

# Size reduction with Planetary Ball Mills



**Retsch**<sup>®</sup>  
Solutions in Milling & Sieving

# Planetary Ball Mills

RETSCH's innovative Planetary Ball Mills meet and exceed all requirements for fast and reproducible grinding down to the nano range. They are used for the most demanding tasks, from routine sample processing to colloidal grinding and advanced materials development.





**Milling**

- Jaw Crushers
- Rotor Mills
- Cutting Mills
- Knife Mills and Blenders
- Mortar Grinders
- Disc Mills
- Mixer Mills

**– Planetary Ball Mills**

**Sieving**

**Assisting**

**Planetary Ball Mills**

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**RETSCH Planetary Ball Mills** are used for the pulverization of **soft, fibrous, hard and brittle materials**. They achieve a very high final fineness down to the submicron range. The feed size depends on the mill and can be as large as 10 mm. If the sample feed size is larger than this then the sample must first undergo preliminary size reduction.

**Mixer Mills**



Fine size reduction with impact and friction can also be carried out with RETSCH Mixer Mills. They are used for **small sample volumes and cryogenic grinding**.

**Preliminary size reduction**



**For the coarse and preliminary size reduction** of hard, brittle or even tough materials, RETSCH Jaw Crushers are the instruments of choice. In contrast, bulky, soft, fibrous or elastic materials are best prepared in RETSCH Cutting Mills.

**Assisting**



For the subsequent pulverization a **representative part-sample** must first be obtained, e.g. with RETSCH's Sample Divider PT 100. For preparing solid samples for XRF analyses RETSCH offers two models of **hydraulic Pellet Presses**.

The main areas of application for Planetary Ball Mills are:

**Agriculture**

plant materials, seeds, soil, tobacco, wood fibres

**Biology**

bones, hair, tissue

**Ceramics and glass**

ceramic oxides, clay minerals, glass, hydroxyapatite, kaolin, quartz sand

**Chemicals and plastics**

carbon fibres, catalysts, cellulose, paints and lacquers, pigments, plastics, polymers

**Construction materials**

bentonite, cement clinker, concrete, gypsum, sand, stones

**Environmental research**

compost, electronic scrap, sewage sludge, waste

**Mineralogy and metallurgy**

alloys, coal, coke, iron ore, metal oxides, quartz, semi-precious stones, slag

and many more...

# Applications

RETSCH Planetary Ball Mills pulverize and mix **soft, medium-hard to extremely hard, brittle and fibrous materials**. They are suitable for both dry and wet grinding. These versatile mills are used successfully in virtually all industry and research sectors, where the quality control process places the highest demands on purity, speed, fineness and reproducibility.

## Free test grinding

Part of the RETSCH professional customer service is about offering our customers the individual advice they need to find the best possible solution for their sample preparation task. To achieve this our application laboratories process and measure samples free-of-charge and provide a recommendation for the most suitable method and instrument.

For more information please visit our website [www.retsch.com/testgrinding](http://www.retsch.com/testgrinding).



## Application examples

Planetary Ball Mills	General remarks	Grinding jar	Grinding balls	Feed size	Sample amount	Grinding time	Revolution speed*	Final fineness
Catalysts		250 ml ZrO <sub>2</sub>	15 x 20 mm ZrO <sub>2</sub>	1 - 20 mm	130 ml	2 min	450 rpm	63 µm
Cement clinker	5 - 10 drops of methanol	125 ml ZrO <sub>2</sub>	6 x 20 mm ZrO <sub>2</sub>	2 - 5 mm	50 g	5 min	450 rpm	100 µm
Coal		500 ml ZrO <sub>2</sub>	25 x 20 mm ZrO <sub>2</sub>	10 mm	150 g	4 min	400 rpm	200 µm
Glass	pre-grinding with 15 x 20 mm balls	250 ml ZrO <sub>2</sub>	60 x 10 mm ZrO <sub>2</sub>	5 - 10 mm	120 g	90 min	420 rpm	20 µm
Metal oxides	wet grinding	250 ml ZrO <sub>2</sub>	500 g x 3 mm ZrO <sub>2</sub>	< 300 µm	100 g + 50 ml IPA	1 - 2 h	450 rpm	< 1 µm
Sand		500 ml ZrO <sub>2</sub>	25 x 20 mm ZrO <sub>2</sub>	1 - 3 mm	200 g	6 min	500 rpm	63 µm
Sewage sludge	pre-grinding with 7 x 20 mm balls	125 ml ZrO <sub>2</sub>	50 x 10 mm ZrO <sub>2</sub>	10 - 20 mm	20 g	30 min	400 rpm	63 µm
Soil		250 ml Stainless steel	15 x 20 mm Stainless steel	10 mm (agglomerates)	120 g	10 min	400 rpm	100 µm
Straw		125 ml ZrO <sub>2</sub>	8 x 20 mm ZrO <sub>2</sub>	0 - 2 mm	10 g	30 min	400 rpm	160 µm

