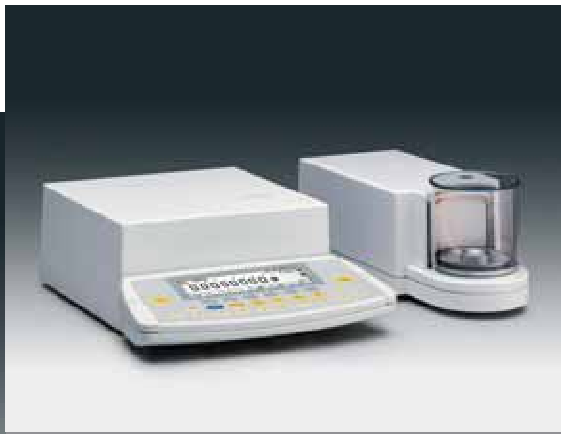
sartorius



# Correct Use and Handling
of Analytical and Microbalances

# Der richtige Umgang
mit Analysen- und Mikrowaagen

# Contents



# Introduction

**Correct Use and Handling of Analytical and Microbalances**

Analytical balances (readability: ≤ 0.1 mg), particularly semimicro- and microbalances, are high-resolution measuring instruments, the accuracy of which depends not only on the balance itself but essentially on ambient conditions, the instruments (weights, etc.) used for measuring, inspection and test equipment, types of sample material and the handling of the equipment.

An unstable or non-repeatable readout can be caused by factors affecting the balance or the sample, such as fluctuations in temperature, evaporation effects, static electricity, magnetism, and others.

In most cases, the root of the problem is a slight change in the weight of the sample, which a high-resolution balance will always detect.

A good understanding of the disturbances that distort weighing results can be very helpful in ensuring that the conditions for the required level of precision are met, which in turn helps prevent misinterpretation of the weighing results obtained.

It is important to read the installation and operating instructions carefully, as they include important and helpful information on working with balances.

# Place of Installation of the Balance

## Workspace

**Response times too long?**
**Weight values unstable? Drift?**
**Unsatisfactory long-term stability?**

- Avoid or minimize structural vibration and vibration caused by machinery.
- Place the balance table in a corner of the room, if possible, as this is the most stable location.
- Avoid direct sunlight; do not set up the balance on the south side of the room.
- Optimum room features: shaded windows and only one door.
- Set air conditioner to a minimal air current. If necessary, take steps to protect the equipment from drafts caused by the air conditioner.
- Ensure a constant room temperature (e.g., 21°C ± 2°C).
- Observe the specified operating temperature range.
- Keep in mind that proximity of air conditioners, open doors, and computer/laptop ventilation fans are sources of turbulence.
- Do not set up the balance in close proximity to heat radiators, lamps or lighting fixtures.
- Rapid changes in temperature influence results of measurement.

## Anti-vibration Balance Table

**Unstable weight values?**
**Poor repeatability?**

- Sartorius balances have excellent filters for eliminating interference; still, transfer of vibration through walls and floors must be avoided.
- A bracket for wall mounting, special anti-vibration balance table or non-bending laboratory bench that does not have contact with the wall can provide a sufficiently stable work surface.
- Do not use the surface on which the balance rests for writing or other tasks, as the balance will react to the slightest vibration or slant.

## Initial Startup

**Balance warmup period, room temperature | "Slow and steady wins the race"**

- Connect the required hardware to the data output port first, then connect the balance to power (see also installation and operating instructions). After 1 day at most, conditioning ("acclimatization") is completed and the balance will have reached a stable operating temperature.
- Preventing changes in the position of the balance in subsequent use will promote the reliability of your weighing results.
- To avoid having to warm up the balance again, leave it in standby mode rather than disconnect it from power.
- Calibrate and, if necessary, adjust the balance regularly prior to use.

## Humidity

**Precision weighing: not a "cut-and-dried" procedure**

- The relative humidity at the place of installation should be between 45% and 60%. Changes in humidity can alter, for example, the air buoyancy effect on weights and samples, thus influencing the weight readout. If the humidity level is too low, static electricity may result.
- Use an ionizing blower to neutralize static electricity as needed.
- If the humidity level is particularly high, make absolutely sure to prevent condensation.

# Operating the Balance

## Leveling the Balance

**Only a level balance can deliver reliable results.**
– Adjust the feet until the level indicator shows that balance is level; operate the balance only in this position. The air bubble must be within (ideally: in the middle) of the circle on the indicator.
– After leveling the balance, perform calibration/adjustment (see below).



