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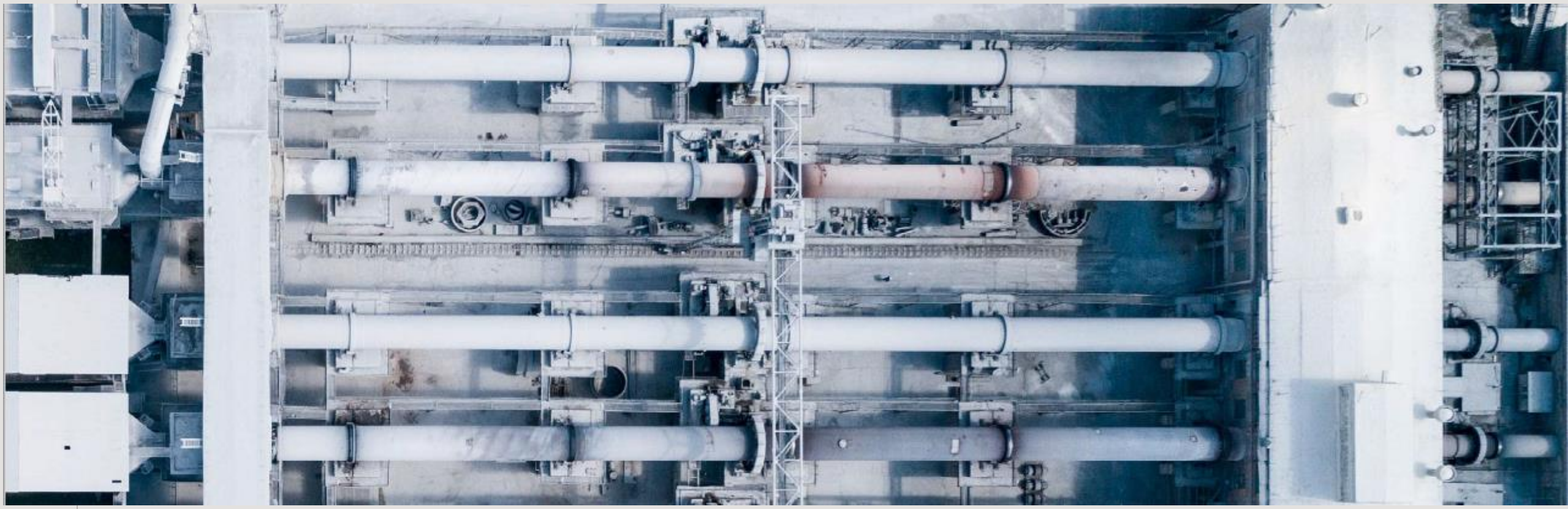

A New Generation of Refractory Castables: Hybrid Bonding Technology Developed by PCO "Żarów"

18.05.2026

Agenda

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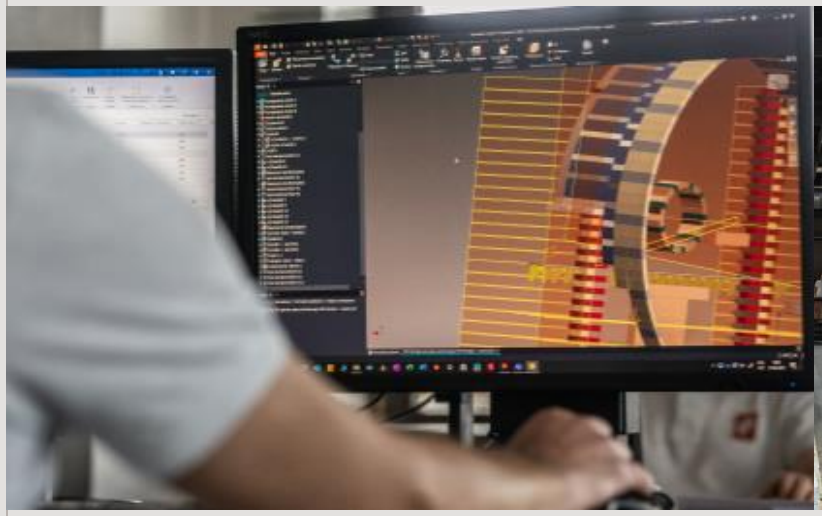
How can we help



Design

By connecting knowledge in the field of material engineering and installation practice, we design the most cost-optimal solutions for the operating conditions of the device. Shaping the property of the lining, by the selection of appropriate materials, application techniques and construction solutions, we are sure that our solutions will ensure the best efficiency.

Refractories

Every day, in our plant, we produce hundreds of tons of refractory products for our customers, designed to work in the most difficult conditions. By using modern production lines and advances in today's material engineering, we provide our clients with the highest efficiency and quality of our materials.

Service

Years of experience in the design and manufacture of refractories have taught us that proper installation is essential for the efficiency of their work. To provide the best support for our clients, we provide services in the field of installation and assembly work, technical supervision and periodic inspections.

Lining installation and routine repairs

We not only select suitable materials and deliver them to the site, but we can also install them. We have an experienced installation services team within our installation company, PCO Serwis S.A. We possess extensive experience in installing refractory linings. Through this collaboration, we can handle the repairs of most industrial furnaces comprehensively, from technological analyses to material production, lining design, and lining installation. Using a single supplier instead of several translates into efficiency, time savings, and minimized risk of errors.

We can provide our support in such areas as:

Project planning and management
Material procurement
On-site installation (mechanical + ceramic works)
Top class safety management systems
Emergency and shutdown repairs
Demolition and material disposal

In our work, we utilize the best standards and practices:

ISO 9001 – Quality assurance system
ISO 45001 – Health and safety management system
ISO 14001 – Environmental management system

Raw materials

JARO

N. STRAŠECÍ ČESKÉ LUPKOVÉ ZÁVODY

CLUZ and JARO are producers of chamotte refractory aggregates. The companies extract clay from their own deposits, particularly refractory, ceramic, and sealing clays, and process mineral raw materials. Their products are mainly used in the production of refractory and sanitary ceramics, as well as in the metallurgy, foundry, and construction industries.

Refractory materials

PCO

The company manufactures aluminosilicate refractory materials such as shaped bricks, concrete, mortars, and concrete prefabricates. The products are designed for industrial applications at temperatures up to 1700°C. The headquarters and manufacturing plant are located in Żarów. PCO employs over 250 specialists and provides refractory solutions to customers worldwide.

