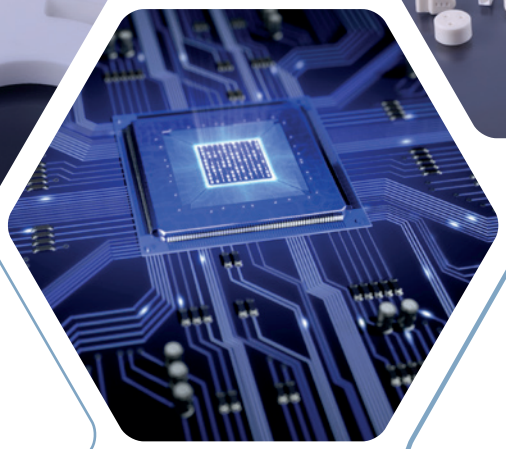
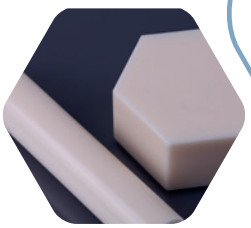
HYCal
MAKING CERAMICS BETTER





SPECIALTY ALUMINAS FOR

TECHNICAL CERAMICS

2024

alteo
SMART ALUMINA//

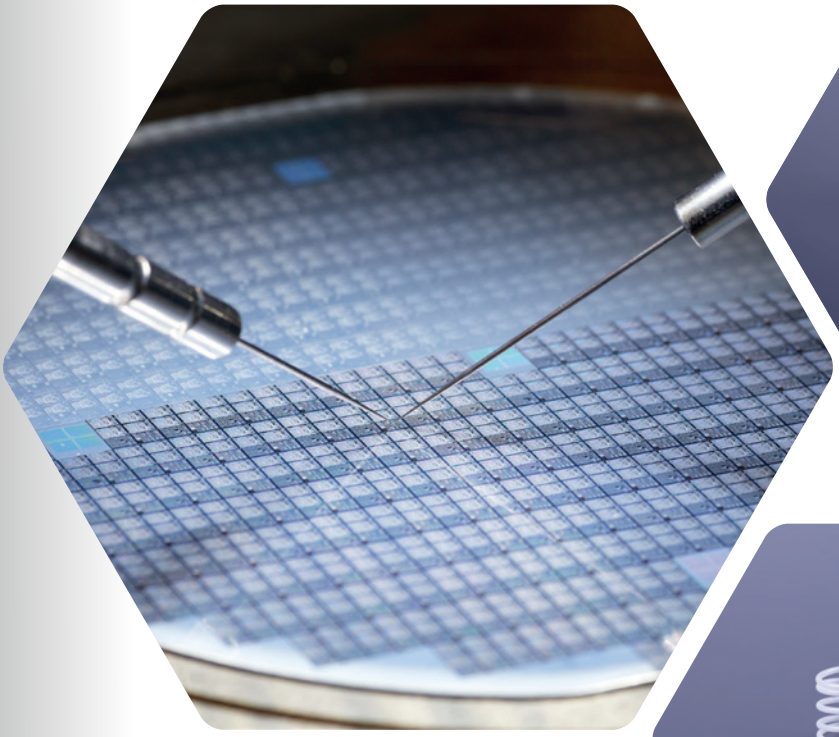
MARKETS & APPLICATIONS

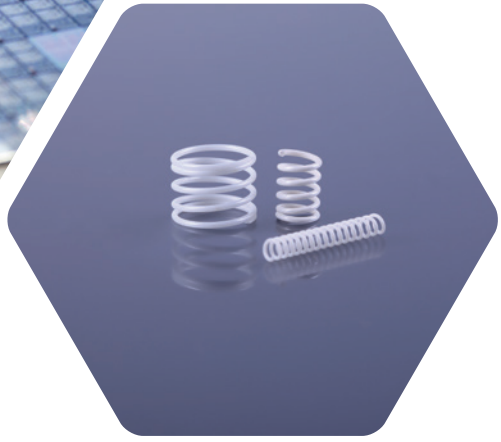
Alumina is one of the most important oxide materials for technical ceramics and is used in a wide range of applications. Finished parts offer high mechanical strength, hardness and resistance to both wear and chemical corrosion. Additionally, alumina ceramics exhibit very favorable thermal and electrical resistance properties, providing dimensional stability when heated and a good ability to dissipate heat.

