

Alumina based refractories

NABALOX®



Nabaltec

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NABALOX[®] calcined
aluminium oxides

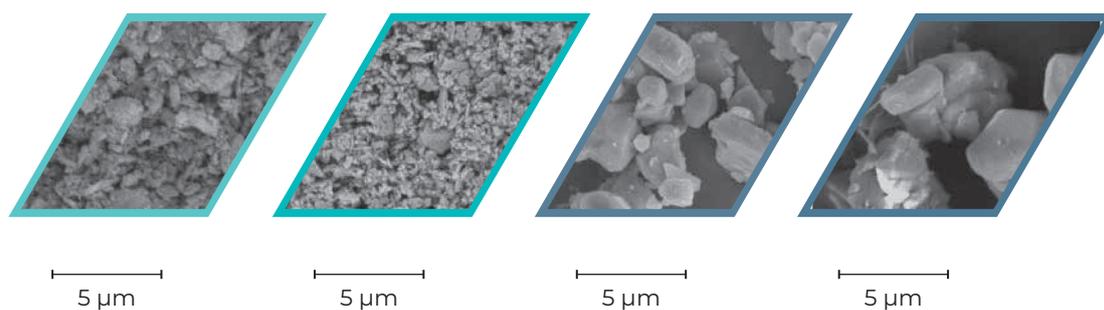
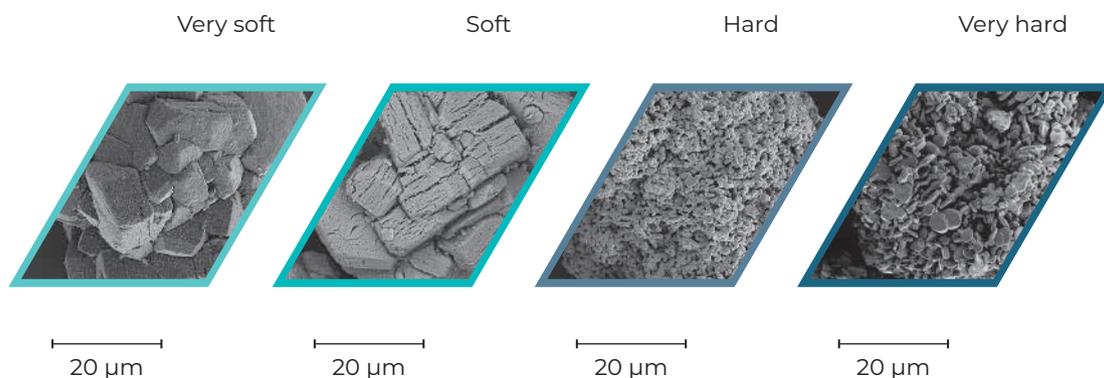
Calcined aluminas (**NABALOX**[®])



Rotary kiln for calcination of basic **NABALOX**[®] grades.

Nabaltec is a worldwide leading and large scale producer of synthetic raw materials for a wide range of application areas in the refractory industry. These include high performance aluminas of the **NABALOX**[®] grades.

High class raw materials are selected according to standardized parameters of quality. By working within tightly controlled production parameters, Nabaltec is able to control and tailor the degree of calcination from very “soft” to very “hard” by sophisticated temperature regulation of the rotary kilns. This high level of control allows the production of aluminas with defined properties such as α - Al_2O_3 -content, size of primary crystals and specific surface area. In addition, using our patent-registered technique we are able to reduce the Na_2O -content to levels below 0.1 %. The high level and long term experience of our staff members guarantees a reliable and consistent high quality product.



Primary crystal size



Specific surface area (BET)



Crystal modification



Calcination temperature

Size of primary crystals, specific surface areas, α-Al₂O₃-content of different calcination degrees.

Typical chemical composition of **NABALOX®** raw materials for refractories.

Typical chemical analysis	[%]
Al₂O₃	> 99
SiO₂	0.04
Fe₂O₃	0.02
Na₂O (low soda)	0.1
Na₂O (standard soda)	0.3

These above listed calcined **NABALOX®** aluminas are continuously processed by different refining steps after calcining. The refinement capabilities of Nabaltec are outstanding and highly sophisticated.

Production include different types of milling, like:

- continous or discontinous,
- vibration or ball,
- wet or dry,
- jet,
- high energy and
- air separation

For refractory applications with demanding or specific application-needs our products are reproducibile and use reliable materials with a maximum of processing safety.

Due to their outstanding homogeneity, Nabaltec products are characterized by highly consistant properties which provides significant advantages in their refractory applications (s. table), along with an excellent price-to-performance ratio. These characteristics make **NABALOX®** aluminas the ideal raw materials for the demanding applications and needs of refractories.

Typical characteristics of NABALOX® aluminas:

