ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Chemical Hygiene and Laboratory Safety Training

Welcome to Environmental Health and Safety's Laboratory Safety Training Program

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This training is designed to meet the University of Delaware obligations under the Occupational Safety and Health Administration (OSHA), Hazard Communication Standard (29 CFR 1910.1200), OSHA Laboratory Standard, (29 CFR 1910.1450), State of Delaware Hazardous Chemical Information Regulation (Title 16, Chapter 24 of Delaware Code), University Policy 7-27, Hazardous Chemical Information and University Policy 7-37, Occupational Exposure to Hazardous Chemicals in Laboratories. Additional training is required based on the type of work performed.

Discussion Items

This training program is designed to familiarize you with safe work practices when working in laboratories with or around chemicals. Topics covered in this training:

- Chemical Safety Program Administration
- Health Hazards and Toxicity
- Physical Hazards
- Hazard Information Sources
- Protective Measures and Exposure Control
- Spills and Personal Contamination
- Shipping Research Samples and Products
- Security
- Chemical Waste Management Synopsis

Part 1 - Program Administration

The goal of the Chemical Hygiene Program is to minimize the risk of injury or illness by ensuring that researchers and students have the training, information, support and equipment needed to work safely in the laboratory.

The University Chemical Hygiene Committee facilitates the implementation of the program through the Department of Environmental Health and Safety. The committee reports to the Provost and has representation from each College or unit that conducts research and activities with chemicals.

http://www.udel.edu/ehs/chemhygienecomm.html

Each department that uses chemical and hazardous materials has local experts and representatives called Departmental Chemical Hygiene Officers.

http://www.udel.edu/ehs/dcho.html

Training and Communication

- It is important to learn safe work practices BEFORE you start work in the laboratory.
- Federal and State Regulations require the University to provide initial and annual safety training.
  - The Federal Occupational Safety and Health Administration (OSHA) **Hazard Communication Standard states that:**
    - "It is everyone's right to know about all of the hazards in their workplace."
    - Workers must be made aware and trained on all hazards encountered in the workplace.
  - **Hazardous Chemical Information Act,** Title 16, Chapter 24 of Delaware Code
    - Requires the employer to provide workers with access to chemical inventories, material safety data sheets and to provide chemical safety training.

Chemical Hygiene Plan (CHP)

- There is another Federal Regulation that applies to the research and teaching operations at the University
  - The OSHA Laboratory Standard, 29 CFR 1910.1450, requires the creation of the Chemical Hygiene Plan (CHP). The CHP must cover the following items:
    - Safe work practices for all research and teaching facilities and operations
    - Procedures and controls to maintain exposures below the established exposure limits
    - Must have provisions for training, medical consultation, hazard identification, respirator use and record keeping
    - There is also a requirement for researchers to receive task and chemical specific training. This training only provides an overview. Your faculty member or supervisor will provide additional training

Chemical Hygiene Plan

- Responsibility
  - University Chemical Hygiene Committee
    - Creates, maintains and administers the plan. The most up-to- date copy is available at:
      - http://www.udel.edu/ehs/chemhygieneplan.pdf
    - Print copies are available upon request
  - Departmental level
    - Creates department specific requirements. These must be as stringent as the University plan
    - Contact your Departmental Chemical Hygiene Officer for information regarding the department specific plan
  - Laboratory Level
    - Faculty and Supervisors must teach and enforce the CHP and provide task/chemical specific training for all new procedures and at least annually. Faculty and supervisors must lead by example and follow all applicable sections.
  - Employee/Student Level
    - Must know and adhere to the CHP

Activities Requiring Prior Approval

- Environmental Health and Safety must be notified when certain operations or projects occur. The notification is required in order for EHS to help researchers and students safely perform the task or process.
  - Renovations to laboratory and research spaces
  - Use of Class IIIB or IV lasers
  - Explosive laboratory reactions or use of high explosives
  - Use of highly toxic chemicals, radioactive materials, carcinogenic materials, reproductive toxins or materials of unknown toxicity
  - Purchasing of refrigerators for chemical storage
  - Purchasing, moving or installing a chemical fume hood, laboratory exhaust ventilation or laminar flow equipment
  - Minors (under 18 years of age) working with hazardous materials or performing hazardous operations
  - Experiment or process that impacts building or laboratory design, i.e. a large piece of equipment or apparatus that blocks sprinkler heads
  - Purchase or use of a respirator.

Activities Requiring Prior Approval

- The Faculty Members, principal investigators or supervisors need to be aware of certain operations and approve the process:
  - Operations that use greater than 22 liters of a hazardous material
  - Unattended operations or reactions
  - Reactions or operations that proceed overnight
  - Operations that use high or low pressure
  - After hours work, including non-hazardous work

Part 2 - Health Hazards

"Health Hazard" refers to chemicals for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees.

It is important to understand how to identify the health hazards you may use at the University, how these materials may make you sick and how you may be exposed to the material.

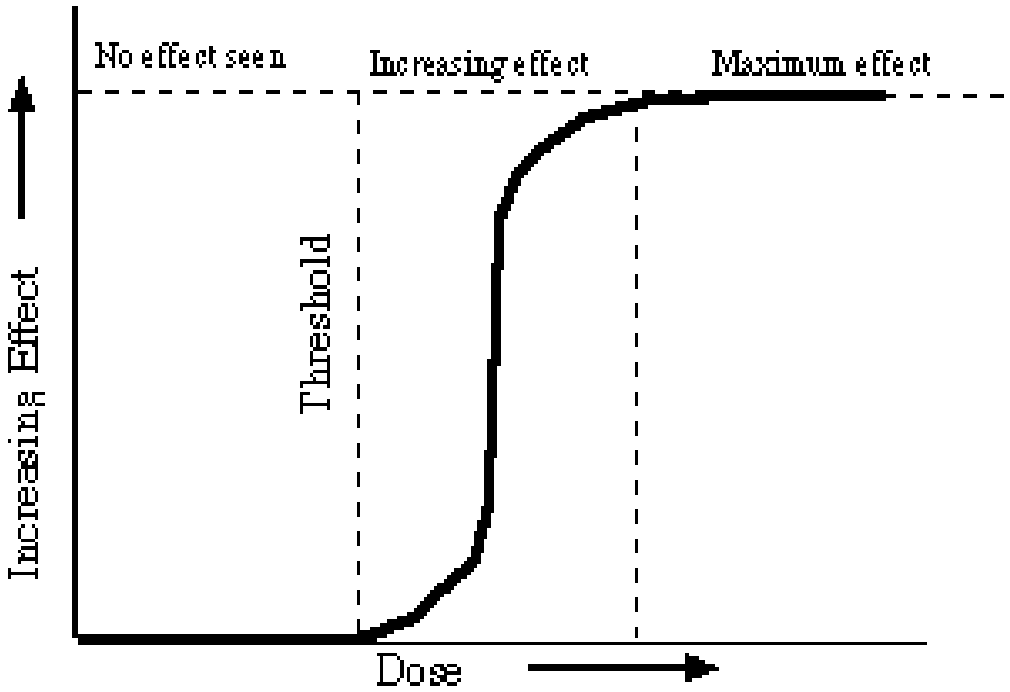
Detailed information is found in the Hazardous Materials Safety Manual and the Chemical Hygiene Plan. Please contact your department or EHS for a copy of the manual or the plan.

Introduction to Toxicity

- **Toxicity** is the ability of a substance to produce adverse health effects. Adverse health effects include cancer, cell toxicity, tissue death and functional deficiencies.
- The **toxicity hazard** is the probability that injury will occur considering the manner in which the substance is being used.
  - For example, the probability of an adverse health effect is greatly reduced if you utilize a fume hood when working with materials that are toxic by inhalation.
- The **dose response** is the correlation between the amount you are exposed to and the resulting effects on the body.
  - Try to work with concentration that is below the toxic dose for the material or use the most dilute concentration possible.
- As the **duration of exposure** increases, more molecules enter the body and cause problems.
  - Limit the amount of time you work with hazardous materials outside of fume hoods

Dose – Response Model

- The dose-response model teaches us that the toxicity risk increases as:
  - Relative Toxicity Increases
  - Concentration Increases
  - Length of Exposure Increases



The threshold of increasing effect will move based on the specifics of the exposure and individual

Toxicity and the Animal Modeling

- Degree of toxicity is often defined by animal modeling and testing. It refers to a dose fed/exposed to an animal population that kills 50% of that population.
- Ingestion, injection and absorption exposures are given as **LD (lethal dose)$_{50}$**. The units are typically mg/kg of body weight.
- Inhalation exposures are given as **LC (lethal concentration)$_{50}$**. The units are mg/m^3 or ppm (parts per million).
- Examples:

Chemical	Type of Test	Route of Exposure	Species	Dose Date
Acetone	LD50	Oral	Rat	5800 mg/kg
Benzene	LD50	Skin	Mouse	48 mg/kg
Hydrochloric Acid	LD50	Oral	Rabbit	900 mg/kg
Potassium Cyanide	LD 50	Oral	Rat	5 mg/kg

Human vs. Animal Dose

Even though this is an animal fatal dose, it is still the best method for relative toxicity. Use the table below to convert animal exposure (oral route for rats) to a human fatal dose.

Toxicity Rating	Animal LD_{50}	Fatal Dose For an Average Adult
Practically Nontoxic	>15 g/kg	more than 1 quart
Slightly Toxic	5-15 g/kg	between 1 pint and 1 quart
Moderately toxic (many lab chemicals fit into this category)	.5-5 g/kg	between 1 ounce and 1 pint
Very Toxic	50-500 mg/kg	between 1 teaspoon and 1 ounce
Extremely Toxic (requires DEHS approval)	5-50 mg/kg	between 7 drops and teaspoon.
Super Toxic (requires DEHS approvals)	<5 mg/kg	a taste (<7 drops)

Carcinogenic Materials

- Chronic exposure to carcinogens increases your risk of developing multiple types of cancers.
  - There are two general categories:
    - Materials Known to Cause Cancer in Humans
      - Significant, empirical, peer reviewed data exists showing that the material causes cancer in humans
      - Examples
        - » Cadmium – Lung cancer
        - » Benzene – Leukemia, lymphoma, multiple myeloma
        - » Ethylene Oxide – Leukemia, stomach cancer
        - » Vinyl Chloride – Liver cancer
    - Materials Suspected to Cause Cancer in Humans
      - Known to cause cancer in animals, but limited human data exists
      - Examples
        - » Formaldehyde – Nasopharyngeal and squamous cell cancer
        - » Carbon Tetrachloride – Liver cancer
        - » Lead and Lead Compounds – Lung, stomach and bladder cancer
        - » Multiwall Carbon Nanotubes – Lung cancer
- An inclusive list of carcinogens is found in Appendix E of the Chemical Hygiene Plan

Reproductive Toxins

- Materials with undesirable reproductive effects can affect both men and women. As long as there is a potential for conception, the student or employee must consider the reproductive effects of the materials they are routinely using.
  - Mutagens and teratogens are substances that may affect the embryo, fetus or the exposed person in a manner which produces cancer or disease. Issues include death of the unborn child, structural abnormality, altered growth and functional deficiencies
  - Certain chemicals can pass through the breast milk to a nursing child.
  - Other chemicals can be brought home on clothing and impact the health of very young children to the unborn child.
  - Physical hazards can also impact reproductive health.
- An inclusive list of reproductive toxins is found in Appendix E of the Chemical Hygiene Plan

Reproductive Toxins

- Examples
  - Mutagens – Impacts germ cells and other genetic material and causes multiple types of abnormalities
    - Lead – CNS deficiencies
    - Mitomycin – Affects stem cells
    - Vinyl Chloride – Damages DNA in sperm cells
  - Teratogens - cause congenital malformations, developmental abnormalities, fetal toxicity
    - Chloroform – Fetal death
    - Methyl tert-butyl ether – cleft palates
    - Toluene – delayed skeletal system growth
  - Sterilization – Impacts the ability to bear children
    - Carbamates (class of pesticides)
    - Cadmium
    - Sodium Dichromate
    - Vinyl Chloride
  - Lactation Hazard – Exposed mother passes the chemical through the breast milk to the nursing child.
    - Carboplatin (chemotherapy drug)
    - Estrogens

Sensitizers

- Causes exposed personnel to develop an allergic reaction in normal tissue after repeated exposures. The allergic reaction can increase in severity over time from a mild rash to anaphylactic reaction.
  - Examples
    - Latex, Chlorinated Hydrocarbons, Nickel Compounds, Formaldehyde

Neurotoxin

- Damages the nervous system. Can cause narcosis, behavioral changes, decreased muscle coordination. Some neurotoxins are cholinesterase inhibitors.
  - Examples
    - Lead, Chlorinated Hydrocarbons, Nickel Compounds, carbamates, organophosphate pesticides

Hepatotoxin

- Causes exposed personnel to develop liver disease such as liver cancer, cirrhosis of the liver, jaundice, liver enlargement and others
  - Examples
    - Organic Solvents, Chloroform, Carbon Tetrachloride, Dimethylsulfate, ethanol (component of alcoholic beverages)

Irritants

- Materials that cause inflammation of the mucous membranes. Can also cause changes in the mechanics of respiration and lung function. Long term exposure can result in chronic bronchitis
  - Examples
    - Hydrogen chloride, halogens, formaldehyde, acetic acid and iodine

Corrosives

- Typically considered a physical hazard. Some chemicals have serious systemic effects.
  - Examples
    - Hydrofluoric Acid – Decalcification of bones, Cardiac Arrhythmias, Cardiac Arrest
    - Phenol- Cytotoxic at the exposure site, water decontamination increases the systemic uptake.

Biohazards

- Exposure to biological organisms such as viruses, bacteria, microorganisms and biological toxins that may result in sickness or disease.
  - Examples
    - Pathogenic *E. coli*– gastrointestinal illness
    - *L. monocytogenes (Listeria)* – food poisoning, CNS impacts, Reproductive Toxin
    - Hepatitis B and C – Liver Cancer

Radioactivity

- Ionizing Radiation at high dose rates can cause tissue death, at low dose it impacts the genetic material of cells and tissues
  - Examples
    - X-Rays, Phosphorus 32, Tritium (H3), Uranyl Acetate
- Non-Ionizing Radiation can cause skin burns, blindness, impact implanted medical devices and affect genetic materials of cells and tissue
  - Examples
    - LASERs, Electromagnetic Radiation, Magnetic Radiation

Routes Into the Body

- There are various ways that a substance may enter the body. Below are possible routes of entry:
  - Dermal: absorption through skin
  - Inhalation: absorption through respiratory tract
  - Ingestion: absorption through digestive tract
  - Injection: puncture to the skin
  - Eyes: are susceptible to both liquid or vapor exposures
- The route of entry increases or decreases the toxicity depending on the circumstances.
  - For example, an acetone splash to the arm (a dermal exposure) may not cause any injury. An average human will receive a fatal exposure if they drink a pint glass of acetone (Ingestion Exposure)

Exposure Standards

- Many groups, some regulatory, publish exposure standards. These are typically **no effect** exposure levels, meaning that an average person should have no toxic effect if they maintain their exposure below the published standard.
- The idea is that the body is capable of responding to and handling a certain level of exposure without a toxic health effect.
- The data is based on animal modeling and testing as well as historical industrial and military exposure information.
- The data is usually for inhalation exposure and absorption exposure(dermal exposure).

Exposure Standards

- Employee exposure may not exceed these set exposure limits
- Employers must measure employee exposure when it is believed to be above an exposure standard.
- If you suspect that you are being exposed immediately contact your supervisor, Departmental Chemical Hygiene Officer, Safety Committee Chair or DEHS.
- You may be sent to the UD Occupational Health Doctor for an evaluation.
- EHS will perform a workplace assessment to determine what additional control may be necessary to protect the employee or student.
- Work with certain materials at the University may require regular visits to the Occupational Health Doctor to assure the workplace controls are minimizing acute and chronic exposure.
- In general, exposure standards do not account for an individual's preexisting medical conditions, exposures to the very old or very young or other mitigating factors.
- EHS's goal is to keep exposure at $^{1}/_{10}$ of an established exposure standard or below to account for individual susceptibility.