The physical properties of alumina ceramic, and hence their expected final properties, will essentially depend on:

- **Powder Preparation** which depends on the alumina characteristics (crystal size, powder particle size distribution, surface area, chemistry, additives, grinding, pH, additives, grinding process used)
- **Forming** which also depends on the process technique (for example pressing, slip casting, extrusion, injection moulding, tape casting, gel casting, 3Dprinting)
- **Sintering** which depends on the method (temperature profile, atmosphere)

Applications often benefit from several ceramic properties and there is no standard classification between uses and function. This example of classification shows some applications that benefit from these characteristics:





Applications by product family

		AC34	ACBJ4C	PGM	P122	P662	P152	P162LS	P172LS	HP range	SDP range
DENSE CERAMICS	**Structural ceramics** • Ballistic protection • Rings, valves, nozzles... • Bio ceramics	●	●	●	●	●	●	●	●	●	●
	Wear resistance ceramics • Grinding media, lining • Thread guides • Cutting tools	●	●	●	●	●	●	●		●	
	Thermal ceramics • HF chips package • Kiln furniture	●			●						
	Dielectric ceramics • High-voltage insulators • Spark plugs • Integrated Circuits package			●	●	●	●	●	●	●	●
	Chemicals ceramics • Semiconductor industry • Medical & food industry • Labware • Hand Former	●	●	●	●	●	●	●	●	●	●
POROUS CERAMICS	**Catalyst support** • Automotive exhaust catalysts • Particulate filters • Catalyst carriers	●				●	●				
	Filtration • Ceramic foam filters • Ultrafiltration membranes	●					●		●		

Shaping process

		AC34	ACBJ4C	P122	PGM	P662	P152	P162LS	P172LS	SPD range	HP range
ALL CERAMICS	**Slurry/suspension** • Dip coating • Coating • Slip Casting • Wet Pressing / Pressure Casting • Tape Casting • Impregnation • Gel Casting • 3D Printing	●	●	●	●	●	●	●	●		
	Plastic Paste • Extrusion • Injection Molding • Jiggering • 3D Printing	●	●	●	●	●	●	●	●		●
	Dry Powder • Dry pressing • Isostatic pressing • Hot pressing • 3D Printing • Machining • Granulation	●	●	●	●	●	●	●	●	●	●