Services

PCO Serwis

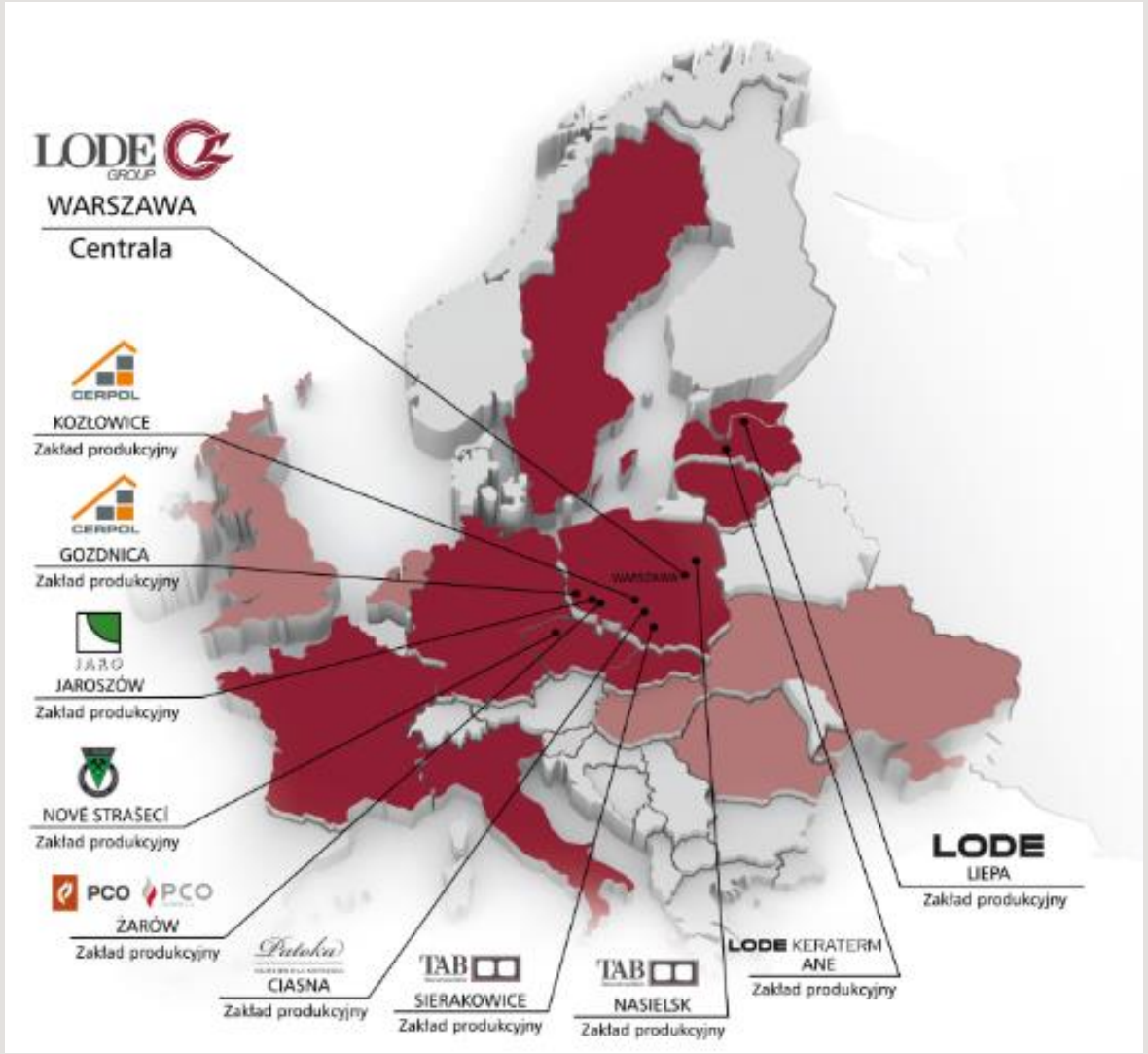
PCO Serwis is now comprised of over 130 specialists providing services in the repair, modernization, and installation of production and technological lines, including ceramic linings, steel structures, transport equipment (conveyors, pneumatic transport), grinding equipment, dust collectors, separators, screens, and crushers.

We are part of the Lode group

Since 2018, the PCO companies have been part of the LODE Group, which is the largest producer of building materials in Central and Eastern Europe. The group currently employs over **900 people** across **10** production plants in Poland and Latvia.

LODE Group specializes in ceramics. The group produces products such as ceramic blocks, clinker bricks and pavers, as well as concrete prefabricates and blocks.

The product brands include LODE, Keraterm, LHL Klinkier, Patoka, Cerpol, TAB.



PCO

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Product portfolio

Dense refractory firebricks

from 20 to 95 %
Alumina content

up to 1700 °C
Max. application temperature

from 0,4 lb up to 440 lb
(200 g up to 200 kg)
Shape weight

over 35 000
Available moulds of individual shapes

Chamotte, andalusite, bauxite, sintered/fused mullite, corundum, SiC
Raw material base

Insulating refractory firebricks

from 28 to 100 lb/ft^3 (450 – 1650 kg/m^3)
Bulk density range

up to 1650 °C
Max. application temperature

Straights and shapes
Available formats

High strength
Special properties

PCO

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Refractory castables, masses, and mortars

from 20 to 95 %
Alumina content

up to 1700 °C
Max. application temperature

Dense, Insulating
Type of lining

Casting, Gunning, Pumping, Ramming
Available methods of application

Cement, low cement, non cement (sol / gel / hybrid)
Available bonding systems

Chamotte, andalusite, bauxite, sintered/fused mullite, corundum, SiC
Raw material base

PCO

Refractory precast shapes

from 20 to 95 %
Alumina content

1700 °C
Max. application temperature

from 2 lb up to 8 ST (1 kg up to 7 tons)
Shape weight

up to 600 °C
Tempered in chamber kiln

Chamotte, andalusite, bauxite, sintered/fused mullite, corundum, SiC
Raw material base

Cement industry — refractory challenges

Cement plant kilns operate across four critical refractory zones — each with its own thermal, chemical and mechanical demands.

Preheater cyclones
300–900 °C
Alkali condensation & sulfur attack

Calciner / riser duct
850–1000 °C
High alkali load & abrasion

Kiln inlet & transition
900–1450 °C
Thermal shock & coating buildup

Kiln outlet / cooler
200–1100 °C
Rapid temperature cycling

Explosive spalling risk

CAC-bonded linings require extremely slow, costly heat-up protocols. Any deviation risks explosive failure — causing weeks of unplanned downtime in cement plant operations.

Alkali & sulfur attack

Cement kiln gases carry aggressive K_2O, Na_2O and SO_3 that penetrate refractory lining. High-alumina materials are particularly vulnerable without targeted protection.

Gunning adhesion

In gunning applications, insufficient green strength causes immediate material loss. Adhesion and stability must be achieved within minutes of installation.

Bonding technology: from conventional to PCO Hybrid

Calcium Aluminate Cement (CAC) – LCC/MCC

ADVANTAGES

✓ High cold strength up to ~1000 °C

✓ Reliable green strength for early handling

✓ Predictable, well-understood setting

✓ Strong in pre-heater zones (< 400 °C)

LIMITATIONS

✗ Bound water released > 500 °C — spalling risk

✗ Slow heat-up protocols required

✗ CaO → low-melting phases at high temp

✗ Cold-surface installation only

✗ Vulnerable to alkali / sulfur attack

Acceptable for pre-heater zones; problematic above 1000 °C

Silica Sol (Colloidal SiO_2)

ADVANTAGES

✓ Fast, safe heat-up — dewaters at ~100 °C

✓ No CaO — no low-melting phases

✓ Hot-surface installation possible

✓ Excellent stability above 1000 °C

✓ Better alkali resistance than CAC

LIMITATIONS

✗ Low green strength: CMOR ~0.6 vs ~5.2 MPa

✗ Fragile below 1000 °C

✗ Insufficient adhesion for gunning

✗ Ceramic bonding only develops > 1000 °C

Excellent at high temps; unsuitable alone for gunning

PCO Hybrid Bonding (NxGel)

ADVANTAGES

✓ High strength across full temperature range;

✓ Fast heat-up;

✓ Multi-installation technology — dry-gunning/shotcrete

✓ Low alkali matrix — reduction of low-melt phases

✓ Both vibro-casting and gunning / shotcrete

✓ Reactive additives boost ceramic phase formation

PCO Hybrid (NxGel) — how it works

1

Colloidal SiO_2 nanoparticles

Silica nanosized particles as the primary bonding medium.