Exposure Standards

- There are two common exposure standards used by EHS to protect laboratory researchers and to evaluate the effectiveness of engineering controls and work practices. Both are based on a time weighted average (TWA) over an 8 hour work day.
  - Threshold Limit Values (TLVs):
    - Developed by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH is non-regulatory. The TLV are available for purchase from http://www.acgih.org/. EHS maintains the current edition for use by laboratory researchers
  - Permissible Exposure Limits (PELs):
    - Regulated by OSHA. These are available online at http://www.osha.gov/.
  - EHS will review the two sources and follow the standard that is more stringent

Exposure Standards

- There are other standards that you will see on a Material Safety Data Sheet (MSDS). These are important and will give you an idea of the degree of toxicity or hazard
- IDLH-Immediately Dangerous to Life or Health
  - Exposure that poses an immediate threat of loss of life or immediate or delayed irreversible adverse effects on health that would prevent escape from a hazardous atmosphere
  - Published by the National Institute of Occupational Safety and Health (NIOSH)
- STEL - Short Term Exposure Limit
  - 15 Minute TWA that should not be exceeded at any time during a work day
  - Typically assigned to carcinogenic and highly toxic materials
- Ceiling Limit
  - Limit that should never be exceeded at any time during a work day
  - Typically assigned to carcinogenic and highly toxic materials

Exposure Standards

Below is a comparison of the NIOSH, OSHA and ACGIH exposure limits based on the 2008 rules and recommendations. The OSHA limits are regulatory and require significant effort on the part of OSHA and the approval of Congress to change. NIOSH and ACGIH are able to update their standards regularly based on the current scientific data.

	Chemical	8 hr TWA	STEL	Ceiling Limit	NIOSH IDLH
ACGIH	Acetone	500 ppm	750 ppm	No Value	2500 ppm
OSHA	Acetone	1000 ppm	No Value	No Value	
ACGIH	Chloroform	10 ppm	No Value	No Value	500 ppm
OSHA	Chloroform	No Value	No Value	50 ppm	
ACGIH	Diethylamine	5 ppm	15 ppm	No Value	200 ppm
OSHA	Diethylamine	10 ppm	25 ppm	No Value	
ACGIH	Formaldehyde	No Value	No Value	0.3 PPM	20 ppm
OSHA	Formaldehyde	0.75 ppm	2 ppm	No Value	

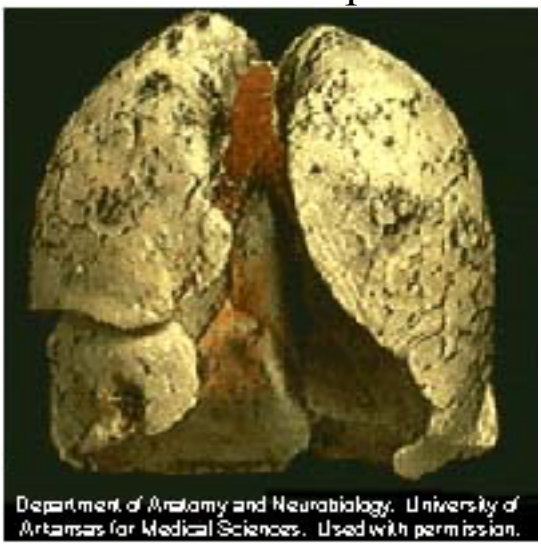
Factors Influencing Toxicity

- The following may increase or decrease the toxicity depending upon the circumstances:
  - The rate of substance entry and the route that it travels.
    - There may be greater chance of a toxic effect if you work with chemicals in high heat and high humidity or if you are performing physical activity while using chemicals. The increased breathing rate and heart rate will bring more molecules into your body.
  - Age, gender, and genetic predisposition
    - The very young and the elderly may experience a greater toxic effect from a chemical exposure. Some workers may have a genetic issue that makes them more susceptible to the toxic effect of an exposure
  - Health state, physical conditions, and lifestyle
    - A healthy person may be less affected by the toxic effects of an exposure. A person whom consumes a significant amount of alcohol and works with organic solvents has two serious exposures that may cause liver cancer or liver disease.
  - Whether or not a previous exposure has occurred
    - Repeated exposure to organophosphate and metals such as lead, arsenic and mercury will increase the toxic effects.

Types of Exposure

- Exposures can be classified into two broad categories. Use of personal protective equipment and engineering controls can protect workers from both types of exposures
- **Acute Exposure:**
  - Characterized by a short duration exposure, where symptoms are typically immediate.
- **Chronic Exposure:**
  - Characterized by prolonged or repeated exposures to a substance for the duration of days, months, or years.
  - Exposure symptoms may not be immediately noticeable
- **Latency Period**
  - The time between the exposure and the resulting effects.

Acid Exposure, an example of an acute exposure



Lung tissue after years of smoking cigarettes, an example of a chronic exposure

Part 3 - Physical Hazards

Materials which present a physical hazard can be safely used if the specific hazard(s) are understood, and measures are taken to address the hazards. If appropriate precautions are not taken, a fire, an explosion, unwanted corrosion, personal injury, or property damage could occur.

Detailed information is found in the Hazardous Materials Safety Manual and the Chemical Hygiene Plan. Please contact your department or EHS for a copy of the manual or the plan.

Physical Hazards Commonly Found in the Laboratory

- Flammable/Combustible Materials
- Corrosives
- Oxidizing Agents
- Peroxide Formers
- Pyrophoric Chemicals
- Water Reactive Chemicals
- Compressed Gas
- Cryogenic Material
- Egress Hazards and Housekeeping
- Electrical Hazards
- Sharps Safety
- Soldering Operations
- Fire Safety
- Special Hazards

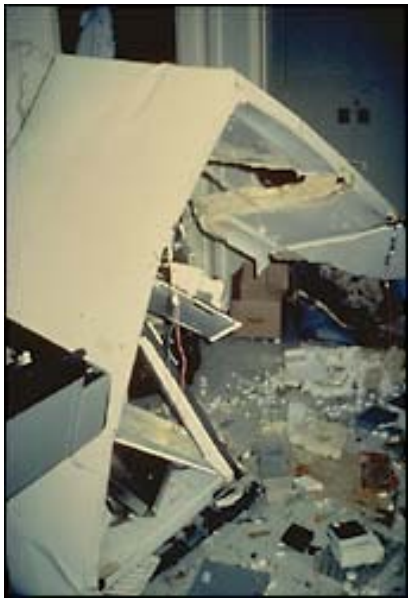
Flammables and Combustibles

- Materials under standard conditions that can generate enough vapor to cause a fire.
  - Flammable Liquid - Flash Point <100° F
    - Examples – Acetone, Benzene, Ethyl Ether, Ethanol, Hexane, Toluene
  - Flammable Gases - Gas that at ambient temperature and pressure forms a flammable mixture with air
    - Examples – Hydrogen, Acetylene, Carbon Monoxide, Propane
  - Combustible Liquid - Flash Point between 100° F - 200° F
    - Examples – Fuel Oil, Pump Oil, Mineral Oil
  - The **Flash Point** is the lowest temperature at which a liquid gives off enough vapor to form an ignitable substance and burn when an ignition source is present.

Flammables and Combustibles

- Work Practice Controls
  - Utilize personal protective equipment
  - Eliminate sources of ignition
  - Work in the chemical fume hood
  - Minimize quantity, limit the number of wash bottles and stock containers on the bench top or in the fume hood
  - Store appropriately - in flammable cabinet
  - Refrigerators/freezers must be explosion proof
  - Never heat using open flames
    - Use steam baths, water baths, oil baths, hot air baths, flask heaters, hot plates and heating mantels.

Store flammable combustible liquids in rated flammable cabinets.



A residential refrigerator explosion due to storage of flammable liquids in the unit

Corrosive Materials

- Can react with skin to form burns or irritation, usually acids and bases.
- Free Hydrogen Ions, due to the disassociation from the salt, denature the proteins and cause necrosis
- Free hydroxides, due to the disassociation from the salt, denature proteins and saponify fats causing deep tissue necrosis
  - Corrosive Liquids have a high potential to cause tissue damage
  - Corrosive Gases are absorbed into the body through skin contact, pose an eye and inhalation hazard
  - Corrosive Solids and their dusts can damage tissue by dissolving rapidly in moisture on the skin or within the respiratory tract when inhaled.
  - If a material has pH of less than 4, there is an acidic hazard
  - If a material has a pH greater than 10 there is a caustic hazard

Corrosive Materials

- Work Practice Controls
  - Additional safety training is recommended
  - Utilize personal protective equipment
  - Use corrosive resistant containers
  - Conduct processes in the fume hood
  - Add acid to water never vice versa
  - Store acids separate from caustics

Use a bottle carrier to move chemicals from storage locations to the use areas

Store corrosive material in a rated storage cabinet

Inorganic Acids | **Caustics** | **Flammable and Organic Material** | **Organic Acids**

Proper segregation for Corrosive Materials

Oxidizing Agents

- Substances that, while in themselves are not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.
- It takes three components for a fire to happen - a fuel source (an organic compound), an ignition source (such as a flame, a spark, friction, etc.) and an oxygen source.
- Common Oxidizer Groups:

Chemical Group	Chemical Formula
Peroxides	O_2^{-2}
Nitrates	NO_3^-
Nitrites	NO_2^-
Perchlorates	ClO_4^-
Chlorates	ClO_3^-
Chlorites	ClO_2^-
Hypochlorites	ClO^-
Dichromates	$Cr_2O_7^{-2}$
Permanganates	MnO_4^-
Persulfates	$S_2O_8^{-2}$

Oxidizing Agents

- Oxidizing agents can be categorized into four classes:

Class Rating	Hazard Description
Class 1	An oxidizing material whose primary hazard is that it may increase the burning rate of combustible material with which it comes in contact.
Class 2	An oxidizing material that will moderately increase the burning rate or which may cause spontaneous ignition of combustible material with which it comes in contact.
Class 3	An oxidizing material that will cause a severe increase in the burning rate of combustible material with which it comes in contact or which will undergo vigorous self-sustained decomposition when catalyzed or exposed to heat.
Class 4	An oxidizing material that can undergo an explosive reaction when catalyzed or exposed to heat, shock or friction.

Oxidizing Agents

	Examples	
Class 1	aluminum nitrate ammonium persulfate barium chlorate barium nitrate barium peroxide calcium chlorate calcium nitrate calcium peroxide cupric nitrate hydrogen peroxide (8-27%) lead nitrate lithium hypochlorite lithium peroxide magnesium nitrate magnesium perchlorate magnesium peroxide nickel nitrate nitric acid (<70%)	perchloric acid (<60%) potassium dichromate potassium nitrate potassium persulfate silver nitrate sodium carbonate peroxide sodium dichromate sodium nitrate sodium nitrite sodium perborate sodium perborate sodium perchlorate sodium persulfate strontium chlorate strontium nitrate strontium peroxide zinc chlorate zinc peroxide
Class 2	calcium hypochlorite (<50%) chromic acid chromium trioxide hydrogen peroxide (27-52%) nitric acid (>70%)	potassium permanganate sodium chlorite (<40%) sodium peroxide sodium permanganate trichloro-s-triazinetrione
Class 3	ammonium dichromate potassium chlorate hydrogen peroxide (52-91%) potassium dichloroisocyanurate calcium hypochlorite (>50%)	sodium chlorate perchloric acid (60-72%) sodium chlorite (>40%) potassium bromate
Class 4	ammonium perchlorate ammonium permanganate guanidine nitrate	hydrogen peroxide (>91%) perchloric acid (>72.5%) potassium superoxide

Oxidizing Agents

- Work Practice Controls
  - Additional safety training is recommended
  - Know the reactivity of the materials involved
    - If a reaction is unknown:
      - Contact Supervisor or DEHS for assistance
      - Conduct a process safety review with a cold run (without chemicals)
  - Conduct a process safety review to identify all potential hazards and develop mitigating steps
  - Consider the use of safety shield, or other methods for isolating the material or the process
  - Store properly away from organic materials, flammables, reducers

Peroxide Formers

- Materials that react with oxygen to form peroxides which can explode due to impact, sudden change in temperature or friction.
- The formation of peroxides can occur under normal storage conditions, concentration by evaporation, distillation or consumption of an inhibitor.

List A Peroxide Hazard on Storage	List B Peroxide Hazard on Concentration	List C Hazard Due to Polymerization
Discard 3 months after opening	Discard 12 months after opening	Discard 12 months after opening
Isopropyl Ether Divinyl Acetylene Vinylidene Chloride Potassium Metal Sodium Amide	Ethyl Ether Tetrahydrofuran Dioxane Acetal Vinyl Ethers 2-Butanol 2-Propanol Cyclohexene Cumene Methylcyclopentane Methyl Acetylene Diacetylene Dicyclopentadiene	Styrene Butadiene* Tetrafluorethylene* Chlorotrifluorethylene Vinyl Acetylene Vinyl Acetate Vinyl Chloride Vinyl Pyridine Chloroprene*
* When stored as a liquid, the peroxide-forming potential of these materials increases and should be considered a List A compound.		

Peroxide Formers

- Work Practice Controls
  - Additional safety training is recommended
  - Conduct a process safety review to identify all potential hazards and develop mitigating steps
  - Date all peroxide formers when received and when opened w/indelible ink
  - Dispose of the material based on the manufacturer's expiration date or within 3 to 12 months based on the specific peroxide former
  - Do not refrigerate below the temperature at which the peroxide freezes or precipitates, this will increase the shock sensitivity
  - Never distill to complete dryness (this concentrates the peroxide) this has been implicated in many lab explosions
  - Store appropriately, according to the manufacturer's recommendations
  - Periodically check for peroxide concentration using test strips
  - Protect from the light
  - Do not open container that has obvious crystal formation, call EHS 831-8475

Pyrophoric Chemicals

- Pyrophoric materials ignite spontaneously when exposed to air. They must be handled so as to rigorously exclude air/moisture. They also tend to be toxic and usually come from the supplier dissolved in a flammable solvent, which increases the flammability hazard.
- Other common chemical and physical hazards include corrosivity, teratogenicity, water reactivity and peroxide formation, along with damage to the liver, kidneys, and central nervous system.
- Examples
  - t-Butyllithium
  - Triethyl zinc
  - Triethyl aluminum
  - Many organometallic compounds
  - Grignard Reagents
  - Yellow or white phosphorus

Pyrophoric Chemicals

- Work Practice Controls
  - Additional safety training is recommended
  - Conduct a process safety review and a standard operating procedure to identify all potential hazards and develop mitigating steps
  - Lab Coat, (not made from easily ignited material like nylon or polyester) *must be worn*. Special fire-resistant lab coats made from Nomex are more expensive ($30 - $50), but recommended for labs using these reagents routinely
  - Handle only in an inert atmosphere
  - Inspect containers for cracked lids or corrosion
  - Store under recommended material, e.g. water, mineral oil or nitrogen
  - Store in isolated area
  - Minimize quantities stored

Pyrophoric Chemicals

- Work Practice Controls
  - Safety shielding is required any time there is a risk of explosion, splash hazard, or a highly exothermic reaction. All manipulations of reactive materials, which pose this risk, should occur in a glove box, dry box or fume hood with the sash in the lowest feasible position.

A glove box is the best engineering control for the use of pyrophoric chemicals

Water Reactive Chemicals

- Water reactive chemicals release heat, flammable, toxic, or oxidizing gas, metal oxide fumes or may form corrosive acids
- Particularly hazardous to firefighters since they generally flood a fire with water
- Indicated on labels and signs by symbol
- Examples
  - Alkali metals
  - Alkaline earths
  - Hydrides
  - Carbides
  - Phosphides
  - Nitrides
  - Metallic peroxides
  - Non-metal and transition metal chlorides

Pyrophoric Chemicals

- Work Practice Controls
  - Additional safety training is recommended
  - Conduct a process safety review to identify all potential hazards and develop mitigating steps and complete a standard operating procedure
  - Handle away from water
  - Even moisture in air can start a fire, or cause an explosion
  - Moisture in skin may form a corrosive
  - Store under recommended material, e.g. kerosene, mineral oil, hexane
  - Store in isolated area
  - Store in water-tight cabinet or dessicated
  - Suitable fire suppressant must be available

A Class D fire extinguisher must be present in laboratories that use large quantities of water reactives.

