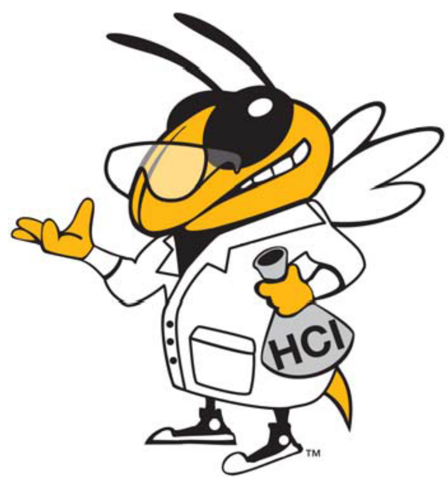
Georgia Institute of Technology Laboratory Safety Manual

Limited Revision on July 12, 2018



Georgia Institute of Technology
Laboratory Safety Manual

This document is an update to the Georgia Institute of Technology Laboratory Safety Manual (April 29 2013 Edition).

The following limited revisions were made:

1. Updating all Georgia Tech Environmental Health and Safety contact information.
2. Updating the GT EHS website links and attachments
3. Updating information regarding the chemical inventory system, Environmental Health and Safety Assistant, implemented in July 2017.
4. Updating the SDS references, previously recognized as MSDS, in compliance with Globally Harmonized Standard.
5. Updating the Nanotechnology and Lab Moving.

Approved: May 29, 2013

Reviewed and Revised: July 12, 2018

Contents

1. Introduction and General Administration

Laboratory Safety at the Georgia Institute of Technology (Georgia Tech) is a multi faceted program managed by Georgia Tech Environmental Health and Safety (EHS) and includes programs in Biological Safety, Chemical Safety, Hazardous Materials Management, Fire and Life Safety, General Safety, and Radiological Safety. Program elements include but are not limited to: Fume Hood Certifications, Biosafety Cabinet Certifications, Laboratory Inspections, Laboratory Self Inspections, Industrial Hygiene, Laser Safety, High Magnetic Field Safety, and other programs addressed in this Laboratory Safety Manual. Questions or concerns about safety in Georgia Tech Laboratories can be directed to the Environmental Health and Safety Personnel at 403-894-4635 (https://ehs.gatech.edu/contact).

GEORGIA INSTITUTE OF TECHNOLOGY

ENVIRONMENTAL HEALTH AND SAFETY POLICY

Ratified by the Institute Council on Environmental Health and Safety August 2008

Policy

Georgia Institute of Technology (Georgia Tech) is committed to:

1. Providing a safe, secure and healthy environment for all faculty, staff, students, and visitors;

2. Conducting research and educational programs in compliance with applicable environmental health and safety laws and regulations; and

3. Demonstrating leadership in pollution prevention, waste reduction and the judicious use of resources for protection of human health, safety and the environment.

Guiding Principles

Good environmental health and safety practices, including compliance, are the responsibility of every faculty member, staff employee, student and visitor at Georgia Tech. This responsibility cannot be transferred or delegated.

Georgia Tech shall make all reasonable efforts to:

1. Protect the health and safety of faculty, staff, students, visitors, and the surrounding community;

2. Provide safe workplaces - academic, research and administrative;

3. Provide information and training to faculty, staff, students and visitors about potential environmental, health and safety hazards;

4. Develop and promote the adoption of environmental health and safety best practices;

5. Identify and correct environmental health and safety hazards, and encourage the reporting of hazards and safety-related incidents;

6. Work cooperatively with the City of Atlanta, the State of Georgia and regulatory agencies to promote a safe and healthy environment; and

7. Comply with applicable environmental health and safety laws, regulations and consensus standards.

Implementing Authority

The Georgia Tech Institute Council for Environmental Health and Safety is the principal implementing authority for this policy. The Council shall adopt, implement and integrate policies and procedures as developed by compliance oversight and other environmental health and safety committees at Georgia Tech.

The Georgia Tech Office of Environmental Health and Safety is responsible for providing technical guidance, oversight, consultation, training and specialized services to assist the Institute community in meeting its public health, safety and environmental protection responsibilities.

Purpose

The purpose of this manual is to provide basic safe operating practices to be applied uniformly in all Georgia Tech laboratories in order to ensure a safe environment in which to work and study for faculty, students, visitors, and staff. New situations and hazards arise in research every day. This manual, therefore, cannot possibly be an all-inclusive list of hazards or solutions to hazards found in Georgia Tech laboratories and research stations. Instead, it is offered as the foundation and guide to approach new challenges and discover ways of safely dealing with them.

Scope

The principles and practices found in this manual apply to all Georgia Tech laboratories including satellite locations and research stations both in the US and abroad.

Authority: Faculty-Led EHS Committees

Institute Council for Environmental Health and Safety (IC-EHS)

The IC-EHS is the over-arching faculty-led Institute safety oversight Council that coordinates policy recommendations, procedures, and practices from each of the Institute's safety-related committees. The IC-EHS is appointed by the President of Georgia Tech and has the authority to approve new or change existing procedures with consultation and input from Council members.

IC-EHS membership is comprised of the Chairs of the Institute's other faculty-led safety committees including the Institutional Animal Care and Use Committee, (IACUC), Institutional Biosafety Committee (IBC), Biological Materials Safeguard Committee (BMSC), Campus Welfare and Security Committee (CWSC), Chemical and Environmental Safety Committee (CESC), Occupational Health and Safety Committee (OHSC), Radiological Safety Committee (RSC), Laser Safety Committee (LSC), as well as members from the Office of Research Integrity Assurance, the Office of Human Resources, Legal Affairs and Risk Management, Student Health Services, and EHS. The IC-EHS reviews the work of the various campus safety committees and has the authority to recommend disciplinary action, in accordance with Institute procedures, for violations of Georgia Tech safety rules.

Institutional Animal Care and Use Committee

This committee, constituted in accordance with federal law, reviews all proposed research and teaching activities involving vertebrate animals. The IACUC is charged with ensuring the humane care, use, and disposition of vertebrate animals involved in teaching and research activities at Georgia Tech.

Chemical and Environmental Safety Committee (CESC)

The CESC is responsible for reviewing and approving this manual and all safety practices and policies applied to GT laboratories; reviewing recent laboratory incidents; communicating trends and issues to the Georgia Tech IC-EHS and to Department Chairs; and recommending changes, as needed, in GT practices and policies.

Occupational Health and Safety Committee (OHSC)

The OHSC considers and advises EHS and the IC-EHS on programs and policies regarding occupational health and workplace safety at Georgia Tech.

Biological Materials Safeguards Committee (BMSC)

The BMSC considers and advises EHS and the IC-EHS on programs and policies regarding the safe and compliant use of non r-DNA biological materials and research protocols at Georgia Tech.

Institutional Biosafety Committee (IBC)

The IBC reviews all registrations for research, teaching, and training that involve the use of rDNA and ensures that the proposed activities comply with federal regulations and Institute policies. The IBC considers and advises EHS and the IC-EHS on programs and policies regarding the safe and compliant use of r-DNA biological materials and research protocols at Georgia Tech.

Radiation Safety Committee (RSC)

The RSC is responsible for maintaining the health and safety standards associated with the use of radioactive materials and ionizing radiation-producing devices at Georgia Tech and ensuring that research activities conform to State of Georgia Regulations. The RSC considers and advises EHS and the IC-EHS on programs and policies regarding the safe and compliant use of radioactive materials and radiation-producing devices at Georgia Tech.

Laser Safety Committee (LSC)

The LSC establishes and maintains safety policies, procedures and guidance regarding the use of class 3B and 4 lasers at Georgia Tech. The LSC considers and advises EHS and IC-EHS on programs and policies regarding the safe and compliant use of class 3B and 4 Lasers at Georgia Tech.

Laboratory Responsibilities

Deans

Deans are responsible for communicating the performance expectation to Department Chairs and Principal Investigators (PIs) that the practices and policies set forth in this manual are to be adhered to in all laboratories within their respective Colleges. Deans are responsible for setting the overall tone regarding establishing and maintaining a culture of safety in all laboratory operations under their control. Safety performance expectations must be clearly communicated to Department Chairs and PIs with the knowledge that disciplinary procedures will be pursued against those who fail to implement safety practices or willfully disregard safety practices and regulatory requirements.

Department and School Chairs

Department and School Chairs are responsible for ensuring that the practices and policies set forth in this manual are adhered to in all Georgia Tech laboratories under their control and for communicating to lab personnel the expectation that a culture of safety is to be maintained in all labs and within all lab groups. Safety performance expectations must be clearly communicated to laboratorians, such as periodic self-inspections and safety meetings, prompt corrective actions when safety deficiencies are identified, and implementing disciplinary procedures for those who fail to work safely or willfully disregard safety practices and regulatory requirements.

Principal Investigators (PIs)

(PIs) have the primary responsibility for controlling hazards and maintaining compliance with applicable regulations and Georgia Tech policies in their laboratory(ies). This shall include promoting a safety culture in the work place by ensuring that all faculty, staff, and students are instructed in laboratory hazards and how to avoid them, making safety discussions part of lab meetings, performing lab self-inspections, and ensuring that all lab users have received the required safety training as described in Chapter 8 of this manual. Additionally, PIs are responsible for controlling visitor/outsider access to Controlled Unclassified Information and Classified Information in laboratories (see Chapters 11 and 15 for more information).

Laboratory Users

Students, staff and faculty shall be responsible for complying with oral and written safety rules, regulations, and procedures required for the assigned task. Students, staff and faculty lab users are responsible for bringing any safety issues to the attention of the PI for appropriate corrective action.

Environmental Health & Safety (EHS)

EHS is responsible for guiding and assisting the Institute community in meeting its public health, safety, environmental protection and compliance responsibilities. EHS shall assist PIs and laboratory users in determining and following safe practices; coordinating safety activities; providing education in safety; investigating accidents and incidents in laboratories and chemical incidents campus wide; conducting lab inspections and verifying proper operation of lab safety equipment and systems. While lab safety programs are most effective when lab groups self-monitor and enforce the rules, EHS is also responsible for monitoring and verifying compliance with state and federal safety regulations and Georgia Tech lab safety policies. In cases of imminent danger to life and health of individuals working in the laboratory and/or others nearby, EHS is authorized to take appropriate action including but not limited to stopping work, closing the laboratory, and evacuating laboratories or buildings.

Institute Responses to Unsafe Actions and/or Unsafe Conditions in Laboratories

The following table provides guidance as to how laboratory hazard levels are identified and responded to by EHS. However, this list is not all inclusive; individual circumstances will vary, and the most appropriate action will be taken:

Level 1: Imminent Hazard with Potentially Severe Consequences

Imminent hazard caused by unsafe conditions or unsafe actions which, in the judgment of the EHS representative on site, have the potential for severe consequences, and may result in

- Loss of life
- Serious injury with possibility of permanent damage to health or permanent disability
- Injury (including those by chemical exposures) likely to result in hospitalization
- May affect people outside of the lab
- May involve multiple victims
- May involve significant property damage, and/or building-wide business disruption and/or business disruption affecting the Institute.

Examples of imminent hazards with potentially severe consequences that may result from unsafe conditions or unsafe acts include but are not limited to:

- Fires
- Floods
- Toxic or flammable gas releases or explosions
- Releases of highly toxic materials
- Releases of highly toxic materials to the environment
- Detonation of potentially explosive materials
- Run away reactions with the potential to cause any of the above Failure to use personal protective equipment or follow lab safety procedures while working with highly–hazardous substances such as pyrophorics or highly- energetic materials

Level 1 Response:

- Safely shut down process.
- If necessary, close lab to protect personnel, contain hazard, or to prevent re-entry by unauthorized personnel.
- Change locks if necessary.
- Situation report to PI, Chair, Dean, Provost, EVP of Finance and Administration, and AVP of EHS.
- For unsafe conditions: lab may open as soon as conditions are rectified to EHS satisfaction/approval
- For unsafe acts by individuals or unsafe practices by lab groups: lab re-opening and /or disciplinary actions to be determined by Chair, Dean and Institute Code of Conduct Procedures

Level 2: Imminent Hazard with Potentially Serious Consequences

Imminent hazard caused by unsafe conditions or unsafe actions which, in the judgment of the EHS representative on site, have the potential for serious consequences, and may result in:

- Temporary illness or minor injury
- May involve victim(s) receiving outside medical attention such as from an Emergency Room or Occupational Medicine Clinic, but is not likely to require hospitalization.
- May involve property damage and/or building-wide business disruption

Examples of serious events that may result from unsafe conditions or unsafe acts include but are not limited to:

- Exposures to one or more individuals to chemical, biological, or radiological materials
- Extremely poor housekeeping, improper segregation or storage of hazardous chemicals. Poor chemical hygiene
- Failure to use protective equipment or follow lab safety procedures while working with hazardous substances.
- Spills of chemical, biological, or radiological materials in a lab or in common areas
- Odor releases of known or unknown substances

Level 2 Response:

- Safely shut down process.
- If necessary, close lab to protect personnel, contain hazard, or to prevent re-entry by unauthorized personnel.
- Change locks if necessary.
- Situation report to PI, AVP of EHS
- For unsafe conditions: lab may open as soon as conditions are rectified to EHS approval
- For unsafe acts by individuals or unsafe practices by lab groups: additional situation reports to Chair, Dean, Provost, and EVP of Finance and Administration.
- For unsafe acts by individuals or unsafe practices by lab groups: lab re-opening and/ or disciplinary actions to be determined by Chair or Dean

Level 3: Not Imminent Hazard but Potentially Serious Consequences

Hazard caused by unsafe conditions or unsafe actions which, in the judgment of the EHS representative on site, have the potential for serious consequences

Examples of Not Imminent Hazard but Potentially Serious Consequences are generally the same as described in Levels 1 and 2.

Level 3 Response:

- Situation report to PI, AVP of EHS
- Follow up in 24 hours
- If no response, additional situation reports to Chair and Dean

Level 4: Not Imminent but Potential for Undesirable Consequences

Hazard caused by unsafe conditions or unsafe actions which, in the judgment of the EHS representative on site, have the potential for undesirable consequences and may result in:

- Minor or minimally dangerous chemical spills
- Non- life threatening unplanned chemical reactions
- Increased risk of fire
- Increased risk of slips, trips, and falls

Examples of undesirable events that may result from unsafe conditions or unsafe acts include but are not limited to:

- Spills caused by poor housekeeping or clutter Unplanned reactions resulting from inappropriately stored chemicals or inadequately labeled waste
- Slips, trips, or falls caused by clutter, or by wires or tubing across walk ways
- Adverse impact to indoor environmental quality in the lab and/or the building.

Level 4 Response:

Situation report or Lab Inspection report to PI within 3 days
If no response or situation still uncorrected after 1 month – situation report to Chair and Dean

Level 5: Repeat Violations/ Failure to Correct

Hazard caused by unsafe conditions or unsafe actions which, in the judgment of the EHS representative on site, have the potential for Level 1-4 consequences

- For unsafe conditions- would include multiple deficiencies which have not been corrected by the lab group in the specified time period
- For unsafe acts by individuals or unsafe practices by groups would include repeated violation of basic safety rules including housekeeping, attire, and personal protective equipment

Level 5 Response:

- Situation Report to Dean/ Request for 1-week lab closure
- Close lab, change locks
- Meet with PI and Chair
- PI to present Chair and EHS with a written plan for correcting unsafe conditions and keeping the lab in the "corrected" condition.
- Lab to reopen at a time mutually agreed upon by EHS, Chair, Dean, and PI, not to exceed 1 week (assuming that all unsafe conditions have been corrected).

Other Circumstances:

- For certain situations such as repeated and willful disregard and/or failure to use personal protective equipment (PPE), or grossly inadequate housekeeping, EHS is authorized to take appropriate action up to and including closing the laboratory until EHS, the Department and School Chair, Dean (or appropriate next level of supervision) authorizes re-opening. The PI, Chair and Dean will be notified promptly when this action is deemed necessary

Disciplinary Actions

Any Georgia Tech student, faculty or staff member who fails to meet their responsibilities for safe conduct of work in laboratories or who knowingly and willfully disregards safety procedures will be held accountable and will be subject to disciplinary action in accordance with Institute procedures.

In addition, any visitors using Georgia Tech laboratories who fail to meet their responsibilities for safe conduct of work or knowingly and willfully disregard safety procedures or fail to comply with direct safety instructions from their Georgia Tech faculty sponsor, EHS or emergency response personnel regarding emergencies or evacuations will be held accountable and subject to loss of privileges to use Georgia Tech laboratory facilities. (NOTE: "visitors" may include contractors, visiting scholars and other non-Georgia Tech personnel

2. Definitions

American Conference of Governmental Industrial Hygienists (ACGIH) is a member based organization that advances occupational and environmental health. The ACGIH publishes the Threshold Limit Values (see below). https://www.acgih.org/

Biological Materials includes infectious agents, environmental samples, materials derived from biologicals, human and animal cell lines, human samples, recombinant materials, and plants.

Chemical and Environmental Safety Committee (Georgia Tech) (GT CESC) provides policy recommendations and oversees the development of procedures by EHS to monitor and enforce lab safety and chemical hygiene plans. Receives periodic risk assessment reports and reviews compliance with policies and procedures.

Cylinders in Use are cylinders which have a regulator attached and are connected to a gas delivery system such as to deliver gas to an instrument which is used no less than monthly. Cylinders are also in use if they are maintained with a regulator in place to accommodate frequent use (no less than weekly). Cylinders used less frequently than described above should be disconnected from the gas delivery system

Dangerous Gas Monitoring System (Georgia Tech) (GT DGMS) An integrated gas monitoring system that is to include all Georgia Tech buildings where dangerous gases are used. This system monitors laboratories for gas leaks, gas releases, ventilation failures, and power failures and alarms locally to warn users as well as sending messages alerting GT Environmental Health and Safety and GT Police.

Don/Doff- to put on/to remove an article of clothing or personal protective equipment

Engineering Controls are built-in systems or equipment that protect people from lab hazards. They include fume hoods, biosafety cabinets, and building ventilation systems.

Explosion Proof Refrigerator- see Flammable Safe Refrigerators

Flammable gases include gases that, at ambient temperature and pressure, form a flammable mixture with air at a concentration of 13% by volume or less or in a concentration range wider than 13% by volume regardless of the lower limit (29CFR1910.1200**).** Examples: hydrogen, acetylene, propane. Refer to Appendix A for more examples. Refer to the SDS for specific flammable gases. Pyrophoric gases include gases that will ignite spontaneously on contact with air at temperatures of 130^{O}F (54.4^{O}C) or below (29CFR1910.1200) Examples: silane, disilane, diborane, and phosphine. Refer to Appendix A for more examples. Refer to the SDS for specific pyrophoric gases.

Flammable Safe/Explosion Proof Refrigerators- Flammable safe refrigerators have protected internal electrical components that cannot provide a source of ignition to the contents of the refrigerator or freezer, making them safe to store flammable materials. Explosion proof refrigerators have protected internal and external components and are safe for storage of flammable materials in areas where large amounts of flammable materials are used or there is a high potential for spills of flammable materials.

Gas Cabinet- a continuously ventilated enclosure for gas cylinders which also provides automatic gas shut off when leaks are detected or when gas flow exceeds pre-set levels

Georgia Public Employees Hazardous Chemical Protection and Right to Know Law, (RTK) Code of Georgia Title 45, Chapter 22, establishes the right of state employees to have access to information and training on the hazards of chemicals which they use or may encounter in the workplace. It also requires all state agencies to conduct semiannual chemical inventories and to make this information available to emergency responders. http://www.lexisnexis.com/hottopics/gacode/Default.asp

Georgia Tech Environmental Health and Safety (GT EHS) provides occupational and environmental protection services to comply with applicable regulations and to prevent occupationally induced disease, injury, property loss, and degradation to the environment.

Laboratory- any room or location where chemicals or biologicals are used on a small "non-production" scale.

Wet bench laboratory- any lab where chemicals, biologicals, or radiologicals are used, stored, or manipulated. Any place where materials of a biological, radiological, or chemical nature are poured, transferred, pipetted, reacted, incubated, heated, or in any way manipulated or stored.

Dry bench laboratory- (AKA dry lab or instrument lab) any lab which is devoted to instrumentation and does not include those elements which define a wet bench lab. Examples may include computer modeling labs, microscope labs, and NMR rooms.

Lecture Bottle- a small compressed gas cylinder up to a size of approximately 2 inches x 13 inches (5 cm x 33 cm).

Lethal Concentration 50 percent (LC50) - refers to toxicological testing on animals in which the route of exposure to the chemical in question is by inhalation. The LC50 is the concentration in air of the chemical at which 50% of the test animals died within a specified time.

Lethal Dose 50 percent (LD50) - refers to toxicological testing on animals. The LD50 is the dose of the chemical at which 50% of the test animals died within a specified time. Means of dosing, (oral, intravenous, intraperitoneal, etc.) is also specified.

Safety Data Sheet (SDS) - Document which manufacturers or distributors of chemicals are required to produce which describe the hazards of their chemical or chemical product and safety precautions/handling procedures/ Personal Protective Equipment that must be used to work with that chemical safely. The United States Occupational Safety Administration (USOSHA) requires MSDSs under 29 CFR 1910.1200 Hazard Communication.

National Fire Protection Association (NFPA) an international nonprofit organization established to reduce the worldwide burden of fire and other hazards. NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. https://www.nfpa.org/

Personal Protective Equipment (PPE) is protective equipment that is worn, such as safety glasses, lab coats, aprons, respirators, etc. PPE is considered a second line of defense against work place hazards and may only be used when other means of protections are not adequate or not feasible.

Permissible Exposure Limit (PEL)- Exposure limit established by the United States Occupational Safety and Health Administration as documented in the US code of Federal Regulations, 29 CFR 1910.1000. Usually based on an eight-hour time weighted average (TWA), this is the maximum level to which a worker may be exposed for eight hours each day, 40 hours per week for a working lifetime without expectation of adverse health effects.

Primary container is the container in which a chemical or chemical product is received.

RAM includes all materials that emit ionizing radiation with a specific concentration greater than 10-06µCi/g (GA 391-3-17.02(21) (a) or having an atomic number greater than 83.

Radiation Producing Equipment - radiation producing devices (X-ray) include all equipment that has the potential for emitting ionizing radiation (X-rays) in excess of 0.5 mR/hr at 5 cm. X-ray diffractometers are common on campus. E-beam evaporators, e- beam lithographs and scanning electron microscopes produce x-rays as byproduct radiation and are considered radiation producing equipment.

Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §6901 et seq. (1976), gives the US EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes.

Secondary container is a container to which a chemical or chemical product is transferred or the container in which a new chemical product/reagent is made and stored.

Secondary containment- a container or device intended to control accidental releases of chemicals or chemical waste to the surrounding area. Examples of small scale secondary containment may be chemically resistant trays, bins or buckets under the chemical containers. These containers must be large enough to hold the entire contents of the largest bottle or container within them. Some chemical storage cabinets are equipped with a lip on the bottom shelf which creates a secondary container. Examples of large scale secondary containment are drum pallets, berms at room doors, and berms around outdoor storage areas.

Select Agents are a group of federally regulated bacteria, viruses, toxins, and fungi that have the potential to pose a severe threat to public, animal, or plant health. The use and possession of these biologicals is restricted by the USA Patriot Act and the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

Tepid Water- water that is neither hot nor cold. Also referred to as lukewarm. Eye washes and emergency showers are required to provide water which is a mix of hot and cold water (tepid) water so as to prevent further injury to chemical exposure victims from water that is too hot or too cold.

Threshold Limit Value (TLV) - A consensus standard established by the American Conference of Governmental Industrial Hygienists (ACGIH). Usually based on an eight-hour time weighted average (TWA) and are occasionally lower (more protective of the worker) than the OSHA PELs.

Toxic gases- gases that have been assigned a 3 or 4 heath hazard rating by the National Fire Protection Association (NFPA) or have a health hazard rating of 2 and have poor warning properties (taste, smell). For a more detailed definition of hazardous gases please see the GT Dangerous Gas Safety Program at https://www.ehs.gatech.edu/chemical/dangerous-gas

United States Occupational Safety and Health Administration (US OSHA) is the main US government agency charged with enforcement of safety and health regulations http://www.osha.gov/

United States Environmental Protection Agency (US EPA) Provides environmental information, and enforces laws and regulations to protect human health and the environment http://www.epa.gov

Georgia Public Employees Hazardous Chemical Protection and Right to Know Law, Code of Georgia Title 45 Chapter 22, establishes the right of state employees to have access to information and training on the hazards of chemicals which they use or may encounter in the workplace. http://www.lexisnexis.com/hottopics/gacode/Default.asp

Used Oil- Used oil means any oil that has been refined from crude oil, or any synthetic oil, that has been used, and as a result of such use is contaminated by physical or chemical impurities. Examples of used oil include motor oil, hydraulic fluid, lubricants and oil coolants.

Waste Oil- See Used Oil

3. The Georgia Right to Know Law

The Georgia Public Employees Hazardous Chemical Protection and Right to Know Law of 1988 (Georgia Department of Labor, Chapter 300-3-19) Ensures that all Georgia State employees:

- Be informed of the hazards associated with the chemicals with which they work
- Have access to Material Safety Data Sheets for the chemicals to which they may be/have been exposed in the course of their employment
- Are protected from discharge or disciplinary action for exercising their right to information
- Receive training on the hazards of the chemicals with which they work
- Receive training at the time of their employment on their rights under this law and, if they work with chemicals, receive re-training annually thereafter.

Chemical Inventory

The law also requires that Georgia Tech takes a complete inventory of all chemicals twice a year. This includes chemicals in laboratories, shops, and custodial supplies. This chemical inventory is submitted in January and July to the Board of Regents of the University System of Georgia

The person responsible for the chemical inventory and the overall compliance to the Georgia RTK Know Law at Georgia Tech is the Georgia Tech Right to Know Coordinator/Lab & Chemical Safety Officer, https://ehs.gatech.edu/contact

The Right to Know Law can be found at http://www.legis.ga.gov/Legislation/en-US/display/20152016/HB/278

The complete Georgia Tech Right to Know Plan can be found in https://www.ehs.gatech.edu/sites/default/files/georgiatechrtkplan9-10.pdf

Chemical Management – EHS Assistant (EHSA)

Georgia Tech adopted EHSA (OnSite Systems, LLC) as the official GT Chemical Inventory System in July 2017. All laboratories and shops are required to enter and track their chemical inventories in EHSA. Georgia Tech practices "Cradle to Grave" chemical management: Chemicals are accounted for when they come on to Tech property, enter the lab, are used up or removed as waste, removed from Tech property by a licensed hazardous waste hauler, and disposed of or incinerated in a federally licensed facility. All labs are required to have a person who has been trained in how to use EHSA and is assigned to keep track the lab's chemicals which includes entering and removing chemicals from the inventory and completing the semiannual inventories.

Before a new chemical can be used in the lab it must first be labeled with an EHSA barcode label (provided by EHS) and entered into the EHSA application (by the lab users). Chemicals that are used in large volume (high container turn over or refillable bulk containers) may be labeled with an EHSA barcode label placed on a green background label (this is referred to as "green labeling"). Green labels should be affixed to the shelf where the container(s) is normally stored, or in the case of gas cylinders, to the wall above where the cylinder is held. If this is not possible, the green labels may be placed in a notebook kept near by in the lab, but must be visible to lab inspectors.

Purchasing/Acquiring Chemicals

Starting in December 2012, all chemical purchases must be made through the GT BuzzMart System.

Semiannual Inventories/Reconciliations

All chemical users are required to reconcile their EHSA inventories between January 1 and June 15 and again between July 1 and December 15, annually.

Disposing of Chemical Waste

EHSA includes a module which allows chemicals to be designated as waste and removes them from the laboratory's inventory. All labs are encouraged to use EHSA for this purpose.

