

Laboratory Conditions



Rules

Policies

Standards

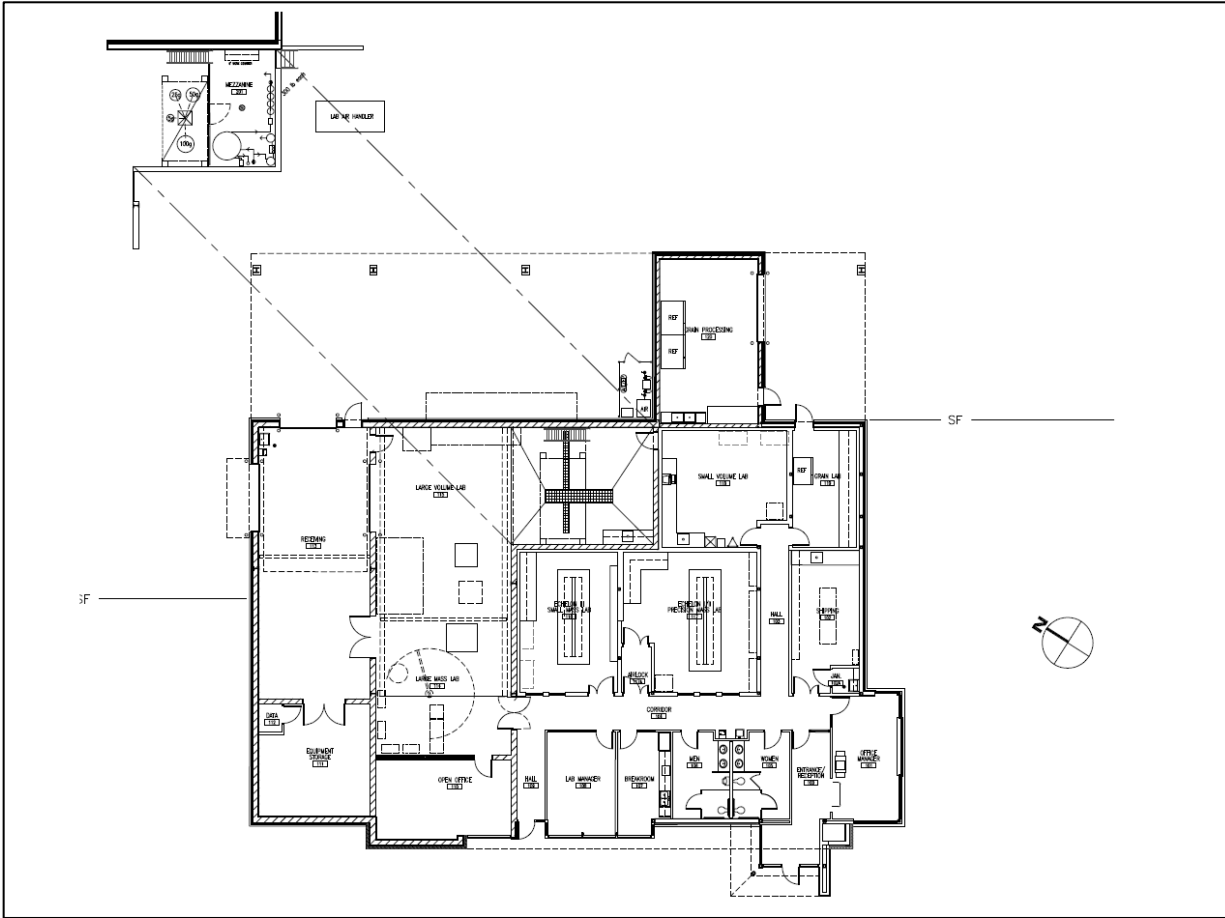
Compliance

Regulati

**Reference
Standards**

ISO/IEC 17025:2017

Section 6.3.1



The laboratory must be designed and operated in a manner that meets the requirements established within measurement procedures adopted by the lab for calibration services.

ISO/IEC 17025:2017

Section 6.3.2

NIST HB 143-2023
December 2023

Table 4. Summary of Environmental Facility Limits Specified in the NISTIR¹ Procedures

Parameter, Echelon	Temperature Range (°C)	Temperature variability from set point (± °C / h)	Max change per calibration (°C / h)	Relative Humidity (RH) Range (%)	RH variability from set point (± % / h)
Mass, I (OIML E ₁)	18 to 23	0.5 °C / 12 h	0.3	40 to 60	5 % / 4 h
Mass, I (OIML E ₂)	18 to 23	1.0 °C / 12 h	0.7	40 to 60	5 % / 4 h
Mass, II	18 to 23	2 °C / 12 h	1.5	40 to 60	10 % / 4 h
Mass, III	18 to 27	5 °C / 12 h	3.0	40 to 60	20 % / 4 h
Force ²	23	NS	0.2	NS	NS
Force ³	18 to 27	5 °C / 12 h	3.0	40 to 60	20 % / 4 h
Volume, I Gravimetric	18 to 23	NS	1.0	40 to 60	10 % / 4 h
Volume, II Transfer	18 to 27	NS	2.0	35 to 65	20 % / 4 h
Dimensional	18 to 22	1 °C / 24 h	0.5	40 to 60	10 % / 4 h
Time	General laboratory conditions; record conditions from laboratory observations				
Tuning Forks	18 to 25	NS	NS	40 to 60	NS
Thermometry	NS	2 °C / 24 h	NS	40 to 60	10 % / 4 h
Hydrometers	Stable	NS	NS	NS	NS
Watthour Meters ⁴	23	NS	1.0	30 to 50	NS

NS = Not Specified.