Compressed Gasses

- An average cylinder contains gas at pressures of approximately 2000 pounds/square in (psi)
- Gas cylinder can contain flammable, toxic, corrosive, reactive or asphyxiating gases
- Additional safety training is recommended
- Work Practice Controls
  - Conduct a process safety review to identify all potential hazards and develop mitigating steps
  - Use smallest size cylinder
  - Handle as high energy sources
  - Do not store a gas cylinder between a work area and an exit.
  - Store in an upright position and chain each independently approx. 2/3 the way up the cylinder
  - Use appropriate cart for moving
  - Always cap with the safety caps when not in use or when moving
  - Do not tamper, lubricate, replace or modify the gauges

Compressed Gases

- Work Practice Controls
  - Never bleed completely-prevents contamination
  - Check labels frequently and replace any that have been damaged or peeling immediately
  - Purchase gas/pressurized liquids from suppliers that accept cylinders back
  - Toxic, corrosive, reactive gases - should contact EHS for specific storage and use instructions
  - Never situate cylinders near heat or where they can become part of an electrical circuit

Compressed Gas Cabinet

Properly secured gas cylinder. Note that the tubing goes up and over as opposed to across the floor

Cryogenic Material

- Extreme cold temperatures can cause frost bite, tissue death and permanent eye damage
- The expansion ratio when the liquefied cryogenic gases go through a phase change can displace all the oxygen in a room or laboratory. For example, liquid nitrogen expands 700 times.
- Special training is necessary to work with cryogenic liquids or use the liquid nitrogen filling station on campus.

Cryogenic Materials

- Work Practice Controls
  - Containers should have pressure relief valves
  - Systems should be able to withstand extreme cold without becoming brittle
  - Follow the established SOP for filling small and large dewars. Available at http://www.udel.edu/ehs/labsop.html
  - Don appropriate personal protective equipment
    - Liquid impervious cryogenic gloves
    - Face shields for filling and pouring operations
    - Hearing protection for filling operations

Required personal protective equipment for cryogenic liquid work.

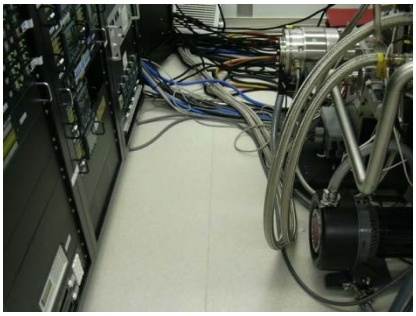
Egress Hazards and Housekeeping

- Do not limit your safe egress from a laboratory with clutter.
- Assure that there is a clear 36” (or greater) aisle space throughout the laboratory.
- Housekeeping issues can cause a minor emergency or spill to be far more serious as excess materials become involved in a fire or chemical spill.
- These materials may prevent the sprinkler system from completely extinguishing a fire.

This a Faculty Member’s office. There are floor loading issues due to the weight of the materials, h/she doe not have a safe way out of the office. There could be a significant fire that the sprinkler system may not be able to extinguish.

Egress Hazards and Housekeeping

Never store chemical or chemical waste on the floor of the laboratory



Do not block an aisle with cords or wires. There is also only a 16” aisle between the 2 pieces of equipment

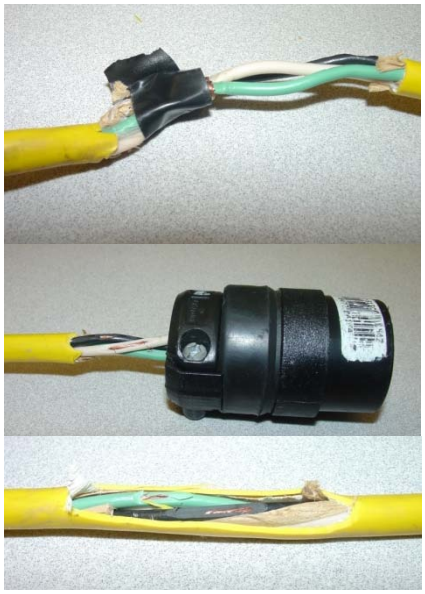
Do not block safety showers, eyewash stations and fire extinguishers with equipment or clutter

Electrical Hazards

- Extension cords are permitted only for temporary use, provided the weight of the cord is adequate for load applied.
- Use UL listed power strips with an inline circuit breaker in place of extension cords
- Check for frayed or damaged electric cords
- Have a certified electrician make repairs to equipment

Do not use extension cords. Use a UL listed power strip with an inline circuit breaker

Always check for damaged, frayed or improperly connected or repaired cord



Electrical Hazards

- Ground Fault Circuit Interrupter (GFI) is required when an outlet is within 36” of a source of water.

Some outlets have the GCFI protection in the circuit breaker box. These outlets should have a label that identifies them as GFCI protected. The label is at the top of the outlet.

Standard GFCI outlet with the test/reset buttons on the outlet

Sharps Safety

- Needles and Syringes shall be secured at all times. Position a sharps container or other collection container directly adjacent to the work area
- Do not recap needles, dispose of them directly into the sharps container.
- If you are reusing needles, utilize a recapping device and store/secure them properly.

Improper way to store needles

An example of an recapping device

Fire Safety

- No storage within 18 inches of sprinkler heads. Storage close to a sprinkler head will limit its ability to extinguish a fire
- Do not store excess combustible material such as cardboard boxes in the laboratory
- Develop written Standard Operating Procedures for operations that use open flames.
- Position ovens and other heating devices away from combustibles and flammable liquid storage areas.

These boxes are stored too closely to the sprinkler head.

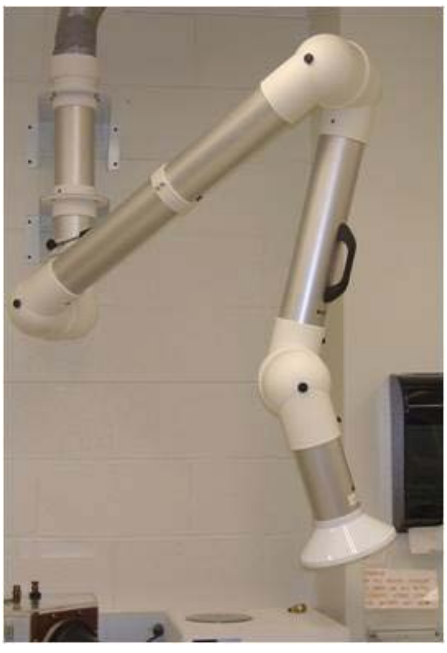
Soldering Operations

- Researchers performing soldering operations may be exposed to the following fumes and gases:
  - Lead oxide
  - Carbon monoxide
  - V.O.C (volatile organic compounds)
  - Abietic, Pimaric acid
  - Aliphatic aldehydes
  - Hydrochloric acid
  - Isocyanates
  - Isopropyl alcohol
  - Trivalent Chromium
  - Phenols and Phenolic Compounds
- Over exposure causes skin irritation, allergenic conditions, bronchitis, Sinonasal cancer, carcinogenic (heart/lung) diseases

Soldering Operations

- Perform all soldering operations in a fume hood or utilize trunk ventilation.
- If laboratory exhaust ventilation is not available, utilize a fume extractor designed for soldering operations

Commercially available Fume Extractors



Articulating Exhaust Trunk

Part 4 - Hazard Information Sources

The Hazardous Chemical Information Act defines a hazardous chemical as any element, chemical compound or mixture of elements and/or compounds which poses a physical hazard or a health hazard.

Many hazard information sources exist. Researchers and students must know how to interpret and understand the available information and data.

The Department Chemical Hygiene Officer and Environmental Health and Safety are available to help with the interpretation and recommendations.

Chemical Inventories

- The OSHA standard requires that employees/students be trained in the hazards present in the workplace.
- New personnel working in a laboratory should first review the chemical inventory to assure that they are properly trained and do not have any issues with the chemicals used or stored in the space prior to beginning work.
- A good inventory will have a complete list of chemicals stored and used in a laboratory or area and include the following information:
  - Common chemical name
  - Storage location
  - Quantities
  - Special hazards
- A new web based inventory and laboratory management program is available: http://ehs.facil.udel.edu:1568

Chemical Inventories

- An updated inventory will also help to:
  - Reduce stockpiling and limits the amount of duplicate compounds stored in the laboratory
  - Provides an opportunity to check the integrity of the chemicals and containers (i.e. picric acid that has become dry)
  - Assures that a laboratory has not exceeded the fire and building code quantity limitations for certain classes of chemicals
- This inventory should be updated on a continual basis to assure compliance with Fire and Building Codes and the Federal Department of Homeland Security Chemical Facility Antiterrorism Act.
- The researcher should contact their supervisor, the Departmental Chemical Hygiene Officer or EHS if they have a concern about the chemicals used or stored in the laboratory.

Material Safety Data Sheets

- Material Safety Data Sheets (MSDSs) contain hazard and safe handling information for hazardous materials
- Every chemical shipped must have an MSDS
- Statements in the MSDS(s) may be general.
- While it is common for MSDSs to have 16 sections, this is not always the case because MSDSs are not currently standardized. They are currently required to have at least 8 sections. Important information will always be included, but not always in the same order.
- **Do not assume** that everything you need to know is in the MSDS(s).
- A current print version of a MSDS must be available for all chemicals used or stored in the laboratory. EHS can provide MSDS if they did not arrive with the chemical.
- Researchers and students should consult two MSDS resources for every chemical they plan to use before they start the experiment or procedure. This review will be used in the development of the SOP and process safety review.
- An annual review of all MSDS should be included as part of the annual chemical safety training refresher.

Material Safety Data Sheets

- MSDS contain information that identify the chemical, including:
  - Chemical names and synonyms.
  - Physical properties (appearance, odor, boiling point, etc.)
  - Recommended Proper Personal Protective Equipment.
  - Spill response information.
  - Health and Physical Hazards
  - Acute and chronic exposure symptoms.
  - Incompatibility information and storage recommendations and requirements
- EHS purchases a subscription to two comprehensive MSDS services. These must be accessed by a computer connected to the UD system or through the proxy server
  - ChemWatch Program
    - http://udel.chemwatchna.com/
  - Canadian Center for Occupational Health and Safety
    - http://ccinfoweb.ccohs.ca/msds/search.html
  - Manufacturer's MSDS used at the University
    - http://www.udel.edu/ehs/msds/msds.html

Chemical Labels

- In most cases, the label will indicate if the chemical is hazardous. Look for key words like **caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen, etc.**
- Old containers of hazardous chemicals (before 1985) may not contain hazard warnings.
- All containers must be labeled, regardless of the container size or the quantity of the substance.
  - When labeling wash bottles, dilutions and containers, use the common chemical name and the percentage of the solution.
  - Abbreviations are only permitted on very small containers.
  - Label all samples and synthesized products with a unique number system. List out the complete information for each sample in the laboratory notebook.
- **Do Not** use any chemical that is not properly labeled

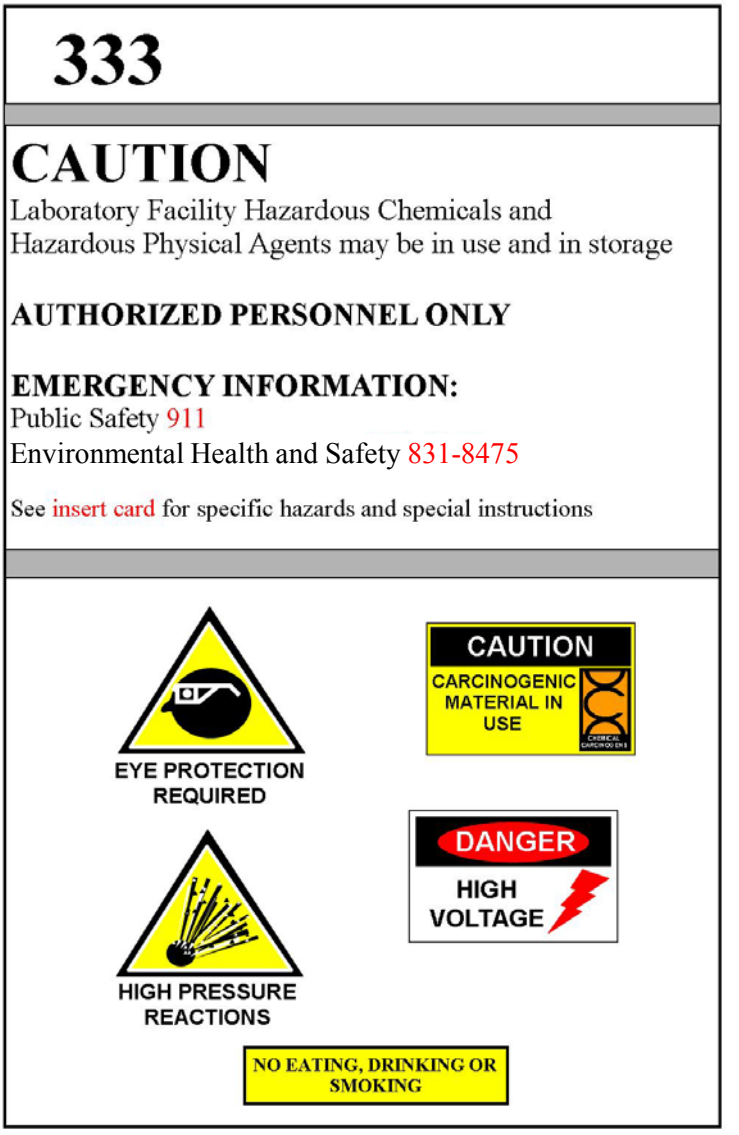
Chemical Labels

- Make sure that labels are not defaced or removed
  - Use annual inventory to check condition of chemicals and labels
- Labels on the chemicals provide information

Explanation of the Hazard Code Systems

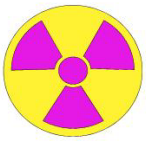
Laboratory Signs

All laboratories and hazardous material storage areas should be placarded with a standard Laboratory Warning Sign. This is an example of a lab hazards sign. The signs will communicate the general hazards found in the room. You will see signs such as this throughout the University of Delaware – **Remember to Dial 9-911 on the Lewes and Georgetown Campuses and 911 on the Newark Campus**

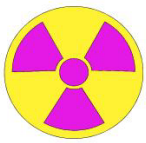


Available Graphics for the Laboratory Warning Signs

X-RAY PRODUCING DEVICES



RADIOACTIVE MATERIALS



STRONG MAGNETIC FIELD

RF/MICROWAVE RADIATION

BIOLOGICAL HAZARD

EYE PROTECTION REQUIRED

ACUTELY TOXIC MATERIAL

ACUTELY TOXIC GAS

HEARING PROTECTION MAY BE REQUIRED

HIGH PRESSURE REACTIONS

Other Information Sources

- The University subscribes to the Registry of Toxic Effects of Chemical Substances (RTECS), a database of critical toxicological information for more than 165,000 chemical substances.
  - http://ccinfoweb.ccohs.ca/rtecs/search.html
- NIOSH has compiled a list of hazard information sources, including international resources.
  - http://www.cdc.gov/niosh/database.html
- The Agency for Toxic Substances and Disease Registry (ATSDR) provides comprehensive hazard information on many industrial and laboratory chemicals.
  - http://www.atsdr.cdc.gov/toxfaq.html

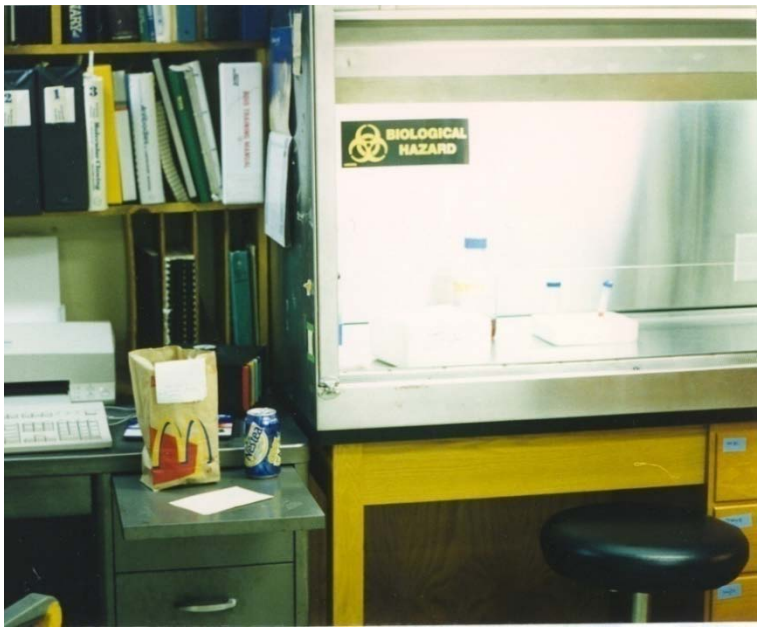
Part 5 - Protective Measures

After researchers and students understand the hazards they may be exposed to in the laboratory setting they must develop protective measures to minimize or eliminate injury, illness or accidents.