This chart serves only for orientation puposes.

\*In a Planetary Ball Mill PM 100

ZrO<sub>2</sub>: Zirconium oxide

The RETSCH application database contains more than 1,000 application reports. Please visit [www.retsch.com/applicationdatabase](http://www.retsch.com/applicationdatabase).

# Planetary Ball Mills

## PM 100, PM 200 and PM 400

Efficient –  
Versatile – Safe

### Benefits at a glance

- Efficient grinding process for excellent results down to the submicron range
- Choice of speed ratios (PM 400)
- Grinding jar volumes from 12 ml to 500 ml, in 6 different materials
- Suitable for long-term trials and continuous use
- Automatic direction reversal helps to avoid agglomerations
- FFCS technology compensates vibrations and ensures perfect stability on the bench (PM 100)
- Reproducible results due to energy and speed control
- Programmable starting time
- Memory for 10 parameter combinations
- Graphics display and ergonomic 1-button operation
- Automatic grinding chamber ventilation
- 2-year warranty, CE-conforming



### Powerful and fast grinding down to the nano range

RETSCH Planetary Ball Mills are used wherever the highest degree of fineness is required. Apart from the classical mixing and size reduction processes, the mills also meet all the technical requirements for colloidal grinding and have the energy input necessary for mechanical alloying processes. The extremely high centrifugal forces of the Planetary Ball Mills result in very high pulverization energy and therefore **short grinding times**.

The Planetary Ball Mills are available in versions with 1, 2 and 4 grinding

stations. The freely selectable machine settings, comprehensive range of grinding jars made from top-quality materials as well as the numerous possible ball charge combinations (number and ball size) allow **individual adaptation of the grinding parameters to the particular size reduction task**.

**Together with the "comfort" grinding jars these Planetary Ball Mills offer the highest possible degree of performance, safety and reliability.**

### Planetary Ball Mill technology

The grinding jars are arranged eccentrically on the sun wheel of the Planetary Ball Mill. The direction of movement of the sun wheel is opposite to that of the grinding jars in the ratio 1:-2 (or 1:-2.5 or 1:-3). The grinding balls in the grinding jars are subjected to superimposed rotational movements, which cause the so-called **Coriolis forces**. The difference in speeds between the balls and grinding jars produces an interaction between frictional and impact forces, which releases high dynamic energies. The interplay be-

tween these forces produces the high and **very effective degree of size reduction** of the Planetary Ball Mill.

The PM 100 CM operates with a speed ratio of 1:-1 (centrifugal mode). The centrifugal forces produced by the rotation movement the sample and the grinding balls against the inner wall of the grinding jar, where size reduction takes place primarily by pressure and friction.



# Benchtop models

## PM 100, PM 100 CM and PM 200

RETSCH Planetary Ball Mills are available in different versions.

Please refer to page 9 for a complete overview of the different performance features.



PM 100

### Type PM 100

The convenient benchtop model with 1 grinding station for grinding jars with a nominal volume of 12 to 500 ml.

Both PM 100 models feature Free-Force-Compensation-Sockets (FFCS) which ensure a safe low-vibration run and minimal oscillation transfers to the laboratory bench.



PM 100 CM

### Type PM 100 CM

The PM 100 CM operates in centrifugal mode, i.e. the speed ratio of sun wheel to grinding jar is 1:-1 (PM 100: 1:-2). This results in a different ball movement which leads to a more gentle size reduction process with less abrasion.



