Laboratory Safety Training

Colorado School of Mines
Environmental Health and Safety
The Environmental Health and Safety (EHS) Department at Mines works hard to keep students, faculty, and staff safe. EHS is here to advise, assist, and ensure compliance on everything safety-related on campus.

Laboratory Safety Training

Who is required to attend?
- Any Mines student (undergraduate and graduate), staff, faculty, or other personnel that may be exposed to hazardous materials or activities in a laboratory environment

When do you need to take Lab Safety?
- BEFORE beginning lab duties

Laboratory Safety Training is required one time, and recommended annually
The Environmental Health and Safety (EHS) Department at Mines works hard to keep students, faculty, and staff safe. EHS is here to advise, assist, and ensure compliance on everything safety-related on campus.

Environmental Health and Safety (EHS)

What does EHS do?
- Lab Safety
- Industrial Hygiene & Occupational Safety
- Environmental Health
- Health Physics (Radiation Safety)
- Chemical Procurement & Distribution
- Sustainability
- Emergency Response
- Fire Safety
EHS is located at two locations on campus. EHS Main Office is located in McNeil Hall, just south of the Geology museum. And, the CSDF is located on the north side of Coolbaugh Hall in the basement (CO 030). Both locations can provide safety equipment, hazardous waste containers and labels, and more!
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“Research conducted at university laboratories is often on the forefront of technology and innovation. It is important that this research continues and thrives. But it must be done within a strong safety culture where preventing hazards is an important value.”

Dr. Rafael Moure-Eraso
Chairperson, Chemical Safety Board
Texas Tech University - two graduate students at Texas Tech University were conducting research funded by the U.S. Department of Homeland Security on energetic or explosive compounds.

The two principal investigators for the research believed they had verbally established a 100 milligram limit on the production of energetic materials, but the Chemical Safety Board (CSB) investigation found there was no formal system for communicating this limit or verifying compliance. Few of the graduate students interviewed during the investigation believed that a strict 100 mg limit existed.

The CSB found that initially, the compound was made in small batches of less than 300 milligrams, but the two students were concerned about potential variability among different small batches of the compound which could affect later test results. They decided to scale up the synthesis to make a single batch of approximately 10 grams, enough for all of their testing. The graduate students believed that keeping the compound wet with a solvent would prevent it from exploding. After producing the larger batch, the more

<table>
<thead>
<tr>
<th>Lab Incident at Texas Tech, 2010</th>
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<tbody>
<tr>
<td><strong>Damage:</strong></td>
</tr>
<tr>
<td>- Graduate student</td>
</tr>
<tr>
<td>- Lost 3 fingers</td>
</tr>
<tr>
<td>- Burns on hands and face</td>
</tr>
<tr>
<td>- Eye damage</td>
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<tr>
<td><strong>Causes:</strong></td>
</tr>
<tr>
<td>- Scaled up production of energetic material (100mg → 10g)</td>
</tr>
<tr>
<td>- Poor communication between supervisor and Graduate Students</td>
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<tr>
<td>- Two “Near Misses”</td>
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senior graduate student observed that it contained clumps that he believed needed to be broken using a mortar and pestle up prior to testing. As the pestle pressed against the compound, it detonated. The graduate student was seriously injured: his left hand severely damaged by the force of the explosion, causing the loss of three fingers, perforation of his eye, and cuts and burns to other parts of his body.

There had been two previous near-misses. While no one was injured, there were similarities in the causes of these previous incidents to the January 2010 explosion. But these key lessons were missed at the time of the earlier incidents.
A Research Assistant (Sheri Sanji) at UCLA was transferring tert-butyllithium, a pyrophoric chemical that spontaneously combusts in air, into another container using a plastic syringe. During the transfer, the syringe came apart and chemical caught on fire, burning graduate student severely. She died from her burns more than two weeks later.

Pyrophoric chemicals, like tert-butyllithium, should never be transferred using a plastic syringe with a short needle. The researcher was not using appropriate lab equipment. Additionally, the researcher was not wearing a lab coat, which exacerbated her burns.

The researcher was never properly trained in lab safety or the safe use of handling pyrophoric chemicals by her lab supervisor.
Everyone at CSM is responsible for ensuring a safe work environment around campus, and especially in the laboratory. As a lab worker, you are primarily responsible for your own safety.

