



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-L200

Analytical Balance Calibration and Operation – Mettler Toledo

Standard Operating Procedure

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1. Purpose

This procedure describes the routine calibration, verification, and proper operation of Mettler Toledo analytical balances used in the EA Program laboratory. Accurate mass measurements are fundamental to nearly every quantitative laboratory procedure, including soil moisture determination ([SOP-L400](#)), loss on ignition ([SOP-L406](#)), DNA extraction ([SOP-L700](#)), and chemical reagent preparation. Regular calibration ensures that balance readings are traceable to national standards and within acceptable tolerance for analytical work (Harris & Lucy, 2020; Mettler Toledo, 2023).

2. Scope

- **Applies to:** All Mettler Toledo analytical balances (0.1 mg readability) and precision balances (0.01 g or 0.001 g readability) in the EA Program laboratory
- **Does not apply to:** Portable field balances, top-loading balances used only for rough weighing (greater than 1 g tolerance), or microbalances (0.001 mg readability) requiring specialized calibration procedures
- **Location:** EA Program laboratory, SGM 133

3. Definitions

- **Accuracy:** The closeness of a measurement to the true (reference) value; assessed by weighing a certified reference weight and comparing the result to the certified mass.
- **Calibration:** Comparison of a balance's readings against reference weights of known mass to establish a correction curve or verify performance within tolerance.
- **Certified reference weight:** A weight whose mass is traceable to national or international measurement standards (NIST or equivalent); classified by tolerance class (OIML E1 through M3 or ASTM 0 through 7).
- **Drift:** Slow, systematic change in balance readings over time, caused by temperature fluctuation, vibration, or electronic aging.
- **External calibration:** Calibration using calibrated weights placed manually on the pan; required on balances without internal weights.
- **Internal calibration (AutoCal):** Automatic calibration using a built-in reference weight that is mechanically engaged by the balance; the Mettler Toledo XPE205 performs internal calibration automatically in response to temperature changes.
- **Linearity:** The degree to which balance readings are proportional to applied mass across the full weighing range; assessed by weighing multiple reference weights spanning the range.
- **Repeatability:** The standard deviation of repeated measurements of the same weight under identical conditions; a key indicator of short-term balance precision.
- **Tare:** The function that zeroes the displayed mass with a container on the pan, so that subsequent readings show only the mass of material added.

4. Responsibilities

Role	Responsibility
Lab PI	Ensure annual professional calibration is scheduled
Lab Manager	Perform monthly verification checks, maintain calibration log
Trained Personnel	Perform daily checks before use, report malfunctions
New Students	Complete training before independent use

5. Safety and Hazards

Hazards

- **Physical:** Calibration weights are dense metal objects; dropping them can cause injury to feet or damage to the balance pan. Handle with forceps only.
- **Chemical:** Some samples weighed on the balance may be hazardous. Refer to the relevant SOP for the material being weighed.

5.1. Required PPE

- ☐ Lab coat
- ☐ Nitrile gloves (when handling calibration weights or chemical samples)
- ☐ Safety glasses (when weighing chemical reagents)

5.2. Emergency Procedures

If a chemical spill occurs on or near the balance, clean the spill per [SOP-L003 Hazardous Materials Handling](#) before resuming use. If the balance pan or draft shield is damaged, remove the balance from service and contact the lab manager.

6. Equipment and Materials

6.1. Equipment

Item	Location	Notes
Mettler Toledo analytical balance	Lab bench, SGM 133	<i>TBD – confirm model number (e.g., ME204, MS205DU, or XPE205)</i>
Anti-vibration table or stone slab	Lab bench	Balance must sit on a stable, vibration-free surface
Spirit level (built into balance)	On balance base	For leveling verification

6.2. Calibration Weights and Supplies

Item	Notes
ASTM Class 1 or OIML Class E2 calibration weight set	Traceable to NIST; includes 1 mg, 10 mg, 100 mg, 1 g, 10 g, 50 g, 100 g, 200 g (or as appropriate for balance capacity)
Weight handling forceps	Never touch weights with bare hands
Lint-free wipes (Kimwipes)	For cleaning the pan
Compressed air canister (filtered)	For removing dust from the chamber
Calibration log binder or digital log	For recording all checks

7. Procedure

7.1. Balance Placement and Environment

Proper placement is essential for accurate weighing. The balance should remain in the same location and should not be moved unless absolutely necessary (Mettler Toledo, 2023).

