted with high-productivity tower melting furnaces. One of the production units has a melting capacity of 8,000 kg/h, provided by three tower furnaces. The customer's first experience of Eredi Scabini refractories dates back to 2009, during extraordinary maintenance of the melting chamber required to repair erosion of the refractory on the side walls, and to reconstruct the crown, damaged by impact during charging. On this occasion - especially for the crown, subject to mechanical impact from the charge and thermal stresses from the burner flames - a Flustone® range product was used.
The solution, designed and then produced by Eredi Scabini for this plant's melting chambers, involved the use of specific products chosen to suit the characteristics and needs of the chamber's different areas/zones. The product chosen for the hearth, back wall and the crown impacted by the charge was Flustone® X AL, a self-distributing concrete with excellent mechanical impact and thermal shock resistance, as well as outstanding non-wetting properties even at high temperatures.
Flustone® X AL was also used for the walls of the loading hopper and on the slagging door sill, reinforced with special steel fibres to increase mechanical and thermal shock resistance.For the burner area, where the use of a non-wetting product would have been counter-productive, a Flustone® product with excellent thermal shock resistance was selected. In 2017 the furnace's entire refractory lining was reconstructed, including the holding chamber, using specific products to suit the different zones.

The furnace hearth and walls were lined with Flustone® V AL, a castable for installation by vibration, with high mechanical strength and excellent non-wetting properties, while the product chosen for the crown was Flustone® V, a castable for installation by vibration with good mechanical and thermal shock resistance and low thermal conductivity. The Flustone® used in the melting chamber burner zone was also used in the burner zone of the holding chamber. Thanks to this careful selection of varying products for the different areas of the furnace, maintenance of some parts - such as the crown subject to impact from the charge and the walls of the loading hopper and melting chamber - was reduced compared to competitor solutions. In particular, Flustone® X AL continues to give excellent results in the areas exposed to the most intensive mechanical and thermal stresses. Last but not lest, slag removal from the walls of the furnace is less problematical.

REF. N.60

Reconstructed melting chamber

Loading hopper after 12 months

Furnace in operation

With RESISTONE™ mechanical abuse and high temperatures are no longer a problem.

As well as its large range of refractory castables and preformed shapes, the company has a line of products specifically developed for industrial floorings subjected to extreme mechanical and chemical stresses combined with heat: RESISTONE™.
RESISTONE™ products are installed by procedures similar to those used for construction concretes, but develop extremely high mechanical strength within just a few hours and can be used with temperatures of up to 1,400°C, even in contact with metal and slag splashes. Its rapid installation and ease of use also make RESISTONE™ excellent for maintenance purposes.

The customer is a historic Italian foundry which specialises in the production of ingots for the downstream extrusion process, with output of 65 thousand tons a year destined for the world market. During the aluminium alloy melting process, hot slag is produced; this is skimmed off and collected by the melting plants prior to storage in a dedicated area. This slag, which moreover still has residual aluminothermic reactions, at very high temperatures, together with the continuous mechanical abuse from the loaders during handling and heaping, caused the construction castable flooring to break up over time, with the formation of holes up to as much as 40 cm deep. The client was therefore forced to carry out continuous partial repairs, or to completely relay whole sectors of flooring.
Considering the needs expressed by the customer overall, Eredi Scabini drew on its experience from even more heavy-duty applications and recommended RESISTONE™ HT, a microchemically set refractory castable based on special aluminas. Installed by the same procedures as construction castables, the product develops four times higher mechanical strength within just a few hours. In spite of a considerable increase in productivity since its installation, the RESISTONE™ HT flooring has been in service without a break for more than five years, with no maintenance or partial repair works.

