

Bryte Chemical Laboratory

Safety Manual

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California Department of Water Resources
Division of Environmental Services
Office of Water Quality
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1. Introduction to Laboratory Safety

1.1 Preparing For Laboratory Work

Before starting to work in a laboratory, familiarize yourself with the following:

- The hazards of the materials in the lab, as well as appropriate safe handling, storage and emergency protocols. Read labels and Safety Data Sheets (SDS) before moving, handling or opening chemicals. Never use a product from an unlabeled container, and report missing labels to your supervisor.
- The agents, processes and equipment in the laboratory. If you are unsure of any aspect of a procedure, check with your supervisor before proceeding.
- The location and operation of safety and emergency equipment such as fire extinguishers, eye wash and shower, first aid and spill response kits, fire alarm pull stations, telephone and emergency exits
- Emergency spill response procedures for the materials you will handle
- Emergency reporting procedures and telephone numbers
- Designated and alternate escape routes

1.2 During laboratory work

- Restrict laboratory access to authorized persons only. Children are not permitted in labs.
- Smoking; eating; drinking; storing food, beverages or tobacco; applying cosmetics or lip balm and handling contact lenses are not permitted in laboratories.
- Wear lab coats (knee length) and safety glasses in laboratories employing chemicals, biohazards or radioisotopes. Open shoes, such as sandals, should never be worn in the lab.
- Tie back or otherwise restrain long hair when working with chemicals, biohazards, radioisotopes, or moving machinery.
- Keep work places clean and free of unwanted chemicals, biological specimens, radios, and idle equipment. Avoid leaving reagent bottles, empty or full, on the floor.
- Work only with materials once you know their flammability, reactivity, toxicity, safe handling and storage and emergency procedures.
- Consult Safety Data Sheets (SDS) before working with hazardous chemicals or infectious material. Replace SDS that are more than 3 years old.
- Prepare and maintain a chemical inventory for the lab.
- Never pipette by mouth; use mechanical transfer devices.
- Walk, do not run, in the lab.
- Keep exits and passageways clear at all times.
- Ensure that access to emergency equipment (eyewashes, safety showers and fire extinguishers) is not blocked.



- Report accidents and dangerous incidents ("near-misses") promptly to your supervisor
- Wash your hands thoroughly before leaving the laboratory.
- Conduct procedures involving the release of volatile toxic or flammable materials in a chemical fume hood

1.3 Cleaning up before leaving

Perform a safety check at the end of each experiment and before leaving the lab. Make sure to:

- Turn off gas, water, electricity, vacuum and compression lines and heating apparatus
- Return unused materials, equipment and apparatus to their proper storage locations
- Label, package and dispose of all waste material properly.
- Remove defective or damaged equipment immediately, and arrange to have it repaired or replaced
- Decontaminate any equipment or work areas that may have been in contact with hazardous materials.
- Leave behind protective clothing (lab coats, gloves, etc.) when leaving the laboratory

1.4 Evaluating Laboratory Hazards

1.4.1 There are many categories of hazards that might be encountered in a laboratory setting, and situations can change frequently. Even after you have identified and controlled all current risks, it is critical that you remain open to the possibility that new unexpected dangers can arise. Carry out monthly inspections on the condition of:

- Fire Extinguishers
- Emergency Wash Devices Such As Eyewashes and Showers
- First Aid Kit Contents
- Fume Hood and Other Ventilation Devices
- Tubing for Circulating Water, Vacuum, Gases
- Chemical Storage Compartments

1.4.2 Ensure that fire extinguishers and emergency showers are inspected, tested and tagged annually. Among potential laboratory hazards, be alert for the following:

- Chemical products
 - Flammable
 - Toxic
 - Oxidizing
 - Reactive
 - Corrosive



- Physical or mechanical hazards
 - Ionizing and non-ionizing radiation
 - Electrical
 - Poor equipment design or work organization (ergonomic hazards)
 - Tripping hazards
 - Excessive noise or heat

1.5 Working alone policy

1.5.1 Working alone in general in the laboratory is an unsafe practice and not allowed.

1.6 Accident/Incident Reporting

- Any occupational injury, accident or near miss incident is to be reported immediately to the employee's supervisor. Depending on the severity of the accident or injury, it may be necessary to call for outside emergency help. To call for local, outside emergency services, dial 911.
- The employee should fill out the Workman's Compensation and provide the original to the Division Safety Office.
- Following an accident or injury, the supervisor and the Laboratory Safety Committee should investigate the incident to determine the cause and whether any modifications to laboratory procedures need to be instituted. The following information is to be obtained at the time of the accident:
 1. Name of person(s) involved
 2. Location of incident
 3. Time of incident
 4. What conditions led to the incident
 5. How incident occurred
 6. Contact telephone number
 7. Location of involved employee(s)

2. WORKPLACE HAZARDOUS MATERIALS

Workplace Hazardous Materials identification and classification in the workplace consists of three main components:

- Labeling
- Material Safety Data Sheets (SDS)
- Training

2.1 Labeling

2.1.1 Labels alert people to the dangers of the product and basic safety precautions. It is imperative that all containers in laboratories are clearly identified.