PM 200

### Type PM 200

The benchtop model PM 200 with 2 grinding stations for grinding jars with a nominal volume of 12 to 125 ml.

The larger sun wheel diameter results in a higher energy input when compared to the PM 100.

## Maximum operating comfort

The Planetary Ball Mills feature a very convenient operator guidance. All the relevant data can be entered or called up via a graphics display with 1-button operation:

- speed
- grinding time
- energy input
- grinding direction reversal with selection of running and pause times
- starting time
- remaining running time

- display of drive load factor
- operating hours
- clear text error messages
- service intervals

10 combinations of speed, grinding time and interval settings can be stored for repetitive grinding tasks.

**With multi-language graphical menu guidance.**



# Floor models

## PM 400 and PM 400 MA

For simultaneous grinding of up to 8 samples

### Type PM 400

The robust floor model PM 400 with 4 grinding stations for grinding jars with a nominal volume of 12 to 500 ml. It can grind up to 8 samples simultaneously down to the submicron range thus generating a high sample throughput. The PM 400 is also available with 2 grinding stations. The freely selectable speed from 30 to 400 min<sup>-1</sup> in combination with an effective sun wheel diameter of 300 mm allow for a particularly high energy input. Thus, the PM 400 produces samples with **analytical fineness in no time**.

### Type PM 400 MA

To generate the high energy input which is required for mechanical alloying of hard-brittle materials, the PM 400 is available as "MA" type with a speed ratio of 1: -2.5 or 1: -3.



PM 400

### Mechanical alloying with RETSCH Planetary Ball Mills

The mechanical alloying of materials in a grinding process to form new materials with new properties is no problem for RETSCH Planetary Ball Mills. For ductile metals the speed ratio of the jar to the sun wheel of 1: -2 is fully adequate in most cases, as the impact energy produced by the ball charge is large enough to form an alloy. However, greater energy is required for hard-brittle materials such as covalently bound semiconductors.

The PM 400 MA with an increased speed ratio of 1: -2.5 or 1: -3.0 is available for such applications. The best speed ratio and all other grinding parameters must be determined experimentally for the specific product.



# Innovative technology for increased safety



The patented **quick-action clamping device** is used in all RETSCH Planetary Ball Mills. It allows the grinding jars to be inserted in the mills safely, yet conveniently.



A **well thought-out operating concept** and, above all, the **optimized safety aspects** set new standards in this product segment and offer the user the possibility of carrying out size reduction tasks optimally and safely. The powerful and maintenance-free mill drive guarantees a constant controlled speed even for **continuous use** in long-term trials and under maximum load.

The Planetary Ball Mills offer a high degree of operating convenience, safety and versatility. Thanks to the **programmable starting time** grinding jobs can be started at night. If a power cut should occur during operation, the mills save all parameters including the remaining grinding time at that point of time. When the power supply is restored the grinding process can be resumed.

A **built-in fan with standstill monitoring** cools the grinding jars during operation. The extraction volume per hour is greater than the 20-fold grinding chamber volume.

Operation of the Planetary Ball Mills is particularly safe. They feature a **Safety Slider** which ensures that the mill can only be started after all grinding jars have been securely fixed with a clamping device. The self-acting lock ensures that the grinding jars are seated correctly and securely.

Thanks to the **automatic cover closure**, the machine only starts when the cover is properly closed. After the grinding process is finished, the cover unlocks automatically. It can only be opened when the mill is at a complete standstill.

**Particularly safe**

## Controlled forces in single-station Planetary Ball Mills

Planetary mills with a single grinding station require a counterweight for balancing purposes. In the Ball Mill PM 100 this counterweight can be adjusted on an inclined guide rail. In this way the different heights of the centers of gravity of differently-sized grinding jars can be compensated in order to avoid disturbing oscillations of the machine.

Any remaining vibrations are compensated by feet with some free movement (Free-Force Compensation Sockets). This innovative FFCS technology is based on the

d'Alembert principle and allows very small circular movements of the machine housing that result in an automatic mass compensation. The laboratory bench is only subjected to minimal frictional forces generated in the feet.

