linco baxo group of companies

LINCO BAXO
SITE HANDBOOK

linco baxo

refractories expertise, together

Since 1949

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LINCO BAXO SITE HANDBOOK – RELEASE 2021

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EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

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EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

BRANDNAMES & GROUPS PRODUCTS LEGENDA

Linco brandnames of unshaped alumina products	*Groups*
LICOFEST	Refractory / insulating castables
LINAX	Service castables
LICO-CLAY	Plastic mouldables
LICOTON	Ramming mixes & mortars
LICODRY	Free cement castables
LICOBLOCK	Special shapes and blocks
MILBLOCK	Precast shapes
LB-FILL / LB-STICK	Mastics / adhesives
Baxo brandnames of unshaped alumina products	
BAXOCAST	Refractory / insulating castables
BAXOPLAST	Plastic casting mix
BAXOVIBRO	Thixotropic castables LCC-ULC-FCC
BAXOGUN	Castables for gunning applications
BAXOFIX / BAXOMIX	Service castables
BAXOPOL	Ready mortars
BAXOCOAT	Refractory coatings
Sirma brandnames of unshaped alumina products	
SIRCAST	Regular dense castables
SIRBRATE	Low cement castables
SIRCHEM	Free cement castables
SIRFLOW	Self flowing castables
PROMOCAST / SIRGUN	Medium cement castables
PROMOGUN	Gunning castables
PROGUN	Low cement gunning mixes
SIRPLAST	Plastic mouldables
SIRCOL	Wet mortars
SIRQUICK	Fast service castables
Kero brandnames of unshaped aluminous and basic products	
COLLIGAN	Ready mortars
KEROCAST	Refractory castables
KEROVIB	Thixotropic castables LCC-ULC-FCC
KEROMIX	Service castables
KEROGUN	Gunning mixes
KEROPATCH	Patching mixes
KERORAM	Ramming mixes
KEROFLOW	Self flowing mixes
KEROLAN	Refractory dry mixes
KEROCRETE	Shotcrete mixes

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

BRANDNAMES & GROUPS PRODUCTS LEGENDA

	Maref & Sirma brandnames of shaped refractories products	
MAREF	+ production code	Fireclay and high-alumina bricks and shapes
ISOM /ALPOR	+ production code	Lightweight bricks and shapes
KERA	+ production code	Specialties for ceramic and brick industries
MAREF	+ production code	Specialties for glass industries
SIRMA	95AT and 99AT	High Alumina bricks for severe operations
CARBO	+ production code	Silicon carbide bricks and shapes
	Tecref brandnames of precast refractories	
REF-AL		Refractories based on alumina
REF-MUL		Refractories based on mullite
REF-COR		Refractories based on corundum
REF-ZIRCON		Refractories based on zircon

INTRODUCTION TO LINCO BAXO MONOLITHICS

Linco Baxo produces insulating & refractory monolithic products containing alumina, alumina silicates, silicon carbide, zircon, magnesite, chromite and graphitic materials which are installed by casting, pouring, rodding, vibrating, slap trowelling, gunning, veneering, ramming shotcreting and other applications. They meet a variety of industrial needs.

Each of these products is a mixture of high quality raw materials which are carefully selected, blended and packed.

One policy of Linco Baxo which is strictly applied to the production of these monolithics is that no aggregates made from exhausted or polluted materials are included in any formulation.

Linco Baxo specialists continually monitor these monolithics during their manufacture as well as the properties of the finished products in order to be certain that they are of uniform excellent quality.

Our product development programme is permanently on-going to ensure Linco Baxo continues to deliver improved and new formulated products. When necessary, monolithics are designed to meet individual customer requirements or specifications.

These instructions and recommendations are offered as a guide in order to obtain the maximum benefits from these fine products.

It is recommended to follow this procedure to the maximum extent and ask for refractory supplier's written approval before any deviations from the suggested one is carried out.

Linco Baxo are always available for consultation should this guide not be sufficient for a specific application and are available on request to provide complete site assistance.

Classification of monolithics

All monolithics are a blend of aggregates and binders.

It is general practice to classify according to the binders, status at delivery and type of installation.

Monolithic type	Linco Baxo brand names
Regular dense & insulating castables	**Licofest , Baxocast , Sircast , Kerocast**
Plastic casting mix	**Baxoplast**
LC & UL castables	**Licofest PL, Baxovibro, Sirbrate, Promocast, Kerovib, Sirquick**

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LINCO BAXO Group of companies
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Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

INTRODUCTION TO LINCO BAXO MONOLITHICS

FC castables	**Licodry, Kerocrete**
Gunning castables	**Licofest TR & G, Baxogun , Sirgun, Promogun, Progun, Kerogun**
Service & repair castables	**Linax, Baxofix, Baxomix, Keromix**
Mouldables	**Lico-clay, Sirplast,**
Ramming mixes	**Licoton, Keroram**
Dry mixes	**Kerolan**
Dry & wet mortars	**Licoton mortars, Baxopol, Sircol, Colligan, Blakpol**
Coatings , glues, mastics Fillers, patches	**Baxocoat , LB Mul Coat , LB-Fill , LB DUR coating, Licoglue, KWG 311, Keropatch**

Classification of castables

Linco Baxo classifies its castables also according to their density after oven drying at 105 °C., as determined on cast specimens.
This classification is tailored to the purpose of this publications, which is meant to provide guidance mainly in Petrochem and Reheat applications.

Castables type	Density after oven drying at 105 °C.		
Very Light Weight	less than	720	kg/m^3
Light Weight		720-1200	kg/m^3
Medium Weight		1200-1840	kg/m^3
Dense	more than	1840	kg/m^3

In order to simplify the reader when consulting this handbook , products are referred to the monolithic type and not to the brandname unless there are tailored guidelines for a Linco Baxo product.

EUROPE CORPORATE HEADQUARTERS:
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

REFRACTORY CASTABLES - BASIC TIPS

Linco Baxo brands of CASTABLES are listed in section 1.0

Introductory remark

CASTABLES are supplied dry in paper bags. To prevent segregation, which for example could take place during transport, the full contents of the bag should be poured into the mixer . If only a portion of the bag is required, it must be pre-mixed dry prior to use.

All equipment & tools that will come into contact with castables must be clean. Old brickwork must be free of all loose particles and thoroughly wet. Shuttering must be impervious to moisture and painted or covered with a separating media such as crude oil, wax etc., before installation of the material.

Mixer and mixing water

Mixing by hand will not give a consistent mixture. Suitable mixing machines are preferable. Dense refractory castables should be mixed in paddle mixer, whereas lightweight or insulating castables should be mixed in a barrel mixer.

Use only clean tap water for mixing. Hard or soft water as well as water containing sulphates decrease the strength and lead to structural faults.

Mixing, conveying, applying

The water additions shown on data sheets are guidelines for castables to attain the desired consistency. The mixing time should not less than 1 minute or not more than 4 minutes.

Refractory castables must not segregate during conveying or application. During the erection of walls for example, a chute or pipe which ends just above the working area, should be installed. Anchors, shuttering and other working faces must not become incrusted.

Ball-in-hand-test

The correct consistency after water addition for vibration can be tested on site as follows:
Make a ball about the size of a snowball from the prepared mix, throw it up about 30 cm. and catch it. If the ball keeps its shape, the consistency is good. If it falls apart, the mix is too dry.
If the mix is too wet it will flow through the open fingers. The rule is too much water impairs the properties of the refractory castable. Each data sheet indicates the water addition suggested for the different application but sometimes must be adjusted on site.

Compacting

Dense castables should be compacted immediately after mixing. A good compaction is possible in using a vibrating poker up to 50 mm. in diameter depending on the thickness of the wall. The vibrator must be inserted quickly into the floor and then withdrawn slowly across and out of the refractory castable. Anchors and shuttering should not come into contact with the vibrator. Prevent interruptions while work is in progress. Refractory castable that shows signs of setting cannot be compacted any further.

Lightweight and medium weight castables and insulating castables should achieve a plastic consistency for placement and subsequently poured. Only medium weight castables can be slightly rodded .

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

Subsequent treatment

During the setting process a portion of the water used in mixing is consumed by dense castables and premature loss of moisture should be prevented. Suitable precautions are: smoothed off surfaces should be covered with plastic sheets, wet bags or similar material. The castable should be kept covered at least 24 hours to attain the greatest possible strength. The same applies to sections or surfaces from which the shuttering is removed.

Setting time might be adjusted by addition of tailored setting reagents or retarder reagents supplied by Linco Baxo.

Do not use any reagents which is not provided by Linco Baxo as this will impair the features and the performance of the castables

For special attention

At temperatures less than 5° C. the setting time will change. Frost can damage the fresh castable. The general rule is:

The temperature of wet castable must be raised to at least 5° C. Do not use frozen material. Install the refractory castable as quickly as possible - if possible - in pre-heated shuttering and compact straight away. Immediately after smoothing, covering of the castable with styropor and/or other insulating blankets will prevent excessive heat loss.

Heating up

Please refer to section 7.1

We can provide heating-up schedule for specific applications, particularly for new installations.

Nevertheless we point out that he dry-out of castables involves more than a heating schedule . Issues such as burner size and placement, exhaust location, air volume, air velocity, thermocouple placement, etc must be properly addressed. Linco Baxo recommends consulting an experienced dry-out company with proper equipment.

Table for water addition

See data-sheets of the related castable which are a guideline subject to adjustment on site upon consultation with a Linco Baxo specialist.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

FUNDAMENTALS OF MOULDABLES

MOULDABLES – BASIC TIPS

Linco Baxo brands of MOULDABLES are listed in section 1.0

Introductory remark

MOULDABLES are supplied in cartons containing plastic material, wrapped in plastic sheet. MOULDABLES can be installed with or without shuttering.

Preparation

Unpack the MOULDABLES . Ensue that the working surface is clean. Whole pieces broken or cut off, can be installed to achieve the desired wall thickness.

If the material is dry before use, the plasticity can be restored as follows:

Unpack the carton, place the draft on plastic sheets and cover with wet bags. Normally the moisture content of the atmosphere is sufficient to restore the necessary plasticity.

Subsequent treatment

After completion the MOULDABLES is shaped by cutting to the required dimensions. The surface is then roughened by a nailed board. To improve drying holes are made by a steel pin at a distance of 150 to 200 mm. apart (staggered). The pin should be about 3 mm. in diameter and should preferably penetrate the whole thickness of the MOULDABLES wall. The holes should be angled up at about 30 - 45°.

Shrinkage cracks can be avoided by notching with a board 1 mm. thick, to a depth of 1/4 of the wall thickness. The resulting sections should not be more than 800 to 900 mm. in length or width. In burners, the notches must be across the thinnest section.

Installation

The ramming of MOULDABLES serves to form the material rather than compact it. Compaction already occurs during the process of manufacture.

The installation is done with a hammer, 1 to 1,5 kgs. in weight or a pneumatic hammer. The latter should have a large flat ramming head (approximately 20 to 50 mm. in diameter).

Important: Installation if possible, should be done vertically to the stress area. The thickness of rammed layer is determined by the thickness of the slices. Roughening of the compacted layers is advisable.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

Anchorage
Areas of more than 1 m^2 should be retained by anchors.

General for heating up
Please refer to section 7.1

We are prepared to supply heating up curves for specific applications, particularly for new installations.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

FUNDAMENTALS OF RAMMING MIXES

RAMMING MIXES & PATCHES - BASIC TIPS

Linco Baxo brands of RAMMING MIXES are listed in section 1.0

Introductory remark

RAMMING MIXES are identified by the letters "K" for ceramic and "CH" for a chemical bond and supplied in bags with the right consistency, ready for use. For the CH-mixes a separate supply of the ramming mix and liquid binder is mandatory and so CH coded ramming mixes are supplied as a two-components mix.
Existing brickwork must be free of all loose particles and in some cases painted with a liquid.

Mixing

Preparation is not necessary as RAMMING MIXES when supplied ready for use. If the mix is too dry due to long storage or any other reason or the ramming mix is supplied as a two components-mix a paddle mixes must be used for preparation. In the case of partly dry material, the correct consistency can be attained by adding water through a sprinkler nozzle.
Our specification for quantities and mixing procedures are to be followed in the preparation of dry mixes.

Two component ramming mixes & patches

Ramming mixes coded CH & patches are supplied as two component mixes when they are phos – bonded and/or chem-bonded . Ramming mixes are instaled only by ramming while patches can be installed either by ramming or by trowelling . The aggregate is supplied as dry / semi-wet component in bags or buckets while the liquid binder is supplied in drums or tanks .
The recomposition of the product shall be done mixing first the aggregate component in the mixer for abt 1 – 2 minutes and then adding 2/3 of liquid binder specified by Linco Baxo and while mixing adding gradually the balance of the liquid binder until the desired consistency is achieved . Normally this is achieved in 3-4 minutes .
Water shall not be added to ramming mixes while a limited amount of water (3-5 %) might be added to patches .
Anyhow please ask specific instructions to Linco Baxo for the recomposition of patches and how to obtain teh desired consistency .

Shuttering

The shuttering must be installed in such a manner that the direction of the ramming is vertical to the stress area. Due to the great stress during installation the shuttering must be firm and abrasion resistant on the inside. A separating media such as crude oil, wax, etc. will facilitate the removal of the shuttering and prevent adhesion to the rammed material.

Ramming

The compaction is done by means of pneumatic rammers with the following typical operating data:

Frequency	about 15 Hz at 6 atü
Piston stroke	150 to 180 mm.
Force of impact	2,5 to 4,5 mkp

To ensue the steady direction of the rammer head, the piston rod must be angular (triangular or square). The rammer head has a rectangular base section of about 70x20 mm. and is ground to a wedge shape. This gives better compaction of the layers.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

FUNDAMENTALS OF RAMMING MIXES

Place the ramming mix behind the shuttering in layers not exceeding 50 mm. in height. Each layer must be thoroughly compacted with a pneumatic rammer. A continual filling during ramming operation will prevent the formation of a proper monolithic mass. When ramming flat surfaces (e.g. hearths), every compacted layer should be roughened before applying the next layer. If anchors are installed, pay particular attention to the bond between the anchor and the material.

