

# WHITEPAPER

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## Laboratory Balances

Necessary Tools for Use in Any  
Environmental Laboratory



## ■ Introduction

The laboratory balance is a central and indispensable piece of laboratory equipment, necessary for almost all work in the modern environmental laboratory. The balance's use ranges from the weighing of neat materials to the actual measurement of the mass of analyte itself. The analytical balance may be used in "gravimetric analysis", a branch of chemistry that determines the concentration of an analyte by direct measurement of its mass. In the gravimetric analysis of environmental parameters, such as Total Suspended Solids, it is not uncommon to routinely measure concentrations as low as 1 ppm.

Gravimetric analysis may be simply evaporation of an aqueous sample to measure the residue, filtration and measurement of the mass collected on the filter, or it may involve the addition of chemicals to form a precipitate that can be weighed.

Gravimetric techniques can be very precise, but are also time consuming. Many environmental tests, such as 2540 B Total Solids Dried at 103 – 105°C (TS), 2540C Total Dissolved Solids Dried at 180°C (TDS), and 2540D Total Suspended Solids Dried at 103 – 105°C (TSS), are gravimetric techniques. Gravimetric analyses are dependent upon the accuracy of an analytical balance.

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Around the turn of the 20<sup>th</sup> century, precision weighing was a time-consuming practice performed only by experienced operators. Placing the sample and small masses on pans hung from a beam with a moving indicator was a tedious process.

The introduction of the direct reading balance has signified a new era in weighing technology and has reduced weighing times by more than 66%<sup>1</sup>. Now, just about anyone can operate an analytical balance obtaining highly precise and accurate results; however, care must still be taken in selection, placement, and daily operation of the balance. A top loading balance accurate to at least 0.1 gram, such as the Shimadzu UX620H (Figure 1), is used for preparing reagents, etc., and an accurate analytical balance, such as the Shimadzu AUW220 (Figure 2), used for preparing standard solutions and reagents requiring small mass measurements (< 1 gram), and for the accurate final measurements of solids by the Standard Methods listed above, are necessary tools in any environmental laboratory.



Figure 1: Shimadzu UX620H Top loading balance



Figure 2: Shimadzu AUW220 Analytical Balance

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<sup>1</sup> Shimadzu Electronic Balances General Catalog, CO54-EO32M

## ■ Installation of the balance in your laboratory

The balance must be installed in a suitable location with a constant and consistent electrical supply to ensure safe and accurate measurement. Avoid the following:

- Air currents from air conditioners, ventilators and fume hoods, or open doors and windows
- Vibration
- Areas that enable direct sunlight to strike the balance or weighing area
- Locations subject to extreme temperature changes, high or low temperature, or high or low humidity
- Exposure to flammable or corrosive gases and/or vapors
- Dust, electromagnetic waves, or magnetic fields

Install the balance on a sturdy tabletop, preferably a stone balance table. Place the table at the edge or the corner of a room and not in the center. Maintain a temperature of  $20 \pm 2^{\circ}\text{C}$  with a 45 – 60 % R.H. Once the balance is properly positioned on the balance table, adjust the horizontal level using the level screws on the feet of the balance. Adjust the level until the bubble is positioned in the center circle of the level indicator. Always verify that this bubble is in the middle before making measurements on the balance.

Keep the area near the balance neat, avoiding clutter, and clean up any spills immediately. Use a camel's hair brush to dust the balance pan being careful to not "jar" the balance.

## ■ Calibration

Turn the balance on and allow it to equilibrate for a minimum of one hour prior to attempting a calibration. For extremely sensitive balances, such as the Shimadzu AUW220D, capable of weighing to 0.01 mg, an equilibration time of at least 4 hours is needed. Perform the calibration without people leaving or entering the room and without airflow or ventilation. For routine operation, it is a good practice for the first person in the lab each day to calibrate the balance.

The Shimadzu AUW series balances perform a calibration automatically after the balance is powered on, or according to timed intervals. A span calibration with a built-in calibration weight is set as a default calibration method. Perform this calibration daily, either manually or as a timed operation, and every time the balance has been moved or the temperature in the room has changed more than  $2^{\circ}\text{C}$ .

Check the calibration with at least one and preferably more NIST traceable weights and record the mass. Verify that the mass is within tolerance limits established by the laboratory Quality Assurance program. Never touch the NIST weights with your fingers. Use tongs or a Kim wipe.

## ■ Weighing on the Balance

Plan everything prior to using the balance. Ensure that the balance area is clean and dust the pan using the camel's hair brush. For accurate measurements, verify the calibration using an NIST traceable weight that is close in mass to the expected mass of the samples to be weighed. Never use containers so large as to approach the maximum load of the balance. For large mass measurements, use the top loading balance.

Make sure that the tare containers or any containers that will be placed on the balance pan are clean and dry. Ensure that samples to be weighed have equilibrated to room temperature. Follow these steps, or similar depending upon the balance used:

1. Make sure display reads zero. If not, zero the balance.
2. Open the glass doors (of the analytical balance) and, using tongs, place the item to be weighed or tared onto the balance pan.

