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Dealing with Electrostatic Charge in Analytical Balances

Electrostatic charge creates forces in analytical balances cause offsets which directly affect the weight measurement . In addition, charge on powders being measured can cause the powder to be scattered in handling, making a mess. Many investigators simply zero out this effect and believe that they have erased the effect of static charge. Some place an ionizer at the door to the balance to neutralize the charge and eliminate both effects. Such an ionizer solves neither problem. The effects of static charge are not a simple, "set it and forget it", variable. This article provides answers to the questions :

Where did the charge come from in the first place?

Why does it keep changing?

How can I find a procedure that gives me the most accurate weight measurement?

What ionizer technology should I use?

Origins of Static Charge

Any time two different materials come in contact, some amount of charge is exchanged between them. The amount of charge exchanged depends upon the electron affinity of the materials, the surface conditions and details of the contact. When they separate, they come away with a potential difference (Voltage) between them.

If these materials are grounded conductors, the charge is rapidly shunted to ground and no net charge remains. If one or both of them are either insulators or ungrounded conductors, the charge remains. Insulators play an important role here and most powders being weighed are insulators as are the windows in the analytical balance. The act of removing the reagent from a glass container will charge it through contact and separation from the glass. Brushing against the window will leave it charged. Voltages of 5,000 Volts are common. The static charge levels normally experienced in the weighing process can easily effect the readings of the balance by 10 mg.

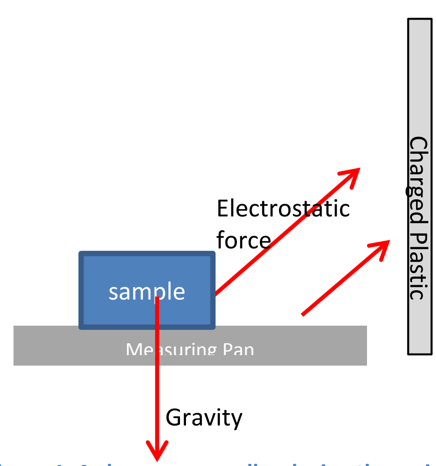

Figure 1. A charge on a wall reducing the weight reading of the analytical balance.

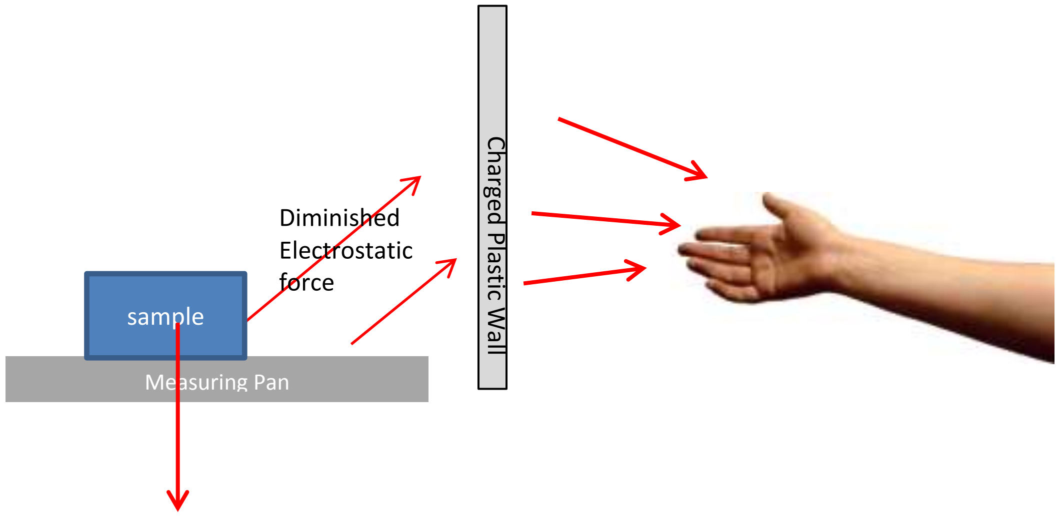

Figure 2. The operator will affect the balance zero adjustment.

Why not Just Zero it Out?