1. Place the balance on a dedicated anti-vibration table or stone slab, away from doors, windows, air vents, and foot traffic
2. Keep the balance away from direct sunlight and heat sources (ovens, hot plates), which cause thermal drift
3. Verify the balance is level using the built-in spirit level. Adjust the leveling feet until the bubble is centered.
4. Allow the balance to warm up for at least 30 minutes after being powered on before performing any measurements or calibration (Harris & Lucy, 2020)

7.2. Internal Calibration (FACT/iSOCAL)

Most Mettler Toledo analytical balances are equipped with an internal calibration function (Fully Automatic Calibration Technology, FACT, or iSOCAL) that uses a built-in reference weight (Mettler Toledo, 2023).

1. Ensure the balance is unloaded and the draft shield doors are closed
2. Press the internal calibration button or navigate to **Menu > Calibration > Internal Calibration** (exact path varies by model)
3. The balance will automatically perform the calibration sequence. Do not touch the balance, lean on the bench, or create air currents during this process.
4. When the display reads “Calibration Done” or returns to the weighing screen, record the date and result in the calibration log
5. If the internal calibration fails, repeat the process. If it fails again, remove the balance from service and contact the lab manager.

i Note

If the balance is set to automatic FACT mode, it will self-calibrate whenever it detects a temperature change of 1.5 C or more. However, manual internal calibration should still be performed monthly as part of the verification schedule.

7.3. External Calibration Verification (Monthly)

External verification uses traceable reference weights to confirm that the balance is reading accurately across its range. This check does not replace the annual professional calibration but provides ongoing confidence in measurement quality (aac_guide2019?).

1. Perform an internal calibration first (Section 6.2)
2. Allow the balance to stabilize with an empty pan and closed draft shield. Tare to read 0.0000 g (for a 0.1 mg balance).
3. Using forceps, place the reference weights on the center of the pan one at a time, starting with the smallest. Record the displayed mass for each weight.
4. Test at a minimum of three points spanning the expected working range of the balance (e.g., low, mid, and high):

Check Point	Reference Weight	Acceptance Criterion (analytical, 0.1 mg)
Low	1 g	Displayed value within +/- 0.5 mg of nominal
Mid	50 g	Displayed value within +/- 0.5 mg of nominal
High	200 g	Displayed value within +/- 1.0 mg of nominal

5. If any reading falls outside the acceptance criterion, re-zero, repeat the measurement, and clean the pan and weight with a lint-free wipe. If the reading is still out of tolerance, perform an external calibration (Section 6.4) or remove the balance from service.
6. Record all results, the date, and the operator initials in the calibration log.

💡 Tip

Always place weights in the center of the pan. Off-center loading (corner loading) can introduce errors, especially on high-resolution balances. Periodically test corner loading by placing a single weight at each corner and comparing readings.

7.4. External Calibration (As Needed)

If the internal calibration or monthly verification indicates the balance is out of tolerance, perform a full external calibration using a traceable reference weight.

1. Navigate to **Menu > Calibration > External Calibration**

2. When prompted, place the specified calibration weight (the balance will display the required mass, typically its full capacity or a specific test weight)
3. Place the weight on the center of the pan using forceps
4. Wait for the calibration to complete and record the result
5. Repeat the verification checks in Section 6.3 to confirm the balance is now within tolerance
6. *TBD – confirm external calibration weight value for the specific Mettler model in the lab*

7.5. Annual Professional Calibration

1. Schedule an annual on-site calibration by a Mettler Toledo service technician or an ISO 17025-accredited calibration laboratory
2. The technician will perform a comprehensive calibration including linearity, eccentricity (corner loading), repeatability, and hysteresis tests
3. Retain the calibration certificate in the lab's quality records binder
4. *TBD – record the current service contract details and contact information for scheduling*

