

## Ball Mills - Guidelines for sample amount and ball charge

### Content

High Energy Ball Mill E <sub>max</sub> .....	1
Planetary Ball Mills PM 100 / PM 100 CM / PM 200 / PM 400 .....	2
Mixer Mills MM 200 / MM 400 / MM 500 vario / CryoMill.....	3
Mixer Mill MM 500 nano/ control.....	4

As a rule of thumb, the grinding balls should be approximately 3 x larger than the largest sample particle. In addition to the instrument settings and the ball size, the filling level of the jar is also of crucial importance for a successful grinding process in ball mills.

**When grinding bulk materials, the jar should be filled with approx. 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.

If an increase or decrease in sample volume is to be expected during the grinding process, the filling levels may be changed according to the range given in the table below (in case of an expected decrease in sample volume, a further deviation is possible).

For wet grinding with grinding balls < 3 mm the ball charge should make up 60 % of the jar volume, while the sample amount should be 30 %. The density of the grinding ball materials is used to calculate the mass of the required amount of grinding balls.

### High Energy Ball Mill E<sub>max</sub>

Volume of the grinding jar	Sample amount	Max. Feed particle size	Dry Grinding Recommended ball charge (Pieces)				Wet Grinding Recommended ball charge (Mass, g)
			Ø 5 mm	Ø 10 mm *	Ø 12 mm *	Ø 15 mm *	Ø ≤ 3 mm
50 ml	5–20 ml	4 mm	160	16	8-12	-	Zirconium oxide: 110 g Stainless steel: 145 g Tungsten carbide: 276 g
125 ml	15–50 ml	5 mm	400	50	35	15-18	Zirconium oxide: 275 g Stainless steel: 364 g

\*Please note: The maximum recommended speed should be considered when using those grinding ball sizes; please refer to the operating manual for further information.

## Planetary Ball Mills

### PM 100 / PM 100 CM / PM 200 / PM 400

Volume of the grinding jar	Sample amount	Max. Feed particle size	Dry Grinding Recommended ball charge (Pieces)						Wet Grinding Recommended ball charge (Mass, g)
			Ø 5 mm	Ø 10 mm	Ø 15 mm	Ø 20 mm	Ø 30 mm	Ø 40 mm	Ø ≤ 3 mm
12 ml	< 5 ml	<1 mm	50	5	-	-	-	-	Stainless steel: 35 g
25 ml	< 10 ml	<1 mm	100	8	-	-	-	-	Stainless steel: 75 g
50 ml	5-20 ml	<3 mm	200	10	7	3	-	-	Zirconium oxide: 110 g Stainless steel: 145 g Tungsten carbide: 275 g
80 ml	10-35 ml	<4 mm	250	25	10	5	-	-	Stainless steel: 235 g Tungsten carbide: 440 g
125 ml	15-50 ml	<4 mm	500	30	18	7	-	-	Zirconium oxide: 275 g Stainless steel: 365 g Tungsten carbide: 690 g
250 ml	25-120 ml	<6 mm	1200	50	45	15	6	-	Zirconium oxide: 550 g Stainless steel: 730 g Tungsten carbide: 1380 g
500 ml	75-220 ml	<10 mm	2000	100	70	25	8	4	Zirconium oxide: 1100 g Stainless steel: 1450 g

## Mixer Mills MM 200 / MM 400 / MM 500 vario / CryoMill

The MM 400 and the CryoMill (at room temperature) are suitable for wet grinding. For optimal wet grinding results, the MM 500 nano or Planetary Ball Mills should be used (optimized jar geometry).

Volume of the grinding jar	Sample amount	Max. Feed particle size	Dry Grinding Recommended ball charge (Pieces)			
			∅ 5 mm	∅ 7 mm	∅ 10 mm	∅ 12 mm
1.5 ml	0.2-0.5 ml	1 mm	1 - 2	-	-	-
5 ml	0.5-2 ml	2 mm	5 - 6	1-2	-	-
10 ml	2-4 ml	4 mm	17 - 20	9 - 12	1 - 2	1 - 2
25 ml	4-10 ml	6 mm	35 - 40	16 - 20	5 - 6	2 - 4
35 ml	6-15 ml	6 mm	55 - 60	25 - 30	6 - 9	4 - 6
50 ml	8-20 ml	8 mm	80 - 90	45 - 50	12 - 14	6 - 8

