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## Top 10 Ways to Ensure Measurement Errors

If guaranteeing errors in your mass calibrations due to environmental and stabilization factors is your prime objective in your work, follow at least one of these proven tips:

1. Test everything as soon as it comes in the door.
2. Disregard any equilibration time for mass standards.
3. Clean precision weights but never allow the recommended 7 to 10 days for environmental equilibration before calibrating.
4. Provide same-day calibrations on precision mass standards.
5. Calibrate precision mass standards without allowing for equilibration in or near the balance for 24 hours (adjustable based on nominal size).
6. Calibrate cold (sometimes VERY cold) cast-iron weights and weight carts as soon as they come into the lab. (You know, the kind with condensation and frost on them!)
7. Calibrate cast-iron mass standards or weight carts when they have water in them without allowing them to dry out.
8. Calibrate mass standards when your facility is outside of the published environmental temperature and humidity control specifications.
9. Avoid using calibrated standards for temperature, pressure, and relative humidity when monitoring and adjusting lab conditions and when performing buoyancy corrections.
10. Use your balances for calibration when traffic is highest, busses and trucks are turning around in your parking lot, heavy equipment is being used to put in a new building next door, and the train is going by.
11. Never, never, never have routine service and cleaning done in your laboratory or inside your balances! (Oops, that was eleven).

The bottom-line: if you want to have **good** mass measurements going out the door, get proper training, follow documented procedures, and do no harm in the care, handling, packing, and shipping. In addition, you must ensure environmental equilibration for the mass standards, operate in a clean and stable environment, and use calibrated standards.

## Considerations for People Using Calibrated Mass Standards

The previous section was written in response to a number of errors that are commonly being made in calibration laboratories. It lists ways to ensure ERRORS! You need to be aware of these errors because they could easily affect the subsequent work you do in testing, adjusting, and calibrating balances and scales.

When you ask for immediate turn-around on the calibration of your standards, you are inviting the potential for measurement errors. If a laboratory indicates that it will provide immediate turn-around, you should ask about potential errors. Your weights react to each environment they are in. Moving weights from an environment warmer or colder than the laboratory environment can cause convection currents around the balance platform/pan where they are weighed (warm air rises and causes a lift on the balance and vice versa). These errors are definitely measurable in the laboratory. In fact, differences as small as 2 °C (<4 °F) have produced errors that are 30 times the uncertainties that the laboratories are reporting. The uncertainty on Class F weights typically used to be about one-tenth of the tolerance. Now, many laboratories are reporting uncertainty values that are closer to one-third of the tolerance. Errors that are 30 times the uncertainties could easily mean that weights are out of tolerance when measured and the laboratory reports values that are in tolerance.

Taking this scenario to the next logical step, consider this: the laboratory temperature is typically around 68 °F and the range of the environment for Class F work is 18 °C to 27 °C (64.4 °F to 80.6 °F). If you have your weights outside and the temperature is below 60.8 °F or above 84.2 °F, and you ask for immediate turnaround on those weights, you could be asking for errors.

Now, even if the temperature is in those ranges outside the laboratory, that is not the limit to potential errors. The laboratory is required to be "stable". This means that it will not be operating in the entire range of the allowable temperatures. So, if it is operating at 68 °F, your weights essentially need to be within the range of 64.4 °F and 71.6 °F to avoid errors.

Extreme cold is much worse. In cold areas of the country, many large scale trucks get their weights tested during the winter because they would rather be "down" when it's cold than at other times of the year when they generate more revenue. In those areas of the country that get COLD (and anymore that means most of you) when the weights are brought inside and develop a layer of condensation or even frost on them, the time it realistically takes for those weights to dry is much longer than when the weights "look dry" to your eyes. Measurements of weights and weight carts with water (either on or inside the weights) and frost have shown significant out-of-tolerance conditions. The amount of time it takes for weights to dry, or equilibrate with the laboratory environment, is related to the actual temperature of the weights, the size, surface areas, and surface condition of the weights.

Cleaning precision mass standards can cause similar problems due to the materials on the surface of the weights and the amount of time that is essential for the weight to equilibrate with lab environment. It has been found that 7 to 10 days are essential for precision weights to stabilize after they have been cleaned and before that are calibrated. Because of the relative uncertainties and the measurable impact, equilibration is even more critical on precision standards.

The bottom-line: if a laboratory asks you to deliver your weights prior to the scheduled calibration time to allow them to equilibrate with laboratory environment; they are just trying to make sure you get high quality measurement results. For example, they may ask you to drop the weights off on Friday afternoon so the weights and their laboratory can stabilize and they can begin testing on Monday. This is a good sign!

Taking this ideas one step further, what happens when you take your weights to a site and use them? The same thing! If your weights are outside and it's cold and you take them inside and they get a thin film of condensation or frost on them, they are likely out of tolerance! To go ahead and calibrate someone's scale with these weights is a disservice and could result in adjusting a balance or scale out of tolerance.