Product Application Instructions: Refractory Mortars

1. Scope of Application

The instructions presented in this document apply to the installation of refractory mortars from the MORTALEX and MORTISOL product lines.

This instruction provides recommendations for the storage, mixing, and installation of refractory mortars and serves as a guide to good practices that should be followed during product application.

In cases where individual installation recommendations have been issued for a specific product, such recommendations shall take precedence over the provisions of this document.

In the event of any questions or problems arising during application, please contact the PCO Technical Team by e-mail at: konsultacja@pco.pl.

2. Glossary of Terms

Refractory mortar – a specialized mixture of binder and refractory aggregate used for bonding, masonry work, and sealing refractory elements (e.g. fireclay bricks, refractory shapes) in structures exposed to very high temperatures and/or aggressive chemical environments.

Refractory mortars can be classified according to the bonding mechanism used to join structural elements, as follows:

Hydraulically bonded mortars – specialized mixtures consisting of a binder in the form of refractory cement and refractory aggregate. They are supplied as dry mixes and require preparation prior to masonry or bonding works.

Chemically bonded mortars – mixtures consisting of binders based on silicate and/or phosphate compounds combined with refractory aggregates. They are supplied either as dry mixes or as ready-to-use wet pastes.

Ceramically bonded mortars – mixtures consisting of a binder in the form of refractory clay and refractory aggregate, supplied as dry mixes.

Refractory adhesive – a refractory mortar mixed with water or a bonding additive and ready for application. In the case of ready-to-use refractory mortars, the product is ready for application immediately after opening the bucket, as the mixing process is carried out at the manufacturer's plant.

Mixing water – the amount of water added to the mix in order to obtain a workable refractory mortar.

3. Storage

3.1. Storage location and conditions

Refractory mortars are most commonly supplied in 25 kg bags or buckets placed on pallets.

Hydraulically bonded and chemically bonded mortars, due to the type of binders used, must be stored in a dry and well-ventilated area. If the packaging is additionally protected with foil, adequate air circulation beneath the pallet must be ensured in order to prevent moisture condensation on the bags. Storage in areas with elevated humidity is not recommended.

Ceramically bonded mortars are less sensitive to weather and temperature fluctuations; however, it is still recommended to store them in a dry, sheltered, and ventilated warehouse.

In cases of short-term storage in areas not protected against precipitation, the material must be protected against moisture ingress by using a waterproof tarpaulin or other suitable protective covering.

The optimal storage temperature ranges from 10°C to 20°C. Storage at other temperatures is permissible; however, prior to installation, the material should be conditioned to the recommended temperature range to ensure optimal installation conditions.

Improper storage conditions may adversely affect the properties of the material during application or service.

3.2. Pallet stacking

Pallet stacking is permitted provided that pallet surfaces and the ground are level and stable. Stacking pallets in more than two (2) layers is not recommended. Mixing pallets containing different types of mortars or castables during storage should be avoided.

Good practice is to use materials of the same grade in the order of delivery, in accordance with the FIFO principle (first in, first out).

3.3. Shelf life

The shelf life of hydraulically bonded and chemically bonded mortars is specified in the Product Technical Data Sheet and typically ranges from 6 to 12 months from the date of manufacture. The production date is printed on all bags, which facilitates identification of the material age. For ceramically bonded mortars, the shelf life is extended and amounts to 24 months.

Signs of aging in hydraulically or chemically bonded mortars supplied as dry mixes include lumping, poor adhesion of the mortar to bricks, or extended setting time. In the case of chemically bonded mortars supplied in buckets, aging may manifest as partial or complete hardening of the mortar inside the bucket, making application impossible even after re-mixing.

The oldest materials should always be used first. If the nominal shelf life has been exceeded, the material should be tested prior to use. It is recommended to open the packaging no earlier than immediately before application.

4. Preparation for Installation

4.1. Personal protective equipment

During installation works, personal protective equipment appropriate to the nature of the work and environmental conditions must be used. In particular, the use of safety goggles and protective gloves, dust masks, and protective clothing is required.

4.2. Tools

All tools, in particular the mixing pan, transport containers, trowels, and all components that come into contact with the mortar, must be dry and free from contamination.

Any residues left on tools may negatively affect the setting time of the refractory adhesive or its mechanical properties.