Charge on an object near the measuring pan will attract the pan and lower the weight reading. See Figure 1. This effect can be zeroed out but the zero point of a balance exhibits a certain amount of wander. Why does this happen? If the measurement pan and the charged wall are separate from anything else, zeroing out the offset works well and no wander will occur.

When a conducting object moves into the environment, the electric field lines from the charged wall are attracted not only to the pan but also to the other conductor. In effect, the second conductor is taking some share of the electrostatic force and lessening the effect on the measurement pan.

A good example of this effect is the operator himself. (Figure 2) Moving into the region near the balance will change the offset weight measured by the balance. When the operator moves away, that effect is eliminated and the offset shifts. The same applies to other objects the field caused by charge on the window until they are several window dimensions (length or width) away from the balance.

What is the Solution?

Unfortunately, the only solution which solves all of these problems is to get rid of static charge in the first place. This is comprised of two steps:

1. Neutralize the entire balance.
2. Keep charged objects away from the balance.

The way to neutralize the balance is to use air ionization to create a neutral environment. An air ionizer produces a balanced population of positive and negative air ions (N_2^+ and O_2^-) that flood the environment of the balance. These ions search out regions of the opposite charge and neutralize them. See Figure 3.

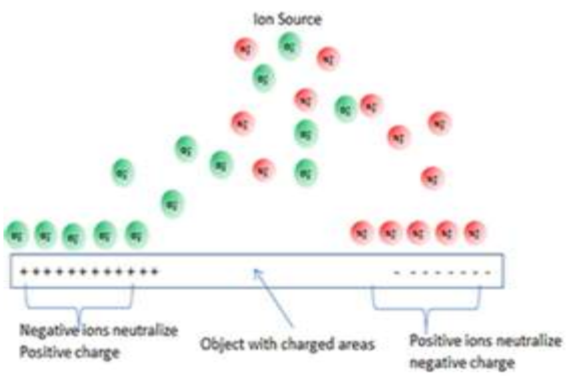

Figure 3. An air ionizer used to neutralize static charge.

What needs to be Neutral?

Everything in the balance chamber must be neutral to avoid electrostatic attraction of the measurement pan. This includes the walls of the chamber and the reagents and container in the chamber. In an attempt to deal with static issues, often ionizers are located at the entrance door to neutralize the sample as it enters. Most technologies do not provide ions that live long enough to traverse the width of the balance so that charge on the surface opposite the door and on the ceiling of the balance are not neutralized. The ionizer must address the issue of recombination to successfully discharge all surfaces within the balance.

Ion Recombination and Ionizer Technology

The ions from the ionizer are subject to recombination. The positive and negative ions are attracted to each other and ultimately neutralize each other, thus limiting the effectiveness of the charge neutralization technique. Depending on what technology is used to make the ions, the ionizer can deliver ions over a few centimeters or a meter. It is important to select an ionizer for your balance which can neutralize the entire balance chamber and not just the entrance port.

The Job of the Ionizer

The job of the ionizer is to neutralize static charge on the sample but also the entire balance chamber. Owing to recombination, most configurations placed at the entrance door do a good job of discharging the sample but not the chamber walls.

The two most common technologies to use for ionization in a balance are corona and alpha. Corona ionization involves the use of very high voltage on sharp needle points. This breaks down the air molecules and creates air ions. Alpha ionization uses collisions between air molecules and alpha particles to create air ions.

Both create a “cloud” of air ions near the ionizer and count on charged object within the balance to draw the ions to them by electrostatic force. Unfortunately, the vast majority of ions from such an ion cloud recombine before they traverse the balance chamber and thus the ionizer does little to discharge the chamber. Measures must be taken to combat recombination so that all of the charges within the chamber are neutralized.

Pulsing a Corona Ionizer

One technique with a corona ionizer is to pulse it positive and negative at a modest rate of about once per second. This technology, called pulsed DC, has the effect of separating the ions into positive and negative clouds which, owing to the separation, do not recombine. This does a good job of extending the range of the ions so that the entire inside of the chamber is contacted by ions. Unfortunately, the voltages required to make ions by corona are ±6,000 to ±15,000 Volts. This is high enough to create measureable forces on the pan and affect the weight reading. For this reason, pulsed DC corona ionizers are not used in balances.