This training provides an overview of laboratory safety, but it is important that each individual in the lab participates in Lab Specific Training led by a lab supervisor. Lab Specific Training will identify the hazards in your lab, and provide information on how to mitigate these hazards. An important resource available to Mines lab workers is the Chemical Hygiene Plan (CHP), which outlines policies and guidelines for safe lab practices. Every Lab Worker should read and understand the CHP.

Hazardous activities and chemicals require the use of written Safe Operating Procedures (SOPs). SOPs instruct lab workers on the hazards of certain activities (including hazardous material handling), and how to properly perform an experiment or procedure.

Mines requires all incidents (injuries, chemical exposures, chemical spills, fires, and near misses) to be reported to a supervisor and EHS. This reporting requirement helps us identify hazards on campus and continually work to make campus a safer place.
Every lab worker has the right to Stop Work Authority. Stop Work Authority is the right and responsibility to stop work when an unsafe condition is perceived without consequence to the individual who stops the work. EHS also strongly encourages the reporting of unsafe conditions on campus.
EHS plays an important role in keeping CSM’s laboratories safe. EHS is a resource for lab workers to offer advice and recommendations of Safe Operating Procedures. Additionally, EHS maintains and updates the Chemical Hygiene Plan to reflect changes in research activity on campus. We monitor compliance at the city, county, state and federal levels. We offer in-person and online training to lab workers including: Lab Safety Training, Hazardous Waste Generator Training, Radiation Safety Training, Laser Safety Training, Bloodborne Pathogen Training, and more. EHS is also on call 24/7 to respond to emergencies like chemical spills, fires, and other emergencies.

Finally, your lab supervisor or Principle Investigator is required to ensure adequate training of all members of the lab, and ensure the effectiveness of emergency equipment and emergency preparedness. PI/Lab Supervisors are required to understand the CHP and develop Safe Operating Procedures within the guidelines outlined by the CHP.
Working Safely with Chemicals

**Three Steps:**

1. **PLAN AHEAD**
   - Determine potential hazards *before* beginning experiment

2. **MINIMIZE EXPOSURE**
   - Wear Personal Protective Equipment & Use Fume Hoods

3. **BE PREPARED FOR ACCIDENTS**
   - Identify emergency equipment and evacuation procedures
Working Safely with Chemicals

Step 1: Plan Ahead

- Hazard Communication
  - Be familiar with chemical hazards and exposure symptoms
  - Read Safety Data Sheet (SDS) before using a chemical
  - Create and/or read Safe Operating Procedures (SOP) before beginning an experiment
  - Review Mines Chemical Hygiene Plan
  - Talk with EHS to discuss new experiments
The Globally Harmonized System is a standardized system to help communicate the hazards of chemicals across the world. Every chemical must be labelled with any of the nine applicable universal pictograms that illustrate hazards. Additionally, chemicals must be labelled with a signal word. DANGER and WARNING are the only two signal words available. DANGER is used for chemicals with a severe hazard, while WARNING is used for chemicals with less severe hazards.
The NFPA 704 Fire Diamond is a standard system for the identification of hazards of materials for emergency response. It is used, primarily by emergency personnel, to quickly and easily identify risks posed by hazardous materials. You will often see this NFPA Fire Diamond on individual chemical containers, or chemical storage areas.

The four divisions are color coded, and rated on a scale from 0 (No Hazard) to 4 (Highest Hazard).
- BLUE: Health Hazard
- RED: Flammability Hazard
- YELLOW: Instability Hazard
- WHITE: Special Hazard (Alkaline, Acidic, Corrosive, Oxidizing, Radioactive, Water Reactive)
Working Safely with Chemicals

*Safety Data Sheet (SDS)*

- Read and understand Safety Data Sheets (SDS) **before** handling chemicals

- SDS MUST be available at or near where chemical is being used
  - Paper or Electronic SDS are OK

- Make sure to get an SDS for new chemicals

- Be sure all SDSs are current and complete

**Where Can I Get an SDS??**

  - Chemical Vendors (Sigma Aldrich, Baker, Fisher, VWR, ...)
  - EHS
  - Internet
Working Safely with Chemicals

