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The Perfect Microbalance for Every Application

New Innovations for Microbalances

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Abstract

Micro- and ultra-microbalances are very precise measurement devices with a scale interval of 0.1 µg or 1 µg that are used to weigh very small sample amounts. Obtaining reliable weighing results with these balances requires special considerations regarding the installation site in addition to optimized ergonomics and technical controls. Sartorius's innovative micro- and ultra-microbalances offer both accuracy and ease of use for routine measurement.

It is fascinating that we can use micro- and ultra-microbalances to weigh sample amounts so small that they are invisible to the naked eye. Considering the conventional visual range of 25 cm, some people can still distinguish structures with a distance of 150 µm. This corresponds to a viewing angle of approximately 2 arc minutes. Others can only distinguish structures at a distance of 300 µm or 4 arc minutes. On average, the healthy human eye can resolve two independent structures at a distance of 200 µm (the normal visual acuity of the human eye at a comfortable viewing distance (d) of 12 inches (appr. 30 cm) is 0.00349 inch (appr. 89 µm) with Φ = 1/60 of a degree).

$$\frac{X}{2} = d * \frac{tan\Phi}{2}$$

A small particle with a density of 2 g/cm^3 and a weight equal to the smallest scale interval of a microbalance has a diameter that is less than 100 µm. An ultra-microbalance with a readability of 0.1 µg can accurately determine the weight of a particle with a diameter of only 45 µm. So even if the particle size is below the visual acuity of the human eye, the weight can be accurately determined. That is why touching a sample or vessel with bare fingers must be strictly avoided.

A single fingerprint can weigh up to 50 µg and therefore has a major impact on measurement accuracy. To put it in another perspective, an ultra-microbalance with a scale interval of 0.1 µg and maximum weighing capacity offers a resolution in 21 million steps. That is comparable to measuring a distance less than 2 meters of the earth's circumference at the equator (approximately 40.075 million meters). In weight units, this is fine enough to measure a weight of 1 g of a total mass of 21 tons. This high resolution provides ideal support for measuring the smallest sample weights below 1 mg within one part per thousand. For such applications, micro- and ultra-microbalances with ten time greater accuracy are needed.

Typical areas of application for the micro- and ultra-range weight measurement are filter weighing (filter particulate matter and residual dirt analysis), pipette calibration, measuring the coating of medical products (stent weighing), pesticide analysis, measuring the incineration or drying of chemicals or finished goods and the dispensing of medical drugs. Micro- and ultra-microbalances therefore play an essential role in R&D and industrial quality control laboratories in the automotive, pharmaceutical, chemical, food, mining industry, and medical device manufacturing. Most of these industries are subject to strict legal regulations. In particular, the international pharmaceutical industries like the United States Pharmacopeia (USP), European Pharmacopoeia (Ph. Eur.) and Japanese Pharmacopeia (JP) set stringent requirements to meet the highest weighing standards. Therefore, the manufacturers of micro- and ultra-microbalances offer technical features and controls that ensure the instrument specifications are not only maintained under optimal conditions in the manufacturer's testing laboratory, but also at the installation site.

Ideally, micro- and ultra-microbalances are set up on a stable worktable, preferably on a weighing table specially designed for this purpose and optimized accordingly. In addition to the ideal installation location, the weighing module must be properly leveled to give reliable results. The new technical feature on the Sartorius micro- and ultra-balances offer motorized automatic leveling. The user can check the leveling in the balance Status center and start the automatic leveling function with a single push of a button (Figure 1).