3. Wait for the reading to stabilize, or press tare if the sample will be weighed into a vessel or weighing dish. Record the reading if applicable.
4. Open the glass door (of the analytical balance) and remove the item weighed, or carefully, using a scoop or spatula, add item to be weighed (sample or reagent) to the tare vessel.
5. Record the reading.
6. Open the glass door (of the analytical balance) and remove the tare vessel containing the item that was weighed.
7. Make sure the balance pan is clean. If reagent was spilled clean immediately with the camel hair brush. Close the glass door.
8. Continue weighing other samples/reagents following the steps above.

The tare vessel, receiver, or weighing pan depends on the quantity and type (liquid or solid) of material that is to be weighed. Weighing bottles, weighing paper, and plastic or metal weigh boats are common. The weighing boat should be as small as possible to adequately contain the substance to be weighed without reacting with it. Never touch the weighing vessel because the oil from your fingers will add weight. Crease weighing paper before placing on the balance pan to make transfer of the solid substance easier. Be sure to handle plastic boats and weighing paper with care to avoid spills.

### ■ Preventing Measurement Uncertainty

Changes in weight during weighing can occur by static charge, or by differences in air density above the object being weighed. It is important that everything weighed in the balance be at room temperature.

Weighing an object too hot can result in low mass measurements. Air buoyancy can introduce significant error, especially if the object being weighed is large. Minimize the size of the vessel being weighed. Air buoyancy and temperature effects play a role in the initial and final measurements of TSS and TDS. Many of the problems with TSS measurements that were related to measuring TSS within 25 milliliter porcelain crucibles are easily resolved by using larger glass fiber filters and weighing only the filter in an aluminum pan.

TDS still presents a problem, especially since a very small mass is measured within a much larger porcelain evaporating dish or small beaker. Thus, much of the error in TDS measurements comes from the error in weighing the mass of the glass beaker or porcelain evaporating dish more so than from measuring the mass of the evaporated residue.

### ■ Balance Accessories That Minimize Weighing Error

Samples or containers that easily become electro-statically charged can cause instability in balance measurement values due to static electricity. The Shimadzu STABLO-EX ionizer (Figure 3) quickly reduces the static charge on samples and containers.



**Figure 3:** Shimadzu STABLO-EX ionizer

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## ■ Increase Productivity using Application-specific Balances and Accessories

### **Moisture Balance**

For greater accuracy and increased throughput, use application-specific balances such as the Shimadzu MOC63u moisture balance (Figure 3) to make determination of Total Solids by Standard Methods 2540G as simple as placing the material on the pan and shutting the cover.

The MOC63u provides prompt and accurate automated measurement of moisture including calculation of the final result. The same rules for installation and calibration of the analytical and top loading balance apply to application specific balances like the MOC63u. Once the balance is properly installed and calibrated, moisture can be measured in samples as follows:

1. Confirm that the balance is in standby mode.
2. Open the heated cover.
3. Place a pan that has been equilibrated to room temperature, onto the pan supporter and close the cover.
4. Allow readings to stabilize and adjust to zero.
5. Open the cover and place sample weighing more than 0.02 grams onto the pan. Spread the sample out as evenly as possible to ensure adequate drying.
6. Close the cover. The measurement will start immediately.

Note: the temperature ramps and the balance will continuously measure the weight loss. The measurement is complete when the balance detects a constant weight.

7. A short beep indicates that the measurement is complete.
8. This display shows the measurement result which can be output to an optional printer, such as the Shimadzu EP-90, or a PC with Shimadzu Windows Direct software installed.
9. The heater stops automatically.
10. Reset prepares the balance for the next sample.

Remove the sample and pan from the balance using the sample handling tool provided. The sample and the pan will still be hot. If you used a disposable aluminum pan, discard both the sample and the pan, otherwise, discard the sample and wash and dry the pan.

**Always remember to spread the sample as flat as possible onto the pan to avoid mounds and lumps, which lead to inconsistent drying and erroneous results.**

For best results, always ensure that the sample and pan are at room temperature prior to placing into the balance and starting the measurement. If they are not at room temperature, evaporation could begin prior to starting the analysis, resulting in measurement error. Always use a consistent time interval between samples when measuring samples in succession. And, always remember to spread the sample as flat as possible onto the pan to avoid mounds and lumps, which lead to inconsistent drying and erroneous results. For more information, refer to Shimadzu Document: 321-78013 Moisture Analyzer Instruction Manual.



**Figure 3:** Shimadzu MOC63u Moisture Balance

## ■ Conclusion

The direct reading balance makes it possible for every laboratory technician to obtain highly precise and accurate gravimetric analysis results; however, the placement and care of the balance is important. By carefully following the procedures outlined above, laboratory personnel will eliminate most potential errors that could be introduced during analysis of environmental samples by:

- Standard Methods 2540 B Total Solids Dried at 103 – 105°C (TS)
- 2540C Total Dissolved Solids Dried at 180°C (TDS)
- 2540D Total Suspended Solids Dried at 103 – 105°C (TSS)

Accessories, such as the STABLO-EX ionizer can help in reducing inaccuracies due to static electric charges. Application-specific balances can increase accuracy and throughput when analyzing moisture by Standard Methods 2540G Total Solids Dried at 105°C (TS). For more information about Shimadzu's general purpose and application-specific balances, refer to Shimadzu C054-E032M Electronic Balances General Catalog.



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