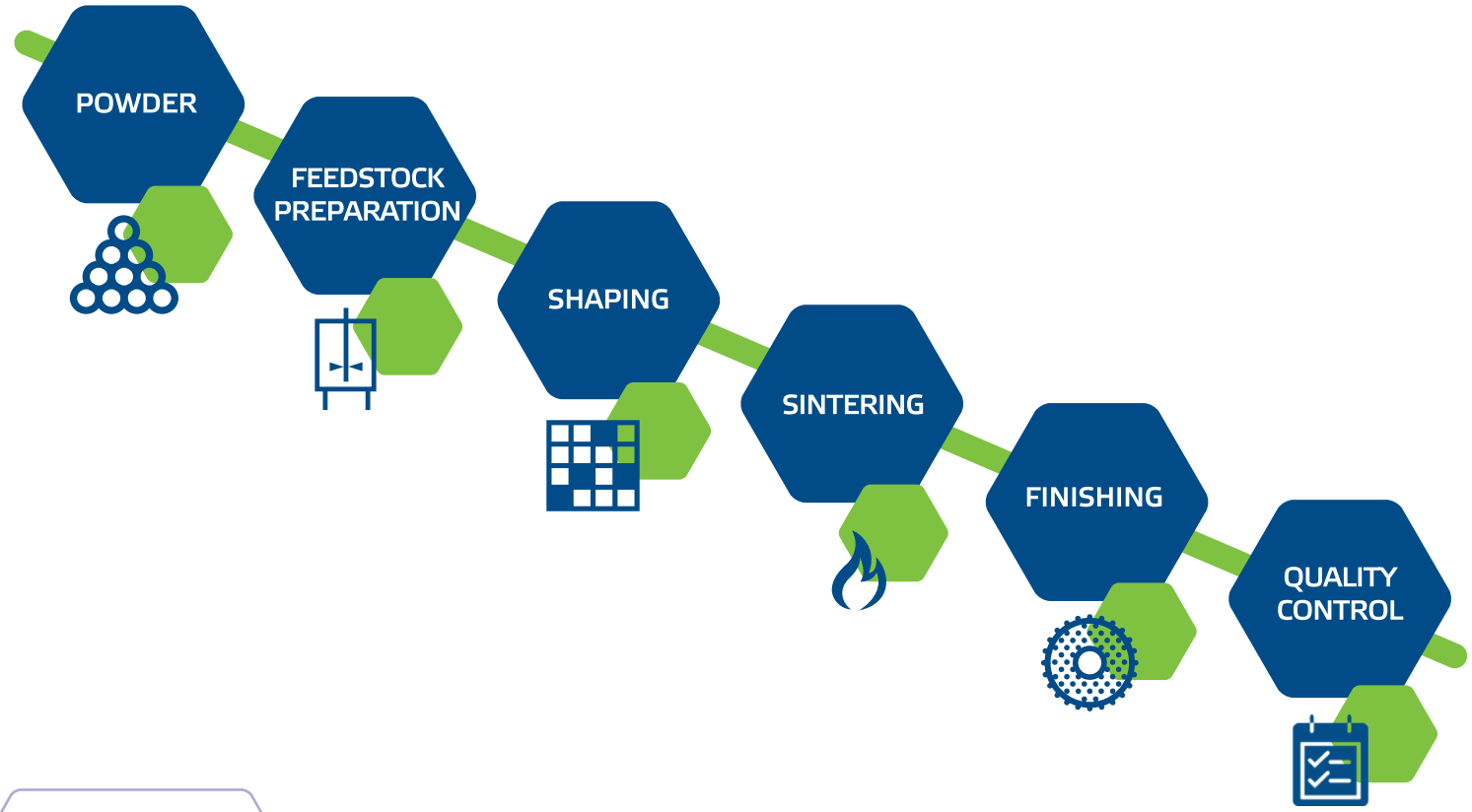
CERAMIC PRODUCTION

Alumina powder has a key role in the final ceramic properties.

Alumina powder's chemical and physical characteristics influence each step of the ceramic production process.
Alteo can provide you with the **best powder options optimized** for each step of your ceramic process.

Our R&D centre can also provide technical service permitting a better understanding and optimisation of the use of our alumina in the different ceramic production steps.

TYPICAL CERAMIC PRODUCTION PROCESS



ALUMINA FOR TECHNICAL CERAMICS

Besides chemical purity, the most critical parameter of alumina for ceramics is the size of its alpha crystals.

During the process of calcination, alumina hydrate first goes through several transitional phases, then α alumina crystals appear and grow, while specific surface area decreases.
For unground calcined alumina, there is a relationship between specific surface area and α crystal size.
ALTEO offers a continuous and tightly controlled range of crystal sizes for ceramists.

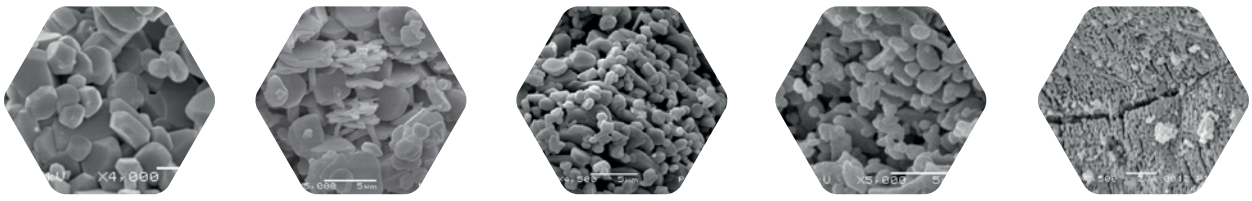
While most grinding operations do not reduce the alumina particle to its α crystal size, alumina D50 is reduced towards the crystal size during grinding.

Alteo defines crystal size and ceramic properties of alumina with a special test known as "Reynolds test" or "R test" :

- **Milling conditions:** 125g of alumina for 4 kg of grinding balls (1 inch); 1.5 gallon jar; 4 hours at 70 rpm.
- **Crystal size:** D50 on Sedigraph after milling
- **Green density*:** uniaxial pressing 4000 psi (≈28 MPa)
- **Fired density*:** heating rate: 22°C/min to 1000°C, 3.6°C/min from 1000 to 1670°C;
  Hold time: 1 hour at 1670°C; natural cooling.

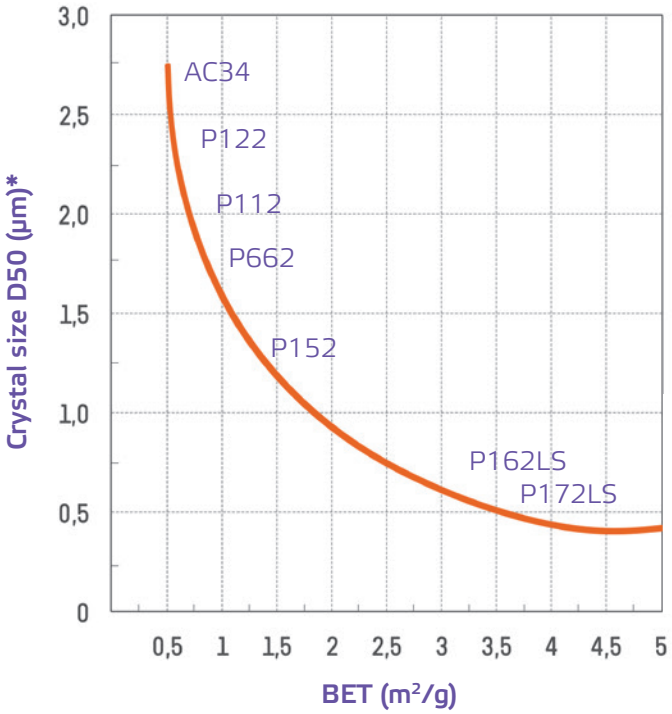
Because of its low compaction pressure and fast sintering, the Reynolds Test is very sensitive to alumina properties. For the same reasons the values obtained for green density and fired density with the R test may be different from typical industrial values.