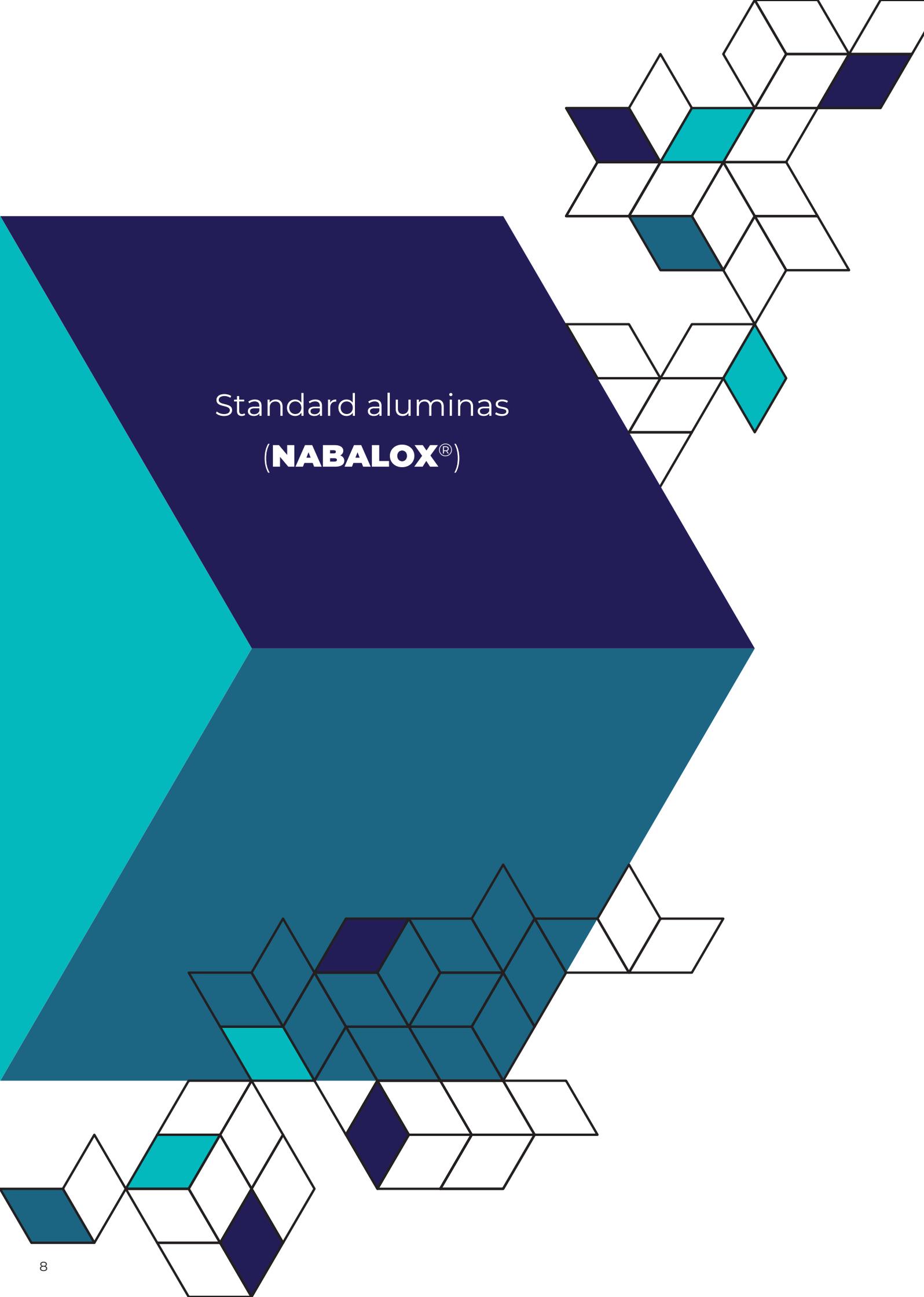
Calcined powders with primary crystal size of < 0.5 µm to 3 µm result in

- reduced sintering temperatures,
- optimized corrosion resistance,
- low water demand,
- high thermal shock resistance,
- excellent high temperature properties, e.g. high RUL*,
- long life time in applications with high wear exposure...

*RUL: Refractoriness under load

Refractory applications (in excerpts)

NABALOX®	foundry products	kiln furniture	high temperature ceramics	shaped products	unshaped products	gunning material
NO 105	•			•		
NO 115-71	•	•		•		
NO 115-25	•	•		•		•
NO 115 G	•	•		•		•
NO 115 TC	•	•		•	•	
NO 125 TC	•	•	•		•	
NO 135	•	•	•	•	•	
NO 315	•	•		•	•	
NO 325	•	•	•		•	
NO 113	•			•		•
NO 313	•			•		•
NO 615-10	•			•	•	
NO 625-10			•		•	
NO 715-10	•			•	•	
NO 725-10			•		•	
NO 613-10	•	•		•		•
NO 713-10 RF	•				•	•
NO 625-30	•	•		•	•	•
NO 645	•				•	
NO 652	•					
NO 660	•				•	
NO 530	•	•			•	



Standard aluminas
(**NABALOX**[®])

NABALOX® milled hard calcined aluminas

The materials are used for a number of different applications (s. table), depending on the established materials of this product group. They are mainly used for the production of refractories.

NABALOX® milled hard calcined (α -Al₂O₃ content 95 – 98 %) standard aluminas (< 325 mesh) are very common worldwide for use

in shaped and unshaped refractory formulations with a particle fraction “< 45 µm” (s. table). With their high purity and their defined and adjusted grain size distribution they are an essential element in high temperature applications. They contribute as a key factor to the main properties of all materials in the system Al₂O₃ – SiO₂, such as Andalusite, Bauxite, Mullite and Corundum.

NABALOX® standard aluminas. Type: < 45 µm (< 325 mesh).

Examples of typical refractory applications.

	foundry products	kiln furniture	high temperature ceramics	shaped products	unshaped products	gunning material
NO 115-25	•	•		•		•
NO 115 TC	•	•		•	•	
NO 125 TC	•	•	•		•	
NO 135	•	•	•	•	•	
NO 315	•	•		•	•	

Recommended **NABALOX®** grades for different groups of refractory materials.

Raw material	RUL (T05)* [°C]	Al ₂ O ₃ content [%]	shaped refractories	unshaped refractories
Chamotte	1300	40	NO 115-25	NO 115 TC
Andalusite	1600	60	NO 115-25 NO 115 TC	NO 115 TC
Synthetic Mullite	1680	72	NO 115-25 NO 135	NO 135
Bauxite	1500	80	NO 115-25 NO 115 TC	NO 115 TC
Alumina	> 1700	> 95	NO 135 NO 315	NO 135 NO 315

*) RUL: Refractoriness under load

Properties of standard aluminas

- < 45 µm (325 mesh)
- Al₂O₃ > 99 %
- Na₂O ≤ 0.3 %
- high degree of calcination

	D50 [µm]	< 45 µm (325 mesh) [%]	BET [m ² /g]	Degree of calcination
NO 115-25	7	95	0.9	Hard
NO 135	6	98	0.8	Very hard
NO 115 TC	6	98	1.0	Hard
NO 315	4	99	1.5	Hard

Main properties of grades of 325 mesh **NABALOX**[®] aluminas.

Shaped refractories

In shaped products **NABALOX**[®] aluminas are applied, e.g. for higher refractoriness. **NABALOX**[®] standard aluminas are an efficient way to fine tune the Al₂O₃-content of all refractory materials in the system Al₂O₃ - SiO₂. With their high degree of calcination they are an appropriate additive to reduce shrinkage and the high temperature creep of refractories.

These characteristics make them an approved and well established raw material.

Low soda types of this product group (325 mesh / < 45 µm) are mainly used in refractory applications for the production of filters and catalyst carriers.



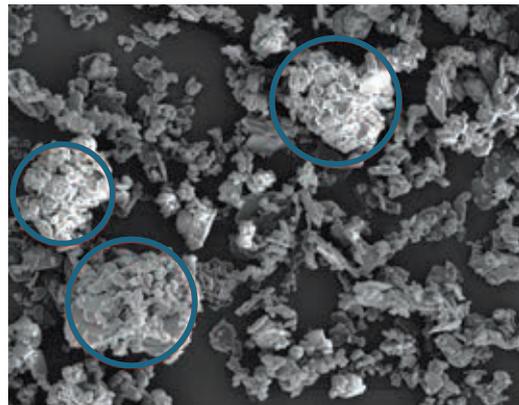
Kiln furniture: Cassette for roof tiles.