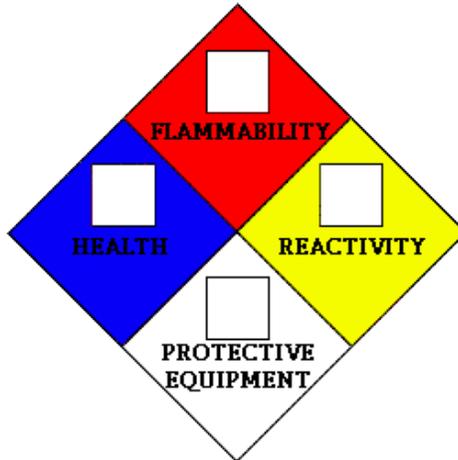
- 2.1.2 Any hazardous material, whether in transit, storage, or use, must be labeled. A label may be a mark, sign, stamp, device, sticker, ticket, tag, or wrapper and must be attached to, imprinted, stenciled, or embossed on the container of the controlled product.
- 2.1.3 There are 2 types of labels prescribed: supplier labels and workplace labels.
- 2.1.4 Supplier's Labels
- Suppliers are responsible for labeling their products. A supplier label must contain the following information:
 - Product identifier (name of product)
 - Supplier identifier (name of company that sold it)
 - Hazard symbols (classification symbols)
 - Risk phrases (words that describe the main hazards of the product)
 - Precautionary statements (how to work with the product safely)
 - First aid measures (what to do in an emergency)
 - Reference to the SDS
- 2.1.5 Workplace Labels
- A workplace label must appear on all containers when:
 - Controlled products are produced, manufactured or prepared (e.g., stock solutions) at the workplace;
 - The controlled product is transferred from the original container into another container; and
 - The original supplier label becomes illegible or damaged or when it is removed;
 - A workplace label must contain the following information:
 - Product identifier (product name)
 - Information for the safe handling of the product
 - Reference to the SDS
 - Product name must include the full name of the product or solution, as it appears on the safety data sheet and include its concentration.
 - HIMIS and NFPA labels will be attached to all containers in the laboratory. See examples of each below.



HIMIS Label

<input type="radio"/> HEALTH	PROTECTIVE EQUIPMENT INDEX	
<input type="radio"/> FLAMMABILITY	A	G
<input type="radio"/> REACTIVITY	B	H
<input type="radio"/> PERSONAL PROTECTION	C	I
	D	J
	E	K
	F	X Ask your supervisor for special handling instructions.

NFPA Label



RATING EXPLANATION GUIDE		
HEALTH	FLAMMABLE	REACTIVE
Recommended Protection	Susceptibility to Burning	Susceptibility to Energy Release
4 Special full protective suit and breathing apparatus must be worn	4 Very Flammable	4 May detonate under normal conditions
3 Full protective suit and breathing apparatus should be worn	3 Ignites under normal temperature conditions	3 May detonate with shock or heat
2 Breathing apparatus with full face mask should be worn	2 Ignites with moderate heating	2 Violent chemical change but does not detonate
1 Breathing apparatus may be worn	1 Ignites when preheated	1 Not stable if heated use precautions
0 No precautions necessary	0 Will not ignite	0 Normally stable



2.2 Material Safety Data Sheets (SDS)

2.2.1 Material Safety Data Sheets (SDS) provide more details than labels. They are technical bulletins that provide chemical, physical, and toxicological information about each controlled product, as well as information on precautionary and emergency procedures. They must be readily accessible to anyone who works with, or who may otherwise be exposed to, controlled products.

2.2.2 Supplier's Responsibilities

2.2.2.1 Suppliers are required to make available SDS to the purchaser. Should any new information arise about a product, the Supplier is required to revise the SDS.

2.2.3 Laboratory's Responsibilities

2.2.3.1 Everyone has the right to review an SDS, whether it is related to their work, or simply because of personal interest.

2.2.3.2 Each laboratory is responsible for ensuring that their SDS Collection:

- Contains the SDS for all chemicals in the laboratory;
- That the SDS are less than 3 years old;
- That the SDS are updated when new information becomes available; and
- That SDS are readily accessible to anyone who works with, or who may be exposed to the product.

2.2.4 SDS location

2.2.4.1 SDS must be readily accessible to anyone who works with, or who may be exposed to controlled products.

2.2.4.2 SDS Collections may be stored in several ways: a filing cabinet, binders, on a personal computer, or by any other means of storage, provided that all the employees are aware of the location, and are able to gain access to the data sheets at any time.