Removal of the shuttering and subsequent treatment

The shuttering of RAMMING MIXES units can be removed immediately after ramming provided that it is not exposed to disturbance before heating up.

General for heating up

For drying and heating up the following rules apply:

24 hours	100 °C.
48 hours	200 °C.
from 200-600 °C.	20 °C./h.
from 600 °C. to operating temp.	30 °C./h.

We are prepared to supply heating up curves for specific applications, particularly for new installations.

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LINCO BAXO Group of companies
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Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

FUNDAMENTALS OF MORTARS

DRY MORTARS – BASIS TIPS

Linco Baxo brands of DRY MORTARS are listed in section 1.0

Mixing (For dry mortars) :

- Use drinking water if no other bonding liquid is indicated
- Use clean tools and containers.
- Use the whole content of a bag or, using parts of it, thoroughly mix the whole bag content before.
- Regulate the working consistency desired by addition of drinking water in a range of ± 10 % of the indicated amount
- Paddle mixer is recommended.
- Smaller amounts are mixable with putty knife or trowel.
- Mix hydraulically and highly reactively bonding mortars with water in small portions up to 20 kg and process them within the lifetime of 30 minutes.
- Let ceramic bonding mortars stand for 1 h after water-mixing.

Mixing (For wet mortars) :

- Wet mortars are supplied in buckets and are already mixed. If the wet mortar is segregated as consequence of ageing it might be restored by mixing with a drill.

Preparation of the underlayer:

- The surfaces to be coated with mortar must be free of dust and dean.
- Pre-watering: for hydraulically bonding mortar required
  for ceramic bonding mortar permitted
  for chemically bonding mortar prohibited

Processing:

- Processing temperature 5 °C min.
- Joint width shall not exceed 2 mm.
- Evenly spread mortar onto the surfaces to be joint and then insert the brick.
- Throw away the set mortar residues.
- Use clean working devices.

First heat-up:

- For hydraulically bonding mortar wait ~ 24 h.
- The heating-up curve does not depend on mortar type, but on the nature of the whole lining.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

STORAGE INSTRUCTIONS FOR CASTABLES AND DRY MORTARS

Castables & dry mortars are packed in a multi-ply paper bags. Bags are packed on pallets and wrapped with water-proof shrink film wrapping.

To maintain the material in peak conditions, it is essential that it be stored in a cool dry, ventilated warehouse, kept off from the floor and away from the walls.

Moistening of the dry material can affect the strength of the castable and cause it to start setting prematurely in the bags. Material affected in this way must be discarded.

If the castable & dry mortars are stored in the open air, they should be placed on a ventilated platform, off the ground and covered with strong tarpaulins to avoid water or ground moisture coming into contact with any of the bags of material. It is advisable to retain the original shrink-film around the pallet as long as possible as extra protection.

Pallets must be stored divided by type of material, commercial name , manufacturing date and production batch.
The pallets of insulating castables shall not be stacked one upon the other to avoid compression of the soft grains of light weight aggregates ,

In cold condition it is recommended that the material be stored in a frost-free environment to ensure that the mixing water does not freeze when added to the dry material. Should such storage not be possible the bags of the dry material should be moved to a warmer area having a temperature of not less than 15°C. for a period of at least 48 hours prior to the addition of water.

In hot climates it is recommended that the pallets of the dry material are stored in areas kept dry and as cool as possible by available means . Needless to say that pallets and the bags should not be exposed to direct sunlight for any length of time.
Pallets of materials should be moved to a colder area having a temperature of 18-20° C for a period of at least 48 hours prior to mixing and addition of water.

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Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

STORAGE INSTRUCTIONS FOR CASTABLES AND DRY MORTARS

Due to the ageing process of the binders used in their formulations the shelf life of castables & dry mortars are limited and they are classified as perishable materials.

As a general rule if such products are stored in cool, dry, ventilated at a temperature not exceeding + 35 °C and not less + 1 °C while the relative atmospheric humidity shall be 60 ± 10 the following shelf-life is expected:

Regular dense & insulating castables		**12**	**months**
Dry mortars chemical bond		**12**	**months**
LC , UL , FC castables		**9**	**months**
All products supplied as two component mix -	**Dry Aggregates**	**12-18**	**months**
	Hydraulic Binder	**12**	**months**
	Chemical Binder	**6-9**	**months**

All castables can be supplied as a two components mix and this is highly suggested for LC, ULC, FC castables shipped overseas to distant locations.

When the castables & dry mortars are required to be installed and have been in store in excess of their shelf life although appears in good condition, they are not recommended for installation. Their properties and features might be impaired and the performance of the lining can be negatively affected .

Should there be any doubt whatever, the advice of a Linco Baxo Refractory Expert should be sought.

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LINCO BAXO Group of companies
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Tel. + 39 02 5520041 Fax + 39 02 5694834
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web page : www.lincobaxo.com

STORAGE INSTRUCTION RAMMING MIXES, MOULDABLES, WET MORTARS, PATCHES AND COATING

Mouldables are delivered in precompacted cartons.

Ramming mixes (K range) are delivered in multy ply hermetic bag in order to avoid that chemical binders became ineffective.

Ramming mixed (CH range) are supplied as a two component mix being the dry aggregate packed in multiply bags and the binder in buckets.

Mouldables and ramming mixes (K range) when supplied as one component mix have required humidity for installation.

Mortars and patches are supplied in buckets.
Patches might be supplied as two component mix usually in buckets.
Coatings, glues and finishing products are delivered as one-component mix or two component mix and packed in multiply bags or buckets.

Top priority shall be given in order to avoid loss of moisture especially when delivered to hot countries with low atmospheric moisture.

In order to avoid migration of moisture toward the ground the floor of the storage area should be covered with a plastic sheet before the products are stored.

Ambient temperature	**25 °C ± 5 °C**
Relative atmospheric humidity	**60 °C ± 10%**

- **under these conditions the products have a shelf-life of about 9 months.**
- **wet mortars instead are supposed about 6 months**

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

ANCHORS SYSTEM

Furnaces linings are supported by various types of anchorage. Anchors are welded or bolted to the shell and are used singly or in combination, to optimise their individual characteristics.

There is a wide range of flexible and fixed anchors as well as supports suitable for all kinds of positions, temperatures and process conditions.

The choice of type and quality of the anchors and supports, as well as the pitch and the pattern are determined in the design stage. Taken into consideration is lining thickness, position, service conditions and method of installation.

The maximum allowable temperature for a metallic anchor depends on a number of factors such as the type of atmosphere in the furnace and the section of the anchor itself. In normal oxidizing atmospheres without sulphur, the following temperatures should be regarded as maximum on the "hot" tip of the anchor:

Steel or Alloy:	**Temperature**
Carbon steel	590° C
Chromium Nickel Alloys	
18% Cr – 8% Ni (Type 304)	870°C
25% Cr – 20% Ni (Type 310)	1100°C
Special Alloys:	
20% Cr – 32% NI (e.g. Alloy 800)	1100°C
23% Cr – 60% NI (e.g. Inconel 601)	1200° C

When the fuel used contains more than 0.5% in weight of sulphur, carbon steel anchors must be avoided.

In general the length of the metallic anchors is such that the anchor tip is 12.5-25 mm from the hot face and the anchor thickness shall be adequate for the actual application.
In any case, relevant client specification must be followed.

Anchors welded to the furnace casing must be securely attached without any weld undercut. It is recommended that the strength of some welds be tested prior to the installation of the castable.

Any anchor, properly welded, shall be capable of withstanding being bent 15 degrees from the as-welded position in the direction of greatest resistance and back without evidence of weld failure.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

ANCHORS SYSTEM

It is recommended that the anchors be wrapped with tape or coated with a bituminous paint in order to accommodate the thermal expansion of the anchors when the lining is heated. This helps to avoid the risk of cracking the lining at the position of the metal anchor while contributing to the reduction of heat load on the anchor.
Sometimes it is possible to obtain metallic anchors having a manufacturer - applied soft plastic coating

Ceramic anchors are used where the castable needs support completely through to the working surface or where the temperature requirements exceed the safe working temperature of metallic anchors.
The tips of ceramic anchors are designed to be exposed to the interior of the furnace and their hot face should be in the order of 2 mm back from the hot face of the refractory lining.

Ceramic anchors shall be at least as resistant to heat as the refractory lining they support and they shall be firmly secured in a metal anchor fixed to the casing before the installation of the lining commences.

Metallic anchors welded on a convection wall

Metallic anchors welded on a convection wall

Ceramic anchors on a side wall of a reheating furnace

SHUTTERING

For all types of castables, shuttering shall be constructed from a non-absorbent, strong, water-proof material; most usually selected is metal plate or wood. In all cases the shuttering structure must be sufficiently strong not to flex under the load of the castable.

Al joints in the shuttering shall be water-tight to avoid the escape of water possibly carrying with it fine cement-rich material.

The problem of leakage becomes more noticeable in casting Very Light Weight castables which need relatively very large quantity of water. Should leakage occur on no account should the viscosity of the castable be increased by reducing the content of water. Apart from modifying the physical properties of the castable the increase in density will result in shortage of material. Such a problem must be solved by modifying the shuttering.

Shuttering shall be oiled or suitably treated to facilitate easy stripping. Each metallic support should be installed with a pitch of about 400-500mm to the others in order to avoid bending shuttering.

There are numerous types of mould release agents and the one chosen should permit the shuttering to be stripped easily without any reaction with the castable surface.

Convection corbels shuttering of a petrochem heater

PLANNING AND PRECAUTIONS

Before the commencement of installation it is recommended to plan the operation. First it should be confirmed that all materials and necessary equipment are available or will be at the time demanded.

All equipments and tools must be in accordance as per Linco Baxo manual.

Ambient temperature

During the placement and curing of the castable, the surrounding environment shall be at a temperature between 10 and 32 °C. If necessary suitable action must be taken to maintain this status. This also applies to areas with which the castable comes into contact such as a furnace shell or existing refractory lining.

Water

The water to be added to the dry castable shall be at temperature between 10 and 25 °C. Only clean, potable water of low acidity, free from salt, sugar and other foreign matter is recommended. Should the quality of available water be uncertain it should be analysed. We recommend that the water used should comply with the following specifications:

PH		6.5 – 8.35
Ca^{2+}	less than	300 PPM
Mg^{2+}	less than	300 PPM
$K^{+} + Na^{+}$	less than	150 PPM
$C1^{-}$	less than	200 PPM
Fe^{3+}	less than	300 PPM
SO^{2-}	less than	200 PPM
Residue after evaporation at 180°C.	less than	1500 PPM

If water does not comply with the above limits, demineralised water should be used.
Equipment used for storing and handling the water must be clean, so preventing possibly contaminating material from being introduced.
For further information consult Linco Baxo refractory specialists.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PLANNING AND PRECAUTIONS

Personnel, Tools and Equipments

It should be that suffient men and equipment are available on site to complete the job in the allowed time including the time required for curing and drying, and that enough shuttering is available to allow the planned rate of installation.
The mixers to be used must be clean and free from such as Portland cement to avoid quicker setting times and reduced strengths.
The equipment and tools such as mixers, buckets, wheelbarrow, trowels and vibrators shall be maintained in clean conditions.
The mixer and surrounding areas shall be clean and sheltered from weather. The steel parts to be lined shall be dry, clean and free from loose millscale, rust, grease, oil, dirt and other similar foreign matter.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

HINTS FOR EQUIPMENT & WORKFORCE

Only for reference and not comprehensive guidance this section summarizes the work force, personnel, tools and equipment usually required for an installation of abt 300/400 mc. of insulating and refractories in a medium size reheat furnace.
Although this schedule can be applicable to similar job and volume, installation companies have their own standards taking into account difficulty factors which might differ at different sites.

WORFORCE & PERSONNEL

Minimum requirement of foremen & workers per shift:

1 LINCO BAXO field supervisor
1 Foreman
4 Brick layers
6 Hodmen
2 Welders/Carpenters

EQUIPMENT AND TOOLS LIST

Minimum requirement for each team per shift:

1-2 paddle mixers for dense castables and/or barrel mixers for insulating castables
1-2 gunning machines if this kind of installation is required.
Gunning machines shall allow air pressure regulation. This is essential for insulating castables in order to avoid undesired decrease in yield.
1 wire-cutter for bricks with 5 spare disks
1 disk cutter with 5 spare disks
4 wheelbarrows
10 plastic buckets
Toolkit with 2 grinding machines with 5 diamond spare disks diam. 150mm
1 stapling machine
1 iron saw
2 water drums
1 water measure
1 drill
1 mortar mixer
Pack-props
Small wooden beams 8x9cm
Wooden fillets 2,5x5x400cm
Wooden panels 3x50x400cm
Wooden boards 2,5x8cm - 15x400cm
Multilayer panel for nose shutters
Scaffolding horses
Tar paper for construction joints
Tar bucket to cover metallic anchors

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

Nails 40/60
Aluminium shafts
Monkey wrenches 16/22
Angles 50x50
Polythene rolls, polystyrene and dismantling paint

Paddle mixers to be used must be clean and free from such as Portland cement to avoid quicker setting times and reduced strengths.
The equipment and tools such as paddle mixers, barrel mixers, buckets, wheelbarrows, trowels and vibrators shall be maintained in clean conditions.
Mixers and surrounding areas shall be clean and sheltered from weather. The steel parts to be lined shall be dry, clean and free from loose mill scale, rust, grease, oil, dirt and other similar foreign matter.