Unshaped refractories

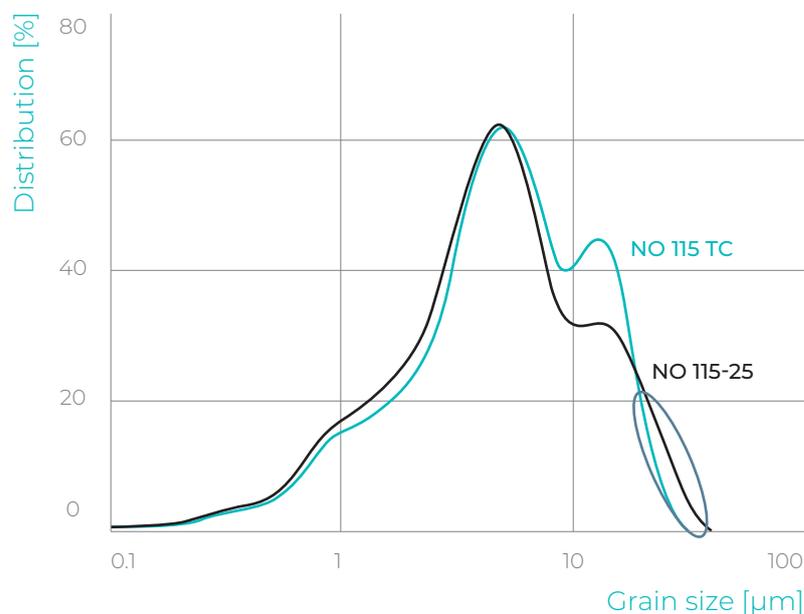
The main difference in the group of 325 mesh **NABALOX**[®] aluminas between NO 115-25 and the group of NO 115 TC, NO 135 and their fine variety NO 315 is defined in the lower (>) 45 µm-value. In opposite to NO 115-25 all other **NABALOX**[®] aluminas have a special production-accompanying step, termed "TC" for "top cut". By a process of air separating, the larger amount of coarse alumina-agglomerates which are present after the milling procedure are separated away.

NO 115-25: The amount of alumina < 45 µm is lower (95 %) compared to the other three products (98 – 99 %), with the additional production step of "air separation".

This results in a lower water demand of "top cut"-types and results thus in better flowability of unshaped refractories when > 45 µm particles have been removed, e.g. at NO 115 TC (s. image).



NO 115-25: Remaining alumina agglomerates, after milling without air separation.



Grain size distribution of milled hard calcined aluminas with (NO 115 TC, no agglomerates are left) and without air separation (NO 115-25, remaining agglomerates between approx. 15 to 40 µm).

These agglomerates exhibit, e.g. when used in unshaped refractories, a behaviour similar to a “sponge”. They only absorb water but cannot offer any flowability effect. Image of the two refractory castable formulations shows the difference in wettability/flowability schematically when an air separated alumina is compared to a “just milled” type in identical proportions of solids and water in a castable.

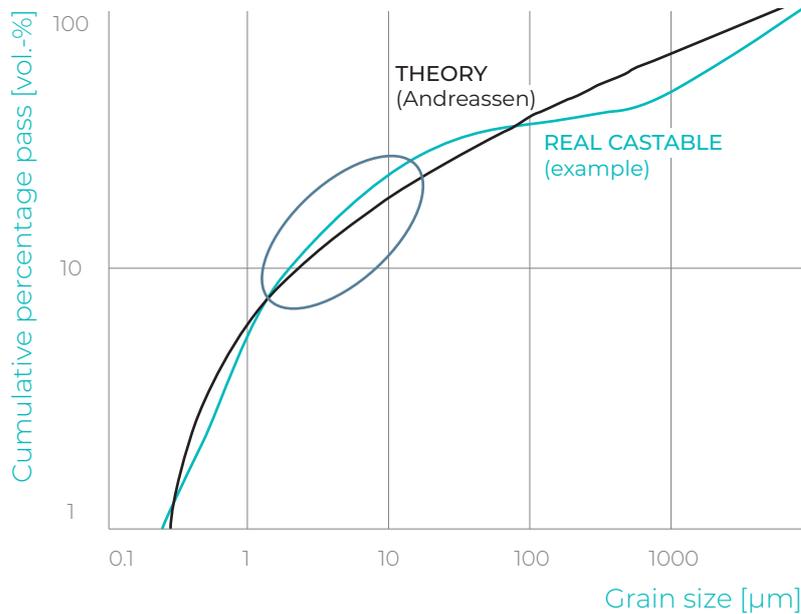
For the highest refractory properties, an optimized particle packing is required for all mixtures. Thus, a continuous cumulative particle size distribution is required, in analogy to the theory of Andreassen*.

NABALOX® standard aluminas represent the grain spectrum between 1 and 15 µm and are utilized in an amount of

10 – 20 % to design castables with the highest packing density and higher alumina content for a better refractoriness.



Identical refractory castable formulation “A” with air separated alumina, “B” without. Both with identical water content.



Cumulative particle size distribution curve shows how close the grain size distribution of the real castable (standard mixture) narrows to the theoretical optimum (black curve). **Orange circle:** Grain size area for standard aluminas: 2 – 15 µm.

* $CPP = \left(\frac{d}{D}\right)^Q$
d: grain size
D: maximum grain size
Q: Andreassen coefficient
CPP: cumulative percentage pass



Reactive **NABALOX**[®]
aluminas

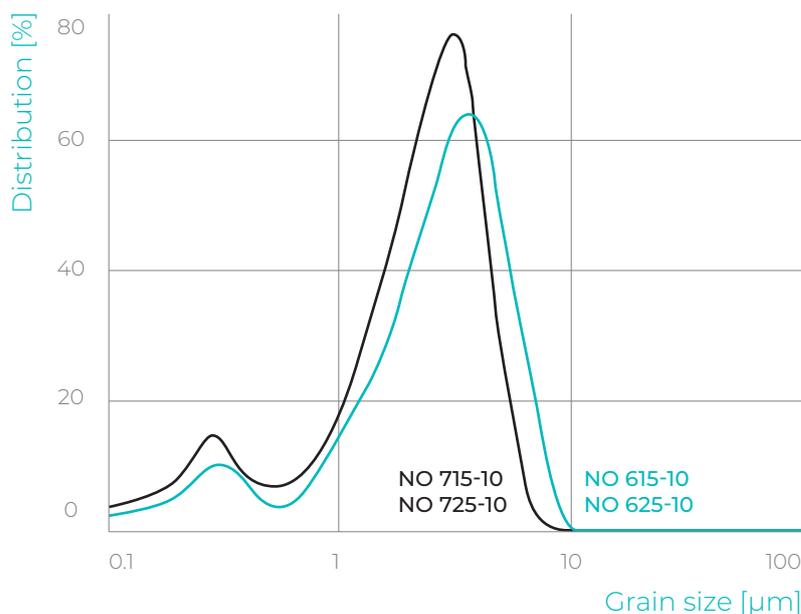
Reactive aluminas (NABALOX®)

