Mass Standards Handbook — Determining Balance Error

The following method establishes step-by-step performance parameters and verification using calibrated weights for electronic balances. Weights with weight calibration certificates are required.

Using calibrated weights, it is possible to determine balance error resulting from internal calibration processes. To verify proper balance performance using calibrated weights, one needs to establish two parameters. The first is to determine the balance's ability to repeat measurements (Repeatability). This is accomplished by calculating a standard deviation and multiplying it by 2 to achieve a 95% confidence interval. The second is to determine how much error (or offset) is introduced when the balance is calibrated.

1. Set-up the balance according to the manufacturer's specifications. Allow the balance to "settle" for at least a 24-hour period to achieve thermal equilibrium.
2. Calibrate the balance using the internal calibration function of the balance and an appropriate calibration weight (see the balance's operation manual for proper calibration weight selection). Some balances have built in calibration weights. It is recommended that an external calibration weight be used.
3. Select a verification weight that represents the mass of a typical sample size or a weight that is in the range of the majority of samples.
4. Tare or zero the balance so the display reads all zeros.
5. Using the verification weight, make at least 20 measurements and record the results of each measurement. Zero the balance before each measurement. After all of the measurements are made, calculate a single standard deviation.
6. Multiply the standard deviation by 2. This is the random error or repeatability that is expected for the balance with a 95% confidence level. The number becomes the upper and lower control limits for the performance verification.

NOTE: Should the single standard deviation be significantly greater than the manufacturer's specification for repeatability, try another location for the balance, and be sure the operator is following good measurement practices. Look for sources of vibration or air currents that may be causing the balance to perform poorly. If other locations do not improve the results, contact the manufacturer and explain the problem. The manufacturer may be able to provide other solutions.

7. Check the weight calibration certificate and obtain the correction of the weight that was used to calibrate the balance. This is the error that was introduced when the balance was calibrated at that load. Most calibration functions in electronic balances set the linear function for the balance from the calibration load down to zero. It is important to note that the error introduced at the calibration load is reduced by 50% at 1/2 of the load and by 75% at 1/4 of the load. In other words, as the load on the balance is reduced, the linear error introduced by the correction of the calibration weight is reduced. An estimation of the linear error of the calibration can be made with the following equation:

Linear error = -1 x Error of cal weight
x Load/Calibration load

If the balance is calibrated using the internal balance weights, the linear error cannot be determined without the value of the internal weights.

8. The expected value for your performance verification is calculated as:

Expected value = Actual mass value
+ Linear error

Where: **Actual mass value** = Nominal value
+ Conventional Mass vs. 8.0 correction

9. Verification: Zero the balance and place the verification weight on the balance. The verification passes if the actual reading is within the random error established in Step 6 of the expected value.

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Recommendations:

A. Perform verifications at different times during the day. If the verifications fail during some time periods but pass during others, the laboratory's environmental conditions are changing throughout the day.

B. Troemner recommends that calibration weights be recalibrated at least annually to verify that they are not changing in value. Actual usage will determine the calibration interval.

C. Chart the actual value after each verification. This may identify trends of drifting or systematic errors that are working into your process.

D. Recalculate the random error periodically to see if the repeatability of your balance is changing.

Example:

Given:

100 g capacity balance is readable to 0.1 mg
Calibration load: 100 g
Samples tested at: 10 g
100 g Class 1 weight with a correction of +0.10 mg and an uncertainty of +/- 0.025 mg
10 g Class 1 weight with a correction of +0.010 mg and an uncertainty of +/- 0.018 mg

Taking 20 measurements, the standard deviation is found to be 0.3 mg. The random error is 2 times 0.3 mg or 0.6 mg for a 95% confidence interval.

Linear Error = -1 X (0.10 mg X 10 g/100 g)
= -0.01 mg

Expected value = 10.00001 g + (-0.01 mg)
= 10.00000 g

Verification Range = 10.00000 g +/- 0.6 mg

Over the next 3 days, 7 verifications are performed and are shown below. The Balance Verification Chart below illustrates that the 2nd and 5th measurements failed, but the rest of the measurements passed. Using control charts like this is an effective method in identifying measurement problems before the quality of your work is affected. Investigation and Corrective Action should be made when measurements fall out of acceptable range.

TEST #	1	2	3	4	5	6	7
Measurement	10.0003	9.9993	10.0002	9.9996	10.0011	10.0004	9.9999