Good Practice Guidance *Note*

Thermal Effects on Balances and Weights

Contents

Introduction

This Guidance Note gives recommendations of good mass measurement practice but should not be considered a comprehensive guide. For further information, readers may be interested in consulting NPL Report CMAM 74 "Thermal Influence on Weights and on Mass Comparators", from which this guidance note has been taken, and the NPL "Guide to the Measurement of Mass and Weight".

Laboratory Environment

Temperature instability in mass laboratories arises from heat sources and heat sinks such as:

- Windows, heating pipes and the transmission of heat from adjacent rooms;
- Equipment located in the calibration area - computers, monitors, weight handlers etc.;
- Effect of lighting;
- Air-conditioning;
- Human operators, who generate heat and create air turbulence.

In a laboratory environment, good thermal stability can be achieved by considering the following:

- Insulation of outside walls with the possible addition of a secondary internal wall;
- Windows, if provided at all, should be double or triple glazed;
- A secondary door to give an air lock between the mass laboratory and the outside;
- Mass comparators should, where possible, be installed away from vertical surfaces;
- If installed, consider the delivery and extraction of air from air-conditioning units.

Recommended temperature limits and stability ranges for mass laboratories are given in Table 1.

	Class E1	*Class E2*	*Class F1*	*Class F2*	*Class M1*
Temperature limit (°C)	18 to 22	18 to 22	17 to 23	16 to 25	15 to 27
Temperature stability (temp. band over 8 hours) (°C)	0.2	0.5	1.0	1.5	2.0

Table 1: Recommended laboratory temperature limits and stability ranges

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Selection and Siting of Environmental Sensors

Various temperature measuring devices are available for measuring the temperature within a balance or mass comparator. Three of the most common types of device used are:

- Platinum resistance thermometers (PRTs)
- Liquid-in-glass thermometers
- Thermistor probes

PRTs are used as reference thermometers in calibration equipment. Sensitivity and accuracy at the mK level is achieved, but the sensor should be mounted in a metal block if the effects of self-heating are not to be significant. A resistance bridge is required to convert the measured value in ohms to temperature units (°C), thereby making the entire apparatus expensive.

Liquid-in-glass thermometers have the advantage of being cheap to purchase and calibrate and usually display long-term stability, with little drift between successive calibrations. They are however, difficult to interface with data handling equipment, and they are usually calibrated in a vertical orientation, which can make them difficult to incorporate in a balance case where it may be easier to lay the thermometer down.

Thermistor probes are a good compromise, providing versatility of use, good measurement uncertainty and modest cost.

Sensors should be mounted within the balance enclosure in the same horizontal plane as the artefacts being calibrated. Figure 1 shows a close up picture of an exposed bead thermistor probe protected by a thin metal sheath (typically 10 mm diameter and 20 mm long) and then an example of this probe positioned inside a balance enclosure.

Figure 1: Thermistor probe and its siting in a balance enclosure

Manual Mass Comparators

Manual mass comparators have thermal stability problems associated with their transformers and display units. Where possible these should be removed from the balance housing and located outside the immediate weighing area. In the case of motorised doors, consideration should be given to ensuring that the motors generate as little heat as possible. The doors should be capable of manual operation if required, and easily adjusted. Doors should be checked for a good fit avoiding gaps at the edges. Secondary housing, either from the manufacturer or custom made, can help to improve thermal stability.

Automatic Mass Comparators

Automatic mass comparators have thermal stability problems associated with the weight handler control motors. These motors have a heating effect, which can raise the temperature of the weighing environment by up to 1 °C on commencing the automatic weighing sequence. Awareness of this heating effect and suitable use of the delayed start and pre-run options in the control software can help to minimise the effects on the weighing data.

Balance Settings

Most modern electronic balances have settings for local environmental conditions such as vibration or the type of weighing application being carried out. However, in practice neither of these settings has any effect on elimination of errors due to thermal drift or thermal influences.