** Except P162LS & P172LS : pressing at 5000 psi (≈35 MPa) and sintering at 1540°C, 2 hours.*

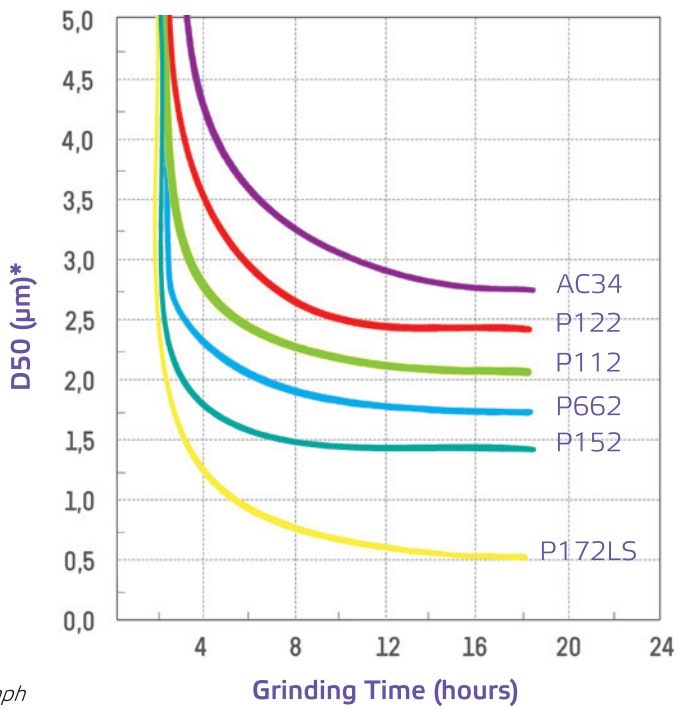


AC34 P112 P662 P152 P172LS

Unground Aluminas for Ceramics



Alumina Dry Grinding



** Sedigraph*

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NORMAL SODA ALUMINAS

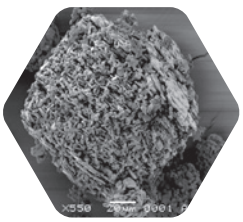
The tightly controlled calcination of **AC34** ensures the absence of under-calcined alumina, making AC34 usable in many applications. It also provides a wide and consistent crystal size distribution, making AC34 particularly suitable for body formulations where a low shrinkage is required. AC34 is available unground or ground (D50=3, 4, or 5 µm) as a cost-effective solution for use in most structural ceramics.

GA4I, a jet milled normal soda alumina for a lower top-cut, has been designed with a narrow almost monomodal size distribution for porous ceramics.

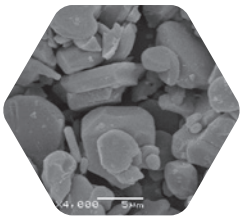
ACBJ4C is an improved version of our GA4I, a product specially tailored by the ALTEO teams in order to offer our customers a calcined product with the lowest screen residue in our alumina range.

		Unground	Ground				
		AC34	AC34B3	AC34B4	AC34B5	GA4I	ACBJ4C
Physical properties	**Unit**						
Specific Surface Area BET	m^2/g	0.5	2.2	1.0	0.8	0.7	0.7
Particle Size D50 laser (Cilas)	µm	80	2.8	4.0	5.0	4.5	4.5
Crystal Size D50 (Sedigraph)	µm	2.4	2.4	2.4	2.4	2.4	2.4
Screen residue >45µm	µm	-	0.1	1	3	0.1	0.01
Chemical properties							
Al_2O_3 on dry basis	%	99.7	99.7	99.7	99.7	99.7	99.75
Na_2O total	ppm	3000	3000	3000	3000	3000	2000
CaO	ppm	85	100	100	100	100	200
SiO_2	ppm	105	115	115	115	115	100
Fe_2O_3	ppm	135	150	150	150	140	200

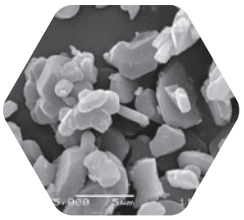
Typical data



AC34



GA4I



AC34B5

VERY LOW SODA ALUMINAS

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The proprietary Reynolds process at the Gardanne plant is used to make very low soda content alumina, around 300 ppm, with primary crystal sizes ranging from 0.4 to 3 µm.