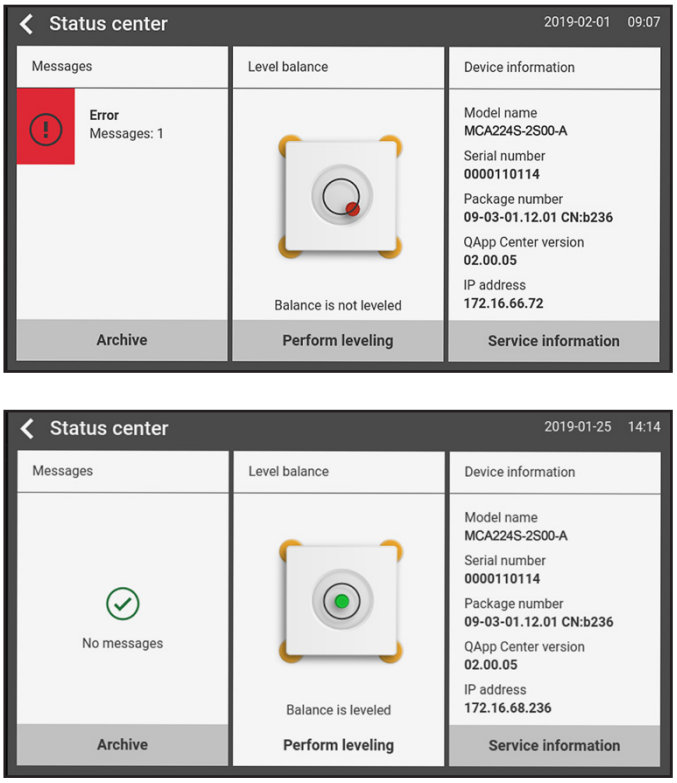

Figure 1. *The Status center displays the leveling status of the weighing module. If the weighing module is not properly leveled, the virtual spirit level is out of center, colored red and the Perform leveling button is active. Pressing the Perform leveling button initiates the automatic motorized leveling function. After leveling, the virtual spirit level is centered, colored green and the button Perform leveling is inactive.*

Additionally, the balance continuously monitors the leveling status and other factors, such as the temperature and the time since the last internal adjustment, and alerts the operator as needed. This is achieved by setting the *Safe Weighing* mode to *Warning*, and the *isoCAL execution mode* to *Manual* (Figure 2).

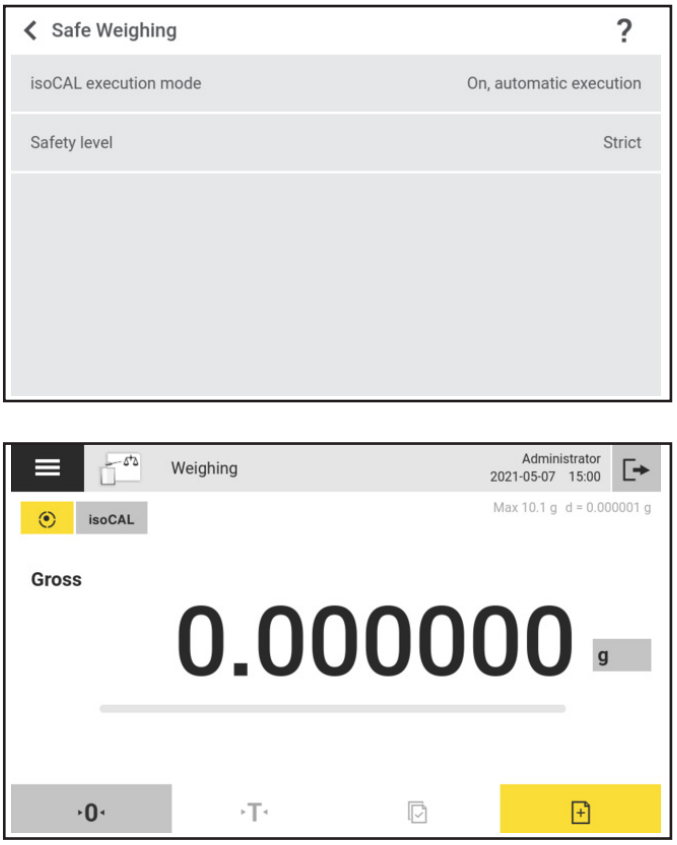

Figure 2. *If the Safe Weighing mode is set to Warning and the isoCAL execution mode is set to Manual execution, the display buttons for leveling or isoCAL are highlighted yellow when the balance must be leveled or if an internal adjustment is needed. The yellow color provides the operator with direct visual feedback when an action is necessary to ensure proper weighing results. If the Safe Weighing mode is set to Strict, weighing measurement only begins once the balance is properly leveled or the internal adjustment is performed.*

When the *Safe Weighing* mode is set to strict, weighing applications will not initiated if the balance is not properly leveled or an internal adjustment is needed. These automatic safeguards ensure the reliability of weighing results and provide peace of mind for the user.