Training EHSA Users

Training in how to use EHSA (Using Chemical Inventory System - EHSA) is available online https://training.osp.gatech.edu and is also offered monthly https://training.osp.gatech.edu and by contacting EHS for assistance at ehsa@gatech.edu

Regulatory Requirements for EHSA

In addition to the State Right to Know Law, Georgia Tech EHS uses EHSA data to ensure compliance with the Federal Clean Air Act and the Department of Homeland Security Chemicals of Interest requirements.

Safety Data Sheets (SDSs)

SDS are available for a large number of the chemicals in the Georgia Tech inventory at ehsa.gatech.edu. You do not have to have an EHSA ID to access this information. When ordering new chemicals not currently in the inventory, users are required to enter the SDS into EHSA at the time the chemical is received.
Additional SDSs for chemicals already in EHSA must be forwarded electronically to EHS at ehsa@gatech.edu for addition to the EHSA collection.

Procurement of Chemicals

All chemicals brought on to Georgia Tech property must be entered into and tracked with EHSA, the Georgia Tech chemical information management system. PIs are responsible for ensuring that all the chemicals in their labs are entered into EHSA upon receipt and removed from their inventories as they are used up or removed as waste (see Waste, Sec 16, below).

4. Restricted Purchases- Chemicals and Equipment

A few chemicals require pre-approval by EHS or pre-notification of procurement by the purchaser to EHS. These include explosives (in any amount), pyrophorics, water reactives, toxic materials with an LD_{50} less than 5 mg/kg, organo-mercury compounds with an LD_{50} of less than 50 mg/kg or are readily absorbed through the skin, and flammable or toxic gases (see the GT Dangerous Gas Safety Program, at https://ehs.gatech.edu/chemical/dangerous-gas)

Equipment that requires pre notification of EHS include ethylene oxide/sterilizers, biosafety cabinets, class 3B or 4 lasers, and X-Ray generating equipment. A complete list of restricted purchases can be found at https://ehs.gatech.edu/chemical/restricted along with a request form to obtain a restricted item or chemical.

5. Signage

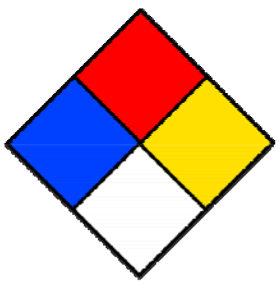
Exterior Lab Doors

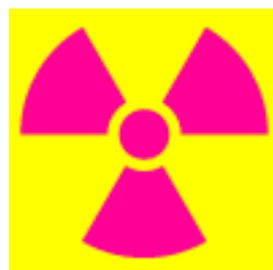
All exterior lab doors (to the hall or to the outside of the building) must be posted with an emergency notification card that has the name and emergency contact telephone numbers of the PI and two other responsible individuals who are qualified to answer questions about lab hazards (include both day and night numbers). Posting the GT Police number or the building manager's number alone is not adequate. These signs must also be posted to designate individual lab areas in buildings designed with 'open labs" (IBB, Whitaker, EBB).
The **emergency notification** card can be found at https://ehs.gatech.edu/chemical/documents as well as requested via Barcode Request feature on EHSA website (ehsa.gatech.edu).
Per the GT Institute Council for Environmental Health and Safety all exterior laboratory doors (those that face hallways or non-laboratory common areas) must be posted with warnings informing laboratorians and non-laboratorians of the hazards within. All persons entering the laboratory must have had at a minimum, basic instruction in hazard avoidance for the hazards indicated on the door.

Instructions for use:

1. Remove symbols that do not apply
2. Fill in the NFPA diamond with the appropriate hazard class numbers:
   - Numbers in the blue, red, and yellow diamonds should reflect the highest rated chemical present in each of the 3 categories (health, fire, reactivity) and should take into consideration hazardous gases as well as solid or liquid chemical hazards.
   - The white diamond should reflect particularly hazardous materials such as water reactive (~~w~~) or corrosive material. See the diagram below or contact EHS (404-894-4635) for help in filling in the appropriate information.
3. The laser hazard warning label applies to Class IIIb and IV lasers only
   - Embedded IIIb and IV lasers are functionally classified as a 1 or a 2 and do not require a sign
4. The magnetic hazard warning labels are designated for locations with high-powered magnets generating more than 5 gauss (0.5 Tesla) in any place a person can walk, sit, or stand.
5. Any use of biological material requires the use of a biohazard warning label.
   - This applies to any location where biological materials are manipulated or stored and includes rooms with incubators or refrigerators as well as cold rooms and warm rooms.
6. All locations where radioactive materials are used or stored or locations with equipment with radioactive sources (x-ray machines, etc.) require radiation hazard warning label

7. Print sign in color
8. Post on exterior room door.
   - Labs or storage areas which can only be accessed via another lab, the door to which is already posted, do not need to be individually posted, but the hazards they contain must also be represented on the sign posted on the exterior access door.

<table>
<tr><td colspan="3">This is a working laboratory.
Safety Glasses are required to enter.
All persons entering must have safety training appropriate for the hazards listed below:</td><td>
Safety Glasses</td></tr>
<tr><td>
Chemical Hazards</td><td>

Biological Hazards</td><td>
Radiation Hazards</td><td>

Toxic Gas Hazards</td></tr>
<tr><td>

Strong Magnetic Field</td><td>
No Cardiac Pacemakers or Ferro-Metallic Medical Implants</td><td>
No Loose Metal Objects</td><td>
Laser Hazards</td></tr>
<tr><td colspan="4">If you have questions regarding these requirements, please contact Georgia Tech Environmental Health and Safety at 404-894-4635.</td></tr>
</table>

For a downloadable version of this poster, see https://ehs.gatech.edu/chemical/documents

THIS SIGN ONLY PERTAINS TO TRAINING REQUIREMENTS AND DOES NOT REPLACE REGULATION-SPECIFIED SIGNAGE FOR BIOLOGICAL, RADIOLOGICAL, OR LASER HAZARDS.

Laser warning signs must be posted on all class IIIB and IV lasers work area. Signs must be lighted electrical signs posted exterior to the laser area and interlocked to the laser power supply. See the GT Laser Safety Program at http://www.ors.gatech.edu/laser/

Radiation warning signs, in addition to the training requirement signs, must be posted per the GT Radiological Safety Program at http://www.ors.gatech.edu/rsm.pdf

All open lab areas such as in the Whitaker Building (BME) or the Petit Institute for Biology and Biosciences (IBB) Building must be prominently posted with room number and PI name/emergency contact information in the lab to distinguish it from the adjacent labs. See https://ehs.gatech.edu/chemical/documents for the "pink card" form to post this information

Interior Lab Signage

All labs must have internal posting of the **GT Emergency Procedures** for lab accidents and emergencies; **SDS Information** availability; and **Hazardous Waste Pick Up** information see https://ehs.gatech.edu/chemical/documents for downloadable copies of these posters as well as the Barcode Request feature on EHSA website (ehsa.gatech.edu). In open lab areas it is acceptable to post this information so as to be accessible to several different labs.

Chemical storage cabinets must have signs which identify their contents.

Laboratory refrigerators and freezers must have signs that say **No Food and No Flammables** along with a biohazard warning sign, if applicable (the no flammables warning can be omitted on flammable safe/explosion proof refrigerators and freezers). Microwave ovens intended for laboratory use must have signs that say **No Food**.

Break room refrigerators and microwave ovens must have signs that say **Food Only**.

6. Container Labels

Primary Containers

A **primary container** is the one in which the material was received from the manufacturer.

The person receiving a chemical or chemical product should verify that all containers received for use are RTK compliant, which is that they are clearly labeled as to the contents; display the appropriate hazard warnings; and list the name and address of the manufacturer.

Secondary Containers

A **secondary container** is one to which a chemical or chemical product is transferred or the container in which a new chemical product/reagent is made and stored.

Immediate use containers are containers which are only expected to last one work shift and are not intended to leave the control of the person who filled them. Immediate use containers must be labeled with the name of the chemical they contain- in English, and the name of the person who is using them. Labels may be temporary, such as with a "Sharpie" marker.

Extended use containers are containers that are intended to remain more than just one shift and include but are not limited to reagent bottles, squirt bottles, and spray bottles. Extended use containers must be RTK compliant in that they must carry a permanent label, in English, with the contents identified by chemical name(s) and either an NFPA or HMIS label, appropriately filled out.

Vials and Test Tubes (Sample Containers)

Vials and test tubes may have hazard labels affixed to the rack or container in which they are held, rather than on each vial or test tube, so long as every vial or test tube in the rack or container presents the same hazard. Lab notebook reference numbers are not an acceptable substitute for chemical name and hazard identification.

Unlabeled Containers

If a container is found in the workplace that is unlabeled or carries a defaced label, the employee should immediately notify a supervisor. If the supervisor is unable to identify the container, the supervisor should call the Georgia Tech Hazardous Materials Manager at 404-894-6224 for assistance. **DO NOT ATTEMPT TO DISPOSE OF UNKNOWN MATERIALS UNTIL THEY HAVE BEEN ADEQUATELY CHARACTERIZRD BY GT EHS.**

7. Controlling Chemical Exposure

The following measures are used to prevent chemical exposures whenever possible or to reduce them to safe levels when prevention is not possible.

Chemical Hygiene

- All wet bench laboratories shall have hand washing facilities to include a sink with warm water, soap, and hand towels.
- No eating, drinking, smoking, applying cosmetics, removing/inserting contact lenses, or putting anything in your mouth is allowed in laboratories.
- Nothing associated with food is allowed in laboratories (except when the food is the object of the research). This includes no storage of food in laboratory refrigerators, no storage of food or food-utensils in laboratory cabinets.
- Do not wash food dishes or utensils in laboratory sinks.
- Do not use laboratory glassware or utensils to contain or handle food.
- No chemicals/lab samples or laboratory glassware or utensils are allowed in break rooms or offices.
- Lab coats and gloves may not be worn in break rooms, offices, or any place else where food is consumed (includes beverages).
- Unless you are transporting chemicals between labs, gloves should not be worn outside of the laboratory.
- Change your gloves before touching computer keyboard/mouse, telephones, and door handles
- Lab coats and gloves must be removed before entering building common areas such as halls, atriums, elevators, and meeting rooms unless chemicals/samples are being transported. See Transporting Chemicals, below.
- Hands shall be washed with soap and water as appropriate throughout the day;

after taking off gloves; before leaving the lab; before eating, drinking, or smoking; and after using the bathroom.

MOUTH PIPETTING IS STRICTLY FORBIDDEN.

Exposure Monitoring

Chemical Exposure Monitoring

Is conducted by EHS upon request, as a part of a routine hazard assessment, or if there is reason to believe that exposure levels for a particular substance may exceed either the action level or the Threshold Limit Value set forth by the American Conference of Governmental Industrial Hygienists (ACGIH). Individuals may contact EHS (404-385-4635) if they have concerns about current or upcoming processes. Results of the monitoring will be made available by EHS to the individual(s) monitored, and their supervisors within 15 working days of the receipt of analytical results. Based on the monitoring results, periodic monitoring may be scheduled at the discretion of EHS.

Biological Monitoring

Is conducted after accidental or suspected exposures as needed. However, it should be noted that biological monitoring is only possible for a small number of chemical substances and frequently is only useful when conducted immediately after the exposure. Exposure monitoring is conducted at the discretion of GT Laboratory and Chemical Safety Manager, and the GT Biosafety Officer.

Engineering Controls

After hygiene, engineering controls are the next most important means of controlling exposure to hazardous chemicals. Engineering controls are anything that that is built or installed to separate people from chemical, biological or physical hazards, and can include fume hoods, biosafety cabinets, glove boxes, and blast protectors. For help in determining what type of engineering control is appropriate for your process, contact EHS (404-385-4635)

Fume Hoods

Fume hoods are containment devices used to control exposure of the hood user and lab occupants to hazardous or odorous chemicals by preventing their release into the laboratory. A secondary purpose is to limit the effects of a spill by partially enclosing the work area and drawing air into the enclosure by means of an exhaust fan. This inward flow of air creates a dynamic barrier that minimizes the movement of material out of the hood and into the lab. Fume hoods are safety equipment and should be reserved for handling hazardous or odorous materials. They should not be wasted by using them to store unwanted equipment, chemicals, or garbage.

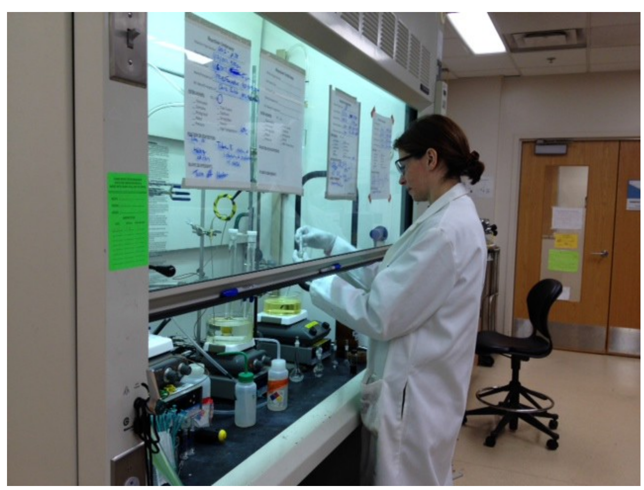
General Information About Fume Hoods

- Recirculation of any laboratory fume hood exhaust air is prohibited.
- Ductless fume hoods are prohibited
- Newly installed fume hoods at Georgia Tech shall either be Standard By-pass hoods or Variable Air Volume (VAV) hoods. Auxiliary-air hoods are generally prohibited unless special energy conditions or design circumstances exist.
- Low flow (AKA high efficiency) hoods are not permitted at Georgia Tech unless approved in advance, in writing, by GT EHS.
- Fume hoods shall not be located in front of air diffusers, or along busy walkways.
- The material that the fume hood interior walls, work surfaces, and the duct are made of is determined by the hood's anticipated use. Most hoods are made of solid resin; ducts are generally stainless steel. Perchloric acid hoods are made of stainless steel.

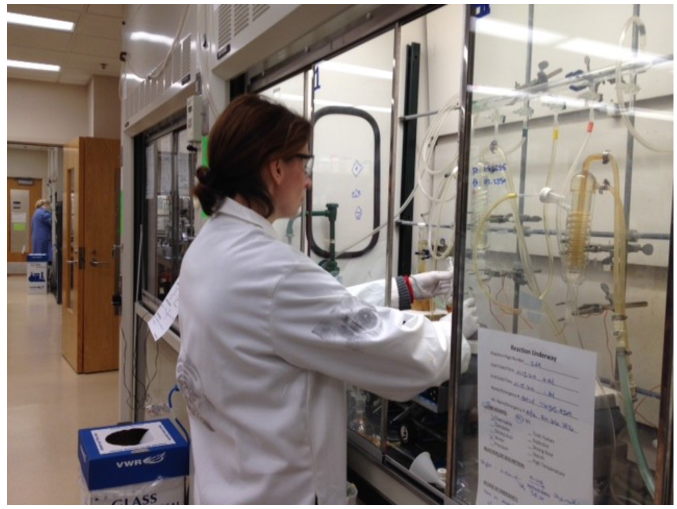
General Rules Regarding Laboratory Fume Hoods

- Before beginning any work, assess the level of hazard presented by the material involved and use only hoods that have adequate face velocity. Any work with chemicals must be in a hood with 100% exhaust.
- Keep all work at least 6 inches behind the plane of the hood sash.
- Never put your head inside an operating laboratory hood to check an experiment.
- The plane of the sash is the barrier between contaminated and uncontaminated air.
- The sash must always be between the user and hood contents:

On hoods where sashes open vertically, work with the hood sash in the lowest possible position; this is generally elbow height.
Never work with the sash in the fully open position.



On hoods where sashes open horizontally, position one of the doors to act as a shield in the event of an accident in the hood



- Keep hoods clean and clear; do not clutter with bottles or equipment. If there is a grill along the bottom slot or a baffle in the back of the hood, clean them regularly so they do not become clogged with papers and dirt.
- Allow only materials actively in use to remain in the hood. Extraneous chemicals left in an active hood can contribute to a fire or explosion.
- Elevate any equipment that needs to remain in hoods on racks or feet to provide airflow under the equipment.
- Post the name of the individual responsible for use of the hood in a visible location.
- Remove chemicals and clean hoods before maintenance personnel work on them.
- Hoods should have visible indicators that they are working. If the indicator is absent, hard to see, or not working, attach a piece of kimwipe to the sash in an area where it will not obstruct the work.
- Report suspected hood malfunctions promptly to GT EHS at 404-385-9531 or 404-385-9381
- Hoods operation shall be evaluated twice per year by GT EHS or a qualified third party and the inspection certified on a tag affixed to the front or side of the hood. If your hood does not have at GT EHS tag dated within the last six months, please report it by calling GT EHS at 404-385-9531 or 404-385-9381. See GT Fume Hood Protocols https://ehs.gatech.edu/content/document-fume-hood-check-procedure
- General purpose hoods shall operate at 100 linear feet per minute (LFPM) ± 20%.
- Hoods used for highly toxic or carcinogenic materials shall operate t 120 LFPM ± 10%. See GT EHS Fume hood certification protocols at https://ehs.gatech.edu/content/document-fume-hood-check-procedure

- Hoods should not, as a matter of course, operate above 150 LFPM to avoid the potential for dangerous turbulence that could result in exposure to the user.
- Always close the fume hood sash when you move away from the hood or leave the lab.
- Removal of fume hood access panels by anyone other that GT Facilities is prohibited.
- Tampering with fume hoods/fume hood exhaust ducts by adding additional equipment on to the load of the hood or cutting/drilling into exhaust ducts without consulting with EHS (404-385-4635) is prohibited.

Perchloric Acid Hoods

Perchloric acid is a clear liquid that has no odor. Solutions below 73% at room temperature are strong non-oxidizing acids. Perchloric acid becomes a strong oxidizer when heated or at higher concentrations; at or above 73%. **ORGANIC, METALLIC AND NON-ORGANIC SALTS FORMED FROM PERCHLORIC ACID OXIDATION ARE SHOCK SENSITIVE AND POSE A SERIOUS FIRE AND**

EXPLOSION HAZARD. There are many documented accidents resulting from the formation of perchloric acid salts.

Digestions and other procedures performed with perchloric acid at elevated temperatures must be done in a specially designed perchloric acid (wash down) fume hoods.

Perchloric acid hoods are equipped with water sources that spray the ducts and baffles of the hood to remove any perchlorates that may have formed there. Hoods must be washed down per the manufacturer's recommendations after each use.

If procedures involving heated perchloric acid are performed only rarely other accepted methods to capture and contain vapors may be used in place of a perchloric acid hood with EHS approval.

If you have been performing perchloric acid digestions in a fume hood not designed for perchloric acid, contact EH&S at (404-385-4635) immediately for an evaluation of perchlorate contamination of the hood.

Perchloric acid hoods may only be used for perchloric acid processes. Other processes/chemicals may not be accomplished in perchloric acid hoods.

Local Exhaust Ventilation

Various forms of local exhaust ventilation are seen in GT Labs and may have been designed and installed for specific processes. These include:

Elephant Trunk

Are useful for small sources of emissions

Canopy

These are useful for hot operations or to exhaust materials that are lighter than air

Slot and Plenum

Are useful for heavy vapors or particulates because they pull the contaminant backwards, away from the user, into the plenum before exhausting it up and out

Persons who have a need for local exhaust ventilation should contact EHS for an evaluation to determine what type of system will work best for your process.

Biosafety Cabinets and Laminar Flow Hoods

Biosafety Cabinets (BSC) are intended to protect the user from hazardous aerosols and are equipped with High Efficiency Particulate Air (HEPA) filters that frequently recirculate air back into the lab. They are not capable of capturing hazardous gases and their baffles and inner workings are not generally chemical resistant. Using a BSC with a hazardous gas not only could ruin the cabinet, it could result in injury to the user. Proper use of BSCs is described the GT Biosafety Manual, https://www.ehs.gatech.edu/biosafety/documents

Laminar Flow Hoods are work benches that continuously bathe the work area with clean, filtered air. Their primary purpose is to protect what ever is being worked on, or "product", not the user. Some Laminar Flow Hoods are also Chemical Benches which both protect the user and the products. These benches exhaust air via an exhaust ventilation system and do not recirculate it back into the lab.

Biosafety cabinets (BSCs) and laminar flow hoods (LFHs) are serviced and certified by a contracted vendor and documented by sticker affixed to the hood. Problems with BSLs or LFHs should be reported to the GT Biosafety Officer. If your hood does not have a sticker indicating that it has been serviced within the last 12 months, or if it does not have a sticker at all, please contact EHS (404-385-4635).

Ventilated Chemical Storage Cabinets

Ventilating chemical storage cabinets is regulated under National Fire Protection Association Standard 45, Standard on Fire Protection for Laboratories Using Chemicals. Ventilation of chemical storage cabinets may only be accomplished with prior approval by GT EHS and requires that the PI or designee start the installation process by filing a project request form with GT Facilities (http://www.facilities.gatech.edu/dc/prf/) Laboratory staff may not ventilate cabinets themselves.

Appropriate Lab Attire

GT implemented a Personal Protective Equipment and Appropriate Attire Policy in August 2011 which can be found at https://www.ehs.gatech.edu/chemical/lsm/7-6 as well as https://www.ehs.gatech.edu/bestifused Excerpts from the policy appear below:

Personal attire while in the laboratory plays a major role in determining the level of risk of exposure to hazardous agents and of physical injury. Appropriate clothing provides an extra layer of protection against spills and splashes of hazardous materials. Appropriate clothing covers the torso, legs, and feet. Therefore, the following practices shall be adhered to in Georgia Tech wet bench laboratories:

Allowed	Not Allowed	Explanation
Hair must be kept away from the eyes. Long hair must be tied back. Hair longer than 6 inches from the nape of the neck must also pinned up (Use of hair nets or hats is acceptable)	Hair must not impede vision, come in contact with the work, or open flames.	Hair can impede vision. Long hair can fall onto the lab bench/come in contact with chemicals or biologicals. Long hair is also a hazard around rotating equipment and open flames such as Bunsen burners or alcohol burners.
Ties and scarves that do not hang loose outside the lab coat	Neckwear such as ties and scarves that hang loose	Dangling neckwear may come in contact with chemicals, biologicals or open flames. These also are a hazard around rotating equipment.
Baseball caps and other headgear as long as they are kept far enough back on the head so that vision is not impaired and also do not interfere with protective eyewear.	Caps worn low over the eyes so as to impede vision	Avoiding accidents means staying aware of one’s surroundings at all times. Unimpeded visual observation is key in this regard.

Allowed	Not Allowed	Explanation
	Use of iPods, MP3 players, or other electronic devices with head-phones is not allowed in laboratories and is highly discouraged in laboratory buildings.	Laboratorians must be aware of their surroundings at all times which includes being able to hear alarms, sirens, run away reactions, and other people calling for help.
Shirts/tops that cover upper torso	Cropped shirts, plunging necklines, spaghetti straps, or ripped shirts.	Layered clothing is a safety asset in that it provides an extra layer of protection against spills and splashes.
Clothing that accommodates lab coat use.	Loose or flowing tops with wide/bell sleeves; outerwear s/a coats or shawls that make it difficult to don a lab coat.	Wearing this type of clothing makes it difficult/uncomfortable to wear a lab coat: The wearer may be tempted to do without the lab coat. Loose sleeves may also be dragged across the bench becoming contaminated and are a hazard around rotating equipment and open flames.
Long pants that cover the wearer to the ankle	Ripped jeans, shorts, capris, or skirts.	Chemicals splash up after they hit the floor; likewise shattered glass bounces up and can inflict injury on unprotected skin. Persons who must wear skirts due to personal reasons should speak with their supervisors to determine an appropriate strategy for this rule.
Completely enclosed shoes that cover the instep of the foot: preferably, of leather which can be wiped clean.	Sandals, open toe, open back, or open weave shoes; shoes with holes in the top or sides; No Birkenstocks, Mary Janes, cloth shoes, or Crocs.	Shoes need to protect the wearer from chemicals, hot liquids, and shattered glass. Cloth shoes can absorb chemicals or hot liquids and hold them against the skin until they can be removed.

Other Recommendations Regarding Lab Clothing

Recommendation	Explanation
Choose clothing made of natural fibers, especially cotton whenever possible	Natural fibers are more fire resistant than synthetic fibers
Avoid wearing pantyhose	Fire and some chemicals may cause the nylon to melt to the skin increasing risk of serious injury
Keep a change of clothes, including shoes, in a desk drawer	After an exposure, the victim will not be allowed to re-don contaminated clothing and will need something to wear home.

Personal Protective Equipment

Protective Equipment (PPE) includes safety glasses, goggles, face shields, gloves, lab coats, aprons, ear plugs, and respirators. Personal protective equipment is carefully selected to ensure that it is compatible with the chemicals and the process used.

Eye Protection

- Safety glasses or chemical goggles must be donned before entering any wet bench lab, including cell culture labs. This applies to lab visitors, GT maintenance and custodial workers as well as staff and students.

- Safety glasses must meet the ANSI Z87.1 standard for impact resistance and have side shields for splash protection.

- Chemical goggles may be required for certain processes where safety glasses are deemed inadequate

- Safety glasses or goggles must be worn over prescription glasses. Safety glasses worn over prescription glasses must be of a type intended for this purpose (Often referred to as Over the Glass Safety Glasses). Regular prescription glasses will not provide adequate protection in this case.

- Prescription safety glasses are acceptable as long as they have side shields for splash protection. (Check with your department to see if they fund such purchases.) Side shields must also meet the Z87.1 standard for impact resistance and be non-vented.
- Safety glasses or goggles are required all labs where soldering or machining/grinding occurs.

Lab Coats

- Shall be donned before handling chemicals, biologicals, or unsealed radiological sources.
- Shall cover the wearer to the knees
- Lab Coat fabric of poly-cotton blends are acceptable. Exceptions include:
    - Labs were open flames are used (such as alcohol burners)- lab coat must be made of 100% cotton or flame resistant material.
    - Labs where pyrophoric materials are handled- lab coat must be of flame resistant materials.
- Contact EHS (404-385-4635) for information about lab coat supply/laundry service.

For more information see the GT Laboratory and Personal Protective Equipment Policy at https://www.ehs.gatech.edu/chemical/lsm/7-6

Face Protection

- Face shields worn over safety glasses may be required for certain processes as determined by the Principle Investigator (PI) and/or GT EHS.
- Face shields must always be worn over safety glasses or goggles, ***not*** instead of safety glasses or goggles
- Processes involving high pressure reactors (>30 PSI) or pneumatic lines (>30 PSI), high pressure air lines, machining operations, and some cryogenic procedures require the use of face shields over safety glasses.

Hand Protection

Chemically Resistant Gloves

Gloves, especially, should be chosen carefully: They must be resistant to the chemicals being used but also not put the wearer at risk because of loss of dexterity, risk of ergonomic injury (s/a increased muscle strain from gloves that are too heavy or stiff for pipetting, handling small objects, etc.), or increased risk of being caught in rotating equipment from gloves that are too loose on the user's hands.

While there is no single glove material that provides 100% protection from all chemicals, a good all purpose glove is the nitrile exam glove. Latex gloves, which have been the most commonly used glove in labs for many years are not resistant to many of the most common solvents found in laboratories. Additionally, latex is a natural product and is also a powerful allergen which readily becomes airborne on glove powder each time a glove is removed. Most hospitals have banned the use of powdered latex gloves. Many institutions have banned latex gloves entirely.

Consult the Safety Data Sheet section on handing instructions before selecting gloves. Some, but not all SDSs contain glove selection information. If you have questions about appropriate glove selection, contact EHS (404-385-4635). Be sure to include the name of the chemical and CAS number.

General Rules Regarding Chemically Resistant Glove Use

- Nitrile exam gloves are the general purpose glove of choice in all Georgia Tech wet bench labs.
- Cell culture labs, labs that deal with only biological samples or live animals, and labs where the purpose of glove use is to protect the product or the lab from human skin oils, may use powder free-latex gloves.