Alteo's aluminas allow ceramic manufacturers to optimise production cost, processability and desired final properties. These grades are suitable for ceramic body preparations from 90% to more than 99% alumina content.

P122 and P112, with large crystals, are mainly used in spark plugs or low sodium structural ceramics where a low level of fine particles is needed.

PGM is designed for the grinding media industry and wear resistant alumina parts.

P662, with round shaped crystals and a low surface area ensuring an easy processing, is used in a wide range of applications, from 90% to 98% alumina content.

P152, with fine crystals but still reasonable surface area, is the best and industry leading alumina balance between processing and final properties. It can be used to produce 99.8% alumina ceramics with a fired density over 3.85 g/cm^3.

P172LS has a lower silica content and the finest alpha crystal on the market. Very high fired densities are achievable with **P172LS** at low sintering temperatures.

P162LS is Alteo's most recently developed alumina where a somewhat coarser crystal size is required;

Different versions of our alumina products are available or can be developed, don't hesitate to discuss your desired properties with us.

		Low Soda						
		PGM	P122	P112	P662	P152	P162LS	P172LS
Physical properties	**Unit**							
Specific Surface Area BET	m^2/g	1.1	0.7	0.8	1.2	1.3	3.0	4.1
Particle Size D50 laser (Cilas)	µm	80	80	80	80	80	80	80
Chemical properties								
Al_2O_3 on dry basis	%	99.80	99.85	99.85	99.85	99.85	99.90	99.90
Na_2O total	ppm	400	200	200	200	250	300	350
CaO	ppm	600	200	200	600	600	200	200
SiO_2	ppm	1000	800	800	800	800	250	200
Fe_2O_3	ppm	400	200	200	200	200	200	200
Ceramic Properties (R test)								
Crystal Size D50 (Sedigraph)	µm	1.60	2.20	2.00	1.50	1.40	0.55	0.40
Green Density*	g/cm^3	2.19	2.21	2.22	2.20	2.20	2.10	2.15
Fired Density**	g/cm^3	3.70	3.25	3.37	3.71	3.80	3.85	3.90
Linear Shrinkage	%	16.0	12.1	13.0	16.0	16.7	18.3	18.0

Typical data

* Green density: uniaxial pressing @28MPa except P162LS-P172LS.
** Fired density: 1670ºC /1h except P162LS-P172LS. Measured after R-test.
Lab tests results without any sintering aids or other additives.

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GROUND VERY LOW SODA ALUMINAS

Our superground product range (SB series) is the ideal choice to achieve a high fired density associated with a homogeneous microstructure. These aluminas are batch dry ball-milled to or very close to, the primary crystal size, ensuring the best compaction and sintering aptitude for a given calcined alumina.

P122SB can be used as-is in a wide range of formulations that require low soda levels.
P122 is also available jet milled at 5.5 µm, as **P122B**.

P152SB is the most versatile product with a fine crystal and enhanced compaction aptitude. Easy to process, P152SB is able to exceed 3.85g/cm^3 fired density without any mineral flux.

P662SB has been developed as an intermediate between P122SB and P152SB.

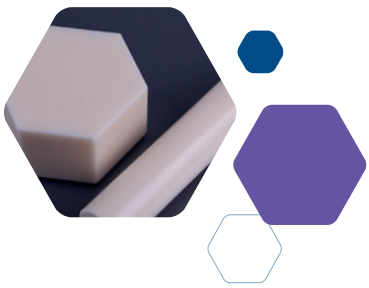
P172LSB is a low silica grade which has the smallest crystal size. Intensive grinding develops a population of very reactive particles which start to sinter at 1000ºC. P172LSB ceramics can be fully densified from 1540ºC. Magnesium oxide is added at different levels, to constrain grain growth during sintering.
In case a slightly coarse crystal is desired, **P162LSB** is your better choice.