Administrative Controls

- The goal of administrative controls is to reduce work hazards through management arrangements and written rules.
- **Administrative Controls Include:**
  - Adhering to safe lab practices as taught by instructors
  - Dispose of waste in designated containers
  - Attend all necessary training
  - Never lock doors while in a lab working (do not block lab windows)
  - Do not limit egress with clutter

Do not eat, drink or store food in the laboratory



Administrative Controls

- **Administrative Controls Include, continued:**
  - Use secondary containers during storage of liquids
  - Good housekeeping & do not stockpile chemicals
  - Restrict access to your laboratory, lock the door and secure the space when no one is in the laboratory
  - Never store liquids above eye level
  - No mouth pipetting
  - Substitute for a less toxic substance
  - Never work alone in the laboratory
  - Develop Standard Operating Procedures (SOP) and Job Hazard Analysis (JHA)
    - SOP's and JHA frameworks and examples are available at http://www.udel.edu/ehs/labsop.html

Administrative Controls

- http://www.udel.edu/ehs/safetyprocedures/hazardanalysischecklist.pdf
- Development of a Job Hazard Analysis is a simple approach to hazard identification and protection.
  - Select the job task to be analyzed.
  - Identify the major sequences for each step
  - Identify the potential hazards for each step
  - Determine preventative measures to protect against the hazards
  - Develop a worker-training program
  - Reevaluation

Administrative Controls

Use a bottle carrier or a sturdy cart to move containers of liquid chemicals.

Administrative Controls

One of the most important administration controls when working with chemicals is to decontaminate before leaving the laboratory and eating, drinking, smoking, applying cosmetics, lip balm, or going to the bathroom

Engineering Controls

- Engineering controls are used to minimize exposure to substances and/or remove contamination.
- These are typically implemented if an administrative control does not eliminate the hazard or exposure.
- **Example of an Engineering Control:**
  - Chemical Fume Hoods
  - Exhaust Trunks
  - General Laboratory Ventilation
  - Glove Boxes

Chemical Fume Hoods

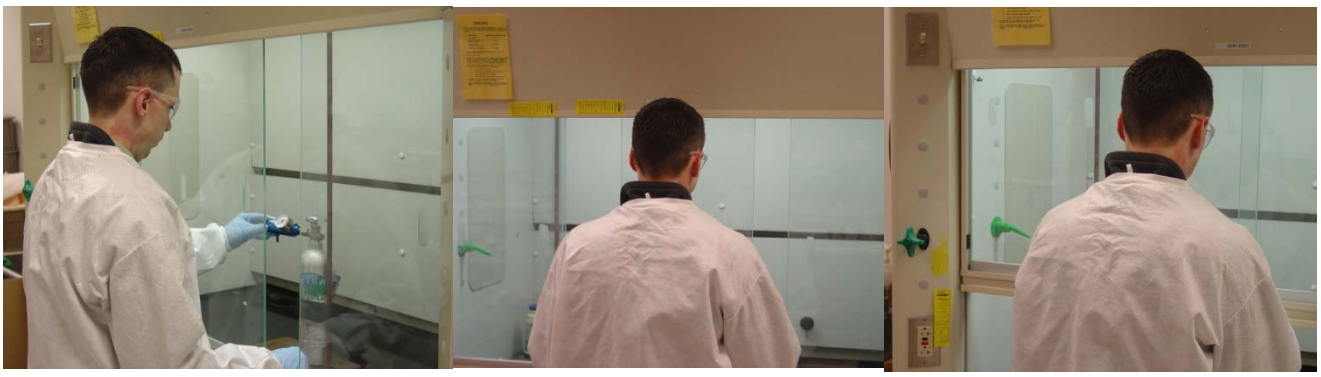
- Chemical fume hoods are used to prevent the inhalation of chemical contaminants. The substances being used are placed inside the fume hood to allow the fan(s) to draw the contaminants away from the individual. Hoods must also be used properly by researchers to prevent exposures

Chemical Fume Hoods

- Check the certification sticker for the expiration date. Do not use the unit if the certification is expired. Lower the sash to the level indicated on the sticker. Contact DEHS to certify the unit.
- Visually check your magnehelic gauge or audible/visual alarm to verify that the system is operational.
- Clear the fume hood deck area. Remove all materials from hood which are not needed for immediate work.
- Locate work at least 6 inches inside the sash and center relative to the hood sides.
- Completely clean and decontaminate your fume hoods regularly.
- Appropriate protective equipment, such as safety glasses/splash goggles, face shields, lab coats, and task specific chemical protective gloves must be worn.
- Report unsatisfactory units to:
  - Facilities Service Desk - x1141
  - Environmental Health & Safety - x8475

Chemical Fume Hoods

- Position the sash so it provides splash, spray and mist protection.
- It should cover as much of the user's body as possible.
- Some hoods have both horizontal and vertical sashes.
- Lower the sash to the level indicated on the sticker.
- If the sash does not provide body and face protection, contact DEHS for assistance.



Proper use of the sash for body and face protection

Chemical Fume Hoods

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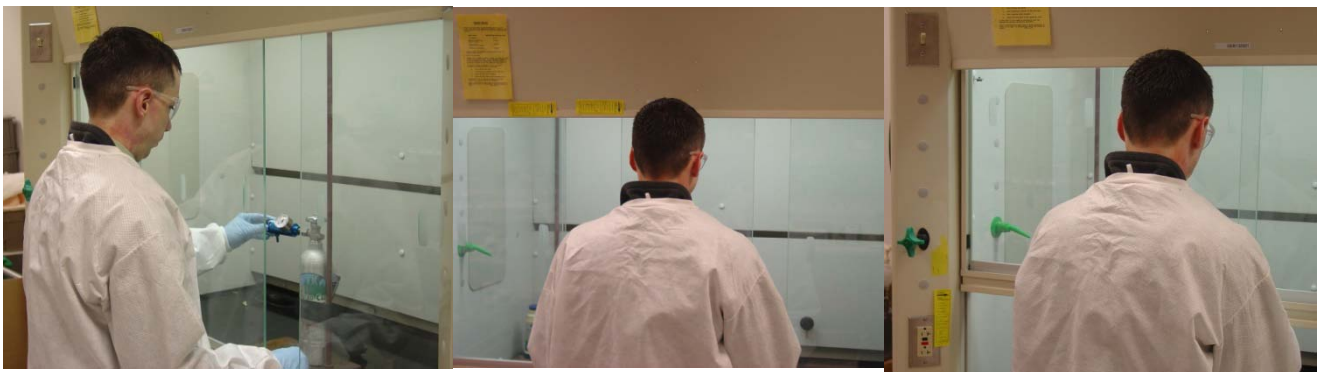
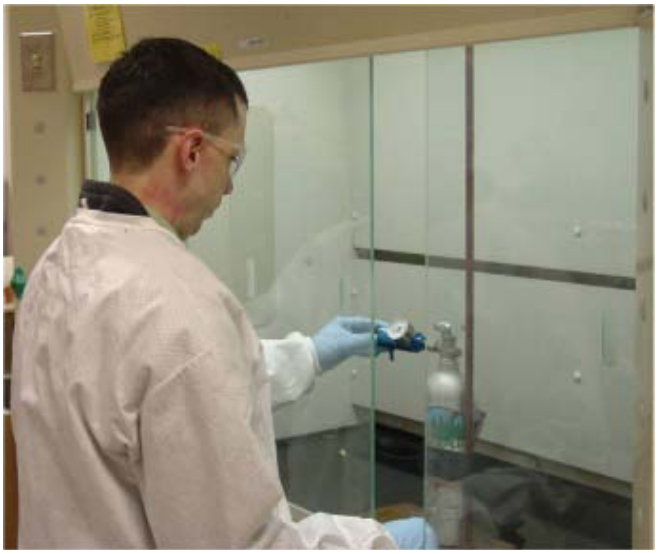


Proper use of the sash for body and face protection

Chemical Fume Hoods

Proper way to work in a Chemical Fume Hood, this arrangement optimizes the capture velocity. The sash acts as a physical barrier and provides splash and spray protection.



Chemical Fume Hoods

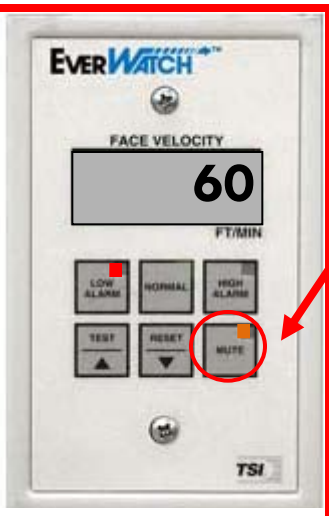
Improper/unsafe way to work in a Chemical Fume Hood, there is minimal capture velocity. The sash does not provide a physical barrier or splash and spray protection.

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Audio/Visual Alarms in LDL And Drake Hall

Normal Operation



Velocity Too Low; Lower the Sash to raise velocity.

It is OK to push the mute button to temporarily silence the audible alarm; however, DO NOT work in the hood if the velocity does not meet the values listed above.

Velocity Too High; Open the sash to lower the velocity below 125 ft/min. Assure that sash still provides face and body protection while actively using the hood.

Close the hood sash completely when not working in the unit. When hood sash is fully closed, face velocity may rise above 125 ft/min. This is normal. When resuming hood work, make sure face velocity falls to normal range before starting work.

Always wear your safety glasses, lab coat and chemical protective gloves when working in the laboratory.

Safety Showers and Eyewash

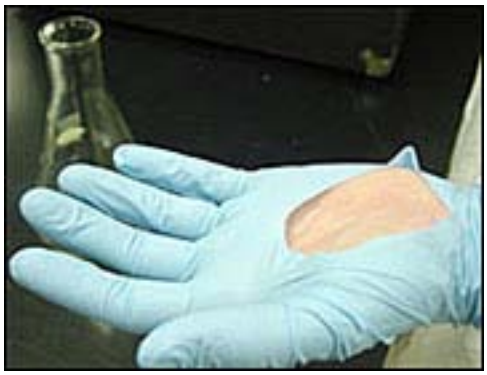
- Safety showers and eye wash stations are used as a safety measure in case of contact with a substance.
- They should be installed in a laboratory or directly outside of a laboratory and accessible at all times
- Units are inspected annually by Plumbing Services
- EHS recommends that users flow the eye washes weekly. Contact EHS for assistance.

Personal Protective Equipment

- Personal protective equipment is used to protect you from chemical and physical hazards.
- **Areas of PPE include:**
  - Eye and Face Protection: (i.e. Safety Glasses, Goggles, and Face Shields)
  - Hand Protection: (i.e. Proper Gloves)
  - Body Protection: (i.e. Aprons and Lab Coats)
  - Foot Protection: (i.e. Safety Shoes)

PPE Considerations

- Frequent inspection – Make sure that there are not any holes, tears, rips etc… that could compromise the protection



- All PPE, such as lab coats, gloves and any contaminated protective equipment, should be removed and left or properly disposed of in the lab area.
- For added protection, general lab clothing should include a laboratory coat, closed toe shoes, sleeved shirts, and pants or dresses that extend below the knees.
- Use a laboratory coat with knit wrists
- Change or launder protective garments as required

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Proper Laboratory Attire

Not ready to work safely in the laboratory

Ready to work safely with corrosive, cryogens and materials that are toxic by absorption

Ready to perform very basic non-hazardous operations in the laboratory

This is a picture of a student's leg who was wearing shorts and spilled a corrosive chemical (Liquid Bromine). Notice how the sock protected her ankle. Long pants and a lab coat may have prevented the injury.

Courtesy of the University of Texas, Used with Permission

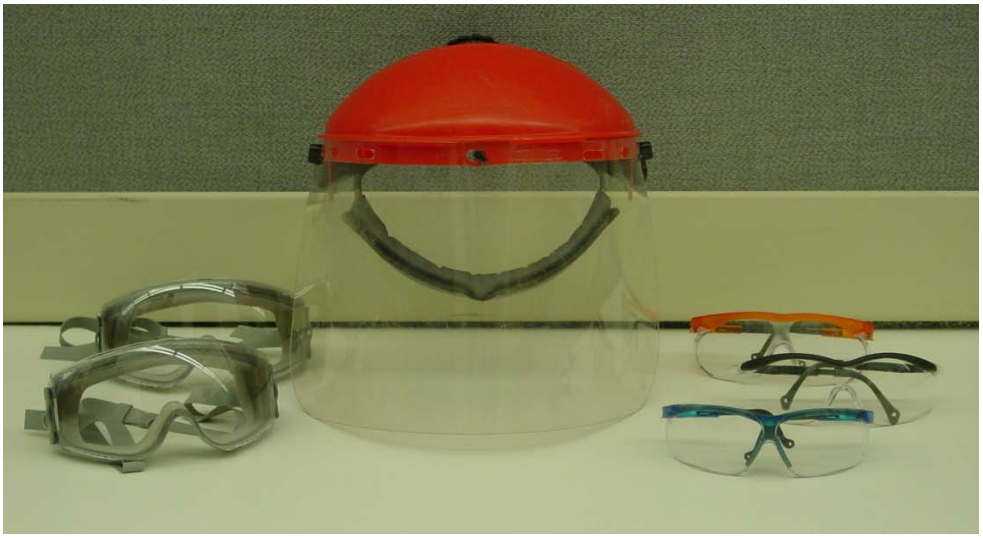
Chromic acid splash on fabric shoes. This student reportedly experienced a chemical exposure due to leakage through the fabric. It is very important to remove all contaminated clothing, including shoes and socks while in the safety shower for fifteen minutes.

Sulfuric acid/Chromege splash. This graduate student received second degree chemical burns to their shoulder, but clothing protected the rest of the body. A lab coat may have prevented the shoulder burn.

Acid Burn to the Feet – A researcher was wearing flip flops and dropped a 4L glass bottle of sulfuric acid on the floor.

Eye Protection

- University Policy 7-23 states everyone is required to wear eye safety protection when in a lab.
- There are three general types of eye protection we will cover:
  - Safety Glasses
  - Goggles
  - Face Shields



Safety Glasses

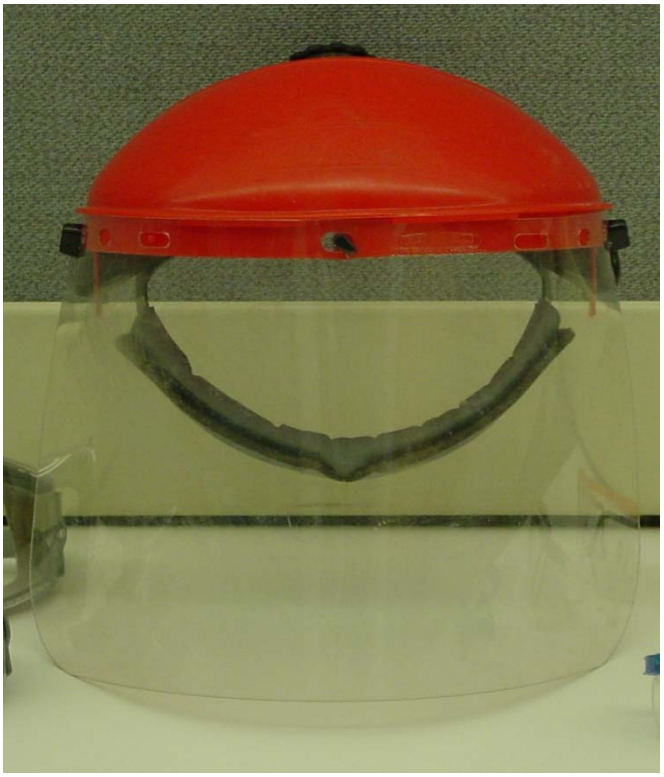
- **Safety Glasses** with side shields are used when there is the potential for dust particles and flying objects to be expelled into the air. They are impact resistant.
- All safety glasses must have side shields and be ANSI (American National Standards Institute) approved.
- Prescription safety glasses must have side shields as well. Contact your supervisor for more information.
- In general, required in a laboratory at all times

Splash Goggles

- **Goggles** shield the entire eye area. They are used for protection against chemical splashes, sprays, mists and/or impact.
- Indirect Venting: used mainly in goggles designed for chemical sprays and mists.
- Direct Venting: used in goggles designed for high impact areas.
- Prescription inserts for goggles are available from the manufacturer. The prescription inserts must be filled by an optometrist. Contact your supervisor for more information.
- Indirect venting splash goggles are required whenever a splash, spray or mist hazard exists.