2.2.4.3 All laboratory personnel must be advised as to the location of the SDS Collection.

2.2.5 SDS Information

2.2.5.1 Toxicological properties: LD50 AND LC50

- Despite the limitations of using toxicity data from animal studies to predict the effects on humans, LD50 and LC50 values often comprise a large part of the available toxicity information, and form the bases for many standards, guidelines and regulations.
- LD50 (Lethal Dose50) is the amount of a substance that, when administered by a defined route of entry (e.g. oral or dermal)



over a specified period of time, is expected to cause the death of 50 per cent of a defined animal population. The LD50 is usually expressed as milligrams or grams of test substance per kilogram of animal body weight (mg/kg or g/kg).

- LC50 (Lethal Concentration50) is the amount of a substance in air that, when given by inhalation over a specified period of time, is expected to cause the death in 50 per cent of a defined animal population. Some LC50 values are determined by administration of test substances to aquatic life in water. The
- LC50 is expressed as parts of test substance per million parts of air (PPM) for gases and vapors, or as milligrams per liter or cubic meter of air (mg/L or mg/m³) for dusts, mists and fumes.
- When assessing the hazards of materials used in the laboratory, it is important to remember that substances with lower LD50 or LC50 values are more toxic than those with higher values.

2.2.5.2 Exposure limits (TLV, PEL)

- An exposure limit is the maximum limit of exposure to an air contaminant. The threshold limit value (TLV) or permissible exposure limit (PEL) can be expressed as the following:
- 8-hour time-weighted average (TWA) is the average concentration to which most workers can be exposed during an 8-hour workday, day after day, without harmful effects
- Short-term exposure limit (STEL), is the maximum average concentration to which most workers can be exposed over a 15 minute period, day after day, without adverse effects
- Ceiling (C) defines a concentration that must never be exceeded; and is applied to many chemicals with acute toxic effects
- It should be noted that most exposure limits are based on industrial experiences and are not entirely relevant to the laboratory environment. Good laboratory practices and well-designed ventilation systems serve to maintain air concentrations well below these limits.

2.2.5.3 Flash point

- The flash point is the lowest temperature at which a liquid produces enough vapor to ignite in the presence of a source of ignition. The lower the flash point, the greater the risk of fire. Many common laboratory solvents (e.g., acetone, benzene, diethyl ether, and methanol) have flash points that are below room temperature.

2.2.5.4 Auto-ignition temperature

- The ignition or auto-ignition temperature is the temperature at



which a material will ignite, even in the absence of an ignition source; a spark is not necessary for ignition when a flammable vapor reaches its auto-ignition temperature. The lower the ignition temperature, the greater the potential for a fire started by typical laboratory equipment.

2.2.5.5 Flammable limits

- Flammable limits or explosive limits define the range of concentrations of a material in air that will burn or explode in the presence of an ignition source such as a spark or flame. Explosive limits are usually expressed as the percent by volume of the material in air:
- The lower explosive limit (LEL) or lower flammable limit (LFL) is the lowest vapor concentration that will burn or explode if ignited. Below this limit, the concentration of fuel is too "lean" for ignition, i.e., the mixture is oxygen rich but contains insufficient fuel.
- The upper explosive limit (UEL) or upper flammable limit (UFL) is the highest vapor concentration that will ignite. Above this limit, the mixture is too "rich" for ignition.
- The flammable range consists of concentrations between the LEL and UEL

2.3 Training

- Training and education provides more detailed instruction on the specific procedures necessary to carry out work safely. Training can be divided into two parts: Core Training and Job-specific Training.

2.3.1 Core Training

- Core Training is basic training that provides instruction on classification of controlled products; include risks and precautions, and the content, purpose and interpretation of information found on labels and in SDS.

2.3.2 Job-specific Training

- Job-specific training refers to instruction in the procedures for the safe handling and storage of the chemicals that are unique to each laboratory, and includes spill or leak remediation; waste disposal; and basic first aid instructions.

3. CONTROL OF CHEMICAL HAZARDS

3.1 Routes of Entry



- o Inhalation of gases, vapors and particulate material (e.g. mists, dusts, smoke, fumes)
- o Absorption through skin of liquids, solids, gases and vapors
- o Ingestion of chemicals directly or indirectly via contaminated foods and beverages and contact between mouth and contaminated hands (nail-biting, smoking)
- o Injection of chemicals through needles and other contaminated laboratory sharps

3.2 Flammable chemicals



- Flammable and combustible liquids, solids or gases will ignite when exposed to heat, sparks or flame. Flammable materials burn readily at room temperature, while combustible materials must be heated before they will burn. Flammable liquids or their vapors are the most common fire hazards in laboratories.

