Application Article

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Effects of Static Electricity on Analytical Weighing

Introduction

Among the various options for eliminating static electricity during analytical weighing, there are simple, low-cost measures available. However, due to the current metrological and practical limitations, many of these measures are difficult and time-consuming to use and are not universally applicable. On the other hand, there are methods that are both powerful and space-saving, particularly when they are integrated directly into the balance.

Static electricity is a physical phenomenon that is a common occurrence in many areas of our daily lives, and it can have tremendous significance in industry and all kinds of research and development laboratories. Electrostatic charging of materials, for instance, in industrial processes and during production sequences or materials analysis can have negative effects. For example, dosing powders with a spatula or dosing heads risks spreading the substance so it cannot be brought into the vessel without spilling. Electrostatic discharges can damage electronic equipment and components. Spark discharges can easily ignite flammable substances in the immediate vicinity, which, for example, can lead to serious accidents. Thus, millions of dollars are spent around the world on efforts to eliminate electrostatic charges and their associated negative effects.

Basics of Static Electricity

Static electricity results from friction between two objects (bodies). This friction process transfers electrons from objects with a lower work function (donator) to objects with a higher work function (acceptor), which results in the production of ions (see Fig.1). A body with excess electrons takes on a negative charge, while a body lacking electrons takes on a positive charge. However, this is only a temporary change in the charge because any excess electrons flow off of the body once it has a certain conductivity or is grounded.

Friction can occur within the sample itself or between the sample and container or tare vessel. For example, during convection in a drying oven, air friction creates a charge on glass containers, and internal friction of powders and liquids when they are transferred between containers creates a charge on particles within that sample. In practice, it is impossible to avoid friction during the processing or transport of substances. Thus, electrostatic charging occurs nearly 100% of the time. Disruptive electrostatic forces can also occur in the area around the balance, due to the direct transfer of charge carriers by people moving around the balance.

Direct Impact on Weighing

All balance manufacturers are called upon to respond to the problems of weighing substances with electrostatic charges with appropriate technological solutions. Static electricity can have a negative effect on either the weighing process itself or on the results, thus requiring time-consuming material selection or material handling procedures to address these effects. In some cases, weighing a material may be close to impossible due to the build-up of electrostatic charges during handling. In addition, the electrostatic properties of some materials may vary as ambient humidity rises and falls, making the attempt to weigh it even more difficult. Often, electrostatic phenomena are worse when the relative humidity falls below 45%–which is often the case in winter in European latitudes or in air-conditioned rooms. Therefore, balance users will experience different conditions from one season to the next or from one day to the next, making it difficult to reproduce their results.

Electrostatic charging of materials can occur in the following conditions:

- in solids, when the surface resistance of the material Rs > 10 GΩ (according to IEC93)
- in liquids, with a conductivity of < 10 nS/m
- in conductive materials that are not grounded

During a weighing operation, the interaction of electrical charges that have built up on the material being weighed and the fixed parts of the balance, which are not conductively connected to the weighing pan, cause this electrostatic force.

An electric field, thus, builds between the material being weighed and the fixed parts of the balance. Some examples of fixed balance parts include the draft shield or housing parts, such as the balance base plate.

The resulting electrostatic forces can cause load changes (displayed values) up to the order of a gram. In practice, a false absolute weight is not the only negative effect associated with static electricity. Severe drift of weight readouts and poor repeatability of results are also serious problems.

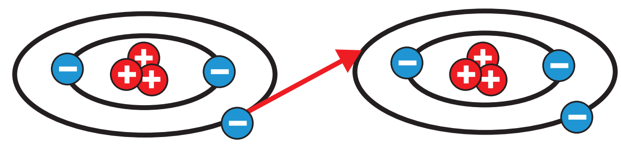

Figure 1a:
Schematic illustration of ion creation: When two neutral atoms collide or experience friction, the body with the lower work function loses an electron.

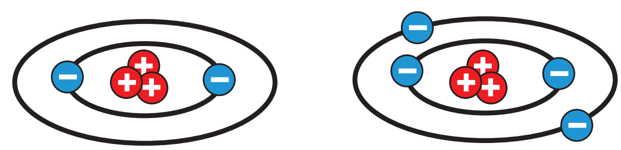

Figure 1b:
The lost electron moves to the body with the higher work function, and an ion is created.The total charge of the atom on the left is positive (positive ion); the total charge of the atom on the right is negative (negative ion).