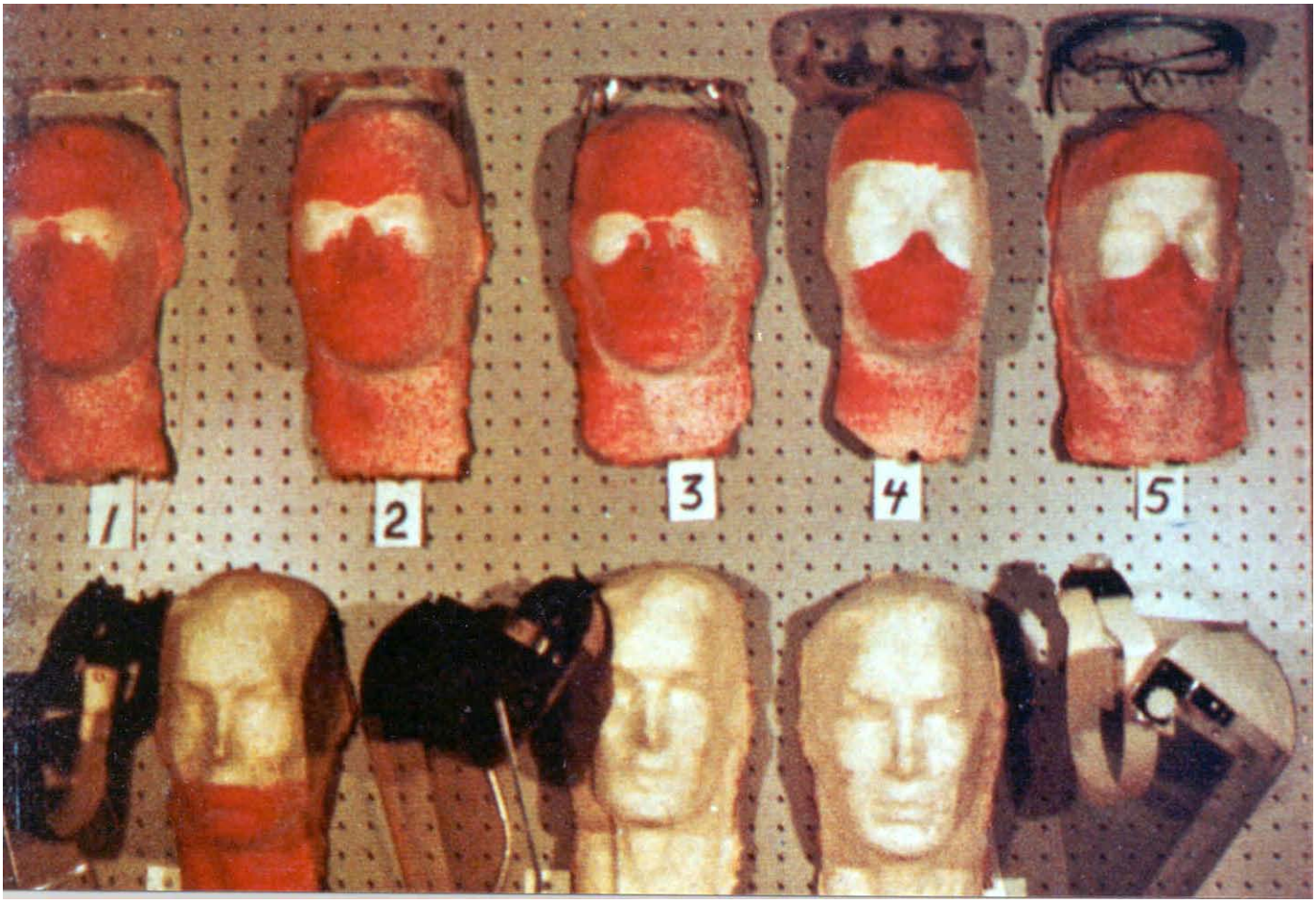
Face Shield

- **Face Shields** shield the entire face and neck. They are used for protection against chemical splashes, sprays, mists and/or impact.
- Used in conjunction with safety glasses or splash goggles.
- Required whenever a splash, spray or mist hazard exists to the entire face.



Eye Protection Effectiveness

This picture depicts the effectiveness of the three types of eye protection when exposed to a chemical spray. The top row shows the effectiveness of safety glasses (the first three tests) and splash goggles (the last two tests). The bottom row shows the effectiveness of three types of face shields.



Courtesy of Stony Brook University. Used with Permission

Chemical Protective Gloves

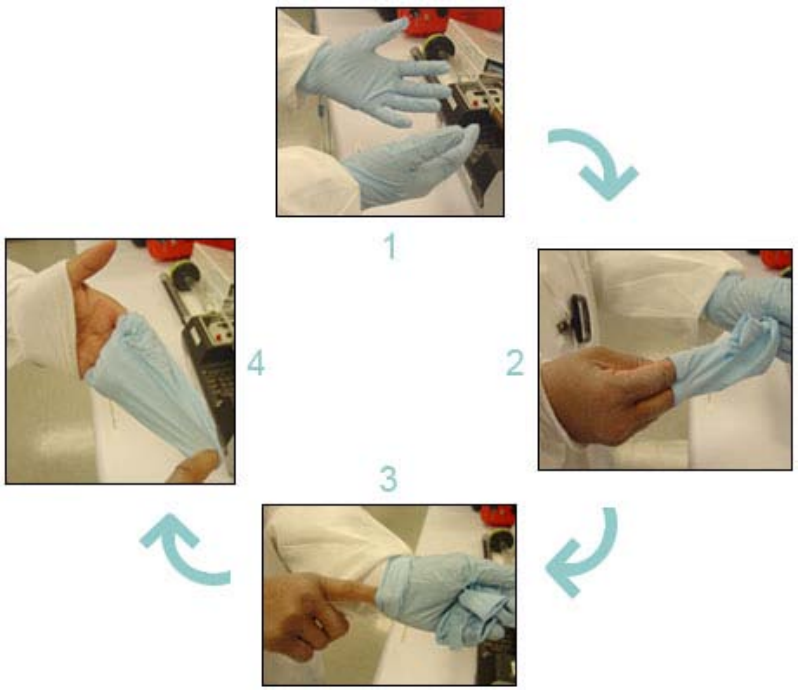
- Gloves are **task specific**; therefore, it is very important to choose the right type.
- One should be aware of the **breakthrough time** of the glove.
  - This is the time it takes for a substance to pass through the protective material of the glove.
- Chemicals will always move through PPE, it is only a matter of the time it takes.
- Disposable gloves are intended for **one time use**
  - Properly dispose at the end of each use or according to the breakthrough time.
- **Note:** Natural latex can cause allergic reactions. Sensitivity to the powder and accelerators in the glove may also occur. Use gloves that are certified latex and accelerator free.
- **Material degradation** occurs naturally to disposable gloves, non-disposable gloves, and even to unused gloves.

How to Don Chemical Protective Gloves

- Proper donning of gloves will lessen the amount of stress on the glove's material. A few general considerations are listed below.
- **To Put On:**
  - Gently inspect glove for damage prior to use. If the glove is damaged it must be properly disposed of.
  - Do not wear jewelry under gloves.
  - Use caution when donning the glove to prevent damage.
  - Make sure fingernails do not puncture the glove.
  - Tuck the knit wrist of the laboratory coat under the glove.

Removing Disposable Gloves

- **To Remove Disposable Gloves:**
  - **First Glove:** Pinch a section on the outside of the glove at the wrist (1/4 of an inch from the end) and pull the glove off the arm, toward and over the fingertips, ultimately turning the glove inside-out.
  - **Second Glove:** Insert fingertip of ungloved hand under the wrist at the end of the glove and pull off (same as above).
  - Dispose of contaminated gloves according to specification. (i.e. chemically contaminated gloves should be disposed of as chemical solid waste.)
- **Important:** Always wash your hands after removing gloves.



Part 6 - Spills and Personal Contamination

Despite initiatives to minimize or eliminate accidents, chemical spills, injuries and exposures, and incidents may occur in the laboratory. A proper, efficient and organized response is necessary to minimize potential harm to personnel, equipment and laboratory space.

Researchers and students must be aware of the proper response to a chemical exposure, spill or injury. This information should be included in the written SOP for the process or use of the material. Training on the response, location or eye wash and safety showers, fire extinguishers, etc. must be provided as part of the initial and annual laboratory safety training.

Injury, Illness, Personal Contamination and Minor First Aid

- All injuries, illness and personal contamination must be reported to your Supervisor, Teaching Assistant or Principal Investigator and Environmental Health and Safety
  - This will assure that you receive the proper medical attention and that the proper forms are filled out for insurance and worker's compensation purposes

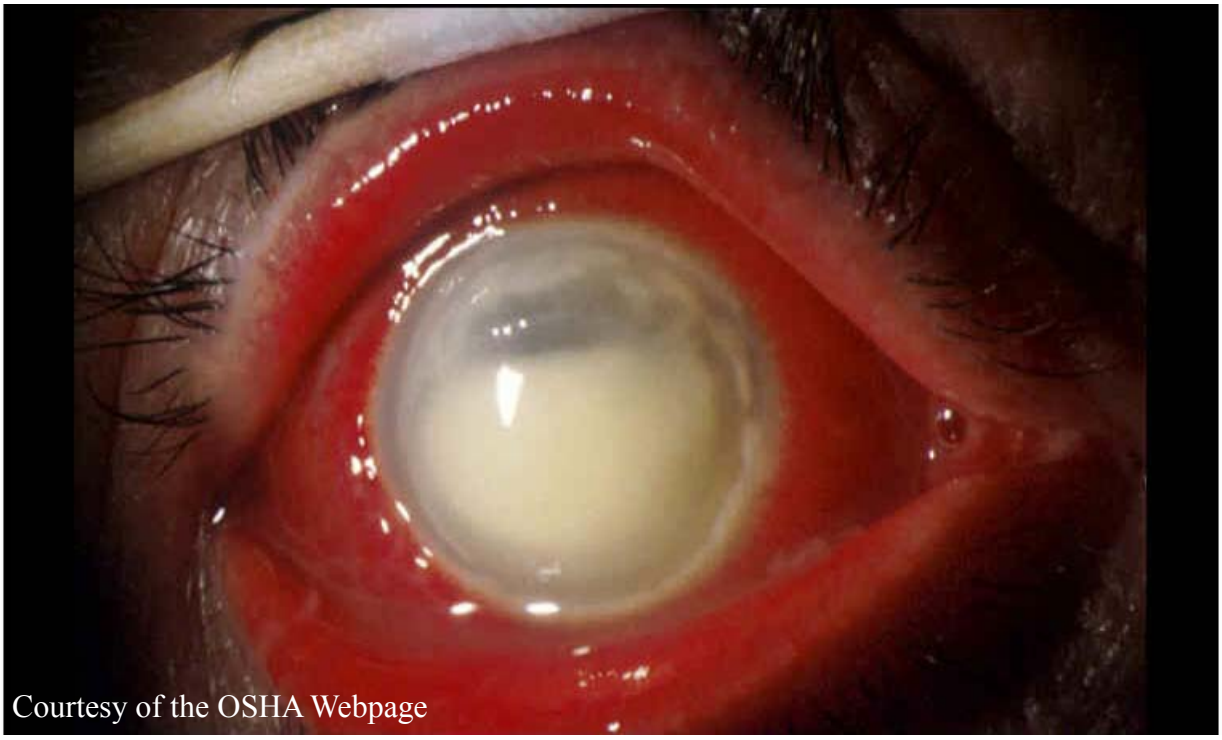
Injury, Illness, Personal Contamination and Minor First Aid

- For non-life threatening or non-serious issues employees report to Environmental Health Services (452-2780) and undergraduate students to Laurel Hall (831-2226). Contact DEHS at 831-8475 for guidance
- For serious injuries, serious illnesses or chemical exposures contact the University Police as follows, they will dispatch the appropriate resources to assist with the emergency:
  - Dial 911 on the Newark Campus for a campus phone
  - Dial 9-911 on the Lewes and Georgetown Campuses from a campus phone,
  - Use an Emergency Call Box/Phone in the hallway
  - Dial 302-831-2222 from a cell phone

Skin and Eye Exposure Response

- **For Spills on the Skin:**
  - The "buddy" or lab partner should assist the person to a safety shower and initiate the call to the University Police.
  - Remove potentially contaminated clothing, jewelry, and other items while in the safety shower.
  - Flush the affected area in the safety shower with water for at least **15 minutes** unless otherwise specified.
  - The "buddy" or lab partner should retrieve the MSDS and provide to EMS.
  - Localized exposures can be flushed under a faucet.
- **For Contamination to the Eyes:**
  - The "buddy" or lab partner should assist the person to an eyewash and initiate the call to the University Police immediately.
  - Flush eyes with water for at least **15 minutes** using the eyewash
  - Hold your eyelids open when using the eyewash.
  - Remove contact lenses if not already removed by the water.
  - The "buddy" or lab partner should retrieve the MSDS and provide to EMS.

Unprotected eyes can easily become damaged by chemical splashes. ALWAYS wear your safety goggles or glasses. An eye injury may result in a permanent, life altering injury that directly affects your quality of life and potentially your career.



Burn caused by a Caustic Liquid. An eye exposure to a 10% sodium hydroxide solution can cause permanent blindness

Inhalation

- The "buddy" or lab partner should assist the person to fresh air and initiate the call to the University Police
  - If trained and necessary, provide Rescue Breathing or CPR
  - The "buddy" or lab partner should retrieve the MSDS and provide to EMS.
- **Important:** Do not enter an area that poses a threat to your own safety.

Ingestion of Hazardous Substances

- The "buddy" or lab partner should initiate the call to University Police
- The "buddy" or lab partner should identify the substance(s) ingested and retrieve the MSDS to provide to EMS

Burning Clothing

- **Do not panic!** Extinguish the fire using:
  - Stop-Drop-and-Roll Technique
  - Safety Shower
  - Cold water from another water source.
- The "buddy" or lab partner should assist as necessary and when safe and initiate the call to the University Police

Chemical Spill

- General Information
  - Anticipate spills by having the proper safety equipment on hand. Obtain spill kits specific for your chemicals.
  - Alert personnel in the area that a spill has occurred.
  - Extinguish flames or ignition sources
  - Do what is necessary to protect life.
  - Large spills you will call for help with the control and cleaning process
  - Small spills lab personnel are responsible for the clean up

EHS builds and sells laboratory scale chemical spill kits on UDMart

Chemical Spill

- Definition of a Large Spill:
  - Involves more than 1 liter of a hazardous material
  - The spill occurs outside of a laboratory in an office, hallway, elevator, etc.
  - Involves **Strong Acids**
    - Examples - Fuming Sulfuric Acid, Red Nitric Acid, Hydrofluoric Acid or Perchloric Acid
  - Involves **Strong Bases**
    - Example - Ammonium Hydroxide
  - Involves materials that are **Poison by Inhalation or Absorption**
    - Examples - Phosphorous Oxychloride, Titanium Tetrachloride, Formates or Isocyanates
  - Involves **Radioactive Material or Infectious Agent**
  - Involves **Reactive Material**
    - Examples - Dry Picric Acid, Sodium Borohydride
  - Involves a **Mercury Compound, Metallic Mercury, Mercury Salts or Aqueous Mercury Solutions**
  - Involves a particularly **Volatile Flammable Liquid**
    - Examples - Ethyl Ether, Benzene, Ethyl Acetate or Hexane
  - You do not feel comfortable cleaning it up.

