

What Is Minimum Weight and How Accurate Weighing Can Be Ensured

The “minimum weight” refers to the minimum quantity of a sample required when the measurement uncertainty (potential error) of the balance used is taken into account.

If the sample quantity to be weighed is too small, uncertainty will take up too large a portion of the weighed value, and consequently make the result of the analysis unreliable. Therefore, if a balance has the minimum weight set to it, operators must pay attention so that the sample quantity (net weight excluding the tare) does not fall below the minimum weight.

USP

In the pharmaceutical industry, the general chapters (GC) <41> and <1251> of the United States Pharmacopoeia (USP) are widely recognized as standards for managing balances, and how a minimum weight is calculated is also stipulated in these chapters.

According to the GC <41> “Balances”, a balance used for samples that necessitate accurate weighing must be calibrated over the operating range and meet the following requirements defined for repeatability and accuracy:

Repeatability requirements

- 1) Repeatability is assessed by measuring one test weight not fewer than 10 times.
- 2) Repeatability is satisfactory when two times the standard deviation (S.D.) of the weighed values, divided by the desired smallest net weight (the smallest sample quantity that users actually intend to measure with the balance), does not exceed 0.10%.

These conditions can be expressed as:

$$(2 \times \text{S.D. of not fewer than 10 repeated weighing}) / \text{smallest net weight} \leq 0.10\%$$

In other words, the following can be said:

$$\text{Minimum weight} \geq 2000 \times \text{Repeatability (S.D.)}$$

Further,

3) When the S.D. obtained is smaller than 0.41d (d = scale interval), that S.D. is replaced with 0.41d.

- The reason why the minimum weight is determined from repeatability is that when the measurement quantity is small, repeatability becomes dominant as uncertainty component (sensitivity, non-linearity and eccentricity can be disregarded).
- Repeatability is not greatly affected by the value of the test weight. Accordingly, when determining the minimum weight, it is unnecessary to use a weight that is close to the expected minimum weight (i.e. too small and difficult to handle). On the other hand, if the weight is excessively large, there rises the risk of eccentricity and other factors that affect the measurement. A few percent of the balance capacity is therefore considered appropriate.
- Repeatability can vary depending on the day-to-day environmental conditions (draft, vibration, temperature/humidity changes, etc.) and the weighing skills of operators. It is thus recommended that the lower limit of the actual sample quantities to be measured (i.e. smallest net weight) be sufficiently, not just barely, above the set minimum weight.

Accuracy requirements

- 1) Using a suitable weight(s), accuracy is satisfactory when the measured value does not deviate by more than 0.10% of the test load value.
- 2) A suitable test weight has a mass between 5% and 100% of the balance capacity.
- 3) The maximum permissible error, or alternatively the calibration uncertainty, of the test weight is not more than 1/3 of the applied test limit of the accuracy test (0.10% of the test load value).

Examples of minimum weights (for reference)

Readability (d)	Model	Specifications		Minimum weight (typical)* ²
		Capacity	Repeatability (S.D.)* ¹	
0.001 mg	BA-6TE	6.2 g	1 µg (for 1 g)	1.8 mg
	BA-6E	6.2 g	1 µg (for 1 g)	1.8 mg
	BM-5	5.2 g	1.2 µg (for 1 g)	2.0 mg
	BM-20	22 g	2.5 µg (for 1 g)	3.0 mg
0.01 mg	BA-225TE	220 g	0.015 mg (for 50 g)	20 mg
	BA-225	220 g	0.015 mg (for 50 g)	20 mg
	BM-252	250 g	0.03 mg (for 100 g)	20 mg
	GH-252	101 g (fine range)	0.03 mg	24 mg
	GH-202	51 g (fine range)	0.02 mg	24 mg
	HR-202i	51 g (fine range)	0.02 mg	24 mg
	GR-202	42 g (fine range)	0.02 mg	30 mg

0.1 mg	BM-500	520 g	0.2 mg	120 mg
	GH-200	220 g	0.1 mg	120 mg
	GR-200	210 g	0.1 mg	120 mg
	GX-324AE	320 g	0.1 mg (for 200 g)	120 mg
	GX-324A	320 g	0.1 mg (for 200 g)	120 mg
	GF-324A	320 g	0.1 mg (for 200 g)	120 mg
	HR-250AZ	252 g	0.1 mg	140 mg
	HR-250A	252 g	0.1 mg	140 mg
0.001 g	GX-203A	220 g	0.001 g	1.4 g
	GF-203A	220 g	0.001 g	1.4 g
	FZ-200i	220 g	0.001 g	1.4 g
	FX-200i	220 g	0.001 g	1.4 g
0.01 g	GX-2002A	2200 g	0.01 g	14 g
	GF-2002A	2200 g	0.01 g	14 g
	FZ-2000i	2200 g	0.01 g	14 g
	FX-2000i	2200 g	0.01 g	14 g

*1 Repeatability specifications in accordance with brochures/data sheets. Corrected sample standard deviation (the denominator is n-1).

*2 Based on actual repeatability measured using a weight of 5% of the balance capacity, which was properly calibrated (adjusted) and operating in a favorable environment

In order to determine the minimum weight for a balance, repeatability needs to be assessed in the actual environment where the balance is used. For high precision balances, especially those with a readability of 0.1 mg or finer, it is important to ensure a good environment as repeatability is influenced by environmental conditions as well as the balance settings.