Before starting installation works, the operating instructions of the equipment must be reviewed, in particular those of mixers and vibrators.

4.3. Material consumption

Material demand calculations can be performed using the following formula:

$$zz = \frac{V \cdot nz \cdot cn}{wk}$$

where:
zz – mortar demand in tonnes
V – lining volume
nz - mortar consumption rate, depending on joint thickness:

- **0.05** for a 2 mm joint (dense bricks),

- **0,10** for a 3 mm joint (dense bricks),

cn - bulk density of the mortar [t/m³]:

- ◦ **1,4** for fireclay mortar,
- ◦ **2,25** for corundum mortar,
- ◦ 0,70 for insulating mortar.

wk – contraction (mixing) coefficient:

- **0,8–0,85** for clay-based (water-mixed) mortars,
- **0,9–0,95** for dry mortars or mortars with water glass.

When planning material requirements, it is recommended to add approximately 10% surplus to compensate for losses caused by, among others, damaged bags, spillage during handling, as well as residual material left in bags or in the mixer.

4.4. Application temperature

The temperature of the material in bags, the mixing water, and the ambient environment has a significant influence on the mixing and setting process of refractory mortars. Low temperatures significantly slow down the setting process, while high temperatures accelerate it.

The temperature of the dry mortar and the mixing water used for mortar preparation should be within the range of 10–25°C.

During winter periods, when the material may be stored at low temperatures, bags containing the mix must be placed in a heated room at a temperature of at least 15°C for a minimum of 48 hours prior to installation.

In summer, when storage temperatures are high, the material should be kept in a cool area for 48 hours prior to application. Formwork surfaces should be cooled by spraying with water, ensuring that water does not enter the interior of the form. If water does penetrate the form, the interior must be dried before casting.

When application is carried out at high temperatures, the available working time of the prepared mix is significantly reduced.

Application of the refractory adhesive until complete setting must take place at temperatures between 10°C and 25°C. If the material freezes before the bonded masonry elements have fully set, this may lead to debonding and flaking of the mortar. Therefore, conditions conducive to freezing must be avoided until the masonry has been properly dried and heated.

5. Preparation of Mortars

5.1. Mixing water

5.1.1. Quality of mixing water

Water used for the preparation of refractory mortars must be clean and meet the requirements for potable water. Its pH value should be within the range of 6–8, and the recommended temperature is 10–25°C. The use of seawater and contaminated water is not permitted. In particular, water containing sulfur compounds, chlorine, magnesium, ammonia, or carbonates in concentrations exceeding 1000 ppm, as well as water containing sugars or suspended solids, must not be used.

The use of contaminated water may negatively affect the setting time of the refractory adhesive.

5.1.2. Quantity of mixing water

The amount of mixing water required for a given type of refractory mortar is specified in the Product Technical Data Sheet. Any deviations from these values may be applied only upon explicit instruction from a PCO representative. When preparing the mix, it is recommended to initially add approximately 80–90% of the specified amount of water, and then—while continuing mixing—add the remaining water in small portions until the required consistency is achieved. The following good practice is recommended:

No.	Joint thickness [mm]	Mortar grain size [mm]	Consistency	Water quantity per 1 m³ of dry mortar [dm³]
1	do 1	0 – 0,5	fluid	550 – 600
2	1 – 2	0 – 1,0	semi-fluid	450 – 500
3	2 – 3	0 – 2,0	stiff	350 – 400
4	> 3	0 – 2,0	very stiff	300 – 350

Since the amount of water added to the refractory mix has a greater influence on its properties than any other factor, it must be accurately measured.

5.2. Type of mixer

For the preparation of refractory mortars of the Mortalex and Mortisol types, the use of counter-current mixers is recommended (Figure 1).

5.3. Mixing process

Mixing of ceramically, hydraulically, and chemically bonded mortars consists of combining the dry components with water to obtain a homogeneous mass referred to as a refractory mortar. The mixing procedures for the different product groups are described below.

Do not mix a larger quantity of material than can be applied within 20–40 minutes from the start of mixing, and do not combine different types of mortars.

