

Processing instructions V 3.6

REFRAJET® Nanobond

Note: Please read the product information sheet first, to ensure that these are the right processing instructions for your product. This document describes the application procedure for dense, **REFRAJET® Nanobond** refractory gunning concretes and the necessary liquid binding agent, **REFRAJET® Nanobond Accelerator**, as well as the **REFRAJET® Addmix** nozzle. It is essential that our **REFRAJET® Addmix** nozzle is used for installing **REFRAJET® Nanobond** refractory gunning concretes.

The instructions contained in this document must be complied with during processing and installation of the respective refractory concrete. These instructions provide general guidelines for storage, processing, and installation of the specific refractory material, as well as a description of the installation procedure and its individual components. The operating principle of the **REFRAJET® Addmix** nozzle is described in detail in a separate processing instruction sheet (V 3.6.1). If, due to specific site conditions, it appears necessary to deviate from the procedures described here, please consult Refratechnik Steel GmbH before starting work. Modification of or deviations from the processing instructions can lead to major problems during installation, and possibly to total failure of the installed refractory material.

Storage

- Always store in cool, dry, and frost-free conditions.
- **REFRAJET® Nanobond** liquid binder and accelerator must always be stored at a temperature of > -20 °C.
- The shelf life stated in the product information sheet is valid from the production date, and only if storage is in accordance with our recommendations. The production date is stated on the packaging label.
- Under certain circumstances, material that has been properly stored may still be usable even after expiry of the stated shelf life. In such a case, conduct a setting test with a sample before using the material. In case of doubt, the expired material can be checked by Refratechnik Steel GmbH.
- Incorrect storage can greatly reduce shelf life, and can impair product quality.
- The original pallet wrapping foil should be left intact for as long as possible to protect the product. However, the foil is not a substitute for storage under cover.
- Also standing water, e.g. due to inadequate drainage of the storage area, can damage the material.
- Stacking of the goods supplied by us (in sacks, Big Bags, etc.) is done under the sole responsibility of the shipping company or customer. Refratechnik Steel GmbH accepts no liability for possible consequential damage (damaged packaging, personal injury, etc.).

Personnel health and safety

- Always wear suitable safety goggles, dust mask, protective clothing, and working gloves.
- Always wash thoroughly after working with the material.
- Observe the safety data sheets of the dry mixture, the **REFRAJET® Nanobond** accelerator, and the liquid binding agent.

General information

- This product is an inorganically-chemically setting refractory concrete for gunning applications. Delivered dry in 25 kg sacks or in Big Bags, suitable equipment on site is used to convey the dry material through a hose to the **REFRAJET® Addmix** nozzle. The dry material consists exclusively of refractory aggregates and does not contain any additives. The necessary

REFRAJET® Nanobond accelerator is injected into the dry material as an aerosol in the **REFRAJET® Addmix** nozzle immediately before application. Subsequently, the wetted material is conveyed to a gunning nozzle via a hose. Here, the wetted material is mixed with liquid binding agent before it is ejected from the nozzle at high pressure. Setting occurs at room temperature (~20 °C) exclusively through the use of the **REFRAJET® Addmix** nozzle and the **REFRAJET®** Nanobond accelerator injected via the nozzle. The application of heat increases the material's green strength.

- **REFRAJET®** Nanobond products are three-component materials:
 - Component 1:
Dry material consisting exclusively of refractory aggregates without setting regulators
 - Component 2:
REFRAJET® Nanobond accelerator
 - Component 3:
Liquid binder
- Only use the supplied **REFRAJET®** Nanobond accelerator and liquid binder for gunning the refractory material. Water may be used for flushing and cleaning the gunning equipment. If water is used for gunning or injection, the **REFRAJET®** Nanobond refractory material will not develop any strength.
- For cleaning the gunning equipment, please observe the instructions under "Processing" below.
- The material may also be gunned onto hot surfaces (hot repair compound).
- Low temperatures can retard or even stop the setting process. Therefore, the temperatures of dry material and liquid binding agent as well as the **REFRAJET®** Nanobond accelerator must be at least 5 °C. It might be necessary to heat the installation site.