In shaped and unshaped refractory applications the reactive **NABALOX®** special aluminas are characterized by an extremely reproducible and homogeneous processability. **NABALOX®** reactive aluminas enable a wide processing window and a significant reduction in water demand. This class of reactive aluminas lowers the production costs and raises the efficiency of the refractory solutions by improving packing density, corrosion resistance and durability of refractory materials.

Properties of reactive NABALOX® aluminas:

- D50 < 3.0 µm
- Al₂O₃ ≥ 99.6 % - 99.8 %
- Na₂O ≤ 0.3 % - 0.1 %
- high degree of calcination
- high specific surface area, results in high sintering ability (starting from 1100 °C)

NABALOX® reactive monomodal aluminas



Aluminas with a high amount (~ 98 %) of α -Al₂O₃ are milled, partially down to the primary crystal (2 µm). These carefully processed raw materials are used as foundry products or for refractory mixes.

The product specific fineness results from the use of a high milling energy. In addition, the grain size distributions of the material are specifically defined and confined within close limits. Material properties of interest include high lifetimes, good work-

ability, etc. These hard calcined aluminas provide a reliable base for the production of sophisticated refractories with a wide variety of different application areas.

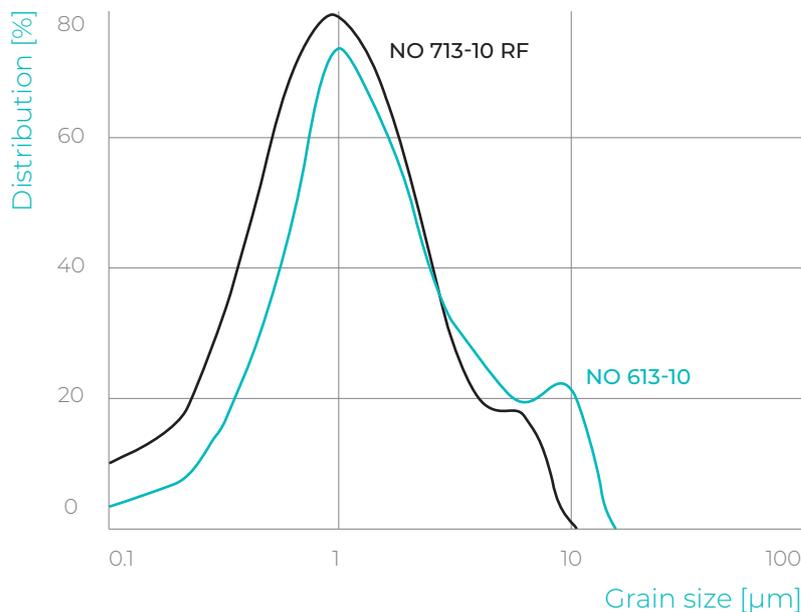
NABALOX®	Al ₂ O ₃ [%]	Na ₂ O [%]	D50 [µm]	BET [m ² /g]
NO 615-10	99.6	0.3	3.0	1.6
NO 625-10	99.8	0.1	3.0	1.6
NO 715-10	99.6	0.3	2.5	2.0
NO 725-10	99.8	0.1	2.5	2.0

NABALOX® super-reactive monomodal aluminas

Nabaltec produces super-reactive, calcined aluminas with a monomodal grain size distribution for a variety of applications. For this purpose, aluminas with a lower content of α - Al_2O_3 , (~ 95 %), so-called “soft” calcined are milled down close to the primary crystal (< 0.5 μm) level. The exceedingly high reactivity of this product group is based on the fineness of the alumina as well on the small primary crystals and their high specific surface area. The low soda-content makes the material suitable for the production of corrosion resistant refractories e.g. ladle linings or precast shapes. Using these ultra-fine α - Al_2O_3 -raw materials, very low viscosities can be achieved.

The high specific surface area (up to 7 m^2/g) of these super-reactive grades is of significant interest for the fabrication of ULC (ultra low cement) and NC (no cement), e.g. chemically bonded, castables or for producing high performance refractory products.

NABALOX®	Al_2O_3 [%]	Na_2O [%]	D50 [μm]	BET [m^2/g]
NO 613-10	99.7	0.1	1	6
NO 713-10	99.7	0.1	0.5	7



NABALOX® reactive bimodal aluminas

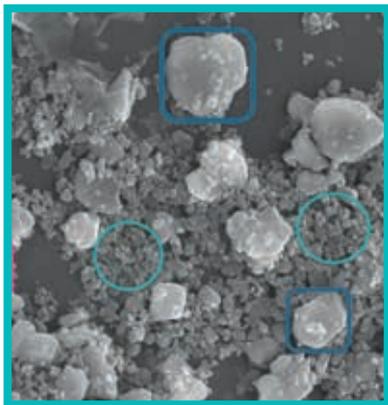
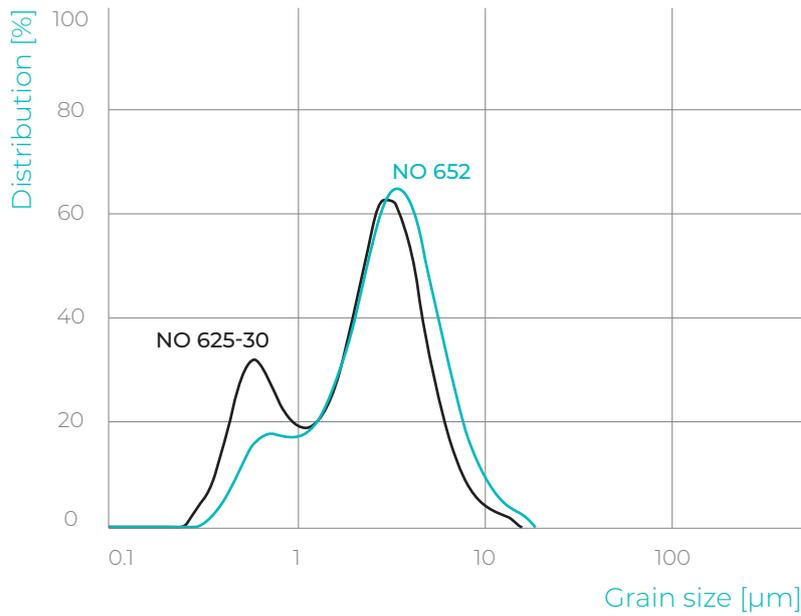
Nabaltec produces super-reactive, calcined aluminas with a bimodal grain size distribution for a variety of applications.