Safety Data Sheet (SDS)

- What’s in an SDS?
- 16 Sections of Information:
  - Product Information
  - Hazardous Ingredients/Identity
  - Physical/Chemical Characteristics
  - Fire/Explosion Hazard
  - Reactivity
  - Health Hazard
  - Safe Handling and Use
  - Control Measures
  - And more!
In order to minimize exposure to chemicals, it is important to understand the Routes of Exposure, or the means by which chemicals can enter your body. The four routes of exposure are listed in this slide. In the laboratory, inhalation (breathing chemicals) and skin contact (splashing chemicals on your skin) are the primary routes of exposure.

Ingestion of chemicals usually occurs involuntarily due to poor hygiene, like not washing chemicals off your hands before eating or smoking. If you do not wash your hands before eating or smoking, residual chemicals on your hands may be accidentally ingested.

Injection can be caused by a dirty needle stick, or other contaminated sharp object cutting your skin and injecting chemical into your body.
Appropriate attire (long pants, closed toe shoes, lab coat, safety glasses, and gloves) is required at ALL times in CSM laboratories and workshops. Dangling jewelry and long hair can get caught in moving machinery, or can get in the way of safely conducting lab or workshop activities. Always tie up long hair, and remove dangling jewelry.

EHS provides safety equipment (lab coats, safety glasses and goggles, cut resistant gloves, chemical resistant gloves, hearing protection, and more!) for free, or at a small cost. Please stop by and request safety equipment.
Safety glasses are required, at a minimum, at all times in labs and workshops. When pouring or working with chemicals, splash proof goggles or a face shield are recommended. Please contact EHS if you are working with lasers. Lasers emit dangerous wavelengths of light, and the correct eye protection must be worn depending on the type of laser.
Physical hazards like hot, cold, and sharp edges can be avoided using the right kind of glove. Make sure to identify the appropriate glove for your physical hazard.

Chemical resistant gloves come in many different flavors. Chemical resistant gloves do not protect you from every chemical. Use a chemical glove selection guide (links below) to help choose the right glove for your chemicals.

Chemical resistant gloves come in many different flavors. Chemical resistant gloves do not protect you from every chemical. Use a chemical glove selection guide to help choose the right glove for your chemicals.

In the chart above, chemicals are listed vertically down the left, and types of gloves are listed across the top. The breakthrough time (the amount of time a glove will protect against a certain chemical) is listed in the body of the chart.

Using this chart, we can use the chemical acetone as an example. Silver-shield and butyl gloves would provide excellent protection against acetone. But, nitrile and Viton gloves are not recommended to use when working with acetone.

Fume hoods protect against inhalation of chemicals, as well as offer some splash protection when the sash is closed. In order for a fume hood to function properly, never store excess chemicals or equipment in a fume hood. Items stored in a fume hood may disrupt air flow, and chemical vapors may escape out of the hood.

To prevent vapors escaping when working in a fume hood, all chemicals should be at least six inches from the front of the hood (see Figure 1).

Chemical fume hoods pull air in from the laboratory, and expel the airflow up and out of the hood into the building’s ductwork. Therefore, you never want to put your head into a fume hood, because you will be in the path of the airflow.

EHS and Facilities Management periodically check fume hoods to ensure proper airflow (~80-120cfm). If you need your fume hood tested, please call EHS.
Working Safely with Chemicals

Step 2: Minimize Exposure: Fume Hoods

Certain activities or chemicals require special laboratory hoods

- Perchloric Acid Wash-Down Hood
  - Required if heating perchloric acid
- Acid Digestion
  - Designated hoods for acids (HF, Picric acid, etc...)
- Filtered Fume Hood
  - Toxic or Radioactive Particulates
- Glovebox
  - Air or moisture reactive chemicals
- Biosafety Cabinet
  - Not for use with Chemicals
Respirators are a last line of defense against inhalation of hazardous materials, and are seldom used on campus in laboratories. Respirators are used when there are no other effective ways (e.g. fume hoods) to minimize exposure to the inhalation of hazardous chemicals.