Chemical Spill Response

- Vacate the hazardous environment and call the University Police as follows:
  - Dial 911 on the Newark Campus
  - Dial 9-911 on the Lewes and Georgetown Campuses from a campus phone
  - Use an Emergency Call Box/Phone in the hallway
  - Dial 302-831-2222 from a cell phone.
- The University Police will dispatch the appropriate resources to assist with the emergency
- If the chemical spill occurs outside of the laboratory:
  - Evacuate the building by pulling a fire alarm pull station. Contact the University Police as directed above from outside of the building and explain the situation.

Small Chemical Spill

- Definition of a Small Spill
  - Less than 1 liter of a hazardous material
  - No fire hazard; not particularly volatile, toxic or corrosive
- Spill Response
  - Confine the spill following the directions in the chemical spill kit. General guidelines can be found at:

http://www.udel.edu/ehs/chemspillkit/chemspillguide.html

  - Immediately notify your supervisor, teaching assistant or principal investigator
  - Dispose of spill clean up material through the appropriate waste program

Part 7 - Shipping and Transportation

Movement of hazardous materials on and off campus are subject to international, federal, state and local regulations as well as general prudent practices.

Improper shipment and transport may result in regulatory fines or hazardous materials incident over the road, on an airplane or in a hallway of a research building. These accidents are severe and have greater potential for serious injuries and damage.

Researchers and students must adhere to the requirements of the Chemical Hygiene Plan and safe work practices to protect life and property.

Shipping Research Samples and Products

- **Federal and International Regulations**
  - Shipment of chemicals, samples or products is strictly regulated by the U.S. Department of Transportation (DOT) and the International Air Transport Association (IATA).
  - Many research samples and chemicals, regardless of quantity, require special handling through DEHS.
  - Fines for non-compliance start at $32,500 per violation.
  - The complete shipping program procedures can found at:
    - Biological Shipments: http://www.udel.edu/ehs/transportbio.html
    - Chemical Shipments: http://www.udel.edu/ehs/transhazmat.html
  - DEHS has created an online class to allow researchers to ship non-hazardous materials shipped on Dry Ice.

Shipping Research Samples and Products

- **Examples (not an inclusive list)**
  - Dry Ice and Liquid Nitrogen
  - Synthesized Products and Samples
  - Materials of Biological Origin
  - Formaldehyde and Formalin
  - Flammable and Combustible Liquids
  - Anything Capable of Incapacitating a Pilot or Driver
  - Equipment Containing or Contaminated with Chemicals
  - Material Preserved with a Chemical
- **Shipping Process**
  - Complete a DOT Shipping Request Form Available at: http://www.udel.edu/ehs/transhazmat.html
  - Email or Fax the Form to DEHS
    - NOTE: DEHS requires a signature certifying that the form was accurately completed
  - DEHS will review the form and either provide guidance to the requester on how to ship the material (if it is not regulated) or make arrangements to pick up the material and ship it for the requester.

Shipping Research Samples and Products

- **Unwanted or Improper Reagents Received from a Vendor**
  - Do not accept the package from the transportation company if you did not order/expect the material.
  - If you open and determine that you received the improper material, contact the supplier and obtain return information.
  - Do not ship the material back to the supplier yourself. Contact DEHS and arrange for shipment.

Transporting Chemicals, Research Samples and Products

- **Transporting Hazardous Material**
  - Hazardous materials can only be transported in vehicles under the following circumstances
    - The transport occurs within the State of Delaware
    - It is performed by University Personnel on University time
    - A University owned vehicle is used
  - Transportation in buildings and between buildings must be done safely
    - Have hazardous material directly delivered to the laboratory whenever possible
    - Use a sturdy cart with at least 4” sides
    - Use a bottle carrier
    - Wear all necessary PPE
  - See http://www.udel.edu/ehs/tranhazmat.html for more information

Part 8 - Security

Chemicals and research equipment used in the research and teaching activities can be used for illicit purposes. Researchers must be aware of the security issues related to their work and take appropriate precaution to secure the chemicals and equipment.

Certain chemicals, such as piperidine and iodine require detailed inventory tracking in order to comply with the Federal Drug Enforcement Agency.

The Federal Department of Homeland Security also regulates the security of certain chemicals. An accurate chemical inventory must be maintained in the online laboratory management program.

Chemical Security

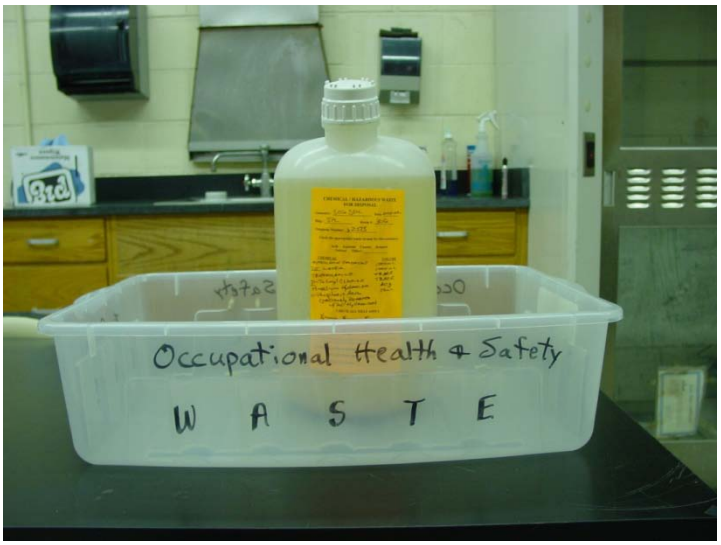
- Make an assessment of your laboratory area for hazardous materials and particular security issues.
- Develop and implement lab security procedures for your lab group. Train lab group members on security procedures and assign responsibilities.
- Secure all hazardous material within your laboratory. Do not leave materials in a common area or loading dock while awaiting pick up or delivery.
- Do not offer or receive any hazardous materials or chemicals from an unknown vendor or person. Ask for an identification card and look for a uniform.
- Report any suspicious activity to the University Police

Part 9 - Chemical Waste Management

This section provides a short overview of the University of Delaware's Chemical Waste Management procedures. This is not a substitute for the full Chemical Waste Disposal Class. Researchers who generate chemical waste must complete the full Chemical Waste Disposal Class annually.

Chemical Waste Management

Approved Containers for Liquid Chemical Waste



LDPE Nalgene Container for Solvents and Non-Corrosive Aqueous Waste Streams

Justrite Safety Container for Corrosive Waste Streams

Chemical Waste Management

Approved Containers for Liquid Chemical Waste

Justrite Safety Container for Solvent or Flammable Waste Steams – Notice the Flame Arrester, Red Label and Yellow Stripe

Other LDPE Containers

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Chemical Waste Management

Do Not Use Glass Bottles for Chemical Waste Management

Chemical Waste Management

Solid Chemical Waste

Normal Trash Cans That Custodial Services Will Empty

Labeled with DOHS Green Non-Hazardous Waste Labels

Laboratory Solid Waste Containers, sealed and labeled with a DOHS Orange Chemical Waste Label

Solid Chemical Waste Container and a Clean Glass Only Box

Clean Glass Only Boxed labeled with a DOHS Green Non-Hazardous Label

Chemical Waste Management

- Empty Chemical Containers
  - Triple rinse with copious amounts of water, collect the first few rinseates as liquid chemical waste
  - Deface the label so it is unreadable.
  - Do not replace cap on container
  - Place Empty/Triple Rinsed Container in glass only box, recycling container or directly into the dumpster

Chemical Waste Management

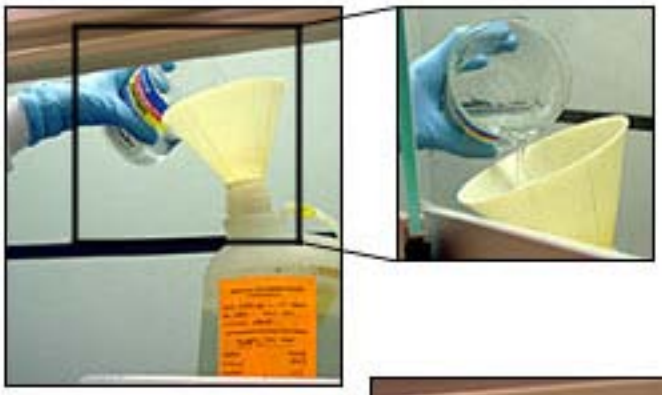
- Recycling
  - Only triple rinsed, defaced glass chemical bottles and metal cans can be recycled
  - Clean, broken glass only boxes must be place in the dumpster
  - Plastic coated glass bottles cannot be recycled
  - Laboratory glassware cannot be recycled

Chemical Waste Management

Liquid Chemical Waste Techniques

Check the orange chemical waste label to assure you are adding waste to the proper container. Remove the lid and insert a funnel

Slowly add the liquid waste, check for unexpected reactions and minimize splashing



When finished adding the waste, remove the funnel and seal the container. Store in the appropriate cabinet or area

Chemical Waste Management

Liquid Chemical Waste Techniques

Check the orange chemical waste label to assure you are adding waste to the proper container. At the start of work, open bag

Add the solid waste to the container

When finished, seal the bag with a bag closure tie or other method

Replace the lid, close the box lid or box flaps. When full, seal the bag and request a waste pick up

Chemical Waste Management

Justrite Container Waste Techniques

Check the orange chemical waste label to assure you are adding waste to the proper container.

1

Apply the first latch and open the container.

2

Attach the second latch to lock the container lid open.

3

Add the waste, watching for any unexpected reactions.

4

Close lid by removing the second latch and store in the appropriate cabinet or area in 2° containment

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Chemical Waste Management

Properly Stored, Sealed and Labeled Chemical Waste Containers

Chemical Waste Management

Central Accumulation of Chemical Waste

- All chemical waste generated by the Brown, Drake and Lammot Laboratories is be brought down to the Brown Solvent Shed.
  - Do not move reactive or highly toxic compounds down to the shed. DOHS will come to your laboratory and remove these compounds.
  - The chemical waste will be removed from the shed on a weekly basis depending on volume by DOHS.
  - Keys can be obtained from the following personnel:
    - Chemistry Storeroom
    - 063 Brown Lab
    - x2545

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Chemical Waste Management

The Brown Solvent Shed

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Chemical Waste Management

The Brown Solvent Shed

Chemical Waste Management

Central Accumulation Procedures

1. All chemical waste procedures and policies must be followed.
2. Must have **documented** Chemical Waste Disposal Training
3. All waste must be properly labeled, dated and in an approved container.
4. Use a sturdy cart and secondary containment bins to move the chemicals to the storeroom.
5. Once in the storeroom, place the waste container in the provided secondary containment according to hazard class.
6. The label must be filled out properly with the date that the waste was moved into the shed.

ENVIRONMENTAL HEALTH & SAFETY

A Safe and Healthful Campus Environment

Chemical Waste Management

Central Accumulation Procedures

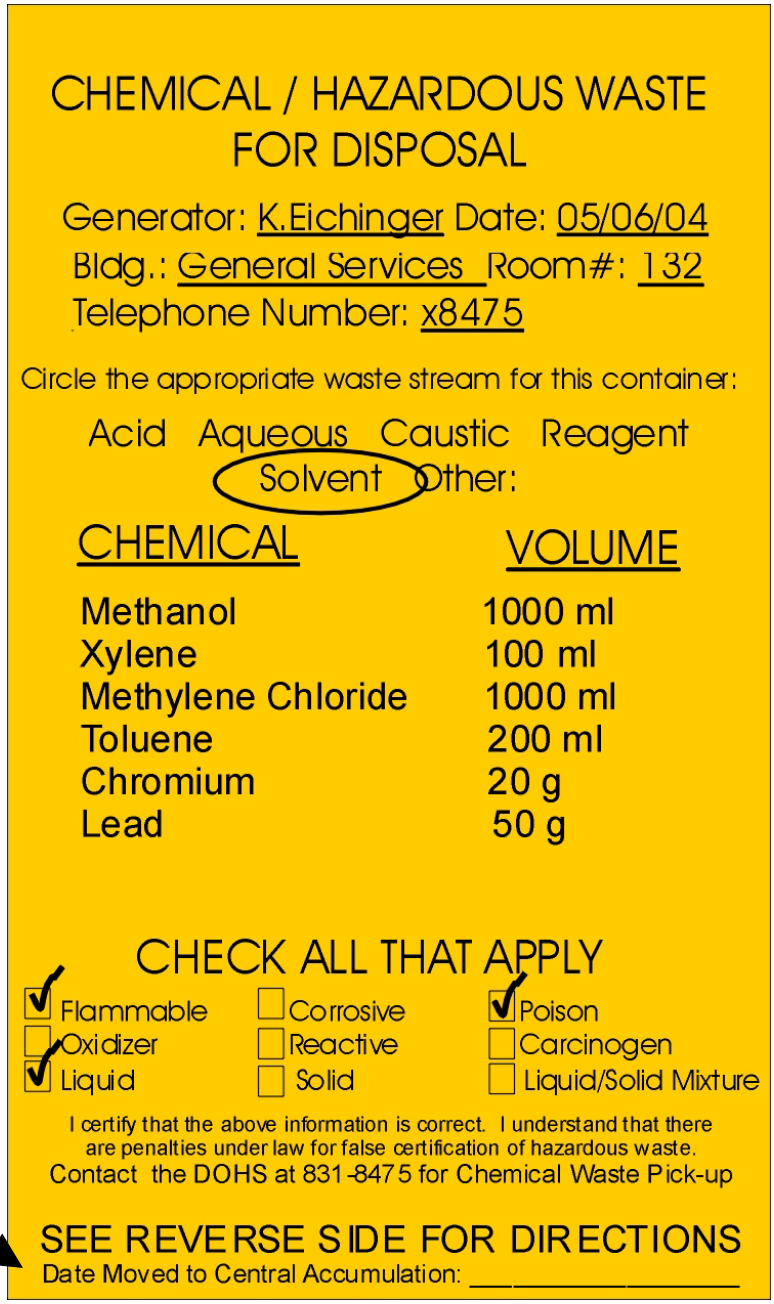
Used a sturdy cart and secondary containment bins to move waste to the CAA. Wear appropriate PPE (Lab Coat, Proper Lab Attire, Gloves and Safety Glasses)

Place the waste in the secondary containment bins in the CAA, segregated per hazard class.

Chemical Waste Management

Central Accumulation Procedures

Date the label with the date that the waste container is moved in the Central Accumulation Area



CHEMICAL / HAZARDOUS WASTE
FOR DISPOSAL

Generator: K.Eichinger Date: 05/06/04
Bldg.: General Services Room#: 132
Telephone Number: x8475

Circle the appropriate waste stream for this container:

Acid Aqueous Caustic Reagent
Solvent Other:

CHEMICAL	VOLUME
Methanol	1000 ml
Xylene	100 ml
Methylene Chloride	1000 ml
Toluene	200 ml
Chromium	20 g
Lead	50 g

CHECK ALL THAT APPLY

☑ Flammable	☐ Corrosive	☑ Poison
☐ Oxidizer	☐ Reactive	☐ Carcinogen
☑ Liquid	☐ Solid	☐ Liquid/Solid Mixture

I certify that the above information is correct. I understand that there are penalties under law for false certification of hazardous waste.
Contact the DOHS at 831-8475 for Chemical Waste Pick-up

SEE REVERSE SIDE FOR DIRECTIONS
Date Moved to Central Accumulation: _____

Information Sources

http://www.udel.edu/ehs

- **Chemical Hygiene Program** – http://www.udel.edu/ehs/chemindex.html
- **Hazardous Materials Manual** – http://www.udel.edu/ehs/hazmatman.pdf
- **Chemical Hygiene Plan** – http://www.udel.edu/ehs/chemhygieneplan.pdf
- **Respiratory Protection Program** – http://www.udel.edu/ehs/respiratory.html
- **Lab Inspection Program** – http://www.udel.edu/ehs/chplabinspct.html
- **Lab Ventilation Program** – http://www.udel.edu/ehs/ventilation/fumehood.html
- **HazMat Shipping/Transportation** – http://www.udel.edu/ehs/transhazmat.html
- **OSHA Laboratory Standard** – http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

Other Recommended Training Sessions, many offered monthly in the EHS Training Room

- Chemical Spill Training
- Chemical Waste Disposal Training
- Compressed Gas Safety
- Corrosive Chemical Safety
- Hydrofluoric Acid Safety Training
- Laboratory Ventilation Safety
- Reactive Chemical Safety
- Toxic Chemical Safety
- See http://www.udel.edu/ehs/ehstrainsched99.html for a list of scheduled training sessions.