**In this way the PM 100 ensures a quiet and safe operation with maximum compensation of vibrations even with the largest pulverization forces inside the grinding jars and therefore can be left on the bench unsupervised.**



*For optimal balancing the counterweight of the PM 100 can slide up an inclined guide rail*

# Selection guide for Planetary Ball Mills

Performance data	PM 100 / PM 100 CM	PM 200	PM 400 / PM 400 MA
	<a href="http://www.retsch.com/pm100">www.retsch.com/pm100</a>	<a href="http://www.retsch.com/pm200">www.retsch.com/pm200</a>	<a href="http://www.retsch.com/pm400">www.retsch.com/pm400</a>
Field of application	pulverizing, mixing, homogenizing, colloidal milling, mechanical alloying		
Feed material	soft, hard, brittle, fibrous – dry or wet		
Feed size*	<10 mm	<4 mm	<10 mm
Final fineness*	<1 µm	<1 µm	<1 µm
For colloidal grinding	<0.1 µm	<0.1 µm	<0.1 µm
Batch/Sample volume	max. 1 x 220 ml	max. 2 x 50 ml	max. 4 x 220 ml
with stacked grinding jars	max. 2 x 20 ml	–	max. 8 x 20 ml
No. of grinding stations	1	2	4 or 2
Suitable grinding jars „comfort“			
12 ml / 25 ml / 50 ml / 80 ml	1 or 2	2	2, 4 or 8
125 ml	1	2	2 or 4
250 ml / 500 ml	1	–	2 or 4
Speed ratio	1 : -2 / 1 : -1	1 : -2	1 : -2 / 1 : -2.5 or 1 : -3
Sun wheel speed	100 - 650 min <sup>-1</sup>	100 - 650 min <sup>-1</sup>	30 - 400 min <sup>-1</sup>
Max. speed of the jars	1300 min <sup>-1</sup> / 650 min <sup>-1</sup>	1300 min <sup>-1</sup>	800 min <sup>-1</sup> / 1000 min <sup>-1</sup> or 1200 min <sup>-1</sup>
Effective sun wheel diameter	141 mm	157 mm	300 mm
Digital grinding time setting (hours:minutes:seconds)	00:00:01 to 99:59:59	00:00:01 to 99:59:59	00:00:01 to 99:59:59
Direction reversal	yes	yes	yes
Interval time	00:00:01 to 99:59:59	00:00:01 to 99:59:59	00:00:01 to 99:59:59
Pause time	00:00:01 to 99:59:59	00:00:01 to 99:59:59	00:00:01 to 99:59:59
Measurement of input energy possible	yes	yes	yes
Serial interface	yes	yes	yes
<b>Technical data</b>			
Power consumption	approx. 1250 W (VA)	approx. 1250 W (VA)	approx. 2200 W (VA)
W x H x D	630 x 468 x 415 mm	630 x 468 x 415 mm	836 x 1220 x 780 mm
Net weight	approx. 80 kg / approx. 86 kg	approx. 72 kg	approx. 290 kg
<b>Noise values (Noise measurement according to DIN 45635-31-01-KL3)</b>			
Emission value with regard to workplace	L <sub>pAeq</sub> up to 85 dB(A)	L <sub>pAeq</sub> up to 80 dB(A)	L <sub>pAeq</sub> up to 85 dB(A)
*depending on feed material and instrument configuration/settings			

## Speed ratios

The working principle of the Planetary Ball Mills is based on the relative rotational movement between the grinding jar and the sun wheel. In addition to the sun wheel diameter and speed of rotation this speed ratio is decisive for the energy input and therefore for the results of the size reduction process. **The higher the speed ratio, the more energy is generated.**

There are Planetary Ball Mills with different speed ratio settings. For example, a ratio of 1:-1 means that

each time that the sun wheel rotates the grinding jar also rotates exactly once in the opposite direction (indicated by the minus sign). With a speed ratio of 1:-2 the grinding jar rotates twice for each sun wheel rotation. In order to follow the rotational movement of the grinding jar you have to imagine that you are standing at the center of the sun wheel. During the sun wheel rotation you will see the red reference point exactly twice, i.e. the grinding jar has rotated twice (see illustration).