2

Reactive hybrid additives

PCO's proprietary additives are incorporated into the dry mix, triggering crystalline phase formation and boosting strength across the full temperature range

3

Gelation network

SiOH groups condense into siloxane bonds forming a 3D gel network with fine pores

4

Ceramic bonding at HT

Above 800 °C, ceramic sintering bonds develop, providing outstanding strength up to 1750 °C.

Green strength vs silica sol

Heat-up via fine gel pores

Consistent strength range

No low-melting phases

Versatile installation

Nano-structured gel pores

Product portfolio for cement plants

Vibro-casting system

Name	Grade	Application	Key raw material	Max °C	Al_2O_3 %	BD @110°C	SiC	ZrO_2
NxGel	X822	Cement Industry/IP/Energy	Chamotte	1300	42	2.20	Nil	Nil
	X422		HD Chamotte + S	1300	40	2.30	10	Nil
	X1524		Andalusite + S + Z	1500	45	2.55	7	9
	X1822		Premium Chamotte + S	1550	57	2.65	10	Nil
	X1724		HA Aggr. + Z + S	1550	53	2.75	9	8
	X1924		Bauxite + S + Z	1650	56	2.85	8	11

Gunning / shotcrete system

Name	Grade	Application	Key raw material	Max °C	Al_2O_3 %	BD @110°C	SiC	ZrO_2
NxGel	X322	Cement Industry/IP/Energy	HD Chamotte + S	1300	40	2.20	10	Nil
	X224		Chamotte	1450	47	2.25	Nil	Nil
	X1223		S + HD Chamotte	1350	20	2.35	50	Nil
	X1722		HA Agg + S	1550	57	2.55	10	Nil
	X1624		Andalusite + S +Z	1550	51	2.45	10	10
	X1324		Bauxite	1650	88	2.75	Nil	Nil
	X1824		White fused alumina	1800	88	2.85	Nil	Nil

Comparative analysis: PCO Hybrid vs conventional binders

Parameter	CAC / LCC	Silica sol	PCO Hybrid
Mechanical strength < 1000 °C	✓✓	✗	✓✓
Mechanical strength > 1000 °C	✓✓	✓	✓✓
Green strength for gunning (adhesion)	✓✓	✗	✓✓
Rapid / safe heat-up	✗	✓✓	✓✓
Installation on hot surface (> 200 °C)	✗	✓	✓
Robotic / shotcrete application	✓	✓	✓✓
Alkali & sulfate attack resistance	★	★★	★★★
No CaO — no low-melting phases	✗	✓✓	✓✓
Max service temperature (cement)	★	★★	★★★
Performance in cement cyclones/calciner	★	★★	★★★
Pre-heater zone applicability	✓✓	✗	✓✓

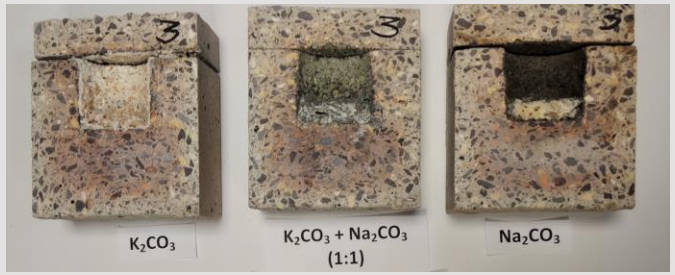
NxGel advantage: 2–3x higher CCS than LCC/Sol across all temperatures (100–140 vs 45–75 N/mm²). ASTM abrasion <6 cm³ vs >10. Low alkali level eliminates low-melting phases. Identical SiC (10%) confirms bonding technology drives performance.

✓✓ Excellent ✓ Good ✗ Limited ★★★ Best in class for cement

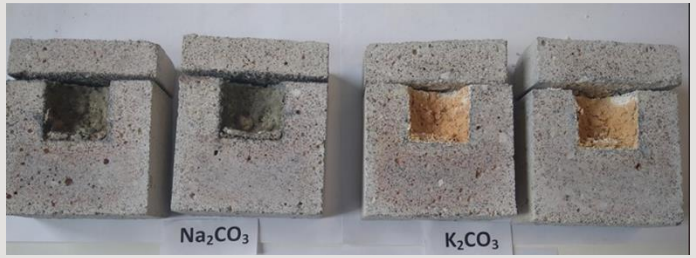
Grade	LCC	Sol	PCO Hybrid
Measured BD (g/cm³)			
Dried 110°C	2.45	2.43	2.36
Fired 816°C/Ox	2.43	2.42	2.35
Fired 1000°C/Ox	2.44	2.42	2.37
Fired 1200°C/Ox	2.43	2.42	2.37
CCS (N/mm²)			
Dried 110°C	60	45	100
Fired 816°C/Ox	69	50	110
Fired 1000°C/Ox	80	55	120
Fired 1200°C/Ox	100	75	140
PLC (%)			
Fired 816°C/Ox	-0.01	+0.30	-0.10
Fired 1000°C/Ox	-0.20	-0.10	-0.50
Fired 1200°C/Ox	-0.40	-0.20	-0.30
ASTM Abrasion (816°C/5hrs)			
Vol. Loss (cm³)	>10	>10	<6.0
Chemical Analysis			
Al_2O_3	36.0	45.0	40.0
SiO_2	48.5	41.0	46.0
CaO + MgO	<2.5	<1.0	<1.0
FeO	0.9	0.9	1.3
SiC	10.0	10.0	10.0

Alkali resistance — comparative test results

- Alkali resistance determined using standard Alcoa alkali method (@1100°C) and using alkali immersion test (embedded in mixture of alkali and chloride salts).

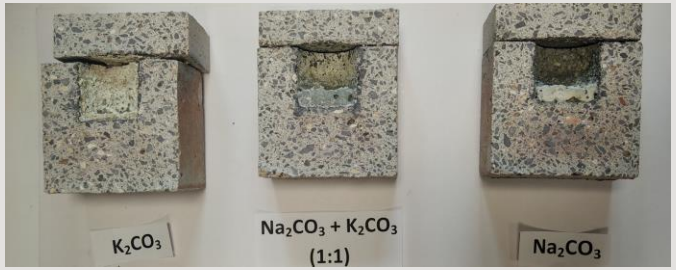


X322 Gunning version

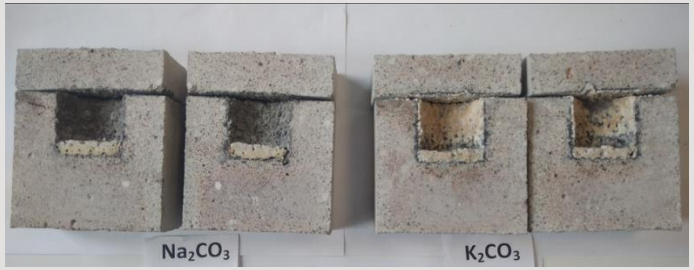


X1722 Gunning version

Surface evolution of NxGel system



X422 Casting version



X1822 Casting version

Application areas

Vibro-casting installations

Cyclone preheater & calciner

Grades: X422 / X1822 / X822

Alkali-resistant chamotte + SiC matrix. Rapid dry-out achieved without lining damage. Consistent CCS performance under thermal cycling.