- Select gloves which are appropriate for the chemical(s) being used and also the process
- Before use, check gloves (even new ones) for physical damage such as tears or pin holes and for previous chemical damage: this is especially important when dealing with dangerous materials such as HF.
- When working, it may be advisable to wash the external surface of the gloves frequently with water.
- Most chemically resistant gloves, especially lightweight disposables, are combustible: keep hands well away from unprotected flames or other high temperature heat sources.
- When removing gloves, do so in a way that avoids the contaminated exterior contacting the skin. See diagram below:

How to Remove Gloves

(Without Contaminating Yourself)

- Wash hands after removing gloves.
- Dispose of contaminated gloves properly.
- Do not attempt to re-use disposable gloves.
- Never wear possibly contaminated gloves outside of the laboratory or to handle telephones, computer keyboards, etc.

Gloves for Protection against Heat or Cold

Thermal gloves for cryogenic applications are commercially available in a variety of lengths to be appropriate for the application. One should remember, however, that no cryo-protective glove is intended to provide protection against direct immersion in cryogenic liquids. Cryo-protective aprons are also available.

A number of glove styles are commercially available for hot work processes, most of them involving layers of leather, Kevlar, and insulating foam. Like any other piece of personal protective equipment, thermally protective gloves must be chosen based on appropriate length, level of protection required, and also the level of dexterity required to accomplish the task at hand. Gloves made of asbestos cloth are not allowed in Georgia Tech laboratories. If you find asbestos containing gloves or hot pads in your lab, please contact EHS (404-385-4635) to remove and dispose of them appropriately.

Respiratory Protection

Respirators are a last resort when it comes to protecting people in the workplace. Under The Georgia Tech Respiratory protection program (https://www.ehs.gatech.edu/chemical/respiratory) and the Federal Respiratory Protection Standard (29 CFR 1910. 134) employers are required to determine that no other method of protecting the employee is feasible before resorting to the use of respirators.

What is a respirator?

A respirator is a device designed to protect the wearer from inhalation of harmful substances. *When chosen correctly and used properly*, respirators can protect the wearer from harmful gases, mists, vapors, fumes, and fine particulates. Respirators fall into the following two general classifications, according to mode of operation

(1) atmosphere-supplying respirators and

Supplied Air (SA) or Air Line Respirator

Self Contained Breathing Apparatus (SCBA)

(2) air-purifying respirators

N-95 Filtering Face Piece Respirator

Half Face Air Purifying Respirator (HF APR) with an Elastomeric Face Piece

Full Face Air Purifying Respirator (FF APR) with an Elastomeric Face Piece

Using a respirator safely involves a lot more than just buying the respirator and strapping it on. Proper use of a respirator involves:

Step 1. A Respiratory Hazard Evaluation to identify the hazard and determine whether it can be adequately controlled with engineering or administrative controls- without resorting to respirator use.

- Done by EHS
- Chemical users should request this when there is a question about the effectiveness of engineering controls or when engineering controls are not possible (Such as for some outdoor processes)
- Users can request Respiratory Hazard Evaluation by contacting EHS (404-385-4635)

Step 2. Medical Clearance to wear a respirator (having a medical professional determine if your heart and lungs are fit enough to handle the strain of wearing a respirator)

- Done only after a Respiratory Hazard Evaluation indicates that the hazard cannot be controlled by means other than use of a respirator
- Provided by an outside Occupational Health Care provider
- Managed through the GT Occupational Health Program (https://www.ehs.gatech.edu/occupational-health)
- No cost to the employee or the employee's department
- Repeated annually

Step 3. Fit Testing in the exact make, model, and size respirator that you will be wearing to work

- Provided by EHS at no cost to the employee or the employee's department
- Will determine the type, make, and model of respirator to be purchased
- Repeated annually

Fit testing an N-95 with Bitrex™

Fit testing a half mask with irritant smoke

Fit testing a half mask using a Portacount™

Step 4. Training in the hazards that make respirator use necessary as well as how to put on, use, and care for the respirator.

- Provided by EHS
- EHS will issue the employee the appropriate respirator at the time of the initial training.
- Training is repeated annually
- Employees must bring their respirators with them to refresher training

The use of respirators here at Georgia Tech is covered by the Georgia Tech Respiratory Protection Program (https://www.ehs.gatech.edu/chemical/respiratory). Outside of GT, respirators are covered by their own section of Federal law: 29 CFR 1910.134. This is because, while using a respirator properly can prevent chemical exposures, using respirators improperly can actually *result in* chemical exposures. This is due to what safety professionals call a *false sense of security.*

Here's an example of how misuse of a respirator led to a chemical exposure that would not have happened if a respirator was not involved: In 2009 in a Georgia Tech lab, a small bottle of a toxic, anesthetic powder was accidentally knocked off a high shelf (about 5 feet off the ground). The bottle shattered and the powder was strewn about.
Some of the powder became aerosolized by the force of the impact. It is also theorized a portion of the material may have sublimed in the bottle and was released as a gas when the bottle shattered. The person in charge of the lab ordered everyone out immediately. She then borrowed a respirator from a neighboring lab group, re-entered the lab, and proceeded to clean up the spill using a dust pan and paper towels. Before she could complete the clean up, she began to feel dizzy. Fortunately, she was able to exit the lab before passing out.

Had the researcher not gained a *false sense of security* by having the respirator, she would not have re-entered the lab and not suffered the exposure.

The bottom line is that you cannot KNOW that the respirator fits you unless you have been fit tested in it. Wearing a respirator that doesn't fit or the wrong respirator IS worse than not wearing the respirator at all.

Summary of Rules Regarding Purchase and Use of Respirators

- No one may purchase or use a respirator of any type in Georgia Tech laboratories without prior permission/certification by EHS (this includes N-95 filtering face pieces)
- No one will be given permission to use a respirator unless there has been:
  - A Respiratory Hazard Assessment
  - Medical Clearance
  - Fit Testing
  - Training
- GT EHS is the only entity on campus which is authorized to choose respirators or respirator cartridges for GT faculty, staff, and students.
- No one who has been certified to use a respirator for one hazard may use the respirator for another hazard without first consulting with GT EHS.
- Respirators are not to be loaned out or shared between lab users.
- GT Rules do not allow the use of respirators for "comfort measures" without prior approval by EHS.

What Is The Difference Between an N-95 Filtering Facepiece and a Facemask?

Facemasks are loose-fitting, disposable masks that cover the nose and mouth, such as surgical masks and nuisance dust masks. Facemasks are not approved by the National Institute for Occupational Safety and Health (NIOSH) for protection against any regulated hazardous material.

Facemasks help stop droplets from being spread by the person wearing them. They also keep splashes or sprays from reaching the mouth and nose of the person wearing the facemask and are therefore useful when cleaning up spills of infectious materials. They are not designed to protect you against breathing in gases, vapors, or very small particles. Facemasks should be used once and then disposed of.

Surgical Mask

Surgical mask

Nuisance Dust Mask

N95's are respirators which are approved by NIOSH for use against certain selected airborne particulates when used as part of a respiratory protection program which includes:

1. Respiratory Hazard Evaluation
2. Medical Clearance
3. Fit Testing
4. Training

There are nine different classifications of respirator particulate filters based on three different levels of resistance to oily aerosols and filter efficiency:

N-95

N-95 close up- Notice the warning which describes how it may be used.

Class	Efficiency
N= not resistant to oil **R**= resistant to oil (somewhat resistant to oil) **P**= Oil Proof (strongly resistant to oil)	**95** % efficient at stopping particles 0.3 microns (μm) in diameter **97**% efficient at stopping particles 0.3 μm 99.97% efficient (but referred to as **100**%)at stopping particles 0.3 μm in diameter

N-95s are approved by NIOSH only for protection against non-oily particulates. A number of N-95s are marketed as "NIOSH Approved" with wording to the effect that they are also for protection against nuisance levels of acids or solvents. These products are NIOSH approved- but only for protection against non-oily particulates. Their use against acid or solvent aerosols is only a manufacturer's suggestion. N-95s are specifically not approved for use with nano-materials.

Anyone at Georgia Tech who feels he or she may be carrying an infections disease, is encouraged to wear a facemask for the purposes of protecting other people. (Please see the GT Policy on Dealing with H1N1 flu) Use of facemasks to protect oneself from infections by others has generally been discounted as ineffective.

Use of N-95 respirators as part of a complete Respiratory Protection Program has been approved for protection of specific at risk groups (Public Safety, Student Health) for protection against respiratory infections. Use of N-95 respirators is also permitted by EHS for specific work groups including GT Maintenance, Housing, Landscaping and

Building Services. Use of N-95s in a laboratory setting is not allowed without prior permission from GT EHS.

For more information about Respiratory Protection at Georgia Tech, please see the GT Respiratory Protection Program at https://www.ehs.gatech.edu/chemical/respiratory or contact EHS (404-385-4635).

Administrative Controls

Administrative Controls are things that you can do to prevent chemical exposures that don't involve Engineering Controls (things you build or install) or Personal Protective Equipment (things you wear) and include thing like proper handling procedures and personnel rotation.

It is the responsibility of the Principal Investigator (PI) to insure that all persons working in his/her laboratory are made aware of all the reasonably anticipated hazards of the laboratory including but not limited to chemical, biological, physical, and electrical hazards. See the General Lab Safety and Training Sections, below, and Creating a Culture of Safety, https://www.ehs.gatech.edu/content/document-creating-safety-culture

Personnel Rotation is a practice whereby, in the absence of lowering the level of a contaminant or other hazard in the workplace, the time that a worker is allowed to be exposed to that hazard is limited, so as to maintain the worker's overall exposure below legal limits: i.e. personnel are *rotated* through the workplace. Personnel rotation is an acceptable practice in some industries where the level of contaminant/hazard cannot be readily controlled/protected against. It is not considered an ethical practice where chemical exposures are controllable, and will not be used at Georgia Tech.

8. Training

All persons working in GT labs must be formally oriented to the lab and its hazards prior to starting work by the PI or a senior lab staff member designated by the PI. Guidelines for creating an Orientation Check List can be found in Creating a Safety Culture in the Laboratory at https://www.ehs.gatech.edu/content/document-creating-safety-culture

Additionally, PIs are required to provide SOPs for processes which are inherently hazardous (highly reactive, pyrophorics, water reactive, etc.) or that involve highly/ extremely toxic materials, or highly reactive materials. Highly toxic materials include materials that have an LD_{50} less than 50mg/kg by oral exposure or an LC_{50} of less than 200 ppm by inhalation exposure. Extremely toxic materials have an LD_{50} of less than 5 mg/kg by oral exposure. (See the GT Dangerous Gas Program (https://www.ehs.gatech.edu/chemical/dangerous-gas, Section 17 on Chemical Storage, and the Section 19 on Process Specific Hazards)

Required training for persons working in laboratories include:

Class	Applies to	Frequency	How Offered
Fire Safety/Fire extinguisher training	Everyone	Initial and annually thereafter	In person, sign up at training.osp.gatech.edu
Georgia RTK	Everyone	Initial and annually thereafter*	
Basic Lab Safety or Equivalent**	Students, junior staff members	Initially with refreshers every 3 years	
Advanced Lab Safety for PIs and Lab Managers	PIs, lab managers	Initially with refreshers every 3 years	
Biological Safety	All persons working with biological materials	Initially with refreshers every year	
Bloodborne Pathogens	All persons working with infectious materials, human blood products or human tissues	Initially with refreshers each year	
Radioactive Material (RAM) Safety	All persons working with or around radioactive materials	Initially with refreshers every year	

X Ray Safety	All persons operating X Ray equipmen mt	Initially with refreshers every 2 years	In person, sign up at training.osp.gatech.edu
Process Specific Training	New employees, junior staff members	As needed	PIs are required to provide process specific training for persons working in laboratories, particularly when the process involves highly hazardous materials or potentially dangerous equipment.
Shipping Dangerous Goods	All persons who need to ship samples to other locations or need to ship samples back to GT from offsite work locations	Once, as the need arises	Training has two components- one is on line, the other is in person, in the lab.
Receiving Hazardous Materials	All persons who take delivery of hazardous materials		In person, sign up at training.osp.gatech.edu
Waste Handling	All lab users	Initially with refreshers every 3 years	In person, sign up at training.osp.gatech.edu
Laser Safety	Laser Users	Initially	Available online at www.ehs.gatech.edu/chemical/#laser

* All Georgia State employees must take RTK initially. Only persons working with chemicals must re-take the class annually.

** Equivalent classes include training sessions given to specific groups. Check with EHS at 404-385-4635 if you have questions regarding training equivalent classes.

9. General Lab Safety

Laboratory workers are expected to take responsibility for their own safety by learning the locations of, and how to use emergency equipment as well as being proficient in emergency procedures.

Access to Hand Washing Facilities

All wet bench labs will have access to a sink suitable for hand washing and will be stocked with hand soap and paper towels.

Emergency Equipment

Includes fire extinguishers, emergency showers, emergency eyewashes, spill kits, and exits.

- All emergency equipment shall be prominently identified with signs.
- All wet bench labs shall have an emergency shower and eyewash within 10 second access those locations where chemicals are handled
- All labs shall have a fire extinguisher of an appropriate type within 75 feet.

Emergency Exits/Means of Egress

- Includes not only exit doors but the corridor, aisle, or stairwell that you must traverse to reach the exit.
- Main aisles inside the lab leading to the exit must be at least 48 inches wide and must not have “trip hazards” or other obstructions such as equipment (temporary or permanent), boxes, or supplies.
- All other aisles must be at least 36 inches wide
- Stair wells may not be used as storage areas for equipment, chemicals, janitorial supplies, etc.

Fire Extinguishers

- All fire extinguishers Need to be located within 75 feet of a potential fire hazard and must be chosen to be appropriate for the hazard. If you have questions about fire extinguishers, contact EHS at 404-894-2990.
- All persons working at Georgia Tech are required to take fire extinguisher training initially and annually thereafter (see training section, above)

ABC Extinguishers

(AKA Dry Chemical Extinguishers) The most commonly found type of extinguisher in GT labs. They are effective against paper fires (Class A fires), burning liquids (Class B fires), and electrical fires (Class C fires) However The ABC extinguisher is filled with monoammonium phosphate, a yellow powder that leaves a corrosive sticky residue that may be damaging to electrical equipment such as a computer, NMRs or other sensitive electrical equipment.

Carbon Dioxide Extinguishers

Are effective against burning liquids, such as hydrocarbons, and electrical fires (Class B and C fires). They are recommended for fires involving delicate instruments and optical systems because they do not damage such equipment. They are less effective against paper, trash or metal fires and SHOULD NOT be used against lithium or aluminum hydride fires.

Met-L-X Extinguishers

And others that have special granular formulations are effective against burning metal (Class D fires). Included in this category are fires involving magnesium, lithium, sodium, and potassium; alloys of reactive metals; and metal hydrides, metal alkyls, and other organo-metallics. These extinguishers are less effective against paper and trash, liquid or electrical fires.

Water extinguishers have been discontinued at Georgia Tech. If your lab still has one of these, please call the Georgia Tech Fire Marshal at 404-894-2990 to have the extinguisher removed and replaced with a more appropriate extinguisher. **DO NOT** attempt to use this extinguisher on electrical, liquid or metal fires.

Using Fire Extinguishers

NEVER ATTEMPT TO USE A FIRE EXTINGUISHER IF THE FIRE IS BETWEEN YOU AND THE EXIT. In such a case the only appropriate course of action is to evacuate. If you do decide to fight a fire, have someone pull the fire alarm and evacuate the building while you fight the fire.

See a summary of fire safety information and how to use a fire extinguisher at http://www.youtube.com/watch?v=ZCSms-jyOao

Spill Kits and Spill Clean Up Procedures

- All labs (or lab suites) shall have a spill kit which is appropriate for the type of materials used in the lab. Typical spill kits contain sorbent materials for acids, bases, and solvents. Spill kits for specific materials are also available, such as for mercury or hydrofluoric acid.
- Small scale inexpensive spill kits can be purchased from any number of sources such as VWR and Lab Safety supply.
- Always use appropriate personal protective equipment when cleaning up a spill: make sure that gloves are chemical- appropriate and heavy enough to protect against physical hazards.
- Do not attempt to clean up a spill if you feel unqualified to do so. If the nature of the spill is such that respiratory protection is needed, evacuate the lab, and call EHS.
- Always dispose of used sorbents as hazardous waste by submitting a waste pick up request via ehsa.gatech.edu.
  DO NOT DISPOSE of Spilled hazardous materials in the regular trash.
- More information about being prepared to deal with spills and what should go in your lab's spill kit can be found at https://www.ehs.gatech.edu/emergency/planning
- Generally, the sorbent material is applied to the spill from the outer edge to the center in order to prevent spreading the spilled material. This applies whether you are using dry pourable sorbents such as clay litter, or using spill pillows or paper towels. Clean up the sorbets working from the exterior to the interior of the spill in a circular pattern, not back and forth in a grid pattern as this will spread the spill.

Chemical Spilled	**Clean-Up Procedures**
Acids, organic	Apply sodium bicarbonate. Adsorb with spill pillow or vermiculite.
Acids, inorganic	Apply sodium bicarbonate/Calcium Oxide or sodium carbonate/calcium oxide. Adsorb with spill pillow or vermiculite. NOTE: Hydrofluoric acid is an exception to the general practice, see below.
Acid Chlorides	Do not use water. Absorb with sand or sodium bicarbonate.
Aldehydes	Absorb with spill pillow or vermiculite.
Aliphatic Amines	Apply sodium bisulfite. Adsorb with spill pillow or vermiculite.
Aromatic Amines	Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation.
Aromatic Halogenated Amines	Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation.

Azides	Absorb with spill pillow or vermiculite. Neutralize with 10% ceric ammonium nitrate solution.
Bases (caustic alkalis)	Neutralize with acid, citric acid, or commercial chemical neutralizers. Absorb with spill pillow or vermiculite.
Carbon Disulfide	Absorb with spill pillow or vermiculite.
Chlorohydrins	Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation.
Cyanides	Cover solids with damp paper towel and push onto dust pan or use a HEPA filter vacuum to collect the solids. Absorb liquids with spill pillow or vermiculite.
Halides, organic or inorganic	Apply sodium bicarbonate.
Halogenated Hydrocarbons	Absorb with spill pillows or vermiculite.
Hydrazine	Avoid organic matter. Apply "slaked lime". Adsorb with spill pillow or vermiculite.
Hydrofluoric Acid	Apply calcium carbonate (limestone) or lime (calcium oxide) rather than sodium bicarbonate. The use of sodium bicarbonate will lead to the formation of sodium fluoride, which is considerably more toxic than calcium fluoride. Be careful in the use of spill pillows used to absorb the acid. Some pillows contain silicates which are incompatible with hydrofluoric acid.
Inorganic Salt Solutions	Apply soda ash
Mercaptans/Organic Sulfides	Neutralize with calcium hypochlorite solution. Absorb with spill pillow or vermiculite.
Nitriles	Sweep up solids. Absorb liquids with spill pillows or vermiculite.
Nanoparticles	Pick up particles with a HEPA or ULPA filtered vacuum.
Nitro compounds/Organic Nitriles	Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation.
Oxidizing Agents	Apply sodium bisulfite.
Peroxides	Absorb with spill pillow or vermiculite.
Phosphates, organic and related	Absorb with spill pillow or vermiculite.
Reducing Substances	Apply soda ash or sodium bicarbonate.

Emergency Showers

- Emergency showers shall be located within a 10 second fast walk of any location where wet bench work is performed.
- Access to emergency showers shall be immediate: shower access is not to be blocked by garbage cans, furniture, boxes, etc.
- Emergency Showers shall have a 30-inch diameter clear space under the shower head and have a pull chain or lever no more than 42" from the floor
- Emergency showers shall not be located near electrical equipment (s/a refrigerators), or within 6 feet of electrical outlets.
- Emergency showers shall be checked no less than once per year by Georgia Tech Facilities and shall have a tag on which indicates the date of the last test.
- Laboratory groups are encouraged to check their showers more frequently, (once per month is recommended) and also record the test on the shower tag.
- For information on how to use an emergency shower - see Emergency Procedures, below

Emergency Eyewashes

- Emergency eyewashes shall be located within a 10 second fast walk from any location where wet bench work, machining operations, or soldering is performed.
- Access to emergency eyewashes shall be immediate: eyewash access is not to be blocked by glassware, equipment, carboys, etc.
- Eyewashes that are located on/near sinks and which drain into the sink, or eyewashes that are independent of sinks but that are plumbed with a drain or are adjacent to a floor drain shall be tested/flushed for no less than one minute every week by the laboratory staff. This test is to be recorded on a tag on the eyewash or on a record sheet posted prominently near by.
- Eyewashes which are independent of sinks and have no immediate access to drains shall be tested/flushed once per year by Georgia Tech Facilities and the test recorded on the eyewash tag. Laboratory groups are encouraged to flush these eyewashes more often and record the test on the tag or on a record sheet posted prominently near by.
- For information on how to use an eyewash, see emergency procedures, below.

Personal Conduct

Persons working in or visiting Georgia Tech laboratories are expected to conduct themselves at all times in a professional fashion. Horseplay, physical rough housing, and

practical jokes shall not be tolerated and will result in the implementation of disciplinary procedures in accordance with institute policies.

Housekeeping

- All lab users share the responsibilities of keeping their work stations and work areas free from the accumulation of materials and equipment. Clutter is a safety hazard that promotes trips and falls, chemical spills, and fires.
- Stock chemicals are to be returned to the storage cabinet when you are done with them and always returned to the cabinet before leaving at the end of the day.
- Dirty Glassware is to be placed in appropriate containers- not left on lab benches or in sinks.
- Minor Spills are to be cleaned up immediately by the lab staff; major spills are to be reported immediately.
- Eliminate safety hazards by maintaining laboratory work areas in a good state of order. Maintain at least two clear passages to laboratory exits.
- Always keep tables, fume hoods, floors, aisles and desks clear of unnecessary material.
- Wipe down bench tops and other laboratory surfaces after each use with an appropriate cleaning or disinfecting agent.
- If experiments must be left unattended, place a copy of the unattended work permit (https://www.ehs.gatech.edu/chemical/documents) next to experimental apparatus indicating the chemicals involved, your name and a number where you can be reached in case of an emergency. Put a copy of this form on the door. (See the Section on Unattended Operations, later in this chapter)
- Keep the laboratory floor dry at all times. Immediately attend to spills of chemicals or water, and notify other lab workers of potential slipping hazards.
- All machinery under repair or adjustment should be properly tagged prior to servicing. All service work should be done by authorized personnel.
- Sink traps and floor drains should be flushed and filled with water on a regular basis to prevent the escape of sewer gases or the release of chemical odors in the event of an emergency. Drains which will not be routinely used may be "topped" with 20 - 30 ml of mineral oil to prevent evaporation of water in the trap.

Fire Safety

- All labs shall post the emergency shut locations off for natural gas, compressed air, or other "plumbed" gases and electricity in a prominent location. Additionally, these shut off locations shall be prominently marked, including marking breaker

  box switches. The existence and location of emergency shut offs shall be included in all new employee orientation programs and the lab's safety program. Be aware of ignition sources in lab areas such as open flames, heat, and electrical equipment.
- Be particularly aware of ignition sources which are less than 24" from the floor, such as vacuum pumps, computers, refrigerator compressors, and other floor mounted electrical equipment. Whenever possible, place vacuum pumps and other small electrical equipment on shelves or stands to elevate them at least 24" above the floor.
- Use of hot plates or hot plate/magnetic stir plate combinations are to be carefully overseen. Use of the hot plate function requires the use of an Unattended Operation Form (https://www.ehs.gatech.edu/chemical/documents). Hot plate/stir plate combination units are not permitted in cold rooms or deli boxes. Users are advised to purchase stir plate-only units for these applications.
- Purchase and store flammable reagents in the smallest quantities available.
- Store flammable liquids that require refrigeration in flammable safe or explosion proof refrigerators. For more information on refrigerating flammable materials see: https://www.ehs.gatech.edu/content/document-chem-refrigerating-flammables
- Store flammable liquids in appropriate safety cabinets and/or safety cans.
- Do not store incompatible reagents together (e.g., acids with flammables) (see the section on Chemical Storage)
- Do not store ethers or conjugated dienes, for extended periods of time as explosive peroxides could form. All Potentially Explosive Chemicals (PECs) should be dated when received and opened. Watch for reminders from EHSA to inspect PECs every 3 months. PECs kept longer than one year should be discarded. Avoid wastage by purchasing no more than a 3 to 6 months supply of any PEC at one time. (See the sections on Working with Highly Hazardous Materials and Chemical Storage). A list of peroxide forming chemicals can be found in the section on Chemical Storage.
- Be aware of the condition of fire extinguishers. Inspect fire extinguishers monthly and record the inspection on the back of the tag. Report any broken seals, damage, low gauge pressure or improper mounting to the GT Fire Marshal (404-894-2990). If the seal has been broken, assume that the fire extinguisher has been used and must be recharged. (Note: Do not use fire extinguishers unless you are trained and feel confident to do so.) Report ALL fires by phoning 911.
- Automatic fire sprinklers must remain clear and unblocked to function properly. Do not store materials within 18" of the sprinkler head or 19" of the ceiling to allow for proper sprinkler function

Electrical Safety

The major hazards associated with electricity are electrical shock and fire. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor.

The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin. The effect of the shock may range from a slight tingle to severe burns to cardiac arrest. The chart below shows the general relationship between the degree of injury and amount of current for a 60-cycle hand-to-foot path of one second's duration of shock. While reading this chart, keep in mind that most electrical circuits can provide, under normal conditions, up to 20,000 milliamperes of current flow.

Current	Reaction
1 Milliampere	Perception Level
5 Milliamperes	Slight shock felt; not painful but disturbing
6-30 Milliamperes	Painful shock; "let-go" range
50-150 Milliamperes	Extreme pain, respiratory arrest, severe muscular contraction
1,000-4,300 Milliamperes	Ventricular fibrillation
10,000+ Milliamperes	Cardiac arrest, severe burns, and probable death

In addition to the electrical shock hazards, sparks from electrical equipment can serve as an ignition source for flammable or explosive vapors.

Even loss of electrical power can result in extremely hazardous situations. Flammable or toxic vapors may be released as a chemical warms when a refrigerator or freezer fails.
Fume hoods may cease to operate, allowing vapors to be released into the laboratory. If magnetic or mechanical stirrers fail to operate, safe mixing of reagents may be compromised.

Avoiding Electrical Hazards

- All equipment should be inspected before use.
- Make sure that all electrical cords are in good condition.

- All electrical outlets should be grounded and should accommodate a 3-pronged plug. Never remove the grounding prong or use an adapter to bypass the grounding on an electrical cord.
- All electrical outlets within 6 feet of a water source (sink, eyewash, etc.) must be equipped with a Ground Fault Circuit Interrupter (GFC) either on the outlet, or somewhere on the electrical line. Note- the GFC may be located at the circuit breaker box. All GFC outlets/ GFC equipped lines shall be clearly labeled.
- All electrical equipment must have 3 prong or polarized plugs (one prong wider than the other).
- Extension cords may only be used on temporary equipment (or equipment which must be moved frequently) and must be rated so as to be adequate for the equipment they serve.
- Permanent equipment (to be in place or has been in place more than 6 months) must have permanent wiring- not extension cords. Extension cords may not be ganged together.
- Power strips with surge protectors are allowed but may not be ganged together.
- All labs should have instructions on where circuit breakers are located to de- energize circuits in the event of emergencies.
- Minimize the use of electrical equipment in cold rooms or other areas where condensation is likely. If equipment must be used in such areas, mount the equipment on a wall or vertical panel.
- Do not place power strips in front of fume hoods or any other location where liquids re routinely handled.
- Electrical outlets may not be located within 24 inches of the center of an emergency shower spray area.
- Electrical outlets located between 24 and 72 inches of the center of an emergency shower spray area must be GFCI equipped.
- Electrical equipment located between 24 and 72 inches of the center of an emergency shower spray area must be protected from water spray and powered via a GFCI equipped outlet.