The Next Step...

- This training only provided an introduction to chemical safety and the University's Chemical Hygiene Plan.
- Your Supervisor/Principal Investigator or Teaching Assistant must provide chemical and task specific safety training for all aspects of your work at the University of Delaware.
- At the request of the Supervisor/Principal Investigator, DEHS can provide specific chemical safety.

DEHS Hazardous Chemical Training Certification

Please review the EHS Hazardous Chemical Training Certification (Web Links are Listed Below), check the appropriate boxes, sign and date, have your supervisor/PI sign and send a copy to EHS.

Word Document:
http://www.udel.edu/ehs/chp1rtk.doc

PDF Document:
http://www.udel.edu/ehs/rtkchemhygcert.pdf

UNIVERSITY OF DELAWARE
DEPARTMENT OF ENVIRONMENTAL HEALTH & SAFETY
LABORATORY SAFETY CERTIFICATION FORM

Use this form to document your Initial or Annual Right-To-Know Training, Chemical Hygiene Plan Training and any other chemical/laboratory safety training as appropriate.

This form is designed for Personnel, Researchers, Faculty, Staff and Students who work in research and teaching laboratories.

Date of Chemical Hygiene Plan/Safety and Right-To-Know Training:	

Please Check All That Apply:

☐ **I DO USE OR WORK AROUND CHEMICALS**
☐ **I DO NOT USE OR WORK AROUND CHEMICALS**

I certify I have received training pursuant to the Hazardous Chemical Information Act (Right To Know) and University of Delaware Policy. In addition to training on my rights under the law, I:

… know where the Workplace Chemical List/Chemical Inventory is located and understand its purpose.
… know how to interpret labels and MSDSs.
… know where the MSDSs are located and know that online resources exist through the EHS Web Page (http://www.udel.edu/ehs) .
… have been instructed in the physical and health hazards, proper handling, storage and disposal practices for the chemicals I use.
… have been instructed in any special hazard consideration (if applicable).
… understand the protective measures, first aid procedures and emergency procedures necessary for the chemicals I use.
… know that the Hazardous Materials Safety Manual is available online at http://www.udel.edu/ehs/hazmatman.pdf and have reviewed the manual. Print copies may be available upon request from Environmental Health and Safety
… have received a Job Hazard Analysis and know what Personal Protective Equipment is required for my duties. I understand that I must wear eye protection at all times in the laboratory when an eye hazard exists.
… understand that there are special procedures and requirements for managing chemical and hazardous waste and that these materials must not be poured down the drain or placed in the regular trash.
… am aware that there are special requirements for shipping and transporting chemicals, research samples, etc. I am aware that I must contact the Department of Environmental Health and Safety to assist with shipping and transporting these materials.
… understand that the Occupational Safety and Health Administration (OSHA) requires that laboratory workers be made aware of the Chemical Hygiene Plan (CHP) (29 CFR 1910.1450). It is located at http://www.udel.edu/ehs/chemhygieneplan.pdf. Contact your Departmental Chemical Hygiene Officer for more information or to access a printed copy.

☐ **SPECIAL TRAINING** (Document any chemical, task specific or laboratory safety training below that is not covered by the Right-To-Know and Chemical Hygiene Plan Training. Attach additional pages as necessary)

The named individual has been thoroughly trained and demonstrates competency in safe work practices involving the chemical and/or special laboratory procedures listed below.

Date	Training Topic	Date	Training Topic

After becoming familiar with the **"University of Delaware Chemical Hygiene Plan and Hazardous Material Safety Manual,"** please complete and return a copy of this form to your supervisor or the Department Chemical Hygiene Officer. By checking the box and signing below you acknowledge that you are aware of the Chemical Hygiene Plan and the policies and procedures applicable to the OSHA standard (29 CFR 1910.1450). Your supervisor will provide additional information and training as appropriate.

Date	**Printed Name of Supervisor/Instructor**
Printed Name of Employee/Student	**Signature of Supervisor/Instructor**
Signature of Employee/Student	**Department**

Distribution: 1. Department Safety File 2. Safety Committee 3. Environmental Health and Safety

Questions???

- For More Information:
  - http://www.udel.edu/ehs
  - Contact Your Safety Committee/Departmental Chemical Hygiene Officer
  - Contact DEHS
    - Kevin Eichinger, 831-2103
    - eich@udel.edu

What is Wrong with this Picture?

What is Wrong with this Picture?

What is Wrong with this Picture?

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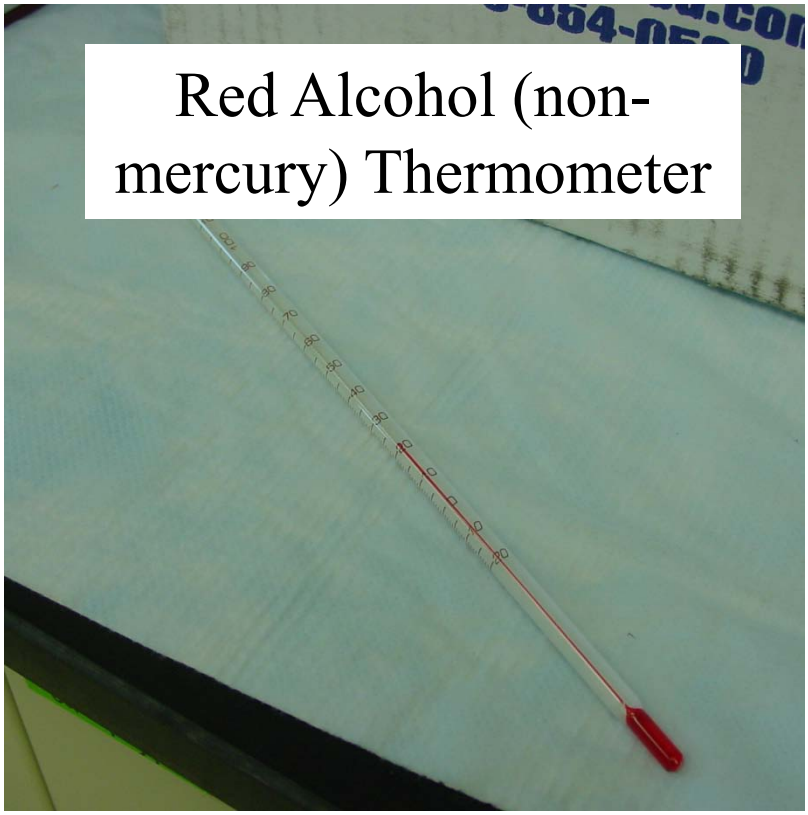
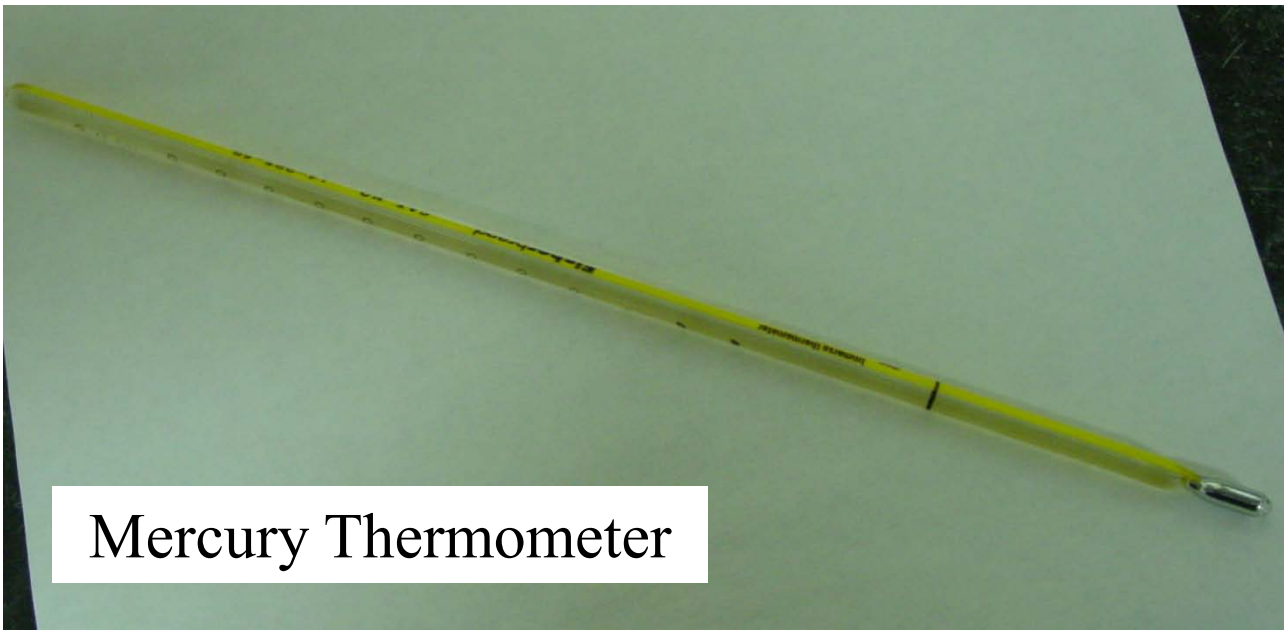
What is Wrong with this Picture?

What is Wrong with this Picture?

How would you clean up this spill?

Which one is safer?





What does this Picture Illustrate?

Is Dry Ice a Hazardous Material?

Can you offer any hazardous materials to a shipper without first contacting EHS?

What is Wrong with this Picture?

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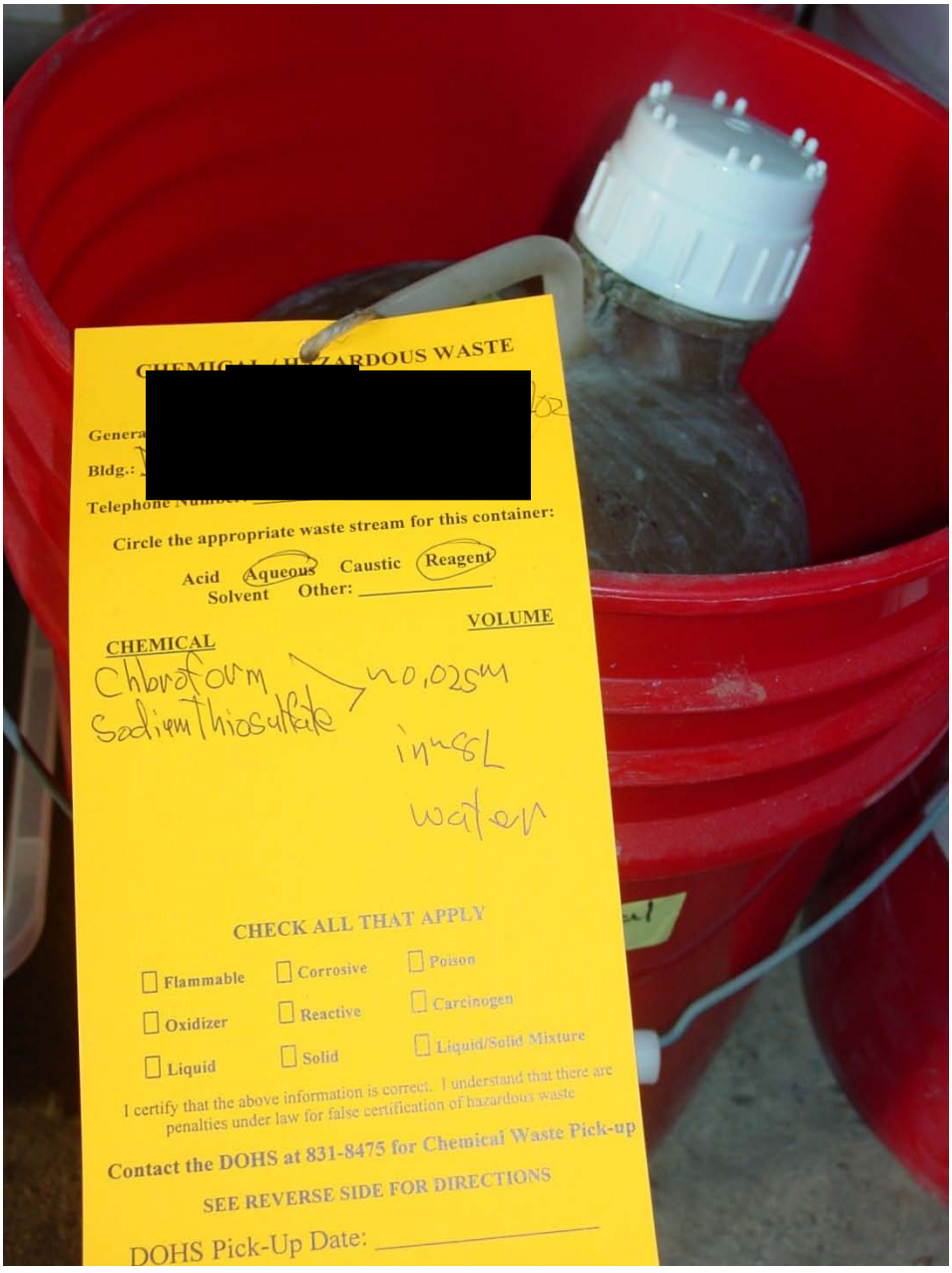

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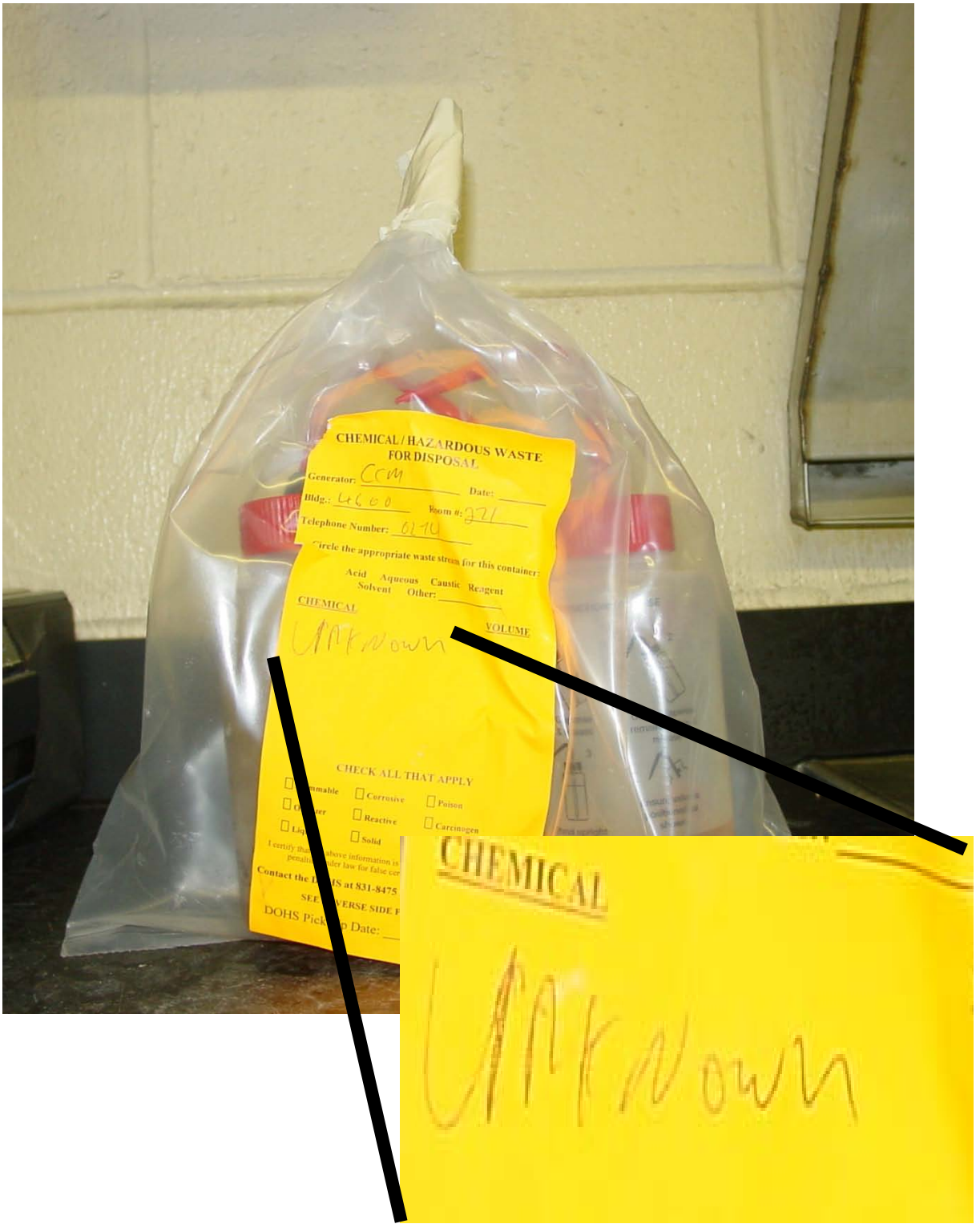