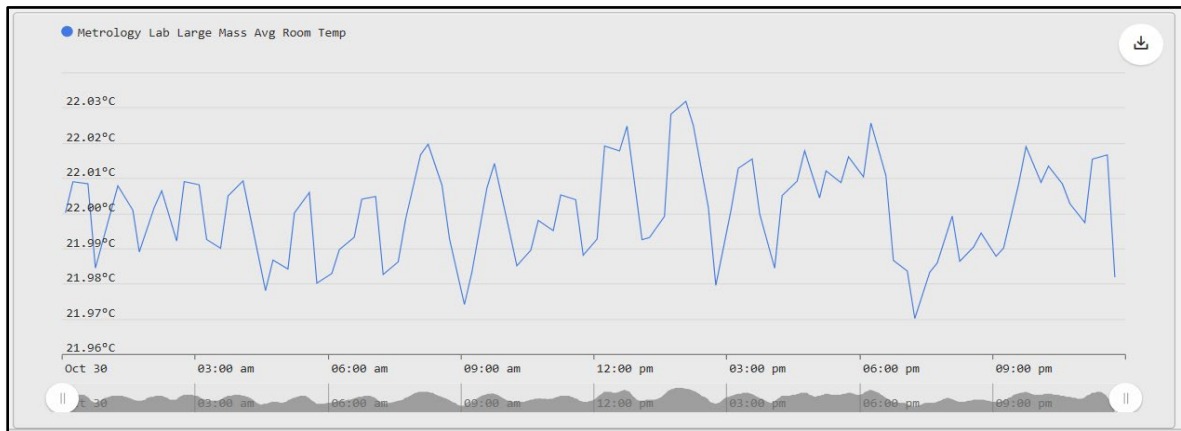
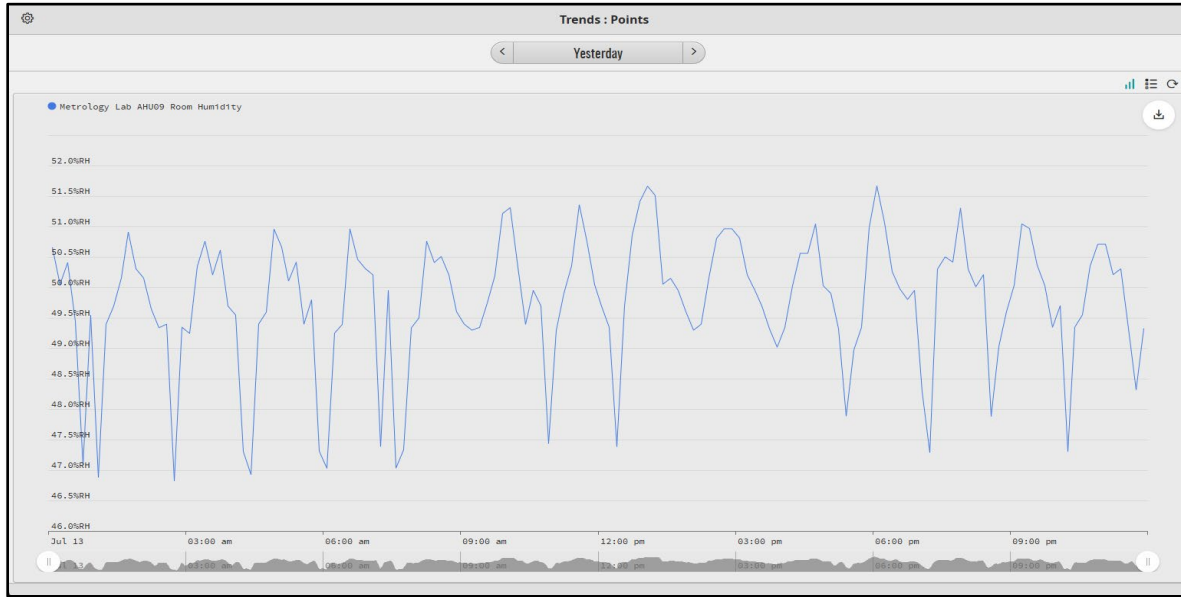
NOTE: [Table 4](#) is provided with the intent to be a useful summary at a glance; the applicable documentary standard and laboratory procedures take precedence in the case of conflicts

The laboratory shall have documentation specifying the required environmental conditions that must be met for the measurement services conducted by the lab.

These requirements may be found in NIST Handbook 143 (Table 4) and specified within the calibration procedure documents.

ISO/IEC 17025:2017

Section 6.3.3

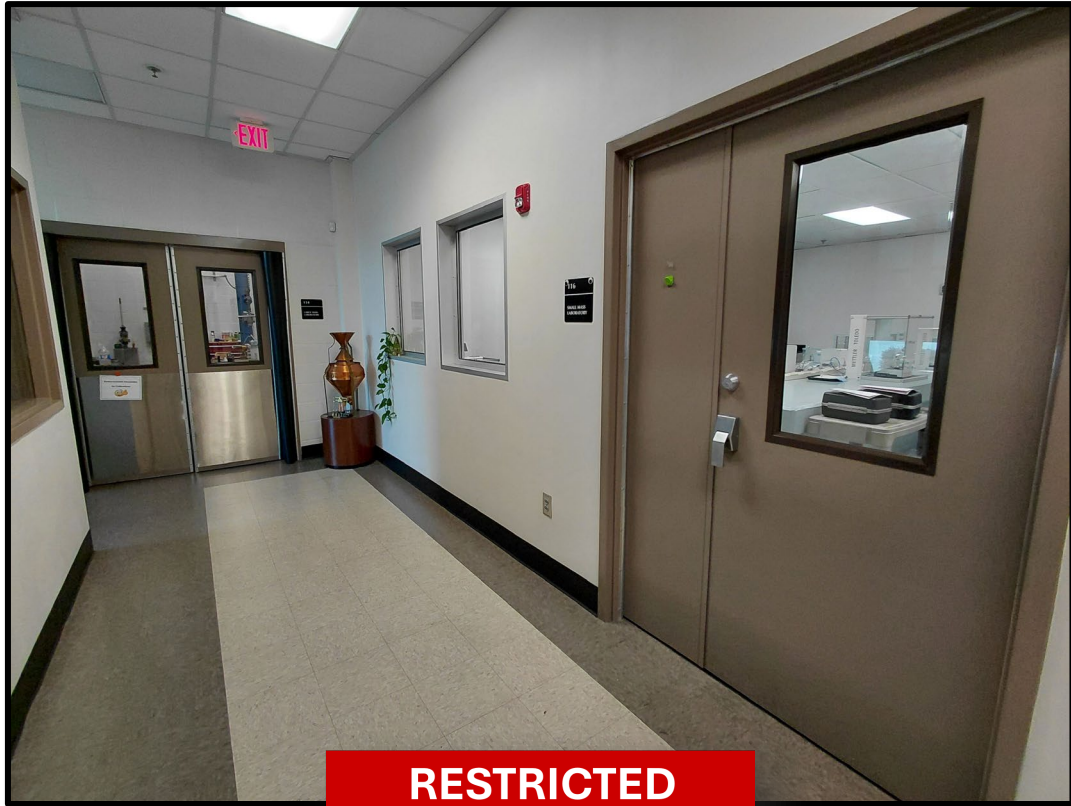


The lab is responsible for control of its environmental conditions.

Environmental conditions should be monitored and recorded. Data logging software can be utilized to improve efficiency in documenting and monitoring temperature and humidity parameters.

ISO/IEC 17025:2017

Section 6.3.4



The lab facilities and environment should not create adverse conditions that invalidate results. This includes influences from:

- Environmental conditions that are outside set parameters.
- Contamination of standards, measuring devices, equipment, or customer submitted items.
- Unauthorized access to laboratory facilities

Lab facilities shall be designed in a manner that provides effective separation between incompatible laboratory activities.

Minimizing Non-Conformities



Install continuous monitoring systems (i.e. data loggers)



Establish environmental set points for temperature and humidity



Maintain a logbook or electronic records to track environmental parameters daily



Maintain a calibration schedule for environmental sensors



Perform regular maintenance of HVAC system



Train staff to identify and respond to environmental changes



Establish procedures for halting operations when conditions exceed limits



Use control systems to limit entry to sensitive areas



Establish a pest control plan



Control and Monitoring

HVAC



Labs are required to have a system in place to maintain and monitor laboratory environmental conditions.