7.6. Daily Use and Best Practices

Follow these practices every time you use the balance to ensure accurate and reproducible results (Harris & Lucy, 2020; Mettler Toledo, 2023):

1. Check that the balance is level before use
2. Close all draft shield doors before taring or reading a mass
3. Allow the reading to stabilize fully (stability indicator appears) before recording a value
4. Use appropriate weighing vessels (aluminum tins, ceramic crucibles, weighing paper, or glass vials depending on the application)
5. Tare the vessel before adding sample material
6. Handle objects with forceps, spatulas, or gloves; fingerprints add mass and oils that cause drift
7. Never place chemicals directly on the pan
8. Clean up any spills immediately with a lint-free wipe or brush
9. Leave the draft shield closed and the balance powered on between uses to maintain thermal equilibrium
10. Record the balance ID, date, and any anomalies in the lab notebook

7.7. Cleaning and Maintenance

1. Wipe the pan and interior of the draft shield with a lint-free wipe after each use
2. Use filtered compressed air to remove dust from hard-to-reach areas inside the weighing chamber
3. If the pan becomes stained or corroded, remove it and clean with mild soap and water; dry thoroughly before replacing
4. Do not use solvents to clean the draft shield (they may damage acrylic or glass)
5. Inspect the draft shield gaskets periodically for wear; replace if they no longer seal properly

8. Quality Control and Acceptance Criteria

- Internal calibration (FACT): at minimum monthly, or after any balance relocation or significant temperature change
- External verification with traceable weights: monthly, recorded in the calibration log
- Annual professional calibration: required; certificate on file
- Daily pre-use level check: required
- Acceptance tolerance for routine analytical work (0.1 mg readability): displayed value within +/- 0.5 mg of the nominal weight for loads up to 100 g, and within +/- 1.0 mg for loads above 100 g
- If tolerance is exceeded after re-calibration, tag the balance “OUT OF SERVICE” and notify the lab manager

8.1. Calibration Log

Maintain a calibration log (paper binder or spreadsheet) with the following columns:

Date	Operator	Check Type	Weight Used (g)	Displayed Value (g)	Pass/Fail	Notes

9. Waste Disposal

No waste is generated by this procedure. Cleaning materials (Kimwipes) can be disposed of in standard trash unless they contacted hazardous chemicals, in which case follow [SOP-L003](#).

10. References

Harris, D. C., & Lucy, C. A. (2020). *Quantitative chemical analysis* (10th ed.). W. H. Freeman.
Mettler Toledo. (2023). *Good weighing practice: The SOP for balances and scales*. <https://www.mt.com/us/en/home/library/guides/laboratory-weighing/good-weighing-practice.html>

11. Training Record

Before using the analytical balance independently, personnel must:

1. Read this SOP in full
2. Observe a trained operator perform internal calibration and external verification
3. Demonstrate proper leveling, taring, weighing, and draft shield use
4. Successfully complete a verification check with reference weights under supervision
5. Be signed off by the PI or lab manager

12. Appendix A: Troubleshooting

Symptom	Probable Cause	Corrective Action
Reading drifts continuously	Air currents or vibration	Close draft shield doors; check placement away from vents and traffic
Reading drifts slowly in one direction	Temperature change or warm sample	Allow balance to equilibrate; cool samples to room temperature before weighing
Balance does not tare to zero	Residue on pan or overloaded tare	Clean pan; remove vessel and re-tare
Internal calibration fails	Significant temperature change or mechanical issue	Allow 30 min warm-up; retry. If persistent, contact lab manager.
Displayed value differs from reference weight by more than tolerance	Calibration drift	Perform external calibration (Section 6.4). If still out, remove from service.
“Overload” message	Sample exceeds balance capacity	Use a balance with higher capacity
Balance will not power on	Power supply disconnected or fuse blown	Check power connection; contact lab manager
Unstable reading with small masses (less than 10 mg)	Static charge on sample or vessel	Use anti-static device or ionizer; ground yourself before weighing