REF. N.69

Eredi Scabini solution: installation of RESISTONE™ HT

Eredi Scabini solution: RESISTONE™ HT flooring after 5 years in service

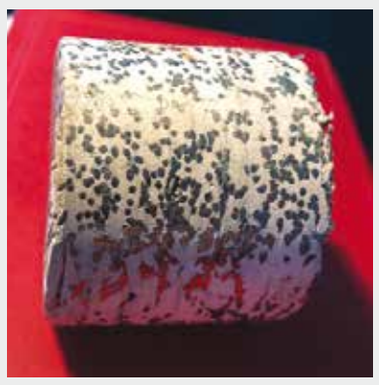
Papers

Refractory concrete: knowing and limiting the explosion hazard.

Regardless of the installation technique used, all monolithics, except dry ramming mixes, may explode if the appropriate procedures are not followed. In terms of the product, a large number of factors may contribute to causing an explosion: density and porosity after installation; type of porosity and monolithics; presence of fibres; and the ex post addition of setting accelerators or retardants. There are also multiple potential factors relating to installation and the first heat-up, which may contribute to an explosion: type of installation; type and percentage of liquids present after installation; the temperature of the product's components and of the liquids used, as well as ambient temperature; finishing; presence of scoring; the type of curing, precast v/s cast insitu installation; the maximum thickness present; the first heat-up curve; the type of furnace and the certainty that the curve can be complied with uniformly and monitored; and the presence of monitoring thermocouples with the relevant recording and read-out instrument. Separately or in association, to a greater or lesser extent, all these factors help to increase or decrease explosion risks. An explosion is a sudden, violent release of thermal and mechanical energy generated by a pressure build-up, accompanied by the production and expansion of gases, normally at high temperature. In the case of refractory castables, in 95% of cases explosion problems are generated by the presence of water. All castables (except dry ramming mixes) contain smaller or larger amounts of water.

Why does a material explode?

Because the pressure and expansion of the gases inside it exceed the mechanical strength with which it is able to retain them. The violence and destructive power of the explosion depend on the density and porosity of the material. High density and low porosity (especially when the pores are closed) lead to violent explosions with destructive effects on the surroundings, while the explosion of low density, open pore items will take the form of more or less significant crumbling and cracking. It should be noted that given the same apparent density of the castables used, plastic ramming mixes are generally more porous and less likely to explode; conventional castables are more porous than the low moisture type but they contain more chemical water since they have more cement; cement-free castables are more impermeable than the conventional and low moisture types even if their total porosity is the same; open pore insulating castables are the most porous of all castables, but it is important to take care with "bubble alumina or special alumina" types with closed or semi-closed pores, where the total porosity is high but the number of open pores is low; "nanoplast" castables have an apparent porosity with pores that are always open, with pore diameter more or less constant regardless of their density. 95% of Eredi Scabini castables contain anti-explosion fibres which help to prevent explosions but which are UNABLE TO GUARANTEE THAT THEY CANNOT OCCUR; however, it is important to know that castables containing metal fibres are less likely to explode than those without them.



Flextrong® 304 coring

Installation by ramming is less likely to lead to explosion than when casting or vibration is used; installation by spraying or shotcrete (pre-humidified concrete, pumped at low pressure, with setting accelerator added at the delivery pipe outlet) will be less at risk than installation by vibration; a pumped material will be less risky than one installed by conventional delivery systems.

Shotcrete

Castables with chemical-setting binders, including Nanoplast® castables, cause fewer problems than those which use only water; naturally, the more water is present, the greater the risks.
All chemical reactions are affected by the ambient temperature and the temperature of the product's components and the water used, which may cause possible abnormal transformations leading to the risk of explosions during the initial heating process.
Smooth pieces without scoring are more likely to explode and crumble; curing at high temperature (37-45°C) with low ambient relative humidity increases the green strength, an important factor in order to counteract the pressure and expansion of steam at temperatures up to 150°C. Covering with plastic film which does not adhere to the surface during the initial curing phases keeps the surface damp to prevent it from "scorching" and ensures that its humidity is the same as that of the layers beneath.