A properly functioning HVAC system is fundamental to maintaining laboratory environmentals at established parameters.

HVAC

To keep systems operating optimally:

- Schedule routine maintenance to service and evaluate the HVAC system.
- Have filters replaced and components cleaned out to improve efficiency.
- Establish a calibration cycle for monitoring sensors.



Monitoring

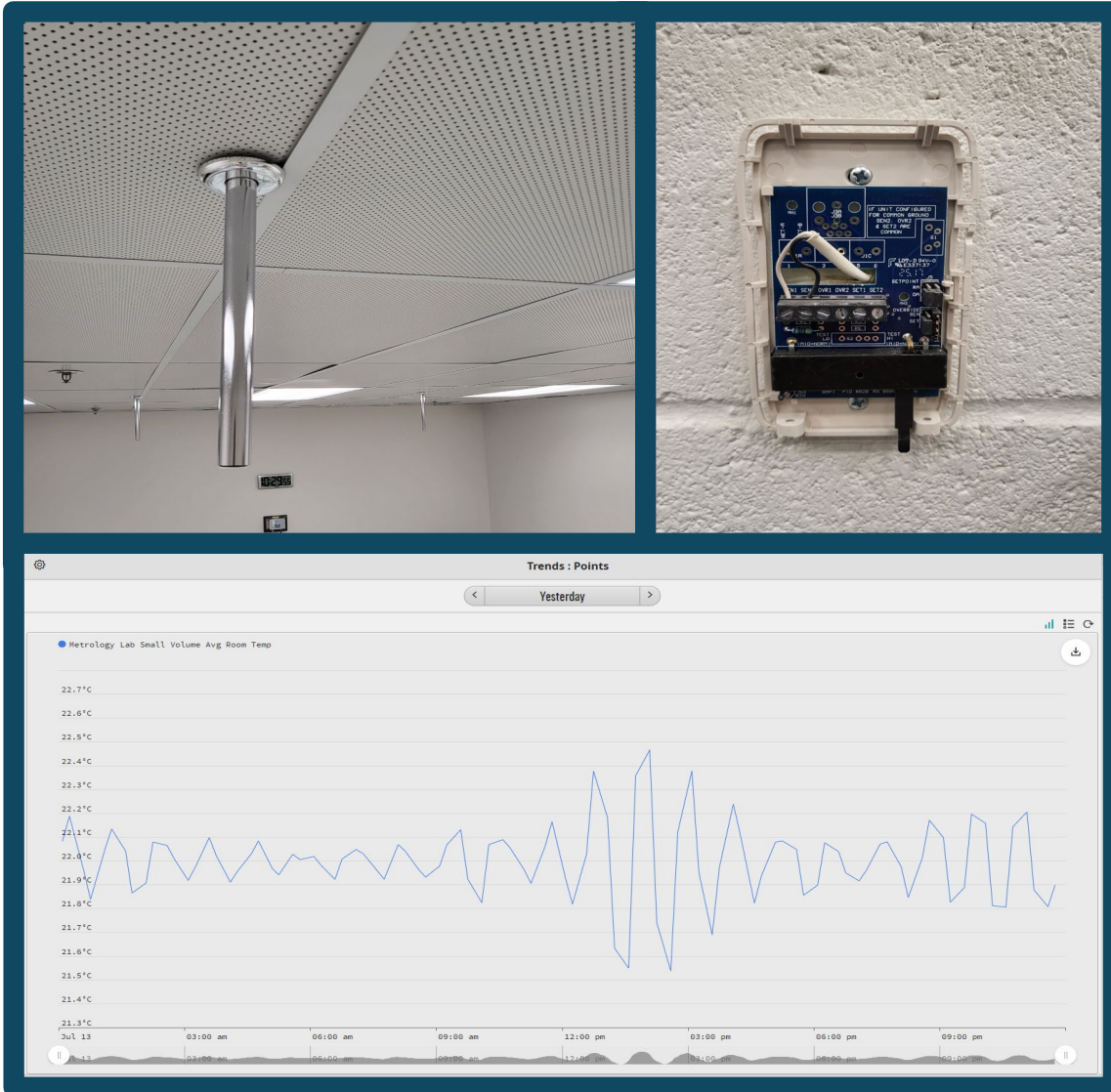


Calibrated environmental readers installed within the laboratory can provide at time measurements for temperature, humidity and barometric pressure readings.

These units must be calibrated for use.

Some models may have internal transmitters capable of connecting to an established data logging program.

Monitoring



Environmental monitoring systems are essential for continuous control and documentation of conditions.

Connected to data logging software, these systems provide:

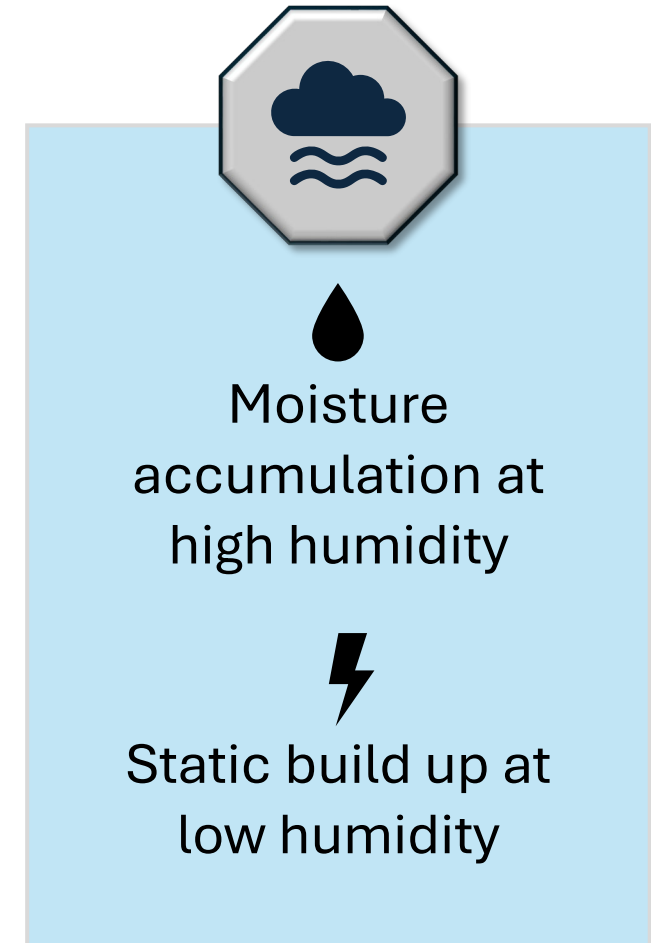
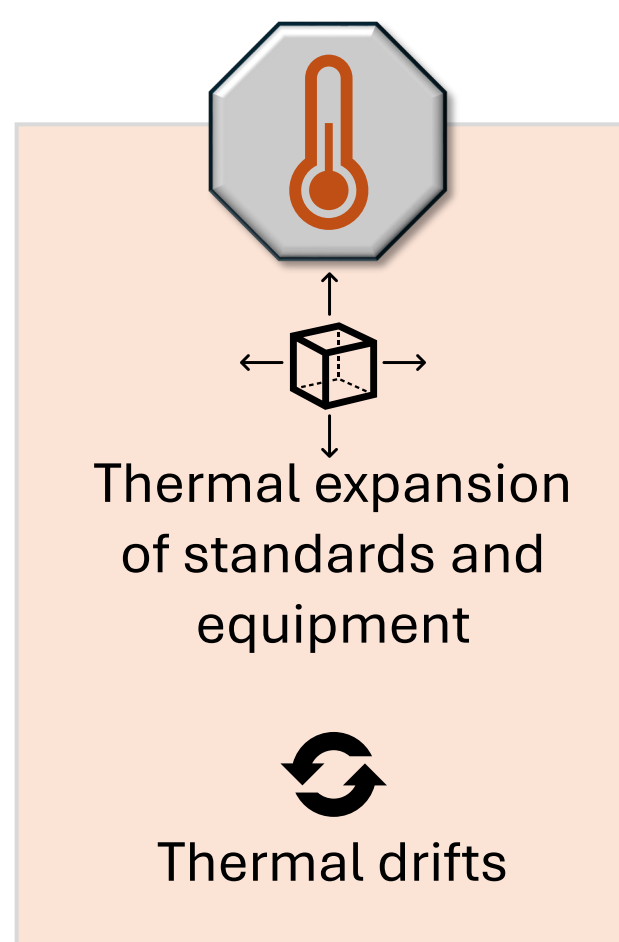
- ◆ Long term visibility of measured temperature and humidity
- ◆ Automated alerts
- ◆ Printable reports