Gas Cylinder Safety

Rules for storing and working with dangerous gases can be found in the Section on Process Safety

General Rules for Handling Gas Cylinders

- All compressed gas cylinders shall be secured with chain or strap between the "waist" and "shoulder of the cylinder at all times. This includes empty cylinders.
- Cylinders not currently in use must be capped. ("in use" includes cylinders connected to equipment or processes used at least 3 times per week)
- Empty cylinders must be capped

Limit the number of cylinders in the lab by keeping no more than 1 back up cylinder for every cylinder in use. (may exclude flammable gases. See GT Dangerous Gas Safety Program at https://www.ehs.gatech.edu/chemical/dangerous-gas

- Cylinders must be kept away from electrical wiring where the cylinder could become part of the circuit.
- Store cylinders in well-ventilated areas designated and marked only for cylinders.
- Store cylinders in an upright position (includes lecture bottles).
- Empty cylinders should be clearly marked and stored as carefully as those that are full because residual gas may be present.
- Mark empty cylinders EMPTY
- Keep valves closed on empty cylinders.
- Protect cylinders from corrosive vapors and sources of heat
- Do not store cylinders in egress areas near emergency exits, hallways, or under stairs.
- Do not keep cylinders more than 5 years past their hydrostatic test date (see receiving cylinders, below).

Receiving Cylinders

- Inspect all cylinders upon delivery for valve protection and hydrostatic test date, which should be within the past 5 years. The hydrostatic test date will be stamped into the collar of the cylinder. A stamp of 2MM84+ indicates that the cylinder was last hydrostatically tested in February of 1984; "MM" are the inspector's initials: "+" indicates that it is authorized for charging up to 10% in excess of its marked service pressure. Retest stamps should also appear on the neck or shoulder of the cylinder: 4L02* means that the cylinder was re-tested in April of 2002 at facility "L". A star after this number means that the cylinder has a 10-year retest cycle, rather than a 5-year cycle.
    - Do not accept the cylinder past it's hydrostatic test certification

      Do not keep a cylinder past its hydrostatic test certification. (This is due to Department of Transportation regulations- it is not legal to transport a cylinder that is out of date, so technically, the gas supply company can't remove it if it is out of date.)

- Check the cylinder's service pressure. This will be found on the collar opposite the hydrostatic test stamp. This stamp will have 3 lines and may look something like this:

  DOT3AA226
  5 K16110
  BTWECO

  - The first line means that the cylinder meets US Department of Transportation Specification 3AA and has a service pressure of 2265 psig at 70^{o}F
  - The second line is the manufacturer's serial number
  - The third line is the manufacturer's unique symbol
- Do not accept cylinders unless they are clearly labeled as to their contents. NEVER rely on cylinder color as an indicator of the cylinder's contents

Cylinder caps and valves should not require anything more than hand pressure to open - do not accept the cylinder if this is not the case.

Cylinder Storage: Chemical Compatibility

Cylinders must be stored in compatible groups:

- Flammables from oxidizers: Keep oxygen cylinders a minimum of twenty feet from flammable gas cylinders or combustible materials. If this can not be done, separation by a non-combustible barrier at least 5 feet high having a fire-rating of at least 0.5 hours is required. NOTE This applies to cylinders in use, "back up" cylinders stored in labs, and "empty" cylinders.
- Corrosives from flammables or oxidizers (20 feet in outdoor storage area; does not apply when cylinders are indoors in gas cabinets) NOTE corrosive gas cylinders are not allowed indoors unless they are in gas cabinets.

Moving/Transporting Cylinders

- Never move a cylinder that is not capped.
- Always use a cylinder cart to move cylinders from place to place, do not roll or "twirl" them from one place to another.
- Don't use the protective valve caps for moving or lifting cylinders.
- Don't drop a cylinder, or permit them to strike each other violently or be handled roughly.
- Moving cylinders and dewars on elevators
  - Whenever possible use freight elevators

- Do not allow other people to ride the elevator with the gas cylinder- politely ask them to wait for the next elevator.

Here's a demonstration of what can happen when an un-capped cylinder is damaged:
http://www.youtube.com/watch?v=ejEJGNLTo84
Same thing- a safety issue for all you SCUBA divers out there:
http://www.youtube.com/watch?v=tyINNUaXa8Q&NR=1

Not for the faint of heart regarding a portable-sized oxygen cylinder:
http://www.youtube.com/watch_popup?v=9lw_fhNAIQc#t=160

Labeling Cylinders

- The cylinder, not the cap, must be labeled as to the contents and supplier. Do not rely on cylinder color to identify cylinder contents: color coding is not universal and varies from one supplier to another.
- Cylinder labels must be facing out so as to be visible to lab inspectors and emergency responders.
- EHSA barcode labels for gas cylinders should be affixed to the wall (preferable) or kept in a note book in the lab. Gas cylinders use the "green label" system for high through-put chemicals: the label stays on the wall, even when the gas cylinder is changed out. There is no requirement to remove the old cylinder from the system and re-enter the new cylinder every time the cylinder is changed out as long as the replacement cylinder has the same contents as the original.

Cylinder Fittings/Gas Tubing

- Cylinder fittings vary between gas types, inert, oxidizing, corrosive, and flammable.
- Never use grease or Teflon tape to force a fitting- you may be putting together two types of incompatible fittings.
- Always use non-sparking tools (brass or aluminum) to work on flammable or oxidizing gas fittings.
- Fittings and tubing must be compatible with the gas. See the GT Dangerous Gas Safety Program at https://www.ehs.gatech.edu/chemical/dangerous-gas for compatibility information.

Regulators

- Must be marked for the maximum cylinder pressure. Cylinder pressure may not exceed 75% of the regulator's maximum rated pressure
- Must be equipped with two gauges: one to show the cylinder pressure and the other to show the outlet pressure. An exception to this is single stage regulators used for corrosive gases.
- Never use an adapter between the regulator and the source cylinder

- Never use an aid, such as Teflon tape to connect a regulator to a cylinder.
- After attaching a pressure-reducing regulator to a compressed gas cylinder
    - Turn the regulator adjustment screw out (counterclockwise) until it feels loose
    - Stand behind the cylinder with the valve outlet facing away from you and observe the high pressure gauge on the regulator from an angle, never pressurize a gauge while looking directly at it.
    - Open the valve handle on the gas cylinder slowly until you hear the space between the cylinder valve and regulator fill with gas. (You can also watch the pressure rise on the high pressure gauge. If you turned the adjustment screw properly, there should be no gas flow out of the regulator and no pressure rise on the low-flow pressure gauge.
    - When you are ready to use the cylinder, open the valve until you feel it stop, then turn it back one-quarter turn.
    - If the regulator does not come with a hand wheel, the wrench needed to open it must be left at the cylinder so that it can be closed quickly in the event of an emergency.

Cylinder Use

Be sure all connections are tight. Use soapy water to locate leaks. (see the Dangerous Gas Safety Program for leak testing on dangerous gas systems: https://www.ehs.gatech.edu/chemical/dangerous-gas

- Keep cylinders' valves, regulators, couplings, hose and apparatus clean and free of oil and grease.
- Keep cylinders away from open flames and sources of heat.
- Safety devices and valves shall not be tampered with, nor repairs attempted. Use flashback arrestors and reverse-flow check valves to prevent flashback when using oxy-fuel systems.
- Regulators shall be removed when moving cylinders, when work is completed, and when cylinders are empty.
- Cylinders shall be used and stored in an upright position
- The cylinder valve should always be opened slowly. Always stand away from the face and in back of the gauge when opening the cylinder valve.

- When a special wrench is required to open a cylinder or manifold valve, the wrench shall be left in place on the valve stem when in use; this precaution is taken so the gas supply can be shut off quickly in case of an emergency; and that nothing shall be placed on top of a cylinder that may damage the safety device or interfere with the quick closing of the valve.
- Fire extinguishing equipment should be readily available when combustible materials can be exposed to welding or cutting operations using compressed cylinder gases.
- Welding and cutting operations in labs require a Hot Work Permit: https://www.ehs.gatech.edu/fire/permit-request/hot_work

The purchase and use of dangerous gases fall under the Georgia Tech Dangerous Gas Safety Program (https://www.ehs.gatech.edu/chemical/dangerous-gas)

- Please review this program before purchasing ANY quantity or concentration of dangerous gases to ensure that you are handing the material per Georgia Tech rules and State Fire Codes

Lecture Bottles

Lecture bottles are small gas cylinders (about 2 inches by 13 inches) and are frequently used for highly hazardous gases to keep the total quantity of a very dangerous substance present in the lab to a minimum. Lecture bottles of dangerous gases are still captured under the Dangerous Gas Safety Program, https://www.ehs.gatech.edu/chemical/dangerous-gas

- Lecture bottles of poisonous and pyrophoric gases must always be kept inside the fume hood, whether or not they are in use.
- The number of lecture bottles allowed in a lab at Georgia Tech is limited to 6.

Other rules that apply to full sized cylinders also apply to lecture bottles such as:

- Secure in-use bottles
- Store upright
- Always use regulators, fittings, and tubing that are compatible with the gas
- Remove regulators when not in use

Holder Available from Sigma Aldrich appropriate for in-use or in storage

Holder available from Sigma Aldrich appropriate for storing lecture bottles

Gas supply companies will not rent lecture bottles: you must buy them. Disposing of a lecture bottle is very expensive (about $1,000.00 each). Some companies, however, will take back lecture bottles that you have purchased from them, for a fee. Please check before you buy and try to purchase lecture bottles from a company that will take them back. Contact EHS (404-894-4635) for help with shipping a lecture bottle back to the manufacturer.

Here is an example of what NOT to do with lecture bottles:

Always dispose of lecture bottles that you no longer need.

Sharps and Glass Disposal

Sharps in laboratories include needles, scalpel blades, razor blades, and broken wafers. Waste glass including Pasteur pipets and glass containers, broken or not, must be disposed in appropriate containers, not the general waste. The first question to be answered when disposing of sharps or glass is: Is it biohazardous or radioactive?

Non-biohazardous or non-radioactive glass must be disposed of in glass disposal boxes, whether it is broken or not. When full, these containers are taped closed and disposed in the building waste dumpster by the lab users.

Biohazardous glass waste must be decontaminated chemically or by autoclaving prior to disposal as glass waste (above). Biohazardous glass Pasteur pipets are best disposed in a sharps container, below.

Glass waste which is contaminated with radioactive material must be disposed of in containers provided by the Office of Radiological Safety (www.ors.gatech.edu). ORS should also be contacted for removal of these containers.

Needles, razor blades, scalpel blades, etc. can puncture cardboard boxes and must be dispose of in a plastic receptacle.

If the sharps are also biohazardous, a red sharps container must be used. When full, these containers can be placed in the hazardous waste area of the lab for pick up by EHS personnel.

Radioactive sharps must be contained in sharps containers provided by the Office of Radiological Safety www.ors.gatech.edu. ORS should also be contacted for removal of these containers

Non-biohazardous/ non-radioactive sharps may be discarded in plastic containers that are any color EXCEPT red:

These containers may be placed in the hazardous waste area for pick up by EHS.

PLEASE REMEMBER!

Sharps and glass in the regular trash can injure the people who pick up your trash. Please think of others when you discard these items and discard them into the appropriate containers!

Hearing Protection

The Georgia Tech Hearing Conservation Program is can be found at https://www.ehs.gatech.edu/sites/default/files/hearing_conservation.pdf This Program is based on the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and not the US Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limits. The difference is that by following the ACGIH guidelines, the GT Program is more protective than federal law would require, were it directly applicable here at GT. The basics of this program are:

A "Hearing Conservation Required Area" is an area where hearing protection must be donned prior to entering because noise levels exceed 82 dBA for 8 hours/day when calculated as a Time Weighted Average (8 hr TWA), or noise levels routinely exceed 115 dBA. An exception to the "don it at the door" rule can be made for areas where the 8 hr TWA does not exceed 82 dBA but noise levels do routinely exceed 115 dBA as a result of pre-planned experiments or activities that can be pre-announced with warning lights, claxons or other type of warning system which has been approved by GT EHS.

Working in a "Hearing Conservation Required Area" requires participation in the GT Hearing Conservation Program and includes annual audiograms. For More information about the GT Occupational health program go to https://www.ehs.gatech.edu/occupational-health

Hearing protection must be selected from the United States Air Force Approved Hearing Protection Devices list. (Appendix B of the GT Hearing Conservation Program https://www.ehs.gatech.edu/sites/default/files/hearing_conservation.pdf). GT uses this list to narrow down equipment selection to devices which have been tested and found to be effective by a testing agency (the USAF) which is independent of device manufacturers. This list contains a variety of readily available makes and models of ear plugs, ear muffs, communication head sets, and helmets.

There are no restrictions on the use of hearing protection devices for intermittent use when working with noisy equipment, however, extended use of hearing protection is not advised as it may interfere with the ability to hear fire alarms and other warning systems.

Working Alone

Working alone with hazardous materials or hazardous processes is discouraged. However, when necessary, the following rules apply:

- The work hours must be approved, in writing, by the lab manager or PI
- The person working alone shall make arrangements with other persons in the building to check with each other periodically.
- Dangerous experiments such as, but not limited to, working with pyrophoric, explosive, or highly toxic materials shall not be performed by a worker who is alone in the lab (see below Working with Highly Hazardous Materials)

Unattended Operations

- Unattended operations which may continue several hours, overnight, or even over several days shall be pre-approved, in writing by the lab supervisor or PI.

The presence of an unattended operation shall be posted on the lab door by means of the Unattended Operation Permit Form (https://www.ehs.gatech.edu/chemical/documents)

- Which identifies the person responsible for the unattended operation and his/her 24hour contact information. It shall also be posted at the operation by means of a second copy of the permit note attached to a fume hood sash or oven door). Unattended Operation Permits are intended for use on processes that use or produce hazardous materials, require water jacket cooling devices, or could become hazardous in the event of an electrical outage, water outage or ventilation failure. Permits are not required for biological incubations, plate rotators, or other low hazard processes, but should be used for those which are odorous.
- Many unattended operations utilize water as the coolant in condensers and other equipment. Use of tap water to cool unattended operations is discouraged. Whenever possible, water cooled operations should utilize recirculating refrigerated water baths to conserve water and protect against floods. However, if this is not possible, the following guidance is provided:
  - A decrease or increase in tap water pressure can have serious consequences: Lower pressure, typical in the early morning as water usage increases, can result in a slower flow and inadequate cooling. Higher pressures can cause leaks, separation of connections and flooding.
  - When setting up unattended operations, regulate the water pressure automatically via the installation of a water pressure regulator. The regulator must be protected by an appropriate filter to prevent clogging. Monitor the water flow so that in the event of interruption, electricity and water supply can be turned off. The latter is necessary because a break in a connection can result in flooding. Position the monitor at some point after the water has passed through the apparatus and is on its way to the drain.
- Operations should be designed to be safe, and plans should be made to avoid hazards in the event of a failure in power, water, gas or some other service. Room lights should be left on and the Unattended Operation Permit Form should be posted on the room door.

10. Lab Inspections: Self/ EHS

- Laboratory groups are expected to self-inspect weekly using the GT self inspection checklist, https://www.ehs.gatech.edu/chemical/documents or one that they have developed themselves which has been approved by GT EHS- Chemical Safety Office.
- Completed Laboratory Self Inspection Checklists for the previous 12 months shall be available in the lab.
- GT EHS- Chemical Safety Office conducts two different types of laboratory inspections in addition to the Fume Hood Certifications, described above. These are the Quick Check Inspections, and Comprehensive Laboratory Inspections.

Chemical Safety Visits/Quick Check Inspections

Quick Check Inspections are usually done by request and are recorded on Georgia Tech Chemical Safety Visit note slips:

Notes may be left on the lab door, or in the lab where the problem(s) has been observed (bench, sink, fume hood, etc.)

PIs are also contacted by e-mail regarding the completion of the inspection and any significant findings.

Quick Check Laboratory Inspection

Building Name, Room No.:
Department:
Lab Inspector:
Time:
Principle Investigator:
Inspection Date:

1. Is there an Emergency Notification card (with contacts for lab) on the outside of the door that is up-to date? If no, please post emergency procedures and fill in applicable information.

2. Is there a chemical inventory posted near the door?

3. Is MSDS information posted anywhere, (i.e. MSDS can be found at….)? Emergency procedures posted somewhere plainly visible (by phone preferably if there is one in the lab)? (If no, please post and fill in applicable information.)

4. Are eyewashes and safety showers unobstructed/checked? (annually for showers/eyewash stations not drained, weekly for those drained showers/eyewashes.)

5. Are gas cylinders secured properly?

6. Are fire extinguishers available (visible, preferably near door), unobstructed and checked?

7. Are flammables stored in flammable cabinets?

8. Is hazardous waste properly contained and labeled? (waste should be labeled with a description of contents by percentage or volume, owner's name, fill-start date; are there large amounts of accumulated waste?

9. Egress/aisle ways obstructed? Trip hazards?

10. Is housekeeping adequate (no clutter on the bench tops, chemicals stored properly, lab maintained in a neat orderly fashion, etc.)?

Comments:

Quick Check Inspections look at 10 different issues in labs:

1. Is there an Emergency Notification card (with contacts for lab) on the outside of the door that is up-to date? (https://www.ehs.gatech.edu/chemical/documents) If no, please post and fill in applicable information.
2. Is there a chemical inventory posted near the door?

3. Is SDS information posted anywhere, (i.e. SDS can be found at https://www.ehs.gatech.edu/chemical/documents)? Are Emergency Procedures (posted somewhere plainly visible (by phone preferably if there is one in the lab) https://www.ehs.gatech.edu/chemical/documents)? If no, please post and fill in applicable information.
4. Are eyewashes and safety showers unobstructed/checked? (annually for showers/eyewash stations not drained, weekly for drained eyewashes.)
5. Are gas cylinders secured properly?
6. Are fire extinguishers available (visible, preferably near door), unobstructed and checked?
7. Are flammables stored in flammable cabinets?
8. Is hazardous waste properly contained and labeled? (waste should be labeled with a description of contents by percentage or volume, owner's name, fill-start date; are there large amounts of accumulated waste?
9. Egress/aisle ways obstructed? Trip hazards?
10. Is housekeeping adequate (no clutter on the bench tops, chemicals stored properly, lab maintained in a neat orderly fashion, etc.)?

General Lab Safety/ Chemical Safety Comprehensive Inspections

Comprehensive Lab Inspections by EHS Chemical Safety are pre-announced through the building manager, lab manager, and Department Chair.

Inspections are completed using a 76 points check list. A copy of the checklist is available at https://www.ehs.gatech.edu/chemical/documents. Inspection reports are generated and sent to the PI within 3 days of the inspection.

Types of Comprehensive Inspections

- Routine (Pre-Notification through building manager, lab manager, or RTK coordinator)
- As a result of an accident (Conducted as part of the accident investigation No special notification given)
- As a result of a highly hazardous situation identified in a Quick Check inspection or some other means (Emergency – no notification given)
- By request from the department, PI, or facility manager (Pre-notification through requesting party -surprise inspections only when specifically requested)

- Comprehensive Inspection Reports are provided to the PI, lab manager, Department Chair, and the GIT Chemical and Environmental Safety Committee (CESC) Chair
- Work order generation: EH&S submits work order requests directly to appropriate maintenance group
- Follow up procedures: Re-inspection will occur between 1 day and 6 weeks after inspection, depending on the level of hazard involved.
- Failure to Correct Notifications are sent to the Department Chair, School Dean, CESC Chair, and the GT Institute Council on Environmental Health and Safety Chair (with a cc to the PI) only if safety issues remain after the re-inspection.
- Routine inspections are done on a building-wide basis. Department Chairs will receive a summary of the inspection results for all of their department's labs in that building, referred to as a "Report Card", within a month of the building's inspections having been completed.
- Lab closures or work stoppages are avoided whenever possible, however, in the event of a safety hazard that poses an imminent threat to the health and safety of Georgia Tech personnel, or presents a serious hazard of property damage, the lab will be closed and/or a particular process will be stopped until the safety hazards are remediated. Disciplinary action up to and including termination of contract may be taken against PIs who fail to remediate safety hazards in their labs.

Frequency of Comprehensive Inspections

It is the intent of GT EHS to conduct comprehensive lab inspections every two years. However, this frequency is subject to personnel availability, and to the risk level posed by the nature of the research being conducted in the lab. New research, as indicated by new research proposals involving chemical agents will result in a re-inspection of any lab that has not been inspected in the last 12 months.

Biological Safety Inspections

The Biological Safety Office conducts lab inspections of laboratories with approved research protocols annually. For more information and for a copy of the Biosafety Inspection Checklist go https://www.ehs.gatech.edu/biosafety/documents

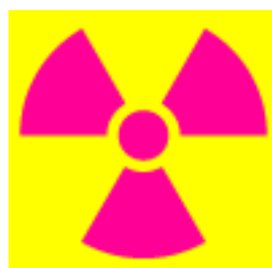
Radiological Safety Inspections

The Office of Radiological Safety performs radiation contamination surveys in designated Radioactive Materials (RAM) labs every 3 months. These surveys also include checks to ensure compliance with state regulations regarding radioactive materials and/or equipment using radioactive sources and general safe handling of radioactive materials. This information can be found in more detail in the GT Radiological Safety Policy Manual at http://www.ors.gatech.edu/rsm.pdf

11. Visitors in Laboratories

Visitors in laboratories include anyone other than Georgia Tech lab staff, students, or faculty including custodial, maintenance, administrative, and Environmental Health and Safety personnel. It also includes family members and visitors from outside the university including visiting students and researchers.

The warning sign on the lab door is intended to inform all visitors that they are entering a hazardous work area and they are required to comply with all applicable safety rules and precautions, such as wearing safety glasses and being alert to the potential hazards in the area.

This is a working laboratory. Safety Glasses are required to enter. All persons entering must have safety training appropriate for the hazards listed below:			 Safety Glasses
Chemical Hazards	 Biological Hazards	 Radiation Hazards	 Toxic Gas Hazards
Strong Magnetic Field	 No Cardiac Pacemakers or Ferro-Metallic Medical Implants	 No Loose Metal Objects	 Laser Hazards
If you have questions regarding these requirements, please contact Georgia Tech Environmental Health and Safety at 404-894-4635.			

Visiting Scientists and Students

It is the responsibility of the PI to ensure that visiting scientists and students have received all appropriate training before being allowed to work in Georgia Tech labs including basic lab safety, waste handling procedures, and lab/process specific safety training. These persons must also be provided with basic personal protective equipment (PPE) such as safety glasses, gloves, and lab coats if they cannot provide their own.

It is also the responsibility of the PI to inform Research Security when visitors may come in contact with Classified Information or Controlled Unclassified Information (CUI) Examples of CUI include but are not limited to Sensitive But Unclassified Information, and DOD and DOE Unclassified Controlled Nuclear Information. PIs may receive guidance on this topic by contacting the Research Security Help desk at 404-407-6661, or by e-mail at rsdhelp@gtri.gatech.edu)

By allowing visiting scientists in his or her lab, the PI also accepts the responsibility for the visitor's actions and is responsible for ensuring that the visitor adheres to all applicable safety and environmental rules and regulations.

Underage Visitors

No one under the age of 16 is permitted to work in Georgia Tech laboratories. Visiting students under the age of 18 must provide a waiver: (https://www.ehs.gatech.edu/minors) by their parent or Legal Guardian to work in GT labs. Additionally, prior to beginning work they must complete Georgia Right to Know Training, either on line: (http://www.usg.edu/ehs/training/rtkbasic/) or in the classroom, and must also attend a Basic Lab Safety class. (Check https://training.osp.gatech.edu for the next available classroom sessions or contact the GT EHS Chemical Safety Office 404-385-9531 to arrange for a special session if the monthly sessions don't fit your student's schedule.)

Visiting Elementary and Secondary School Groups

GT welcomes visiting "future scientists" as long as the appropriate waivers have been signed and a pre-visit safety review by GT EHS has been performed. Please contact the EHS office at 404-385-4635 to discuss prior to the field trip.

12. Emergency Procedures - Fires, Spills, and Chemical Exposures

All labs shall have a copy of the GT Emergency Procedures posted, (https://www.ehs.gatech.edu/chemical/documents) preferably near a telephone, when possible.

In the event of an incident, you will have to determine how to proceed by first asking the question-is this a major or a minor event?

Spill Procedures: Major and Minor Incidents

See also the section on Spill Kits and Spill Clean Up Procedures on Page 55

Minor Incidents

- Minor Incidents= spills you can handle by yourself
- Less than 4 liters spilled
- Isolate the area (don't let others walk near or through the spilled material)
- Alert people in the immediate area of spill.
- Avoid breathing vapors from spill (if this is unavoidable, evacuate the lab and call for help.
- Put on protective equipment, including safety goggles, suitable gloves, and long sleeved lab coat.

How to Clean Up a Minor Spill:

- Confine the spill to as small an area as possible by cleaning it up from the outer edge inward.
- Use appropriate materials to neutralize and absorb inorganic acids and bases.
- For other liquids, absorb spill with vermiculite, dry sand, or adsorbent pads.
- For solid spills. Cover the spill with a slightly damp paper towel to avoid creating a cloud of dust, Push the material into a dustpan or other instrument using the towel- do not use a broom/dust brush.
- Collect material, used adsorbents/neutralizing agents, etc. in a polyethylene bucket or bag
- Place the contained waste in the EHS waste pick up area
- DO NOT ALLOW THE HOUSEKEEPERS TO REMOVE THIS WASTE

- Please contact EHS regarding the waste clean up

- Replenish Spill Kit
- Conduct an after incident review to examine what went wrong

Major Incidents

- Major Incidents + Anything you don't think you can handle
- Greater than 4 L
- Highly toxic
- Flammable
- Any combination of the above
- If you are worried about your safety s/a should I be wearing a respirator to do this?
- Human exposure
- Any time medical attention is required
- Violent or run-away reactions
- Highly dangerous or unknown material
- Fires

WHEN SOMEONE HAS AN ACCIDENT IN A LABORATORY, IT IS EVERYONE'S RESPONSIBILITY TO HELP. **ALL ACTIVITY STOPS** UNTIL THE ACCIDENT VICTIM IS ATTENDED TO.

Major Incidents – what you should do

- ATTEND to injured or contaminated persons and remove them from exposure
- ALERT people in the area to evacuate. If danger is believed sufficient - pull the fire alarm and evacuate the building
- NOTIFY the Georgia Tech Police at 404-894-2500 or Call 911for help and tell the operator:
  - That you are on the Georgia Tech Campus at______________street address (on the emergency procedures poster) and in room_______.
  - The nature of the emergency (spill, chemical exposure, fire)
  - If there is an injury involved, tell the operator that an ambulance will be needed.
  - Provide as much of the following as is known.

- What chemical(s) are involved.
- How much was spilled.
- Where the spill is located.
- Nature of any injuries.
- What control measures have been taken.
- Your name and phone number (or where you will be located).

- IF POSSIBLE
  - Close the fume hood, shut off equipment
  - Post a warning
- DO NOT LEAVE THE AREA until given permission to do so by a GT EHS representative

Fires

In the event of a fire you can:

- Choose to pull the fire alarm and fight the fire yourself (see fire safety section)
- Choose to pull the fire alarm and exit the building, picking up the copy of the lab chemical inventory kept by the lab door as you exit

Chemical Exposures

In any chemical exposure it is the responsibility of the person nearest to the victim to become the "Helper" and come to the aid of the exposure victim.

