White Paper

Calibration: What is it?

Separate from Adjustment

This document will establish a clear message about calibration: what it is, and, what it is not. It will prove that calibration and adjustment are not the same thing. While the concept of calibration applies to all measurement devices, this paper focuses on weighing devices.

The VIM, the International Vocabulary of Metrology, produced by the Joint Committee for Guides in Metrology (JCGM) states the following about Calibration:

"Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication."

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1 Calibration and adjustment are two separate things

The first and most important concept to learn is that calibration and adjustment are two separate things.

You calibrate a weighing device to understand how it behaves. You adjust the device to change its behavior. This is important, and worth repeating. You calibrate something to understand how it behaves. You adjust it to change the behavior. How could you know to change the behavior of something until you first understand how it is behaving?

It makes sense that you would not want to change the behavior of a weighing device until you first understand how it behaves. If the device does not behave well enough, then you adjust something to change its behavior. The process to understand how the weighing instrument behaves is the calibration. Therefore, it is reasonable and common to calibrate a weighing device without adjusting it.

Calibration establishes a relationship between a known value (standard) and a measured value.

For all units of measurement, there are standards defined as the basis for a particular unit. In the context of weighing devices, standards come in the form of test weights. The test weight has a value (as indicated by the calibration certificate for the weight set) and the weighing device indicates a value when the test weight is placed on the weighing receptor. This relationship between the value of the known test weight and the value that the weighing device indicates are how you understand the behavior of the weighing instrument. If you place a 5 kg test weight on a balance/scale and it indicates 6 kg then you have established a relationship between the known value and the measured value. You could reasonably assume that placing 10 kg of known mass would lead to the device providing an indication of 12 kg. That is a simplified example, but the concept is important. This is the basis of calibration – the understanding of the behavior by establishing a relationship between known and measured values.

The criteria for determining if a measuring device behaves "well enough" come in the form of a tolerance.

Tolerances come from a variety of sources, and there is no "correct" tolerance. The manufacturer can specify tolerances which the weighing instrument should meet. International testing recommendations (like OIML R 76 or HB44), and regulations (e.g. USP General Chapter 41) also specify tolerances. Furthermore, the customer (the user of the measuring device) can also specify tolerances. In the context of weighing devices, GWP® (The Global Weighing Standard introduced by METTLER TOLEDO) emphasizes that the user of a scale or balance should use it according to tolerances defined for their individual processes.

Using tolerances to determine a "pass" or "fail" is part of an assessment. True calibration does not have an assessment, although nearly all calibration certificates come with a pass/fail statement. The best practice is to make assessments in a separate section, or "annex" to the calibration certificate. The calibration should only give you an understanding, not tell you if the behavior is "good enough".

2 The Importance of Measurement Uncertainty

The determination of measurement uncertainty is becoming increasingly important in the global measurement community. Measurement uncertainty is a calculated value which is applied to a measurement taking into account various factors (random and systematic errors).

Measurement uncertainty is a quantitative indication of the quality of a measurement.
A measurement with a corresponding value of measurement uncertainty means that you can be reasonably "certain" that the actual value of your measurement falls within the range created by applying the measurement uncertainty value above and below your measurement. For example, if your weighing instrument indicates 100g with a 0.01g calculated measurement uncertainty value, then you can be certain (generally with 95% confidence) that your value lies somewhere within 99.99g and 100.01g.

"No calibration is complete without the determination of the estimated measurement uncertainty" – International Bureau of Weights and Measures (BIPM).

Some measurement authorities require calibrations to include the determination of measurement uncertainty. The ISO 17025 standard for assessing the competence of calibration and testing laboratories dictates that measurement uncertainty must be included in calibration certificates.

Remember, calibration is about understanding how the weighing device behaves. The determination of measurement uncertainty enhances the understanding of the behavior. One example is that calculating measurement uncertainty allows you to determine the minimum weight of the weighing device.

Minimum Weight: Crucial to understanding the behavior of a weighing device. The minimum weight is the smallest net sample mass that is weighed on the instrument, still complying with a specified relative user weighing tolerance requirement, or, in other words, when weighing more than the minimum weight, the associated relative measurement uncertainty is smaller than the weighing tolerance requirement.
Knowing the minimum weight is a very valuable piece of information that dramatically enhances the understanding of how the weighing device behaves. If you do not have this understanding, then you could be weighing in an area of the weighing range which is unsafe to weigh because the measurement uncertainty is very high.

3 Summary

Adjustment is not calibration. You can calibrate a measurement device without adjusting it. Calibration is developing an understanding of a measurement device. Calibration should include the determination of the measurement uncertainty to enhance the understanding of the measuring device.

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