Temperature and Humidity are significant variables impacting:

➤ Accuracy

➤ Reproducibility

➤ Validity of Work



Temperature



All materials expand or contract when heated or cooled. These changes can impact the accuracy and repeatability of results during calibrations.

Equipment, such as mass comparators, have ambient temperature limits.

- Internal components are also susceptible to contraction and expansion related to surrounding temperature, affecting the reliability of the equipment.

Temperature



Temperature differences can create convection currents. These currents can generate enough force to act on the equipment, impacting accuracy of calibration results.

To minimize these effects, artifacts should be given enough time to acclimate to the laboratory environment prior to the start of a calibration procedure.

Table 2. Stabilization time.

Temperature Range for the Artifact	Minimum Equilibration Time
Inside upper or lower limits $> 18\text{ }^{\circ}\text{C}$ and $< 27\text{ }^{\circ}\text{C}$	None
Outside of upper or lower limits $< 18\text{ }^{\circ}\text{C}$ or $> 27\text{ }^{\circ}\text{C}$	24 hours/overnight

Humidity



Ideal humidity ranges are typically 40 % RH to 60 % RH.

Humidity levels **below 40 % RH** increase the risk for electrostatic buildup.

- Static buildup can impact accuracy and repeatability of mass calibrations.
- Electrostatic discharge can damage sensitive electrical components in equipment.

Humidity levels **above 60 % RH** increase the amount of moisture content in the air.

- Moisture content can be absorbed by the surface film of mass standards, artificially increasing the mass of the standards.
- Increased moisture levels can increase the risk for corrosion.

Air Pressure

Barometric air pressure readings (mmHg) do not have a set minimum and maximum level to maintain.

The lab shall maintain equipment that measures air pressure readings. These values are used in mass calibrations for air buoyancy corrections.

SOP 2

**Recommended Standard Operating Procedure
for
Applying Air Buoyancy Corrections**

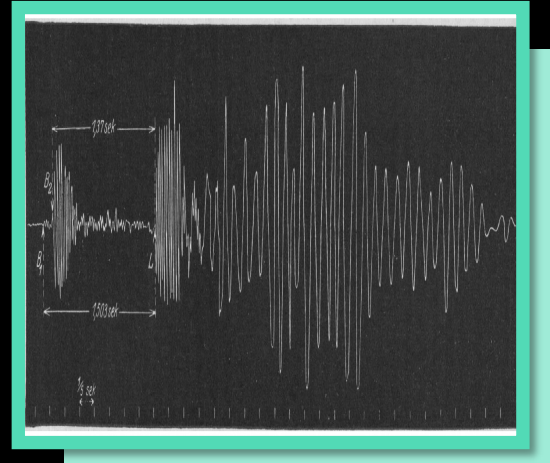
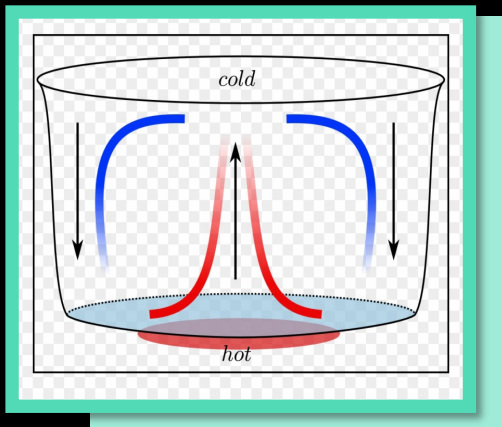
Cybersecurity and HVAC



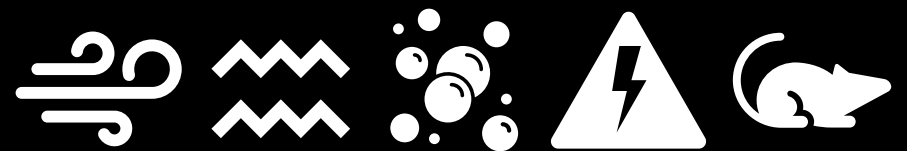
HVAC software and systems are increasingly more at risk for cybersecurity attacks as systems become more integrated into online controls and management.

- ◆ IP address connections
- ◆ Automation platforms
- ◆ Cloud access
- ◆ Mobile app connections
- ◆ Vendor firmware security

Depending on your department's requirements, HVAC and data logging software systems may be maintained offline for cybersecurity purposes, reducing the advantages provided by data logging software.