Even with proper leveling and the optimal installation location, micro- and ultra-microbalances are susceptible to changes in environmental conditions, such as temperature, air pressure and relative humidity. Air pressure changes, for example, affect the air buoyancy, and low relative humidity can increase interference by static electricity. Both air buoyancy and static electricity can affect weight readings. Therefore, it is important to monitor the laboratory climate and maintain a constant environment around the weighing stations. The Sartorius micro- and ultra-microbalances come with an optional climate module tower that measures temperature, humidity, and the barometric air pressure. The data is accessible on the unit *Status center* (Figure 3) and is used to perform corrective weight adjustments by some software applications.

If the relative humidity drops below 40%, the risk of interference by static electricity raises significantly. lectrostatic influences are easy to detect by the continuous drift of displayed weight readouts. Increasing the air humidity to 60% and using an ionizer can eliminate the effects of static electricity. Ionization can neutralize electric charges on surfaces, such as glass vessels.

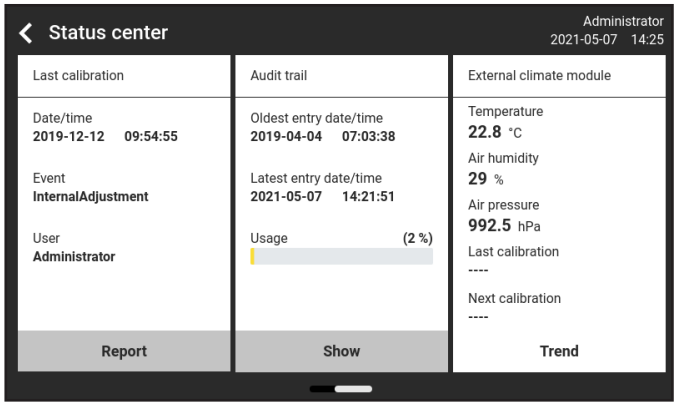

Figure 3. *The external tower with climate modules transfers data to the balance. The real-time temperature, air humidity and air pressure can be viewed on the balance status center.*

Magnetism is another factor that impairs weight measurement. Weighing magnetic materials, or magnetizable tare vessels or samples may compromise the weighing accuracy and reproducibility. Using tare vessels or samples containing iron, steel, cobalt, or nickel can lead to stable, but non-repeatable weight readings. Depending on the position of the vessel or sample on the weighing pan, different weight values are displayed. Magnetism could also be caused by the weighing pan or a sample holder made of steel. If the sample holder or weighing pan is rotated to achieve a better vessel accessibility, the orientation of the magnetic fields changes and can influence the weight measurement. This is why the sample holders, weighing pans and the draft shield base plate of Sartorius's micro- and ultra-microbalances are made of titanium as this metal is non-magnetic (Figure 4).

Figure 4. *Microbalance weighing module with crystal clear glass draft shield and sample holder for stent weighing. The draft shield base plate and sample holder are made of titanium. The round, flat weighing pans with a diameter of 20/30 mm and 50 mm, which are part of the standard delivery contents, are also made of high-quality, non-magnetic titanium. The weighing chamber can be dissembled easily and within a few seconds for cleaning purposes.*

Cleanability is also important for routine maintenance. Titanium is easy to clean and offers high resistance against many corrosive chemicals. The weighing chamber of micro- and ultra-microbalances is made of high-quality materials with smooth surfaces and can be easily disassembled for cleaning.

Ergonomics plays an essential role in accurate weighing of very small sample amounts. Transferring sample from a piece of weighing paper or foil into a vessel carries the risk of sample loss. Depending on the sample properties, a significant portion of weighed sample might remain on the paper or foil during transfer, leading to inaccurate sample preparation. Direct weighing into the vessel requires a specific set of accommodation from the balance unit. Balancing powdery or granular samples on a spatula and in parallel opening the draft shield manually is distracting for the operator. In regulated pharmaceutical industry settings where highly active substances are measured, this could not only fatigue the user, but also be dangerous. Sartorius's micro- and ultra-microbalances with glass draft shield have proximity sensors that detect the operator's hand in front of the weighing module and automatically open/close the smooth-action draft shield, facilitating fast and ergonomic work procedures (Figure 5).