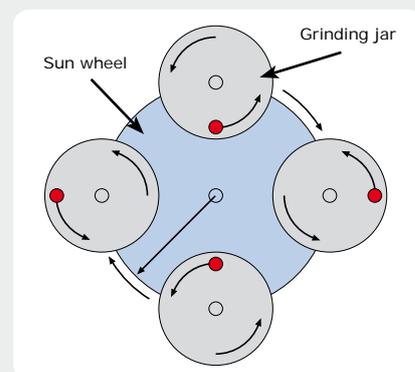


Diagram: speed ratio 1:-2

# “comfort” grinding jars for PM 100, PM 200 and PM 400



## Grinding jars for excellent grinding results

The performance and the result of sample preparation are also determined by the choice of the grinding jar and its ball charge. The choice depends on the amount of sample and the final fineness and purity of the ground sample that are necessary for the subsequent analysis.

The “comfort” range of grinding jars has been specially designed for extreme working conditions such as long-term trials, wet grinding, high mechanical loads and maximum speeds as well as for mechanical alloying.

In the PM 100 and PM 400 each grinding station can accommodate 2 stacked 12 - 50 ml “comfort” grinding jars. The 50 ml grinding jars require an additional adapter, the smaller grinding jars can be stacked directly.



## The unique advantages of “comfort” grinding jars

- Unusually simple and safe handling
- Safe, non-slip seating with built-in anti-rotation device and conical base centering
- O-ring for gas-tight and dust-proof seal
- User-friendly gripping flanges on jar and lid
- Gap between jar and edge of lid for easy opening
- Stainless steel protective jacket (for agate, sintered aluminum oxide, zirconium oxide and tungsten carbide grinding jars)
- Grinding jar identification (item number, material and volume)
- Labeling field (e.g. for sample information)

In addition to the instrument settings, the filling level of the jar is also of crucial importance for a successful grinding process in Planetary Ball Mills. For grinding bulk materials a jar filling should consist of about 1/3 sample and 1/3 ball charge. The remaining third is the free jar volume that is necessary for the free movement of the balls. The table provides guidelines.

### Grinding jar filling levels – guidelines for sample volume and ball charge

“comfort” grinding jar		Max. feed size	PM 100	PM 200	PM 400	Recommended ball charge					
nominal volume	Sample amount					Ø 5 mm	Ø 10 mm	Ø 15 mm	Ø 20 mm	Ø 30 mm	Ø 40 mm
12 ml	up to 5 ml	<1 mm	■	■	■	50 pcs.	5 pcs.	–	–	–	–
25 ml	up to 10 ml	<1 mm	■	■	■	100 pcs.	8 pcs.	–	–	–	–
50 ml	5 - 20 ml	<3 mm	■	■	■	200 pcs.	10 pcs.	7 pcs.	3 pcs.	–	–
80 ml	10 - 35 ml	<4 mm	■	■	■	250 pcs.	25 pcs.	10 pcs.	5 pcs.	–	–
125 ml	15 - 50 ml	<4 mm	■	■	■	500 pcs.	30 pcs.	18 pcs.	7 pcs.	–	–
250 ml	25 - 120 ml	<6 mm	■	–	■	1200 pcs.	50 pcs.	45 pcs.	15 pcs.	6 pcs.	–
500 ml	75 - 220 ml	<10 mm	■	–	■	2000 pcs.	100 pcs.	70 pcs.	25 pcs.	8 pcs.	4 pcs.

### Material composition guidelines

Grinding jar	Material no.	approx. hardness	Material analysis (in %)
Hardened steel	1.2080	62-63 HRC	Fe (84.89), Cr (12), C (2.2), Mn (0.45), Si (0.4), P (0.03), S (0.03)
Stainless steel	1.4034	48-52 HRC	Fe (82.925), Cr (14.5), Mn (1), Si (1), C (0.5), P (0.045), S (0.03)
Tungsten carbide		1180-1280 HV 30	WC (94), Co (6)
Agate		6.5-7 Mohs	SiO <sub>2</sub> (99.91), Al <sub>2</sub> O <sub>3</sub> (0.02), Na <sub>2</sub> O (0.02), Fe <sub>2</sub> O <sub>3</sub> (0.01), K <sub>2</sub> O (0.01), MnO (0.01), MgO (0.01), CaO (0.01)
Sintered aluminum oxide		1750 HV	Al <sub>2</sub> O <sub>3</sub> (99.7), MgO (0.075), SiO <sub>2</sub> (0.075), CaO (0.07), Fe <sub>2</sub> O <sub>3</sub> (0.01), Na <sub>2</sub> O (0.01)
Zirconium oxide*		1200 HV	ZrO <sub>2</sub> (94.5), Y <sub>2</sub> O <sub>3</sub> (5.2), SiO <sub>2</sub> / MgO/ CaO/ Fe <sub>2</sub> O <sub>3</sub> / Na <sub>2</sub> O/ K <sub>2</sub> O (< 0.3)