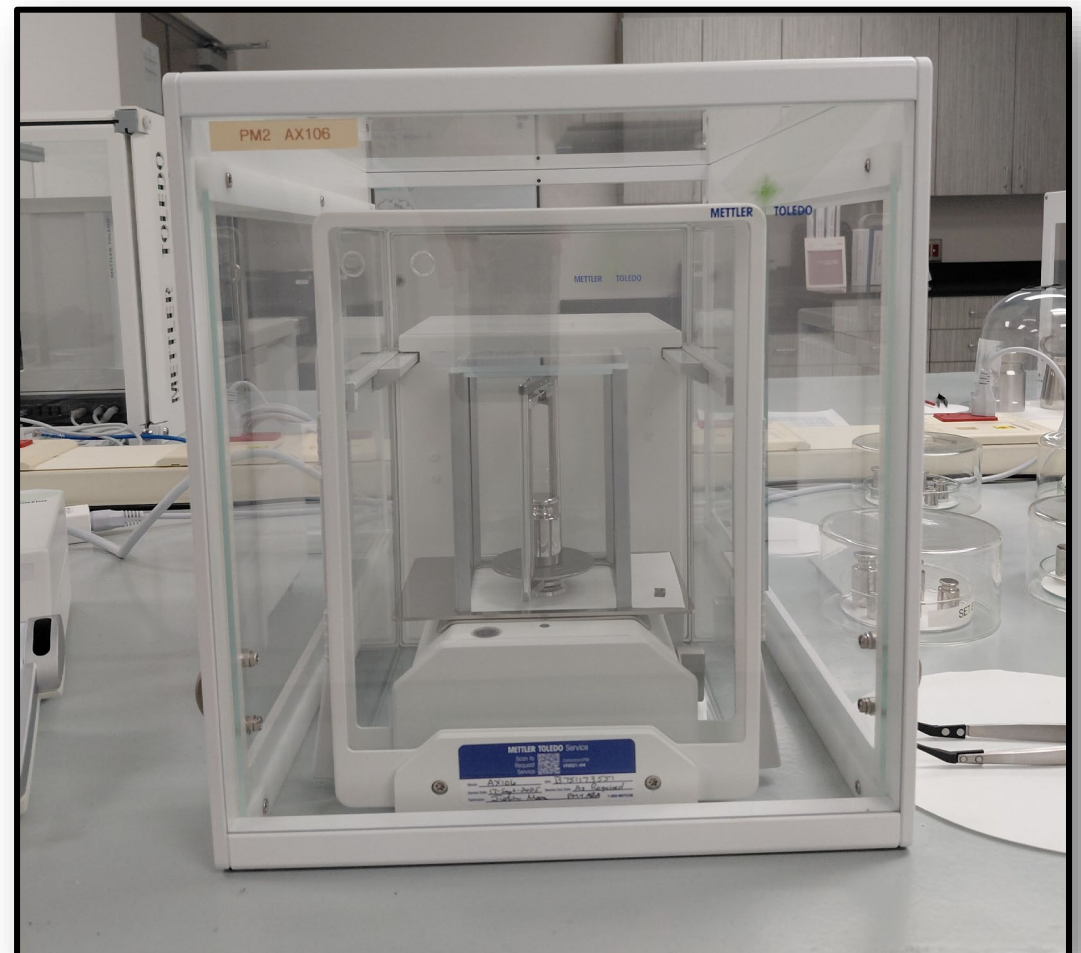
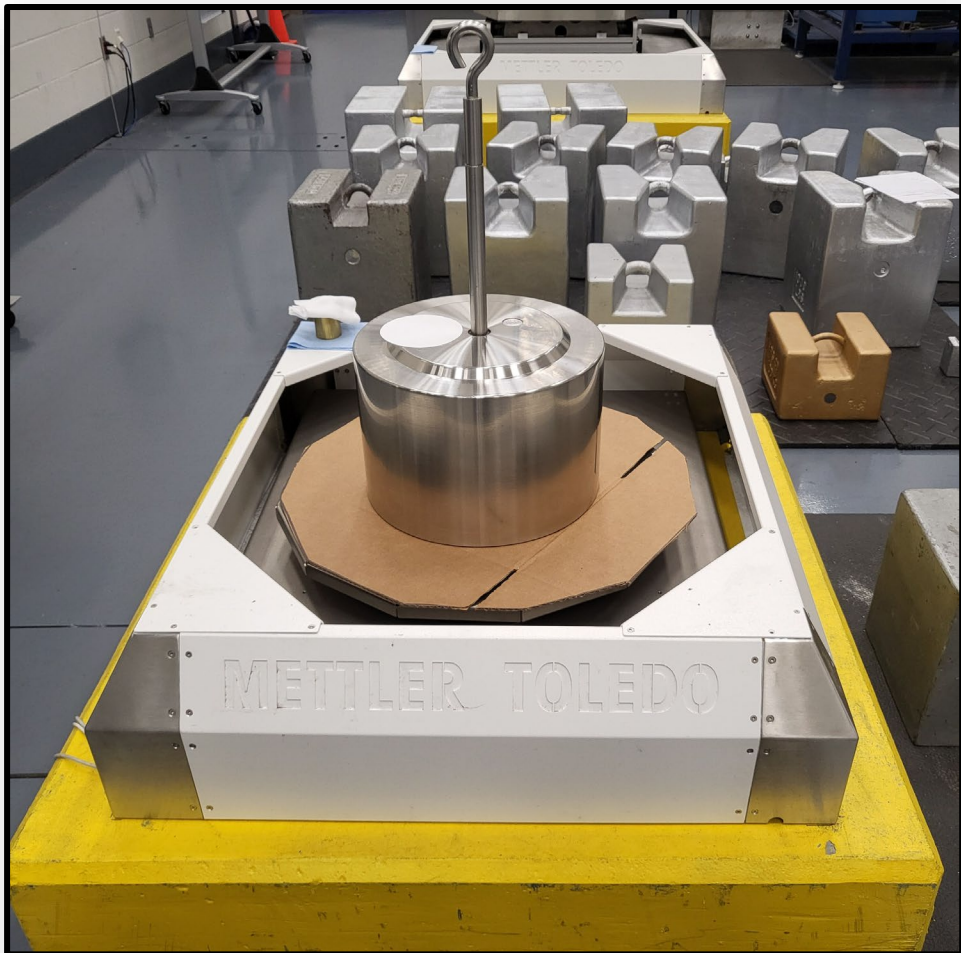


Mitigating Negative Effects



Air Drafts

Draft shields can reduce the effect of air currents created by air vents or user movements.



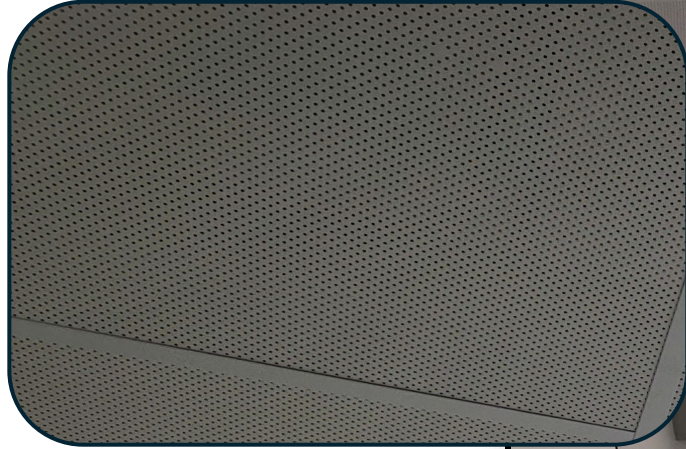
Air Drafts

A laminar air flow system dissipates air in a uniform, continuous manner.



A vertical flow system (*as pictured*) releases air from the ceiling, returning through intakes located along the floor.

Air Drafts



Porous ceiling tiles allow for slow, equal distribution of air down from the ceiling.