3.3 Oxidizing chemicals



- Oxidizers provide oxidizing elements such as oxygen or chlorine, and are capable of igniting flammable and combustible material even in an oxygen-deficient atmosphere .Oxidizing chemicals can increase the speed and intensity of a fire by adding to the oxygen supply, causing materials that would normally not burn to ignite and burn rapidly. Oxidizers can also:
 - React with other chemicals, resulting in release of toxic gases
 - Decompose and liberate toxic gases when heated
 - Burn or irritate skin, eyes, breathing passages and other tissues

3.3.1 Precautions to follow when using and storing oxidizers in the laboratory include the following:

- o Keep away from flammable and combustible materials
- o Keep containers tightly closed unless otherwise indicated by the supplier
- o Mix and dilute according to the supplier's instructions
- o To prevent release of corrosive dusts, purchase in liquid instead of dry form
- o Reduce reactivity of solutions by diluting with water
- o Wear appropriate skin and eye protection
- o Ensure that oxidizers are compatible with other oxidizers in the same storage area

3.4 Reactive chemicals



- May be sensitive to jarring, compression, heat or light
- May react dangerously with water or air
- May burn, explode or yield flammable or toxic gases when mixed with incompatible materials



- Can vigorously decompose, polymerize or condense
- Can also be toxic, corrosive, oxidizing or flammable
- Some chemicals may not be dangerous when purchased but may develop hazardous properties over time (e.g. diethyl ether and solutions of picric acid).

3.4.1 Follow these precautions when working with dangerously reactive chemicals:

- Understand the hazards associated with these chemicals and use them under conditions which keep them stable
- Store and handle away from incompatible chemicals
- Keep water-reactive chemicals away from potential contact with water, such as plumbing, fire sprinkler heads and water baths
- Handle in a chemical fume hood
- Wear the appropriate skin and eye protection
- Work with small quantities
- Use up or dispose of these chemicals before they attain their expiry date

3.5 Corrosive chemicals



- Corrosives are materials, such as acids and bases (caustics, alkalis) which can damage body tissues as a result of splashing, inhalation or ingestion. Also:
 - They may damage metals, releasing flammable hydrogen gas
 - They may damage some plastics
 - Some corrosives, such as sulfuric, nitric and perchloric acids, are also oxidizers; thus they are incompatible with flammable or combustible material
 - They may release toxic or explosive products when reacted with other chemicals
 - They may liberate heat when mixed with water

3.5.1 Precautions for handling corrosive materials include:

- Wear appropriate skin and eye protection
- Use in the weakest concentration possible
- Handle in a chemical fume hood
- Use secondary containers when transporting and storing corrosives
- Always dilute by adding acids to water
- Dilute and mix slowly
- Store acids separately from gases

3.6 Types of spills

3.6.1 This section describes how to clean up some of the chemical spills that may occur in the laboratory.



3.6.2 Flammable and toxic liquids

- If you can do so without putting yourself at risk, immediately shut off all potential ignition sources
- If fire occurs, alert everyone present and extinguish all flames. If the fire cannot be controlled immediately pull the nearest fire alarm.
- If no flames are evident, pour adsorbent around the perimeter of the spill and then cover the rest of the material. Wear an appropriate respirator if toxic vapors are involved.
- Wear gloves resistant to the chemical being handled. Using a plastic utensil (to avoid creating sparks), scoop up the absorbed spill, place it in a plastic bag, seal it, and place in a labeled container.

3.6.3 Corrosive liquids

- Alert everyone present. If vapors are being released, clear the area.
- Do not attempt to wipe up a corrosive liquid unless it is very dilute.
- Gloves, boots, apron and eye protection must be used when neutralizing an extensive corrosive spill. Respiratory protection is required if the liquid releases corrosive vapor or gas.
- Pour the required neutralizing or adsorbing material around the perimeter of the spill, then carefully add water and more neutralizing material to the contained area. Carefully agitate to promote neutralization.
- Use pH paper to verify that all contaminated areas are neutralized and safe to wipe up.
- If an adsorbent (e.g. spill control pillows) is used instead of a neutralizer, scoop up the absorbed spill, place it in a plastic bag, seal it, and then place in a labeled box. If neutralized material contains no toxic heavy metals (e.g. chromium), flush down the drain with plenty of water.

3.6.4 Corrosive solids

- 3.6.4.1 Small spills can be cleaned up mechanically with a dustpan and brush. Larger spills should be cleaned up using a HEPA (high-efficiency articulate) filter vacuum. For spills containing fine dusts, an air-purifying respirator with dust filters is recommended, as are gloves, protective goggles, and a lab coat.

3.6.5 Toxic solids

- 3.6.5.1 Avoid disturbing such solids (e.g. asbestos) which may release toxic dusts. Wet the material thoroughly, then place it in a plastic bag and label it appropriately. If wet removal is not possible, a vacuum equipped with a HEPA (High Efficiency Particulate Air) filter is required.

3.6.6 Mercury

- 3.6.6.1 If a small amount of mercury is spilled (e.g. broken thermometer), use



an aspirator bulb or a mercury sponge to pick up droplets, place the mercury in a container, cover with water, seal it, and label the bottle appropriately. To clean up the residual micro-droplets that may have worked into cracks and other hard-to-clean areas, sprinkle sulfur powder or other commercially available product for mercury decontamination. Leave the material for several hours and sweep up solid into a plastic bag, seal it and label it appropriately.