Paddle mixer for dense castables

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

Gunning machine

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
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e-mail : info@lincobaxo.com
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web page : www.lincobaxo.com

Disk cutter

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

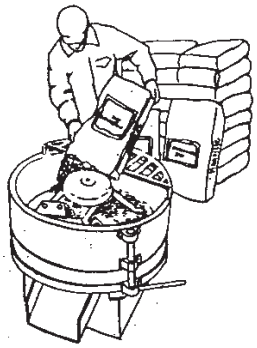
MIXING OF CASTABLES

It is strongly recommended that a paddle mixer is used for dense castables while while a barrel mixer is required for insulating castables.

Paddle mixer for dense castables

Paddle mixer is essential for dense castables in that it allows the material to be mixed properly and evenly with a much lower water content than for example with the barrel type castable mixer.
On the other side paddle mixer is not suitable for insulating castables as it will grind and disrupt the soft grains on the mix and in doing so increase the density and the yield

The moisture content is critical for dense castables where maximum strength with optimum density is required. Insulating castables by nature are weaker than dense castables and therefore it is important that they too are mixed properly with the correct amount of water.



Too much water will reduce density and strength, too little will decrease the yield (with possible undesired shortage of material at site).
Because of the possibility of segregation of the various components of the castable within the bag during shipment from factory to site, it is essential that only complete bags of castable be mixed with the required water.
Should, for some reason, it be absolutely impossible to use a complete bag of dry material, the entire content of a bag must be intimately mixed before taking and using the required quantity.

For large project, mostly those abroad, where long transportation and possibly warehousing times prior to installation are anticipated, Linco Baxo are prepared to supply several types of their castables as two separate components. Packed in one group of bags is the inert material such as aggregates whilst in another group of bags is the binder.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
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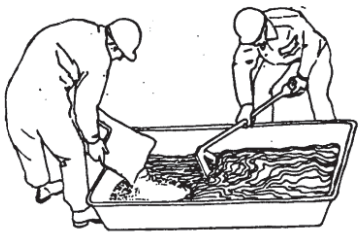
MIXING OF CASTABLES

The quantities of each are so arranged that a complete number of bags of inert material are mixed with a complete number of bags or drums of binder without the need for weighing on site.
The recomposition must be made strictly in accordance with Linco Baxo instructions by skilled labour under close supervision if the required physical properties are to be obtained. The dry mixing can be made by hand or by means of a paddle mixer (for at least two minutes). In case of hand-mixing, the whole recomposed dry castable mix should be turned at least 6 times in a clean container or on a clean surface.
The quantity of water to be added must be as given in Linco Baxo data sheets in order to obtain the indicated physical properties. To mix castable, it is recommended to add first 80-90% of the amount of water specified by Linco Baxo, then, while mixing gradually, add the remaining water a little at a time until the desired consistency is achieved.
Mixing water reported on Linco Baxo data sheet can be considered "theoretical" and recommended, obtained from laboratory tests at 20-24°C with humidity 45-50%but can be adjusted at site under the close eye of the supervisor.



Although acceptable methods are available to determine the right consistency and a few expert supervisors have the experience to do so by visual appearance, the following good practice is suggested (unless instructions have been provided by Linco Baxo for the castables for a particular application):

- for insulating castables, water additions should be those indicated in Linco Baxo data sheet adapted / adjusted to site condition . Sometimes this will lead to some discrepancies between product data sheet and site requirements

- for dense castables, use the minimum amount of water needed to install the material, which does not exceed the one indicated in the Linco Baxo data sheets. The best way to gauge the amount of water for dense castable is the "ball in hand test", described later.

The mixing time is normally around 3 minutes and should be controlled: a too long mixing of a light weight insulating castable changes the properties of the material, as most insulating aggregates are either soft or compressible and may become broken down by extended mixing.
Only batches of size that can be installed within 20 minutes of the adding of water should be mixed. In some hot conditions it might be better to have smaller batches of castable that can be installed within 10 minutes. In no circumstances must castables be remixed after they have stiffened or started to set.

"Ball in hand" test

Add sufficient water to allow the castable to hold together in a ball when "bounced" in the palm of the hand.
Too dry the ball will break up into a crumbly mass; too wet it will slump through the fingers. This "bouncing" in the hand should impart a slight glistening to the surface of the ball of castable but there should be no appreciable transfer of water and cement to the palm.

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e-mail : info@lincobaxo.com
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MIXING OF CASTABLES

The sketches below show the 3 situations:

Dry *Correct* *Wet*

CASTING

During the castable installation, the furnace casing and the castable lining temperatures shall be maintained between 10 and 32 °C.

Should the temperature be above 32 °C iced water it is recommended for mixing.
The castable shall be installed immediately after it has been mixed. The material must be poured in such a way as to minimise possible segregation.

It should be poured slowly into position, taking care that every undercut or profile be completely filled and that no air pockets are allowed to form.

For insulating castables, rodding or tamping is usually sufficient to remove voids and consolidate the material without excessive compaction.

If a vibrator is needed, then a light poker should be used in order to move the castable rather than to compact it.

Pouring of insulating castables - especially those Linco Baxo "light weight" and "very light weight" grades containing relatively weak aggregates and/or soft aggregate such as exfoliated aggregates - must be sufficient to correctly move the castable into place, but not excessively so in order to prevent disintegration of aggregate and compaction of exfoliated soft aggregates which would result in increased density (with possible undesired shortage of material at site).

For dense type castables the use of vibrator is more important and the effect of vibration during installation is beneficial in that it effectively reduces the amount of entrapped air thus achieving the optimum density.

Vibration should cease when no air can be seen coming from the mix, generally vibration should not exceed 2-3 minutes. Too long vibration can cause segregation of the mix (should there be an accumulation of water on the surface during vibration if is an indication that the mix is too wet and less water should be added to the next batch).

All movements of the vibrator within the castable should be slow and deliberate allowing the material to flow and fully fill the space made by the vibrator as it is moved.

Care should be taken to move the vibrator around the castable within the shuttering so that it is all fully consolidated. Special care must be provided at the corners of the shuttering and around anchors.
The vibrator should not be employed once the castable has started to stiffen and set.

Once the application has started it should proceed without any interruption until the entire section of the lining has been completed.

If an unavoidable interruption does occur, the "wet" edge of the lining shall be cut back at right angle to the surface for the fully

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

thickness of the lining (or of the layer being placed, in case of multi-layers linings).
All material ahead of the cut shall be removed and discarded.
The time between the pouring of consecutive batches must be such that the setting of the first batch has not begun.

For large surfaces it may be necessary to divide them into smaller and more manageable sections.

When the material is cast in horizontal position, the individual section should preferably be around 1 m x 1 m in dimensions but not larger than 1.5 m. x 1.5 m.

Each batch from the mixer shall be installed so that the full thickness of the lining is produced, rather than the building up of the thickness in layers.

When the castable is cast in a vertical position, the shuttering employed shall be at least of 0.5 m. high and 1.5 m. long.

The castable shall be cast evenly along the length of the shuttering and consolidated in order to obtain the required homogeneous lining.

Where multi-layer linings are installed, the surface of the first layer must be treated in order to prevent the absorption of water from the subsequent layer unless otherwise specified.

Under no circumstances should another layer be added before the previous one has been completed.

The surface shall be levelled off simply with a screed or a wood float and not be trowelled to a smooth finish.

In case of circular stacks and ducts it is sometimes found more convenient to install the lining with the stack or duct in the horizontal position on the ground.
The lining is cast in “horizontal” sections and completed circumferentially in stages by partially rotating the stack or duct.

For diameters less than 1.5 m. the recommended number of steps is 4 (90 degrees each) although under some conditions this might need to be reduced to 3 but this must be considered minimum.
For larger diameters more steps will be necessary.
Linco Baxo insulating castables may be installed in this manner by reducing the amount of mixing water normally specified in order to make the wet mix more viscous

The resulting lining might show an increase in density but this is outweighed by the advantage of easier installation.

While estimating the quantity of castable required for an application by casting, a site allowance must be forecast. An allowance of 5-10% usually is sufficient to cover damaged bags, spillage, material left in bags and mixer etc.
In difficult or remote areas the allowance should be increased to 10-20% or more depending upon actual conditions to be encountered.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

GUNNING

LINCO BAXO acknowledges that the gunning method of installation is faster and therefore offers a number of materials suitably formulated for the application by gunning.

Where LINCO BAXO materials are gunned it is recommended that the dry gunning principle is employed with the castable being pre-damped.

It is essential that the gunning machine is equipped with a device which will allow full regulation of the air and water pressure .
When dense castables are gunned we suggested that regulation for air pressure shall range between 1 and 10 bar while water pressure should be set between 0 to 5 bar.
For insulating castables installation we suggest to set air pressure at 5 bar – 8000 lt/minutes and the water pressure at 7 bar .
This is of great importance to achieve the desired yield of insulating castables avoiding increase of density due to the compactation of the soft exfoliated grains of the mix .

Here below for Your guidance a picture of a gunning machine which is suitable for application of all the gunning castables .

Gunning machine

GUNNING

Gunning machine

In this process the pre-damped castable is pneumatically conveyed to the installation area using especially developed equipment and finally projected onto the surface to be lined through a nozzle which includes a water injection system.

The predamping of the castable is preferably carried out in a special predampener.
If this is not available, a paddle mixer might be used and placed immediately next to the gunning machine.

The water required to pre-damp both dense and insulating castables is approximately 1/5 of the total water required at the nozzle . Water addition indicated in Linco Baxo data sheet is not provided for guidance as water addition shall be adjusted to the type og gunning machine -
The remaining water is added, as a fine spray, at the nozzle in such quantity to achieve the correct gunning consistency (usually this is the maximum addition that can be tolerated without the refractory slumping).

The predamped material must be mixed until it is homogeneous with no lumps and used within 20 minutes of mixing.
Predamping reduces the presence of dust at the nozzle with improved visibility for the operator permitting better control of the necessary water addition and easier adjustment of the lining thickness.

In addition pre-damped material more readily accepts further water at the nozzle improving gunnability and resulting in minimum segregation and rebound losses.

GUNNING

The ultimate success of gunning application depends to a great extent on the skill of the operator and the correct use of equipment and material.

The gunning machine requires a constant supply of water and air, the respective necessary pressures of which depending on such factors, as the distance between the gunning machine and the nozzle, the nozzle-size, the elevation above the ground level of the surface to be lined and always the type of castable being gunned.

It is essential that there a be a direct communication between the nozzle operator and the gun-machine operator. The use of two-way telephone system is recommended where they are out of direct vision.

Once gunning has started, the application of the lining shall be continuous until the unit or section is completed.
Any break in gunning must be timed to coincide with the completion of a section.

When an interruption is expected to extend longer that 10-15 minutes, the area not gunned to the full thickness must be cut out and removed.
At no stage shall additional material be placed over previously applied material to build up the required thickness.

Where multi-layer linings are installed, the first layer must be suitably treated to prevent absorption of water from the subsequent layer.
The edges of “unfinished” sections of castable shall be cut back at right angle, to the backing surface.

All material ahead of the cut shall be removed and discarded.
The work shall always proceed along the wet edge of the band just finished and reach full linings thickness as quickly as possible before proceeding to another section.

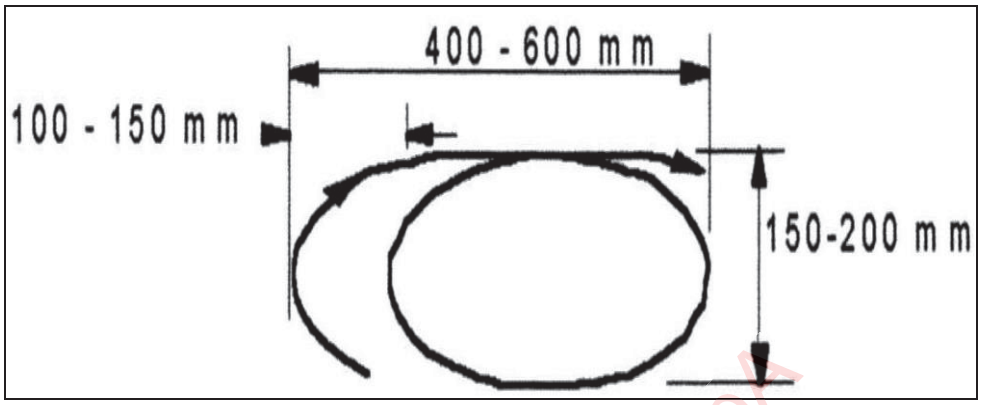
The work area is generally divided into sections approximately 2 m x 2 m wide.
Thickness control is accomplished by profile boards of a depth equal to the lining thickness: alternate sections are installed and, when set, the profile boards are removed and the alternate sections gunned.

An alternative method for thickness control, which is necessary for spherical surfaces, for example, is to provide pins of about 2 mm diameter welded to the casing with 600 mm spacing and of a length equal to the lining thickness.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

GUNNING

The gunning nozzle should be held at approximately 90 degrees to the receiving surface and maintained at a distance of approx. 1 m from the surface (it depends on material density). The nozzle shall be moved in a small circular motion as per sketch as follows to reduce the rebound loss and the risk of laminations and gives an equal material structure.



Direct nozzle spray to form loops

It is important that the material be gradually built up to the full thickness over a small area at a time.
Progress should be made from bottom to top when gunning castable on vertical walls, this prevents rebound material dropping down and sticking to the unlined shell and to the anchors below.

Care must be taken to ensure that no rebound material be trapped in the stream of new material because voids and weak areas will result.
A normal gunned surface finish will be pitted to the extent of a variation between peaks and troughs of 3-10 mm, largely dependent upon the maximum aggregate size used in the mix.

For some applications this finish is acceptable, and the lining thickness is taken to the mid-point between peaks and troughs.
For many other applications it is easier and even faster to gun slightly over thickness and trim back to the desired precise thickness.
This is particularly important where a given distance between lining surfaces and process tubes must be respected, or wherever precision of thickness is imperative.
Where trimming is required, the surface shall be scraped with a trowel or a steel float or, better, with a special nailed brush as soon as possible after completion of the gunning.
A trowelled smooth surface finish must be avoided.