Kiln inlet & outlet

Grades: X1724 / X1924

Multi-phase aggregate (mullite/bauxite + SiC + ZrO_2) provides combined alkali, abrasion and corrosion protection. Low iron content.

Complex geometry — Arcade

Grades: X1822/ X1724 / X1924

Vibro-casting allows intricate shapes impossible with bricks. Robust matrix maintains dimensional stability during heat-up.

Gunning / shotcrete installations — by PCO Serwis

Cyclone buildup zones

Grades: X322 / X1722 / X422

SiC additive improves buildup resistance in cyclone necks. PCO Hybrid green strength ensures adhesion immediately after application.

Calciner/Riser duct

Grades: X1722 / X1624/ X1724

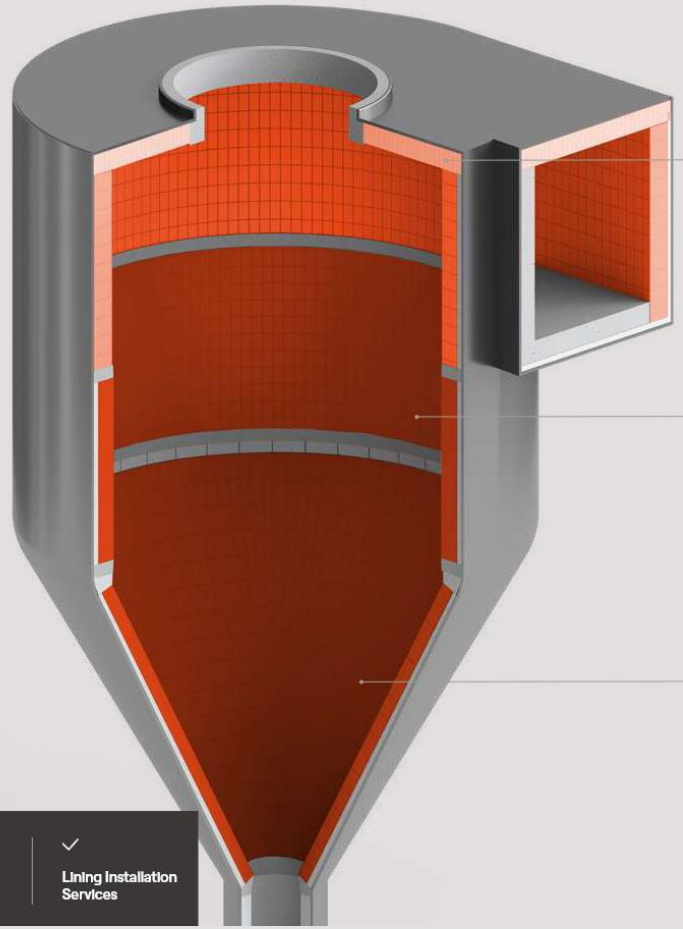
Nano silica gel bonding enables gunning on hot surfaces (>200 °C). No shutdown required. PCO Serwis robotic application reduces personnel exposure.

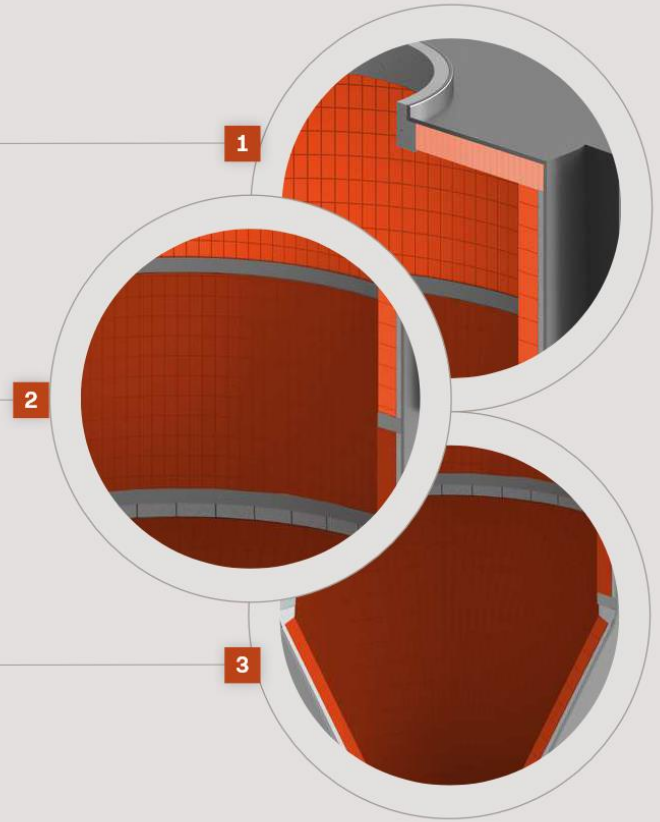
TAD

Grades: X1624 / X224

High-SiC abrasion-resistant lining for tertiary air ducts exposed to intense particulate wear. PCO Serwis Hybrid bonding delivers consistent abrasion resistance and structural integrity under high-velocity particle impact.

Upper cyclone stages – overview of solutions





Our products in use:

1 PCOCAST BN135N
PCOGUN 135S
NXGEL 322
NXGEL 422

2 PCOCAST BN135N
PCOGUN 135S
NXGEL 322
NXGEL 422
EXTRATON A28HS
ABRAL A30S10

3 PCOCAST BN135N
PCOGUN 135Zr
NXGEL 422

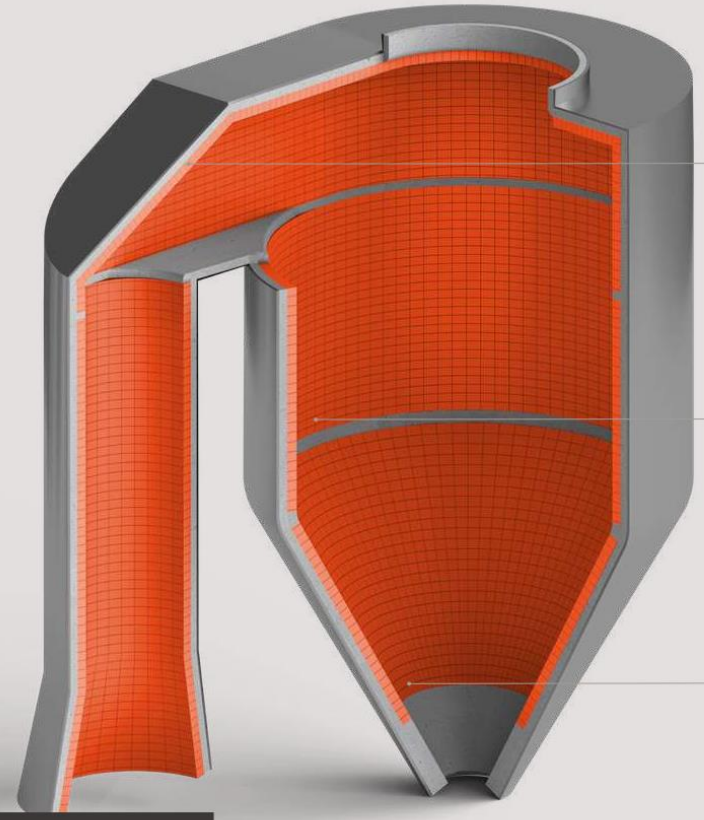
The full technical specifications of our products can be found at the end of the catalog.