Respiratory Exposures

- Move victim to fresh air,
- Do not leave victim alone
- Remember to take a cell phone with you if you taking the victim out of the immediate area to get fresh air
- Tell someone in the lab where you are going

Skin Exposures

In the case of skin exposures it may be necessary for the victim to strip down to bare skin. In such an event, a person of the same gender must be found to stay with the victim while everyone else leaves the lab (and keeps other people away from the lab windows).

Victim	**Helper** = closest person to the victim at the time of the accident
1. SHOUT for Help Rinse for 15 minutes in tepid, NOT hot, water 3. If skin exposures involve a body part that cannot be rinsed under a faucet an emergency shower must be used 4. Remove clothing on the way to the shower 5. Shower for 15 minutes in tepid, NOT hot, water 6. Use soap to help remove non water soluble materials 2. Do not re-don contaminated clothing	1. Help victim into shower 2. Call GT Police at 404-894-2500 for help 3. If you are not the same gender as the victim, find someone who is to take your place 4. Check the clock- the victim must remain in the shower for 15 minutes 5. Bring the victim hand soap to help remove oily/ non water soluble materials 6. Bring the victim a towel (Note: GT EHS can provide) 7. Bring victim something to wear (extra clothes, clean lab coat, clean room garment- note GT EHS can provide) 8. Find out if the victim knows what he/she was splashed with and print out 4 copies of the SDS: one goes to victim, one goes to the paramedics, one goes to the GT Police, one to EHS. 9. If the victim is going to the hospital, make sure they have their ID, wallet/purse, cell phone, and copy of the emergency procedures (take it down off the wall) for billing information. 10. The victim must be transported by ambulance to the hospital, they may not drive themselves, neither may a helper take them. 11. Inform the victim's supervisor so that a First Report of Injury can be filed.

1. The need for medical follow up in cases of skin exposure is determined on a case by case basis.
2. When medical follow up is needed, GT EH&S recommends that all chemical exposure cases go to Grady Hospital to ensure proper care.

Eye Splash

In the event of an eye splash, it is particularly important that the nearest person to the victim goes to their aid- they may be blinded and unable to find the eyewash by themselves.

Victim	**Helper**
1. Shout for help 2. Hold your eyelids open with your fingers as you rinse your eyes 3. Rinse for 15 minutes in TEPID water while moving your eyes up and down/back and forth to expose all areas of your eyes to the water 4. You MUST seek medical attention immediately afterwards	1. Call GT Police at 404-894-2500 for help 2. Watch the clock- victim must rinse eyes for 15 minutes 3. Coach victim to keep eyes pried open and to move eyes up and down and back and forth to work the water under the eyelids. 4. Find out if the victim knows what he/she was splashed with and print out 4 copies of the SDS: one goes to victim, one goes to the paramedics, one goes to the GT Police, one to EHS. 5. Before sending victim to the hospital , make sure they have their ID, wallet/purse, cell phone, and copy of the emergency procedures (take it down off the wall) for billing information

1. Eye splashes require immediate medical follow up. GT EH&S recommends that all chemical exposure cases go to Grady Hospital to ensure proper care
2. Chemical exposure victims must be transported by ambulance to the hospital, they may not drive themselves; neither may a helper take them.

13. Hazardous Waste

The full content of the Georgia Tech Hazardous Waste Policy can be found at https://www.ehs.gatech.edu/sites/default/files/documents/hazardous/hazmat.pdf
Federal, state, and local governments impose strict regulations concerning the management, storage, and disposal of hazardous materials. Compliance with these laws, good safety practices, and the necessity to avoid future liabilities dictate that the Institute take a conservative approach in handling this material.

The term "hazardous waste" as used in this manual means any substance no longer of use to the possessor whose chemical or biological properties have the potential to endanger personnel, material, or the environment if handled improperly. Hazardous waste includes, but is not limited to items specifically identified as "hazardous waste" under federal and state statutes.

Research groups/organizations shall not arrange for off or on site disposal of hazardous material or use the Institute's EPA ID number without prior coordination with GT EHS. This does not preclude the routine transfer of chemicals between GT laboratories or the use of the GT EPA ID number on research proposals.

Georgia Tech EH&S is charged with ensuring that all hazardous waste generated at Georgia Tech is handled properly. Within specific activities, EH&S will provide advice and technical assistance. However, it is the responsibility of each individual to know the possible dangers associated with any material being used or generated, and know how the material should be handled and disposed of BEFORE A PROJECT IS BEGUN.

Materials for which GT EHS is responsible include:

- Chemical waste to include Highly Toxic Material.
- Highly Toxic Material is any chemical which is either specifically identified by the Environmental Protection Agency (EPA) as an "acute hazard" or has a Lethal Dose 50 (LD_{50}) of 50 mg/kg or less oral-rat. Samples include inorganic cyanides, many pesticides, arsenic compounds, etc. A listing of EPA listed "acute hazards" may be obtained from EH&S, or found at the EH&S web site (www/safety.gatech.edu)
- Used oil (handle the same as chemical waste).
- Biological/Infectious Waste.
- Fluorescent Bulbs and Ballast
- Batteries.
- Asbestos
- Lead-Based Paint
- Radioactive waste, to include mixed waste (chemical and radiological) is the responsibility of the Radiological Safety Office of GT EHS (404-894-3600).

Material for which EH&S is NOT Responsible:

- Broken glass, whose only danger comes from its ability to inflict wounds, is not considered hazardous waste. Activities which anticipate generating broken glass should obtain puncture proof containers and dispose of the material appropriately.

Computers and related equipment (monitors, keyboards, scanners, etc.) and parts (cards, cords, etc.) are an environmental concern. Most components contain metals such as lead, which are regulated by the Environmental Protections Agency, and, hence, cannot be disposed of as normal trash. When these items are replaced or otherwise no longer needed they need to be disposed of properly. At Georgia Tech all such items, whether or not they carry a Georgia Tech Inventory number, are to be processed through Capital Assets Accounting. Specific procedures can be found at: http://www.procurement.gatech.edu/logistics.php

EHSA Waste Module

Georgia Tech's Chemical Inventory System (EHSA) provides mechanisms for:

- Identifying and bar-coding containers of chemicals to include items generated in the workplace.
- Creating labels to include bar codes for waste containers.
- Requesting pick-up of waste via the internet.
- Automatic updating of inventories when the material is removed by Hazardous Material personnel.

Activities which have transitioned to EHSA are encouraged to use these procedures.
Contact EHS, for help in using the EHSA waste module at ehsa.gatech.edu

Chemical Waste Management

Government regulations and cost effectiveness require that as little hazardous waste as possible be generated. The following guidelines are a checklist to accomplish waste minimization – they are not intended to restrict activities:

- Before beginning a project, determine the hazards associated with the material. Where possible substitute less hazardous substances.
- Use small batch or micro-level reactions where possible.
- Order and maintain minimum quantities of chemicals.
- Certain chemicals are difficult and/or costly to dispose of and should be given special consideration. Some types are:
    - Any heavy metal, e.g., mercury, barium, cadmium, chromium, beryllium, silver, selenium, tellurium, either elemental or in compounds.

- Chlorophenols, dioxins, and cyanides.
- Compressed gases (to include lecture bottles) or containers with liquids under pressure (especially if the substance is poisonous). Where possible arrange with the supplier to accept return of used containers.
- Manufacturers' samples. Either arrange for the manufacturer to accept return of unused material or ensure they provide an ample description of the product and its characteristics.

Chemical Waste Disposal

Chemical waste is to be contained in a compatible container (see below) for removal by GT EHS.

Generate a waste card and request a pick up via EHSA (ehsa.gatech.edu)

Containers that have been emptied by normal means (e.g. pouring) are considered "empty" and most are not considered hazardous (see highly hazardous, below). Remember that plumbing systems whether or not they are "chemically resistant" and whether or not they are equipped with "dilution tanks" are capable of handling only incidental quantities of waste – they are NOT designed for use as a primary disposal method.

Solvents and Organics

- May not go down the drain- ever.
- Shall be containerized with compatible materials. Usually this is halogenated or non-halogenated solvents.
- The empty containers should be left overnight in a fume hood to evaporate any remaining residue
- Deface the container label (a big X with a wide tipped marker will suffice)
- Discard uncapped container in the appropriate waste container (glass disposal box, if appropriate)

Acids and Bases

- May not go down the drain (Except in facilities equipped with an "active" acid-base neutralization system- if you are not sure if your lab has one of these ASK before putting acids and bases down the drain.)
- Get containerized with compatible materials
- Triple rinse empty container, pouring the rinsate down the drain

Deface the container label (a big X with a wide tipped marker will suffice

- Discard uncapped container in the appropriate waste container (glass disposal box, if appropriate)
- In lab waste neutralization is allowed but should be undertaken with caution.

Highly Hazardous Wastes

Also known as EPA "P List" waste or "Acutely Hazardous" waste, these materials must always be containerized for disposal. These chemicals are identified at https://www.ehs.gatech.edu/sites/default/files/documents/hazardous/hazmat.pdf, Apendix A. The original containers of "P" listed waste are also considered chemical waste and must also be removed by EHS. If you are using a P listed material:

- Containerize the waste
- When empty, cap the container and label it "Waste"
- Do not rinse the bottle
- Do not dispose of the bottle as glass waste or regular trash
- Use EHSA to generate a waste pick up request

Waste Accumulation

Excess amounts of waste and/or unneeded material are not to be allowed to accumulate.

- Waste generated in the process of conducting research or other activities (e.g., spent solvents) will be removed on a routine basis.
- In no case, will an activity allow more than 50 gallons (~200 kg) of waste to accumulate (no more than 1 quart (~1 kg) of a Highly Toxic Waste) nor will any waste container be retained for longer than one year.
- At the end of any project or prior to the departure of an individual, all research products and other material shall be clearly identified and disposed of.

In addition:

Each laboratory/activity will conduct at least an annual physical survey of their area and dispose of unneeded/expired material. Special attention will be given to the following:

- Refrigerators and freezers.
- Ethers and other peroxide forming substances.
- Materials that become more dangerous due to evaporation such as sodium, organo-metallic compounds in solvents, or picric acid.
- And, a responsible individual (e.g., Primary Investigator or Shop Foreman) will review the biannual Right to Know Inventory and attest to the fact that the materials retained are required. Records will be maintained of these reviews.

Segregation of Waste

To the extent feasible, waste should be segregated and not combined. Mixing of different type waste poses dangers:

- Incinerated lab hood at the University of Kentucky (right) following an explosion involving the mixing of two incompatible wastes. The explosion threw glass shards over 20 feet into the lab. Fortunately, no one was injured.

- In 2008 a GT student received acid burns to the face after accidentally pouring sulfuric acid waste into a solvent waste container.

Waste Containers

It is the responsibility of the generating activity to provide suitable waste containers for waste accumulation prior to pick-up.

Waste containers must be compatible with the waste collected, kept closed unless material is being added, capable of being transported, and appropriately labeled. Do not use containers over 5 gallons/20 liters without prior consultation with EH&S.

Multiple small containers, such as sample vials containing research products, should be consolidated into single packages.

EH&S cannot guarantee that re-useable containers will be returned to the waste generator.

Labeling of Waste

- **WASTE CONTAINERS MUST BE LABELED BEFORE THE WASTE GOES INTO THEM** (Remember you can always change the label if the contents deviate from what you expected.)
- EH&S will supply barcodes; activities may use their own or utilize EHSA generated "waste labels".

- Containers of excess materials, with the manufacturers' original label, need not be re-labeled - unless, the manufacturers' label does not identify the contents by chemical name. In such case the lab must appropriately label the container or provide a SDS for the material.
- "Found" unwanted materials that have never been entered into EHSA do not need to be entered into EHSA for EHS to remove them.
- EHS recommends using an EHSA waste label for unwanted material in original "bar-coded" containers in order to ensure that the material is removed from the lab's inventory.
- Waste collection containers must be clearly labeled with the following BEFORE the waste is added:
    - The word "WASTE" in a conspicuous location.
    - The type waste being accumulated in the container, e.g., "halogenated solvent, hydrochloric acid."
        - Generic terms that give no indication of the type hazard associated with the waste, e.g., "aqueous waste", are not acceptable.
        - Simply writing the word "waste" on the container's original label is not acceptable
    - Approximate amount or percentage of each constituent.
    - The date the first waste was added to the container.
- Before the material is picked-up the following must be on the label:
    - The name and telephone number of an individual who certifies the waste container contents.
    - The actual contents of the container – provide chemical names, not abbreviations, or formulas or structural diagrams.
- Use EHSA to generate a waste pick up request
- Please leave at least 5% of the container space empty to allow for thermal expansion of the waste during transport and storage.
- Containers of excess or spent oil shall be labeled "USED OIL" (see next section)

Used Oil

Used oil means any oil that has been refined from crude oil, or any synthetic oil, that has been used, and as a result of such use is contaminated by physical or chemical impurities. Examples of used oil include pump oil, motor oil, hydraulic fluid, lubricants and oil coolants.

Containers and aboveground tanks used to store used oil must be labeled or marked clearly with the words "Used Oil", and NOT "Waste Oil."

Generators of used oil throughout the campus must store used oil in containers that are in good condition (no severe rusting, apparent structural defects or deterioration) and not leaking (no visible leaks). Remove damaged tanks or containers from use or repair immediately.

Used Oil containers must be kept closed except when adding or removing used oil (do not leave funnel in the neck of the open container). Used oil containers must be kept inside secondary containment or other spill management practices to prevent oil from reaching the environment in the event of a leak or a spill.

Used oil containers are potentially subject to the Spill Prevention, Control and Countermeasures rule (40 CFR Part 112). When a container of used oil with a capacity of at least 55 gallons is placed in service, notify EHS so that it can incorporate the container into Georgia Tech's SPCC Plan as necessary.

Recycle vacuum pump oil and do not mix with organic solvents or other chemicals. If the pump oil is not mixed with solvents or other chemicals, manage it as used oil according to the procedures above. If it is mixed with solvents or other chemicals, indicate on the label as "pump oil contaminated with other chemicals" (specify which chemicals) and treat as a hazardous waste. (Do not mix with other waste streams).

Please leave at least 5% of the waste container empty to allow for thermal expansion of the waste during transport.

- Generate a waste card and request a pick up via EHSA (ehsa.gatech.edu) when the container is full.

Fluorescent and Other Mercury Containing Light Bulbs

Fluorescent/HID light bulbs removed from incubators, refrigerators and other pieces of lab equipment are regulated by the Environmental Protection Agency (EPA) under the Heading of "Universal Waste". These lamps may not be disposed of as regular or glass trash and must be appropriately handled and disposed. Georgia Tech faculty, staff and students who handle or have responsibility for managing used lamps must participate in an awareness training session that describes proper handling and emergency procedures. Training must be conducted prior to initial involvement in these activities, and annually thereafter.

EHS has developed Fluorescent Bulb On-Line Training is now available. Anyone who handles these items should take the program. To access the program:

1. Login to the training website . Create a new user profile if it's your first time logging into the learning management system
2. Click "I want to take free online tutorials" open
3. Click "Submit"
4. Click "Continue"
5. Ensure that you have the "Flash Player" downloaded onto your system

6. Click "Hazardous Waste" link to access online tutorial.
7. Select the tutorial on Fluorescent Bulbs/Ballasts

Generate a waste card and request a pick up via EHSA (ehsa.gatech.edu)

Contaminated Equipment

Equipment that is potentially contaminated must be decontaminated prior to leaving the lab: examples include relocation to another lab, going to surplus because it is no longer needed, or being disposed of/recycled because it is no longer useful. Equipment such as fume hoods must also be emptied of chemicals, biologicals and radiologicals and decontaminated before servicing by GT Facilities.

Decontamination is the responsibility of the lab group. For advice on how to decontaminate a piece of equipment yourself or for contact information on an outside vendor who can decontaminate it for you, contact EHS at 404-894-6224.

Lab Clean Outs

Annual lab clean outs are a mandatory safety practice. Regular clean outs prevent the accumulation of unwanted chemicals, including those that become dangerous with age, and are essential for finding and identifying inadequately labeled materials (usually old samples) before their owners forget what they are or (even worse) leave GT leaving behind no clue as to the material's identity and hazards.

Clean outs should be attended by all lab group members to ensure that nothing valuable is discarded and to ensure that everyone has equal responsibility for keeping the lab safe. (See creating a culture of safety at https://www.ehs.gatech.edu/content/document-creating-safety-culture) Clean outs are most effective when done in conjunction with one of the chemical inventory reconciliations. Reducing the size of the inventory makes it easier to reconcile.

It is the PI's responsibility to ensure that work space clean outs, including disposing or transferring materials to another researcher are accomplished prior to the departure/graduation of a student or post doc.

Contact EHS for help in wasting out chemicals (404-894-6224) or for help reconciling your EHSA inventory (404-894-4635).

Lab Closing

When labs close down, such as when a researcher leaves or a project ends, a broader scope clean out than done at other times is required. In this case it is the School Chair's responsibility to ensure that all phases of material or equipment transfers or disposal are appropriately managed. This would include but not be limited to: equipment decontamination prior to moving, transfer of useful chemicals to other labs being

reflected in the EHSA application, identification and appropriate labeling of unwanted chemicals and samples, and finally, calling EHS to remove the unwanted materials.

EHS will not remove any chemical from a lab without the permission of the owner (in this case the School Chair or Chair's designee) unless the material is inherently dangerous and presents a hazard to people or property by being left in place.

Other concerns in lab closings are that energized equipment be de-energized (electricity, hydraulic systems, pressurized gas systems). Toxic and flammable gas systems must be purged, depressurized, with regulators removed and cylinders capped. It is the responsibility of the Department Chair (or designee) to arrange for and oversee the return of gas cylinders to the appropriate vendor.

The Lab Move Procedures document details how to commission a lab, prepare for intra-campus moves, and decommission a lab is available on EHS website, https://ehs.gatech.edu/chemical/lab-moves This document was prepare with the input and feedback from several faculty and staff colleagues across the Institute, and approval from the Institute Council.

14. Chemical Storage

Proper chemical storage is required to minimize the hazards associated leaks, spills, and accidental mixing of incompatible chemicals.

General Storage Guidelines for Solids and Liquids

Use sources such as SDSs at ehsa.gatech.edu for guidance on storage, incompatibility, reactivity and stability for chemicals.

- Do not tip bottles when returning them to a shelf. Shelves must have enough clearance to accommodate the largest container.
- Do not store chemicals (except cleaners) under sinks. Use approved flammable storage lockers, corrosive storage lockers, shelves or cabinets.
- Avoid stockpiling chemicals.
- Purchase only what is needed. If possible borrow chemicals from a colleague or contact the contact EHS for assistance at ehsa@gatech.edu to assist you in finding a source of the chemical at GT.
- Conduct periodic cleanouts to prevent accumulating unnecessary chemicals.
- Do not sort and store chemicals alphabetically unless they have first been separated into hazard classes

- Ensure that caps and lids on all chemical containers are tightly closed to prevent evaporation of contents. A Teflon or PVC cap liner may be used to provide a better seal. These are available through several commercial sources, including VWR Scientific.
- Avoid exposure of chemicals to heat or direct sunlight. This may lead to the deterioration of storage containers and labels, as well as the degradation of the chemicals. Some time-sensitive chemicals such as peroxide-formers (see below) can be affected as well.
- Store solids on shelves or in cabinets.
- Avoid storing chemicals on countertops or in fume hoods except for those being currently used.

Segregation and Storage of Chemicals according to Hazard Class

There are a number of different strategies for storing solid and liquid chemicals ranging from extremely complicated (over 24 compatibility groups) to extremely simple (alphabetical- easy, but unwise). GT EHS requires that chemicals be stored by simple compatibility group:

- Acids
- Bases
- Flammables
- Oxidizers
- Water Reactives
- Air Reactives (Pyrophorics)
- Extremely Toxic.

Chemical storage guidelines are presented below. Use these to segregate and store chemicals according to their hazard class. This prevents an undesirable chemical reaction from occurring should two or more chemicals accidently mix. Consult sources such as the substance's Safety Data Sheet for specific storage guidelines.

Chemical Incompatibility Matrix

The chemical incompatibilities shown below are not exhaustive. As a result, it is important for Laboratory personnel to research the properties of the chemicals they are using. Use sources such as SDSs for guidance on chemical incompatibility. Also ensure you read the container's label – it should also have storage guidelines.

	Acids, inorganic	Acids, oxidizing	Acids, organic	Alkalis (bases)	Oxidizer s	Poisons, inorganic	Poisons, organic	Water- reactives	Organic solvents
Acids, inorganic			X	X		X	X	X	X
Acids, oxidizing			X	X		X	X	X	X
Acids, organic	X	X		X	X	X	X	X	
Alkalis (bases)	X	X	X				X	X	X
Oxidizers			X				X	X	X
Poisons, inorganic	X	X	X				X	X	X
Poisons, organic	X	X	X	X	X	X			
Water- reactives	X	X	X	X	X	X			
Organic solvents	X	X		X	X	X			

X = Not compatible—do not store together

Acids

Storage requirements are provided below. Consult the chemical's Safety Data Sheet for specific storage and incompatibility.

- Store acids and bases separately from each other and from other incompatible chemicals. For example, store oxidizing acids (such as nitric, perchloric, and sulfuric acids) separately from combustible and flammable liquids/materials.
- Segregate acids from reactive metals such as sodium, potassium, and magnesium.
- Nitric acid and hydrochloric acid may be stored in the same corrosive storage cabinet, but they must be kept in separate drip trays. These can combine to form chlorine and nitrosyl chloride gases—both are toxic.

- Segregate organic acids (acetic, formic, etc.) from mineral acids (nitric, hydrochloric, etc.) by use of separate secondary containers. These acids are combustible and will react if they come in contact with an oxidizing acid.
- Segregate acids from chemicals that could generate toxic or flammable gases upon contact, such as sodium cyanide, iron sulfide and calcium carbide Store in a cool, dry environment free from extremes of temperature and humidity.
- Store in sealed, air-impermeable containers. Containers with tight-fitting caps are necessary. Containers with loose-fitting lids or glass stoppers should not be used.
- Do not store piranha etch (a mixture of 98% sulfuric acid and 30% hydrogen peroxide in ratios ranging from 2-4:1), aqua regia (1:3 mixture of concentrated nitric and hydrochloric acids), or Nitol (a mixture of nitric acid and ethanol that becomes explosive if the nitric acid exceeds 10%). Make these solutions just prior to use and dispose of left over material with the process waste in a "vent- able" container. (See Waste, below)
- Use storage cabinets specifically designed for corrosives. These should be connected to exhaust ventilation whenever possible. Usually, at least one of the cabinets directly under the fume hood will be passively connected to the fume hood exhaust.
- Use secondary containment for all liquids. Do not store aqueous sodium and potassium hydroxide solutions in aluminum drip trays. These will corrode aluminum and compromise its integrity.

Bases

Storage requirements are provided below: Consult the chemical's SDS for specific storage and incompatibility.

- Segregate bases from acids, metals, explosives, organic peroxides and easily ignitable materials.
- Do not store aqueous sodium and potassium hydroxide solutions in aluminum drip trays. These will corrode aluminum.
- Store in a cool, dry environment free from extremes of temperature and humidity.
- Store in sealed, air-impermeable containers. Containers with tight-fitting caps are necessary. Containers with loose-fitting lids or glass stoppers should not be used.
- Use storage cabinets specifically designed for corrosives. These should be connected to exhaust ventilation whenever possible. Usually, at least one of the cabinets directly under the fume hood will be passively connected to the fume hood exhaust.
- Use secondary containment for all liquids. Do not store aqueous sodium and potassium hydroxide solutions in aluminum drip trays. These will corrode aluminum and compromise its integrity.

Flammable and Combustible Liquids

Flammable and combustible chemicals include liquids such as organic solvents, oils, greases, tars, oil base paints, and lacquers, as well as flammable gases. Flammable gases are discussed in the Georgia Tech Dangerous Gas Safety Program at https://www.ehs.gatech.edu/chemical/dangerous-gas

The emphasis of this section is on flammable and combustible liquids.

Flammable and combustible liquids are defined by their flash points. The flash point of a liquid is the minimum temperature at which it gives off sufficient vapor to form an ignitable mixture with the air near its surface or within its containment vessel. A liquid's flash point is a function of its vapor pressure and boiling point. Generally, the higher the vapor pressure and the lower the boiling point of a liquid, the lower its flash point will be. The lower the flash point, the greater the fire and explosion hazard

Flammable and combustible liquids are classified by the National Fire Protection Association (NFPA) based on their flash points:

Flammable Liquids (Class I): Liquids with flash points below 100°F (37.8°C) and vapor pressures not exceeding 40 pounds per square inch (absolute) at 100°F (37.8°C).
Flammable Class I liquids are subdivided as follows:

- Class IA: Liquids having flash points below 73°F (22.8°C) and boiling points below 100°F (37.8°C). Flammable aerosols (spray cans) are included in Class IA. (These are 4 on an NFPA Diamond)
- Class IB: Liquids having flash points below 73°F (22.8°C) and having boiling points at or above 100°F (37.8°C). (These are a 3 on an NFPA Diamond)
- Class IC: Liquids having flash points at or above 73°F (22.8°C) and below 100°F (37.8°C). The boiling point is not considered. (Also a 3 on an NFPA Diamond)

Combustible Liquids (Classes II and III): Liquids having flash points at or above 100°F (37.8°C). Combustible liquids in Classes II and III are subdivided as follows:

- Class II: Liquids having flash points at or above 100°F (37.8°C) and below 140°F (60.0°C).
- Class IIIA: Liquids having flash points at or above 140°F (60.0°C) and below 200°F (93.4°C).

Storage requirements are provided below. Consult the chemical's Safety Data Sheet for specific storage and incompatibility.

Flammable Storage Lockers and Refrigerators

- Store flammable and combustible liquids in a cool, dry environment free from extremes of temperature and humidity.
- Keep away from heat, flames, and other sources of ignition.
- An approved flammable storage cabinet is recommended for storing more than 1 gallon (3.7L) of flammable liquid and is required for storing flammable liquids totaling 10 or more gallons. These should be constructed of steel and be equipped with self closing doors with a three-point latch arrangement.
- Storage cabinets may be connected to an exhaust system with the approval of GT EHS.
    - All work must be done through the GT Facilities Design and Construction group to assure that the work is completed to GT standards and is compliance with applicable Fire Safety regulations.
    - To get an existing flammable storage cabinet ventilated, the PI must initiate a project request with GT Facilities at http://www.facilities.gatech.edu/dc/prf/.
    - Lab Users may not contract this work out or attempt to do it themselves. To do so may result in the removal of unauthorized work at the PI's expense.
- Ensure caps and lids are securely tightened on all containers. This prevents evaporation of contents. Teflon liners can be inserted into caps to help form a tighter seal.
- Use drip trays for all liquids.
- *No more than 120 gallons of Class I, Class II, and Class IIIA liquids, combined, may be stored in a storage cabinet. Of this total, no more than 60 gallons may be of Class I and Class II liquids, combined, and not more than three such cabinets may be in a single fire compartment area. (i.e., a room that is separated from other rooms/areas by fire walls).*
- Ordinary domestic refrigerators and freezers must not be used for storing flammable liquids because they contain electrical components (light bulbs, switches, contacts and motors) that are potential ignition sources which may initiate a fire or an explosion if flammable vapors are present.
    - Refrigerators and freezers for storing flammable liquids (including ethanol) must be designed, constructed and approved for that purpose.

      (See definitions- Flammable Safe Refrigerator) Contact EHS for guidance on purchasing refrigerators and freezers.
    - Domestic refrigerator/freezers as well as units that have been modified to remove spark sources are not acceptable.

Flammable and Combustible Storage Containers

- Flammable and combustible liquids can be stored in metal or polyethylene safety cans provided they have been approved for such storage, i.e., the containers are UL listed and that they are equipped
with a:
  - Self-closing cap, automatic vent, and flame arrester
  - Current carrying insert embedded into the can for proper grounding, and a
  - Funnel.