Volume of the grinding jar	Sample amount	Max. Feed particle size	Dry Grinding Recommended ball charge (Pieces)			Wet Grinding Recommended ball charge (Mass, g)
			∅ 15 mm	∅ 20 mm	∅ 25 mm	∅ ≤ 3 mm
1.5 ml	0.2-0.5 ml	1 mm	-	-	-	Stainless steel: 4.5 g
5 ml	0.5-2 ml	2 mm	-	-	-	Stainless steel: 15 g
10 ml	2-4 ml	4 mm	-	-	-	Zirconium oxide: 20 g Stainless steel: 30 g Tungsten carbide: 55 g
25 ml	4-10 ml	6 mm	1 - 2	-	-	Zirconium oxide: 55 g Stainless steel: 75 g Tungsten carbide: 140 g
35 ml	6-15 ml	6 mm	2 - 3	1	-	Zirconium oxide: 75 g Stainless steel: 105 g
50 ml	8-20 ml	8 mm	3 - 4	1	1	Stainless steel: 145 g

The Mixer Mills are also used for cell disruption of biological cells. Specific adapters for 1.5 ml or 2 ml vials are required. The **MM 400** also accepts 5 ml vials, 30 ml wide mouth bottles or 50 ml conical centrifugation tubes. The **MM 500 vario** keeps adapters for 1.5 ml / 2 ml / 5 ml vials. The conical centrifugation tubes are limited suitable for dry grinding. Please contact RETSCH's application team if you wish to homogenize tissues like liver or dried plant materials in conical centrifugation tubes.

Vial	Sample amount	Max. Feed particle size	Dry Grinding Recommended ball charge (Pieces) Stainless steel or zirconium oxide				Cell disruption of biological cells
			∅ 4 mm	∅ 5 mm	∅ 7 mm	∅ 10 mm	Glas beads (0.1-0.25 mm/0.25-0.5 mm/0.75-1 mm/1-1.5 mm) Grinding balls zirconium oxide (< 3 mm)
1.5 ml	0.2-0.5 ml	<1 mm	2-4	-	-	-	~ 0.75 ml
2 ml	0.3-0.75 ml	<2 mm	3-6	2-4	1-2	-	~ 1 ml
5 ml	0.5-2 ml	<2 mm	12	-	-	-	~ 2.5 ml
30 ml*	5-12 ml	<5 mm	40-45	20-22	10-14	6-10	~ 15 ml
50 ml*	8-20 ml	<4 mm	-	-	-	-	~ 25 ml

\* Please note for MM 400: The total weight of adapter, bottles, sample and grinding balls should not exceed 650 g per grinding station.

## Mixer Mill MM 500 nano/ control

Please be aware that the maximum allowed ball size may vary, depending on the jar material!

The MM 500 nano is perfect for wet grinding and mechanochemistry.

The MM 500 control is suitable for dry, wet grinding and cryogenic grinding with temperatures down to  $-100\text{ }^{\circ}\text{C}$ . As heating and cooling is possible, the MM 500 control is perfect for a temperature regulation in the field of mechanochemistry.

Material	Grinding jar volume	Sample amount	Max. initial sample size	Dry grinding Required amount of grinding balls (pieces)						
				Ø 5 mm	Ø 7 mm	Ø 10 mm	Ø 12 mm	Ø 15 mm	Ø 20 mm	Ø 25 mm
Hardened steel, stainless steel	50 ml	5 - 20 ml	8 mm	160	45	16	8-12	-	1	1
	80 ml	10 - 32 ml	10 mm	260	70	32	23	12	3	1
	125 ml	15 - 50 ml	10 mm	400	110	50	35	15-18	8	-
Zirconium oxide	50 ml	5 - 20 ml	8 mm	160	45	16	8-12	-	-	-
	80 ml	10 - 32 ml	10 mm	260	70	32	23	12	-	-
	125 ml	15 - 50 ml	10 mm	400	110	50	35	15-18	-	-
Tungsten carbide	50 ml	5 - 20 ml	8 mm	160	45	16	8-12	-	-	-
	80 ml	10 - 32 ml	10 mm	260	70	32	23	12	-	-

Grinding jar volume	Sample amount	Max. initial sample size	Wet grinding Recommended ball charge (Mass, g)	
			< Ø 3 mm	
50 ml	5 - 20 ml	8 mm	Zirconium oxide: 110 g Stainless steel: 145 g	
80 ml	10 - 32 ml	10 mm	Zirconium oxide: 176 g Stainless steel: 232 g	
125 ml	15 - 50 ml	10 mm	Zirconium oxide: 275 g Stainless steel: 364 g	