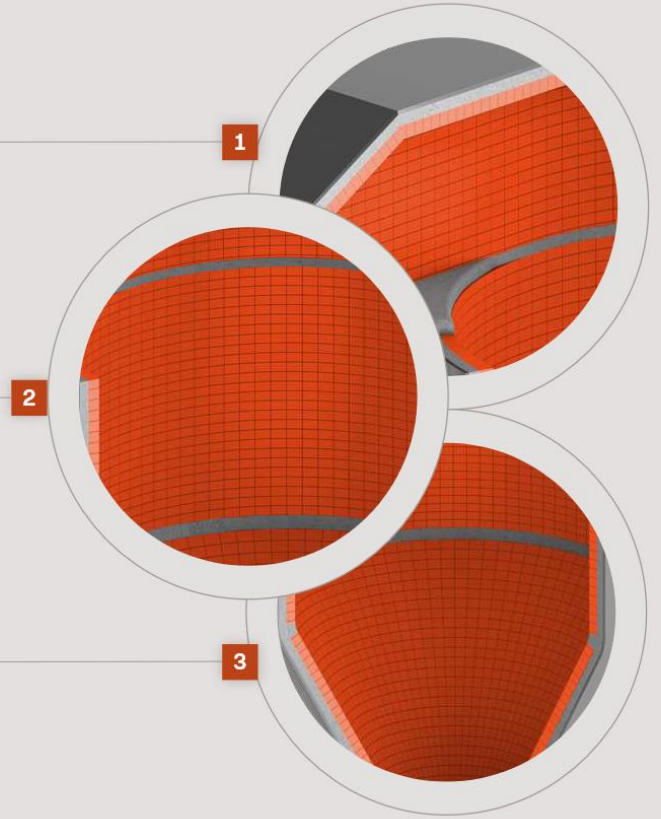
✓ Lining Design

✓ Refractory Products Supply

✓ Lining Installation Services

Lower cyclone stages – overview of solutions





Our products in use:

1
MULCAST BN45S5
NxGel X1822
NxGel X1722
PCOGUN 150MS5
ABRAL A50S15
ABRAL A50S10

2
MULCAST BN45S5
NxGel X1822
NxGel X1722
PCOGUN 150MS5
ABRAL A50S15
ABRAL A50S10

3
MULCAST BN45S5
NxGel X1822
NxGel X1722
PCOGUN 150MS5
ABRAL A50S15
ABRAL A50S10

The full technical specifications of our products can be found at the end of the catalog.

✓ Lining Design

✓ Refractory Products Supply

✓ Lining Installation Services

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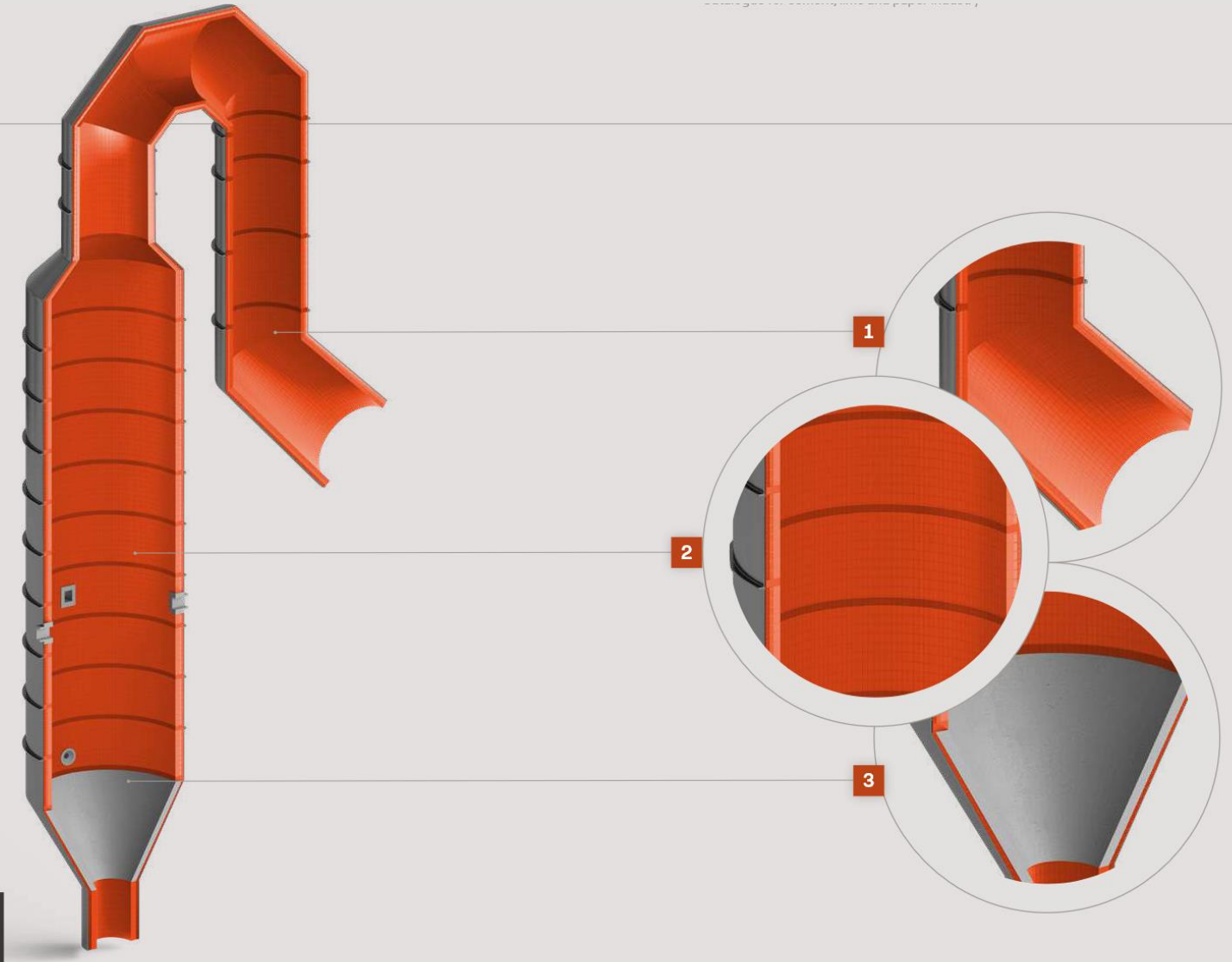
Calciner – overview of solutions



Our products in use:

1
PCOGUN 155AZS
PCOCAST 160AZS
NxGel X1822
NxGel X1722
ABRAL A50S10

2
PCOGUN 155AZS
PCOCAST 160AZS
NxGel X1822
NxGel X1722
GELCAST X321
BNSIC BN 30/45
ABRAL A50S15

3
PCOGUN 155AZS
PCOCAST 160AZS
NxGel X1822
NxGel X1722
GELCAST X321
BNSIC BN 30/45

ⓘ The full technical specifications of our products can be found at the end of the catalog.