In connection with this application, there is a need for a homogeneous mixture (see

SEM-image) of fine and coarse alumina primary crystals (0.5 – 2 μm) in precisely balanced proportions. Optimized, long milling and homogenization procedures guarantee a consistent product to achieve the best processability results. For example,

for the production of free flowing refractory mixes, the formation of bimodal reactive aluminas with coarse grains added by the user, results in an optimized grain size distribution. This leads to a reduced water demand combined with an excellent flowability.

NABALOX®	Al ₂ O ₃ [%]	Na ₂ O [%]	D50 [µm]	BET [m ² /g]
NO 625-30	99.7	0.1	2.3	3.5
NO 645	99.7	0.1	2.2	4.0
NO 652	99.7	0.1	3.0	2.8
NO 660	99.7	0.1	2.5	3.0



- PRIMARY CRYSTAL HARD CALCINED approx. 2 µm
- PRIMARY CRYSTAL SOFT CALCINED approx. 0.5 µm

Fine and coarse aluminas “deeply” homogenised

- combination of soft and hard calcined aluminas
- interacting of “fine” and “coarse” grain size distributions
- homogenisation via intensive mixing or milling
- sophisticated grain size distribution for castables

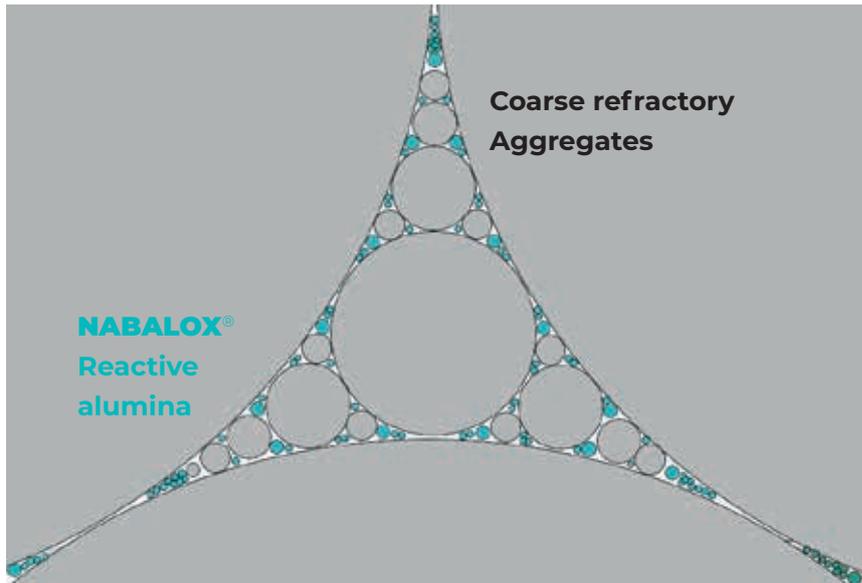
All this result in higher refractoriness

- green density ↑
- sinter density ↑
- porosity ↓
- water demand ↓
- flowability ↑

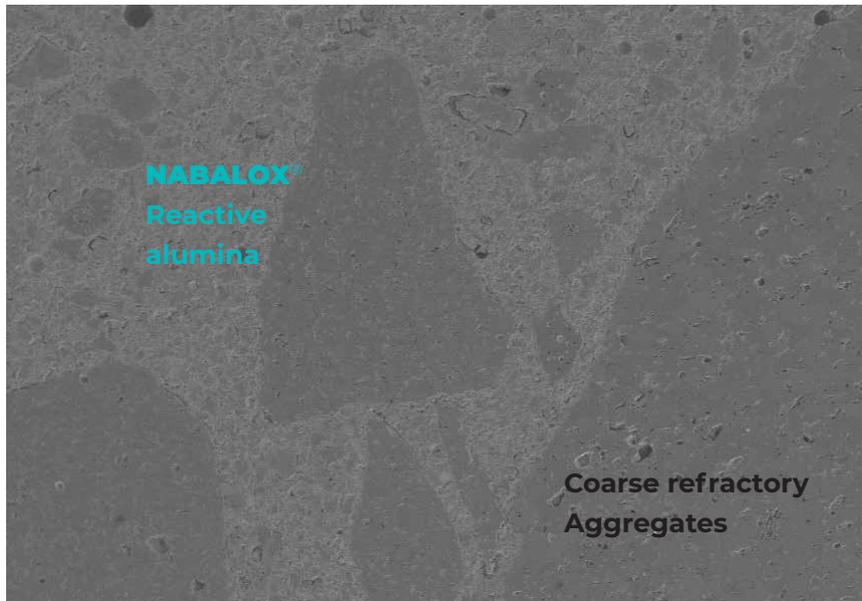
Theory and practice of particle packing

Reactive aluminas are mainly used in unshaped refractories to represent the particle fraction $< 5 \mu\text{m}$, and thus, to act as a micro-filler. They are able to fill the smallest

pores in the microstructure of refractory castables, reducing the water content/demand and thus also its viscosity.



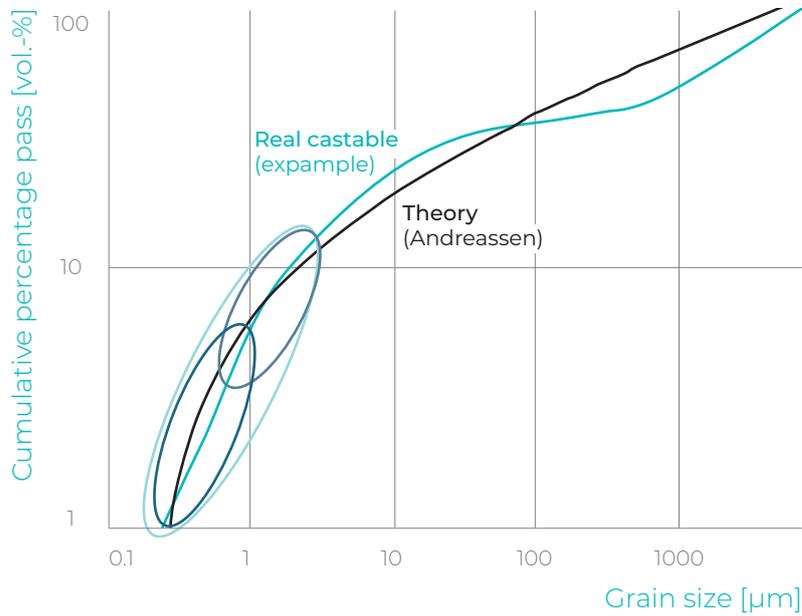
Theory: Optimized particle packing with continuous grain size distribution.