Table 1. Containers for Combustible and Flammable Fluids

	Flammable liquids			Combustible liquids	
Class	1A	1B	1C	II	III
Glass	1pt[a]	1qt[a]	1gal	1gal	5gal
Metal (other than					
Department of Transportation (DOT)	1ga	5gal	5gal	5gal	5gal
Safety cans [b]	2gal	5gal	5gal	5gal	5gal
Metal drums (DOT specifications)		60gal	60gal	60gal	60gal
Approved portable tanks	660gal	660gal	660gal	660gal	660gal

- Glass containers of no more than 1 gallon capacity may be used for Class IA or IB flammable liquids if such liquid either would be rendered unfit for its intended use by contact with metal or would excessively corrode a metal container so as to create leakage hazard. **<u>NOTE: This exemption does not apply to the accumulation of noncorrosive ignitable hazardous waste</u>**.

Gravity-Dispensing Flammable Liquids

Class I B liquids (e.g., ethanol) may be transferred from containers or tanks by gravity through piping, hoses and self- or automatic closing valves that have been reviewed and approved by the GT Fire Marshal (4-2990) Such transfer operations must be done with spill control and secondary containment. Moreover, the nozzle and containers must be bonded to each other (i.e., electrically interconnected) to prevent static electricity discharges.

Oxidizers

Oxidizers are compounds that supply their own oxygen and heat (ignition source) when in contact with organic compounds. These are chemicals that can react vigorously and explode.

Common oxidizing liquids and solids include:

- bromine
- bromates
- chlorinated isocyanurates
- chlorates
- chromates
- dichromates
- hydroperoxides
- hypochlorites
- inorganic peroxides
- ketone peroxides
- nitrates
- nitric acid
- nitrites
- perborates
- perchlorates
- perchloric acid
- periodates
- permanganates
- peroxides
- peroxyacids
- persulphates

Storage requirements are provided below. Consult the chemical's Safety Data Sheet for specific storage and incompatibility.

- Store in noncombustible secondary containment (glass). Do not store directly on combustible shelving.
- Keep away from combustible and flammable materials.
- Keep away from reducing agents such as zinc, alkali metals, and formic acid.

Water Reactives

Water reactives are chemicals that react with water, sometimes violently, and may produce toxic or flammable gases. Examples of water reactive substances include sodium, potassium, and phosphorous pentachloride.

Storage requirements are provided below. Consult the chemical's SDS for specific storage and incompatibility.

- Store in a cool, dry place, away from any water source.
- Make certain that a Class D fire extinguisher is available in case of fire.

  Separate alkali metals from incompatible chemicals. In addition to being water-reactive, alkali metals can also react with oxygen, acids, halogenated hydrocarbons, and carbon dioxide). Consult the SDS for specific storage guidelines.
- Store all metals in the container provided by the manufacturer.

- Store alkali metals under mineral oil or in an inert atmosphere. NOTE: Lithium may react with nitrogen. Containers should be stored in a cool, dry environment, away from light and free from extremes of temperature and humidity.
- Use secondary containment

Air Reactives (Pyrophorics)

Pyrophorics are chemicals that will ignite spontaneously in air at temperatures 130^{o}F (54.4^{o}C) or less. Titanium chloride and white phosphorous are examples of solid pyrophorics; t-butyl lithium and tributylaluminum are examples of pyrophoric liquids.

Storage requirements are provided below. Consult the chemical's SDS for specific storage and incompatibility.

- If in original (unopened) container, store in a cool, dry place, making provisions for an airtight seal.
- Store in a glove box under an inert atmosphere after the container has been opened.

Extremely Toxic Chemicals

Extremely toxic chemicals are chemicals that have a Lethal Dose 50 Percent (LD_{50}) of 5 milligrams or less per kilogram (mg/kg) of test animal body weight. (Seven drops or a "taste" to a human.) LD_{50} is defined as the dose at which 50% of the test animals died, usually within 1-2 hours. These chemicals are so toxic that their use and location must be accounted for at all times. These chemicals will be segregated according to their physical properties, (acid, base, flammable) but with the additional requirement of that they must be kept in a locked cabinet (or refrigerator) inside a locked lab. The PI or Lab Manager must be responsible for the key and there must be a sign out sheet to document who uses the material and how much. Examples of chemicals with a LD_{50} < 5 mg/kg include puffer fish toxin and botulism toxin.

Peroxide Forming Chemicals

Peroxide formation in common laboratory chemicals is caused by an autoxidation reaction. The reaction can be initiated by light, heat, introduction of a contaminant, or the loss of an inhibitor. Some chemicals have inhibitors such as BHT (2,6-di-tert-butyl- 4-methyl phenol) hydroquinone and diphenylamine to slow peroxide formation. Most organic peroxide crystals are sensitive to heat, shock, or friction, and their accumulation in laboratory reagents has resulted in numerous explosions. For this reason, it is important to identify and control chemicals that form potentially explosive peroxides.

In general, the more volatile the compound, the greater its hazard, since the evaporation of the compound allows the peroxide to concentrate. Peroxide accumulation is a balance between peroxide formation and degradation. Some common compounds that are known to form peroxides are listed in the following table. NOTE: This is not an exhaustive list. Researchers must consult the SDSs and other sources of information for the chemicals used in their work areas to determine their peroxide-forming potential. Group A are chemicals that spontaneously form peroxides on exposure to air without further concentration or evaporation. These materials should be tested or disposed of within three months of opening (testing is discussed later in this section). Group B lists chemicals that form peroxides only upon concentration by evaporation or distillation.

The materials in this list should be tested or disposed of within one year of opening their containers. Group C is a representative list of monomers that form peroxides that may act as a catalyst, resulting in explosive polymerization.

Group A: Chemicals That Form Explosive Levels of Peroxides Without Concentration (Safe Storage Time After Opening: 3 Months)				
Chemical	**CAS**	**Synonyms**	**State**	**Reference**
Butadiene(1,3)	106-99-0	1,3-Butadiene	G	4
Chloroprene (1,3)	126-99-8	2-Chloro-1,3-butadiene	L	4
Divinyl acetylene	821-08-9	1,5-Hexadien- 3-yne	L	5
Isopropyl ether	108-20-3		L	5
Tetrafluoroethylene	116-14-3		G	4
Vinyl ether	109-93-3	Divinyl ether	L	5
Vinylidene chloride	75-35-4	1,1-Dichloroethylene	L	5
Group B: Chemicals That Form Explosive Levels of Peroxides on Concentration (Safe Storage Time After Opening: 12 Months)				
Chemical	**CAS**	**Synonyms**	**State**	**Reference**
Acetal	105-57-7		L	5
Acetaldehyde	75-07-0		L	4
Benzyl alcohol	100-51-6		L	4
2-Butanol	78-92-2		1	4
Cyclohexanol	108-93-0		1	4
Cyclohexene	110-83-8		1	5
2-Cyclohexen-1-ol	822-67-3		1	4

Cyclopentene	142-29-0		l	5
Decahydronaphthalene	91-17-8		l	4
Diacetylene	460-12-8		g	5
Dicyclopentadiene	77-73-6		l	5
Diethylene glycol dimethyl ether	111-96-6	Diglyme	l	5
Dioxane	123-91-1	1,4-Dioxane	l	5
Ethylene glycol dimethyl ether	110-71-4	Glyme	l	5
Ethyl ether	60-29-7	Diethyl ether	l	5
Furan	128-37-0		l	5
4-Heptanol	589-55-9		l	4
2-Hexanol	626-93-7		l	4
Isopropyl benzene	98-82-8	Cumene	l	5
Methyl acetylene	74-99-7	Propyne	g	5
3-Methyl-1-butanol	123-51-3	Isoamyl alcohol	l	4
Methyl cyclopentane	96-37-7		l	5
Methyl isobutyl ketone	108-10-1	Methyl-i-butyl ketone	l	5
4-Methyl-2-pentanol	108-11-2		l	4
2-Pentanol	6032-29-7		l	4
4-Penten-1-ol	821-09-0		l	4
1-Phenylethanol	98-85-1	alpha-Methyl-benzyl alcohol	l	4
2-Phenylethanol	60-12-8	Phenethyl alcohol	l	4
2-Propanol	67-63-0	Isopropanol	l	6, 7
Tetrahydrofuran	109-99-9		l	5
Tetrahydronaphthalene	119-64-2		l	5

Group C: Chemicals That May Autopolymerize as a Result of Peroxide Accumulation (Safe Storage Time After Opening: Inhibited Chemicals, 12 Months; Uninhibited Chemicals, 24 Hours)

Chemical	CAS	Synonyms	State	Reference
Acrylic acid(2)	79-10-7		l	5
Acrylonitrile(2)	107-13-1		l	5
Butadiene(1,3)	106-99-0		g	5
Buten-3-yne	689-97-4	Vinyl acetylene & Butenyne	g	5

Chloroprene(1,3)	126-99-8	2-Chloro-1,3-butadiene	l	5
Chlorotrifluoroethylene	79-38-9		g	5
Methyl methracrylate(2)	80-62-6		l	5
Styrene	100-42-5		l	5
Tetrafluoroethylene	116-14-3		g	5
Vinyl acetate	108-05-4		l	5
Vinyl chloride	75-01-4	Mono-chloroethylene	g	5
Vinylidene chloride	75-35-4	1,1-Dichloroethylene	l	5
2-Vinyl pyridine	100-69-6		l	5
4-Vinyl pyridine	100-43-6		l	5

Notes

1. When stored as a liquid monomer.
2. Although these form peroxides, no explosions involving these monomers have been reported.
3. Also stored as a gas in gas cylinders.
4. Kelly, R.J., Review of Safety Guidelines for Peroxidizable Organic Chemicals, Chemical Health and Safety, September/October, 1996.
5. National Research Council, Prudent Practices in the Laboratory, Handling and Disposal of Chemicals; National Academy Press; Washington, D.C., 1999.
6. Clark, D.E., Peroxides and Peroxide-Forming Compounds, Chemical Health and Safety, September/October, 2001.
7. This material is peroxidizable but not dangerous unless distilled or concentrated. Testing (see "Peroxide Testing Method") is required only prior to distillation or concentration.

Safety Data Sheet for specific storage and incompatibility

- DO NOT TOUCH OR DISTURB A PEROXIDE FORMER THAT HAS VISIBLE CRYSTALS as the crystals are explosive and are shock, friction, and heat sensitive-call EHS at 404-894-6224 for help in removing.
- Label bottles with date received and date opened as this is essential in assessing the level of hazard that the material poses.
- Most peroxide forming chemicals are also flammable liquids: Follow the storage guidelines in Flammable and Combustible Liquids (above) if the material is either flammable or combustible.

- Store in airtight containers in a flammable storage locker.
- Segregate from oxidizers and acids.
- Store peroxide-forming chemicals in a cool, dry environment, away from light and free from extremes of temperature and humidity.
- All peroxide-forming chemicals should be stored in sealed, air-impermeable containers. Dark amber glass containers with tight-fitting caps are required. Containers with loose-fitting lids or glass stoppers should not be used.
- Use secondary containment for all liquids.

Safe Storage Times

- The table (above) provides safe storage times and peroxide- testing frequencies
- Georgia Tech requires that all peroxide formers be visually inspected every 3 months (EHSA sends a reminder) and disposed of after 1 year.
- Storage for longer periods of time is allowable provided that testing is conducted at the indicated frequencies and that the results are negative (see Peroxide Testing Method below). Contact EHS at ehsa@gatech.edu for assistance in resetting the EHSA reminder messages.
- Containers of unknown age or history, as well as those that have exceeded their shelf lives and that have no evidence of testing should not be opened or disturbed. (See Disposal, below)
- Testing and labeling (see below) are necessary to ensure the container can be safely handled.

Peroxide Testing

- Peroxide Test Strips are available from Lab Safety Supply and VWR. Follow manufacturer's instructions for testing and interpreting results.
- If the material tests positive for peroxide, it should be disposed of (it is possible to remove the peroxides, but not generally considered to be worth the effort).

Disposal of Peroxide Formers

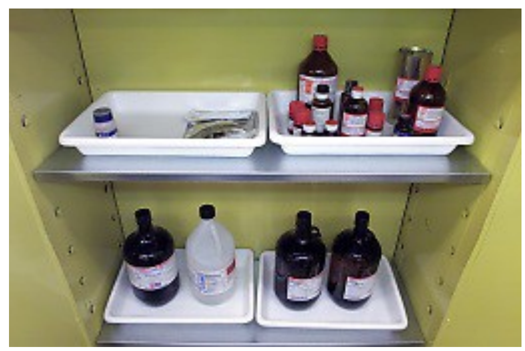
If a peroxide-forming compound has been stored either beyond its useful shelf life, or if its age or history can not be determined, or of visible crystals are present, DO NOT OPEN OR DISTURB. It must be considered unsafe and must be disposed of as hazardous waste. The container should be conspicuously labeled as a "Peroxide Former". You may submit a waste pick up request through EHSA but must also call 404-894-6224 to explain the situation and arrange for a waste pick up at a time when you can be there.

Spills of Peroxide Formers

- Consult the Emergency Procedures section for emergency actions regarding chemical spill and personal exposure to chemicals.
- In addition to these requirements, the following applies to spills of peroxide- forming compounds:
    - Do not attempt to clean up peroxide former spills if there is any indication that these actions could initiate a detonation.
    - Never use combustible or reactive materials (such as paper towels) to clean up or absorb spills of peroxide formers. Keep an adequate number of appropriate spill kits to meet anticipated needs. (These are commercially available). Typically, products containing diatomaceous earth are used for absorbing organic solvents.

Secondary Containment for Liquids

Store all hazardous liquid chemicals in secondary containment, such as drip trays. This is to minimize the impact and spread of a spill resulting from broken/leaking containers Tray capacity must be 100% of the largest container.



- Drip trays are available in different materials which provide varying resistance to chemical attack. It is important to use chemical resistance data to select the proper material when using plastic drip trays. This is discussed in more detail below. Avoid using aluminum roasting pans. They do not offer good resistance to corrosive chemicals such as acids and alkali bases. Moreover, disposable roasting pans are flimsy and will develop cracks and tears.
- Photo trays
    - Generally, these provide good resistance for aqueous solutions and some organic solvents. But may not be a good choice for halogenated solvents
    - Photo trays are available through several commercial sources, including VWR Scientific. An additional source of spill containment trays is Scientific Plastics. This company provides trays in several depths, with width and length in 1" increments.
- Polypropylene and Hi Density Polyethylene
    - These are subject to attack by some aromatic and halogenated hydrocarbons.

  - The Nalgene website has a chemical resistance database for these materials
- Stainless Steel and Pyrex
  - Stainless steel and Pyrex trays are resistant to a broader spectrum of chemicals. However, they are more expensive than plastic trays and aren't available in as many different sizes and configurations.
  - Glass trays or beakers are required as secondary containment under perchloric acid

Squeeze Bottles, Chemical Compatibility

- Label all containers (e.g., squeeze bottles, wash bottles and Nalgene bottles) to which hazardous materials are transferred with the identity of the substance and its hazards. See the section entitled Container Labels for more information.
- Be aware that squeeze bottles and Nalgene bottles have varying resistances to different chemicals. (They are usually made from plastics, such as high-density polyethylene, low-density polyethylene and polypropylene). Moreover, they may deteriorate over time, especially when exposed to direct sunlight or UV sources. Consult the Nalgene chemical resistance guide http://www.nalgenelabware.com/ to determine the chemical resistance of different plastic materials.

Chemical Storage Cabinets

Use approved flammable storage cabinets to store flammable solids and liquids. Flammable cabinets may be vented in accordance with the requirements of NFPA 45 2011. Venting of cabinets must be done through GT facilities: lab groups should submit a project request by going to www.facilities.gatech.edu/dc/prf/

Use separate corrosive storage cabinets made of chemically resistant components to store acids and basis

Refrigerators

Domestic refrigerators used for storing non-flammable chemicals, samples or media must be labeled simply “NO FOOD, NO FLAMMABLES”

Refrigerators and freezers for storing flammable liquids must be designed, constructed, approved, and labeled for that purpose. These refrigerators must be labeled “NO FOOD”. NOTE: Ethanol-water solutions greater than or equal to 15% ethanol must be stored in a flammable safe refrigerator).

Domestic refrigerator/freezers as well as units that have been modified to remove spark sources are not acceptable alternatives: the results can be disastrous, as can be seen in this photo (right). This explosion of a flammable material set off the by the refrigerator’s thermostat blew the door off its hinges and melted the interior liner of the refrigerator (as well as all the contents).

Chemical Storage for Gases

Storage and use of dangerous gases is detailed in the GT Dangerous Gas Safety Program at https://www.ehs.gatech.edu/chemical/dangerous-gas

Storage requirements for non-hazardous gas cylinders can be found under Gas Cylinder Safety.

15. Renovations, Repairs, and Custodial Services in Laboratories

Renovations

Renovations in laboratories must be made with the involvement of GT Facilities Design and Construction Group and can be initiated by making a Project Request at (http://www.facilities.gatech.edu/dc/prf/). Such projects might include changes or additions to the exhaust ventilation system (such as fume hoods, ventilated enclosures, ventilated equipment); changes or additions to plumbing systems (such as adding or moving safety showers or eyewashes); changes to electrical service; cutting, or drilling into walls, doors, fume hoods, or laboratory bench tops.

Damage done to GT facilities during unauthorized renovations (such cutting into a fume hood or fume hood duct or disturbing asbestos containing materials) will be repaired at the PI's expense.

Repairs and Maintenance of Laboratory Facilities

Repairs and maintenance of laboratory facilities are the responsibility of the Georgia Tech Facilities Maintenance Department. Their responsibilities include but are not limited to electrical systems, lighting systems, plumbing systems, air handling systems, and the exhaust ventilation system.

Requests for repairs should be made through the Building Manager. Problems with exhaust ventilation systems / fume hoods are considered an immediate safety hazard and should be brought to the immediate attention of Environmental Health and Safety (404-385-4635).

Maintenance workers entering laboratories are specifically prohibited from moving chemicals or chemical apparatuses to access the area where they must work; it is the responsibility of the lab group to clear these items away from the area in order to allow the work to be completed. For example, fume hoods must be cleared of all chemicals for repairs to be made to the interior of the hood; storage areas under sinks must be cleared of all items for repairs on faucets and drains. To facilitate this, it is suggested that the lab group provide a contact number of someone who can assist with this at the time that the work request is submitted to the Building Manager.

Custodial Services in Laboratories

Georgia Tech custodial services in laboratories includes daily non-hazardous trash pick up, twice weekly sweeping, once weekly wet mopping, once a year floor stripping and waxing, and refilling hand soap and towel dispensers as needed. The actual frequency of these services is dependent on the nature of the activities in the lab, however. It is the responsibility of the lab group to arrange for custodians to have access to the lab, or

alternatively, make sure that the lab trash cans are left out in the halls after 3 pm each day. Georgia Tech Custodians are specifically prohibited from the following activities in laboratories:

- Cleaning up chemical spills
- Moving chemicals
- Removing spill cleanup materials as regular trash
- Cleaning up residues from spill clean ups without prior EHS approval
- Allowing lab personnel to use custodial supplies, especially mop heads, to clean up chemical spills
- Entering laboratories with illuminated laser hazard warning signs OR, when only paper signs are present, from entering the lab when there is no one inside to tell them that it is safe to enter.

Custodians are allowed in labs to clean up floods, vomit, and blood, but will only do so after procuring the appropriate cleaning equipment and personal protective equipment (PPE).

Do not help yourself to the Custodian's equipment to clean up chemical or biological spills. If you need help with a spill of a hazardous material, contact the GT Police at 404-894-2500, explain the situation, and ask them to contact EHS.

16. Process Specific Hazards

Working with Dangerous Gases

The Full text of the Georgia Tech Dangerous Gas Safety Program can be found at https://www.ehs.gatech.edu/chemical/dangerous-gas

Summary of GT Dangerous Gas Safety Program

The GT Dangerous Gas Safety Program covers flammable and toxic gases in laboratories and is based on the International Fire Code (which is Georgia law), as well as the National Fire Protection Association Standards 45 (Laboratories), 55 (Compressed Gases), 318 (Semiconductor Facilities). It also takes guidance from the publication Prudent Practices in the Laboratory (National Research Council, 1995) and Dangerous Gas programs in effect at other research universities in the US.

Requirements:

Flammable gases are defined as: (A) gases that, at ambient temperature and pressure, form a flammable mixture with air at a concentration of thirteen (13) percent by volume or less; or (B) Gases that, at ambient temperature and pressure, form a range of flammable mixtures with air wider than twelve (12) percent by volume, regardless of the lower explosive limit; (29CFR1910.1200)**.** Examples: Hydrogen Acetylene, Propane

- Flammable gas cylinders in sprinkler equipped labs require flow restrictors and must be limited to no more than 1 backup cylinder per cylinder in use, not to exceed a total of 8 cylinders (or 2000 cubic feet) of flammable gas per lab.
- Flammable gas cylinders in non-sprinkler equipped labs require flow restrictors and constant monitoring by the GT Dangerous Gas Monitoring System (DGMS). They must also be limited to no more than 1 backup cylinder per each cylinder in use, not to exceed a total 4 cylinders (or 1000 cubic feet) of flammable gas per lab.
- Exceptions to the above rules can be made for lecture bottles which are kept in fume hoods. Contact GT Environmental Health and Safety (EHS) for details.

Pyrophoric gases are defined as gases that will ignite spontaneously on contact with air at temperatures of 130°F (54.4°C) or below (29CFR1910.1200) Examples: silane, disilane.

- Purchases of pyrophoric gases require pre-notification of GT EHS and pre-approval by the GT chemical and Environmental Safety Committee.
- In sprinkler equipped laboratories, pyrophoric gas cylinders require containment in gas cabinets.
- Exceptions to the above rules can be made for lecture bottles which are kept in fume hoods. Contact GT EHS for details.
- Pyrophoric gas cylinders are not allowed in non-sprinkler equipped laboratories.

Toxic Gases are defined as gases that have a Lethal Concentration-Fifty Percent (LC_{50}) in air of 3000 parts per million (ppm) by volume or less of gas or gas vapor, or 30 milligrams per liter (mg/l) or less of mist, fume, or dust. These gases will be rated a 3 or 4 on the health section of the NFPA warning diamond. Toxic gases also include gases that are rated a 2 on the health section of the NFPA warning diamond AND have poor warning properties. Examples: hydrogen chloride, carbon monoxide.

- Purchases of toxic gases require pre-notification of GT EHS and pre-approval by the GT Chemical and Environmental Safety Committee.
- Toxic gases require containment in gas cabinets and monitoring by the GT DGMS.
- Exceptions to the above rules can be made for lecture bottles which are kept in fume hoods. Contact GT EHS for details.

The Georgia Tech Dangerous Gas Safety Program can be found at: https://www.ehs.gatech.edu/chemical/dangerous-gas

For more information, contact Environmental Health and Safety at 404-385-4635.

Working with Highly Reactive Materials

Highly reactive materials are those agents that undergo rapid chemical change causing exothermic or other self-accelerating reactions when subjected to heat, impact, friction, light, catalysts, or other initiation. These agents are materials that will detonate or deflagrate. Highly reactive materials encompass (but are not limited to):

- Air-reactive chemicals (e.g., palladium or platinum on carbon, platinum oxide, Raney nickel)
- Metal hydrides (e.g., lithium aluminum hydride, sodium borohydride)
- Cryogenic materials/liquefied gas, supercritical fluids (e.g., oxygen, nitrogen, helium)
- Highly water-reactive chemicals (e.g., aluminum bromide, metal hydrides, phosphorus pentachloride, tin tetrachloride, titanium tetrachloride)
- Explosive dusts (e.g., magnesium powder, zinc dust, carbon powder, flowers of sulfur)
- Explosives, other (e.g., diazomethane, hydrogen peroxide, hydrogen, chlorine, polymerizing acrolein, trinitrotoluene)
- Organic peroxides (e.g., acetyl peroxide, benzoyl peroxide)
- Organometallic chemicals and active metals (e.g., trimethyl gallium; sodium, magnesium, lithium, potassium)
- Oxidizing agents (e.g., halogens, oxyhalogens, peroxyhalogens, permanganates, nitrates, chromates, persulfates, peroxides)
- Perchloric acid and perchlorates (e.g., sodium perchlorate)
- Peroxide-forming chemicals (e.g., acrylonitrile, dioxane, ether, isopropanol, tetrahydrofuran)
- Polymerization reactions (e.g., acrylate monomers)
- Polynitro organic chemicals (e.g., picric acid, dinitrophenylhydrazine, methyl nitronitrosoguanidine)
- Pyrophoric chemicals (e.g., boranes, white phosphorus, alkyl metals such as n-butyllithium and dibutyl magnesium)
- Shock-sensitive and other unstable chemicals (e.g., acetylides, azides, nitro compounds, organic nitrates, perchlorates).
- Solutions such as piranha, nitol, aqua regia, and electropolishing solution.

Many of the above classes of materials overlap with other hazard types (e.g., organometallics may be pyrophoric). The list is intended merely to provide guidance for determining whether this section applies to the research in your lab. Exact classification is not necessary.

General Rules for Working with Processes That Involve Highly Reactive or Explosive Materials

NOTE: A process may involve more than one type of hazard for example, compounds may be reactive, may cause system over pressurization, and may be used with vacuums (e.g. highly reactive materials, high-pressure systems, vacuum systems). Be sure to address all the hazards that apply to your process.

1. All persons working with highly reactive material in Georgia Tech laboratories shall receive training in the hazards of the material and in how it is to be used in a particular process from the PI or a senior lab staff member. This training is to be documented (see https://ehs.gatech.edu/content/document-creating-safety-culture).
2. All labs using highly reactive materials will complete a pre-start up safety review (Appendix I) and have a Lab Safety Plan (Appendix H) prior to obtaining the material. These will be used to produce a Standard Operating Procedure (SOP) as soon as reasonably possible.
3. New processes involving pyrophoric material must be pre-approved by the GT CESC prior to material purchase. (Contact EHS at 404-385-4635 for help in completing this process.)
4. All purchase requests for pyrophoric and water reactive materials are routed through Buzz Mart to EHS for approval.
5. Heating will be by heating tapes, mantles, or water, steam, or oil baths which will be utilized in such a way as to contain explosions whenever possible.
6. Prior to starting an experiment involving potentially explosive material, the lab Safety Plan will be reviewed by the entire lab staff to ensure that all persons know what to do, were an explosion to occur. Additionally, it will be to ensure that

   provisions have been made to contain the entire reaction mixture, should a mishap occur. A template for a lab safety plan can be found in Appendix H.
7. Dry ice-solvent baths may not be not used for reactive gases.
8. Hot liquids may not bring into sudden contact with lower-boiling liquids.
9. Boiling chips may not be added once the heated liquid has exceeded its boiling point.
10. The areas where highly reactive chemicals, high-pressure, or vacuum equipment are used shall be posted with signs to warn colleagues of potential danger.
11. When a reaction becomes uncontrollable, turn off the heat, the addition of reagents shall be suspended, nearby lab workers shall be notified, and the chemical fume hood sash shall be closed until the temperature has dropped.
12. When a potentially hazardous reaction is attempted, total quantities of reactants shall be limited to 0.5 g in the reaction vessel.
13. It is the responsibility of the researcher to ensure that emergency equipment is on hand for reactions that could runaway violently prior to beginning the experiment, and rechecking that all the equipment is still in place prior to repeating the experiment.
14. When appropriate, tongs will be used to manipulate highly reactive chemicals to prevent exposure of any part of the body to possible injury (e.g., when immersing

sodium metal in solvents, handling heated crucibles, or removing weighing dishes from ovens).

Operational Practices For Specific Classes of Reactives**:** The categories listed below are not exhaustive and do not necessarily cover all possible circumstances that must be controlled.

