A Knowledge Pill about Weighing Devices and Weighing – an Interview with Slawomir Janas, PhD

One of the important issues that is related to the laboratory concerns weighing. Unfortunately, very often many factors negatively affect this activity and can disturb the correct result.

We invite you to read an interview with Slawomir Janas, PhD who has been involved in topics related to metrology, mass measurement, water content measurement and validation of measurement methods for more than 25 years. He is the author of numerous guides on practical aspects related to the use of electronic weighing devices and several scientific publications published in Metrology and Measurement Systems, Heat and Mass Transfer. In the area of legal metrology, he is responsible for cooperation in testing with notified bodies. Currently, he is Head of the Testing Laboratory at the RADWAG Metrology Testing and Certification Center.

The interview was conducted by Anna Baranska.

Anna Baranska: What factors do we need to pay attention to when setting up the balance in the laboratory room so that they do not adversely affect the weighing?

Slawomir Janas: Measuring weight seems like a fairly simple activity, and this is in fact the case. An object placed on the weighing pan is attracted by the Earth with a gravitational force F, the value of which, in general terms, can be given as the quotient of the mass of the object being weighed and the Earth's acceleration at the place where the measurement is made (F = mg). The value of gravitational force is scaled at the factory against the weight of certified mass standards, which allows the final presentation of the result of measuring the weight of a load in such units as gram, kilogram, milligram, etc. Thinking about conditions in the laboratory, two aspects should be taken into account, namely the influence of environmental factors on the operation of the balance and on the condition of the weighed sample. It should be noted that a balance is a de facto measuring instrument, which, from a metrological point of view, is characterized by such features as elementary plot, precision of measurement, systematic error and stability of indication. It is obvious that the manufacturer of the balance tries to develop the design of the balance so that it works correctly under all conditions. Potentially, this is possible, but it would require huge expenditures and a lot of testing, and thus the unit cost of such a balance would be absolutely unacceptable to the market. For this reason, all balances have a certain range of temperature and humidity defined in which they will work correctly. It should be unequivocally stated that the most important thing is not the value of the temperature and humidity in which the balance operates, but rather the dynamics of changes in these factors per unit of time. A definite negative factor that interferes with the operation of balances is excessive air movement. This is usually the result of air conditioning or personnel movement. Reducing the impact of this factor is achieved by so-called blow shields – this is the cheapest and effective solution to this problem. In more sophisticated systems, the air is transported through a system of multiple ducts, resulting in the so-called laminar air movement. This is a rather complicated solution when you consider that the air must have certain parameters – it must be humidified and dehumidified while maintaining a stable temperature. The last important factor is the vibration of the substrate, which can significantly disrupt the mass measurement process. Not all vibrations are destructive, and their effect on the accuracy of mass measurement depends on the nature of the vibration (frequency, amplitude) and on the design of the balance. Reducing the impact of vibrations is achieved by using anti-vibration tables and partly by electronic filtering of the measurement signal. In conclusion, it can be said that for proper operation of electronic balances, stable temperature and humidity in the workplace are required. Stability here should be understood as a slight variation in temperature and humidity relative

to a certain set value. On the other hand, the influence of environmental factors should be considered in the context of balance resolution. Much better stabilization of temperature and humidity is required for a microbalance with a resolution of 20 million divisions, such as MYA 21.5Y, than for a balance with a resolution of 2 million divisions, such as AS 220.X2 PLUS. This aspect should also be kept in mind when evaluating the laboratory's suitability for various electronic scales.

One of the most common questions on the minds of laboratory staff is how often to perform balance calibration. What factors should be taken into account to set this date in our "Calibration Schedule for Measuring and Testing Equipment"?

Undoubtedly, calibration of the balance is an important element in the quality management system of any laboratory. Through this procedure, reliable information is obtained regarding how accurately the balance is able to measure weight. In most cases, there are no normative requirements governing the periods between calibrations. For this reason, most laboratories perform calibrations with a 2-year interval. The question as to why such an interval is adopted is usually not satisfactorily answered. Some guidance on the method of determining calibration intervals can be found in ILAC document G-24:2022. Several methods for determining intervals between calibrations are presented there, but note that current information on the condition of the balance is obtained as a result of daily checks. Therefore, it can be said that from a metrological point of view, it is the current information that provides the main premise for whether it is already time for the next calibration. Such an approach is as logical as possible, since the checking system, if well designed and implemented, is valuable information about the potential variability of the balance readings over time. For such a concept, the so-called SOP (Standard Operation Procedure) becomes crucial, where the awareness, knowledge and skills of the balance operator are important.