- On the other hand, the setting process may be significantly accelerated at temperatures above 25 °C.
- Please take the expansion of the respective refractory material for your specific furnace application into account. The reversible and irreversible expansion values and the respective material properties are given in the product information sheet. Depending on kiln operating conditions and the specific characteristics of the refractory material, any arising stresses and pressures must be compensated by suitably designed expansion joints.
- During installation of the monolithic refractory material, please ensure correct anchoring to the existing furnace structure and/or to the existing or adjacent refractory material (e.g. with steel anchors, ceramic anchoring systems, etc.).
- Suitable measures must be taken to ensure that the water or water vapour generated during the drying & heat-up process is removed from the refractory lining without pressure build-up.
- With certain kiln structures and refractory linings, the drying process can cause the generated water or water vapour to diffuse outwards in the direction of the furnace shell instead of inwards to the hot side (kiln chamber). Therefore, suitable measures must be taken to ensure that the water or water vapour can escape to atmosphere. For this purpose, 10-mm holes drilled into the kiln's outer steel shell (at least 5 per m²) have proved to be successful.
- Regarding the build-up of water vapour pressure, attention must be given to the entire wall structure of the lining (wear lining/permanent lining/insulation). In the area behind the wear lining, it must also be ensured that only such materials are used, which provide an adequate (highest possible) permeability to the steel shell.

- If the permanent lining/insulating layers are used several times and only the wear lining is replaced, they can become clogged in the course of time due to moisture transport with dust contaminations, salts, etc., thereby also impeding moisture transport. Consequently, multiple use of such layers must be seen as counterproductive in terms of dewatering performance. It might even be safer also to replace the permanent lining, in order to ensure perfect flowthrough to the cold side.
- To ensure a continuous drying process, the complete kiln chamber must always be flushed with an adequate amount of fresh air during the entire drying and heat-up procedure. The air circulating in the kiln chamber may never be saturated with moisture.
- During heat-up, it essential that flames do not impinge on the refractory lining only in small areas. Local overheating can result in severe damage of the refractory material. Therefore, it must be ensured that the entire lining surface is heated uniformly and without significant temperature differences.

Processing

- Low temperatures can retard or even stop the setting process. This can result in a risk of the material slipping. Therefore, the temperatures of dry material, liquid binding agent, and the **REFRAJET®** Nanobond accelerator must be at least 5 °C. It might be necessary to heat the installation site.
- If in doubt about the reactivity of the liquid binding agent or **REFRAJET®** Nanobond accelerator (e.g. if its shelf life has expired or undefined storage conditions, etc.), please contact the R&D Dept. of Refratechnik Steel GmbH before starting work.
- Processing is done with suitable gunning equipment operating either with the rotor principle or a two-

chamber system. Common to both processes is that they use compressed air to convey the dry mixture through hoses into two jet mixing chambers. In the 1st jet mixing chamber, the **REFRAJET® Addmix** nozzle, the **REFRAJET® Nanobond** accelerator – which is essential for setting – is injected into the material stream as a finely dispersed aerosol. Via a separate hose connected to the 2nd mixing nozzle, the amount of (equally essential) liquid binding agent required for the setting process is applied to the dry material as a fine spray. Depending on the gunning requirement, the precise amount of liquid binding agent is set manually by the gun operator via a control valve on the nozzle.

- The gunning unit requires a constant supply of liquid binding agent, **REFRAJET® Nanobond** accelerator, and air at a sufficient pressure. For this reason, separate air compressors and water pumps should be used.
- For correct operation, the gunning unit requires an air pressure of at least 7.5 bar and an air quantity of > 10 m³/min.
- Ideally, the **REFRAJET® Nanobond** accelerator is conveyed to the **REFRAJET® Addmix** nozzle by means of a double diaphragm pump. Hereby, make sure that the accelerator is conveyed at a pressure that is at least 3 bar higher than the dry material conveying pressure.
- The liquid binding agent can be supplied by means of a normal water pump. If provided, the pressure boosting pump must ensure a constant supply pressure of >20 bar.
- The pressure of the liquid binding agent must be constant, and higher than the material pressure at the spray nozzle. Experience has shown that for short distances at ground level, a pressure of 20 bar is sufficient. If greater height differences must be overcome,

pressures of 20...50 bar might be necessary.

- To prevent pressure drops, the gunning unit should be positioned as close as possible to the place of installation. However, to ensure as even a flow of the wetted dry material as possible, the overall length of the delivery hose should not be less than 20 m, particularly for rotor gunning units.
- The design of the 2nd nozzle mixing chamber is decisive for ensuring homogeneous and complete mixing of wetted material and liquid binder in the injection nozzle at the end of the hose. We recommend an 18-hole water ring with hole diameters of 1.2 mm, and a spray angle of 45° in the gunning direction. For the most precise and sensitive control of liquid binder injection possible, we recommend using a needle valve. The mixing section (distance between the water ring and the nozzle outlet) should have a length of 60 cm to ensure the greatest possible internal mixing.
- If possible, the diameter of the mixing section should taper down from 32 mm at the water ring to 24 mm at the nozzle outlet.
- For optimum material compaction, combined with the least possible liquid binder content, and taking the spray characteristics (rebound, formation of dust etc.) into account, the gunning pressure should be as high as possible. Please ensure that the pressure of the **REFRAJET® Nanobond** accelerator is 3 bar higher than the pressure in the material conveying hose.
- The distance between nozzle outlet and the surface being gunned should not be greater than 1 m. Perform circular movements with the nozzle, keeping it perpendicular to the surface being gunned. This procedure minimizes rebound and achieves a uniform material structure.