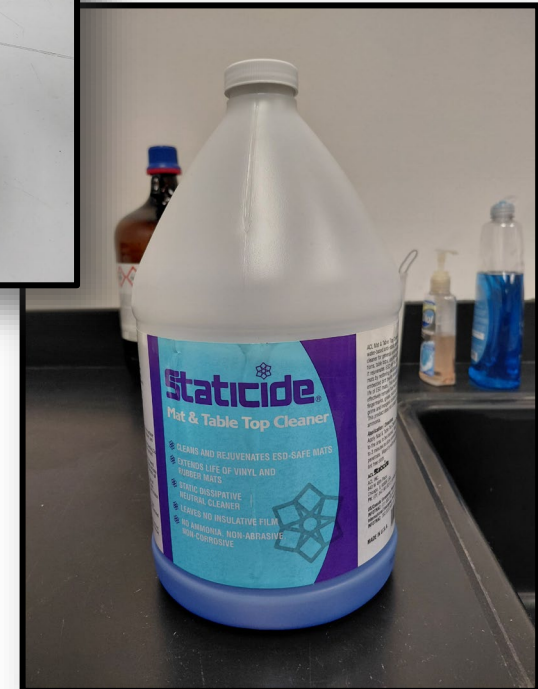
A false wall covers the air return, with gaps present along the floor to allow for air return behind the wall.

Electrostatic Discharge (ESD)

- Maintain humidity set points to between 40 % RH to 60 % RH.
 - Moisture present in air acts as a conductor to static electricity.
- Caution with certain clothing fabric should be taken to reduce electrostatic buildup from the material rubbing together.
 - Synthetic fabrics are more prone to this buildup.
- ESD control resinous flooring (e.g., ElectraGuard) is a conductive epoxy floor paint that can be applied to the lab floors and grounded to the building's main electrical grounding system.

Electrostatic Discharge (ESD)

- ESD chairs are designed with materials that conduct electricity and safely transfer it through grounding systems built into the chair.
- Dissipative neutral cleaners are solvents for use on ESD coated surfaces, designed to clean and revitalize ESD coated surfaces.



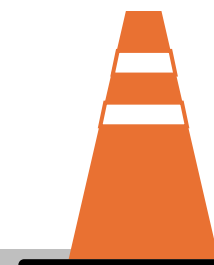
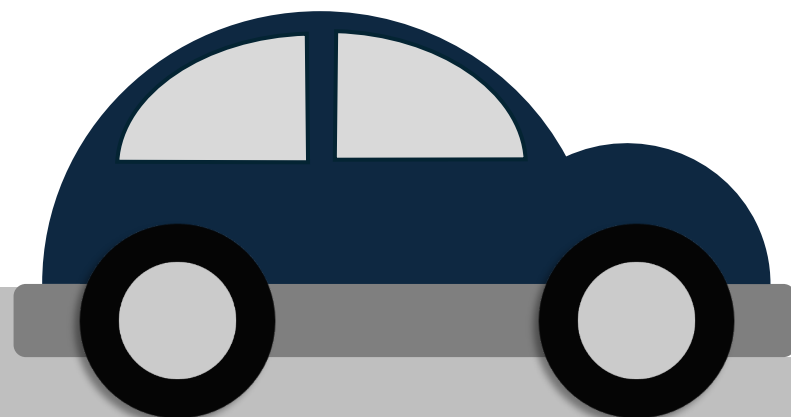
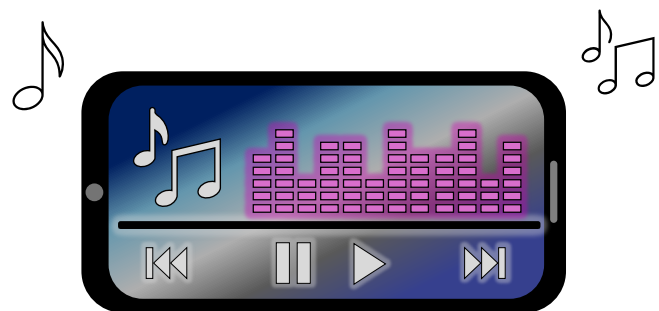


Vibration

Vibrations can impact accuracy of readings obtained during measurements.

Potential sources for vibrations include:

- Road traffic/Air Traffic/Trains
- Neighboring business/industrial complexes
- Nearby construction
- Audio emitting devices (i.e. phones; radios)
- Air conditioning units
- Earthquakes



Vibration



To dampen effects from vibrations, mass comparators may be set up on:

- Marble tables
- Balance tables with isolators
- Vibration damping pads

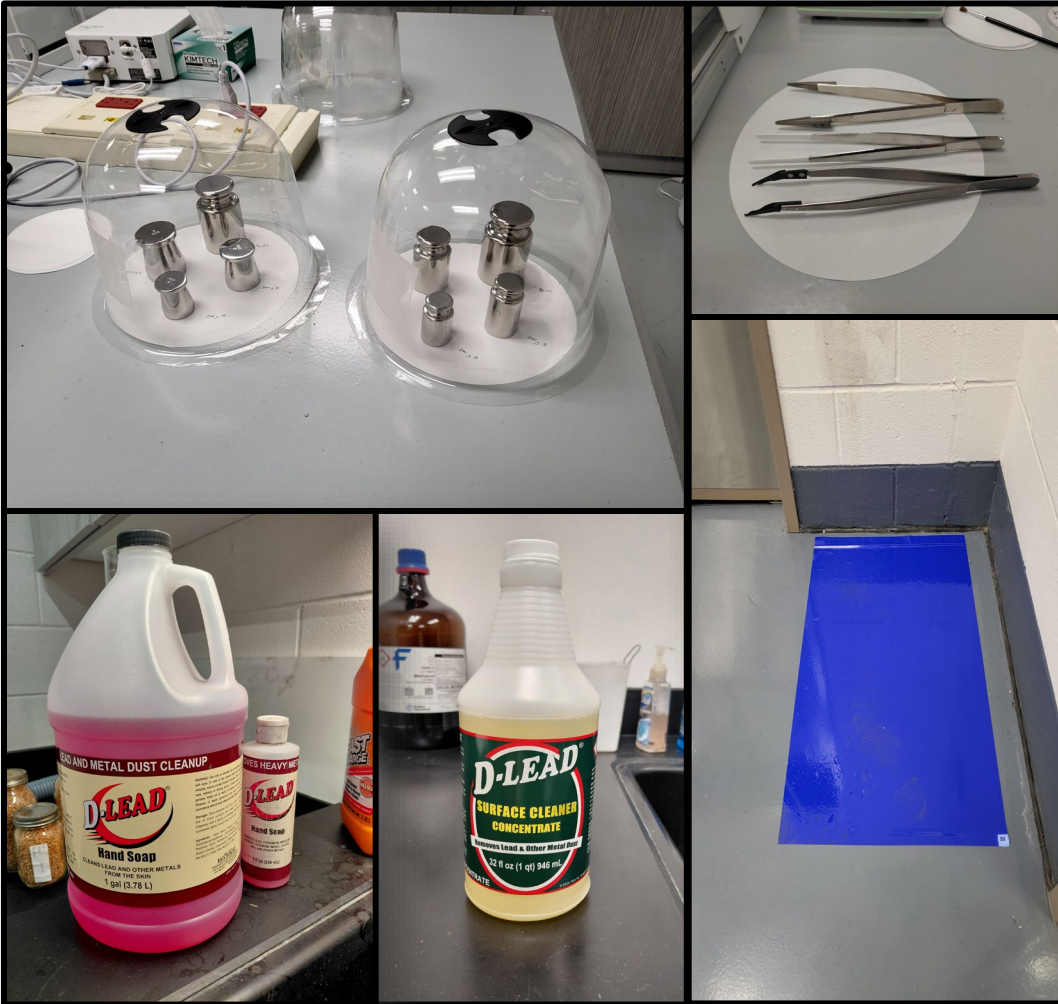
Vibration



If feasible, construction of a solid concrete table (inertia table) can provide excellent dampening to vibrations.