✓ Lining Design

✓ Refractory Products Supply

✓ Lining Installation Services

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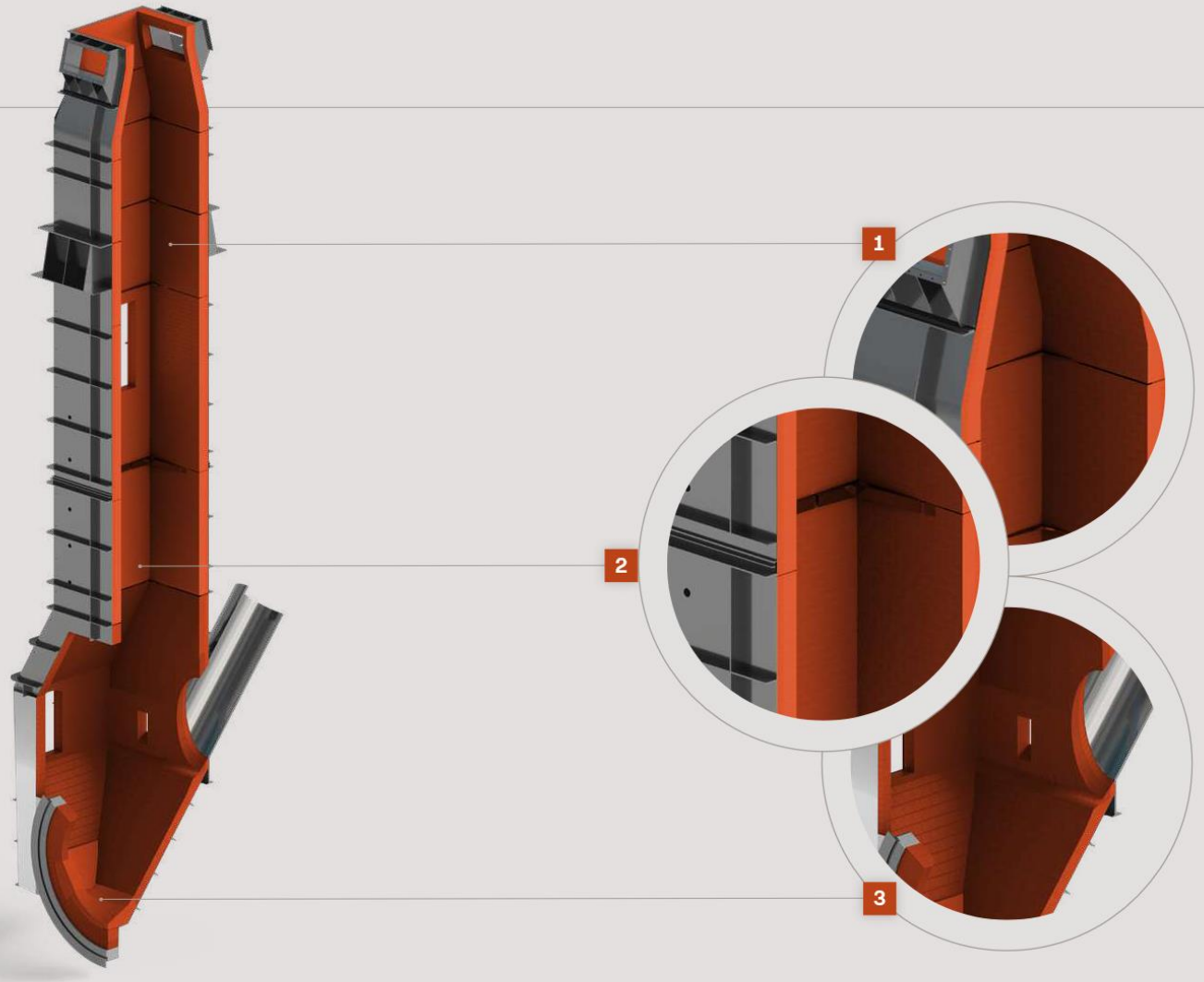
Riser duct and inlet chamber – overview of solutions



Our products in use:

1. EXTRATON A33Hs
   BAUXITEX B62Hc
   NxGel 422
   PCOCAST BN145N
   PCOGUN 150M
   ISOCAST BI9/0,8

2. NxGel 1722
   PCOCAST BN160AZS
   ANDALUX A60c
   ABRAL A60s10
   ISOCAST BI11/1,1

3. ABRAL A50s10
   ANDALUX A60c
   GelCast X121
   NxGel X1722
   PCOGUN 155AZS
   ISOCAST BI11/1,1

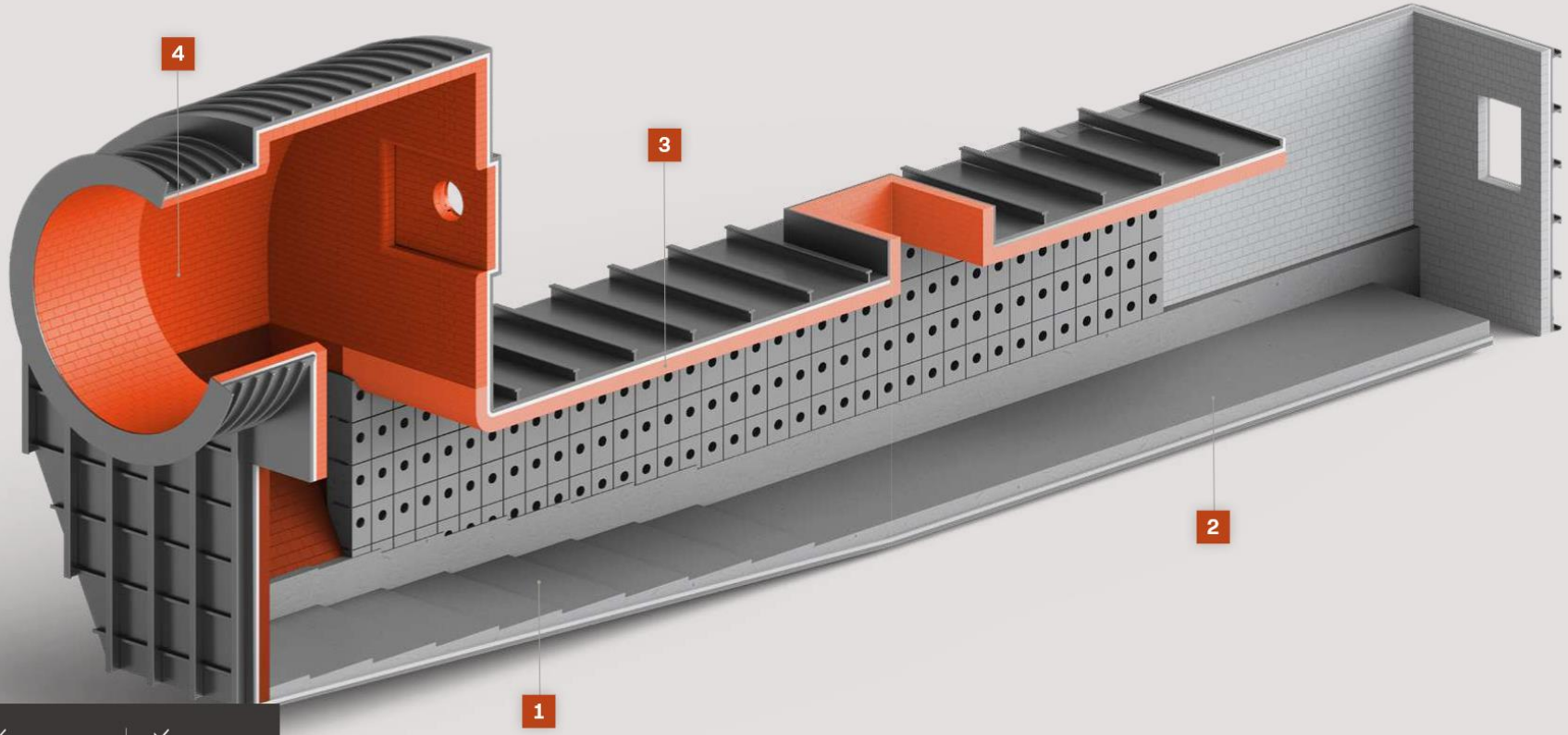
ⓘ The full technical specifications of our products can be found at the end of the catalog.