## Calibration, Adjustment

**Determine, evaluate and reduce deviations**
– Deviations in sensitivity/span should be determined at regular intervals (e.g., once a day) using a calibration weight.
Calibration = determination of the difference between nominal and actual values
– If tolerance limits are exceeded, the span accuracy must be adjusted.
Adjustment = minimize or eliminate the difference determined in calibration
– Calibration is additionally required any time the ambient conditions (temperature, humidity or air pressure) change or the balance has been leveled.

When the "isoCAL" feature is active, the balance performs calibration automatically for greater accuracy. This also helps to reduce long-term effects.

**Important note:**
It is essential that you observe the tolerance limits of the weights used for calibration. For example, due to the permissible tolerance limits for a 200-g class E2 calibration weight, the readout may differ from the actual weight by up to ±0.30 mg.


Warmer = lighter


Colder = heavier

## Samples and Containers

**Determine the sample weight; reduce influencing factors**
– Use the smallest possible sample container to reduce the effect of flow forces.
– Plastic materials can cause static electricity (at very low humidity, you may encounter the same problem with glass containers).
– Never touch samples or samples containers with your bare fingers (avoid leaving fingerprints). Wear gloves or use long anti-magnetic forceps.
– Condition the sample container and sample to the ambient temperature before weighing.
– Avoid fluctuations in temperature; changes in temperature can cause an unstable readout.

If the objects weighed (sample/container) are too warm, the value displayed will be too low; if too cold, then the value will be too high. (See also the installation and operating instructions.)

## Placing a Sample on the Balance

**Reliable results: a "central" topic**

– Center the sample as precisely as possible. If the load is not in the middle of the weighing pan (off-center or eccentric loading), the weight readout might be slightly skewed (off-center loading error).

## Weighing Procedure

**A smooth, steady pace improves accuracy**

– Always close the draft shield before reading the result.
– Press the tare key to zero the display.
– After positioning the sample/calibration weight on the pan, wait until "g/mg" (stability indicator) is displayed.
– Note the weighing results at identical intervals (e.g., every 3 s); if necessary, set the stability parameter in the operating menu to meet your requirements.
– If more than 15 minutes have elapsed since the last individual weighing operation in a series, load the weighing pan briefly, unload it again, and then tare the balance before continuing weighing operations.

## Care of the Balance

**Cleanliness reduces disturbances**

– Keep the weighing pan and weighing chamber clean at all times.
– Use a fine brush or hand-held vacuum cleaner to remove sample residues; if necessary, remove weighing pan and shield ring for cleaning.
– Use an absorbent cloth to remove liquids.

# Physical Influences Caused by the Sample

Analytical balances, particularly semimicro-, micro- and ultra-microbalances, react to even the slightest change in ambient conditions or other physical variables. This is why even unwanted changes in physical influence quantities caused by the sample and/or container affect the readout.

Possible causes include, for example:
- Container or sample was not conditioned to the prevailing temperature
- The sample is hygroscopic or evaporating
- Container or sample is electrostatically charged
- Container or sample is magnetic.
- Gravitational acceleration
- Air buoyancy/density of the sample

## Temperature Differences

**What you see:**
- Poor repeatability
- Unexpected weighing results
- The readout value drifts even though the display is stable when the balance is not loaded.

**What you can do:**
- Condition the sample/container

## Moisture Absorption | Evaporation

**What you see:**
- The readout increases or decreases continuously; the readout drifts even though the display is stable when the balance is not loaded.

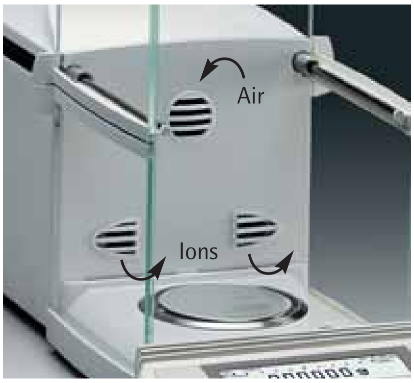
**What you can do:**
- To prevent evaporation: cover the container (e.g., with a petri dish).
- Do not handle containers/samples with bare fingers; fingerprints are hygroscopic.

Less suitable Better

Suitable

## Sample Containers

- Optimize containers as needed (e.g., provide covers).
- The weighing pan and sample container must be clean and dry.
- Graduated flasks and Erlenmeyer flasks are more suitable than beakers with wide openings.
- Use containers with small openings.
- Always use the smallest container feasible.