The table pictured is built on a separate foundation, made of concrete and fiber glass poured 12 feet underground.

Contaminants



Reduce contamination of equipment by:

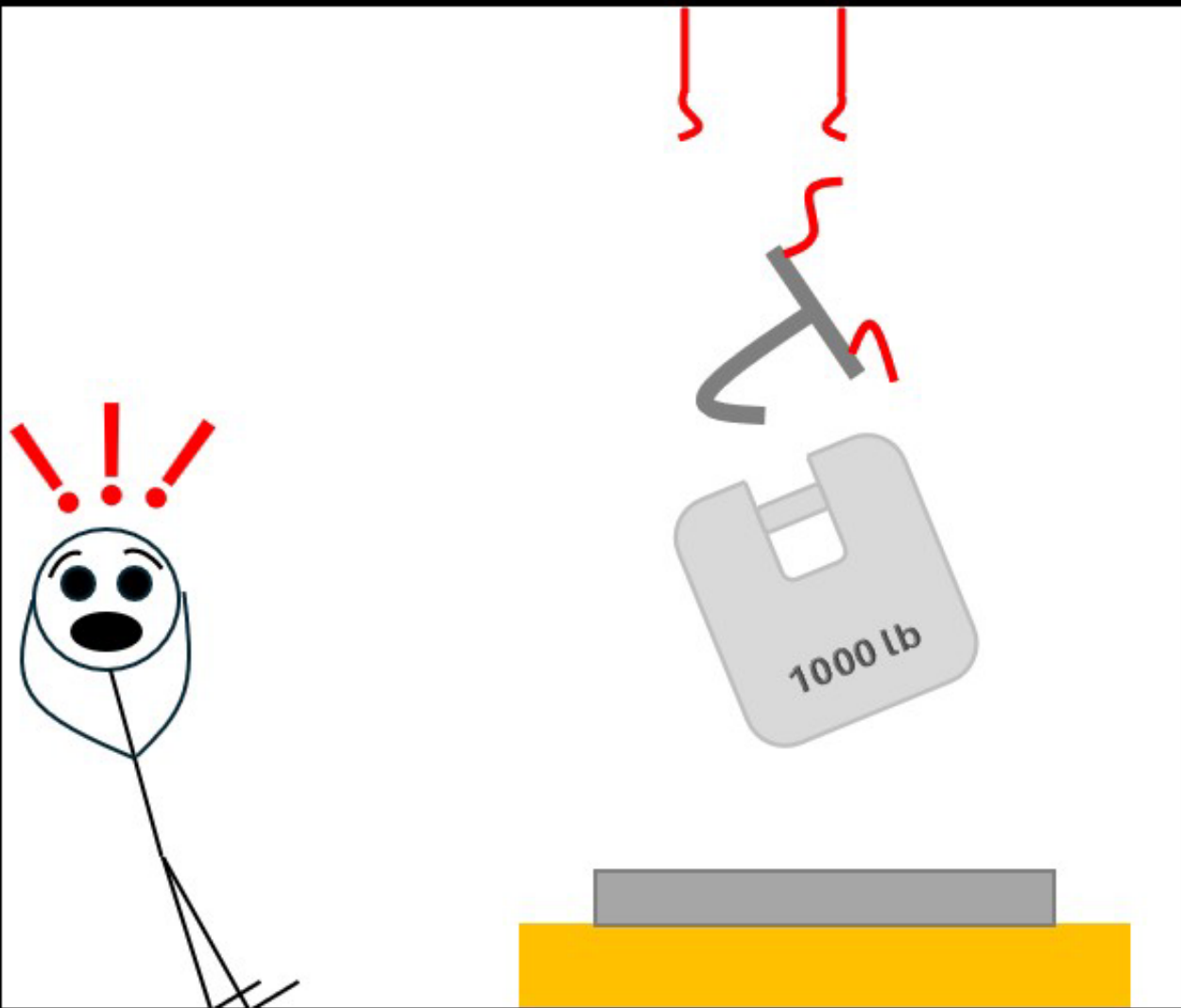
- Covering standards when not in use;
- Using forceps, tweezers, or lifters to move standards.

To reduce lead contamination:

- Lead cleaners can be used to remove lead from work surfaces and skin;
- Sticky mats can be utilized to reduce spread from foot traffic

Pests

- Pests, such as rodents or insects are a nuisance that can affect the laboratory environment, such as:
 - Rodents can chew through cables, damaging equipment;
 - Pests can contaminate the environment or equipment;
 - Cockroaches love electronic equipment, and can damage the internal components of equipment.
- The lab should establish a routine pest service to treat exterior areas.
 - Care should be taken to not spray chemicals within the laboratory to prevent contamination of equipment or standards.
 - These areas can be treated through the use of non-chemical pest control, such as glue traps.



