

Balance Calibration

AN INTRODUCTION TO MODERN LABORATORY BALANCES

Get the best balance for the job and get the best out of your balance.

Everybody in the lab knows what a balance does; but what is the value of that weight data to the user? And what will it be used for?

These are important basic questions that have to be answered when deciding which is the right balance for the job. There are after all a lot of balances out there, costing anything from a few pounds to several thousand pounds. And each one will serve some purpose – after all a \$10 bathroom scale is (usually) more reliable than a quick look in the mirror!

The electronic balance:

Modern balances have come a long way from the days of the knife-edge beam balance (which nevertheless still has important uses in the laboratory).

Today's electronic balance is (or can be) a sophisticated weighing device complete with a suite of software to record and process the results achieved during weighing. The first electronic balances appeared in the late 60's, at which time the ability to read and display one part in 10,000 (e.g. a balance with a total capacity of 1 kg reading to 0.1g) was quite an achievement. Today it is possible to display a weight to within 1 part in several million using new weight detection systems and sophisticated electronics.

For general laboratory applications there are two basic types of electronic weight detection system in common use. The strain gauge load cell and the electro-magnetic force system, both of which will be explained later in this article. There are of course other equally valid systems such as the tuning fork, which is based on the different frequencies emitted by a tuning fork or stretched wire under different loads, and the ceramic capacitance which reads the different levels of capacitance between two plates which are being urged together under a load.

What's the difference between a \$200 balance and a \$2000 balance?

Both are valid, both produce useful results. It all depends on what you want to do with those results. Spending £2000 will almost certainly give you more precise, dependable results than a £200 balance of equivalent capacity. This does not mean, however, that they will be of any more use. Fundamentally the difference lies in the type and degree of sophistication of the weighing technology used, and hence the level and reliability of the resolution achievable. The application usually will identify the type of balance needed.

Do you need to know absolute weights or relative values? Do you need high levels of repeatability? Do you need high levels of linearity? What other factors are important to you (speed? convenience? use by an unskilled operator? data collection via a PC? portability? Use in an industrial environment? Etc)

What most users believe they want is accuracy. So let's start by exploding a few myths. What exactly is accuracy? Is there in fact any such thing? Let's assume "accuracy" to be the balance's ability to measure a mass to within certain acceptable tolerance of traceable international standard. By this criterion no balance is inherently accurate. The traceable international standard must itself be the source against which the balance is calibrated. And there lies the key! Calibration, using appropriate reference weights, * providing a constant environment and calibrating at the location where the balance is to be used are the first steps towards an accurate result – and it is entirely a matter for the user to what lengths this process is taken.

The principal inherent features of a balance which contribute towards accuracy are resolution, repeatability and linearity. Calibrate with a 500g bag of sugar and the balance will not be very accurate but it may very well have excellent resolution, and linearity, and produce repeatable results!

Resolution: (sometimes called readability or division) is the number of divisions into which the total capacity is broken down for the purpose of displaying the weight value. This is normally expressed in grams. Thus a balance may be described as 1kg (capacity) x 0.1g (resolution)

Repeatability: is really self-explanatory. The same weight placed on a balance should give the same (or near enough the same) reading each time, under stable environmental conditions. It is the phrase "near enough" which is important here. What's near enough for your purpose? Repeatability is closely tied to resolution and is generally quoted as plus or minus so many scale divisions.

Linearity: is the ability of the balance to respond consistently throughout its capacity range. It should weigh within the acceptable tolerances at all points in its capacity. Not just at the calibration points.

External environmental factors affecting performance.

The most obvious external factors affecting performance are temperature and physical stability, and both of these can be overcome.

Most electronic balances have some form of internal temperature compensation. In high resolution balances it is often desirable to recalibrate the balance whenever the temperature varies outside predetermined limits. To this end analytical balances are frequently equipped with their own internal calibration weight and recalibration programmed.

It is also useful if the balance itself alerts the user to these temperature changes, which may otherwise go unnoticed. In any event an electronic balance must be given adequate time to stabilize after switching on before it performs correctly. For an analytical balance this could be several hours. Physical stability is improved by the use of a draft shield, which is standard on balances reading to 0.0001g or less, useful on 0.001g balances but of doubtful value on a balance reading to 0.1g.

Further improvements in stability can be introduced by the use of an anti-vibration weighing table.

So where is all this leading us? How can we decide which type of balance we need?

The most important fundamental factors in the balance specification are its maximum capacity and its resolution.

For coarser levels of resolution strain gauge load cells will give a perfectly adequate performance. They will generally not be able to achieve the levels of linearity and repeatability of an electro-magnetic force balance but modern software developments have facilitated significant advances in their performance.

The strain gauge load cell is an aluminum or steel element which bends almost imperceptibly when the load is applied. Precision resistors mounted on the cell are affected by this bending and variations in their resistance are used to calculate the amount of load being applied.

Electro-magnetic force, or force restoration, is the name given to the system in which a delicate mechanical structure is maintained in equilibrium by an electromagnetic field acting against the gravitational force applied by the mass to be weighed. The current required to maintain this equilibrium provides a very fine measure of the mass itself. This is a far more precise form of measurement and is the system most commonly used in laboratory balances with higher levels of resolution.

The combination of capacity and resolution must to some extent be a compromise.

It would be nice to have a balance capacity of 1 kg with a resolution of 0.1mg if the budget would stand it, but for the vast majority of applications this is not economically feasible! Having decided on the most appropriate combination it is now time to consider the importance of factors like repeatability, linearity, portability etc. Who will be using the balance? Where will it be used? Are absolute weight readings required or will reliable comparisons suffice?

Is regular calibration likely to be necessary? If so will a printed record be needed for GLP compliance? Is the weighing pan big enough for what you intend to weigh? If not does the balance have a “weigh-below” facility (a hook which allows cumbersome loads to be suspended below the balance for weighing)?

Additional features.

An RS-232 interface for data analysis is regarded as virtually indispensable on a modern laboratory balance.

If the balance is likely to be required regularly for density determination of solids or liquids it may well be advisable to look at a balance with density determination software. This feature is often available on balances weighing to 3 and 4 decimal places, and includes apparatus specifically designed to allow the user to weigh samples in air and in a liquid. The balance will

then calculate the material density using Archimedes' Principle and display the result in gm/cm³. For calculation of liquid density a glass sinker of a known volume is usually supplied and an appropriate calculation will be carried out by the balance software.

An extension of the modern electronic balance is the so-called moisture balance, which incorporates a heat source for drying samples while they are being weighed. The weight is continuously compared with the weight of the starting sample in order to establish weight loss and calculate original moisture or solid content as a percentage.

Used in a large number of industries, including food manufacturing, plastics, pharmaceuticals, chemicals etc, the moisture balance has dramatically decreased the time taken for routine moisture content analysis, using as it does, a very small sample which is quickly dried and its moisture content determined to within 0.01%.

Note* It is important to use a calibration weight appropriate to the balance. Most balances require a calibration weight of a specific value. The accuracy of the weight is described by its OIML classification number (M1, F1, F2 etc). For coarse resolution load cell balances M1 is adequate. For higher resolutions a correspondingly higher specification weight should be used.

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