Figure 5. T*he proximity sensors are located on the left and right of the glass draft shield. The sensors detect the operator's hand and automatically open the draft shield, and close it when the hand is moved out of the sensor's detection range.*

The sensitivity range for the left and right proximity sensor can be adjusted independently of each other in three steps (short, medium, and long) under the balance settings menu (Figure 6). A fourth option allows for switching off a proximity sensor to prevent the draft shield opening to the unwanted side

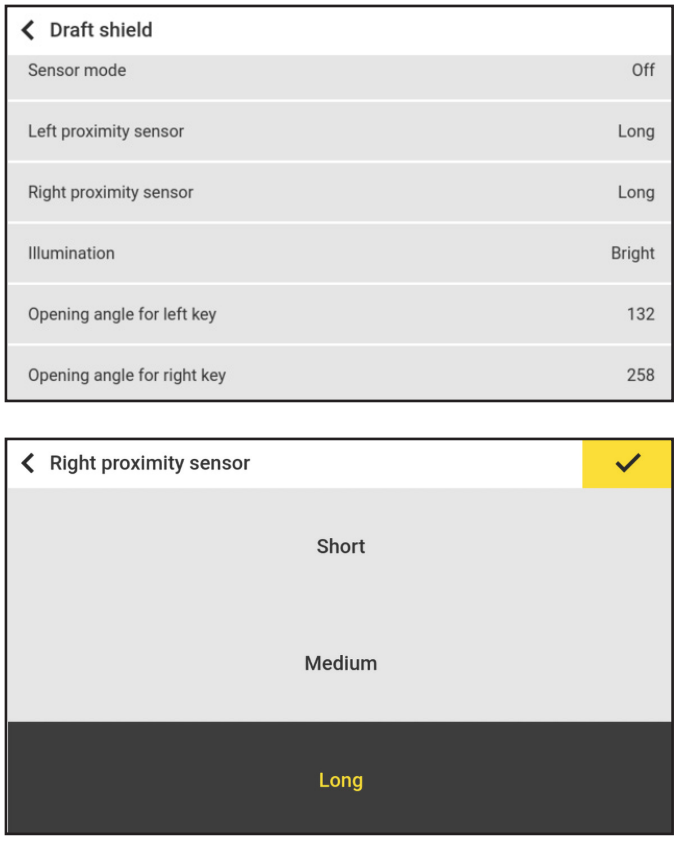

Figure 6. *Settings menu for proximity sensors and palm keys. The proximity sensor sensitivity range can be adjusted in three steps or the sensor can be switched off. Under the settings menu, the operator can use the palm keys to define (in degrees) the draft shield opening angle.*

The automatic draft shield functions and settings significantly increase safe sample handling and prevent the interruptions from manual operations. However, users who prefer not to use the proximity sensors can control the draft shield via palm keys located on the display (Figure 7).

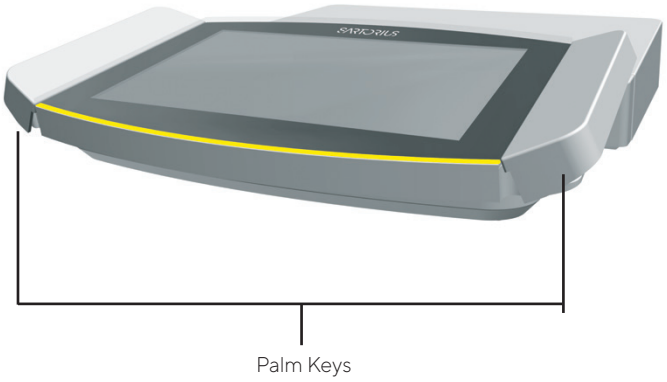

Figure 7. *Removable palm keys located at the Cubis® II MCA display.*

Gentle pressing on the palm key opens or closes the automated glass draft shield to the opening angle defined in the balance settings menu (Figure 6). The palm keys are held in place by magnets and can be removed from the display for easy cleaning.

Another factor influencing sample weighing ergonomics is the visual workflow control. Sartorius's micro- and ultra-microbalances are equipped with a crystal-clear tempered glass draft shield plus LED backlight illumination. The LEDs are located in the weighing module and light the draft shield interior (Figure 8).

