# Testing Your Laboratory Balance

If you use a laboratory balance in your day-to-day work, you may have wondered whether it is accurate. Here are four tests that you can use to confirm your instrument's accuracy. In this article you will learn to make these tests yourself.

***Repeatability*** refers to the instrument's ability to repeatedly deliver the same weight reading for a given object when it is weighed several times. It is expressed as a standard deviation. Standard deviation, or repeatability , is often an advertised performance specification for a lab balance.

***Cornerload*** errors are those errors associated with different positions on the weighing pan of the object being weighed. A given object should produce the same reading regardless of its position on the weighing pan.

***Linearity*** is the characteristic which quantifies the accuracy of the instrument at intermediate readings throughout the weighing range of the instrument. Since a lab balance will often be used to weigh items much smaller than the capacity of the instrument, this is a critical aspect.

***Span*** refers to the difference between the weight reading of a given mass standard, and the actual value of that standard. This measurement is often done at or near full capacity. This is the test (or adjustment) that most people thing of when the refer to *calibration* of their instrument. For many users, it is the only test or adjustment they will choose to make routinely.

The following pages contain specific instructions for performing these tests.

# Preliminaries

### *Handling test weights*
The weights used to test lab balances are precision devices and need to be handled accordingly. When handling weights, avoid direct hand contact with weights by using clean gloves. Avoid sliding weights across any surface, especially across the stainless steel weighing pan of the balance under test.

### *Environment*
In order to pass any test of reproducibility an instrument must be operating in an acceptable environment. A poor environment will degrade the results of a standard deviation (SD) test and falsely suggest that the performance is substandard. There are several aspects of the environment which impact the performance of a lab balance.

### *Temperature*
The accuracy and overall performance of any lab balance is affected by the room temperature. For best stability and performance the room temperature should be regulated to within one degree Fahrenheit without interruption. The instrument should remain with power ON continuously.

### *Air Drafts*
In the cases of measurements with resolution of .001 gram and less, the force exerted by moving air is readily detectable. A shroud or enclosure around the weighing pan will shield the pan from these effects. Avoid plastic materials for draft shields.

### *Static Electricity*
Static electricity exerts a mechanical force which is readily detectable by analytical and microbalances. An example of static electricity exerting a mechanical force would be lint sticking to clothing. Static will be a problem when it exists on the object being weighed, on the person using the balance, on draft shields, or on weighing vessels. Sources of static are carpets, Vibrum shoe soles, plastic draft shields, plastic weighing vessels, and melamine (Formica) table tops. Low ambient humidity exacerbates static problems.

You can test for a static problem easily. On an analytical balance place a metal enclosure (a coffee can works well) over the weighing pan, so that the pan is enclosed by the can but NOT touched by it. If the weight readings stabilize with the can in place, then static may be the cause of the instability. Notice that the coffee can provides an effective draft shield too.

### *Floor vibration / Table Instability*
Many lab balances are extremely sensitive to vibration or movement. If the weight readings change as you walk around the instrument, or if the readings change as you lean on the table or move objects on the table, then the table and floor are affecting weight readings. You can minimize these effects by using an especially sturdy table and minimizing movement. Users of microbalances often need specially built marble tables on concrete floors.

# Reproducibility Testing

Reproducibility testing entails repeatedly weighing a given object, recording the results, and analyzing those results. Select a test weight equal to, or nearly equal to, the weighing capacity of the instrument. Utilize the chart titled "Reproducibility Test Chart."

1. Tare the instrument to read all zeros.
2. Place the test weight on the pan.
   Record the reading in the column labeled "FULL SCALE" .
3. Remove the weight (DON'T REZERO), and record the reading under "ZERO"
4. Repeat steps 2 and 3 until lines 1 through 11 are all filled in.
5. Transcribe the two columns of numbers into a spreadsheet program.
6. Use the program to calculate the standard deviation of both columns of numbers.
   (consult the program documentation, or "HELP" system for the spreadsheet)
7. Calculated standard deviations larger than allowed in the instrument specifications indicate that the instrument is either operating in an unstable environment (static, air draft, warm-up, vibration, etc.), or that the instrument is in need of repair.

## Reproducibility Test Chart

| Line | Zero | Full Scale |
|---|---|---|
| 1 | x | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | x |
| Standard Deviation (SD) | | |

Instrument Model ________________ Instrument Serial Number__________

Date ___________________________ Person _________________________

# Cornerload

Cornerload testing verifies that the instrument delivers the same weight reading, regardless of where on the weighing pan the object being weighed is placed. Cornerload performance specifications are often not advertised. Typical tolerances are shown below.

1. Select a test weight close to the weighing capacity of the instrument.
2. Place the test weight in the center of the weighing pan. Then re-zero the display.
3. Move the weight one half way from the center to the front edge of the pan. Record the reading on the "Cornerload Chart" under the heading "FRONT."
4. Repeat step 3 at the half way locations for right, rear, and left edges, recording the readings in the appropriate spaces in the chart.
5. Cornerload tolerances are often not a component of advertised specifications. The table below shows typical tolerances for instruments operating in both laboratory and industrial conditions. The lab environment presumes a specially built, leveled, rigid table and uninterrupted temperature control within one degree Fahrenheit. The industrial environment includes a sturdy table and uninterrupted temperature control within four degrees Fahrenheit.