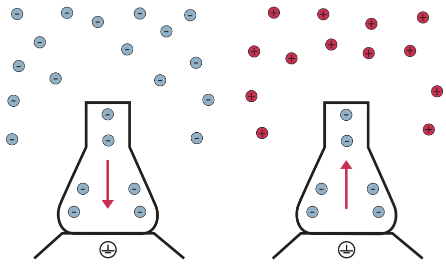


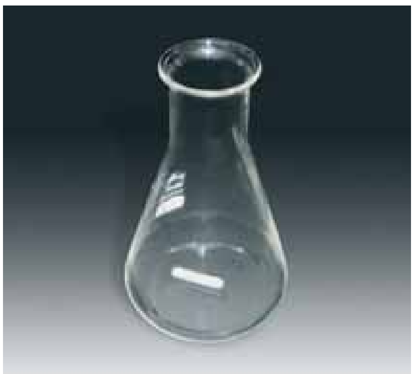

## Static Electricity

**What you see:**
- The weight readout drifts in one direction; values are non-repeatable.

Problem:
- Static electricity occurs on substances or containers with low electrical conductivity and great surface area (such as plastic or glass containers, or powdered substances).
- Very low humidity

**What you can do:**
- Increase humidity
- Use a metal container or metal foil to shield the sample.
- Use an ionizing blower to neutralize static electricity on the sample. (Sartorius ME series balances are equipped with a built-in ionizer.)





## Magnetic Effects

**What you see:**
- Weight values are stable, but non-repeatable.
- Different values are displayed depending on the position of the sample on the weighing pan.
  Problem: Magnetic materials in samples or containers, such as nickel, iron, steel, etc., particularly tin cans) generate force fields that act on the weighing pan and weighing chamber.

**Exercise caution when using a magnetic stirring bar.**

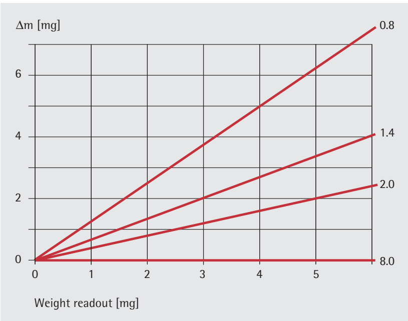
**What you can do:**
- Perform degaussing (demagnetization) before weighing.
- Use a nonmagnetic object (e.g., an upside-down beaker) to increase the distance of the sample from the weighing pan.
- Use Mumetal foil as shielding.
- Use special anti-magnetic weighing pans (available from Sartorius).

## Changing the Location of the Balance

**Calibrate and adjust the balance where you want to use it!**
Gravitational acceleration is a significant quantity that influences weight measurement (“influence quantity”).

Example (approximate values)
Degree of dependence on altitude:
1 ppm per building story
Dependence on latitude:
92 ppm per degree of latitude
(1° equals approximately 120 km in a north/south direction)

– Just a 3-meter increase in height at the place of use, for example, affects the weighing results: with 200 g on the balance, the readout shows only 199.9997 g – a difference of 0.0003 g. This is why it is essential to adjust the balance at the place of use following initial installation or after the location of the balance has been changed.




## Air Buoyancy Correction

Archimedes' principle states that a body subject to the Earth's gravity and immersed in an encompassing medium will decrease in weight by an amount equal to the weight of the encompassing medium which it displaces. In a weighing operation, the encompassing medium is air. The average density of air is 1.2 kg per m³. A body made of steel (density: 8,000 kg/m³), for example, with a mass of 200 g weighs 30 mg less in air than it would weigh in a vacuum. A body that has a mass of 200 g but a density of just 1,000 kg/m³ even loses 240 mg – approximately 1/4 g – when weighed in air.

This reduction in weight is inevitably reflected in the value displayed by a highly sensitive weighing instrument. As noted, the above examples are based on an air density of 1.2 kg/m³. Unfortunately, the density of air is subject to change over the course of the year. In particular, air pressure has a significant effect on air density, as do temperature, humidity and the composition of the air in a particular area.

The effects of these factors can be reduced by adjusting the balance to built-in or external reference weights before weighing. Reference weights have a density of about 8,000 kg/m³. The effect of sample density on weight, as described above, applies to reference weights just as to any other sample material.

$$m = m_w * \frac{1 - \frac{\rho_a}{\rho_c}}{1 - \frac{\rho_a}{\rho}}$$

Following correct calibration/adjustment of the instrument, the difference in weighing results for a body with 200 g mass and a density of 1,000 kg/m³ is still 210 mg.