4. STORAGE AND HANDLING IN LABORATORIES

4.1 General Storage Guidelines

- Do not block access to emergency safety equipment such as fire extinguishers, eyewashes, showers, first aid kits or utility controls such as breaker boxes or gas shut-off valves
- Avoid blocking exits or normal paths of travel: keep hallways, walkways and stairs clear of chemicals, boxes, equipment and shelf projections
- Ensure that the weight of stored material does not exceed the load-bearing capacity of shelves or cabinets
- Ensure that wall-mounted shelving has heavy-duty brackets and supports and is attached to studs or solid blocking. Regularly inspect clamps, supports, shelf brackets and other shelving hardware
- Arrange items so that they do not overhang or project beyond the edges of shelves or counter tops
- Do not stack materials so high that stability is compromised
- Leave a minimum of 18 inches (45.7 cm) of clearance between sprinkler heads and the top of storage
- Use a safety step or stepladder to access higher items; never stand on a stool or a chair.

4.2 Ergonomics

- Store frequently used items between knee and shoulder height
- Store heavy objects on lower shelves

4.3 Chemical Storage

- Store hazardous chemicals in an area that is accessible only to authorized laboratory workers
- Minimize quantities and container sizes kept in the lab
- Do not store chemicals in aisles, under sinks or on floors, desks or bench tops
- Store chemicals away from sources of heat (e.g., ovens or steam pipes) and direct sunlight
- Never stack bottles on top of each other
- Do not store chemicals above eye level/shoulder height



- Store larger containers on lower shelves
- Store liquids inside chemically-resistant secondary containers (such as trays or tubs) that are large enough to hold spills
- Store chemicals inside closable cabinets or on sturdy shelving that has 12.7 mm-19 mm (½ - ¾ inch) edge guards to prevent containers from falling
- Ensure that chemicals cannot fall off the rear of shelves
- Store chemicals based on compatibility and not in alphabetical order. If a chemical presents more than one hazard, segregate according to the primary hazard
- Designate specific storage areas for each class of chemical, and return reagents to those locations after each use
- Store volatile toxic and odorous chemicals in a way that prevents release of vapors (e.g., inside closed secondary containers, ventilated cabinets, paraffin sealing)
- Store flammables requiring refrigeration in explosion-safe or lab-safe refrigerators
- Label reactive or unstable chemicals (e.g., ethers) with the date of receipt and the date opened
- Inspect chemicals weekly for signs of deterioration and for label integrity
- Dispose of unwanted chemicals promptly through the Waste Management Program
- Keep inventory records of chemicals, and update annually

4.4 Flammable liquid storage cabinets

- 4.4.1 Flammable chemicals should be stored inside flammable liquid storage cabinets. Only those flammables in use for the day should be outside the cabinet. Guidelines for cabinet use include:
- Use NFPA or UL approved flammable liquid storage cabinets
 - Keep cabinet doors of the cabinet closed and latched
 - Do not store other materials in these cabinets

4.5 Chemical compatibility

4.5.1 Examples of incompatible combinations of some commonly used chemicals.

CHEMICAL	KEEP FROM CONTACT WITH:
Acetic Acid	chromic acid, nitric acid, hydroxyl compounds, perchloric acid, peroxides, permanganate
Acetylene	chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals (e.g. Sodium)	water, chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia, Anhydrous	mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium Nitrate	acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided combustible materials
Aniline	nitric acid, hydrogen peroxide
Bromine	same as chlorine
Carbon, Activated	calcium hypochlorite, all oxidizing agents



CHEMICAL	KEEP FROM CONTACT WITH:
Chlorates	ammonium salts, acids, metal powders, sulfur, finely divided combustible materials
Chromic Acid	acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids
Chlorine	ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Copper	acetylene, hydrogen peroxide
Flammable Liquids	ammonium nitrate, inorganic acids, hydrogen peroxide, sodium peroxide, halogens
Hydrocarbons	fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrofluoric Acid	anhydrous ammonia, ammonium hydroxide
Hydrogen Peroxide	copper, chromium, iron, most metals or their salts, alcohols, acetone, aniline, nitromethane, flammable liquids, oxidizing gases
Hydrogen Sulfide	fuming nitric acid, oxidizing gases
Iodine	acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	acetylene, fulminic acid, ammonia
Nitric Acid	acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Oxalic Acid	silver, mercury
Perchloric Acid	acetic anhydride, bismuth and its alloys, organic materials
Potassium	carbon tetrachloride, carbon dioxide, water
Potassium Chlorate	sulfuric and other acids
Potassium Permanganate	glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Silver	acetylene, oxalic acid, tartaric acid, ammonia compounds
Sodium Peroxide	alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate
Sulfuric Acid	potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)

4.6 Chemical Segregation

- Read the label carefully before storing a chemical. More detailed storage information is usually provided by the SDS (Material Safety Data Sheet).
- Ensure that incompatible chemicals are not stored in close proximity to each other.
- For more detailed information refer to the reactivity section of the Material Safety Data Sheet or a reference manual on reactive chemical hazards.