## Cornerload Chart

| Front | Right | Rear | Left |
|---|---|---|---|
| | | | |

Lab Environment Cornerload Tolerances (digits)

| Resolution | .1 g | .01 g | .001 g | .000 1g | .00001 g |
|---|---|---|---|---|---|
| Capacity | | | | | |
| 30 gram | - | - | - | 2 | 5 |
| 100 g | - | - | 2 | 4 | 10 |
| 300 g | - | 2 | 4 | 10 | - |
| 1000 g | 2 | 4 | 10 | - | - |
| 3000 g | 3 | 6 | - | - | - |
| 10 Kg | 4 | - | - | - | - |
| 30 Kg | 12 | - | - | - | - |

Industrial Environment Cornerload Tolerances (digits)

| Resolution | .1 g | .01 g | .001 g | .0001 g | .00001 g |
|---|---|---|---|---|---|
| Capacity | | | | | |
| 30 gram | - | - | - | 4 | 10 |
| 100 g | - | - | 4 | 8 | 20 |
| 300 g | - | 4 | 8 | 20 | - |
| 1000 g | 4 | 8 | 20 | - | - |
| 3000 g | 6 | 12 | - | - | - |
| 10 Kg | 8 | - | - | - | - |
| 30 Kg | 24 | - | - | - | - |

# Linearity Testing

Linearity testing verifies the accuracy of the instrument at intermediate values of weight. Manufacturers often use the term "accuracy" in advertised specifications.

1. Use two weights, each of approximately one-half the weighing capacity of the instrument. It is imperative that these two weights not be interchanged within this procedure. Refer to the individual weights as "weight A" and "weight B."
2. Rezero the display. Place "A" on the pan (at the center), and record the reading on the "Linearity Chart" in the column marked " 0% – 50% ."
3. Remove "A" and place "B" on the pan next to the center. Rezero the display.
4. Again place "A" on the pan. Record the reading under the column marked "50% - 100%."
5. Calculate the difference between the two (0-50 and 50-100) readings.
6. The difference should be less than the advertised tolerance for linearity or accuracy.

## Linearity Chart

| 0%– 50% | 50% - 100% |
|---|---|
| | |

***Special Note:***
A common **error** in linearity (accuracy) testing is to simply place test weights on the weighing pan and observe the difference between the indicated weight and the nominal value of the test weight. This process fails to account for the fact that test weights are imperfect and that the difference between the nominal value and the actual weight might be significant. This is especially true with analytical balances, where the balance may be more accurate than any standard test weight. The above procedure nullifies this problem by comparing the weight readings of the same object, both with and without a preload. The accuracy of the test weight is thus immaterial.

# Span

***Span*** refers to the adjustment of the sensitivity of the instrument across the full weighing range. Span differs from the previous performance parameters in that it is readily *adjustable*, whereas cornerload, linearity, and repeatability generally are not. Span adjustment of instruments is different from instrument to instrument. Generally, the adjustment procedure is described in the user's manual which comes with the instrument. Follow the instructions in your user's guide.

Many (not all) instruments now include internal calibration weights, so calibration is as easy as pushing a single button. The user may reasonably ask, "How do I know the internal calibration weight is correct ?" The answer is that the only way to know is to have an external standard for comparison. The advantage of an external standard, whether it's used to adjust span, or just to confirm the internal weight, is that it is completely external to the instrument, and can therefore be compared to external standards. By that process, the overall calibration of the instrument is matched to international standards and all other weighing instruments.

Standardized test weights are made to various levels of accuracy. ASTM class 1 is the most accurate weight class commonly available. Most weights in ASTM class 1 are accurate to one part in 400,000. Since many lab balances are considerably more accurate (resolution of greater than one part in a million), one might reasonably wonder how a standard weight can be used to test or adjust analytical balances. The answer would be that the standard weight can itself be calibrated to a level of accuracy that exceeds even the most accurate lab balances. The characterization of the weight will determine the actual value of the weight to a much higher degree of precision than required by the ASTM class 1 standard. Such a weight can be used to verify the accuracy of an internal calibration weight. Simple "traceability" of an external weight is insufficient. A calibration certificate for a class 1 weight must specify the actual weight value with deviation from nominal. A calibration service which supplies such a certificate should be registered (via A2LA, or similar) to provide that level of accuracy. The registration confirms via third party testing that the calibration certificate issuer is capable of such accuracy and is audited to be delivering that accuracy reliably.

After placing a test weight on an operating instrument and finding that the displayed weight value does not exactly match the nominal value of the test weight, many users have concluded that the instrument is miscalibrated. However, that conclusion is by no means certain unless the test weight has been calibrated and its correction from nominal value is known. The calibration weights internal to high quality lab balances are more accurate than commonly available test weights. In the absence of a calibration certificate for a specific weight, users should presume that internal weights are more accurate than external test weights.