Pulsing an Alpha Ionizer

The idea of pulsing the ionizer positive and negative successively can also be applied to alpha ionizers. Putting a voltage waveform on the source itself creates a modest electric field that pushes one polarity of ions into the balance at a time, thus limiting recombination. This technique is called AlphaBoost. This allows the alpha source ions to move through the entire balance chamber and neutralize the entire instrument. See Figure 4.

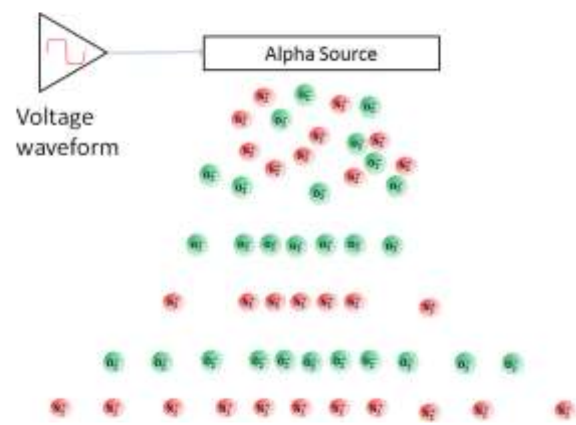

Figure 4. A pulsed alpha ionizer used to minimize recombination and discharge the entire chamber volume.

This accomplishes the goal of complete ionization and the voltages required are roughly 10x smaller than those used by a pulsed corona ionizer, thus minimizing the affects upon the weight measurement.

Wireless Technology

The design goal for the pulsed alpha ionization system was to minimize the difficulty in installing the electrical connections into the balance necessary to pulse the alpha ionizer. One objective was to make no holes in the instrument. This was accomplished by a novel technique of passing the driver electric field waveform through the plastic or glass wall of the balance. A driver electrode is placed on the outside of the balance using adhesive and a driven electrode is placed inside the chamber adjacent to the driver. See Figures 5 and 6.

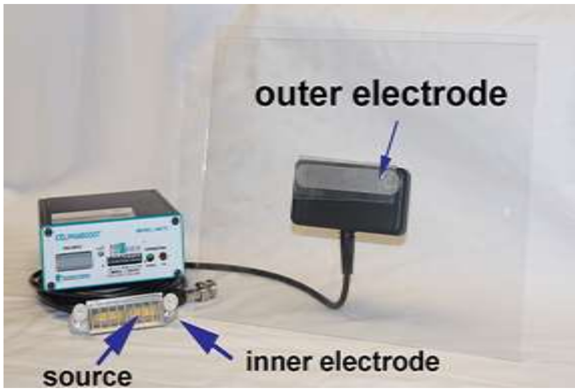

Figure 5. The wireless alpha ionizer components.

Figure 6. Passing electric fields through a glass wall.

The fields pass un-attenuated through glass or plastic and work as if there were a hard wire connecting them to the source. Ions are delivered throughout the balance chamber.

Secondary Electrostatic Effects

The remaining step for the greatest accuracy in the most sensitive of weighing applications is to keep the environment of the balance free from objects which are likely to be charged. These include plastic bags, glass reagent jars and laboratory glassware. They should be several times their own dimension away from the balance. For example, a 6 inch (15 cm) test tube should be kept at least 1 foot (30 cm) away from the balance.

Also, for the greatest accuracy in weighing, it is recommended that the operator be grounded. The standard grounding technique is the use of a wrist strap Thee are worn around the wrist of the operator and connected to a ground (3rd terminal of the power line or directly to a water pipe. (Figure 7).

Figure 7. A wrist strap serves to eliminate static charge on the operator.

Summary

The most sensitive weighing applications suffer from offset wander due to both static charge within the balance and objects in their environment. Use of an air ionizer eliminates most of the effects of electric fields from static charge if an ionizer with pulsed technology is used. Far and away the simplest to install is the wireless AlphaBoost alpha ionizer.

Keeping the environment of the analytical balance free from insulators and grounding the operator are the steps that should be taken for the most demanding applications.