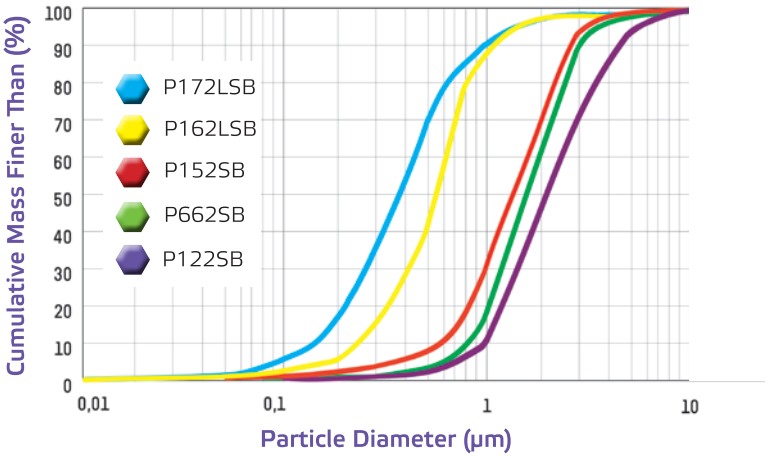
Do not hesitate to discuss with us your desired properties.

		Ground	Superground				
		P122B	P122SB	P662SB	P152SB	P162LSB	P172LSB
Physical properties	**Unit**						
Specific Surface Area BET	m^2/g	1.0	1.8	2.0	2.6	5.7	8.0
Particle Size D50*	µm	5.5	2.3	1.7	1.4	0.55	0.4
Chemical properties							
Al_2O_3 on dry basis	%	99.85	99.85	99.80	99.80	99.85	99.85
Na_2O total	ppm	200	200	200	250	300	350
CaO	ppm	200	230	600	600	250	250
SiO_2	ppm	800	800	900	800	300	300
Fe_2O_3	ppm	200	200	200	200	200	200
MgO	ppm	50	50	50	50	500	500
Ceramic Properties							
Crystal Size D50 (Sedigraph)	µm	2.20	2.20	1.50	1.40	0.55	0.40
Green Density**	g/cm^3		2.21	2.20	2.23	2.15	2.15
Fired Density***	g/cm^3		3.25	3.71	3.85	3.87	3.92
Linear Shrinkage	%		12.1	16.0	16.6	17.8	18.1

Typical data

*D50 is measured by sedimentation-Sedigraph on SB (Superground) products and laser-Cilas on B (ground) products.
**Green density: uniaxial pressing @28MPa except P162LSB-P172LSB (35MPa).
***Fired density: 1670ºC / 1h except P162LSB-P172LSB (1540ºC/2h).





HIGH-PURITY ALUMINAS

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P172HPB is a further processed P172LSB, with an enhanced chemical purity at 99.95% Al_2O_3, which is ball-milled to the primary crystal size with high-purity media.

MgO can be added to control the grain size distribution after sintering.

A higher fired density than P172LSB is achievable. Ceramics made with P172HPB have an exceptional bending strength and corrosion resistance at high temperature and other extreme environments.

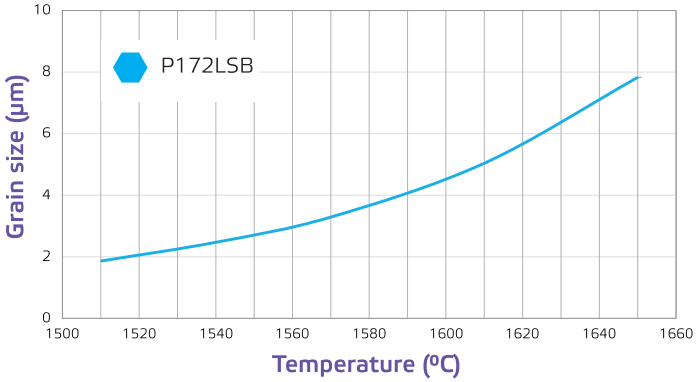
P162HPB is a high-purity ground version of P162LS with coarser crystals than P172HPB and an even lower soda content.

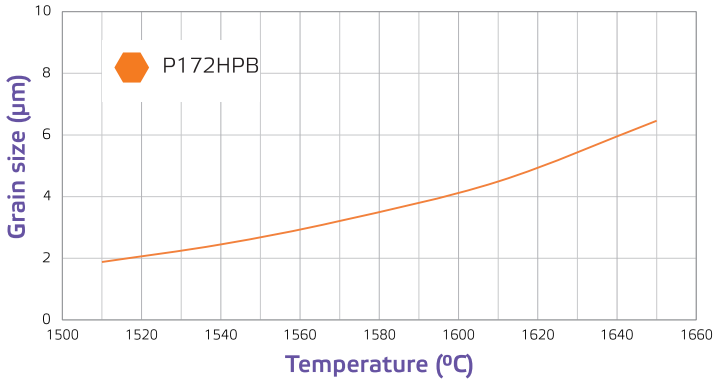
Thanks to its know-how, ALTEO can customize the chemistry of all its very low-soda grades to achieve a purity of around 3N5 and can also adapt & reduce the PSD.