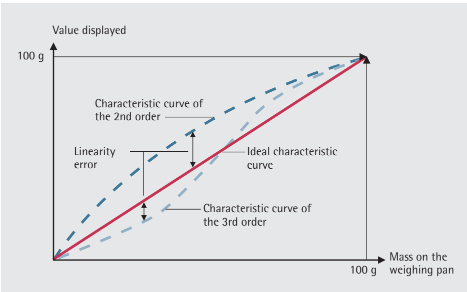
The corrective equation (shown on the left) must be applied for correction after calibrating/adjusting the balance with a built-in calibration weight directly prior to weighing

| | | | |
|---|---|---|---|
| where | $m_W$ | Balance readout | g, ct, etc. |
| | $m$ | Sample mass | g, ct, etc. |
| | $\rho_a$ | Air density during weighing | kg/m³ |
| | $\rho$ | Sample density | kg/m³ |
| | $\rho_c$ | Reference density | 8,000 kg/m³ |

As can be seen in this equation, the quality of the correction is dependent on the knowledge of the sample density and air density. Because these density values are generally known only to within a certain range, the uncertainty of measurement must be taken into account to improve the accuracy of the correction.

# Technical Terms

| | |
|---|---|
| **Adjustment** | Setting a weighing instrument to eliminate discrepancies between the value on the readout and the actual value for the mass on the weighing instrument (balance). |
| **Autotare/Auto zero** | The readout is automatically set to zero by the balance, to eliminate minor deviations and correct any slow zero point drift. |
| **Calibration** | Determination of the correlation between the displayed value and the true mass of the sample on the balance. Calibration does not entail making any changes within the weighing instrument. |
| **Conventional mass value** | The conventional weight of a body is equal to the mass of a mass standard that has a density of 8 g/cm$^{-3}$, which keeps this body in equilibrium at 20°C, and an air density of 1.2 mg/cm$^{-3}$. If a body has a density of 8 g/cm$^{-3}$, its conventional weight and its mass are identical. |
| **Drift** | Slow change, over time, of the readout with a constant load on the balance. |
| **Gravitational acceleration (g)** | The acceleration imparted to an object during free fall due to the gravitational force of the Earth. Gravitational acceleration is location-dependent; due to centrifugal force, it is slower at the equator than at the poles. It also decreases as the altitude above sea level increases. In Germany, the mean gravitational acceleration is g = 9.81 ms$^{-2}$. |
| **Influence quantity** | Quantity that is not the subject of a measurement, but that affects its result. |
| **isoCAL** | Most balances today come equipped with this type of fully automatic calibration/adjustment function, activated at specific or at user-defined intervals. In addition, when a defined temperature difference is exceeded, the calibration/adjustment procedure is triggered automatically. This makes it possible to ensure the accuracy of the balance without operator intervention. |
| **Kilogram** | International base unit of mass; defined by the mass of the international kilogram prototype in Sevres (France). |
| **Level indicator** | Tool for horizontal adjustment. |
| **Linearity; linearity error; non-linearity** | Deviation from the theoretical linear slope of the characteristic curve of two interdependent variables. If the zero point and adjustment are correct, the linearity can be determined from the positive or negative difference of the displayed value from the actual load. |

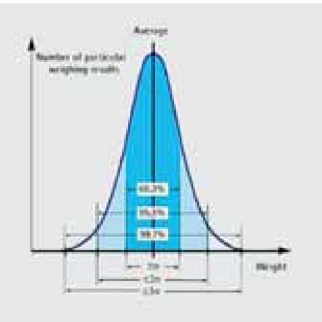



| | |
|---|---|
| **Maximum permissible error in service** | Limits on the measurement error of a verified balance; may not be exceeded during operation of the balance. The maximum permissible error in service is twice the maximum permissible error on verification. |
| **Maximum permissible error on verification** | Limits on the measurement error which may not be exceeded when a balance is verified. |
| **(Measurement) uncertainty** | Short form for –> Uncertainty of measurement |
| **Minimum sample quantity acc. to USP (United States Pharmacopeia)** | Section 41 of the USP specifies the use of balances and weights. It states that the minimum sample weight measured on a balance may not be less than 1,000 times the uncertainty of measurement (or the uncertainty of measurement must not be greater than 0.1% the minimum sample weight). Tare loads, such as sample containers, may not be included in the calculation of the minimum sample quantity.<br><br>Determination of the minimum sample quantity must be performed and documented at the place of installation. Under good installation conditions, the minimum sample quantity for a semi-microbalance is generally 15 to 25 mg. |
| **Motorized calibration weight** | Built-in, semi- or fully automatic mechanism for calibration/adjustment of the balance for high accuracy. Because of the high accuracy of this internal method, a built-in, motorized calibration weight is preferable to an external weight. |