The above percentages are mean values. We reserve the right to make alterations.

\*Yttrium-part-stabilized

# Accessories for grinding jars "comfort"

## Optimum safety during wet grinding and under inert atmosphere

The Planetary Ball Mills are not only suitable for dry grinding but also for wet grinding, e.g. for the production of colloidal systems. The **"comfort" grinding jars** offer maximum safety. They are gas-tight and dust-proof and can be equipped with special **safety closure devices**. It permits the gas-tight handling inside and outside of a glovebox and ensures the safe transport of the grinding jar. Furthermore, overpressure which may build up during and after the wet grinding process cannot escape.

The **aeration cover** is used to create an inert atmosphere in the grinding jar.



Grinding jar "comfort" with safety closure device

Aeration cover

## Pressure and Temperature Measuring System PM GrindControl



In order to understand the processes which occur during grinding with ball mills (e.g. chemical reactions, phase changes), it is helpful to record the most important thermodynamic parameters: pressure and temperature.

Planetary Ball Mills are frequently used for the development of new materials by mechanical alloying due to their high energy input. The processes and reactions which take place in the grinding jar during grinding can be monitored and controlled.

The PM GrindControl is available with a stainless steel grinding jar of 250 ml or 500 ml.

A bidirectional connection between grinding jar and PC ensures the sending and receiving of data. The jar lid is equipped with a sender/receiver module, the corresponding module is connected to the PC via a USB flash drive. Thus, grinding jar and PC communicate via a robust and secure wireless connection.

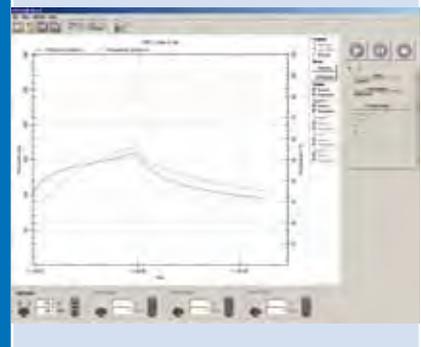
The measurement data can be recorded with different sampling rates; the longest interval is 5 seconds, the shortest 5 milliseconds.

The data are exported by mouse click and are available in ASCII format so that they can be easily processed with common software programs such as Excel.

The complete system – including accessories such as the grinding jar and a conversion kit for gassing – is delivered in an aluminum case.

### Benefits at a glance

- Measurement ranges
  - gas pressure: up to 500 kPa
  - temperature: 0 - 200 °C
- No modification of the mill required
- Indoor range approx. 15 m
- Max. operating time with fully charged accumulator 80 h
- Simultaneous operation of 4 measurement systems possible
- Multilingual software
- Robust design



Planetary Ball Mills order data

Planetary Ball Mills PM 100, PM 200, PM 400				Item No.
PM 100 (please order grinding jars and grinding balls separately)				speed ratio
PM 100	for 230 V, 50/60 Hz	with 1 grinding station	1 : -2	20.540.0001
PM 100 CM	for 230 V, 50/60 Hz	with 1 grinding station	1 : -1 centrifugal mode for gentle size reduction	20.520.0001
PM 200 (please order grinding jars and grinding balls separately)				speed ratio
PM 200	for 230 V, 50/60 Hz	with 2 grinding stations	1 : -2	20.640.0001
PM 400 mounted on casters (2 x lockable) (please order grinding jars and grinding balls separately)				
PM 400	for 220-230 V, 50-60 Hz	with 4 grinding stations	1 : -2	20.535.0001
PM 400/2	for 220-230 V, 50-60 Hz	with 2 grinding stations	1 : -2	20.535.0005
PM 400 MA	for 220-230 V, 50/60 Hz	with 4 grinding stations	1 : -2.5 special version for mechanical alloying	20.535.0007
PM 400 MA	for 220-230 V, 50/60 Hz	with 4 grinding stations	1 : -3 special version for mechanical alloying	20.535.0008
Accessories				
Add-on weight for PM 100 (if total weight of grinding jar, grinding balls, sample material and accessories is >7.3 kg)				22.221.0002
Other electrical versions available for the same price				