It should also be borne in mind that a cast insitu part is more at risk than a pre-casted shape of the same density, porosity, maximum thickness and geometrical form; the thicker the piece, the more accurately the initial heating curve must be designed, considering any insulation present. Eredi Scabini initial heating curves are the outcome of theoretical simulations and the company's practical experience built up over the last 40 years, but CANNOT BE CONSIDERED ABSOLUTELY SAFE unless every detail of the project has been weighed up.

Moreover, unsuitable heat treatment equipment (furnaces, burners, thermocouples, temperature recorders, fans, etc.) can put a carefully executed project at risk, causing an explosion which destroys the equipment where the refractory is installed and also causes serious safety risks for the people concerned.

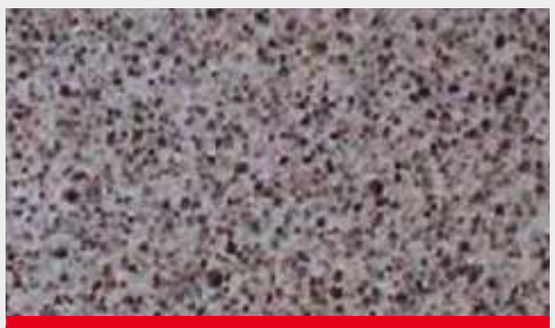
The role of water

In general, water performs various functions in refractory castables: it saturates the open pores; it serves as a lubricant between particles after the open pores have been saturated; it interacts chemically with other elements in the dry mix to create new chemical compounds (chemical or chemically bonded water) which generate flocculation or deflocculation, setting (solidification) of the product, and so on; it provides temperature balancing where required (the temperature in the piece does not rise too quickly in the areas which contain large amounts of water); and it provides surface protection during initial heating to prevent "scorching" of the visible surface of the piece. Basically, pure water evaporates with temperature, whatever this may be, but it takes a considerable amount of time to eliminate it, so it is heated to +100°C to transform it into steam, thus increasing ambient relative humidity. The density of the steam is 1/1800 compared to the density of water. From 110°C to 150°C, as steam increases in temperature, it becomes superheated and expands, generating the first significant build-up of pressure inside the piece, which will withstand it to a greater or lesser extent depending on the mechanical strength it has acquired during curing. It is in this phase that tiny cracks, sometimes invisible to the human eye but with undesirable results in the heating process which follows, are normally formed.
From 110°C to 150°C the water/cement and other bonds start to break, and so the piece's mechanical resistance starts to decrease, unlike the pressure and expansion of the water vapour, which increase considerably. As already explained, steam dispersal depends on the piece's degree of porosity (permeability), the presence of anti-explosion fibres, which disappear at 90°C -150°C to leave tiny pathways, its maximum thickness and the time for which the piece is allowed to remain at this temperature. Uneven distribution of anti-explosion fibres may lead to tiny cracks and/or explosion. Clumping of anti-explosion fibres is normally due to the use of unsuitable mixers, generally of standard construction type, or suitable ones but with the wrong type of blades or rotation speed. The fibres are electrostatic so high speeds and abrasion with aggregates tend to agglomerate. The presence of excess fibres increases apparent porosity but at the same time it reduces the mechanical strength of the piece overall and generates more transmigration of the super-fine particles in the mix, which may clump to create more impermeable zones or layers; this situation is therefore very hazardous and does not bring any benefits in terms of steam dispersal. Depending on fibre type and length, the optimal value is between 0.06%w and 0.1%w; below this size sufficient steam is not dispersed, but above it mechanical strength is reduced and the amount of steam dispersed does not significantly increase.
Normally, the use of setting accelerators or retardants - with the same curing time - reduces the mechanical strength, both unfired and at the critical intermediate temperatures, which is undesirable for the prevention of explosions.
The temperature should not be increased over 150°C until the water trapped in the material's open pores has been eliminated.
The chemical water is the water which has been used to form other compounds, and it therefore accounts for only a small proportion of the total water (from 1%w to 15%w depending on family). It is eliminated within the temperature range from 150°C to 890°C depending on the compounds contained in the various families of castables. In Eredi Scabini castables, the most significant loss, by weight, takes place between 220°C and 300°C.