In all gunning operations some of the material rebounds from the work area and falls down; this material must be removed and discarded.
The amount of this lost material depends an many factors especially in the initial part of the installation whilst being gunned against the steel surface.

For a thin lining, the rebound loss is higher that for a thicker lining installed in similar conditions; overhead gunning will cause a higher rebound loss than gunning onto a vertical wall.

Allowance

While estimating the quantity of castable required at site for an application by gunning, an allowance must be forecast as the sum of site allowance, material allowance and job difficulty allowance.
LINCO BAXO gunnable castables require a material allowance of approx. 10%.
Site allowance is usually 5% for domestic jobs, but for difficult or remote areas it must be increased to 10% (possibly even more).
Job difficulty allowance depends on several factors such as the skill of the operator, the position of the surface (e.g. roof or vertical wall), the anchors spacing and type, the thickness of the lining, the environmental conditions.

Although tables exist giving difficulty factors for a variety of cases, as a practical guide the following factors may be considered:

- Vertical walls : 10-15%
- Roofs : 30-40%

The sums of the 3 allowances give the following total gunning allowances:

	Material allowance		Site allowance		Difficulty allowance		Total allowance
➢ Domestic projects	10%	+	5%	+	10-15%	=	25-30%
- Vertical walls	10%	+	5%	+	30-40%	=	45-55%
- Roofs							
➢ Difficult/remote areas	10%	+	10-15%	++	10-15%	=	30-40%
- Vertical walls	10%	+	10-15%		30-40%	=	50-65%
- Roofs							

All engineering companies have their own standards for total gunning allowances, which generally lie in the above intervals, but the best - for equipments and operators - installation companies are able to stay close to the lower limits of even better.
Consult LINCO BAXO specialist for selection of materials, estimate of allowances and further advice if in any doubt.

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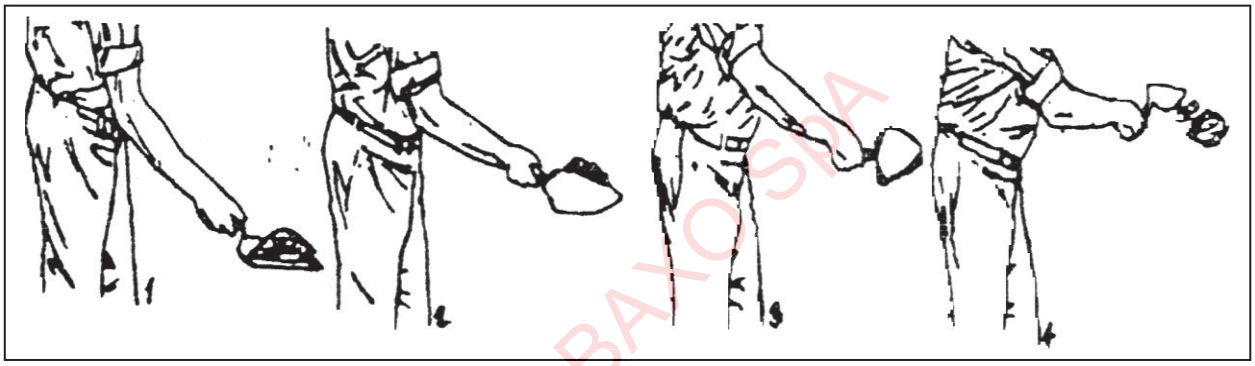
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

SLAP TROWELLING

It should be understood that some engineering companies accept trowelling for contouring only while trowelled linings are not generally permitted.

However, there are instances where castables may only be installed by trowelling; for example very thin linings or difficult positions where it is impractical to attempt installation by casting or gunning.

Trowelling is the installing of small quantities of castable (mixed to a stiff consistency) which are picked up on a trowel and "thrown" against a surface to be lined. (This is usually accomplished with upward sweeping motion of the arm and a flick of the wrist which imparts sufficient velocity to the wet mass of material for it to stick where it is placed and consolidated into a monolithic coating with the material previously and subsequently placed). By this method it is possible to penetrate wire mesh or lath which forms the anchoring system for the lining.



The water addition in this type of application must be the minimum require to develop the stiff consistency. Water content can be varied as the job progresses to suit the requirements of the individual craftsman making the lining. Extra water should not be added to a mix if it becomes stiff. This "retempering" causes reduction in strength and thus a mix should be discarded if it becomes too stiff.

This is probably an indication that too large batches are being mixed, therefore it is recommended that smaller batches are used.
Using this technique, an installation best proceeds from bottom to top, or from left to right, or from bottom left to top right. Manageable amounts of castable should be placed near the point of installation so that the craftsman making the lining may work efficiently.

Less desirable than slap trowelling is a "pushing" approach. castable is picked up on the bottom of a trowel and pushed through anchoring so that it sticks to the surface and consolidates with previously "pushed" material.
"Pushing" may be a necessity with anchoring containing small openings.

Castable should not be applied in thin multiple layers as it will peel and spall during curing and upon exposure to heat A single thickness layer is preferred.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

SLAP TROWELLING

The surface should be trimmed with the trowel edge or screened with the edge of a board to produce the correct lining thickness. The preferred finishing technique is as little as possible with the minimum action of a trowel bottom. Water should not be added to the surface. After the surface has been levelled it may be rubbed with a damp cloth to provide a textured surface.

Excessive working of the surface pulls water, fines and the cement binder to the surface which can cause cracking and spalling during curing and upon exposure to the ambient conditions. It will almost certainly cause spalling upon exposure to elevated temperature.

The mix should there be an accumulation of water on the surface during vibration, this is an indication that the mix is too wet and less water should be added to the next batch.

All movements of the vibrator within the concrete should be slow and deliberate allowing the material to flow and fully fill the space made by the vibrator as it moved.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

CURING

When water is added to castables containing calcium aluminate cement, hydration occurs accompanied by the generation of heat.

The amount of heat generated is sufficient to release some moisture as steam thus preventing full hydration from taking place.

To compensate for this moisture loss and allow complete hydration to develop the optimum strength of the cement, a curing process is necessary. This consists in keeping the lining surface sufficiently damp and cool by spraying, with clean fresh water at frequent intervals or by covering it with wet sacks which must be maintained wet. In some cases with ducts, small vessels, etc. an alternative method is by air-proof closing of the equipment to keep all the moisture inside.

The curing process should start immediately after initial setting when the lining furnace has set hard enough to permit impinging spray water from washing out the surface cement, and shall proceed for at least 24 hours. Forms and shuttering my remain in place.

During curing operation, the refractory lining temperature shall be maintained between 10°C. and 32°C.

In cold temperature conditions the rate of evaporation is generally low, therefore the wet curing operation may not be necessary; however the lining temperature must be maintained above 10°C. and under no circumstances must the material be allowed to freeze during setting and curing or until the lining has been dried to stable conditions.

In hot temperature conditions the rate of evaporation is generally high, then the wet curing operation is the greatest importance. The lining must be kept damp and cool within the first 24 hours. When the lining installation is carried out in open air, the surface shall be protected by shading from direct sunlight until the curing operation has been completed.

Refractory lined equipment shall not be moved, on site, until the curing operation has been completed and shall not be packed and transported until air drying operation has been carried out.

The steel casing stiffening shall be such that flexures and distortions are prevented in order to avoid damage of the lining.

In order to reduce risk of cationic hydrolysis the applications of **CURING MIX 106** mixture is recommended. **CURING MIX 106** is a product specifically studied to allows a safe hardening by forming a protective film/membrane which, isolating the castable from the direct contact with the atmosphere, avoids also the formation of white dust or moulds (carbonization). This product is applicable by spraying. Linco Baxo recommends to apply Curing Mix 106 coating on the wet castable and to repeat the applications after the setting of the castable.

The protective film/membrane usually lasts a sufficient time to cover transport and other intermediate operations prior to drying-out.
For applications refer to relevant data sheet.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

AIR DRYING & VENTILATION

When the curing process is complete, the castable lining must be air dried at an ambient air temperature at least over 10°C. for as long as possible (but not less than 72 hours) in order to obtain stable conditions prior to initial heating.

This operation allows the reduction of the amount of free water in the castable which might otherwise cause undesired chemical reactions between the lining surface and the atmosphere. This is likely to happen if the lining, after the curing, is permitted to remain for a time in a damp, humid ambient air without any drying.

Freshly placed lightweight castables are prone to a deteriorating condition called alkali hydrolysis (AH) or carbonation when they are kept in a non-dried state for a sustained period of time in a damp and humid environment **(1).**

In general this phenomenon, know as “alkali hydrolysis” (AH) or “carbonation”, takes place more readily with insulating castables which are based on porous aggregates that absorb high percentages of mixing water. This effect is more likely to be evident on installations made in high-humidity sites as the air is humid and the rate of evaporation is low. Closed ambient, such a condition that exist in complete box type furnaces with no ventilation, are more likely to facilitate this undesired phenomenon.

Accordingly, AH and carbonation are accelerated by the penetration of water. It is especially important to stop the movement of water to suppress carbonation.

The ideal recommendation is therefore to fully dry the castable lining immediately after the curing has been completed. Where this is not possible, the castable lining shall not be allowed to remain in a closed humid environment. It is recommended to ensure sufficient air ventilation either by leaving the lining in a well dry-ventilated area or, preferably, by providing a forced ventilation on the whole surface with an adequate fan or, even better, by a hot air blower.
Linco Baxo suggest also to perform pre dry-out at 260° C for about 45 hours in order to partially remove water from the lining . This usually reduce the risk of AH.

Another practical way to overcome this undesired situation and to reduce risk, is to apply **CURING MIX 106**, a liquid base curing compound, which forms a membrane / protective film preventing the formation of “cationic hydrolysis” and then protecting the lining.
The main effect of a surface coating in delaying/reducing carbonation is to stop the penetration of water.

In the Petrochemical Industry recent furnace construction trends, favour reducing installation time at site by using steel casing modules lined in the shop of the steel casing supplier or not far away from such shop. In such cases, it is recommended to air dry and ventilate the castable lining before the module is packed for transportation and to ensure that packaging is adequate to protect it from the ingress of water.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

AIR DRYING & VENTILATION

Complete cured and dried castable linings must not be left in such a way that they may be exposed to rain and its damaging effects on properties.

Linco Baxo specialists are at your disposal for further information and advice.

(1) Carbonation of Alumina Cement-Bonded Castable Refractories by SATOSHI SAKAMOTO and EHCHI KUDO published on Journal of the Technical Association of Refractories, Japan 20 (1) 18 – 23 (2000)

LOW TEMPERATURE CONDITIONS

Neither dense or insulating castables shall be installed when ambient temperature is below 10°C. In cold weather, the minimum temperature of 10°C. must be maintained by artificial heating of the water, the castable and its surrounding area ,including the furnace shell, until the installed material has been cured and dried.

When the installation is made in an open shop , it may be necessary to externally lag the unit being lined and also provide adequate heaters to maintain temperatures at a satisfactory level.

It is recommended that the castables are stored in conditions that they are frost free and moved into a warmer area with a minimum temperature of 15°C. for at least 48 hours before installation.

The mixing water temperature shall be in excess of 10°C. and it is recommended that it be heated, if possible, to 20 °C., while never exceeding 30°C. The temperatures of the dry mix and water shall be controlled in such a way to always obtain at all times a temperature of the wet mix above 10°C. In gunning applications, the higher the material temperature, the better the gunnability and the lower the amount of rebound loss. The recommended water temperature is between 20° and 25°C. Setting time can be adjusted by accelerating reagent supplied by Linco Baxo on request .

During the application and curing, the castable lining temperature must be maintained above 10°C. and under no circumstances must the material be allowed to freeze.
When the curing operation has been completed, the lining shall be air dried at an ambient temperature above 10°C. for as long as possible to obtain stable conditions of the refractory material.

The air drying operation is of the greatest importance when lightweight insulating castables are installed, due to the high percentage of mixing water that they require.
The freezing effect on the refractory castables after curing depends only by the content of free water. If the castable has been fully dried, freezing has a limited effect to deteriorate the lining

Electrical heaters

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

HIGH TEMPERATURE CONDITIONS

The castables must be stored in a cool and dry ventilated warehouse, avoiding direct exposure to the sun. If the temperature of the dry mix is high, it should be kept in a cool place before use, its temperature being maintained below 32°C.

Cool fresh water shall be used for mixing. If necessary, chilled water must be used, but under no circumstances must it be below 5°C. The water and the dry mix temperatures should be controlled in such a way to always obtain a temperature of the wet mix below 25°C.

If the steel casing is exposed to sunlight, it is recommended that it be cooled down, during installation, setting and curing so that its temperature be below 32°C. This can be done by shading from direct sunlight and/or by spraying with water the outside of the steel casing.

Because high temperature castables tend to stiffen quickly, rodding or tamping soon restore the material to a normal consistency. The addition of excessive water to improve flowability shall be avoided and if necessary smaller batches of castable should be mixed and installed.
Setting time can be adjusted by retarding reagent supplied by Linco Baxo on request.

If the material is installed by gunning, the same precautions should be taken as in casting.

A cool place should be selected. The mixer, the dry mix and the mixing water should not be allowed to be exposed to sunlight.
During the curing operation, as with a cast lining, the refractory lining temperature must be maintained below 32°C. The lining must be kept damp and cool within the first 24 hours; this is particularly important for the castables with a high evolution of heat of hydration, as they are particularly vulnerable to cracking and explosive spalling if they are not correctly cured.

Where none of the above is possible, the installation should be carried out at night.

For a correct curing procedure, see section 4.1.

Chilled water bucklets

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

JOINTS OF CASTABLES LINING

Refractories expand when heated.

Expansion joints are used to permit thermal expansion in refractory castable lining where they are considered necessary by the engineer responsible for the design of the unit in order to protect the lining and the shell against forces which might be caused by unrelieved thermal expansion.