Built up charges flow off slowly via the weighing pan, so that the resulting forces are not constant over time, causing drift and poor repeatability. Depending on the polarity the charge carries, the interaction can be either repulsive or attractive, meaning the weight results can deviate both positively and negatively.
A repulsive interaction occurs when both the charge on the sample and the ambient charge have the same polarity (both + or both −) (see Fig. 2). The material being weighed seems heavier than it actually is.

An attractive interaction, on the other hand, occurs when the charge on the sample and the ambient charge have different polarities (one + and one −). An attractive interaction will, thus, make the material being weighed seem lighter than it actually is (see Fig. 3).

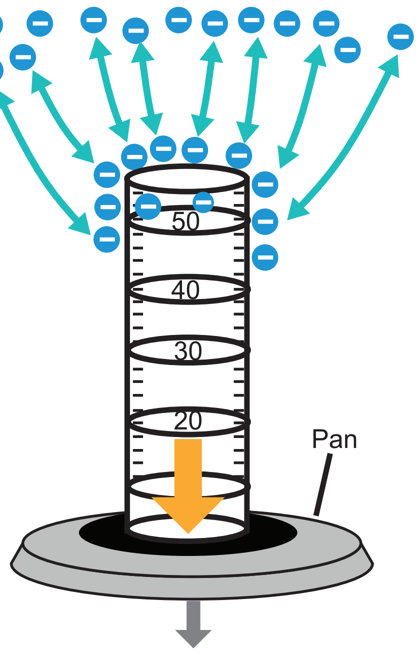

Figure 2: Repulsive interaction during weighing. When both the weighing container and the environment are negatively charged, the resulting force is directed downward (yellow arrow). This makes the sample appear heavier.

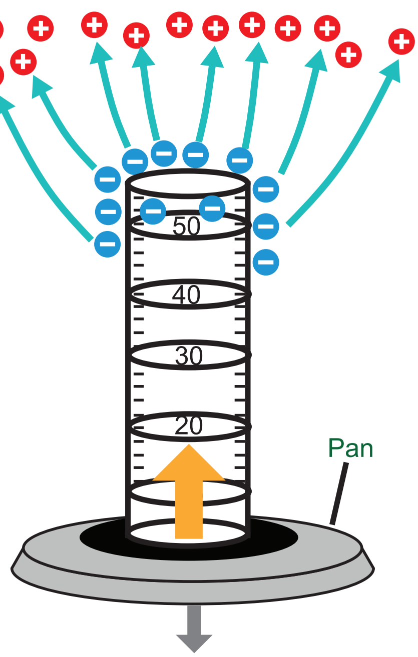

Figure 3: Attractive interaction. When the weighing container and the environment have opposite charges, the resulting force is directed upward (yellow arrow).This makes the sample appear lighter.

Neutralizing Electrostatic Charges

To eliminate the effects of static electricity on weighing, keep both the sample and the area around it free of any charges. One method that has yielded excellent results to shield the weighing chamber and the weighing pan from electrostatic fields is to use a fully transparent conductive coating on all glass elements of the balance draft shield. All glass draft shields of the Cubis® II series include this important feature.

Another solution includes using ionizers and anti-static pens near the balance (see Fig. 4). This solution works on the principle of surface neutralization via ion bombardment. In most situations, surface neutralization is very effective at reducing charge buildup when it is helpful to eliminate electrostatic charges on vessels and samples in the external environment of the balance.

Figure 4: Ionizer and anti-static pen

Below-balance weighing can be used for weighing bulky materials, such as plastic blocks. The sample is secured using a hanger beneath the weighing pan to take advantage of the proportional reduction in electrostatic force that occurs with the square of the distance between the charge carriers. Of course, this method of reduction of the influence of electrostatic charges can also be used while weighing on the weighing pan; any influence of electrostatic forces on weighing results can be reduced if the distance between the sample and the weighing pan is significantly smaller than the distance between the sample and the fixed parts of the balance because the weighing pan provides an effective shield. However, if the opposite is true, electrostatic charges will still affect the weighing process. Sometimes it is sufficient to place an object between the sample and the weighing pan, reducing the forces to the point that they have no noticeable effect on the weighing result. For some applications, it is also enough to increase the shielding effect of the weighing pan. For this purpose, special pans (Figure 5) with a greater diameter than standard pans are offered.