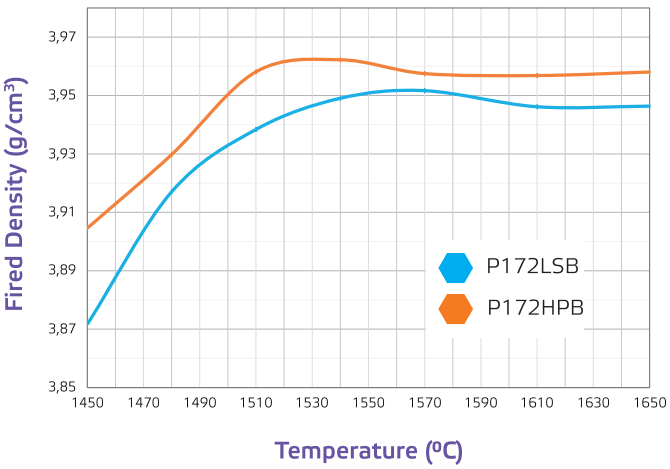
		P162HPB	P172HPB
Physical properties	**Unit**		
Specific Surface Area BET	m^2/g	5.8	8.1
Particle Size D10 (Sedigraph)	µm	0.25	0.2
Particle Size D50 (Sedigraph)	µm	0.55	0.4
Particle Size D90 (Sedigraph)	µm	1.15	1.0
Chemical properties			
Al_2O_3 on dry basis	%	99.95	99.95
Na_2O total	ppm	<50	50
CaO	ppm	<50	<50
SiO_2	ppm	100	100
Fe_2O_3	ppm	175	175
Ceramic Properties (R test)			
Crystal Size D50	µm	0.55	0.40
Green Density (35MPa)	g/cm^3	2.16	2.16
Fired Density (1540ºC/2h)	g/cm^3	3.92	3.94
Linear Shrinkage	%	18.0	18.1

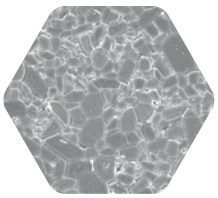
Maximum final properties can be obtained by adding up to 500ppm of MgO.

Typical data









P172LSB

P172HPB

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READY TO PRESS ALULMINAS

P172SDP is a spray-dried P172LSB. This ready-to-press powder is recommended for high alumina content ceramics (99.8%). The reactivity of P172SDP permits high fired density (over 3.92) with a sintering temperature below 1600°C.

P172SDP-02 grade contains 2% of organic additives and is suitable for all types of forming processes.
A second version, P172SDP-01, has 3% of additives in order to achieve a higher green mechanical strength. This version is therefore suitable when isostatic pressing (CIP, HIP) is followed by cutting and polishing of the green piece before firing.
An alternative version (P172SDP-05) is also available with a higher level of organic additives, 5%, and smaller D50 granule sizes (80µm).

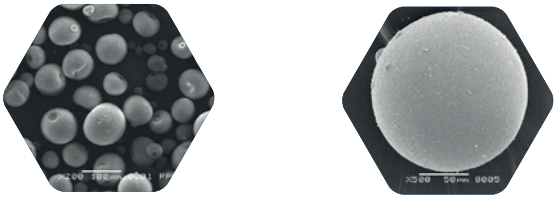
HPP7 is a spray-dried P172HPB that is recommended for the production of advanced ceramics with a very high alumina content when very low impurity levels & high mechanical strength is required.

P172SDP & HPP7 contains MgO to better control final microstructure, no additional additives are required to process this alumina.

Alteo is able to spray-dry its other very low soda grades.

		P172SDP-01	P172SDP-02	P172SDP-05	HPP7
Physical properties	**Unit**				
Specific Surface Area BET	m^2/g	8.0	8.0	8.0	8.0
Granulate Size D50	µm	120	120	80	115
Loss On Ignition (20-1000°C)	%	3.3	2.1	4.9	2.3
Moisture (20-105°C)	%	0.3	0.3	0.3	0.3
Chemical properties					
Al_2O_3 on dry basis	%	99.8	99.8	99.8	99.96
Na_2O total	ppm	350	350	350	50
CaO	ppm	250	250	250	65
SiO_2	ppm	300	300	300	130
Fe_2O_3	ppm	200	200	200	165
MgO	ppm	500	500	500	500
Ceramic Properties (R test)					
Crystal Size D50 (Sedigraph)	µm	0.40	0.40	0.40	0.40
Green Density (100MPa)	g/cm^3	2.26	2.26	2.27	2.26
Fired Density (1540°C/2h)	g/cm^3	3.92	3.93	3.92	3.93
Linear Shrinkage	%	16.8	16.8	16.6	16.8

Al_2O_3 content is given including added MgO *Typical data*



P172SDP

ALTEO PACKAGING & LOGISTICS SOLUTIONS

PACKAGING

To ensure you a smooth manufacturing process, we offer different types of packaging and minimum logistic units, which will suit all your production requirements.