The expansion joints are generally placed with regular spacing, not greater than 1,5mt., in horizontal and vertical directions.

The expansion joints between adjacent panels, when panel constructions are used, should be packed with ceramic fibre having an adequate service temperature limit, such as blankets or felts/ceramic fibre.

Separation joints and separation cuts (or score lines) are used to distribute the shrinkage of the lining uniformly and to prevent the formation of random cracks. They should have a regular spacing of no more than 1,5mt. in horizontal and vertical directions.

The separation cuts are manually made by scoring the castable surface before its setting and shall be approx 1,5 mm. wide and 25 mm. deep. The surface cuts are always required with “facings” of dense type castables: they are not strictly required – but still recommended – with “medium weight” and lighter facing materials. The cuts should not be made by grinding after the installation when the castable has already hardened.

It is good practice to cover the roof joints of the working layers with dense refractory splits in order to prevent any passageways.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP

Before operating the furnace, refractory lining must be fully dried.

The necessity of efficient and professional drying & safe heating-up is a prerequisite in order to discharge free and chemically bonded water content. Drying & correct heating-up minimize the risk of steam explosion or thermal shock and thus help to ensure optimum condition of the refractory castables before the lined furnaces and plants start operations.

Refractory castables, which are not dried, show a low permeability, therefore water must be slowly removed to avoid hydraulic high pressure which can breakout due to the internal stress of water turning into steam.

The new generation of dense castables possess better physical properties such as heat insulation, abrasion resistance and resistance to chemicals, slags and alkalis. Unfortunately, these enhanced properties are at the expenses of porosity.

Porosity is however , the key of successful drying.
Low porosity means fewer escape routes for steam and water.
A major amount of residual water remains in the refractory mixes as only about 1/4 of the mixing water is needed for the hydraulic bond.
This water can be present in various forms namely a:

- Free water which escapes at 100/110 °C
- Physically / chemically – bonded water (Hydrate shell) which escapes at 250-350 °C
- Crystalline-bonded water which escapes at 600-650 °C

Dry-out procedure must be performed then following a detailed curve which will depend on quality/type of refractory castables and the thickness of the linings.
Generally, greater the thickness and higher the density of refractories longer the process.
Dry-out never must be stopped or interrupted.
In case of inevitable interruption, the refractory lining must be kept warm or it must be cooled down following the original curve.

General rules must be followed as guidelines:

- A nonstop hot air flow must be across all the furnace to remove humidity
- **Mobile burner equipment is generally used for drying because furnaces/plants are usually not equipped with burners that could regulate the drying in the lower temperature range in such a way that the temperature progression could be successful**
- Until 650° C avoid to use free flames directly to refractory lining
- Avoid as much as possible quick temperature changes.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP

The dry out and heating-up of refractory lining involves more than following a heating schedule. Issues such as burner size and placement, exhaust location, air volume, air velocity, thermocouple placements, etc. must be addressed.

This work is not always part of the services provided by the company installing the refractories.

Linco Baxo recommends consulting an experienced dry out company equipped with professional burner equipment.

Some requirements must be fulfilled to ensure successful drying & heating up. These requirements are independent of the used heating medium. It must be ensured that after installation of the refractory material no additional water, for example rain, tap water or similar, enters the furnace/plant to prevent condensed water. The furnace/plant must also be protected against frost.

The furnace/plant must be tight. In order to obtain slight excess pressure, all openings must be closed that are not needed for the discharge of the hot gases. This is particularly important to ensure that the incoming hot air does not flow as streams without any effect through the furnace/plant. In order to regulate this excess pressure, depending on the air amount blown in, a control valve should be installed at the hot gas discharge location. It must be considered that with the same cold air amount and increasing temperatures the air amount at least doubles at the standard drying & heating up temperatures up to 500 °C. This alone demonstrates how important and useful a control valve can be.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

Preparations

Drying & heating up is prepared for as follows:

- The supply lines are set up or installed,
- fans are set up,
- burners are set up or installed in front of the defined openings,
- the thermocouples are installed at the specified locations,
- functioning of fans and thermocouples is tested with a “cold operation test”,
- the tightness of pipelines and supply lines for gas, oil, and compressed air is tested and,
- the seals of the vessel are subjected to a visual inspection.

The following must also be checked in advance:

- How should the moist flue gas (exhaust vapor) be discharged?
- Is it possible to discharge condensate, can the buildup of condensate be prevented?
- Is there a sealing-off on the flue gas side to other parts of the furnace/plant?
- Are possibly pressure parts or boiler pipes filled with water or must still be filled with water? Then a new thermal (heat) balance must be prepared.

With complicated furnaces/plants it may well be necessary to conduct a risk (danger) analysis and prepare a checklist with the required testing steps (refer to **Table A)**.

A sufficient number of fire extinguishers must be located in the vicinity of the burners

PRINCIPLES OF DRYING & HEATING UP

checklist/testing list for heating to dry a furnace/plant					
order no:			project:		
no.	Description of check/test	responsibility customer	contractor	checked by	result
1	General				
1.1	Drying & heating up regulation (drying heating up procedure exists/approved)				
1.2	Acceptance of the refractory lining				
1.3	Flue gas discharge on site (in position)				
2.	Heating equipment to perform drying & heating up work				
2.1	Conformity declaration/CE mark/permits				
2.2	Cordoning off of burner areas				
2.3	Number and type of burners according to drying & heating up procedure				
2.4	Positioning (arrangement) of burners according to drying & heating up procedure				
2.5	Positioning (arrangement) of thermocouples according to drying & heating up procedure				
2.6	Temperature recording equipment checked				
3	Gas				
3.1	Gas pipelines/gas control routes etc. checked in regard to tightness (leaks)				
3.2	Permits for gas hoses on site				
3.3	Gas pressure controller installed (if required)				
3.4	Safety shut-off device installed for specific purpose				
3.5	Function test of gas control routes and burners successful				
3.6	Function test of safety features on burner equipment successful				
4.	Safety measures				
4.1	Cordoning off of safety-relevant areas				
4.2	Extinguishers in position with valid inspection sticker				

Table A: Example of a checklist/testlist for dry heating

PRINCIPLES OF DRYING & HEATING UP

Execution

The burners are positioned in such a way that the heating energy is, for example, guided through door openings or manholes into the inside of the furnace/plant. The heating energy must reach all areas, which are to be dried, and then flow out through the chimney of possibly and emergency chimney. As already mentioned, air is injected concurrently via the fan which mixes with the burner flame. A flame, which may possibly form directly at the outlet (discharge) nozzle of the burner, may not impinge the refractory lining.

In addition, the temperature in the immediate area of the burner must be kept within a limit. This can be achieved by having thermocouples check the temperature directly in the burner area.

Endangered areas are protected with blankets out of ceramic/soluble wool or other heat insulation materials.

Once the preparation work has been completed or the end customer has given his “go ahead”, the execution of drying & heating up can start according to the drying & heating up curves provided by the supplier of the refractories or by the refractory engineering company. The following guidelines apply to establish a rough estimate of the drying & heating up period:

Depending on the refractory materials, there can be major differences in regard to the temperature gradients. Consequently, only recommendations are given here and the minimum requirements mentioned.

Up to 100 °C it is generally not required to adhere to a specific progression of the temperature. Heat transmission is relatively low and the steam pressure cannot exceed 1 bar. The drying & heating up speed of refractory mixes is the fastest in the lower temperature range. Consequently, it makes sense, if working with plastic mixes, to have holding times in the lower temperature range of 120 to 150 °C **Table B** given standard values and data

type of material	Duration h	Curve	Setting and air drying time h
plastic mixes, mouldables and ramming mixes	113	A	24
dense, standard refractory castables	112	B	24
insulating refractory castables	112	B	24
dense refractory castables with medium and low cement content	176	C	48
self flowing (self-leveling) dense refractory castables	176	C	48
FC castables (Licodry)	69	D	12
brickwork out of alumina of bricks-blocks-shapes	30	E	12
construction out of fired itemized mullite and sillimanite shapes	95	F	24
construction out of fired itemized high alumina shapes	95	F	24
construction out of fired itemized zircon and zircon mullite shapes	96	G	24
construction out of unfired itemized shapes	See underlying castables		

for temperature progression above 100 °C and possible waiting periods between the end of lining work and start of the dying & heating up procedure.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP

The indicated temperatures should never refer to the surface of the lining but always to the hot gas or hot air. This ensures a certain degree of safety because the temperature in the material is always behind.

Refractory linings usually consist of various refractories. If a lining is commissioned that has several types of refractories one selects the temperature curve for the material with the lowest permissible heating-up curve.

However, the following always applies: Drying & heating up should not start 24 hours after working with (installing) refractory mixes, mortars (an exception to this are plastic and ramming mixes) so that the setting (hardening) process is not prematurely interrupted by temperature impingement.

If there should be disturbances during drying & heating up heating or heating-up, it is necessary to continue to increase the temperature starting at the temperature level that existed at the end of the disturbance period.

If one goes through and already completed temperature holding period, then it does not have to be repeated. If there is, however, a disturbance during a holding period then one must go through the entire heating period once again.

Cooling down must be done with extreme care because dangerous tensile stress can occur. It is not permitted to use water or ducted (forced) air.

The temperature are preferably measured with NiCrNi-thermocouples. Higher temperature should be measured with Pt RhPt-thermocouples with shell. This ensures the following advantages:

- They are easy to handle and operate,
- the temperatures are precisely recorded and
- due to their small size the refractory lining is hardly influenced.

A thermocouple, which records the waste gas temperature in the vicinity of the burner, controls the increase of the temperature.

Furthermore, thermocouples located in located in various areas of the furnace/plant measure the flue gas temperatures and continuously record them with a temperature printer. The measuring location must be arranged in such a way that the measured values (counts) are not falsified upward or downward by direct flame radiation or shadow areas.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP

In order to avoid any influence by the walls while measuring the temperature, the thermocouples must project 80 to 100 mm into the furnace chamber. They may not be in contact with the refractory lining. The temperatures of specified reference measuring locations are decisive for temperature regulation/control.

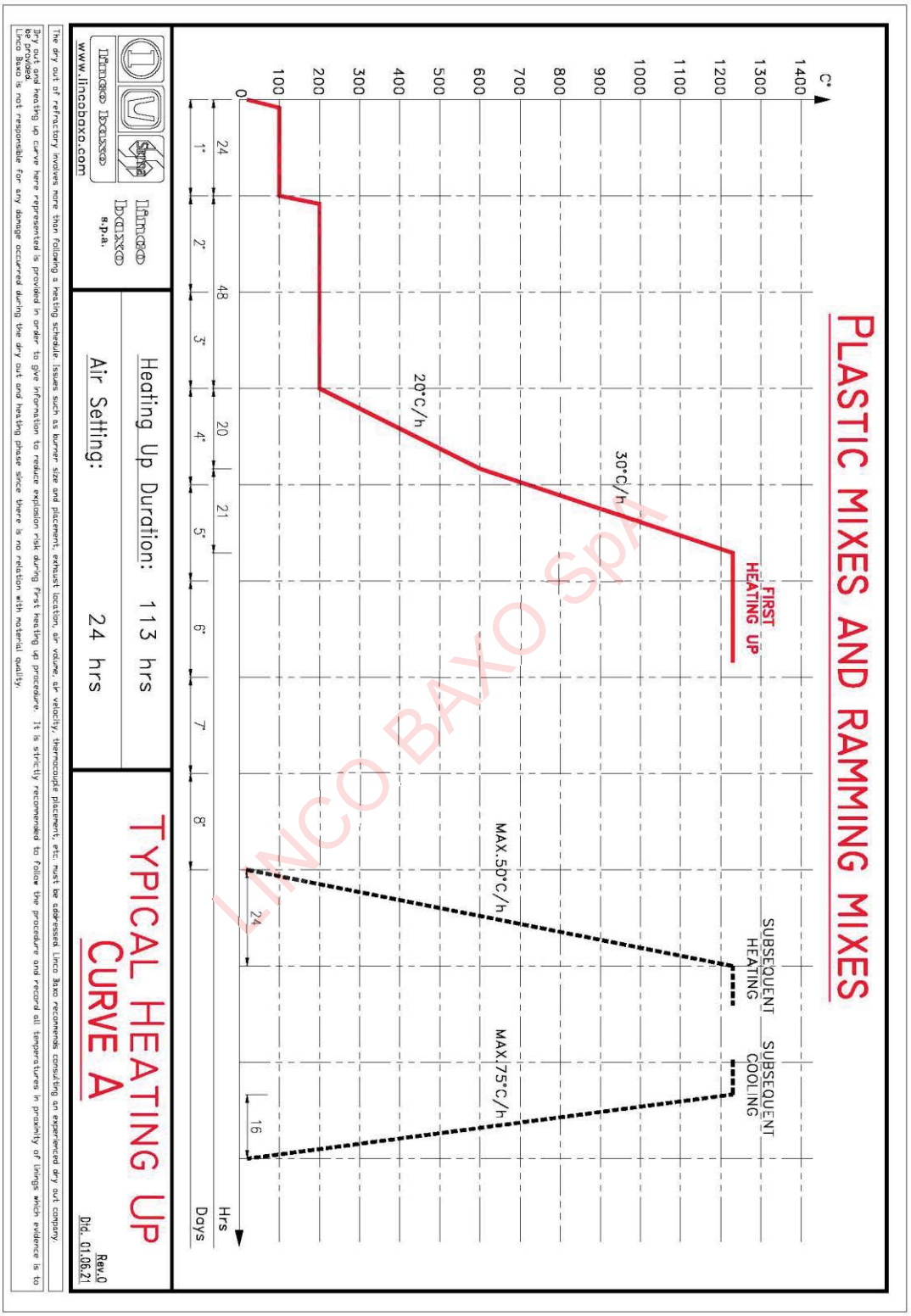
Further criteria are mentioned here below as an example:

- Drying must be done by experienced personnel!
- The company performing the drying work must establish a procedure that has to be approved.
- The arrangement of the thermocouples is given.
- With excessive steam buildup the temperature must be held until the buildup of steam discontinues.