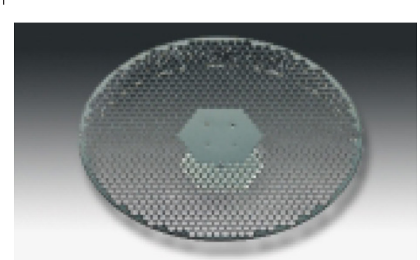

Figure 5: Anti-static weighing pan for improved shielding of electrostatic charges from samples. Designed as a perforated disk to reduce its weight, this pan style is used primarily for weighing filter materials.

Figure 6 shows an example of a specific balance for weighing filters which uses a Faraday cage (a grounded metal shield) to solve the problem of electrostatic charges. While weighing, the weighing pan and an electrically conductive cover attached to the pan shield the filters completely. This filter weighing balance is often used to determine particulate matter in emission measurements in the automotive industry or environmental institutes.

Figure 6 : Cubis® II Micro balance with special draft shield M for weighing filters of sizes up to 90mm.

Useful Equipment to Avoid Influences of Electrostatic Charges

Generally, the time needed to neutralize electrostatic charges depends on the material, surface, and shape of the sample, as well as the relative humidity in the vicinity of the balance.

The new Cubis® II balance offers the Q-Stat ionizer, which is integrated in the draft shield I of the modular balance series and eliminates electrostatic charges within a few seconds.

Figure 7: The Cubis® II motorized automatic draft shield I includes an ionizer with four jet nozzles for effective elimination of electrostatic charges.

In the draft shield I of the Cubis® II, four nozzles jets are positioned in the rear wall (see Fig. 4). The physical functional principle of these nozzles is Corona Discharge, a process by which a current flows from an electrode with a high voltage into the air. Around the very thin needle, the electric field strength is so high, that the air molecules are ionized and create a region of plasma around the electrode. The generated ions pass the charge to areas of lower potential. After recombination with free charges they form neutral gas molecules again.

The use of four nozzles in the Cubis® II balance makes charge elimination very effective. By using opposite polarity of the nozzles, a kind of focusing effect in the area of the weighing pan occurs. This makes the neutralization of electrostatic charges from sample containers and substances, for instance, powders, very effective without disturbing airflows. This prevents errors from electrostatic forces in the weight measurements.

Moreover, the fully transparent conductive layer on the draft shield glass panels of this models provide additional protection from electrostatic fields in the immediate proximity of the balance. This too ensures stable and correct weighing results independently of electrostatic charges.

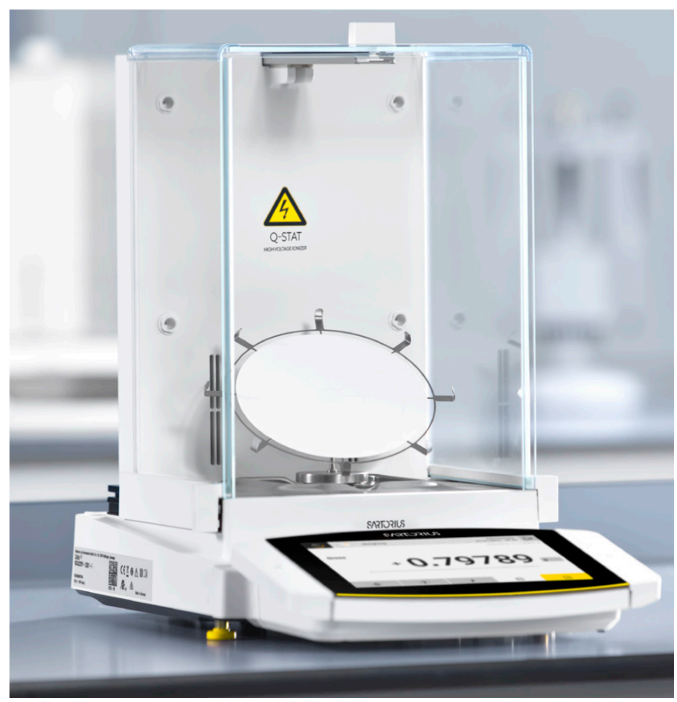

Figure 8

Cubis® II supports different applications in which an elimination of electrostatic charges is essential to measure very small amount of particles on filters (here with special holder YSH30 for filter diameters up to 150mm).

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