We offer 3 different types of packaging depending on your production needs:

- **Paper bags**
- **Bulk bags**
- **Bulk**

Specific type of packaging can be offered on demand.

Type of packaging	Bulk	Bulk bags	Bags
Products	AC34, PGM	All Hycal® range	All Hycal® range
Packaging characteristics	-	Outer sleeve bottom (1)	- Valve bags - Thermo sealable valve bags
Location availability	Gardanne workshop area only	All workshops and stock points	All workshops and stock points
Minimum logistic units*	Silo truck	Pallet	Pallet
Tons per logistic unit	25 29 (France only)	1.0	1.0
Article per logistic unit	1	1	40

(1) Flat bottom available on demand
(*) The smallest item established and/or storage

LOGISTIC

To match your requirements in terms of deliveries, we offer different logistics solutions.

Our basic offer in terms of DELIVERY is:

Type of Transportation	Road transportation	Sea shipping
Point of delivery (2)	At Customers' plant Ex works - Gardanne plant Ex works - stock point	At Port of Destination

(2) Other type of delivery on demand

ALTEO R&D

For Alteo, innovation and application R&D are major parts of its growth strategy.

Alteo enhances its R&D capabilities through its **Innovation and Technical Excellence Center**: the installation of state-of-the-art equipment, the recruitment of technical experts and collaborations with key partners and university laboratories.

Alteo constantly strives for the best specialty alumina-based solution to your ceramics ambitions: our applications laboratory can study ceramic properties in porous and dense ceramic applications.

Alteo has the know-how and equipment to analyze and evaluate raw materials and finished parts, as well as being able to simulate production processes.

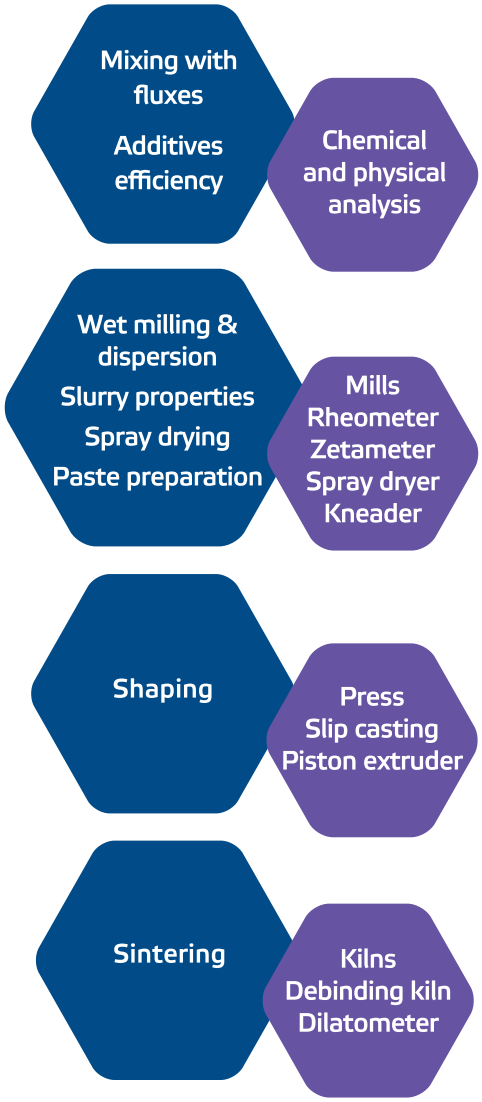
Contact our R&D team now at
www.alteo-alumina.com/contact

CUSTOMER CARE COMMITMENT

To meet your highest expectations, our Customer Care team will always strive to ensure a **first class** service.

Our commitment is to provide **full support** from your first call to the delivery of our products; with technical assistance, packing solutions and short lead times.

R&D CAPABILITIES



ALTEO AT A GLANCE

- A leading integrated supplier of specialty products with the largest production capacity worldwide for calcined, pure and fine alumina.
- A global sales network with 4 regional hubs, 16 offices and more than 35 local warehouses around the world.
- A development center in France.
- A leading raw material supplier to the following industrial markets: Advanced Ceramics, Performance Refractories, Thermal Management EV-Batteries, Flame retardant, Specialty Glass, Polishing.

alteo
SMART ALUMINA//

www.alteo-alumina.com

Design : Emeline MARTEL - Communication