MURPHY'S LAW
It applies everywhere

**When
Things
Go
Awry**



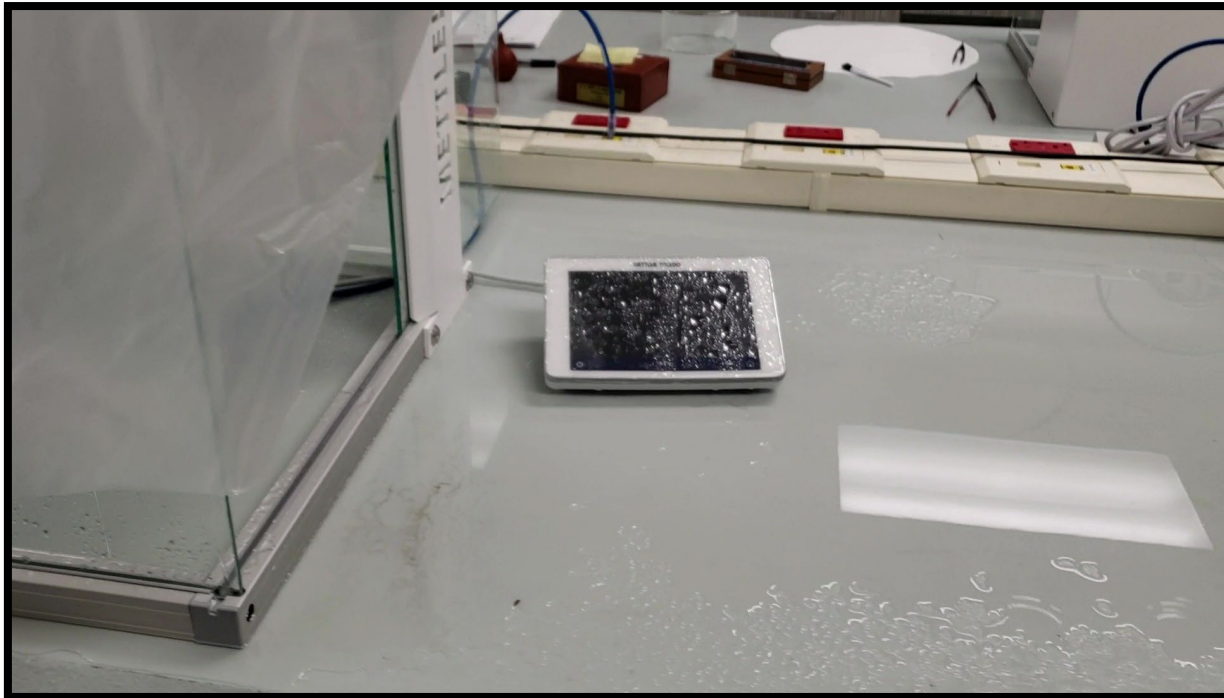
HVAC Water Line Break

A crack in a water pipe of the HVAC unit caused significant damage to laboratory equipment.

The unit is housed in a second floor space above the laboratory.

When the pipe burst, all the water flooded into the lab space below.

The Impact



Two mass comparators were ruined and needed to be replaced.

- The cost of replacement for the two comparators totaled \$50,000.
- The lab was fortunate to be under a 1 year warranty with the contractor, who covered the cost of replacement.

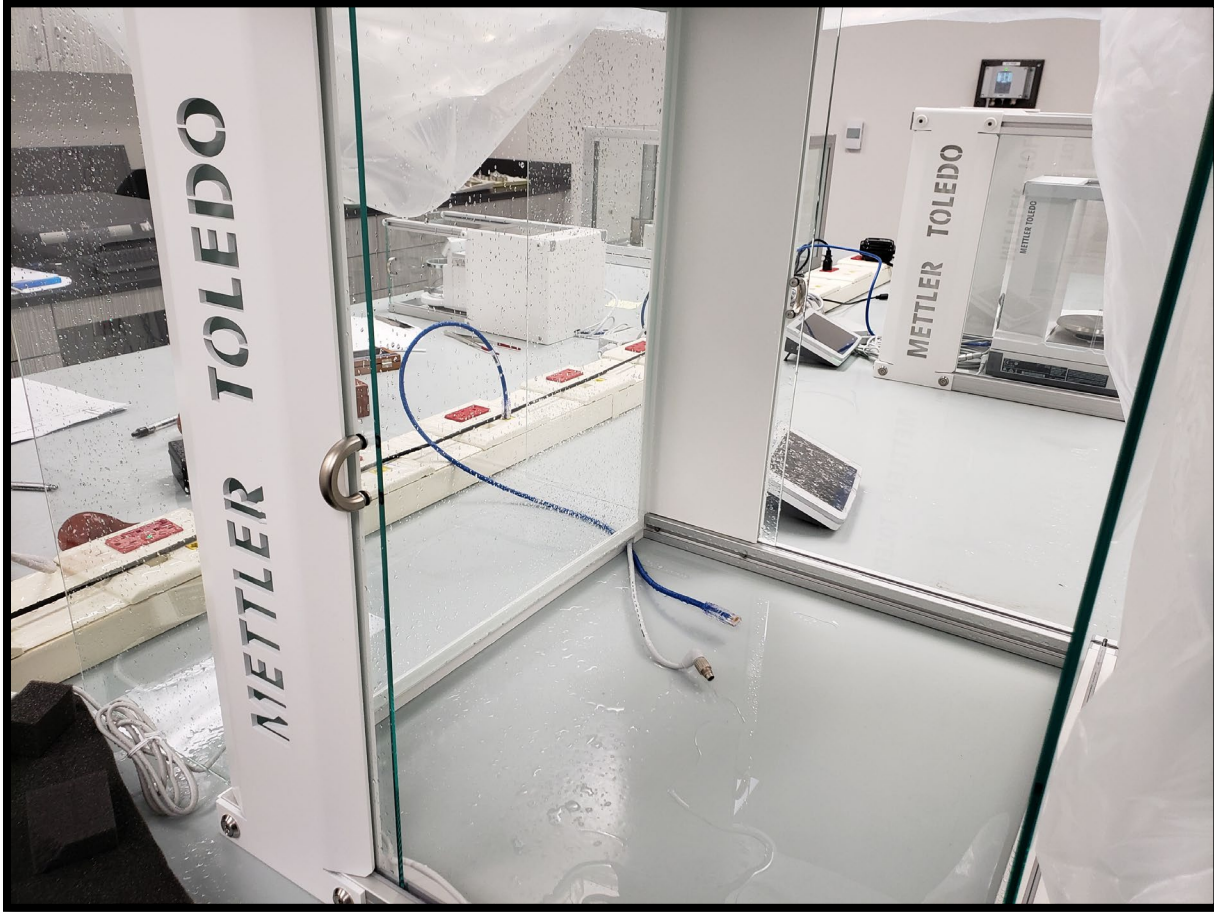
The Impact



Standards were contaminated from the water and debris that came through the ceiling.

- Standards had to be thoroughly cleaned and allowed time to reacclimate to the lab environment.
- Standards had to be recalibrated before being placed back into service.

The Impact



Calibration of Small Mass, Mass Echelon III customer work was impacted.

- Calibrations were halted until the Small Mass standards were cleaned and recalibrated.
- Downtime was minimized by utilizing the comparators in the Precision Mass Laboratory.

Action Plan Taken



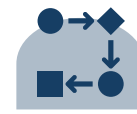
Impact Assessment

- What laboratory equipment was impacted?
- What customer items were impacted?
- What calibrations are impacted?
- What is the financial impact?



Corrective Steps

- Standards were cleaned and allowed time to reacclimate to the lab environment.
- Damaged mass comparators were replaced.
- Customer work was briefly halted.



Risk Mitigation

- Standards were covered with cloche dome.
- A metal pan was placed under the HVAC units over the labs to catch any water runoff from leaks.



Effectiveness

- In early 2026, a water line came loose above the Small Mass Lab.
- The majority of the water was collected in the metal pan.
 - There was water that entered into the lab space below, but the amount of water was minimized.
 - No equipment was damaged.
 - No standards were contaminated.

References

- NIST Handbook 143-2023, “NIST Office of Weights and Measures (OWM) Recognition Program Handbook, 7th Edition”
- ISO/IEC 17025:2017, “General Requirements for the Competence of Testing and Calibration Laboratories”
- NCLSI, Recommended Practice 7 (RP-7): Laboratory Design