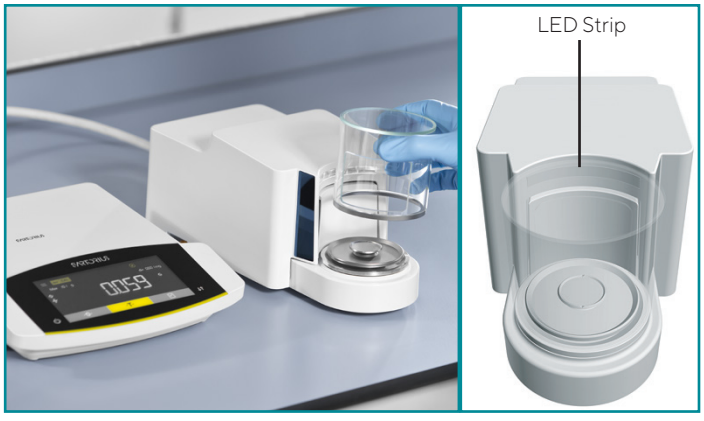

Figure 8. *The crystal-clear glass and LED backlight illumination improve visibility of all the actions inside the draft shield. The LEDs are located in the weighing module and their intensity can be adjusted under the balance settings menu.*

The illuminated draft shield allows for clear sample viewing and optimal handling of even the smallest sample amounts. For light sensitive samples the LED intensity is adjustable in three steps or can be switched off (bright, medium, dark, or off) (Figure 9).

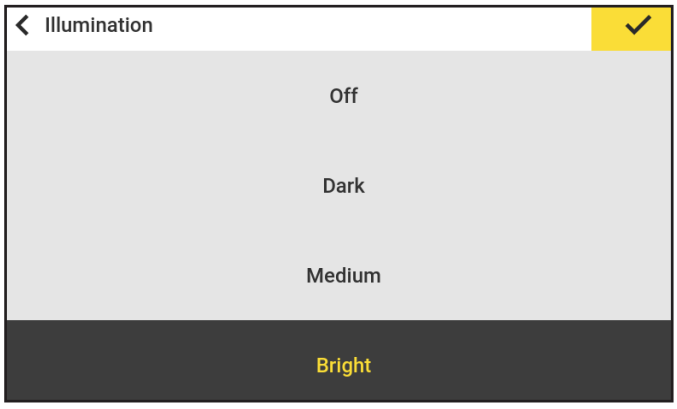

Figure 9. *Settings menu for the LED intensity.*

In addition to the LED illumination, the round glass draft shield has no frame components that interfere with the operator's line of sight on the small – sometimes microscopic – samples and provides a learning function. The desired opening angle can be adjusted in the balance settings menu by entering the angle (in degrees) using the numeric keypad, or by manually opening the draft shield to the desired position. The balance software saves the actual angle and opens the draft shield to the same angle the next time. Using the draft shield learning capability, the balance can be adapted quickly and easily to changing routines. Furthermore, the glass shield is treated with a special conductive coating that helps to prevent static electricity, which often occurs under conditions of low humidity (see above, paragraph on static electricity).

The Cubis® II micro- and ultra-microbalances series offers models with different weighing capacities and scale intervals. For the highest sensitivity, the ultra-microbalance 2.7S is available with a maximum capacity of 2.1 g and a resolution of 0.1 µg. For higher loads, the single range microbalance models 6.6S and 10.6S offer a maximum capacity of 6.1 g and 10.1 g, respectively, and a scale interval of 1 µg. A poly range balance is also available in the Cubis® II microbalance portfolio with the model 3.6P. Here, the weighing capacity is divided into three ranges, 1.1 g, 2.1 g and 3.1 g, with different resolutions. At up to 1.1 g the balance weighs at a resolution of 1 µg, up to 2.1 g at 2 µg resolution, and up to 3.1 g at 5 µg resolution. Depending on the load, the balance automatically switches between the different resolutions. It is important to note the shift of the resolution range; if using a high tare load, the highest resolution is applied for the first 1.1 g of sample weight.

Cubis® II MCA micro- and ultra-microbalances have approximately sixty preinstalled weighing applications and extended functions in the QApp Center. In the QApp Center, applications are grouped by topic into different packages. The Essentials package offers thirteen different license-free weighing applications, covering basic weighing applications. Other applications or extended functions are grouped into five additional packages (Pharma, Advanced Applications, Utilities, Connectivity, and Specials). Except for the Specials software application, the remaining four software packages can be factory licensed at the time of purchase. Software applications and extended functions in these packages offer optimal support and technical controls for 21 CFR part 11 (audit trail, electronic signatures and user management) and USP chapter 41 (determination and monitoring of the minimum sample weight) or EURAMET cg-18 compliance (measurement uncertainty) and for guided weighing applications for filter or stent weighing (filter particulate matter, backweighing).

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