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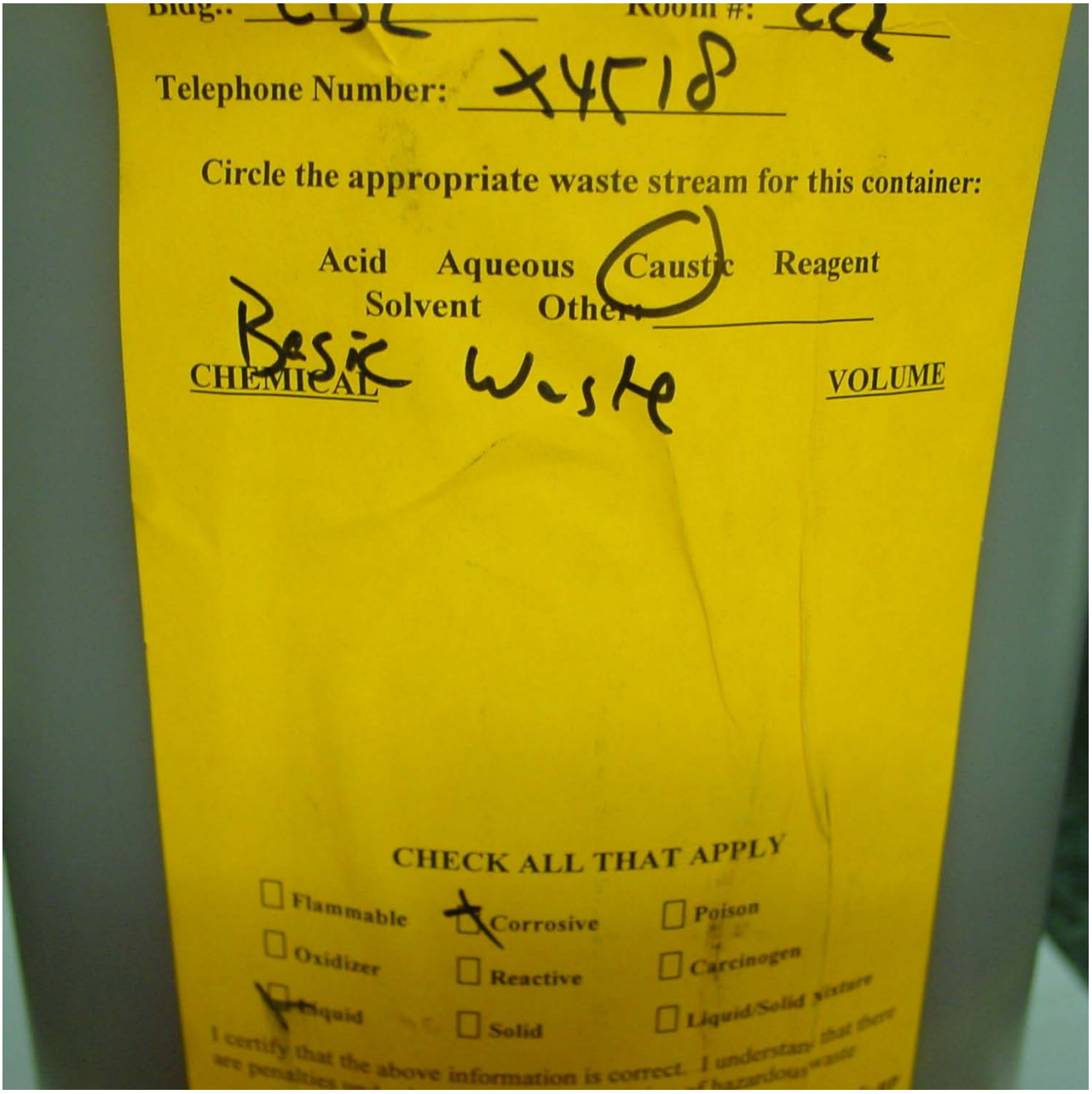

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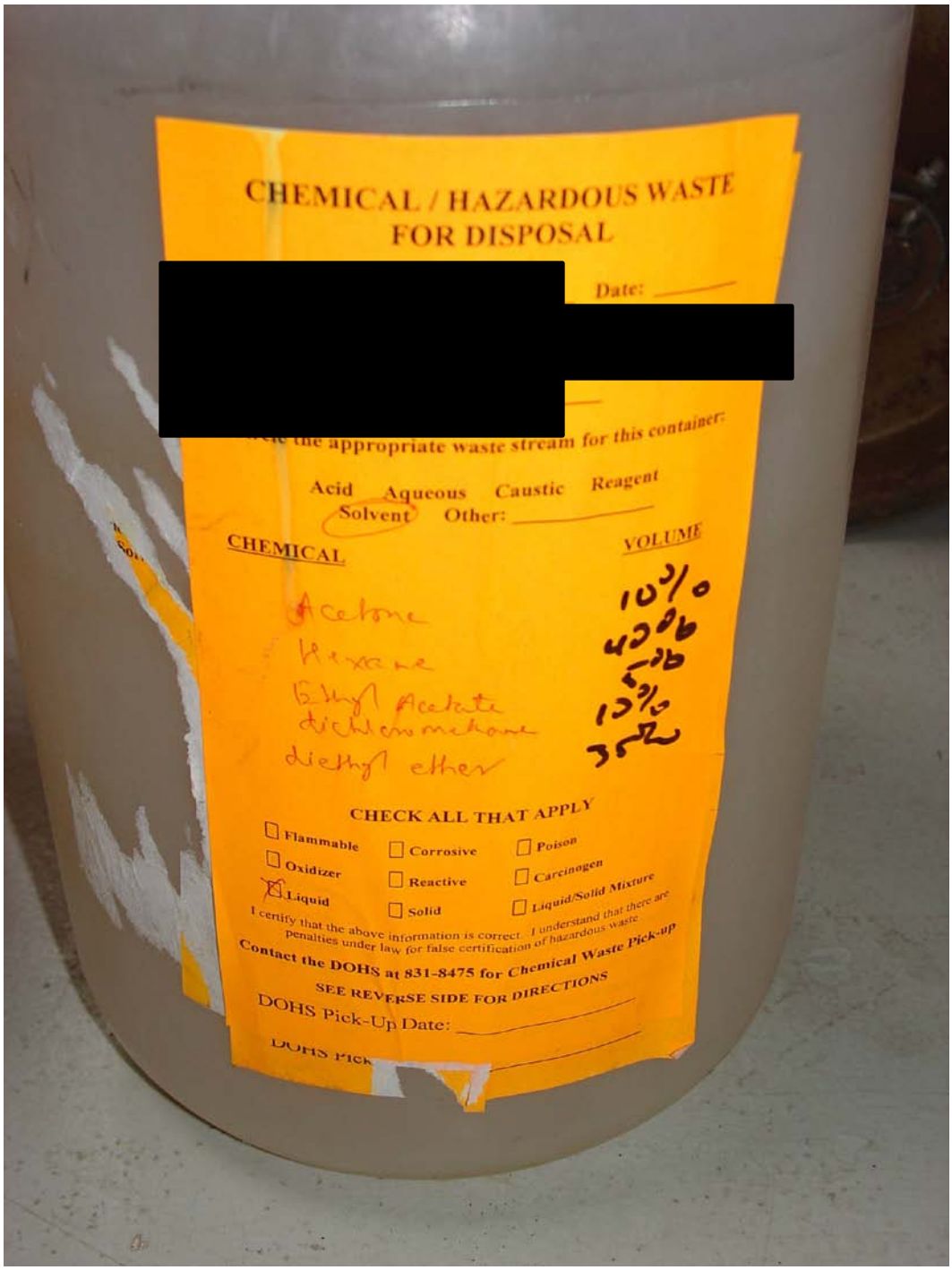

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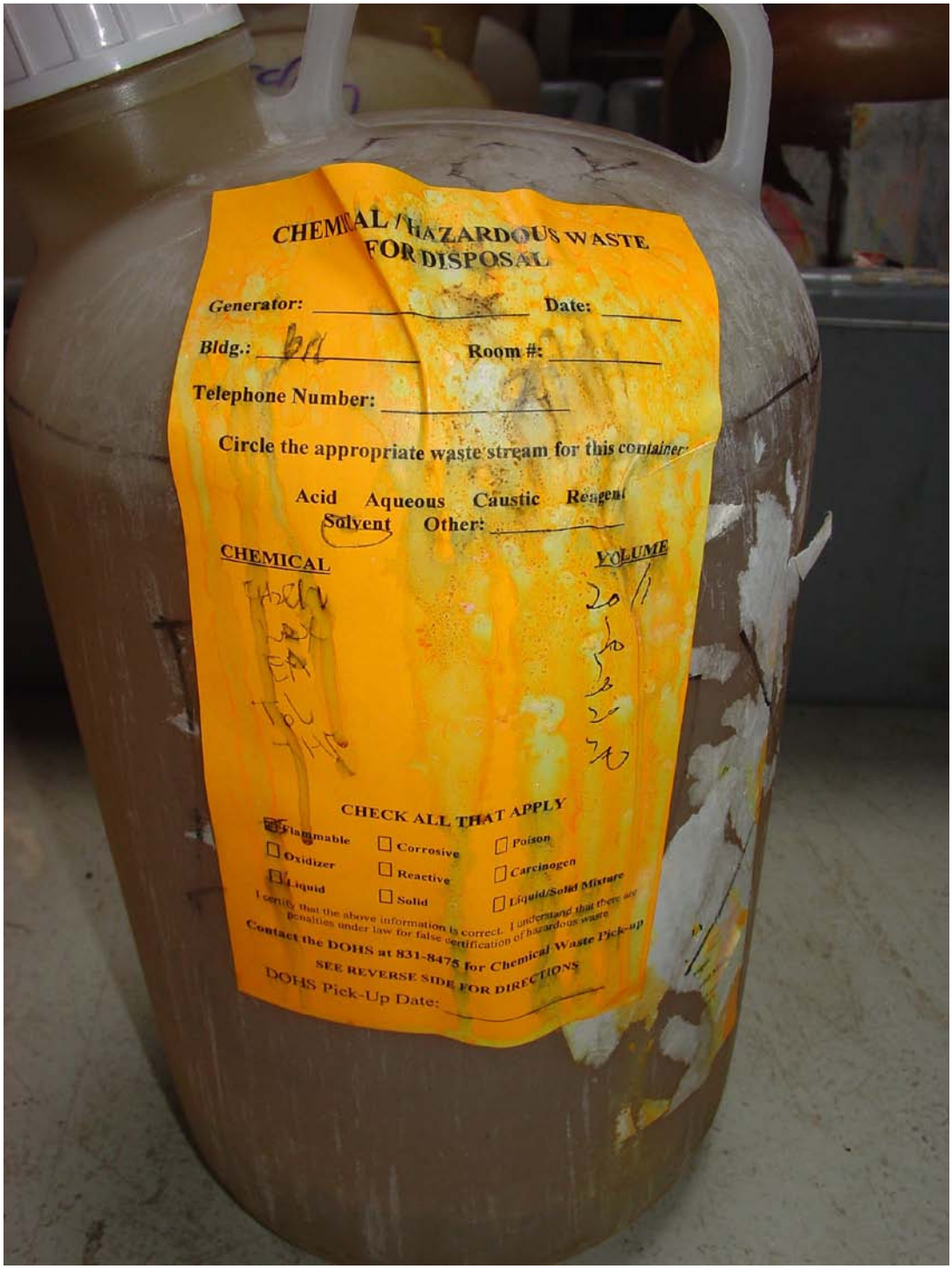

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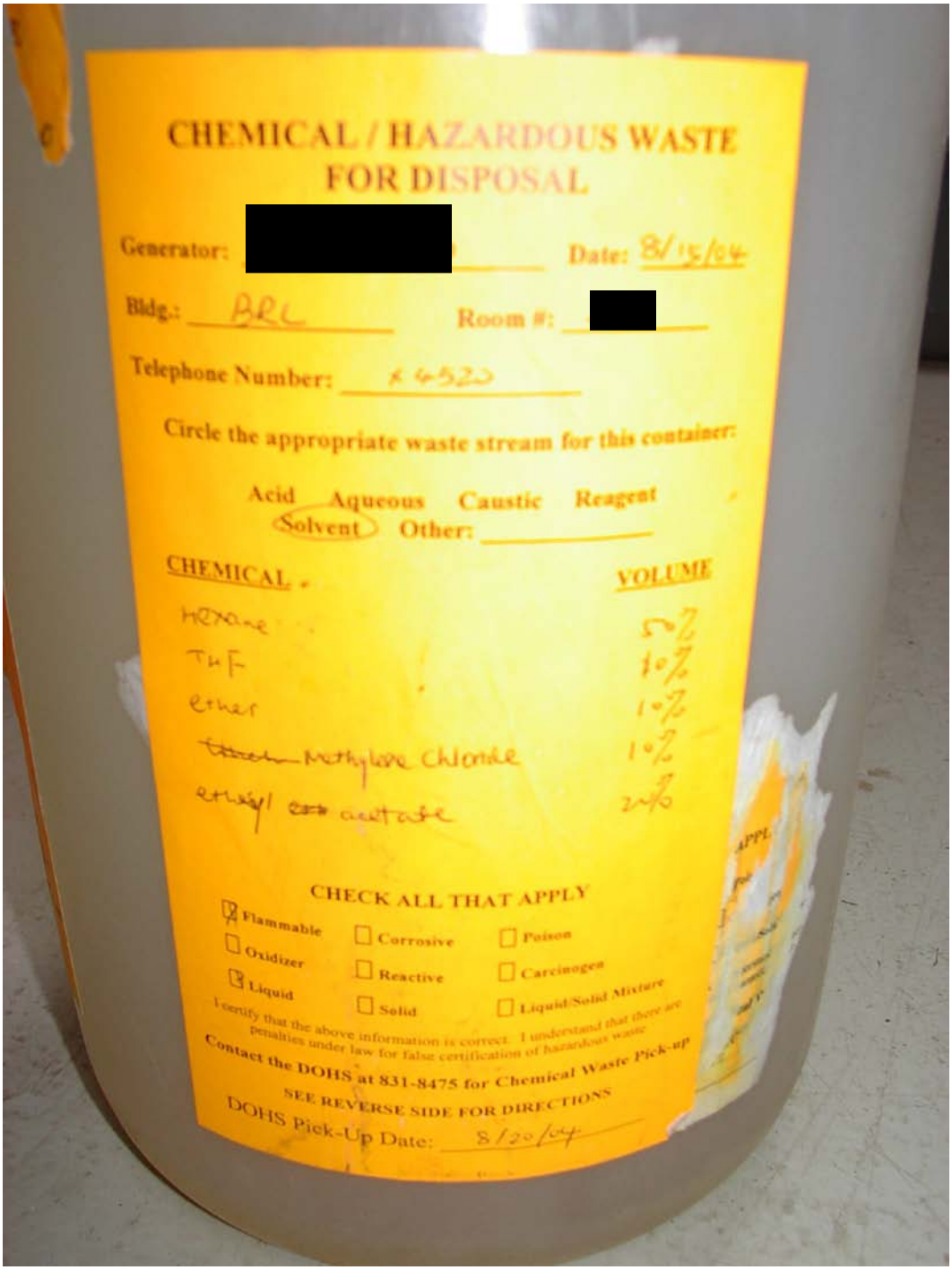

After Effects of the Use of a Fire Extinguisher on a Fume Hood Fire