Practice: Real refractory microstructure with reactive alumina particles filling the gaps between the coarse aggregates.

Water demand of a free flowing castable can be reduced by the use of fine reactive aluminas

Alumina	Medium grain size D50 [μm]	Water demand for free flowing properties [%]
NO 115 TC	6	5.5
NO 315	4	5.0
NO 615-10	3	4.8
NO 715-10	2.5	4.5



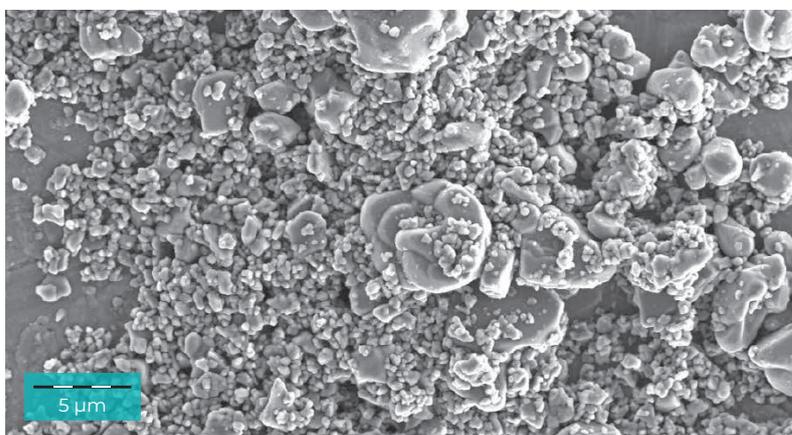
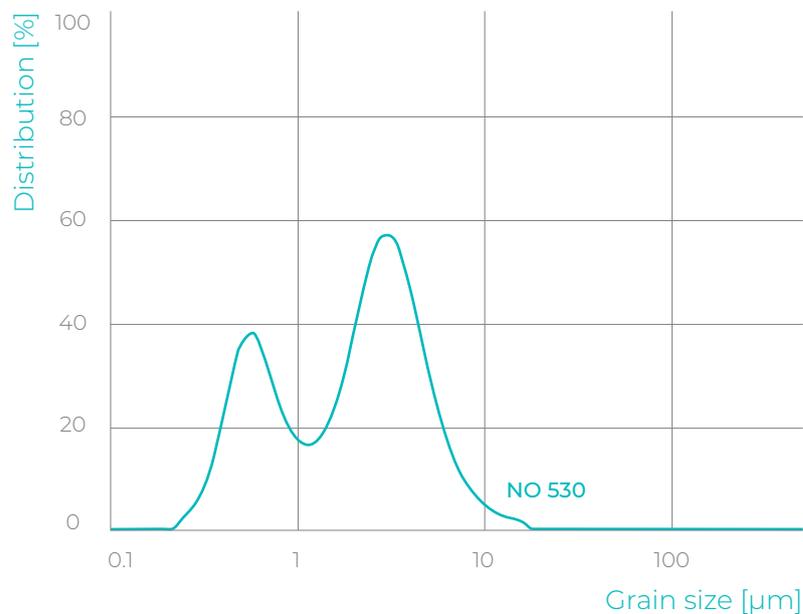
Cumulative particle size distribution curve shows how close the grain size distribution of the real castable (standard mixture) narrows to the theoretical optimum (black curve).
 Blue circle: Grain size area for super reactive aluminas (0.2 – 1.5 μm).
 Light blue circle: Grain size area for reactive monomodal aluminas (1 – 5 μm).
 Turquoise circle: Grain size area for bimodal reactive aluminas (0.2 – 5 μm).

Viscosity optimized reactive alumina NO 530

In modern refractory applications, niches can be found, where highest demand for thermomechanical properties meets the necessary for easy workability. State of the art reactive aluminas commonly need a compromise between a.m. properties. So highest refractoriness resp. slag resistance can be achieved with lowest water demand, but followed by extremely dilatant castable viscosity or the need for vibration.

The new generation of **NABALOX®**, viscosity optimized reactive alumina NO 530 allows the combination of both, lowest water demand and practice compatible free flowing consistency.

NABALOX®	Al ₂ O ₃ [%]	Na ₂ O [%]	D50 [µm]	BET [m ² /g]
NO 530	99.7	0.1	2.0	4.0



NO 530 shows via SEM bimodal grain size distribution.

Test castable formulation

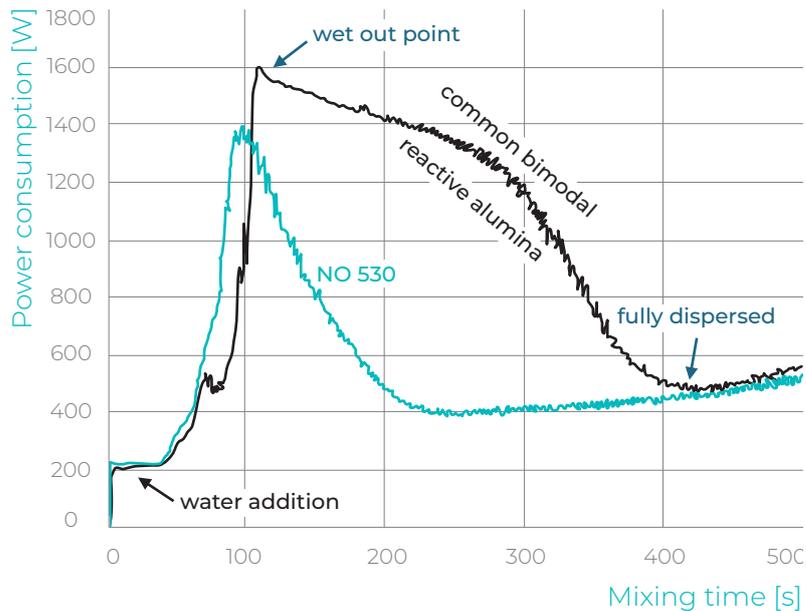
	[mm]	[%]
Tabular alumina	3 – 6	24
Tabular alumina	1 – 3	16
Tabular alumina	0.5 – 1	15
Tabular alumina	0 – 0.5	7
Tabular alumina	0 – 0.3	5
Tabular alumina	0 – 0.045	12
NABALOX® NO 315		5
NABALOX® NO 530 (or common bimodal reactive alumina)		13
CAC*		3
PCE**		0.1
Water (deion.)		3.8