If you think you that your research requires the use of a respirator, contact EHS immediately.
Before you begin work in a laboratory or a workshop, you must identify the locations of emergency equipment. This equipment may save your life, and you don’t want to be looking for it during an emergency. Plan ahead!
Chemical contact on your skin or eyes can cause very serious injuries. If chemicals are spilled onto your skin or clothes, you must rinse it off immediately to minimize exposure. Rinse contaminated areas for at least 15 minutes. Remove the contaminated clothes and call emergency personnel for help.

EHS will clean up all chemical spills 24 hours a day/365 days a year. Do not hesitate to call 303-273-3316. If the spill presents an imminent threat of fire or explosion, evacuate the lab and pull the fire alarm or call 911.
Working Safely with Chemicals

Step 3: Be Prepared for Accidents: Working Alone

Never Work Alone in a Laboratory or Machine Shop
Working Safely with Chemicals

Step 3: Be Prepared for Accidents: Fire

Pull Fire Alarm and Evacuate Building
- Provide first responders with details of fire
Working Safely with Chemicals

Step 3: Be Prepared for Accidents

70% Nitric Acid Spill
Splashed On Your Skin, Lab Coat and Pants.

What do you do?
Working Safely with Chemicals
Step 3: Be Prepared for Accidents

70% Nitric Acid Spill
Splashed On Your Skin, Lab Coat and Pants.

What do you do?

1. Use emergency shower to rinse acid. Remove contaminated clothing and rinse for 15 minutes.
2. Get help from lab members
3. Get medical attention
4. Notify your advisor and EHS

Do NOT worry about flooding the hallway
Working Safely with Chemicals

Step 3: Be Prepared for Accidents

Exploded Hazardous Waste Container

What do you do?

Thankfully the sash was closed, no injuries occurred, and the spill is contained in the hood.
Working Safely with Chemicals

Step 3: Be Prepared for Accidents

Exploded Hazardous Waste Container

Thankfully the sash was closed, no injuries occurred, and the spill is contained in the hood

What do you do?

1. Get out of the lab and call EHS at 303-273-3316
2. Provide as much detail concerning the materials and waste containers stored in the hood
3. Do not attempt to clean this up
4. Be sure to clean up/neutralize small incidental spills

Two students at Mines received skin burns this year from residual acid or caustic spills in labs.
HAZARDOUS MATERIALS
EMERGENCY INFORMATION

Weekly Laboratory Telephone

Chemical Spill:
- Small Spill: If a small spill occurs, the Environmental Health and Safety (EHS) team will be notified. Do not attempt to clean up spills yourself. Call EHS at 303-273-3316.
- Large Spill: If a large spill occurs, call EHS at 303-273-3316 immediately. DO NOT attempt to clean up the spill yourself. Contact EHS for instructions.

Chemical Exposure:
- If you suspect chemical exposure:
  1. Call 911 immediately.
  2. Do not attempt to treat the affected area.
  3. Follow proper safety procedures.

If you are exposed to a chemical:
- Wash your hands and face with soap and water.
- Shower in the shower area.
- Bathe with soap and water only.
- Do not use any other means to clean yourself.

Emergency Guidelines for:
- Chemical Spills
- Chemical Exposures
- Hazardous Waste
- Fire
- Injuries

Every Lab Must Have a Hazardous Materials
Emergency Information Poster!
Mines requires all incidents (injuries, chemical exposures, chemical spills, fires, and near misses) to be reported to a supervisor and EHS. This reporting requirement helps us identify hazards on campus and continually work to make campus a safer place.

Report incidents to your supervisor, and EHS at 303-273-3316
Working Safely with Chemicals

Chemical Storage

- Always segregate and store chemicals based on hazard class.
  - The most common hazard classes are:
    - Flammables, Acids, Bases, Oxidizers, Toxics, Compressed Gases, Water Reactive
    - Store each hazard class in separate storage areas
- Label storage areas with the hazard class found in that area
- Accidental contact between incompatible chemicals can result in fire, explosion, release of toxic or flammable gases, or other dangerous reactions.
- DO NOT store chemicals in a sink.
- DO NOT store chemicals alphabetically, unless they are compatible!
## Chemical Storage Chart