4.6.1 Suggested Segregation for Chemical Storage

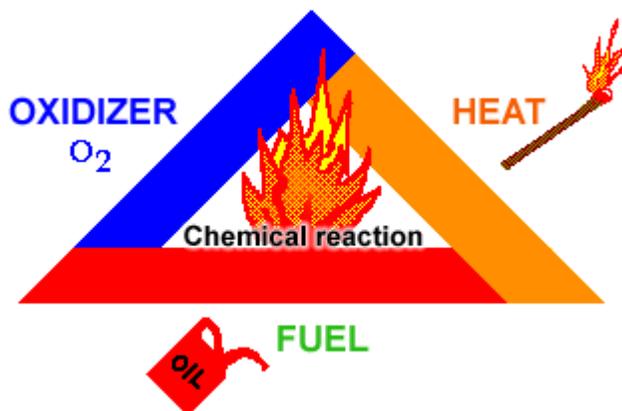
<p>Flammables Store in grounded flammable liquid storage cabinet Separate from oxidizing materials Examples: Acetone Ethanol Glacial acetic acid</p>	<p>Non-Flammable Solvents Store in cabinet Can be stored with flammable liquids Separate from oxidizing materials Examples: Carbon tetrachloride Ethylene glycol Mineral oil</p>
<p>Acids Store in cabinet of non-combustible material Separate oxidizing acids from organic acids Separate from caustics, cyanides, sulfides Examples: Nitric acid Hydrochloric acid Sulfuric acid</p>	<p>Caustics Store in dry area Separate from acids Examples: Ammonium hydroxide Sodium hydroxide Potassium hydroxide</p>
<p>Water Reactive Chemicals Store in cool, dry location Separate from aqueous solutions Protect from fire sprinkler water Examples: Sodium Potassium Lithium</p>	<p>Oxidizers Store in cabinet of non-combustible material Separate from flammable and combustible materials Examples: Sodium hypochlorite Benzoyl peroxide Potassium permanganate</p>
<p>Non-Oxidizing Compressed Gases Store in well-ventilated area separate physically from oxidizing compressed gases Examples: Nitrogen Hydrogen Carbon Dioxide</p>	<p>Oxidizing Compressed Gases Separate physically from flammable compressed gases Examples: Oxygen Chlorine Nitrous oxide</p>
<p>Non-volatile, non-reactive solids Store in cabinets or open shelves with edge guards Examples: Agar Sodium chloride Sodium bicarbonate</p>	



5. FIRE SAFETY

Laboratory fires can be caused by Bunsen burners, runaway chemical reactions, electrical heating units, failure of unattended or defective equipment, or overloaded electrical circuits. Familiarize yourself with the operation of the fire extinguishers and the location of pull stations, emergency exits and evacuation routes where you work. In the event that the general alarm is sounded use the evacuation routes established for your area and follow the instructions of the Evacuation Monitors. Once outside of the building, move away from the doors to enable others to exit.

Fire cannot occur without an ignition source, fuel and an oxidizing atmosphere (usually air), the three elements that comprise what is called the "fire triangle":



Fire will not be initiated if any one of these elements is absent, and will not be sustained if one of these elements is removed. This concept is useful in understanding prevention and control of fires. For example, the coexistence of flammable vapors and ignition sources should be avoided, but when flammable vapors cannot be controlled elimination of ignition sources is essential.

5.1 Classes of fire

5.1.1 The National Fire Protection Association (NFPA) has defined four classes of fire, according to the type of fuel involved. These are:

- o Class A fires involve combustibles such as paper, wood, cloth, rubber and many plastics.
- o Class B fires entail burning of liquid fuels like oil-based paints, greases, solvents, oil and gasoline.
- o Class C fires are of electrical origin (fuse boxes, electric motors, wiring).
- o Class D fires encompass combustible metals such as magnesium, sodium, potassium and phosphorus.

5.2 Fire extinguishers

5.2.1 Fire extinguishers are rated as A, B, C or D (or combinations of A, B, C and D) for use against the different classes of fires. Familiarize yourself with the fire class ratings of the extinguishers in your work area so that you will know what types of fire you can attempt to extinguish with them.



5.2.2 Learn how to use the extinguisher in your lab, as there will be no time to read instructions during an emergency. Attempt to fight small fires only, and only if there is an escape route behind you. Remember to have the extinguisher recharged after every use. If you do fight a fire, remember the acronym "PASS" when using the extinguisher:

- P: Pull and twist the locking pin to break the seal.
- A: Aim low, and point the nozzle at the base of the fire.
- S: Squeeze the handle to release the extinguishing agent.
- S: Sweep from side to side until the fire is out.
- Be prepared to repeat the process if the fire breaks out again

5.3 Preventing fires

5.3.1 Use the following precautions when working with or using flammable chemicals in a laboratory; keep in mind that these precautions also apply to flammable chemical waste.