Further specifications required

- that the hot gas volume being guided through the furnaces/plant must be sufficient in order to prevent condensation and
- that the burner is operated with at least 50% excess air.

PRINCIPLES OF DRYING & HEATING UP



Typical Heating up Curve for plastic mixes, mouldables and ramming mix

PRINCIPLES OF DRYING & HEATING UP

Typical Heating up Curve for dense, standard refractory castables and insulating refractory castables

PRINCIPLES OF DRYING & HEATING UP

Typical Heating up Curve for LC, ULC, self flowing castables

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP

Typical Heating up Curve for FC castables (Licodry)

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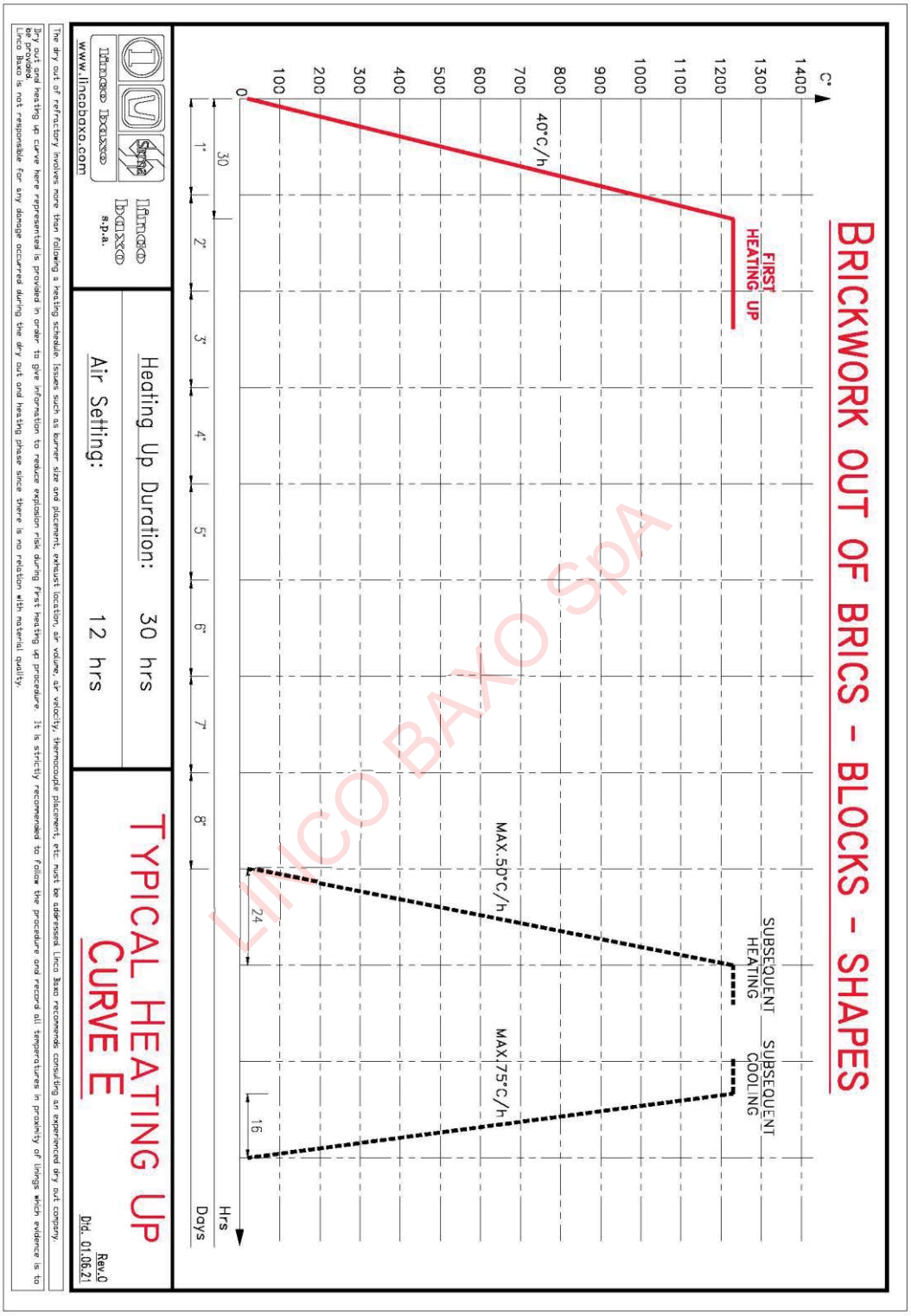
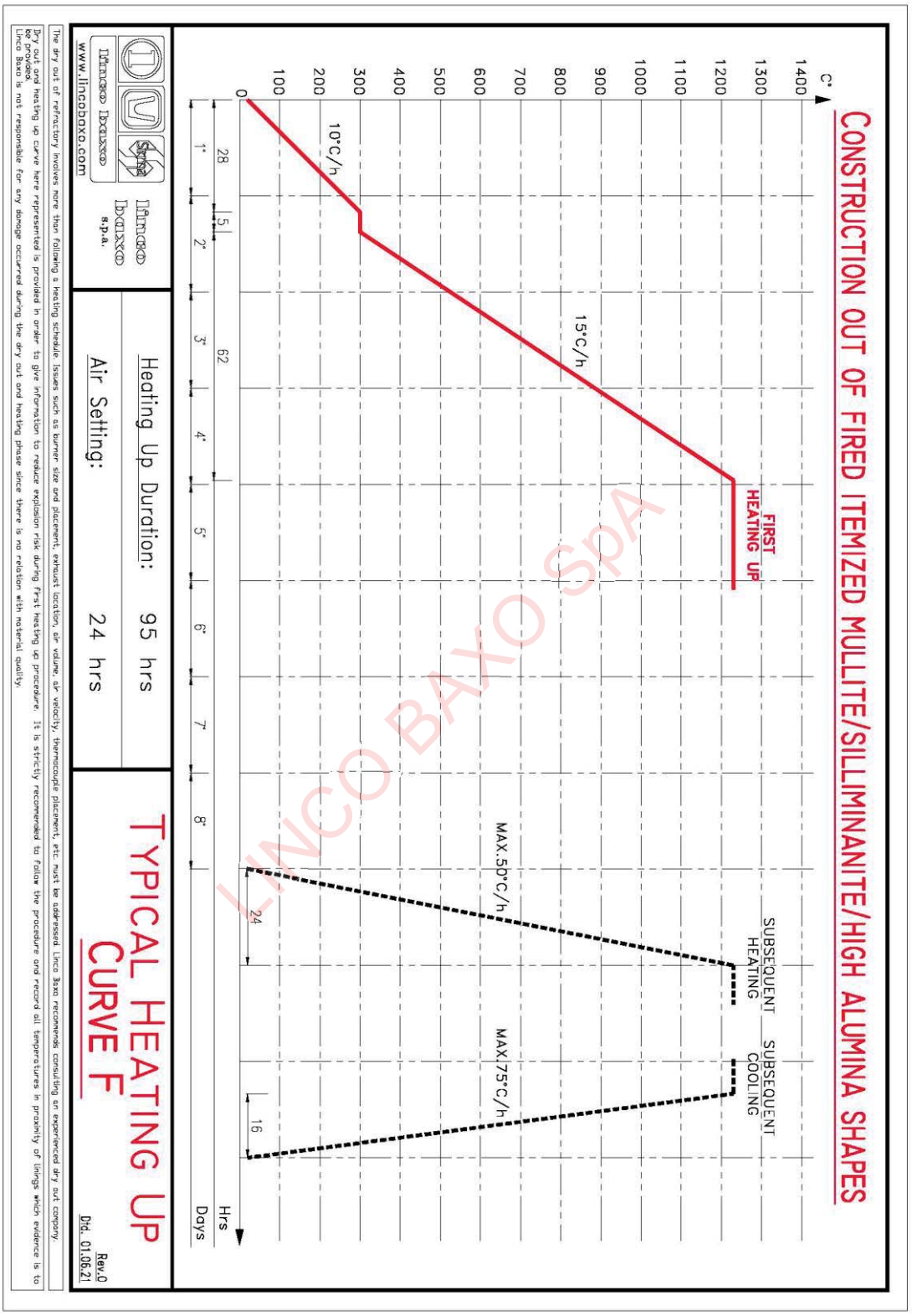
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP



Typical Heating up Curve for brickwork out of alumina bricks-blocks-shapes

PRINCIPLES OF DRYING & HEATING UP



Typical Heating up Curve for construction out of fired itemized mullite, sillimanite and high alumina shapes

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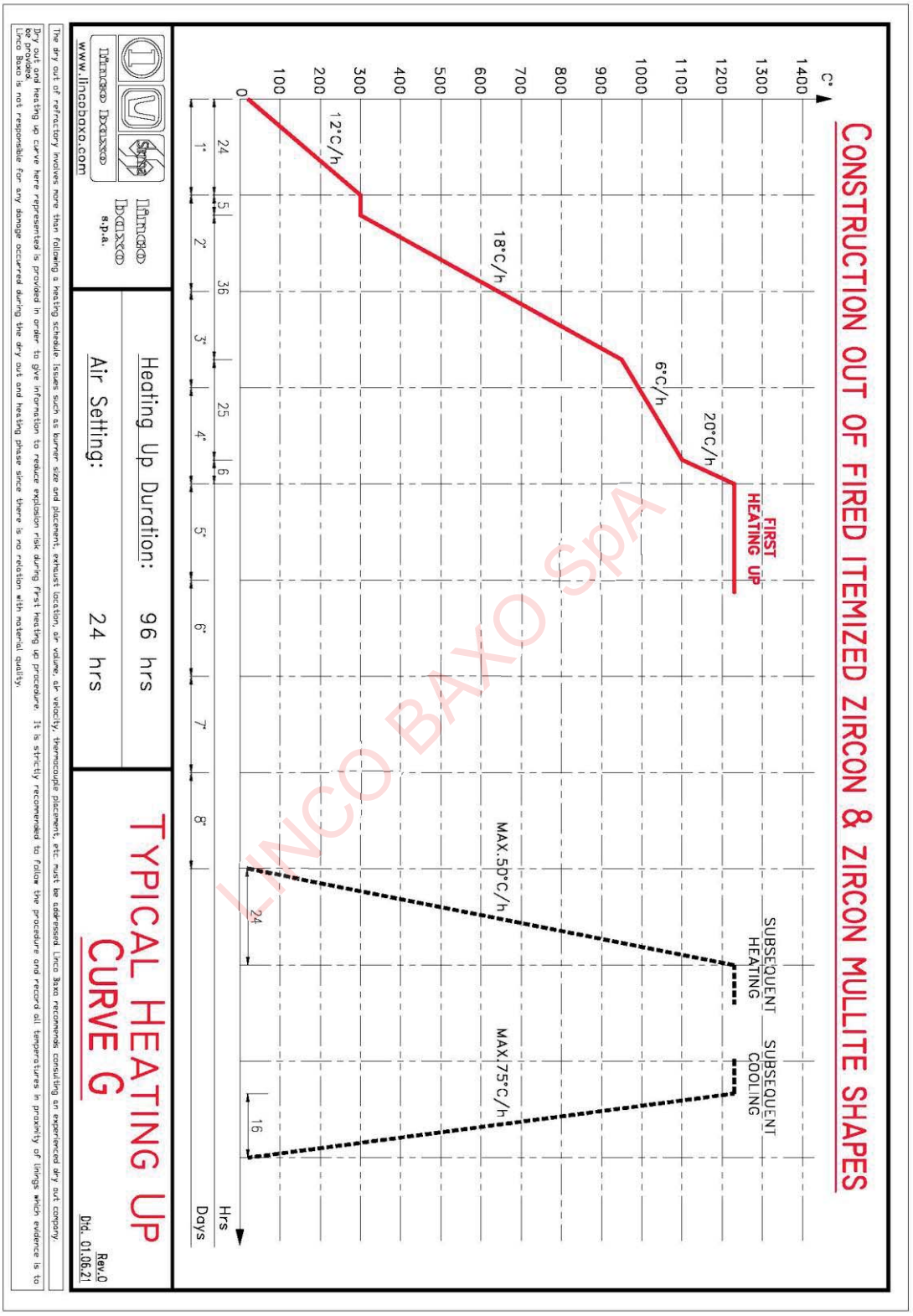
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRINCIPLES OF DRYING & HEATING UP



Typical Heating up Curve for construction out of fired itemized zircon and zircon mullite shapes

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

LINING INSPECTION

After it is installed, the lining must be inspected to confirm that it conforms to the design requirements and to ensure that it can withstand the conditions under which the unit will operate.

The lining should be inspected only by experienced engineers.
Inspection must be visual and audio (by using a test hammer) and is carried out after both normal air drying and firing dry-out.

Visual Inspection

Visual inspection should reveal is cracks or local concentration of cracks have formed. If cracks are found a decision becomes necessary to decide whether they are such that they are likely to adversely affect the normal operation of the unit.

Repairs should be made to areas containing cracks each wider than 3 mm. as well as complete areas having random cracks up to about 3 mm. width but which are within 300 mm. of each other.

Irrespective of this width, repairs should be made to areas, where cracks criss-cross forming "blocks" that are likely to fall off with time/temperature.

Linings in general tend to move more on heat up and as a result tend to develop more cracks on cooling.

Visual inspection is required to further ensure that the lining finish is satisfactory and that its dimensions are correct.

The sizes and positions of the expansion joints must be inspected and confirmed correct. This inspection should also reveal if expansion joints have become infiltrated in any way with foreign matter. Such matter might resist the normal movement of the lining therefore it is necessary that any joint so affected be cleaned out and repacked with the correct material.

Audio Inspection (Hammer Test)

This type of inspection is generally referred to as a Hammer test. It involves the practice of striking the lining over its entire area with a ball point machinist hammer having a recommended weight of 450 grams. The lining is struck according to various but specified grid patterns.