<table>
<thead>
<tr>
<th>Flammable liquids</th>
<th>Acids</th>
<th>Bases</th>
<th>Oxidizers</th>
<th>Toxics</th>
<th>Compressed gases</th>
<th>Poison inhalation</th>
<th>Water reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not store with acids or oxidizers</td>
<td>Do not store with bases, flammables, or cyanides</td>
<td>Do not store with acids</td>
<td>Do not store with flammable liquids or solids</td>
<td>Secure at all times even when empty</td>
<td>Store in a vented gas cabinet or a chemical fume hood</td>
<td>Secure at all times</td>
<td>Do not store under the sink Store away from aqueous solutions</td>
</tr>
<tr>
<td>Only store in refrigerators rated for flammables</td>
<td>Do not store under the sink</td>
<td>Avoid storage on wooden shelves</td>
<td>Do not store under the sink Avoid storage on wooden shelves</td>
<td>Store on sturdy shelves below eye level or in secured cabinets</td>
<td>Store with cap when regulator is removed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Examples
- Acetone
- Methanol
- Ether
- Hexane
- Sulfuric acid
- Hydrochloric acid
- Nitric acid
- Acetic acid
- Sodium hydroxide
- Potassium hydroxide
- Bleach
- Silver nitrate
- Ammonium persulfate
- Sodium periodate
- Sodium cyanide
- Sodium oxide
- Aniline
- Ethidium bromide
- Helium
- Nitrogen
- Oxygen
- Hydrogen
- Carbon monoxide
- Chlorine gas
- Ethylene oxide
- Ammonia gas
- Sodium borohydride
- Hydrazine
- Sodium metal
- Phosphorus
Working Safely with Chemicals

Chemical Storage

Flammable Material Storage

- Never store flammables with oxidizers or any other hazard class
- **Do not** store more than 10 gallons of flammable liquids outside of an approved flammable storage cabinet
- **Do not** use domestic style refrigerators to store flammables
  - Domestic Fridges may explode due to build up of vapors
- Refrigerators used to store flammables must be rated for flammable storage
Working Safely with Chemicals

*Food and Drink in the Lab*

**NO Food and Drink in the Lab!**
- Do Not Eat or Drink in the Laboratory
- Do Not Store Food or Drink in the Laboratory

*Laboratory Freezers, Refrigerators, and Microwaves MUST be Labelled:*
  “No Food or Drink”
The Chemical Storage and Distribution Facility (CSDL) orders, receives, and distributes ALL chemicals on campus. The CSDL barcodes and inventories every chemical on campus. It is important to inform the CSDL (CSDL@mines.edu) when you empty or move any chemical on campus.

It is against Mines policy to purchase hazardous materials using a personal or Mines affiliated credit card. Additionally, you are not allowed to transport chemicals in your personal vehicles, according to the Colorado Department of Transportation.

In order to purchase chemicals, you must first complete Hazardous Waste Generator Training through EHS.
Working Safely with Chemicals

*Transporting Chemicals*

**Transporting Chemicals Across Campus**

- Always use proper chemical carriers during transport
- Wear Personal Protective Equipment
- DO NOT transport chemicals in your personal vehicle
Safe Lab Rules

- Label ALL Chemical Containers and Waste Containers
  - Include: Chemical Name(s), Concentration, Date
- Segregate Chemical Storage by Hazard Class (not Alphabetically)
- Never Work Alone (Buddy System)
- Wash Your Hands Often and When Exiting the Lab
- Wear Proper Attire and PPE
- Keep Labs Clean and Clutter-Free
Other Laboratory Hazards

- Compressed Gases
- Cryogenic Materials
- Radioactive Materials (Requires Specific Training)
- Lasers (Requires Specific Training)
- Laboratory Equipment
Other Laboratory Hazards

Compressed Gases

**TRANSPORTING GAS CYLINDERS**
- Make sure cylinder cap is in place
- Verify cylinder contents
- Use cylinder cart to transport
  - Ensure cylinder is strapped to cart
- NEVER roll or carry a cylinder

**SAFELY STORE GAS CYLINDER IN YOUR LAB**
- Secure the cylinder (with a chain) to a wall or other fixed point
- Only use appropriate regulator and tubing to deliver gas
- Close cylinder valve when not in use
Cryogenic materials like: liquid nitrogen, liquid oxygen, and liquid argon are common hazards in the lab. Cryogenic liquids are extremely cold and have boiling points less than 238 degrees F. Be sure to always wear PPE when transferring, pouring, or working with cryogenic materials (insulated cryogen gloves, goggles, face shield, long pants and sleeves).