✓ Lining Design

✓ Refractory Products Supply

✓ Lining Installation Services

Cooler and Kiln Hood – overview of solutions



Our products in use:

1. BNSIC BN 40/40M
   GELCAST X121
   GELCAST X2921A
   NxGel X1822
   NxGel X1722
2. NxGel X422
   NxGel X322
   MULCAST BN45M S5
   MULCAST BN80M
3. PCOCAST BN145N
   MULCAST M55 ZS10
   NxGel X1822
   NxGel X1722
4. GELCAST X121
   BNSIC BN 40/40M
   NxGel X1722
   NxGel X1624G

The full technical specifications of our products can be found at the end of the catalog.

- ✓ Lining Design
- ✓ Refractory Products Supply
- ✓ Lining Installation Services

PCO

- Cyclone 4;
- NxGel X322;
- February 2024 – still in operation
- Cemex

2 years after installation

- Bull Nose;
- NxGel X1822;
- February 2024 - still in operation
- CRH

1 year after installation

- Calciner;
- NxGel X1722;
- February 2025 – in operation
- CRH

- Burning zone under the mill;
- NxGel X1722;
- February 2024 – patching 2026
- CRH

2 years after installation

Conclusions & outlook

PCO's hybrid bonding system addresses the key limitations of both CAC and silica sol binders in cement industry applications.

01

High green strength

>300% better green strength vs silica sol; matches CAC at high temp.

02

Safe rapid heat-up

Nano pores enable aggressive heat-up; no spalling.

03

Alkali & corrosion resistance

Alkali-low matrix components eliminates anorthite/gehlenite formation.

04

Quasi-shotcrete installation

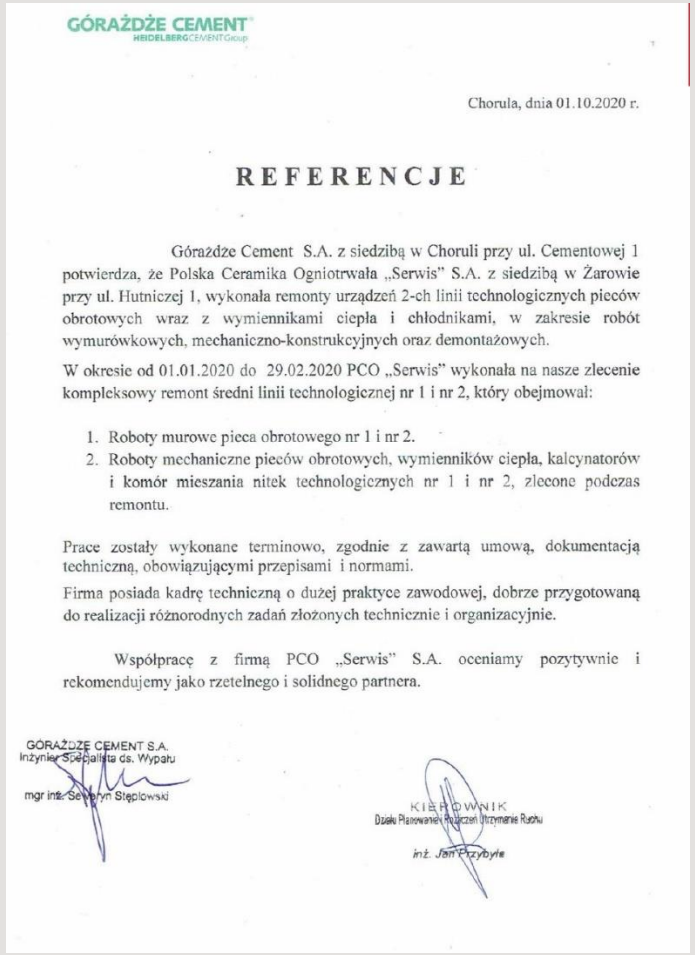
The gunning system achieve high density thus providing the quality like shotcrete linings;

05

Field validated

Successfully implemented at multiple cement plants by PCO Żarów & PCO Serwis.

References



GÓRAŻDŻE CEMENT
HEIDELBERGCEMENT Group

Chorula, dnia 01.10.2020 r.

REFERENCJE

Góraźdze Cement S.A. z siedzibą w Choruli przy ul. Cementowej 1 potwierdza, że Polska Ceramika Ogniotrwała „Serwis" S.A. z siedzibą w Żarowie przy ul. Hutniczej 1, wykonała remonty urządzeń 2-ch linii technologicznych pieców obrotowych wraz z wymiennikami ciepła i chłodnikami, w zakresie robót wymurówkowych, mechaniczno-konstrukcyjnych oraz demontażowych.

W okresie od 01.01.2020 do 29.02.2020 PCO „Serwis" wykonała na nasze zlecenie kompleksowy remont średni linii technologicznej nr 1 i nr 2, który obejmował:

1. Roboty murowe pieca obrotowego nr 1 i nr 2.
2. Roboty mechaniczne pieców obrotowych, wymienników ciepła, kalcynatorów i komór mieszania nitek technologicznych nr 1 i nr 2, zlecone podczas remontu.

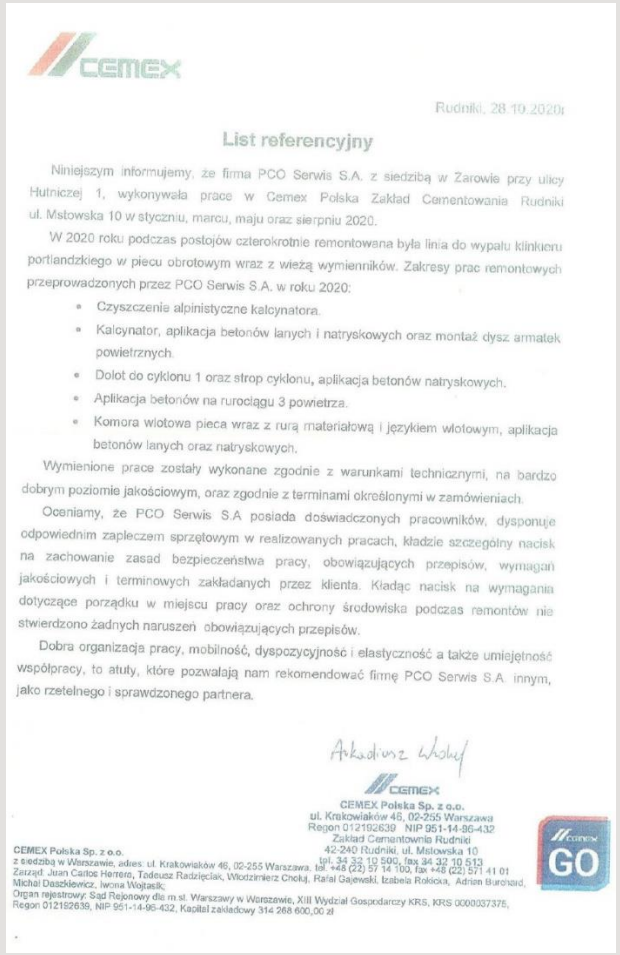
Prace zostały wykonane terminowo, zgodnie z zawartą umową, dokumentacją techniczną, obowiązującymi przepisami i normami.