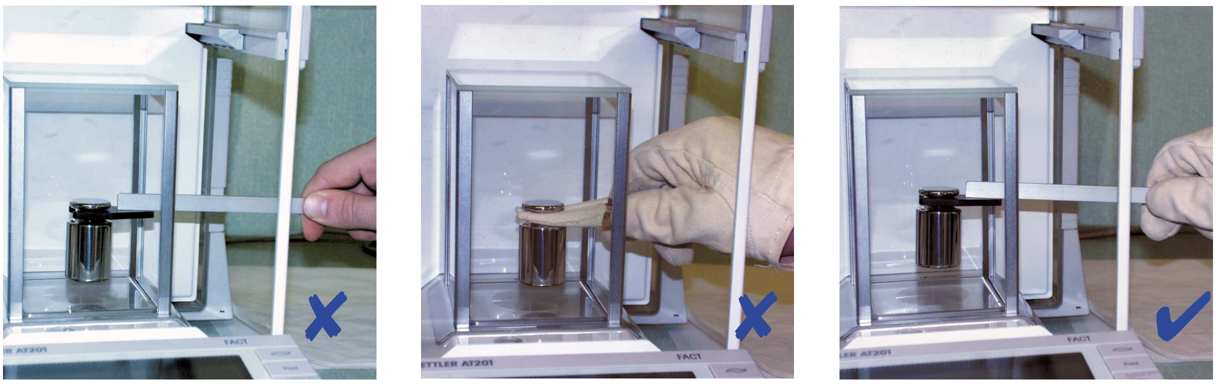
The auto-zero setting automatically re-zeros the balance when it has drifted from zero by a specified number of digits. It is recommended that the use of auto zero should be:

- Switched off – for comparison weighings
- Switched off – for direct reading weighings when a correction is made for the zero reading before and after the weighing
- Switched on - for direct reading weighings when only the loaded balance reading is taken

The balance should always be connected to the power supply in standby mode so that thermal equilibrium is established in the balance. However, if this is not possible the balance should be switched on for a minimum of 1 hour before use.

Weight Handling

The presence of human operators inevitably influences the temperature stability of the weighing environment and the weights. The use of chamois leather gloved hands and suitable handling equipment can help to minimise this effect. Figure 2 shows three examples of loading a mass standard onto a weighing pan. The third example is recommended; using a gloved hand, which does not enter the weighing enclosure. Handling and loading of a mass standard in this way will help to minimise the thermal influence the operator.



Ungloved hand, potential heat transfer to weight and balance enclosure

Operators hand enters the balance enclosure affecting the thermal stability

Recommended practice

Figure 2: Examples of incorrect and correct weight handling

***Note**: Where possible the weight handling equipment should be of a suitable length to allow the operator to load the mass comparator without their hand entering the weighing chamber, whilst still maintaining a good degree of handling stability.*

Stabilisation Times

Before commencing any weighing, all the weights to be used must have had the opportunity to reach thermal equilibrium with the balance environment. The required acclimatisation time will depend on the size of the weight and the difference between the temperature in the balance case and the temperature in which the weights have previously been stored. Table 2 gives suggested minimum acclimatisation times.

Nominal Value	Class E1	Class E2	Class F1	Class F2	Class M1
1 000 kg	72	48	36	24	24
100 kg	36	24	18	12	12
10 kg	24	12	9	6	4
1 kg	12	6	4	3	2
100 g	6	3	2	2	1
10 g	3	2	2	1	1
1 g	2	2	1	1	0.5
< 1 g	2	1	1	0.5	0.5

Table 2: Recommended minimum temperature stabilisation times (in hours)

The data in Table 2 are based on theoretical estimates and, as an example, Figure 3 shows the theoretical exponential decay of temperature against time for a 1 kg mass standard with an initial temperature 5 °C above that of the balance enclosure. The recommended waiting or stabilisation times for the five different classes of weights are indicated.

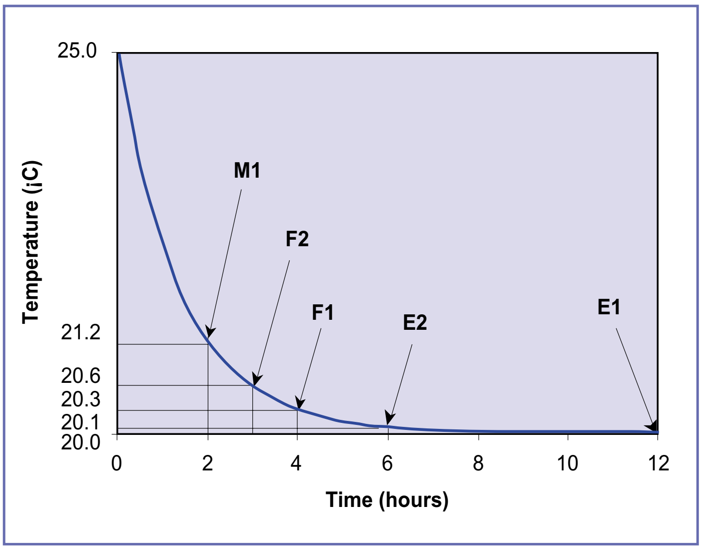


Figure 3: Thermal stabilisation of a 1 kg mass

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