Cryogenic liquids boil rapidly at room temperature. A very small amount of liquid cryogen will evaporate into a large amount of gas. It is important to never work in a confined space, or ride in an elevator with liquid cryogens because they may displace the breathable oxygen in small areas. This means you may suffocate.

Even Dewars used to transport liquid cryogens (see the picture in the above slide) vent periodically to relieve pressure. So, it is never safe to be in a confined space with a Dewar with liquid cryogen.
Other Laboratory Hazards

Radioactive Materials

Work with radioactive material requires specific training.

- Contact Haitao Dong
  Campus Radiation Safety Officer X3573
Other Laboratory Hazards

Lasers

Work with Lasers Requires Laser Safety Training

- Laser specific training covers:
  - Appropriate eyewear
  - Operating procedures
  - Laser generated air contaminants

Contact EHS for Training
303-273-3316
The machine shops at Mines contain a lot of dangerous equipment. It is your responsibility to be properly trained on EVERY machine BEFORE using.
Lockout Tagout (LOTO)

- What is Lockout Tagout (LOTO)?
  - LOTO is a technique used to prevent energy from being released during the servicing of equipment
  - LOTO is accomplished by placing locks and tags on energy isolation devices prior to starting work
  - LOTO is completed to ensure that the person servicing the equipment remains safe
- DO NOT attempt to start up equipment that has been isolated, locked, blocked and/or tagged
- DO NOT remove or damage locks and tags. Removal of locks and tags may place you and the person performing servicing work at risk of injury
- Mines uses red master locks and labels indicating “DO NOT OPERATE Equipment Locked Out”
Life and Fire Safety
Life and Fire Safety

Know the locations of emergency equipment:
- Fire Extinguishers
- Fire Alarm Pull Stations
- Emergency Exits
- Safety Shower/Eyewash

DO NOT obstruct access to emergency equipment!

Do not block access to fire extinguishers

COLORADO SCHOOL OF MINES
EARTH & ENERGY & ENVIRONMENT
Life and Fire Safety

Fix Displaced Ceiling Tiles
- Displaced ceiling tiles allow smoke to travel quickly throughout a building in a fire

Do Not Prop Doors Open
- Many doors on campus are designed to withstand flames and prevent a fire from spreading
Life and Fire Safety

Emergency Equipment should be easily accessible!

Access to emergency phone is obstructed by a table. Keep this area clear!
Life and Fire Safety

Keep the area around safety showers and eyewashes clear of clutter!
Life and Fire Safety

DO NOT block doors!
Fire Extinguishers are used:

- To assure your escape path
- To knock down a small fire before it spreads

If one extinguisher does not put out the fire, there is no time to get another one. Get out!
Life and Fire Safety

Laboratory Refrigerators

- **Do not** use domestic style refrigerators to store flammables
  - Domestic fridges may explode due to build up and ignition of vapors

- Refrigerators used to store flammables **must be rated for flammable storage**
Safety Review

- Wear safety glasses/goggles, long pants, lab coat, & closed toe shoes.
- Wear gloves when handling hazardous materials.
- Never eat or drink while working in a laboratory.
- Make sure all chemical containers are sealed.
- Clean your work area before leaving the lab.
- Wash your hands when you leave the lab.
- Music ear buds in the lab? No
Hazardous Waste Generator Training

Want to Buy Chemicals or Submit Hazardous Waste??

Who is required to attend?
- Any Mines student (undergraduate and graduate), staff, faculty, or other personnel that work with hazardous chemicals, generates hazardous waste, or purchases chemicals on campus.

When do you need to take Hazardous Waste Generator Training?
- BEFORE working with or purchasing hazardous chemicals or waste.

Hazardous Waste Generator Training is required annually

Sign up at: https://inside.mines.edu/EHS-Training
Thank You

Contact EHS if you Have ANY Questions!

Test Score of 80% is Required for Course Completion