Loss of free water + combination water for traditional and low moisture castables (Cast-Lite™ - Castone™ - Flusto-ne® - Dystone® - Vibro-steel™ - Gunstone™ - Patchstone® - Resistone®): modern technology means that explosions do not occur up to temperatures of 150°C; however, the risk of micro-cracks persists. Obviously, if more time were available the heating gradients would be so gradual that, given our products' open porosity, explosions would definitely be avoided. It has also been proven that the highest pressure occurs in traditional and low moisture castables between 150°C and 470°, after which the pressure and expansion of the remaining steam decrease, and mechanical strength increases in proportion with the temperature. This means that explosion is avoided if the body temperature has been uniform up to this point and the heating curve has been followed correctly, at least up to the dwell time at 430°C (minimum safety temperature). Attention has to be focused on the 110°C - 430°C range: if there is uncertainty concerning the reliability of the heating equipment, the quality of the product and the complexity of the geometrical forms, and the thickness is over 50mm, up to a maximum of 700mm, the heating gradient up to 110°C must not exceed 50°C/h and the dwell time at 110°C must be 1h for every 40mm of the maximum thickness. The heat is then increased to 430°C without ever exceeding 5°C/h, and dwell times at 430°C must be calculated with a ratio of 1 hour for every 50 mm of maximum thickness.

Loss of free + combination water for cement-free castables (Histone®): the binding system in this family is based on a cement-free sol-gel solution ("sol-gel" is a technology which uses colloidal solutions of metal oxide particles in a suitable solvent -"sol"- to create continuous reticulations of metal oxides -"gel"- which generate gelling and solidification), which provides final setting after suitable curing, although mechanical strength is low and decreases even more after 110°C. Moreover, in the 150°C-250°C range, this sol-gel becomes denser, decreasing the permeability of the piece, which thus becomes more vulnerable to explosions if the thicknesses concerned exceed 100 mm and the heat treatment equipment is not reliable. The transformations generate products with excellent corrosion resistance. With these materials, users are advised to request the best initial heating curve from our Technical Department on a case-by-case basis.

Texture of Histone® TAB similar to Carrara marble



Open nano porosity

Loss of free water + combination water for Nanoplast® castables (Alfaplast®, Sigmaplast®, Zetaplast®): the bonding system of these materials allow the achievement of extremely uniform porosity, also open on the surface, and also does not generate chemical compounds which transform pure into combined water.
The water saturates the pores, lubricates the components and is dispersed by evaporation (Zetaplast®) or through the formation of wet steam (Alfaplast®; Sigmaplast®). In practice, about 95%w of it is eliminated by evaporating it, with low levels of pressure and expansion, at the temperature of 150°C. The only constraint is the thickness of the piece and thus the time needed to achieve this result.

Initial heating curves for castables and preformed shapes. There is a difference between these two operations. For castables, the heat energy travels to the cold external part and is more or less blocked by other layers of materials, including the insulators. With preformed shapes, the heat strikes the whole surface and attempts to reach their core as the water present is gradually eliminated. While for shapes the variable factor, for the same quality, is thickness, for castables many are the variables and they must all be considered, but the absolute difference in terms of time is not so great: the numbers are virtually the same.

We simulated a comparison between a preformed shape and an in situ casting with the same material and thickness.
For the in situ casting we added the following alternative scenarios concerning insulation and/or safety lining:
"A" = 7mm of Micropor SF1100 boards on a contatto carpenteria ferrosa da 10mm
"B" = 5mm of Micropor SF1100 boards + 120mm of Patch-lite 94 castable (pre dried)
"C" = 5mm of Micropor SF1100 boards + 114mm of K23 insulating bricks + 114mm of 44% Al2O3 dense bricks.

The final result of the two heating curves at 800°C and related cooling indicates 40.82 hours for the preformed shape against an average of the three scenarios of 40.72 hours.

Written by Daniele Scabini