GMP 14

Good Measurement Practice for the Selection and Use of Sensitivity Weights in Weighing Procedures

1. Introduction

Mass calibration procedures are based on comparing the unknown mass, *X*, to a standard mass, *S*, utilizing the balance as a comparator. This comparison relies on the accuracy of balance indications. Most balance indications are not accurate enough for precision mass calibrations, and they tend to drift with time. Drift can often be assumed to be linear over a short period. Concerns over balance inaccuracy and drift result in two possible causes of errors in mass determination procedures. Inaccuracy of the balance indications can be corrected by incorporating a sensitivity weight in the procedure that calibrates the range of use of the optical scale (mechanical balances) or of the digital indications (electronic balances). Errors due to drift can be minimized by using the correct comparison method, selecting a suitable sensitivity weight, and by consistent timing within the procedure. The proper selection of procedures (GMP 12), the adherence to those procedures, and equal time intervals between weighing operations will allow the measured difference between *X* and *S* to be corrected for inaccuracy of the balance indications and for balance drift.

1.1. Purpose

The following practice will guide you through the process of selecting and using a correct sensitivity weight for mass determination procedures.

1.2. Prerequisites

1.2.1. Verify that valid calibration certificates are available for the masses to be used as standards, sensitivity weights, and tare weights.

1.2.2. Verify that weight-handling equipment is available and in good operational condition.

1.2.3. Verify that the operator is familiar with the design and the operation of the balances and familiar with weighing procedures.

1.3. Safety

1.3.1. Handling of large or small weights can represent a hazard to either the weights or personnel if the weights are dropped.

2. Methodology

2.1. Summary

A sensitivity weight is selected to calibrate the balance over the range to be used in the measurement procedure. Minimizing the difference in mass values between X and S is critical when choosing an appropriate sensitivity weight. Therefore, tare weights may be necessary whenever the difference in mass values is significant. Minimizing the difference between X and S works to our benefit since the range of the measurements is minimized and reduces potential errors that can be introduced by nonlinearity of the balance.

2.2. Apparatus

2.2.1. Sensitivity weights with accurate and traceable calibration values.

2.2.2. Tare weights with accurate and traceable calibration values.

2.2.3. Clean forceps to handle the weights, or gloves to be worn if the weights are to be moved by hand.

2.3. Procedure for selection

2.3.1. Conduct preliminary measurements to determine the approximate mass value for the difference between the standard and the unknown ($X - S$).

2.3.2. Define the range of use for the balance to be used:

2.3.2.1. Equal arm – number of scale divisions

2.3.2.2. Mechanical – optical scale

2.3.2.3. Combination – digital indications

2.3.2.4. Fully electronic – capacity

2.3.2.5. Comparators – digital indications

2.3.3. Determine the need for tare weights if the difference between X and S exceeds the values shown in Table 1.

Table 1. Maximum allowed difference between *X* and *S*

Balance	*(X – S)*
Equal arm	balance each other within one division on the scale
Mechanical	1/10 optical scale
Combination	1/10 digital range
Fully electronic	0.05 % capacity
Comparator	1/10 digital range

2.3.4. Select tare weights, if necessary, making sure that the difference between X and S, with the appropriate tare weights, do not exceed the values shown in Table 1.

2.3.5. Select a sensitivity weight according to Table 2.

Table 2. Selection of Sensitivity Weight

Balance	Procedure	Sensitivity Weight
Equal Arm	SOP 3, 5, 6, 7, 8, 28	change turning points by 20 %
Mechanical	SOP 4, 5, 7, 28 SOP 8	≥4 times ($X – S$); ≤ ½ optical scale ≈ ¼ optical scale
Combination Electro-mechanical	SOP 4, 5, 7, 8, 28	≥4 times ($X – S$); ≤ ½ digital Range
Fully Electronic	SOP 4, 5, 7, 28 SOP 8	≤ 1 % capacity 2 times the applicable tolerance
Comparator*	SOP 4, 5, 7, 8, 28	≥4 times ($X – S$); < ½ digital range

*A sensitivity weight is not required if the electronic mass comparator that is used has been tested (with supporting data available) to determine that the balance has sufficient accuracy, resolution, repeatability, and stability so that no advantage is gained using a sensitivity weight. For example, any possible errors must be less than the last digit retained in the expanded uncertainty. When a mass comparator is used without a sensitivity weight, the sensitivity must be periodically verified and documented (e.g., prior to each use).

2.4. Use of sensitivity weight

The sensitivity weight is used to ensure that the mass differences determined with the optical scale, or electronic range, have valid accuracy and traceability. The sensitivity weight calibrates the range of use of the balance used for making the mass determinations. Using a sensitivity weight provides us with a sensitivity value in terms of mass units per division.

$$sensitivity = \frac{mass\ units}{divisions} = \frac{M_{sw}}{deflection}$$

Where M_{sw} represents the mass of the sensitivity weight.

3. Calculations

No special calculations are associated with this practice. See each mass SOP for calculation of sensitivity within the procedure.

4. Uncertainty

No uncertainty calculations are associated with this practice. See the appropriate SOP for the calculations of uncertainty. (The uncertainty of the sensitivity weight does not need to be included in calculations of uncertainty since the uncertainty value is distributed across the range of use. However, it does no harm to incorporate it in uncertainty calculations when spreadsheets are set up to handle all of the data.)