For example a roof might be struck at 600 mm. intervals while side walls and floor at 900 mm. intervals.

Hammer testing will indicate whether or not a lining is homogeneous. An experienced ear will determine, in more detail, faults which might cause a lining to collapse such as voids and delaminating etc.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

LINING INSPECTION

When struck with a test hammer, the sounds emitted are more clearly distinguishable in fired linings rather that in those only naturally air dried; therefore, after dry-out, faults are more easily located. For multi-layer linings, the hammer test should be conducted on each layer: after the curing of the back-up layer (s).

If sounding indicates the presence of an abnormality in an area greater than 150 mm. x 150 mm., this area must be repaired. Also all soft or dry fill areas that reduce the effective lining thickness by more than ¼ of the original thickness or if more than 13 mm. deep.

If the area of defects - i.e. voids, “dry fill”, cracks wider than 3 mm., or any defect in designated critical surfaces – is found to be more than 35% of the total lining surface, it is usual that the entire lining is replaced.

The inspector or the Owner’s Engineer will make the decision on replacement.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

REPAIRS

If inspection reveals defective areas as previously defined greater than 150 mm. x 150 mm., the full thickness of the defective castable layer must be removed for a minimum area that includes 3-4 anchors.

Care must be taken in the removal of the faulty material that the surrounding sound lining is not damaged and neither, if it is present, the back-up lining.

The removal of the refractory castable should progress at a small angle to the shell and the periphery of any repair be located mid-way, between anchors.

The area being repaired should be cleaned of all loose castable and debris and the adjacent sound material thoroughly wetted before any new castable is installed.

Only the same castable as originally employed should be used for replacement and wherever possible, particularly in large areas, the same installation method as was originally used.

Where repair to only a random crack is necessary the full thickness of lining should be removed for an area same 120-150 mm. each side of the crack and parallel to it, total length 240-300mm.

It is recommended that if possible some auxiliary anchors should be installed along the area being repaired, in order to have a new longitudinal and transversal anchor pitch of about 200 mm.

The new castable should be cast using forms made of boards propped and fixed again the sound castable surface.

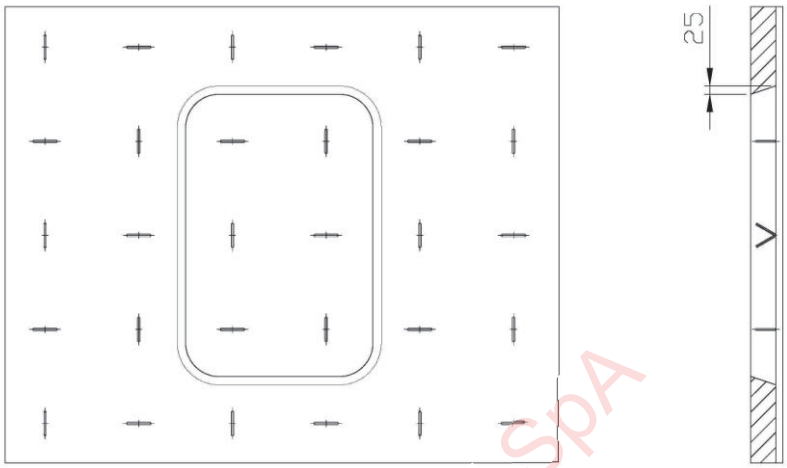
When areas after drying out are found to have a soft surface the defective material need to be removed and replaced only if it is considered that sufficient material will become disengaged to adversely affect the normal operation of the unit.

If replacement is considered necessary the removal shall be accomplished by scraping the soft castable until sound material is encountered.

The removed lining thickness may be less than the limits defined in section 7.1. If it exceeds these limits the defective area shall be reinstalled entirely unless it is confirmed that the reduced lining thickness will meet the entirely unless it is confirmed that the reduced lining thickness will meet the designed insulating properties satisfactorily. The Inspector or the Owner's Engineer, however, might reject this demonstration and request the repair of that affected area of the lining.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

Curing, air drying and dry-out procedures for repaired areas are the same described in the section 4.1, 4.2, 6.2. For small repairs (less than 3 m^2), accelerated procedures if required may be discussed with Linco Baxo refractory specialists.



Insulating refractory lining reparation scheme

SAMPLING AND TESTING

For quality testing of consignments of refractory castables, sampling involves the selection of relatively small quantities of materials which must be considered to be representative of the total consignment and from which test-pieces may be prepared under closely controlled laboratory conditions (PRE-INSTALLATION TESTS).

In addition, it is often the case with refractory castables that laboratory testing is required of test-pieces which are prepared on the site of an installation. This is done in order to gain some appreciation of the quality of linings which may be installed under site conditions very different from those encounters in a laboratory and which are sometimes far from ideal (AS INSTALLED TESTS).

After the installation, visual and audio (hammer testing) inspections are the common non-destructive tests of a lining (AFTER INSTALLATIONS TEST).

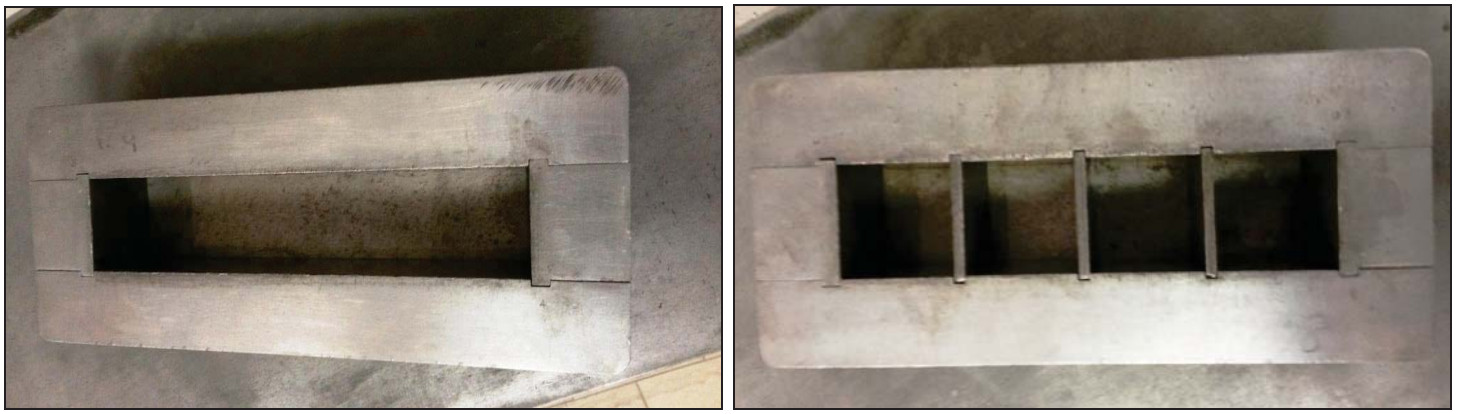
The amount of sampling and the extent of testing must of necessity be a compromise between customer and supplier.

The total quantity of castable involved in a particular project and the time that is available for physically testing samples, reporting results, review and the granting (or otherwise) of approval are important consideration in deciding the maximum amount of testing that can be accommodated, both by the testing laboratory involved and by the rate of installation desired.

It is essential therefore that the properties to be tested and the number of tests required be agreed at the time the castable materials are ordered.

The test methods used are those accepted by all countries such as ASTM, DIN, AFNOR and JIS.
Usually LINCO BAXO carries on an in-house test method based on ASTM standard developed for a specific purpose .

LINCO BAXO normal policy is to hold themselves ready for discussion with their clients in order to agree a mutually accepted plan.



Sampling shuttering

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRE-INSTALLATION AND PRODUCTION TESTING

Linco Baxo operates a Corporate Quality/Assurance Policy, part of which dictates that all products made at their plants be tested, approved and released for shipment only on the authority of the same Quality Control Manager for the particular plant at which the product is made as per ISO 9001:2015..

The very first stage of quality control concerns the suitability of the raw materials that need to be employed. The properties required of all raw materials are covered by a stringent Linco Baxo Purchase Specification which is imposed on all suppliers. In spite of this, all incoming materials are tested on arrival at the plant before being accepted for castable production.

The blending of the raw materials is PLC monitored at any time is then possible raw materials tracking as per quality and batch as per formula, which eliminates the risk of quality failure at a later stage due to initial incorrect blending. Thereafter each shift of production is routinely controlled by the laboratory for sieve analysis, water/mix ratio, cold compressive strength and permanent linear change. Period tests are carried out at various intervals on chemical analysis, thermal conductivity, thermal shocks resistance, modules of rupture , abrasion resistance, refractoriness under load and when applicable resistance to effects of CO dissociation.

For large project, pre delivery testing may be performed in Linco Baxo laboratories in the presence of a customer's inspector or his nominated representative on samples selected at random from materials awaiting shipment. By utilising such a procedure the entire process of sampling, specimen preparation, testing and acceptance can be achieved under the most ideal conditions.

Should a project call for a particular requirement, customer's engineers are invited to liaise with Linco Baxo specialists in the initial stages of the contract in order to arrive at a mutually acceptable sampling plan and testing procedures for the required materials prior to shipment.

Panel test – Gunning application

A particular example of pre-installation testing is the gunned panel test which is usually employed to qualify the compatibility of gun operators along with their equipment for a particular concrete.

With gunned applications, panel tests are imperative and are made prior to the actual lining placement. Each operation should gun at least one panel of each concrete to be installed. The test panel must always be produced with the same gun equipment that will be used under site conditions.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

PRE-INSTALLATION AND PRODUCTION TESTING

The size of the panel shall be 900 mm. x 900 mm. minimum and having a depth, the same as the lining to be installed.

The test panels are gunned in the vertical position with the nozzle of the gun equipment held approx 1 m. from the panel surface.

The panel should be produced in accordance with the gunning procedure as in section 3.3.
The panel should be cured for 24 hours, then dried at 105°C. for a further 24 hours. The integrity of the panel is checked by hammer test (sect. 7.1) and its density established. A sound panel having density within acceptable limits will serve to qualify the operator and his equipment.

At the discretion of the customer or his representative the panel may be cut into 4 pieces for internal examinations for inclusions and lamination.

AS INSTALLED TESTS

Test pieces prepared on site are often on accepted standard dimensions, but specimens are sometimes preferred by some engineering companies or plant owners. The object of this type of test piece is to be able to sample a monolithic lining in order to assess its quality without the need of core drilling or cutting the complete lining.

The process employed is, in effect, the production of test pieces in the same manner, as close as possible as the lining installation proper.

Generally agreement is reached by the interested parties of a project that test pieces be fabricated from batched material which has been prepared for installation. Sample test pieces are taken at times corresponding to installation of various sections of the lining and marked accordingly (if preferred, the sampling may be based on shifts worked).

Linco Baxo suggest the following sampling method at site:

Application by casting

One sample per section of the lining (or per shift) for each quality for each production batch of castable being installed is taken during actual installation.
Each sample shall comprise three 50 mm. ± 0.4 mm. (or 2" ± 1/64) cubes which are cast in approved metal or plastic moulds, the required quantity of castable being taken from the material which is being installed. The cubes are cured, carefully coded and marked and the codes indicated on drawings of the lining. Also recorded should be the type of castable installed in that particular position.

Application by gunning

One sample per section of lining (or per shift) for each quality of concrete being employed is taken during installation. Each sample of concrete consists of three specimens 114x114x64 mm. ± 1.0 (or 4"-1/2x4"-1/2x2"-1/2±1/32).
The concrete required for the tests is obtained from a panel 600x600x75 mm. which is gunned by each gun operator working the particular lining section (or shift). The concrete is gunned into a test box (from 25 mm. timber or 3 mm. thick metal plate) which is rigidly mounted in a vertical position with the gun nozzle held approx. 1 m. from the sample box (see section3.3). The panel is produced slightly over 75 mm. and finally carefully trimmed back.
A section approx 300 mm. square is cut for the fully depth from the middle of the test panel before the concrete finally sets, it is cured in a plastic bag coded and recorded for future use.
Should testing be required specimens shall be cut out with a diamond saw, dried at 105°C. and tested.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

AS INSTALLED TESTS

Linco Baxo consider this preparation of panel acceptable believing the panel to be sufficiently representative of the actual lining. However, preparation of specimens by successive diamond saw cutting may introduce micro cracks and stresses in the specimens being cut. The strength comparison of such specimens cut to 50 mm., with that of cubes cast in the same concrete should allow for an additional variation of say 10% to accommodate possible weaknesses introduced by sawing.

Properties to be tested on cast or gunned specimens depend on many factors such as type of equipment, type of lining, service conditions. Another factor which might be introduced depends on whether the castable has been delivered as two components-mix.

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LINCO BAXO Group of companies
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e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

MANUFACTURING OF MOULDED PIECES IN SHOP

A variety of pieces - such as burner blocks, peephole and support blocks, baffles, dampers, etc. are often pre-cast in moulds in the shop using a vibrating table instead of an immersion poker. Metal moulds are preferred, but wooden moulds with special coating on the internal surfaces may be used. Moulds shall be designed to allow easy casting and stripping of the pieces and shall be sufficiently strong to withstand vibration cycles. Care must be taken that moulds are securely clamped to obtain the maximum amount of vibration.

In the design stage of moulded shapes, special attention must be provided to be sure that pieces can be manufactured by casting; this means that the shape shall be such that it is possible to remove it from the mould, possibly modifying the design of the shape if the problem cannot be solved with the design of the mould.

For large series, lost burnable moulds - or cores - may be foreseen: the material ca be cast and cured in the moulds, then drying and firing of material and moulds together can be made. In such a case, a cheap method to produce the moulds - for instance, in polystyrene - must be available.

Mixing, casting, curing drying and heating instructions for shop moulded pieces are the same as already described. However, for economical reasons, it is advisable that the shop be adequately equipped with paddle mixers, batteries of vibrating tables, a curing room, drier and furnace of sufficient capacity.