- While gunning, no moisture may be drawn out of the refractory material by adjacent dry and absorbent surfaces. Therefore, any existing refractory lining should be pre-wetted. Any moisture-sensitive materials should be covered with foil.
- Only walls and ceilings may be gunned. If floors are gunned, the material compaction will suffer, because rebound material will inevitably be mixed in.
- On no account may rebound material be reused.
- Prevent layering.
- In general, bays are gunned individually, whereby they are divided by means of partitioning formwork so that the bays are lined one by one. The surface of a bay can be touched up immediately after it has been gunned (caution: Do not seal the surface by trowelling it).
- Depending on layer thickness and heating-up time, it may be advisable to provide evaporation holes. Immediately after gunning, prick or drill evaporation holes into the lining (diameter 4 mm, spacing 120 mm, but not in areas subjected to the liquid phase).
- Even after short work interruptions, the nozzle and water ring should be cleaned with water. A large suitable container with water should be kept available for this purpose.
- At the end of work, all pumps and hoses must be thoroughly cleaned with water. Thoroughly rinse the **REFRAJET® Addmix** nozzle with water, and remove any material adhesions.

Setting and curing

- The material must be protected from frost until start of the heat-up procedure.
- Strength is increased by drying temperatures above 100 °C.

Drying and heating up

- Compared with hydraulically bonded refractory concretes, Nanobond bonded concretes are significantly less sensitive during heat-up. Heat-up can be started immediately after gunning has been completed, in accordance with the general heat-up instructions for the product used.
- The refractory material should be heated up immediately after installation to ensure that all the contained water is removed. Drying/heating up should be started immediately after completing the installation of the respective refractory concrete. In exceptional cases, please contact Refratechnik Steel GmbH beforehand.
- During the first heat-up, also make sure that no other materials are heated up, which are not suited for fast heating up.
- Please check the product information sheet to ensure that you have the right heat-up instructions for your product.
- The heat-up instructions must always be followed precisely. Hereby, it must be ensured that the respective heating curve is followed, monitored, and recorded by means of several correctly-positioned thermocouples. Moreover, a homogeneous temperature distribution must be ensured throughout the refractory lining.

REFRAJET® Nanobond – Advantages of the new development: General optimization of dry gunning technology, particularly for sol-gel bonded dry gunning concretes

The fundamentally new development means that our dry material no longer requires a setting regulator. We inject our REFRAJET® Nanobond accelerator downstream and separately from the gunning equipment in the form of an aerosol coaxially into the material stream that consists only of refractory dry material. Injection is carried out by means

of a special nozzle unit (REFRAJET® Addmix nozzle) developed by Refratechnik. This injection nozzle was developed specifically for the installation of cement-free, sol-gel bonded refractory concretes (Nanobond). The nozzle can be adapted to all conventional gunning equipment without problems, i.e. it can be used globally. Compared with present standards, the advantages of the REFRAJET® Addmix system can be summarized as follows:

- Compared with dry mixes containing powdery setting regulators, the injection of suitable liquid additives in the form of an aerosol mist into dry mixes that are free of cement and setting regulators, and the resulting higher reactivity offers significant advantages in terms of processing behaviour as well as ultimate strength.
- By injecting a defined amount of aerosol, and the associated pre-wetting, a significant reduction of dust and material rebound at the gunning nozzle is achieved.
- Various additives can be injected into the material stream (setting additives, accelerators, retarders, wetting agents, dust binding agents, etc.). This enables processing and physical properties to be adapted and optimized.
- By injecting the setting regulator into the material stream during installation, the shelf life of the dry mix is greatly increased, as the binder and reactive agent are stored separately from each other and from the dry material, thereby preventing a premature reaction. Thanks to this procedure, practically unlimited storage times are possible for the dry mixes, which consist exclusively of dry refractory material. The dry component contains no chemical additives that could require corresponding marking of the product.
- The REFRAJET® Addmix nozzle system can be installed immediately downstream of the gunning equipment

or somewhere along the hose to the gunning nozzle. In this way, the gunning operator is not hampered by additional equipment or handling procedures, thereby enabling him to concentrate on the actual installation work.