- Minimize the quantities of flammable liquids kept in the laboratory.
- Do not exceed the maximum container sizes.
- Except for the quantities needed for the work at hand, keep all flammable liquids in approved flammable liquid storage cabinets. Keep cabinet doors closed and latched at all times. Do not store other materials in these cabinets.
- Use and store flammable liquids and gases only in well-ventilated areas. Use a fume hood when working with products that release flammable vapors.
- Keep flammable solvent containers, including those for collecting waste, well capped. Place open reservoirs or collection vessels for organic procedures like HPLC inside vented chambers.
- Store flammable chemicals that require refrigeration in "explosion-safe" (non-sparking) laboratory refrigerators.
- Keep flammable chemicals away from ignition sources, such as heat, sparks, flames and direct sunlight. Avoid welding or soldering in the vicinity of flammables.
- Bond and ground large metal containers of flammable liquids in storage. To avoid the build-up of static charges, bond containers to each other when dispensing.
- Use portable safety cans for storing, dispensing and transporting flammable liquids.
- Clean spills of flammable liquids promptly.

5.4 Evacuations

5.4.1 In the event that the general alarm is sounded, follow the evacuation routes established for your area. Bryte Laboratory personnel are to meet at the MWQI Field Trailers. Once outside the building, move away from the doors to allow others to exit.



6. LABORATORY VENTILATION AND FUME HOODS

6.1 General ventilation

6.1.1 General ventilation, also called dilution ventilation, involves dilution of inside air with fresh outside air, and is used to:

- Maintain comfortable temperature, humidity and air movement for room occupants
- Dilute indoor air contaminants
- Replace air as it is exhausted to the outside via local ventilation devices such as fume hoods
- Provide a controlled environment for specialized areas such as surgery or computer rooms

6.1.2 General ventilation systems comprise an air supply and an air exhaust. The air may be supplied via a central HVAC (Heating, Ventilation and Air Conditioning) system or, especially in older buildings, via openable windows. Laboratory air may be exhausted through either local exhaust devices or air returns connected to the HVAC system.

6.2 Local ventilation devices

6.2.1 Local exhaust ventilation systems capture and discharge air contaminants (biological, chemical, radioactive) or heat from points of release. Common local exhaust ventilation devices found in laboratories include:

- Chemical fume hoods
- Canopy hoods
- Slotted hoods
- Biological safety cabinets
- Direct connections

6.2.2 Chemical fume hoods

6.2.2.1 Chemical fume hoods are enclosed units with a sliding sash for opening or closing the hood. They are able to capture and exhaust even heavy vapors, and are preferred for all laboratory procedures that require manual handling of hazardous chemical material.

6.2.3 Canopy hoods

6.2.3.1 Canopy hoods are designed to capture heat from processes or equipment, such as atomic absorption spectrophotometers or autoclaves; a canopy or bonnet is suspended over a process and connected to an exhaust vent. The following limitations make canopy hoods poor substitutes for chemical fume hoods, because they:

- Draw contaminated air through the user's breathing zone
- Do not capture heavy vapors



- Provide less containment than chemical fume hoods, and are more affected by air turbulence
- Do not provide adequate suction more than a few inches away from the hood opening

6.2.4 Slotted Hoods

6.2.4.1 Slotted hoods, or benches, have one or more narrow horizontal openings, or slots, at the back of the work surface; the slots are connected to exhaust ducting. These special purpose hoods are used for work with chemicals of low to moderate toxicity only, such as developing black and white photographs.

6.2.5 Biological Safety Cabinets

6.2.5.1 Biological safety cabinets are for use with biological material; depending on the cabinet class, they provide protection of the environment, user and/or product. They are not recommended for use with hazardous chemicals because most models recirculate air into the laboratory, and because the HEPA filter that is integral to the protective function can be damaged by some chemicals.

6.2.6 Direct connections

6.2.6.1 Direct connections provide direct exhausting of contaminants to the outdoors and are used for venting:

- Flammable liquid storage cabinets
- Other toxic chemical storage cabinets
- Solvent and waste reservoirs, such as for HPLC solvent systems
- Reaction vessels, sample analyzers, ovens, dryers and vacuum pump outlets

6.3 Ventilation balancing and containment

6.3.1 By regulation, more air is exhausted from a laboratory than is supplied to it, resulting in a net negative pressure (vacuum) in the laboratory. Negative pressure draws air into the laboratory from surrounding areas, and serves to prevent airborne hazardous chemicals from spreading outside the laboratory in the event of an accidental release inside the laboratory. Balancing of laboratory ventilation must take into consideration the amount of air exhausted by local ventilation devices such as fume hoods.

6.4 Safe Use of Laboratory Fume Hoods

6.4.1 Fume hoods properly used and maintained, will render substantial protection, provided the user is aware of its capabilities and limitations.