5.3.1. Mixing procedure for Mortalex and Mortisol mortars:

1. Pour the material into the mixer pan and dry-mix for 10–30 seconds,
2. Add 80-90% of the quantity of mixing water recommended for the specific refractory mortar (see Product Technical Data Sheet),
3. Mix with water for 5 minutes,
4. If necessary, add the remaining amount of water,
5. The refractory mortar should have a homogeneous consistency,

It should be noted that ceramically bonded mortars must be prepared at least 1 hour prior to application. Prepared adhesives must be used within:

- 30 minutes from preparation for chemically bonded mortars,
- 40 minutes from preparation for hydraulically bonded mortars,

5.4. Consistency control

Mixing of the refractory mortar with water should be continued until a homogeneous mass is obtained. Consistency can be assessed by applying the mortar with a trowel onto the surface of a dense refractory product. If the mortar spreads well over the surface and forms a uniform, glossy structure, application works may proceed. Otherwise, the amount of mixing water should be increased to improve the mortar consistency.

If the mortar exhibits excessive fluidity, gradual addition of dry mortar is recommended to achieve the correct consistency. Both excessively long and excessively short mixing times must be avoided. Prolonged mixing causes the mass to heat up, which—in the case of hydraulically and chemically bonded adhesives—affects the setting time. Insufficient mixing may result in a non-homogeneous structure and the presence of lumps.

In the case of mixers with bottom discharge, at least the first two batches should be discarded to clean the discharge gate. The recovered material may be immediately returned to the mixer and re-mixed. After each mixing cycle, the discharge gate must be thoroughly cleaned to prevent accumulation of old material. The mixer and all tools used for the application of refractory adhesive must be kept clean, as residues from previously mixed materials may cause accelerated setting. Periodic cleaning of the mixer between consecutive batches is also recommended to prevent the build-up of hardened refractory mortar.

5.5. Mansory work

Masonry work should be carried out at an ambient temperature above 10°C, and the temperature of the mortar itself and the water used for its preparation must not be lower than 10°C.

Refractory products bonded with mortar must be dry and free from dust contamination, as dust reduces mortar adhesion and may promote chemical corrosion.

6. Setting Process of Mortars

After completion of mortar application, the setting process must be carried out in order to ensure proper bonding between the mortar and the refractory masonry elements.

Once application is completed, the refractory mortar must be left for a minimum period of 24 hours to allow full setting of the bonded elements. During this time, the surface may be cleaned and any excess mortar that appears on the surface of the refractory lining may be removed.

	In the case of outdoor installations, the mortar surface must be protected from direct sunlight until the curing process is completed.
	If the mortar sets either too slowly or too quickly, the PCO Technical Department must be contacted immediately. Following consultation, setting accelerators or retarders may be used for hydraulically and chemically bonded mortars. For ceramically bonded mortars, the setting process is time-controlled and the mortar must be allowed to fully set naturally.
	Independent selection and use of setting time modifiers is not recommended. Improper selection or excessive dosage of such substances may permanently and adversely affect the performance properties of the refractory adhesive.

7. Drying and Heating-Up

7.1. Free drying

After completion of refractory masonry works, the lining must be subjected to free drying at an ambient temperature of at least 10°C for as long as possible, but not less than 24 hours. This is intended to stabilize conditions prior to the commencement of proper drying and bonding of the adhesive within the refractory lining. The best practice is to carry out full drying immediately after completion of the setting process. If this is not possible, the lining must not be left in a closed, humid environment. Adequate ventilation must be ensured, for example by using forced air circulation with a fan, or preferably a hot-air blower. After completion of free drying, the lining must not be exposed to rainfall, as this could adversely affect its properties.

7.2. Initial heating-up

Prior to commissioning, all refractory linings must be thoroughly heated up.

The heating-up process must be carried out in accordance with strictly defined guidelines for heating-up time and temperature. These guidelines are determined and confirmed by the refractory material manufacturer. They depend on the type and quantity of refractory material used as the working lining and on the total lining thickness — in general, the thicker the lining, the longer the time required for drying and firing. The proposed guidelines are also applicable to Mortalex and Mortisol products.

Once the planned heating-up process has started, it must not be stopped or interrupted. In the event of an unavoidable interruption, the lining must be kept warm. If cooling is unavoidable, it must be carried out slowly, and reheating must follow the original heating-up procedure