- Contrary to conventional pre-wetting systems, the aerosol generated by our nozzle system is injected centrally into the stream of dry material. This offers the advantage of intense mixing as well as uninterrupted installation work, because the liquid aerosol does not come into contact with the inner hose wall, which could result in adhesions that can disturb or even block the material flow.

REFRAJET® Addmix nozzle:

- Injection of the aerosol via the REFRAJET® Addmix system is continuous, i.e. without interruptions. Hereby, the generated aerosol is injected immediately into the center of the dry material stream, without delays or interim storage. The continuous generation of aerosol as well as the immediately subsequent transport and injection at high flow speeds are the basic requirements for operating the nozzle and system.
- With REFRAJET® Nanobond concretes, the aerosol (REFRAJET® Nanobond accelerator) must be generated continuously, and be injected centrally into the dry material without delay. Hereby, and depending on local installation conditions, the injected amount can be varied. However, a minimum quantity of injected aerosol is essential. Without an injected aerosol, the dry REFRAJET® Nanobond gunning concrete mixes cannot be used.
- When using the REFRAJET® Addmix nozzle for cement-free dry gunning concretes of the REFRAJET® Nanobond type, a continuous generation and flow of material with a constant volume must be ensured. Underdosing or a discontinuous flow of generated aerosol will

inevitably lead to a system failure and thereby to a faulty installation. The use of REFRAJET® Nanobond materials always involves the compulsory use of our REFRAJET® Addmix nozzle. The combined use of REFRAJET® Nanobond dry material with the REFRAJET® Addmix nozzle results in a self-regulating system, which automatically leads to unsatisfactory installation results if the specified continuous volume flows (in particular the aerosol) are not observed.

The following diagram illustrates the system's function:

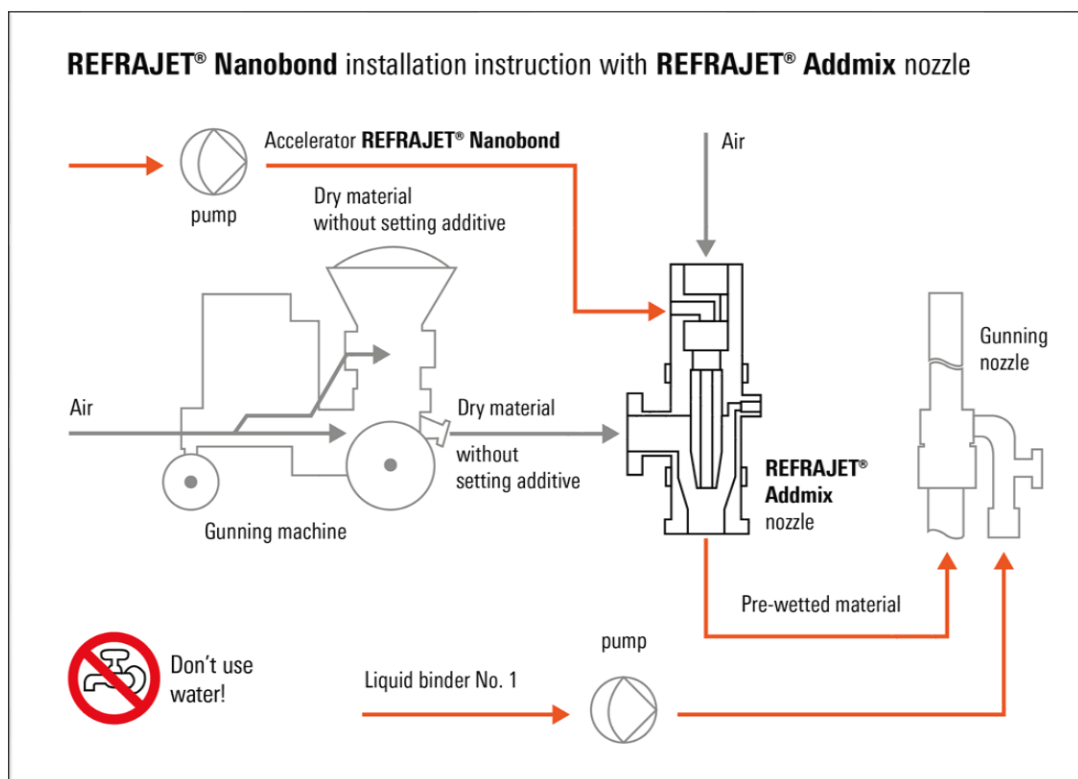


Fig. 1: Use of the REFRAJET® Addmix nozzle for dry gunning concretes of the REFRAJET® Nanobond type. Operation and handling of the REFRAJET® Addmix nozzle is described in detail in a separate processing instruction sheet (V 3.6.1).