* Calcium-aluminate-cement

** Poly-carbonate-ether

Properties of test castable

Flow spread 3.8 % H ₂ O (EN1402-4)	[%]	125
Green density (110 °C)	[g/cm ³]	3.2
CCS (110 °C)	[MPa]	66
Setting time (ultrasonic)	[h]	10



“Wet out point” is the state during the mixing process of a castable when all particles are wettened. At this point the power consumption of the mixer is very high, due to tough consistency of the mix. Once, this point is passed, dispersion starts to improve and viscosity decreases until complete dispersion, i.e. highest flowability is reached.

Viscosity optimized reactive aluminas can provide:

- Shorter time from “wet out” to “fully dispersed”
- Shorter mixing time at the construction place
 - Lower maintenance costs in steel mills
- Good workability is achieved quickly in the mixer
 - Lower risk of too high water addition
- Lower power consumption at peak
 - Higher loading of mixer possible
- Lower resistance to mixing tool
 - Higher lifetime of equipment



Special applications

Viscosity adjustment for gunning mixes

NABALOX® milled soft calcined aluminas:

By comparison with the hard calcined aluminas, the soft calcined exhibit a high specific surface area, based on their typically small primary crystals (< 0.5 µm).

As a result, they are an ideal raw material

to adjust the viscosity of plastic materials or e.g. refractory gunning mixes.

The use of other additives for plasticizing is often not necessary. A number of foundry products, e.g. coatings are influenced positively regarding their refractoriness and stability.

Application recommendations	NO 113	NO 313	NO 183	NO 283
Foundry products	•	•		
Shaped refractories	•	•	•	•
Gunning mixes	•	•	•	•

Typical chemical and physical analysis of NABALOX® for viscosity adjustment

Analysis	Unit	NO 113	NO 313	NO 183	NO 283
Al ₂ O ₃	[%]	99.6	99.6	99.6	99.6
Na ₂ O	[%]	0.3	0.3	0.3	0.3
SiO ₂	[%]	0.03	0.03	0.02	0.02
Fe ₂ O ₂	[%]	0.02	0.02	0.02	0.02
Spec. surface area (BET)	[m ² /g]	9	10	10	10
α-Al ₂ O ₃ content	[%]	> 70	> 70	> 70	> 70
D10	[µm]	1	1	3	2
D50	[µm]	11	5	27	11
D90	[µm]	55	30	75	35
Primary crystal size	[µm]	< 0.5	< 0.5	< 0.5	< 0.5

Service

for our customers

Technical service development / production

Nabaltec AG develops new products and refines innovative products in close cooperation with our customers and raw material suppliers.

Here we use our own lab facilities as well as our excellent contacts to external test institutes and laboratories to offer our customers a wide range of service to support them in formulation development and test procedures.

The successful implementation of this development and the intensive customer consultations enable Nabaltec AG an interaction with our customers in a cooperative, responsible and innovative manner. This culminates in the development of high performance products at the customer as well as in our facility.

Additionally, we have the capacity to fashion tailor made products for special customer requirements and their highly sophisticated and demanding markets.

Laboratory services

Our analysis centre is responsible for independent production control and quality offers laboratory services for customers intending to use our large analytical equipment.

With this excellent equipment we are able to execute analytic tests in the area of inorganic solids, trace elements and water quality.

The certification in accordance with DIN EN ISO 17025 confirms the high service standards of our lab.

We will gladly inform you about our capabilities.