Firma posiada kadrę techniczną o dużej praktyce zawodowej, dobrze przygotowaną do realizacji różnorodnych zadań złożonych technicznie i organizacyjnie.

Współpracę z firmą PCO „Serwis" S.A. oceniamy pozytywnie i rekomendujemy jako rzetelnego i solidnego partnera.

GÓRAŻDŻE CEMENT S.A.
Inżynier Specjalista ds. Wypału
mgr inż. Seweryn Stęplowski

KIEROWNIK
Działu Planowania Realizacji Utrzymanie Ruchu
inż. Jan Przybyła



cemex

Rudniki, 28.10.2020r

List referencyjny

Niniejszym informujemy, że firma PCO Serwis S.A. z siedzibą w Żarowie przy ulicy Hutniczej 1, wykonywała prace w Cemex Polska Zakład Cementowania Rudniki ul. Mstowska 10 w styczniu, marcu, maju oraz sierpniu 2020.

W 2020 roku podczas postojów czterokrotnie remontowana była linia do wypału klinkieru portlandzkiego w piecu obrotowym wraz z wieżą wymienników. Zakresy prac remontowych przeprowadzonych przez PCO Serwis S.A. w roku 2020:

- Czyszczenia alpinistyczne kalcynatora.
- Kalcynator, aplikacja betonów lanych i natryskowych oraz montaż dysz armatek powietrznych.
- Dolot do cyklonu 1 oraz strop cyklonu, aplikacja betonów natryskowych.
- Aplikacja betonów na rurociągu 3 powietrza.
- Komora wlotowa pieca wraz z rurą materiałową i językiem wlotowym, aplikacja betonów lanych oraz natryskowych.

Wymienione prace zostały wykonane zgodnie z warunkami technicznymi, na bardzo dobrym poziomie jakościowym, oraz zgodnie z terminami określonymi w zamówieniach.

Oceniamy, że PCO Serwis S.A posiada doświadczonych pracowników, dysponuje odpowiednim zapleczem sprzętowym w realizowanych pracach, kładzie szczególny nacisk na zachowanie zasad bezpieczeństwa pracy, obowiązujących przepisów, wymagań jakościowych i terminowych zakładanych przez klienta. Kładąc nacisk na wymagania dotyczące porządku w miejscu pracy oraz ochrony środowiska podczas remontów nie stwierdzono żadnych naruszeń obowiązujących przepisów.

Dobra organizacja pracy, mobilność, dyspozycyjność i elastyczność a także umiejętność współpracy, to atuty, które pozwalają nam rekomendować firmę PCO Serwis S.A. innym, jako rzetelnego i sprawdzonego partnera.

Arkadiusz Wolski
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Zarząd: Juan Carlos Herrera, Tadeusz Radzięciak, Włodzimierz Cholój, Rafał Gajewski, Izabela Rokicka, Adrian Burchard, Michał Daszkiewicz, Iwona Wojtasik;
Organ rejestrowy: Sąd Rejonowy dla m.st. Warszawy w Warszawie, XIII Wydział Gospodarczy KRS, KRS 0000037375,
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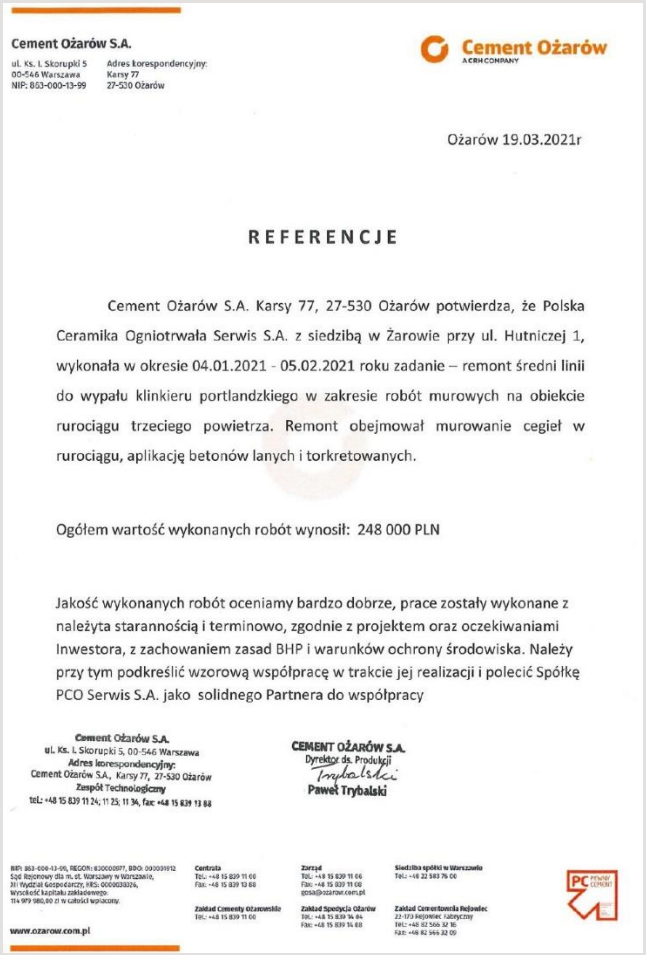

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Cement Ożarów
A CRH COMPANY

Ożarów 19.03.2021r

REFERENCJE

Cement Ożarów S.A. Karsy 77, 27-530 Ożarów potwierdza, że Polska Ceramika Ogniotrwała Serwis S.A. z siedzibą w Żarowie przy ul. Hutniczej 1, wykonała w okresie 04.01.2021 - 05.02.2021 roku zadanie – remont średni linii do wypału klinkieru portlandzkiego w zakresie robót murowych na obiekcie rurociągu trzeciego powietrza. Remont obejmował murowanie cegieł w rurociągu, aplikację betonów lanych i torkretowanych.

Ogółem wartość wykonanych robót wynosił: 248 000 PLN

Jakość wykonanych robót oceniamy bardzo dobrze, prace zostały wykonane z należyta starannością i terminowo, zgodnie z projektem oraz oczekiwaniami Inwestora, z zachowaniem zasad BHP i warunków ochrony środowiska. Należy przy tym podkreślić wzorową współpracę w trakcie jej realizacji i polecić Spółkę PCO Serwis S.A. jako solidnego Partnera do współpracy

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CEMENT OŻARÓW S.A.
Dyrektor ds. Produkcji
Paweł Trybalski

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PCO

Why is it worth working with us?

Many products from a single source

Our manufacturing offer is complemented by the supply of other essential furnace renovation materials resistant to high temperatures: steel anchors, brackets and fastening elements, ceramic mats, ceramic papers, and silicate-calcium boards. Purchasing multiple items at one stop minimizes the risk of discrepancies or order errors, simplifying supply management.

We Have Our Own Team of Engineers/Designers and Service Team

PCO not only specializes in producing Refractory products but also in designing furnace lining. Our engineers can offer consultation on the design of brick shapes and brick assemblies for lining structures.
We help optimize or validate the Refractory lining design to minimize total production costs (including molds), while maintaining the core project requirements. We work with the most popular programs: AUTOCAD, Inventor, Creo, and Simu-Therm.