Piranha

Piranha solution is used frequently in the microelectronics industry, to clean, for example, photoresist from silicon wafers. It is used in scientific research to make highly hydrophilic surfaces. It is sometimes used to passivate glassware prior to doing sensitive chemical reactions. Unlike chromic acid solutions, piranha will not contaminate glassware with heavy metal ions.

There are two different piranha solutions: The most common is the acid piranha: a 3:1 mixture of concentrated sulfuric acid (H_2SO_4) with hydrogen peroxide (H_2O_2). The other is base piranha: a 3:1 mixture of ammonium hydroxide (NH_4OH) with hydrogen peroxide (H_2O_2). Both are equally dangerous when hot, although the reaction in the acid piranha is self-starting whereas the base piranha must be heated to 60 degrees to initiate.

Acid piranha is a mixture of sulfuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2), used to clean organic residue off of substrates. Because the mixture is a strong oxidizer, it will remove most organic matter, and it will also hydroxylate most surfaces (add OH groups), making them extremely hydrophilic (water compatible).

Piranha is considered a "Highly Reactive Substance". As such, all labs making or using piranha must have:

- A Lab Safety Plan (See Appendix H for a template)
- A Pre-start up safety review (Appendix I) which can be use to develop:
- A standard operating procedure
- All labs using piranha need to keep a written copy of this Section in the lab with an attached signature sheet

In addition, all labs using piranha must have:

- A fume hood
- The required PPE:
- Lab coat or clean room garment
- Acid resistant apron with long sleeves
- Safety glasses
- Face shield
- 6 ml nitrile gloves
- Heat resistant gloves

All persons working in GT labs are required to dress appropriately per the GT Appropriate Attire and Personal Protective Equipment Policy (https://ehs.gatech.edu/content/document-chem-ppe-policy) including:

- Long pants
- Shirt that completely covers the torso

- Shoes that completely enclose the foot (no open toes or backs), preferably of a material that can be wiped clean
- Hair tied back

Making Piranha

- Piranha may only be made in a fume hood or, if in a clean room, an exhaust-ventilated chemical bench.
- Piranha solutions may only be made on the day that they are to be used. They may not be made in advance and may never be stored.
- Whenever handling piranha, only use glass containers (preferably Pyrex) as piranha will attack some plastics and can get hot enough to melt others)
- Containers used to make piranha should be 3X larger than the volume of piranha that you intend to make.
- Containers holding piranha must be very clearly labeled and have RTK compliant warning sign, visible by any user working under the hood. Signs must be posted at all time to indicate that the vessel contains piranha mixture.

- Mix the solution in the laboratory hood with the sash between you and the solution. Wear the required PPE. Always add the peroxide to the acid or the base. When making acid piranha, the H_2O_2 is added immediately before the etching process because it immediately produces an exothermic reaction with gas (pressure) release.
- Any variation from the standard 3:1 acid: peroxide mixture require written approval in advance, from the Principle Investigator.
- Peroxide used to make piranha may not exceed 49% concentrations as higher concentrations may cause an explosion.
- Piranha solution is very energetic and potentially explosive. It is very likely to become hot (more than 100^{o}C). Handle with care using appropriate thermally protective gloves.

Using Piranha

- Substrate should be rinsed and dried before placing in a piranha bath. Piranhas are used to remove photoresist and acetone residue, not the compounds themselves.
- The hot (often bubbling) solution will clean organics off of substrates, and oxidize/hydroxylate most metal surfaces. Cleaning usually requires about 10 to 40 minutes, after which time the substrates can be removed from the solution.
- Anything removed from the solution should be rinsed with a large amount of deionized water. The substrates should now be hydrophilic, which is easily verified by ensuring that the rinse water is wetting (spreading out over) the substrate.
- Immersing a substrate (such as a wafer) into the solution should be done slowly. This is to prevent a thermal shock that may crack the substrate material.
- Leave the hot piranha solution in the fume hood in an open container until cool. Never store hot piranha solutions. Piranha stored in a closed container will likely explode.

- Adding any acids or bases to piranha or spraying it with water will accelerate the reaction.
- Mixing hot piranha with organic compounds may cause an explosion. This includes acetone, photoresist, isopropyl alcohol, and nylon.
- Wash bottles containing organic compounds should be removed from the hood before making piranha

Piranha Waste Disposal

- The primary hazard from storage of piranha waste is the potential for gas generation and over pressurization of the container when the solution is still hot. If you store a hot solution in an air tight container, it will explode!
- Prior to storing the waste piranha solution, it must be left in an open container in order to cool down for several hours (overnight).
- It is your responsibility to make sure that the open container is very clearly labeled and left in a safe area for overnight cool down. Fill in your name and contact information on the label. It is your responsibility to make sure that you return the next morning to bottle up the cooled waste
- Once cooled down, the solution can be transferred into a closed glass container for waste storage. The container must be very clearly labeled with the solution name and composition and must include VERY VISIBLE warning signs not to add any other types of chemicals.
- Use EHSA to generate a waste card (ehsa.gatech.edu) and request a pick up. Contact the HazMat Manager if you have any questions.

Emergency Procedures

- Runaway reactions
    - Evacuate area
    - Pull fire alarm
    - Call GT police at 404-894-2500
    - Remain on scene to provide information to first responders
- Exposures to Piranha
    - In case of large exposure, the victim should be removed from the contaminated area, placed under a safety shower while GT police are contacted at 404-894-2500 (4-2500 from a GT land-line)
        - All contaminated clothing should be removed immediately with appropriate gloves and safely discarded.
    - In case of contact with the skin, the affected area must be immediately rinsed with large amounts of water for at least 15 min.
    - In case of contact with the eye, irrigate the eye for at least 15 minutes, keeping the eyelids apart and away from eyeballs during irrigation. Place ice pack on eyes until reaching emergency room.
    - Call GT Police at 404-894-2500. Tell them that you will need an ambulance.
    - In case of inhalation, it may irritate the respiratory tract.
        - Conscious persons should be assisted to an area with fresh, uncontaminated air (always send a helper, who has a cell phone, out with the victim- do not let the victim go out alone).
    - Seek medical attention in the event of respiratory irritation, cough, or tightness in the chest.
    - Symptoms may be delayed/ Serious, life-threatening effects may manifest 4-5 hours after exposure.
    - Call GT Police at 404-894-2500. Tell them that you will need an ambulance.

Combustible/ Explosive Dusts

Many people are unaware that the most mundane of powdery materials (dusts) can ignite and even explode under the right set of conditions: A dust explosion is the fast combustion (deflagration) of dust particles suspended in the air in an enclosed location. Coal dust explosions are a frequent hazard in underground coal mines, but dust explosions can occur where any powdered combustible material is present in an enclosed atmosphere. There are four necessary conditions for a dust explosion: A combustible dust; the dust is suspended in the air at a high concentration; there is an oxidant (typically atmospheric oxygen); and there is an ignition source. A fifth favorable, but not strictly necessary condition is that the dust be confined.

Many materials which are commonly known to oxidize can generate a dust fires or explosions, such as coal, sawdust, and magnesium. However, many otherwise mundane materials can also lead to a dangerous dust cloud such as grain, flour, sugar, powdered milk and pollen. Many powdered metals (like aluminum and titanium), can form ignitable/explosive suspensions in air. On Feb 8, 2008, a dust explosion in Port Wentworth, GA, leveled a sugar refinery, killed 6 workers, and injured 44 others. In May of 2009 a mostly empty jar containing metal and resin powders caught fire in the hand of a Georgia Tech researcher while she shook it to loosen the powder stuck to the side of the jar; she was not injured.

For ignition to occur, dust must also consist of very small particles, presenting a large surface area, allowing it to support combustion. Dust is defined as powders with particles less than about 500 micrometers in diameter, but finer dust will present a much greater hazard than coarse particles by virtue of the larger surface area.

Common sources of ignition include:

- electrostatic discharge
- friction
- sparking from machinery or other equipment;
- hot surfaces
- fire

Different dusts will have different combustion temperatures and dust of various types will either suppress or elevate this temperature in relation to the stoichiometric concentration

of the dusts. It is necessary that sufficient energy, generally either thermal or electrical, be applied to trigger combustion. Due to the small volume in relation to the large surface area, combustion can then proceed very rapidly and the flame front can also travel quickly. For example, 1 kg of powder, 120 µm in diameter will have a surface area of 50 m^2 or 540 sq ft. Due to the thermal expansion of the gas, the pressure increases. In an enclosed space this leads to the over pressurization of the “container” which could be a jar in a laboratory or an entire building, causing it to burst or “explode”.

General Rules for Working with Oxidizable Dusts:

- All care shall be taken to avoid aerosolizing the oxidizable particulates.
- Suspensions of oxidizable particles shall be handled wet, when this is not possible, they shall be handled under inert atmospheres.
- The airborne particulates shall not be exposed to ignition sources.
- Adequate local exhaust ventilation or a fume hood shall be provided to control the concentration of airborne dusts; dilution (room) ventilation is not acceptable.

Organometallics and Pyrophoric Chemicals

In December of 2008, a young researcher at UCLA was badly burned while working with tertiary (t) - butyl lithium. She died as a result of her burns a few weeks later. T-butyl lithium and other organometalic compounds are very reactive; many are also pyrophoric and ignite spontaneously upon exposure to air. Due to the potential risks involved in working with organometallics and pyrophoric materials, it is especially important to assure that all possible steps have been taken to prevent mishaps while handling these materials:

Pyrophoric materials are on the GT Restricted Purchases list (https://ehs.gatech.edu/chemical/restricted): please complete the Pre-notification form at the website (above) and contact GT EHS Laboratory and Chemical Safety Manager 404-894-4635 (http://www.ehs.gatech.edu/organization/contacts.php) before acquiring any pyrophoric material that you have not used previously at Georgia Tech. The acquisition must be approved by the Georgia Tech Chemical and Environmental Safety Committee before you may proceed.

To help with the approval process, please provide a copy of your Standard Operating Procedures for working with the material in question which describe

- The training the people who will handle it have received
- Where (building, room) it is to be used
- Engineering controls to be used (fume hoods, glove box)

Additional rules regarding the use of pyrophoric gases can be found in the Georgia Tech Dangerous Gas Safety Program at https://ehs.gatech.edu/chemical/dangerous-gas An excellent reference for working with organometallics can be found at: http://www.sigmaaldrich.co,/chemistry/aldrich-chemistry/tech-bulletins.html

General Rules for Working with Organometallics and Pyrophorics

- Where organometallics are used, Class D fire extinguishers shall be provided.
- All pyrophorics shall be used and stored in an inert atmosphere (e.g., under nitrogen or argon).

- Glove boxes used with pyrophoric materials are to be vented to the exhaust ventilation system (fume hood exhaust), not to room air or the room air exhaust system.
- Pyrophorics shall only be handled in a glove box or fume hood
- Prior to starting work with a pyrophoric material, remove all flammable and combustible material from the fume hood/glove box that is not associated with the procedure you are about to accomplish
- Prior to starting a transfer of a liquid pyrophoric material, the stock bottle must be firmly clamped in place.

Transfers of liquid materials involving more than 10 mL shall only be accomplished by the double tipped needle method

- Regulators shall be set correctly to prevent glassware from being over pressurized with nitrogen or argon.
- To avoid spills resulting in fires, breakable glass bottles shall be stored inside a rubber or plastic bottle carrier.
- Personal Protective Equipment for working with organometallics and pyrophorics shall include 100% natural fiber clothing and Flame Resistant lab coat, appropriate gloves, and safety glasses or goggles. (See the GT Personal Protective Equipment and Appropriate Attire Policy at https://ehs.gatech.edu/content/document-chem-ppe-policy.

Organic Peroxides and Peroxide-forming Chemicals

Organic Peroxides and Peroxide forming chemicals are classified as Potentially Explosive Chemicals (PECs) under EHSA, the computer program used by Georgia Tech to track and manage chemicals. An organic peroxide is any organic (carbon- containing) compound having two oxygen atoms joined together (-O-O-). This chemical group is called a "peroxy" group. The main hazards related to organic peroxides are their fire and explosion hazards. Most undiluted organic peroxides can catch fire easily and burn very rapidly and intensely. This is because they combine both fuel (carbon) and oxygen in the same compound. Some organic peroxides are dangerously reactive. They can decompose very rapidly or explosively if they are exposed to only slight heat, friction, mechanical shock or contamination with incompatible materials. See the section on Chemical Storage for more information on peroxide forming chemicals and how E H S A can help you manage them safety.

General Rules for Working with Organic Peroxides and Peroxide-forming Solvents

- Organic peroxides and peroxide-forming materials shall be stored blanketed with an inert gas (nitrogen or argon) protected from and stored away from heat and light.
- Keep peroxide formers cool but do not refrigerate. Refrigerator temperatures may freeze out or precipitate the peroxide.

- Ceramic, or plastic, spatulas shall be used with organic peroxides. Metal spatulas must never be used.
- Never purchase more than "immediate use" quantities of organic peroxides and peroxide formers.
- Never re-package organic peroxides in glass containers with screw caps or glass stoppers.
- Never submit peroxides to friction, grinding, or other forms of impact.
- Organic peroxides should be diluted with inert solvents such as mineral oil to reduce their sensitivity to heat and shock.
- Liquid organic peroxides are must never be allowed to freeze, as phase changes increase the sensitivity of these compounds to shock and heat.
- Peroxide-forming solvents shall be checked for the presence of peroxides upon receipt from the manufacturer and after every 3 months of storage (EHSA will send a reminder). Testing may be conducted with instantaneous peroxide indicator strips. If positive, material should be treated to remove the peroxide or wasted out. A label should be affixed to the container to record that the material has been checked- and when.
- Peroxide-forming solvents shall also be checked for the presence of peroxides prior to heating.
- EHSA will automatically send an expiration notice for peroxide forming chemicals one year after purchase. Peroxide formers for which there is no planned use should be disposed of through Environmental Health and Safety.
- EHSA expiration notices on materials which have been checked for crystals or tested may be "reset". Contact EHS for assistance at ehsa@gatech.edu
- Before distilling any known or suspected peroxide former, check it carefully for peroxide. If any is present, eliminate it by chemical treatment or percolation through a suitable adsorbent, or add a high-boiling aliphatic hydrocarbon (such as mineral oil) to prevent the peroxide from concentrating to a dangerous level. Never distill a peroxide former to dryness.

Working with Ether Used as an Anesthetic

- Like other peroxide-formers, ether must be stored in a cool, dry, well-ventilated place, out of direct sunlight. It must be purchased in small containers, no more than is absolutely necessary. It shall be stored as far back on a shelf as possible to minimize the potential for falling. It should be easy-to-reach to prevent knocking against the container.
- Ether shall be checked for peroxides quarterly. It is recommended that ether be discarded 6 months after opening/1 year after purchase. Peroxide test strips are available from Lab Safety Supply and other reputable safety supply distributors (e.g., Fisher, Baxter).

- Both unused ether supplies (older than 6 months) and ether known to contain peroxides must be disposed of through EHS. Evaporation of ether in a chemical fume hood is forbidden by law, except for residual amounts in an empty can. Disposal down the drain is also unlawful.
- Animal carcasses containing ether must be stored in flammable safe refrigerators or freezers where ether vapors cannot ignite.

Oxidizers

Oxidizing materials are liquids or solids that readily give off oxygen or other oxidizing substances (such as hydrogen peroxide, nitrates, nitrites, and permanganates). They also include materials that react chemically to oxidize combustible (burnable) materials; this means that oxygen combines chemically with the other material in a way that increases the chance of a fire or explosion. This reaction may be spontaneous at room temperature or may occur under slight heating. Oxidizing liquids and solids can be severe fire and explosion hazards. See the Section on Storing Chemicals- Oxidizers for more information.

General Rules for Working with Oxidizing Agents

- Oxidizing agents must be kept separate from reducing materials, metals, ordinary combustibles and from each other.
- Oil baths shall not be used when oxidizing agents are present.

General Rules for Working with Perchloric Acid and Perchlorates

- Laboratories must inform EHS before beginning work with hot processes involving perchloric acid.
- Organic materials shall be digested with nitric acid before the addition of perchloric acid.
- HEATING PERCHLORIC ACID OUTSIDE OF A PERCHLORIC ACID HOOD IS STRICTLY FORBIDDEN Operations involving heating perchloric acid above room temperatures (i.e., during acid-based digestion) shall be accomplished only in a wash-down laboratory chemical fume hood of noncombustible construction.
- Chemical fume hoods in which perchloric acid is heated are inspected frequently by EHS for the accumulation of perchlorates. Deposits are saturated with water and removed.
- Perchloric acid is never used near, nor stored on, wooden shelves.
- Perchloric acid bottles shall be stored in secondary containers (trays, beakers) made of glass or ceramic.
- Perchloric acid and perchlorates shall not be stored with organic materials.
- Perchloric acid shall not be heated with sulfuric acid.

Polynitro compounds

Acquisition of explosive polynitro compounds is restricted under Georgia Tech Rules and may involve permitting under Federal Regulations and/or Georgia State Fire Safety Regulations, even if limited to "Laboratory Quantities". Please contact EHS at 404-894-4635 BEFORE purchasing or agreeing to accept these materials from outside Georgia Tech or from other Georgia Tech researchers.

General Rules for Working with Polynitro Organic Chemicals and Shock-sensitive or Unstable Compounds

- Poly nitro compounds and shock- sensitive compounds may only be purchased in immediate use quantities.
- The stock of polynitro compounds shall be stored separately from other lab chemicals.
- Stock of poly-nitro compounds shall be inspected quarterly for degradation or dehydration, as these compounds may become more shock-sensitive with age (EHSA will automatically send a reminder).
- Polynitro compounds shall be disposed of through EHS when the project for which they were purchased ends, or at 1 year after purchase. They may not be placed in storage for future use, as they may become more hazardous over time.
- When polynitro and shock-sensitive compounds are moved, they must be handled by the container bottom and never by the cap or lid.
- Picric acid shall be kept hydrated or kept in solution to reduce sensitivity. It may never be allowed to dry out completely.
- Picric acid containers must be inspected to ensure that it is fully hydrated quarterly (EHSA will send a reminder)
- Picric acid shall be disposed of through EHS after the project for which it was purchased has ended or after 1 year (EHSA will send a reminder automatically)
- Solid sodium azide, in quantities above 25 g, should be dissolved when it arrives in the lab. Solutions of sodium azide do not pose the danger of shock-sensitivity associated with the solid form; however, the hydrazoic acid generated when the azide is dissolved is extremely toxic. Therefore, the solution is always prepared inside a chemical fume hood. If not dissolved, solid azide must be stored in a locked cabinet.
- Teflon or other nonmetal spatulas must be used with solid sodium azide due to its reactivity with metals.

Cryogenic Materials

Cryogenic liquids have boiling points less than -73ºC (-100ºF). Liquid nitrogen, liquid oxygen and carbon dioxide are the most common cryogenic materials used in the laboratory. Hazards may include fire, explosion, embrittlement, pressure buildup, frostbite and asphyxiation.

Many of the safety precautions observed for compressed gases also apply to cryogenic liquids. Two additional hazards are created from the unique properties of cryogenic liquids:

Extremely Low Temperatures –The cold boil-off vapor of cryogenic liquids rapidly freezes human tissue. Cold burns and frostbite caused by exposure to cryogenic liquids can result in extensive tissue damage. Also, proper materials selection is important in cryogenic conditions. Most metals become stronger upon exposure to cold temperatures, but materials such as carbon steel, plastics and rubber become brittle or even fracture under stress at these temperatures. Proper material selection is important. Cold burns and frostbite caused by cryogenic liquids can result in extensive tissue damage.

Vaporization - All cryogenic liquids produce large volumes of gas when they vaporize. Liquid nitrogen will expand 696 times as it vaporizes. The expansion ratio of argon is 1: 847, hydrogen is 1:851 and oxygen is 1:862. If these liquids vaporize in a sealed container, they can produce enormous pressures that could rupture the vessel. For this reason, pressurized cryogenic containers are usually protected with multiple pressure relief devices. The expansion ratio of cryogenic liquids, (except oxygen) in an enclosed
area can significantly reduce the percentage of oxygen in the area and cause asphyxiation. Vaporization of liquid oxygen can produce an oxygen-rich atmosphere, which will support and accelerate the combustion of other materials. Vaporization of liquid hydrogen can form an extremely flammable mixture with air.

Properties of Common Cryogenic Materials

Gas	Gas Boiling Point (°C)	Liquid to Gas Volume Expansion Ratio
Helium	-268.9	1-757
Hydrogen	-252.7	1-851
Nitrogen	-195.8	1-696
Fluorine	-187.0	1-888
Argon	-185.7	1-847
Oxygen	-183.0	1-860
Methane	-161.4	1-579

Most cryogenic liquids are odorless, colorless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, the cold boil-off gases condense the moisture in the air, creating a highly visible fog.

Always handle these liquids carefully to avoid skin burns and frostbite. Exposure that may be too brief to affect the skin of the face or hands may damage delicate tissues, such as the eyes.

General Rules Regarding Handling of Cryogenic Materials

- Labs using cryogenic materials must have a lab specific Standard Operation Procedure (SOP) that covers not only how the material is to be used, but how the dewars are to be transported to and from the building loading dock
- **BEST PRACTICE WHEN TRANSPOTING A DEWAR IS TO AVOID TRAVELING WITH A DEWAR IN A PASSENGER ELEVATOR**. Release of a material such as liquid nitrogen in the small space such as an elevator may pose an asphyxiation hazard. Employ the buddy system and have a fellow employee/student remain outside the elevator on the sending and receiving floors. Nitrogen does not have good warning properties and can displace oxygen to dangerously low levels
- Do not store dewars in unventilated or poorly ventilated spaces
- Cryogenic materials shall not be used in a confined space with inadequate ventilation due to the potential for asphyxiation. (This includes cold rooms and warm rooms)
- Cryogenic materials shall not be warmed in closed containers.
- Dewars shall be inspected daily for ice plug formation.
- Cryogenic materials containers shall have relief devices that have been engineered into the containers or closed systems.
- **TAMPERING WITH OR ALTERING THE PRESSURE RELIEF VALVE ON A CRYOGENIC MATERIAL CONTAINER IS STRICTLY FORBIDDEN**
- Boiling and splashing always occur when charging or filling a warm container with cryogenic liquid or when inserting objects into these liquids. Perform these tasks slowly to minimize boiling and splashing. Use tongs to withdraw objects immersed in a cryogenic liquid.
- Ensure that whatever you are putting a cryogenic material into is suitable for the material. Glass dewars should be wrapped in protective mesh or taped.
- Use extreme caution with cryotubes. An explosion hazard exists if liquid nitrogen has entered the tube through any defects or cracks and may expand rapidly causing an explosion/shrapnel hazard
- Never touch un-insulated pipes or vessels containing cryogenic liquids. Flesh will stick to extremely cold materials. Even nonmetallic materials are dangerous to touch at low temperatures.
- Use wooden or rubber tongs to remove small items from cryogenic liquid baths. Cryogenic gloves are for indirect or splash protection only, they are not designed to protect against immersion into cryogenic liquids.
- Cylinders and dewars should not be filled to more than 80% of capacity, since expansion of gases during warming may cause excessive pressure buildup.
- Check cold baths frequently to ensure they are not plugged with frozen material.

Protective Clothing for Working with Cryogenic Materials

- Face shields worn over safety glasses or chemical splash goggles and lab coat are required during transfer and handling of cryogenic liquids.
- Trousers (cuffless) should be worn on the outside of boots or work shoes.
- Wear loose fitting, dry, insulated cryogenic gloves when handling objects that come into contact with cryogenic liquids and vapor.

Cooling Baths and Dry Ice

- Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air, because oxygen can condense from the air, leading to an explosion hazard.
- Wear insulated, dry gloves and a face shield when handling dry ice.
- Add dry ice slowly to the liquid portion of the cooling bath to avoid foaming over. Do not lower your head into a dry ice chest, since suffocation can result from carbon dioxide buildup.

Liquid Nitrogen Cooled Traps

Traps that open to the atmosphere condense liquid air rapidly. If you close the system, pressure builds up with enough force to shatter glass equipment. Therefore, only sealed or evacuated equipment should use liquid nitrogen cooled traps.

Emergencies Involving Cryogenic Materials

- Anticipate emergency situations, have proper handling equipment in the lab and readily available for spills.
- Check the SDS to determine what is appropriate.
- In the event of a spill or adverse reaction notify lab personnel immediately that an incident has occurred.
- Do not attempt to clean up a spilled cryogen. If a large volume of gas is released, leave the area immediately and call the Georgia Tech Police at 404-894-2500.
- If a flammable or oxidizing gas is involved, evacuate and pull the fire alarm. If you can do so safety, turn off all ignition sources at the breaker box on your way out of the building.
- Remain on site to speak with First Responders.
- If skin comes in contact with a cryogen or dry ice, run the area of skin under lukewarm water for 15 minutes (do not use hot or cold water). Seek professional medical attention.

- If your finger is burned, do not place it in your mouth. This could burn your mouth. Do not rub the area — this can cause further tissue damage.

Extremely and Highly Toxic Chemicals

The toxicity of materials is assessed by their Lethal Dose 50% (LD_{50}) or Lethal Concentration 50% (LC_{50}). LD_{50} is defined as the dose at which 50 percent of the exposed test animals (generally, rats or mice) died, usually within 1-2 hours after being dosed by ingestion, injection or skin exposure. LC_{50} is defined as the concentration in air at which 50 percent of the test animals (generally rats or mice) died, usually within a specified time after being exposed by inhalation.

A substance is considered extremely toxic if it has an LD_{50} of less than 5 mgs/kg of animal body weight. To humans, this is the equivalent of a taste (less than 7 drops). It is Highly toxic if it has an LD_{50} of between 5 and 50 mg/kg of animal body weight to a human, this would be about a teaspoon.

Georgia Tech requires that all labs be kept locked however, there are additional security measures that owners of extremely toxic chemicals must implement to ensure that the chemicals' location is always known and that only persons who have the PI's permission may have access to them. This means that extremely toxic chemicals:

- Must Be stored in a locked cabinet or drawer in the lab
- Must have a sign out sheet document the following information
    - who uses them,
    - how much they used and
    - when they used it

Additionally, organo-mercury compounds, which have an LD_{50} in the 5-50 mg/kg range (highly toxic) must also be kept locked up and treated like the extremely toxic group.
This is because many of these materials are absorbed through the skin and have no immediate symptoms. In 1997 a researcher at Dartmouth College died as a result of a miniscule skin exposure to dimethyl mercury (http://en.wikipedia.org/wiki/Karen_Wetterhahn) In 2010, a cache of "lost and forgotten" dimethyl mercury containers were found in a GT lab during a lab clean out by students who had no idea as to what they were handling: It is extremely important that we never "loose track" of these chemicals, hence the requirement to treat them as "extremely toxic".

Before you purchase or start working with any substance read the SDS. If the material is highly or extremely toxic, or if you are unsure about its level of toxicity, call EH&S for a Hazard Assessment

EHS will:

- Review the toxicological data for the material with which you intend to work.
- Inspect your work area.
- Review your Standard Operating Procedure for working with highly and extremely toxic compounds.

- Review the training records of all persons in the lab.
- Test engineering controls as appropriate.
- Test safety equipment as appropriate.
- Provide recommendations for PPE appropriate for the particular material with which you are working.
- Determine if medical surveillance of affected employees is needed.

Before purchasing a highly or extremely toxic material, please read the guidelines for handling these materials under ChemFacts on the EHS website: http://www.ehs.gatech.edu/sites/default/files/highly_and_extremely_toxic_materials.pdf

Hydrofluoric Acid

Hydrofluoric acid (HF) is not just a corrosive, it is a potentially deadly poison with latent effects that may not manifest for up to 24 hours after the exposure, depending on the concentration of the acid and the duration of exposure.