Nabaltec

product portfolio

ACTILOX®

Boehmite, as flame retardant filler and catalyst carrier

APYRAL® AOH

Boehmite, as flame retardant filler and functional filler

APYRAL®

Aluminium hydroxides, as flame retardant and functional filler

GRANALOX®

Ceramic bodies, for the production of engineering ceramics

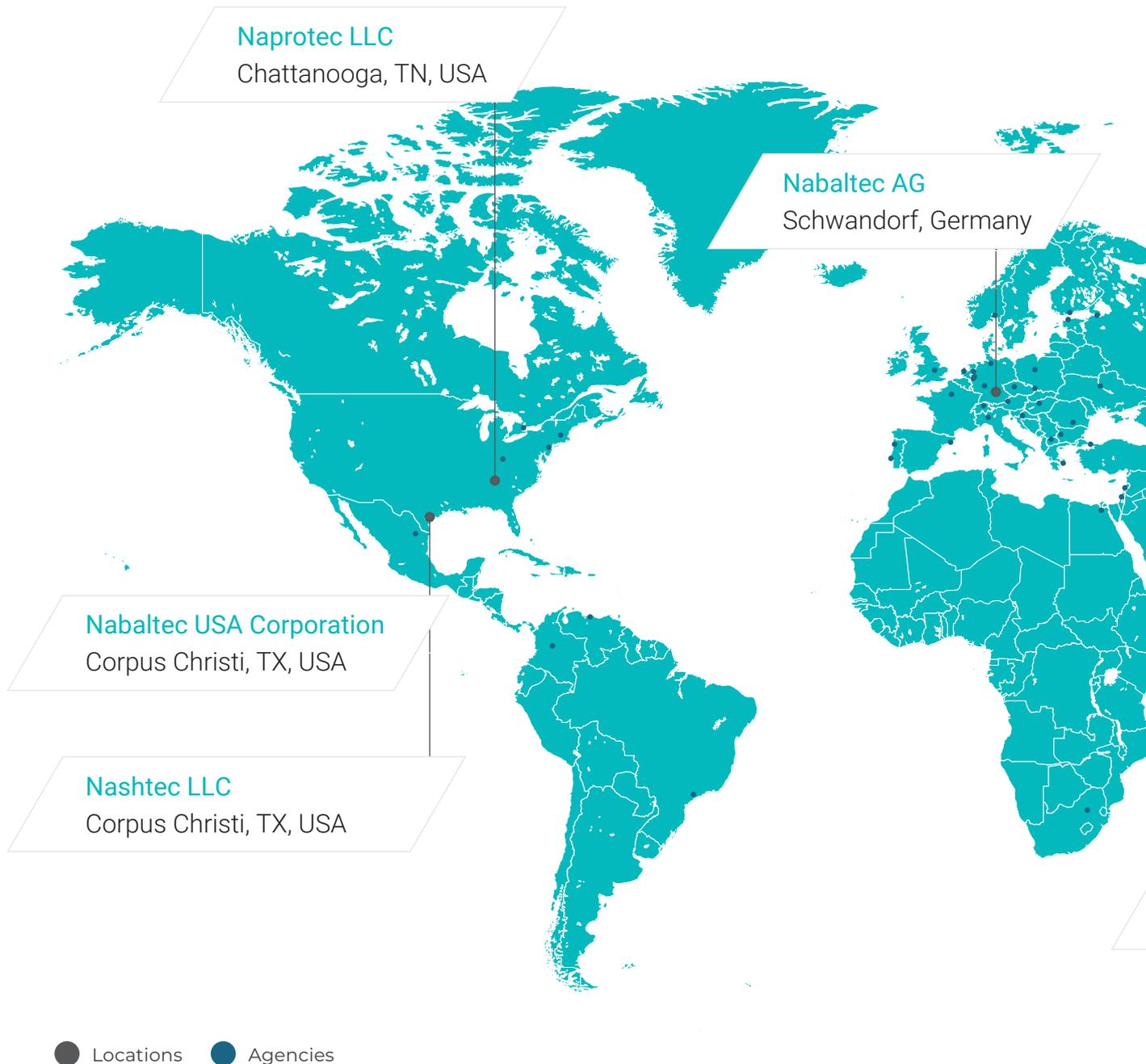
NABALOX®

Aluminium oxides, for the production of ceramic, refractory and polishing products

Nabaltec

worldwide

Visit us at our website www.nabaltec.de where you will find the latest company updates and recent versions of all available certificates free for download as PDF-documents.





Nabaltec (Shanghai) Trading Co., Ltd.
Shanghai, China

Further information:

Nabaltec AG

P.O. Box 1860 · 92409 Schwandorf

Phone +49 9431 53-0

www.nabaltec.de

info@nabaltec.de

Customer Service

Phone +49 9431 53 910

sales@nabaltec.de

Technical Service

Phone +49 9431 53 920

tec-service@nabaltec.de

Nabaltec AG

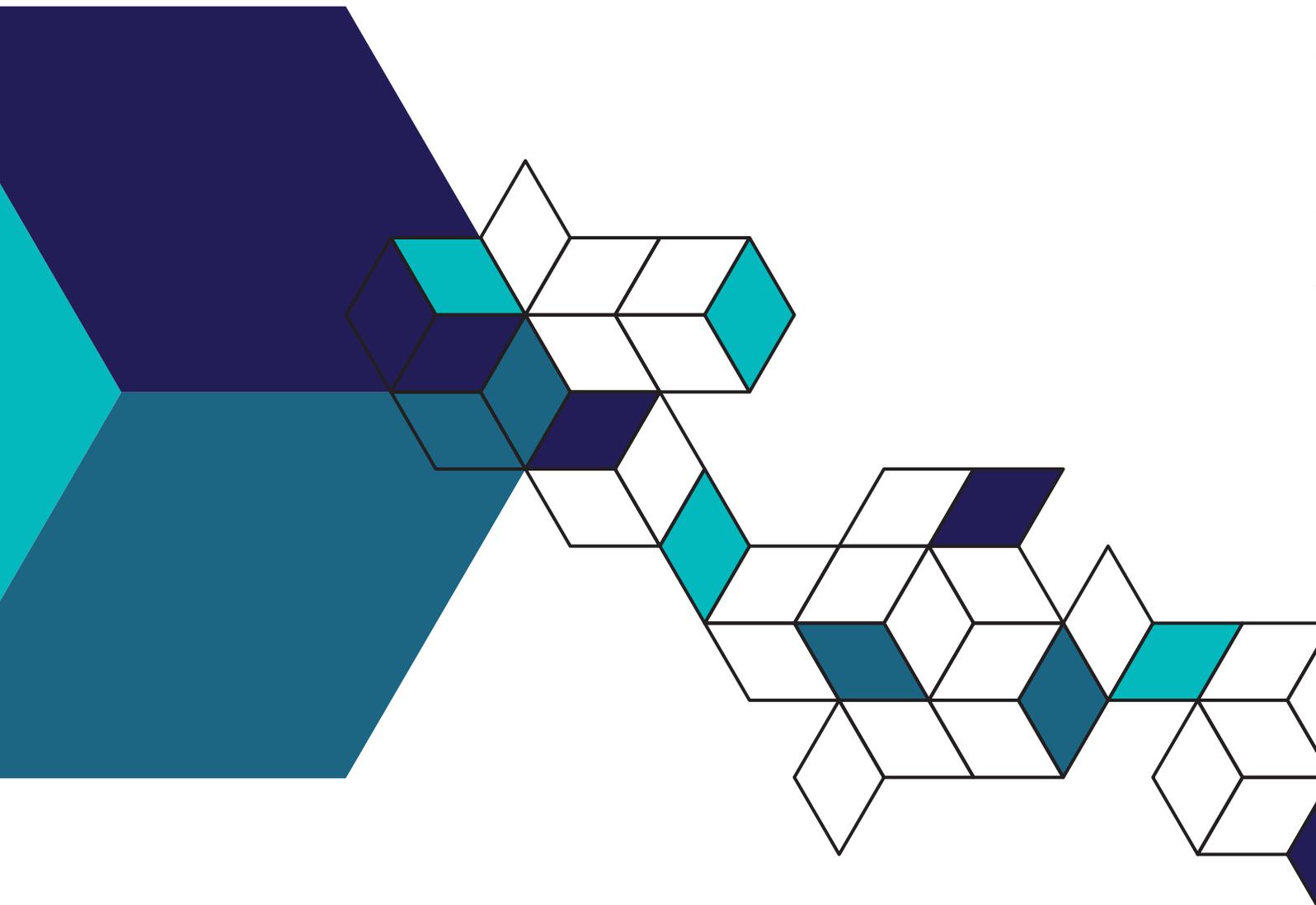
P.O. Box 1860 · 92409 Schwandorf

Tel +49 9431 53-0

Fax +49 9431 61 557

www.nabaltec.de

info@nabaltec.de



All data listed in this brochure are reference values and subject to production tolerance. These values are exclusive to the product description and no guarantee is placed on the properties. It remains the responsibility of the users to test the suitability of the product for their application.