Measuring system PM GrindControl for PM 100 and PM 400				Item No.
Pressure and temperature measuring system PM GrindControl, incl. measuring transceiver, stationary transceiver, software, case and grinding jar				
PM GrindControl with grinding jar "comfort" 250 ml, stainless steel, for PM 100 and PM 400				22.782.0004
PM GrindControl with grinding jar "comfort" 500 ml, stainless steel, for PM 100 and PM 400				22.782.0005

"comfort" grinding jars for PM 100, PM 200 and PM 400							Item No.
"comfort" grinding jars	12 ml	25 ml	50 ml	80 ml	125 ml	250 ml*	500 ml*
Hardened steel	-	-	01.462.0145	-	01.462.0144	01.462.0224	01.462.0229
Stainless steel	01.462.0239	01.462.0240	01.462.0149	-	01.462.0148	01.462.0223	01.462.0228
Tungsten carbide	-	-	01.462.0156	01.462.0267	01.462.0155	01.462.0222	-
Agate	-	-	01.462.0139	01.462.0197	01.462.0136	01.462.0220	01.462.0225
Sintered aluminum oxide	-	-	01.462.0153	-	01.462.0152	01.462.0221	01.462.0226
Zirconium oxide	-	-	01.462.0188	-	01.462.0187	01.462.0219	01.462.0227
*not for PM 200							

Accessories for "comfort" grinding jars							Item No.
Adapter for stacking 50 ml "comfort" grinding jars in the PM 100 or PM 400							
for 50 ml "comfort" grinding jars made from hardened steel or stainless steel							03.025.0002
for 50 ml "comfort" grinding jars made from tungsten carbide, agate, sintered aluminum oxide, zirconium oxide							03.025.0003
Aeration cover							
for 250 ml "comfort" grinding jars made from stainless steel							22.107.0005
for 250 ml "comfort" grinding jars made from tungsten carbide							22.107.0006
for 500 ml "comfort" grinding jars made from stainless steel							22.107.0007
for 500 ml "comfort" grinding jars made from zirconium oxide							22.107.0010
Safety closure devices for "comfort" grinding jars			50 ml	80 ml	125 ml	250 ml	500 ml
Safety closure device			22.867.0002	22.867.0007	22.867.0003	22.867.0004	22.867.0005

Grinding balls									Item No.
Grinding balls	2 mm Ø	3 mm Ø	5 mm Ø	10 mm Ø	15 mm Ø	20 mm Ø	30 mm Ø	40 mm Ø	
Hardened steel	-	-	05.368.0029	05.368.0059	05.368.0108	05.368.0033	05.368.0057	05.368.0056	
Stainless steel	22.455.0010 <sup>1)</sup>	22.455.0011 <sup>1)</sup>	22.455.0003 <sup>2)</sup>	05.368.0063	05.368.0109	05.368.0062	05.368.0061	05.368.0060	
Tungsten carbide	-	-	05.368.0038	05.368.0071	05.368.0110	05.368.0070	05.368.0069	05.368.0068	
Agate, polished	-	-	05.368.0024	05.368.0067	05.368.0111	05.368.0028	05.368.0065	05.368.0064	
Sintered aluminum oxide	-	-	05.368.0019	05.368.0021	05.368.0112	05.368.0054	05.368.0053	05.368.0052	
Zirconium oxide	05.368.0089 <sup>1)</sup>	05.368.0090 <sup>1)</sup>	22.455.0009 <sup>2)</sup>	05.368.0094	05.368.0113	05.368.0093	05.368.0092	05.368.0091	

<sup>1)</sup>container = 500 g, <sup>2)</sup>container = approx. 200 pcs.



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