A rather troublesome factor during weighing is electrostatics. Please tell us what electrostatic charges can arise during weighing and how to deal with them?

Electrostatics, in general, is the presence of unbalanced electrical charges in our environment. Bodies with such charges on them attract or repel each other. When a weighed object has such unbalanced charges on its surface during mass measurement, the result of the mass measurement is usually incorrect or unstable. The simplest method of obtaining unbalanced electrostatic charges is friction between two surfaces. Another way to transfer electrostatic charges is by touch or induction. Regardless of how this disturbance is generated, its elimination requires the use of a deionizer whose task is to restore the electrostatic neutral state of previously electrified objects. It should be mentioned here that an important factor that promotes the formation of static electricity is low humidity in the laboratory. The phenomenon of electrification of weighed samples is particularly evident when measuring the mass of a very dry powder. During dispensing, a certain amount of the substance "sticks" to the walls of the vessel. This is a serious problem, especially when the cost of purchasing this substance is significant.

What are the most common factors affecting weighing accuracy?

The answer to such a question must take into account the fact that accuracy is a qualitative concept, and we need to think here more about the systematic and random error associated with weight measurement. The potential systematic error is rooted in the change in sensitivity of the balance, so the dynamics of temperature changes in the laboratory is an important factor here. As is well known, the prescription for this ailment, i.e., a change in balance sensitivity, is adjacency. This process is done for many balances in automatic cycles, but it is a good habit to perform adjustiment before a series of measurements. As for the random error, its magnitude depends on many factors, such as operator skill, ergonomics, variability of the working environment, etc. In this aspect, it is worth mentioning that

the accuracy of the measurement can also be “lost” as a result of the reaction of the weighed sample to the conditions in the laboratory. An inaccurate measurement will be obtained for an electrified sample, as well as for a low-moisture powder whose mass is determined in the laboratory, where the relative humidity is, for example, 50%. There is no single set of factors that can be identified as those critical to the accuracy of the weighing process. Rather, here we should consider the influence of the weighing method, the type and size of the sample, as well as the variability of the environment and the resolution of the balance on the accuracy of mass measurement. It is a set of individual factors that characterize a given process taking place under specific conditions.

How often should the balance be checked with a mass standard and how often should the mass standard be calibrated?

The evaluation of the balance’s condition should be done daily before starting work. This is reasonable if we consider that the balance may be used by many lab technicians and they need to be sure that the measurement they take is accurate. The daily check of the accuracy of the balance’s measurements is carried out using mass standards to the extent that the balance will be operated. When the balance is used to measure the weight of strainers, filters, the daily check uses standards of, for example, 200 mg, 500 mg. In other cases, the inspection applies to the entire measuring range of the balance and can be carried out for different loads, although it is often 50 g or 100 g. The range of inspection is basically arbitrary, but the task of the laboratory is to demonstrate that the balance’s measurements are still correct. As for the mass standards, of course, they should be calibrated periodically to confirm their current mass, as the standards simply wear out. The calibration interval for a mass standard is usually 2 years, but this is a decision of the person in charge of the laboratory’s quality management system.

What elements are checked when calibrating a balance?

When calibrating a balance, four parameters are evaluated, namely measurement error, weighing precision, centricity error and measurement uncertainty. In many cases, the calibration range is predefined by the calibration laboratory, but it is always possible to calibrate a balance in the range in which the balance is used. The calibration certificate is an important document; on the one hand, it is important for the quality management system (audit), and on the other hand, it is important metrologically, as it gives information about the variability of the balance over time and the accuracy of the measurement.

Mr. Slawomir, please tell us whether balances can be calibrated in a non-accredited laboratory?

The essence of any measurement is that it should be consistent, accurate, by which it gives us confidence that the quality of the process we perform has a high level. For this reason, we need to periodically undergo evaluation by an organization independent of us with proven competence. Such an organization is an accredited laboratory. So, is it possible to calibrate balances in a non-accredited laboratory – probably yes, but it does not make sense, since we will not be sure that the calibration results are correct. An apt commentary for such a question posed is the maxim of Prof. L.N. Cooper which he included in his book “The Essence and Structure of Physics”: “Science requires us to make measurements for several reasons. One is the recognized need to separate our observations from our beliefs; the use of impersonal machines is one way of doing this. A second reason is the obvious desire to make measurements more accurate than our senses, unarmed by any apparatus, allow. The third is the utility of measurements that can be repeated in different places and by different people. So if we say that science measures, we mean this effort to obtain knowledge that is both accurate and consistent, so that people all over the world can reproduce it under the right conditions.”

Interviewed by: Anna Baranska