HF readily penetrates the skin, causing deep tissue layer destruction. Severity and rapidity of onset of signs and symptoms depends on the concentration, duration of exposure, and penetrability of the exposed tissue. Pain may be delayed.

CONCENTRATIONS LESS THAN 20% - Erythema and pain may be delayed up to 24 hours, often not reported until tissue damage is extreme. In one study, 7% HF produced symptoms in 1 to several hours, 12% HF in less than one hour, and 14.5% HF immediately.

CONCENTRATIONS 20 TO 50% - Erythema and pain may be delayed from 1 to 8 hours, and is often not reported until tissue damage is extreme.

CONCENTRATIONS GREATER THAN 50% - Produces immediate burning, erythema, and tissue damage.

Systemic fluoride toxicity may result from ingestion, inhalation, or extensive dermal burns. Hypocalcemia, hypomagnesemia, hyperkalemia (potassium), pulmonary edema, metabolic acidosis, ventricular arrhythmias, and death are possible.

Eye exposure may result in severe ocular damage with concentrations greater than 0.5%. Fume exposure commonly causes eye irritation and can also cause ocular injury. Signs and symptoms may be delayed.

Ingestion may result in vomiting and abdominal pain; painful necrotic lesions, hemorrhagic gastritis, and pancreatitis have been reported after significant exposure.

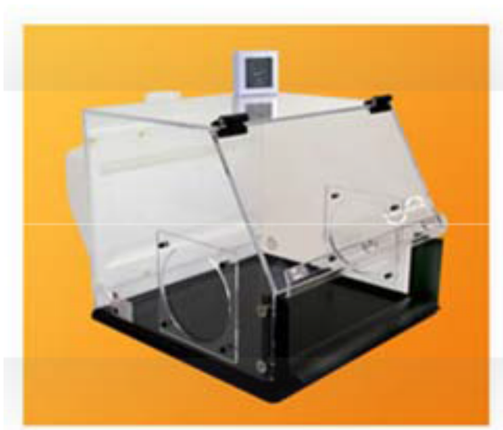
Inhalation of hydrofluoric acid vapors may cause severe throat irritation, cough, dyspnea, cyanosis, lung injury and pulmonary edema resulting in death.

HF should always be handled in a fume hood. PPE should include a long-sleeved acid resistant apron and a face shield in addition to the usual lab coat and safety glasses.
Gloves must be chosen to be resistant to HF but also be compatible with the process: Heavy 6 mil nitrile, butyl or neoprene gloves worn over nitrile examination gloves are preferred, but may inhibit manual dexterity to a point of interfering with the work and endangering the laboratorian. In this case, double gloving with nitrile examination gloves is recommended

while keeping alert to any wetness on the outer glove- in which case the outer glove should be changed immediately.

Dangerous Powders

"Dangerous Powders" include antineoplastics, nanomaterials, and other chemicals that are simply poisons. The #1 concern in working with these materials is exposure to the aerosolized powder, so the first step in avoiding this hazard to buy it directly from your supplier in suspension. If this is not possible, the next step is to dissolve or suspend the powder in a liquid as early in your process as possible. Dangerous powders should be weighed in a balance enclosure. Balance enclosures can be simple:



Plexigalss box with lid and hand holes

Glove box with venting capability

Or more elegant:

Balance enclosures do not necessarily have to be ventilated but remember to always wet wipe the outside of the container, the balance and the inside of the enclosure when you are done **whether or not you *think* you spilled anything.**

- Seal the receiving container before you take it out of the enclosure, glove box or fume hood.
- If possible, dissolve or suspend the material in liquid before taking it out of the enclosure, glove box or fume hood
- Do not do anything that might aerosolize the powder
  - Do not broom, dry sweep or vacuum (no, not even with the ones that say HEPA)
- Clean up spill from the outer edge toward the center, not side to side:
  - Cover the spill with wet paper towels
  - Using the paper towels, scoop the material into a PLASTIC dust pan (or just pick it up with two hands)
  - Repeat using additional wet paper towels until the material is all gone
  - Wet wipe surface (from outer edge to center)
    - Bag and label the waste
  - Use EHSA to generate a waste card (ehsa.gatech.edu) and request a pick up

Antineoplastic Agents

Antineoplastic agents are covered under restricted purchases. (See the Section on Restricted Purchases). The complete program can be found un In Vivo Agents at https://www.ehs.gatech.edu/chemical/in-vivo

Nano Materials

Nanotechnology is the manipulation of matter on a near-atomic scale to produce new structures, materials, and devices. The technology promises scientific advancement in many sectors such as medicine, consumer products, energy, materials, and manufacturing. Nanotechnology is generally defined as engineered structures, devices, and systems.

Nanomaterials are defined as those materials that have a length scale between 1 and 100 nanometers. At this size, materials begin to exhibit unique properties that affect physical, chemical, and biological behavior. Researching, developing, and utilizing these properties is at the heart of new technology.

The hazards of nanomaterials are generally still unknown. Because of this, Georgia Tech considers all nanomaterials hazardous and requires specific handling and waste disposal procedures. If you have any questions or concerns regarding nanomaterials, please contact us.

The GT Guidelines for working with nanomaterials can be found at: http://www.ehs.gatech.edu/chemical/nanotechnology.doc

Carcinogens

Carcinogens are substances which are capable of causing cancer. Cancer, simply put, is the uncontrolled growth of cells that can occur in any organ. Carcinogenic chemicals come in all forms: solid, liquid, and gaseous. A big difference between carcinogens and many other chemicals is that there is not necessarily a dose- response relationship between exposure and the development of cancer. Therefore, all effort must be taken to avoid exposure to carcinogens. Also, cancer has *latent* effects, often not manifesting for 10 to 30 years after the exposure.

Protection from carcinogens in the lab is no different than working with other dangerous substances: hygiene; engineering controls such as fume hoods, biosafety cabinets, and glove boxes; personal protective equipment such as gloves, safety glasses, and lab coats; proper procedures; and training. Carcinogens are treated with the same level of caution as extremely toxic materials, starting with increased fume hood speeds from an average of 100 lfm to 120 lfm. If you are working with a carcinogen, please contact EHS to conduct a safety review of your process and to have your fume hood speed increased from the normal 100 linear feet/minute to 120 linear feet/minute.

The Occupational Safety and Health Administration (OSHA) regulates 26 recognized carcinogens (http://www.osha.gov/SLTC/carcinogens/index.html) :

1,2-dibromo-3-chloropropane
1,3-Butadiene
2-Acetylaminofluorene
3,3'-Dichlorobenzidine (and its salts)
4-Aminodiphenyl
4-Dimethylaminoazobenzene
4-Nitrobiphenyl Acrylonitrile
alpha-Naphthylamine
asbestos
Benzene
Benzidine
beta-Naphthylamine
beta-Propiolactone
bis-Chloromethyl ether
Cadmium
Coke oven emissions
Ethylene oxide
Ethyleneimine
Formaldehyde
Inorganic arsenic
Methyl chloromethyl ether
Methylene Chloride
Methylenedianiline
N-Nitrosodimethylamine
Vinyl chloride

OSHA adopted the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) in April of 2012. This system recognizes 3 hazard levels for carcinogens:

Category 1 Known or Presumed Carcinogen		**Category 2 Suspected Carcinogen**
Subcategory 1A **Known Human Carcinogen** Based on human evidence	Subcategory 1B **Presumed Human Carcinogen** Based on demonstrated animal carcinogenicity	Limited evidence of human or animal carcinogenicity

Other Organizations such as the International Agency for Research on Cancer (IARC) and the American Conference of Governmental Industrial Hygienists (ACGIH) also have classification systems for carcinogens. All of these systems are based on the availability of human data, giving those chemicals with more human data, the higher (more dangerous) rating.

Work Practices for Handling Carcinogens will vary, depending n whether it is a solid, a liquid, or a gas. Some examples of good work practices can be found on the EHS website http://www.ehs.gatech.edu/sites/default/files/highly_and_extremely_toxic_materials.pdf

Working with High Pressure Systems

High-pressure reactions are those experiments that are carried out at pressures above one atmosphere. This includes most hydrogenation reactions since explosive oxygen- hydrogen mixtures can be formed as a result of these reactions.

Operational Practices

- Pressure vessels should be labeled to indicate the maximum allowable working pressure and temperature.
- Service lines shall not be not connected to any closed apparatus incapable of withstanding the maximum pressure of the service line (air, water, etc.).
- All pressure systems shall be protected with appropriate pressure-relief devices.
- The pressure-relief device shall be installed so that the discharge is directed away from the area where a person could be affected (preferably toward the back of a hood)
- Pressure-relief devices shall be inspected periodically by lab staff. Orifices on both sides of the pressure-relief device should be checked for obstruction.
- Pressure gauges with pressure ranges about twice the working pressure of the system shall be used.
- Containers, fittings, and other equipment to be used when working with pressure vessels shall be chosen to able to withstand the stresses imposed by the given pressures and temperatures.
- Pressure vessels containing liquids shall not be filled above capacity (no more than half full is preferred).

- The pressure levels of high-pressure devices shall be monitored periodically as heating proceeds.

Working with Vacuum Systems

Vacuum systems include those activities involving mechanical vacuum pumps, building vacuum systems, water aspirators, or steam aspirators.

Work with vacuum systems poses a substantial danger of injury to the operator from flying glass shrapnel released during an implosion. Other hazards may include:

- The toxicity of the chemicals in the vacuum system
- Fire following breakage of a flask containing flammable solvents
- Toxicity from the mercury in manometers and gauges
- Over- or under-pressurization arising with thermal conductivity gauges
- Electric shock with hot cathode ionization systems.

Operational Practices

Vacuum Apparatus

- Vessels used in vacuum operations shall be protected with suitable relief valves (vacuum breaker).
- A protective shield shall be placed around evacuated systems.
- “Fish net” or electrical tape shall be wrapped around all glassware under reduced pressure.
- PPE for laboratorians shall include safety glasses or goggles AND face shields when working with evacuated systems or setting up such systems.
- The vacuum system shall be been arranged to allow the equipment to be moved without transmitting strain to the neck of the flask; flasks are to be supported from below as well as by their necks.
- The vacuum apparatus must be well out of the way of traffic to avoid being struck inadvertently.
- Belt-driven mechanical pumps shall be equipped with protective guards to enclose the moving belts (machine guarding).

Capture of Contaminants

- Each vacuum system used for solvent distillation operations shall be protected by a suitable trapping device (cold trap, filter, liquid trap) with a backflow check valve.
- Water, solvents, and corrosive gases shall be trapped and not allowed to be drawn into the building vacuum (house) system.

- When mechanical vacuum pumps are used with volatile substances, the input line to the pump shall be fitted with a cold trap to minimize the amount of volatile materials entering the pump and dissolving in the oil.
- Use pump oil that is appropriate for the contaminant such as Fomblin® when working with corrosives or other materials that are not compatible with hydrocarbon based oils.
- If particulates could contaminate a vacuum line (e.g., from an inert atmosphere dry box or glove box), a HEPA filter shall be installed.
- If pump oil becomes contaminated, it shall be drained and changed to prevent the exhaust of chemicals into room air.
- Used pump oil shall be labeled Used Oil and disposed of through GT EHS.
- Records of pump use shall be maintained for general-purpose lab pumps in order to forestall cross-contamination or reactive chemical incompatibility problems.
- The exhaust from evacuation of volatile, toxic, or corrosive materials shall be vented to an air exhaust system such as a chemical fume hood or local exhaust duct.

Vessels

- Glass vessels used in conjunction with the vacuum system should be checked with polarized light for cracks, scratches, or etching each time the vessel is used. At minimum, a visual inspection will be conducted.
- Dewar flasks shall be wrapped with tape or enclosed in wooden or metal containers.
- Reduced pressure must never apply to flat-bottomed flasks unless they have been designed for this purpose.
- Vacuum desiccators shall be made of borosilicate/Pyrex glass or plastic.
- Evacuated desiccators must never be carried or moved.
- Desiccators shall not be opened until atmospheric pressure has been restored.
- If rotary evaporators are used, increases in rotation speed and application of vacuum to the flask are gradual.

Distillations

Solvent Stills: Procedure for Set-Up Use, and Neutralization

Although the procedures for purifying laboratory chemicals are inherently safe, care must be exercised if hazards are to be avoided. Solvent distillation equipment in which flammable liquids are purified by distillation with reactive metals or metal hydrides such as Na, K, CaH_2, or $LiAlH_4$ are possibly the greatest danger in any organic chemistry laboratory. The potential fire and explosion hazards associated with the combination of air- and/or water-reactive metals with large amounts of organic solvents are great and the effects on personnel and equipment can be catastrophic. The chances of personnel escaping such an incident unharmed are very low.

Consider using alternative solvent purification systems and methods before proceeding (see column purification method below for a procedure that avoids all heat and distillation).

Set up and Operation

All distillations of flammable materials shall be done in a fume hood

1. Use proper personal protective equipment (e.g., gloves, safety glasses, and fire- resistant or all cotton lab coat) while operating a distillation unit.
2. Any solvent stills containing reactive metals should be located in a fume-hood.
3. After set up and before start up get prior approval and a final equipment check from the principal investigator or an approved competent person.
4. The total volume of solvent used in these stills shall be kept to a minimum (BUT they should never be allowed to go "dry"). Their useful working volume is ¼ to ⅔ of filled capacity.
5. Stills should be operated under an inert gas atmosphere of nitrogen or argon.
6. Several types of drying agents can be used:

    a) Na, K, or Na/K must never be used for solvents containing C-Cl or O-H bonds.

    b) Because of their pyrophoric nature (possible spontaneous ignition upon contact with air) the use of sodium/potassium alloys (NaK), which are liquids at ambient temperature should be avoided. Solvent flasks containing $LiAlH_4$ must never be heated. As a drying agent $LiAlH_4$ is therefore only suitable for non-reducible solvents that can be obtained pure by flask-to-flask vacuum-transfer at ambient temperature.

    c) The use of potassium alone is recommended for THF only – in these solvents the metal will melt providing a fresh & reactive surface. Be aware that it is much more reactive than sodium, especially when quenching a solvent still (see below).

    d) The use of sodium alone is recommended for diethyl ether and all other hydrocarbons such as toluene, benzene, pentane, hexane, heptane, etc.

    e) Calcium hydride is recommended for methylene chloride and other halogenated solvents.

    f) Magnesium/Iodine is recommended for methanol and ethanol.

g) For all high boiling solvents, the use of 4 Å molecular sieves (activated by heating under full dynamic vacuum overnight) is recommended.

Solvent stills should never be left running (i.e., being heated to reflux) while unattended – especially not overnight.

7. Stills should be deactivated and restarted with all fresh solvent and drying agents on a regular basis to avoid buildup of metal hydroxides and benzophenone "cakes" that would impair stirring necessary during deactivation.
8. To deactivate a solvent still containing reactive metals follow the procedure below for deactivation and neutralization.

Reference: Armarego, W.L.F., Perrin, D.D., *Purification of Laboratory Chemicals*, Fourth Edition, 1998.

Deactivation and Neutralization

Please read and follow these procedures carefully. **This procedure can be dangerous** and requires plenty of time to complete. Do not rush the process. Only properly trained persons are to perform this procedure.

1. Notify other laboratory occupants and your supervisor of your intent to perform this procedure.

Do not perform this procedure "after-hours".

2. Wear a lab coat, safety glasses, face shield, and gloves. Orient yourself with the location of the nearest emergency shower, fire blanket, and exit. Have a dry-chemical fire extinguisher available.
3. Inspect the still flask. The still flask should not be more than 1/5 full and the mixture must be stirring freely using a magnetic stir bar. If it is not, carefully attempt to break up any solid deposits in the flask using a large spatula. If this does not work, seek assistance from your supervisor.
4. In a fume hood cleared of all other reactions and equipment, set up a reaction apparatus as illustrated in the attached scheme. Securely clamp the still flask and all other parts of the apparatus to a sturdy lab-stand or support rod.
5. Make sure that there is an ample supply of nitrogen or argon that will last at least 24 hours with a slow rate of bubbling and establish that both nitrogen/argon and cooling water are flowing at a reasonable rate with the hose connections to the condenser secured by copper wire or similar.
6. If the solvent still contains **sodium or potassium**:
    a. With stirring, slowly add an equal volume of toluene or preferably xylene to the flask (see attached figure) while maintaining a slight counter-flow of nitrogen or argon through the apparatus. The counter-flow should be maintained during any additions to the flask throughout the entire procedure. Stir for 5-10 min. observing the reaction.
    b. With stirring, add 1 ml of n-butanol or t-butanol and observe the reaction. In the presence of active metal hydrogen gas evolution will occur. Further 1 ml portions of the alcohol are added at such a rate that the heat evolved by neutralization does

not cause the reaction mixture to come to reflux. This will take several hours, or even longer. The reactivity of the mixture can be monitored by briefly interrupting the nitrogen flow and monitoring the bubbler. As long as there is gas evolution from the apparatus, reactive metal is present.

c. When no further reactivity is observed, procedure b) is repeated with ethanol. Again this may take several hours, or overnight, until all hydrogen evolution ceases.

d. Add 50-100 ml methanol in 5 ml portions and monitor the reaction. Stir at least 1 h or until no further gas evolution is observed.

e. Repeat procedure b) with water until no further gas evolution is observed.

f. Dispose of the contents of the flask as organic chemical waste from your laboratory.

7. If the solvent still contains **lithium aluminum hydride**:

a) With stirring, slowly add 1 ml portions of 95 % ethanol to the flask containing the hydride in solution (see attached figure) while maintaining a slight counter-flow of nitrogen or argon through the apparatus. The counter-flow should be maintained during any additions to the flask throughout the entire procedure. Stir for 5-10 min. observing the reaction.

b) When no more gas evolution is observed slowly add a saturated solution of ammonium chloride.

c) Separate the organic and aqueous layers formed.

d) Dispose of the two components in the appropriate manner, i.e., the organic layer into the organic waste collection container, the aqueous layer into the aqueous waste container in your laboratory.

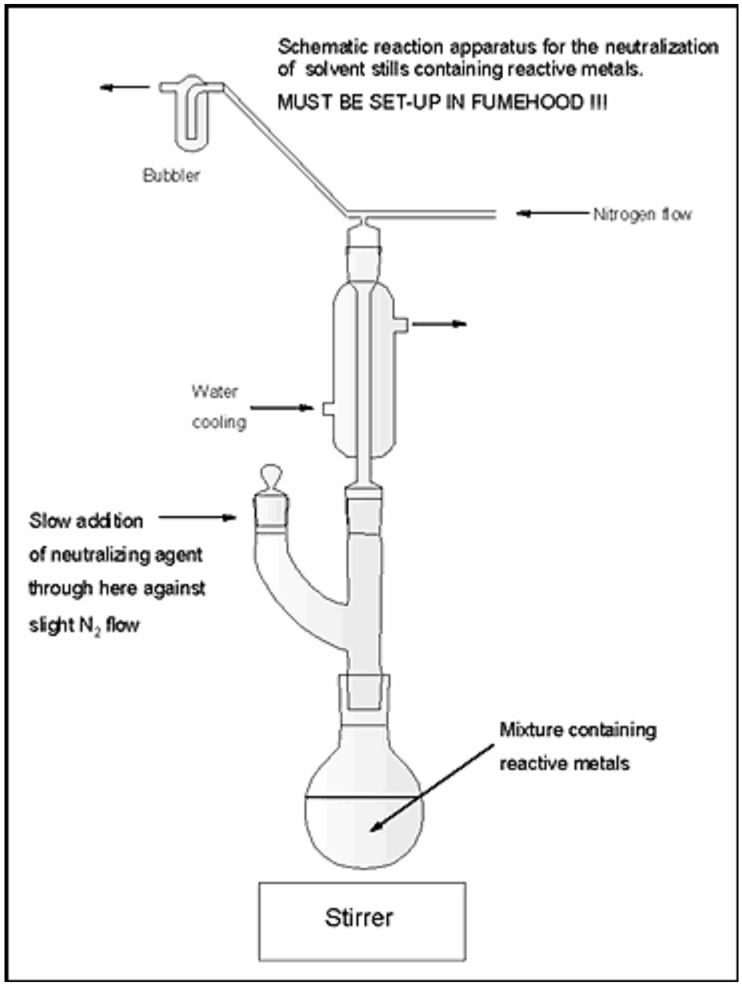
8. If the solvent still contains **calcium hydride in dichloromethane (CH_2Cl_2)**:

a) With stirring, slowly add 1-2 ml portions of methanol to the flask (see figure) while maintaining a slight counter-flow of nitrogen or argon through the apparatus. The counter-flow should be maintained during any additions to the flask throughout the entire procedure. Stir for 5-10 min. after each addition observing the reaction.

b) When no more gas evolution is observed slowly add excess water.

c) Separate the organic and aqueous layers formed

d) Dispose of the two components in the appropriate manner, i.e., the organic layer into the halogenated organic waste collection container, the aqueous layer into the aqueous waste collection container in your laboratory



Column Purification Systems

Commercially available column purification systems are a viable alternative for some distillation procedures. While the column method does not have the fire or explosion initiators that distillation units have, they do, however, have their own set of safety considerations that must be accounted for.

1. The quantities of solvents in the system tend to be larger so the units must be used in an appropriate location equipped with flammable liquid cabinets, fire doors, sprinklers, and the quantity limits imposed by the building codes must not be exceeded.

2. The columns are pressurized from 5-50 psi therefore; they must be secure and equipped with the appropriate valves and plumbing. Peroxides may accumulate on the columns and must be changed in accordance with the manufacturer's recommendation.

3. Some solvents, including tetrahydrofuran and methylene chloride, are incompatible with the copper catalyst therefore; the column method may not be suitable for some applications.

References: Cournoyer, Michael E., and Dare, Jeffery H., The Use of Alternative Solvent Purification Techniques, *Chemical Heath and Safety*, July/August, 2003

Magnetic Fields

Static Magnetic Fields

Man made static magnetic fields are generated whenever direct current (DC) is use, such as in some electric trains, electroplating operations, and medical imaging devices such as Magnetic Resonance Imaging (MRI) and Nuclear Magnetic Imaging (NMR).
Strong static magnetic fields have been linked to slight increases in blood pressure, interference with the operation of cardiac pacemakers, and movement of implanted ferrometallic medical implants.

There are no OSHA Standards on Static Magnetic Field exposure, however the ACGIH has published Threshold Limit Values (TLVs) for static magnetic field exposure: Routine occupational exposure should not exceed 2 Tesla (T) in the general work environment but can have ceiling values of 8T for workers with special training who are operating in a controlled work environment.

Special training involves making workers aware of transient sensory effects that can result from rapid motion in static magnetic fields with flux densities greater than 2T.

A controlled work environment is one in which forces exerted by static magnetic fields on metallic objects do not create potentially hazardous projectiles.

Exposure to the limbs of workers in the general work area should not exceed 20T.

Workers with implanted ferrometallic or electronic devices should not be exposed to static magnetic fields exceeding 0.5mT.

Projects to install high powered magnets must take the surrounding areas into consideration (both horizontally and vertically) and take care to locate the magnet so that no area accessible by the general public would be subjected to magnetic field strengths of more than 0.1mT. This is often referred to as the 1 gauss line (1mT=10G).

GT EHS conducts magnetic field surveys on new installations of electromagnets and on request.

Sub Radio-Frequency Magnetic Fields

In this context a sub-radiofrequency magnetic field (Sub-RF) refers to a field with a frequency range at 30kHz (kilohertz) and below.

The 1 to 300 Hz portion of this range is referred to as the extremely low frequency (ELF) range. Non-static electromagnetic fields can be found around high voltage electrical lines and even around in-home electrical wiring.

Some evidence suggests that these fields can cause cancer, however, to date, neither IARC or ACGIH lists non-static electrical fields as carcinogens.

OSHA does not have a standard for exposure to non-static magnetic fields, but the ACGIH does have TLVs, which vary according to the frequency range of the field. Please refer to ACGIH TLVs and BEIs- most recent version, for more information on this subject.

Like static fields, non-static magnetic fields are also capable of interfering with the function of implanted medical devices, which makes it especially important for owners of these devices to understand the hazards before they start to work.
Any concerns about sub-RF magnetic fields should be directed to the EHS chemical safety group (404-385-4635)

17. Related Safety Programs

Biological Safety

The EHS Biological Safety Office is responsible for biological lab safety training; inspecting biology labs; overseeing the GT Occupational Health Program; safety procedures for select biological agents, toxins and viral vectors; overseeing the biological material shipping and biological safety cabinet testing/certification programs.
Information on Biological Safety can be found at http://www.ehs.gatech.edu/biological/

Radiological Safety

The EHS Office of Radiological Safety is responsible for all aspects of the use of radioactive materials and radiation-generating devices at GT; developing and implementing safety and control measures to keep personal and public exposures as low as reasonably possible. Information on Radiological Safety can be found at http://www.ors.gatech.edu/

Laser Safety

Falls under the Office of Radiological Safety. The primary objective of the Georgia Institute of Technology (Georgia Tech) laser safety program is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) limit reaches the human eyes or skin. Additionally, the program is designed to ensure that adequate protection against collateral hazards is provided. These collateral hazards include, but are not limited to, the risk of electrical shock, fire hazard from a beam or from use of dyes and solvents, chemical exposures from use of chemicals and vaporization of targets, and the emission of ionizing and non-ionizing radiation from power supplies associated with the operation of the laser or laser system

Information on Laser Safety can be found at http://www.ors.gatech.edu/

Occupational Health

Falls under the Biological Safety Office. Workplace Occupational Health is an important issue for Georgia Tech and its employees. Scientific research and other work activities involving the use of chemical, biological, and/or radiological materials has the potential to expose employees to health hazards. These hazards can create both short-term and long-term health issues. Georgia Tech is strongly committed to protecting the health of a11 its employees through awareness, training, medical evaluations, engineering controls and appropriate workplace protective measures.

Information on the GT Occupational Health Program can be found at https://www.ehs.gatech.edu/occupational-health

Shipping and Receiving Chemical and Biological Materials

The GT Program on shipping biological and chemical materials can be found at: http://www.ehs.gatech.edu/shipping/shipping.pdf

Shipping Chemical and Biological Materials

Shipping biological and chemical materials from Georgia Tech to another location or from a field research site back to Tech is regulated by the federal government.
Attempting to ship materials without the proper training and certifications can result in jail time, hefty fines, and in the worst case, loss of life, as in the crash of Valujet Flight 592 in 1996. There are no small quantity exemptions or special dispensation for educational institutions in the shipping regulations: In 2011 The Federal Aviation Administration (FAA) fined the Massachusetts Institute of Technology (MIT) $175,000 for improperly shipping devices containing with lithium batteries. Also in 2011, GT paid $3,000.00 in fines because two different researchers who were not certified shippers signed shipping papers indicating that they were certified. Please note also that future fines incurred by GT employees with be paid by the employee, not the Institute.

Becoming a certified shipper is a complicated process involving 40 hours of classroom training and 8 hours of refresher training every two years. GT EHS personnel are trained and certified in shipping hazardous goods and will ship your materials for you. All you need to do is go to our shipping website (https://www.ehs.gatech.edu/shipping) and learn what you need to do to take advantage of this service- EHS takes care of everything else.

Researcher are advised to plan ahead when doing research at sister institutions by purchasing chemicals and having them delivered directly to the sister institution. Chemicals and biologicals being shipped back from field locations must be shipped by certified shippers at the field destination- please contact EHS in advance so that an appropriately trained shipper in the area can be identified and arrangements can be made to ship your samples back to Tech.

Receiving Chemical and Biological Materials

Any person with the potential of receiving, or otherwise processing incoming chemical or biological materials must receive training on hazard recognition, safety precautions, security, and incident response. This includes the person in the lab whose only job is to open the box). Training on receiving biological and chemical materials is available on line through the GT Training Department (http://www.trains.gatech.edu/). Only Radiological Safety personnel may receive radiological materials.