| | |
|---|---|
| **Non-automatic weighing instrument (NAWI)** | A non-automatic weighing instrument requires operator intervention during the weighing procedure; e.g., to place a sample on the balance or to obtain the result. |
| **Off-center loading error; eccentricity; eccentric loading** | Change in the value displayed when a given load is placed in different positions on the weighing pan. |
| **ppm** | Abbreviation for parts per million = $10^{-6}$ (e. g., 0.0001 g of 100.0000 g) |
| **Readability** | The smallest difference in mass that can be displayed by the balance |
| **Repeatability** | The ability of the balance to produce the same result repeatedly under specified test conditions when the same load is placed on the balance in the same manner multiple times in series (generally, 6 times). The –> standard deviation serves as a quantitative expression of repeatability.<br><br>The measurement of the repeatability must include both the balance specifications and the ambient conditions (vibration, fluctuating air current/temperature/humidity, etc.). Operator handling of the balance is also included in the standard deviation. |
| **Reproducibility** | –> Repeatability |
| **Resolution** | No standardized definition; generally used to indicate the quotient of maximum capacity and readability.<br><br>Example: a semi-microbalance with a 230 g weighing capacity and a readability of 0.01 mg has a resolution of 23,000,000 [23 million] digits.) |
| **Response time** | –> Stabilization time |
| **Sensitivity** | Change in the displayed value divided by the change in load which caused it. With a correctly adjusted balance that has a digital display, the sensitivity must always be exactly 1. |
| **Span** | The correlation of the displayed weight value with the conventional mass value of the test weight on the balance is checked. The test weight should be traceable to a national standard, and is subject to monitoring. |
| **Stabilization time** | The time that elapses between completely placing the sample on the balance and obtaining the final result of the measurement. The stabilization time can be influenced by selecting a different digital filter algorithm in the balance operating menu. |
| **Standard deviation** | A mathematic quantity for assessment of a balance with respect to its repeatability. The standard deviations "s" is defined as |

$$s = \sqrt{\frac{1}{n-1} * \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

where:
n = number of individual results
x = arithmetic mean of the individual results $x_i$



Example of a normal distribution:

| | | | | |
|---|---|---|---|---|
| Within | ± 1 s | ± 1.5 s | ± 2 s | ± 3 s |
| lie | 68 % | 87 % | 95 % | 99.7 % of all measured values |

| | |
|---|---|
| **Taring** | Sets the display to zero when a load is on the balance. This allows the display to be zeroed when an empty container is on the weighing pan, and the net weight to be read off after the container has been filled. |
| **Temperature coefficient** | Relative alteration of a value (e.g., zero point or sensitivity) when the temperature changes; the value is divided by the amount of temperature change.<br><br>It can be stated in ppm/K or $10^{-6}$/K;<br><br>e.g., a temperature change of 1 Kelvin (1°C) and a temperature coefficient of $1 \cdot 10^{-6}$/K yields:<br><br>$\Delta m = 1 \cdot 10^{-6}\,K^{-1} \cdot 1\,K \cdot 100\,g = 0.0001\,g$ |
| **Traceability** | Characteristic of a measurement result that can be traced back to a national or international reference weight through an unbroken chain comparative weighing operations. |
| **Uncertainty of measurement** | This indicates the range above and below the result of measurement within which the unknown, error-free result lies with a statistical certainty of generally 95%.<br><br>Example of a weighing result indicated with the uncertainty of measurement:<br><br>m = (139.27457 ± 0.00002) g.<br><br>Sartorius technicians can determine the uncertainty of measurement at the place of use of the balance and record it an official calibration certificate (accredited by the German Calibration Service, or DKD, in Germany for instance).<br><br>Designation of the relative uncertainty of measurement (relative to the initial weight) is an important parameter for evaluation in the laboratory environment. |
| **Verification** | The legally mandated evaluation of a measuring instrument to determine its conformity with legal requirements, based on both a technical examination and the labeling of the instrument. |
| **Verification scale interval (e)** | A value expressed in a legal unit of measurement (mg, g, kg, t, ct) used during the evaluation of the weighing instrument and referenced in defining the maximum permissible error on verification. |
| **Weighing instrument verifiable for legal metrology** | A balance that has been approved for verification. |