The shop must be clean, having a proper potable water supply and exhaust system. The shop should be maintained at a convenient temperature and provided with storage facilities for the moulds. Skilled labour is imperative.

After the stripping of one cast piece the mould must be carefully cleaned, oiled and prepared for the next casting. All Linco Baxo castables normally permit manufacturing of two pieces per day using the one mould (excluding the night shift).

This must be kept in mind when deciding the number of moulds to be provided to meet contractual delivery schedules, not forgetting the time for curing, drying and - if required - firing the pieces, plus a reasonable allowance for any production losses.

In some cases with dense castables - mainly when the quantity of pieces combined with a short delivery time results in a larger number of moulds that would greatly affect the total cost of the piece - it may be convenient to select one of the Linco Baxo vibrated castables which allow high frequency stripping, thus limiting the number of moulds.

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Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

MANUFACTURING OF MOULDED PIECES IN SHOP

All Linco Baxo dense vibrated castables require less than 6% mixing water: in spite of this low quantity, the drying and firing operations of the pieces require special care to avoid cracks and explosive spalling, unless the quick-heating types of castables have been chosen. Even more important than for normal casting, skilled operators are imperative for manufacturing of vibrated pieces.

For best results Linco Baxo specialists should be contacted at the beginning of every shop operation of moulded pieces manufactured with Linco Baxo castables and in some cases the visit of the specialist to the shop may be beneficial.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
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e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

STORAGE INSTRUCTION FOR UNPERISHABLE REFRACTORIES

Fired bricks & blocks , back up insulation materials , ancillary items and metallic parts shall be stored in a covered warehouse

They have to be kept in homogeneous groups and orderly arranged in different bays.
This will provide easy access and facilitate inventory report as the job is progressing.

We strongly suggest to keep expensive stainless steel components in a locked warehouse.

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LINCO BAXO Group of companies
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Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

BRICKWORKS GUIDELINES

Certain basic exist for the bricklaying of refractory bricks. They generally apply for all designs and construction parts.

These rules can be summarized in the “ten rules of the “furnace construction worker”.

1. Refractory bricks must be laid horizontally unless the design of the furnace or plant requires inclined positions or inclinations as is the case for crowns of inclined parts.

2. The construction dimensions in the design drawings must be always be observed by taking the indicated tolerances into consideration. The fists layer (course) must be installed with extreme care, aligned and checked before giving the “go ahead” for further bricklaying work.

3. All joints must be filled with the prescribed joint material. Thicknesses of the joints must be observed taking the indicated tolerances into consideration.

4. All joints must be completely filled over the entire surface with the joint material. This is only possible if the brick is “rubbed” intensely being laid. It is not permissible to apply the mortar with a “collar” because there is the danger of hollow spaces forming in the joints.

5. If, due to size tolerances of the bricks, the prescribed joint thickness cannot be accomplished, the person responsible for the refractory design will have to decide if it is possible to deviate from the given joint thickness. Other measures include sorting or sorting out of bricks shapes, finishing the bricks or changing the shapes in exceptional cases.

6. The brickwork must be kept clean, specifically the expansion joints may not be contaminated.

7. Already laid bricks can only be aligned in the direction of the bed or vertical joint.

8. Readjustment is not possible if the mortar has started to harden to a greater degree. Bricks not placed correctly must be removed, cleaned, and installed again with fresh mortar.

9. Bricks with signs of spalling, cracks or slight inclusions may only be installed if these damages are insignificant or within the acceptable tolerance range. This also applies for the rear side of the brickwork and for the brickwork behind. The criteria for the acceptance are indicated in the specifications or must be agreed upon mutually by contractor, manufacturer and party placing the order before the start of lining work at the construction site.

10. Brickwork out of refractory materials must be designed in such a way that no hollow space forms. Dust or fly ash can penetrate hollow spaces. This results in uncontrolled buildup of pressures which may destroy the brickwork. Damages can also occur by roaming gases.

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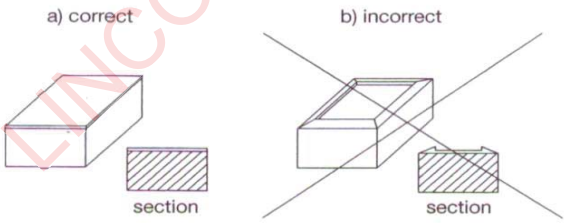
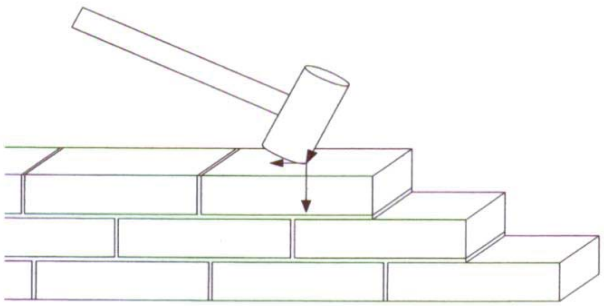
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

BRICKWORKS GUIDELINES

The following know-how must be taken into consideration in refractory engineering before actually starting erection/installation of brickwork:

- Measure, check and compare the construction components with the installation drawings before start of work.
- The first layers must be installed and aligned very precisely to avoid unnecessary cutting work and to obtain uniform joint thickness. It specific cases it may even be required to stall a few layers dry in advance.
- If the brickwork consists of multiple layers it is best to work section by section; for example from support to support or from expansion joint and to install one layer after the other. This is especially recommended if the individual brick layer consist of different refractory grades and must be installed with different mortars.
- If in brickwork consisting of several layers the individual layers are separated by sliding joints, it is very important to ensure that everything is kept very clean. Preliminary damage can occur quite easily if the relative movement is impaired by dirt or mortar bridges (pieces).
- If the steel walls of the furnace casing are not level, then the brickwork must be adjusted to the shape of the steel walls if the deformations only consist of slight waves that are not too deep. The bed joints must be maintained in absolute horizontal position. The bricks will then protrude in the form of steps. If, however, the operation conditions of the furnaces call for an absolutely level brickwork surface on the hot side (inside), the deformations of the furnace casing must be filled with unshaped refractories (monolithic).
- If the bricks are cut, the given joint thickness must also be considered at the cut edge. For the key (fitting) bricks in crowns and rotary kilns there always is a minimum thickness requirement of 40 mm which must be observed.





MORTARS AND COATING MIX INSTALLATION GUIDELINES

Mixing (For dry mortars) :

- Use drinking water if no other bonding liquid is indicated
- Use clean tools and containers.
- Use the whole content of a bag or, using parts of it, thoroughly mix the whole bag content before.
- Regulate the working consistency desired by addition of drinking water in a range of ± 10 % of the indicated amount
- Paddle mixer is recommended.
- Smaller amounts are mixable with putty knife or trowel.
- Mix hydraulically and highly reactively bonding mortars with water in small portions up to 20 kg and process them within the lifetime of 30 minutes.
- Let ceramic bonding mortars stand for 1 h after water-mixing.

Mixing (For wet mortars) :

- Wet mortars are supplied in buckets and are already mixed. If the wet mortar is segregated as consequence of ageing it might be restored by mixing with a drill.

Preparation of the underlayer:

- The surfaces to be coated with mortar must be free of dust and dean.
- Pre-watering: for hydraulically bonding mortar required
  for ceramic bonding mortar permitted
  for chemically bonding mortar prohibited

Processing:

- Processing temperature 5 °C min.
- Joint width shall not exceed 2 mm.
- Evenly spread mortar onto the surfaces to be joint and then insert the brick.
- Throw away the set mortar residues.
- Use clean working tools.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

MORTARS AND COATING MIX INSTALLATION GUIDELINES

Processing of coating mix:

Coatings, protective layers are always only required if the untreated original material will not resist the expected stress in service.

The surface protection itself will be damaged over a long period of time, for example by thermal stress, but in most cases increases the service life of the underlying material

- Processing temperature 5 °C min.
- Follow tailored instructions for mixing
- Evenly spread coating mix onto the surface to be protected
- Throw away set mortar residues.
- Use clean working tools

First heat-up:

- For hydraulically bonding mortar wait ~ 24 h.
- The heating-up curve does not depend on mortar type, but on the nature of the whole lining.

CERAMIC FIBRES & ASSOCIATES PRODUCTS INSTALLATION GUIDELINES

General

Working with ceramic fiber materials and high temperature glass fibers (AES fibers) requires the employment of expert personnel with experience in work procedures. They must be able to work with the special tools which are occasionally required.

The metallic anchoring elements are positioned with stud welding equipment. The construction plans showing the arrangement of the anchoring elements and the instructions for positioning the modules must be precisely observed. If this is not the case, faulty installation will effect open joints or leakages leading to impermissible overheating of the furnace casing (shell).

Wallpapering, Veneering

Wallpapering or veneering is the covering and gluing of ceramic fiber modules on the hot side of the refractory lining. This technique can be applied for new constructions as well as for furnaces already in operation. In the latter case the brickwork must first be checked to see if it can serve as gluing surface.

Adhesive (glue) on brickwork with low strength is critical, for example on Insulating refractory bricks of ASTM groups < 28 and various insulating refractory castables. With these materials the wallpapering/veneering materials to be installed must often be anchored in addition.

The surface must be free of dust, coatings, loose particles. Cleaning is best accomplished by applying liquids or brushing. Glazed surfaces must be prepared by blasting or chiselling off the glaze. Greater unevenness must be rectified before the start of work. The fiber elements cannot be glued in place until the equalization layer has completely dried and hardened.
The type of adhesive used and adhesion will depend on:

- condition and make of the surface.
- shape of module and type of fiber,
- temperature of the construction parts to be worked on,
- ambient temperature at the construction site and,
- expected operation temperature.

The adhesive (glue) must have the correct consistency for installation before being placed with a trowel or spatula on the refractory wall or module surface. Depending on the type of module. the modules are aligned in rows, positioned precisely and pushed down tight by hand or with a board. The modules are offset or each module turned by 90°.

Layer Design

If ceramic fiber materials are installed in layers, it will first be necessary to apply the anchoring plan to the steel-sheet casing (shell). The anchoring elements must be fixated at right angles on the casing (shell). If this is not the case, great difficulties will arise during installation work. If holding studs are used with nubs, it is important that the nubs point in one direction.

Mats, blankets, plates and felts are installed with installation clips so that they do not sag on roofs and sit tight on walls. Ceramic fibers on walls should be installed in a horizontal direction in order to prevent them from sagging under their own weight. Vacuum-shaped fiber products can be installed in horizontal or vertical direction.

EUROPE CORPORATE HEADQUARTERS
LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
web page : www.lincobaxo.com

The ceramic caps or heat-resistant metal end clips are not installed until the final layer has been positioned. If using ceramic caps, in order to simplify installation work the fiber blankets/mats can be cut out in the area of the holding studs (cut to shaft length of the ceramic cap) or a cut is made in the blanket/mat having the shape of an x. Before positioning the uppermost fiber rolls, the holding studs are to be extended intermittently with auxiliary studs.

After installation of the fiber material, all holding devices and end clips must be checked to see if they fit tightly. If the holding studs are welded correctly, a visual check is easily possible. If mounted properly, the clips are arranged in the same direction. The same applies for the direction of the markings on the caps.

The vertical joints of the individual layers should be staggered. At the impact spots of the rolls, the blankets/mats are compressed or overlapped.

Fibre Modules

The most commonly used module is the so-called strip module. It is fixated mechanically or glued. In order to safely secure the adhesive embedment, a stretch metal suited for the existing temperatures is attached to the steel casing (shell) with wire nails or by spot welding. Once positioned, the modules may no longer be pulled out of the embedment.

Flexible ceramic fibre modules are generally fixated directly on the steel casing (shell). The anchoring elements are welded or screwed to the steel casing according to a given installation plan. They are either integrated in the modules or are fixated according to the comb-anchor system. The modules are positioned in such a way that the individual layers point in the same direction During installation the modules must be installed in compressed state depending on the given set-up and fixation elements.

Furnaces lined with fibre materials must be inspected before commissioning as part of preventive maintenance procedures and to keep the shrinkage joints closed. One design possibility to prevent shrinkage joints is to insert compensation strips out of premium-grade aluminium oxide fibres between the module rows.

Coatings

Coatings can protect the surface of construction parts made out of ceramic fibers. The instructions for preparation and use provided by the manufacturers contain more detailed information.

WET MORTARS & ASSOCIATES INSTALLATION GUIDELINES

Wet mortars are suited for firm laying , mortaring or gluing refractory and insulating bricks as well as precast shapes.
They have different compositions out of fine grain aggregates and binders which are formulated to suit a specific brick or application.

They are supplied wet ready to use in plastic buckets.
Generally there are two types:

- Mortars which set upon being subjected to higher temperature and harden as a result of a chemical or ceramic bond
- Mortars which set upon contact with air and harden as a result of chemical bond at room temperature

Bricks shall not be pre watered when wet mortars are used.

The surfaces of bricks shall be free of dust.

Use a clean spatula as a trowel to spread uniformly for about 1 minute the wet mortars as joint material on the bricks.

Insert the trowel into the bucket and take a quantity of about one third to cover the spade of the trowel

Keep minimum joints widths, max 2 mm.

Processing temperature min 5 °C

Temperature above 45 °C accelerates the hardening of air setting wet mortars

Throw away set mortars residues

After use of wet mortars clean working devices because removal after bonding is difficult

These instructions shall be followed also for associated products such as coatings . glues , patches were applicable .

Some superfine coatings , such as KWG 311 , LICOGLUE , BAXOCOAT can also by applicable by brushes or spraying when used as protective of lining or steel case.

Ask detailed instructions to a Linco Baxo specialist.

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LINCO BAXO Group of companies
Via C. Boncompagni 51/8 I – 20139 Milano
Tel. + 39 02 5520041 Fax + 39 02 5694834
e-mail : info@lincobaxo.com
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