6.4.2 The required minimum face velocity used at this facility is 100 feet per minute (FPM) at a minimum sash height of 18 inches. The fan system shall be able to accommodate all fume hoods on the same fan system opened to 18 inches while



still achieving 100 FPM face velocity.

6.4.3 Hoods shall ventilate by a dedicated exhaust fan with ducts leading directly from the hood to the roof. Horizontal ducts shall be pitched down to prevent accumulations of vapors in low spots. Duct velocities shall be maintained high enough to minimize the trapping of vapors in the exhaust system. Terminal exhaust points shall be located at least 25 feet from any possible air intake (e.g., air intake grills, doors, operable windows) and positioned at a height that allows adequate dispersion of fumes.

6.4.4 Fume Hood Certification

6.4.4.1 All fume hoods shall be inspected, tested, and certified initially and annually thereafter. The Laboratory Safety Officer will perform certification in accordance with CCR Title 8 5154.1 and manufacturer's specifications.

6.4.4.2 All fume hoods are required to a proper face velocity of 100 FPM. The airflow into and within the fume hood shall not be excessively turbulent (anything above 150 FPM). It is agreed that too high a face velocity can be detrimental to performance and user protection. All fume hoods functioning properly shall have a certification label affixed to the sash height at which the fume hood was certified. Any fume hood not working properly shall have a yellow sign affixed to the sash prohibiting its use until serviced. These fume hoods shall be checked by the Laboratory Safety Officer on a routine basis during laboratory safety reviews. See Attachment 1.



7. COMPRESSED GASES AND CRYOGENICS

7.1 Hazards of compressed gases

7.1.1 Compressed gases are hazardous due to the high pressure inside cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can break the cylinder valve; the resulting rapid escape of high pressure gas can turn a cylinder into an uncontrolled rocket or pinwheel, causing serious injury and damage. Poorly controlled release of compressed gas in the laboratory can burst reaction vessels, cause leaks in equipment and hoses or result in runaway chemical reactions. Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated areas and causing asphyxiation.

7.2 Safe handling, storage and transport of compressed gas cylinders

7.2.1 All gas cylinders, full or empty, should be securely supported using suitable racks, straps, chains or stands.

7.2.2 When cylinders are not in use or are being transported, remove the regulator and attach the protective cap.

7.2.3 An appropriate cylinder cart should be used for transporting cylinders. Chain or strap the cylinder to the cart.

7.2.4 Verify that the regulator is appropriate for the gas being used and the pressure being delivered. Do not rely upon the pressure gauge to indicate the maximum pressure ratings; check the regulator's specifications.

7.2.5 Do not use adaptors or Teflon tape to attach regulators to gas cylinders.

7.2.6 Never bleed a cylinder completely empty; leave a residual pressure.

7.2.7 Do not lubricate the high-pressure side of an oxygen regulator.

7.2.8 Do not expose cylinders to temperature extremes.

7.2.9 Store incompatible classes of gases separately.

7.3 Cryogenic hazards

7.3.1 Cryogenics are very low temperature materials such as dry ice (solid CO₂) and liquefied air or gases like nitrogen, oxygen, helium, argon and neon. The following hazards are associated with the use of cryogenics:

- Asphyxiation due to displacement of oxygen (does not apply to liquid air and oxygen)
- Embrittlement of materials from extreme cold
- Frostbite
- Explosion due to pressure build up
- Condensation of oxygen and fuel (e.g. Hydrogen and hydrocarbons) resulting in explosive mixtures



7.3.2 Cryogenic handling precautions

- Control ice build up
- Use only low-pressure containers equipped with pressure-relief devices.
- Protect skin and eyes from contact; wear eye protection and insulated gloves.
- Use and store in well-ventilated areas.
- Keep away from sparks or flames.
- Use materials resistant to embrittlement (e.g. latex rubber tubing).
- Watches, rings, bracelets or other jewelry that could trap fluids against flesh should not be worn when handling cryogenic liquids
- To prevent thermal expansion of contents and rupture of the vessel, do not fill containers to more than 80% of capacity.

8. PHYSICAL HAZARDS AND ERGONOMICS

8.1 Electrical safety

- 8.1.1 Purchase and use only UL-approved electrical equipment.
- 8.1.2 All electrical outlets should carry a grounding connection requiring a three-pronged plug.
- 8.1.3 Never remove the ground pin of a three-pronged plug.
- 8.1.4 Remove cords by grasping the plug, not the cord.
- 8.1.5 All electrical equipment should be wired with a grounding plug.
- 8.1.6 All wiring should be done by, or under the approval of, a licensed electrician.
- 8.1.7 Electrical equipment that has been wetted should be disconnected at the main switch or breaker before being handled. Familiarize yourself with the location of such devices.
- 8.1.8 Know how to cut off the electrical supply to the laboratory in the event of an emergency.
- 8.1.9 Maintain free access to panels; breaker panels should be clearly labeled as to which equipment they control.
- 8.1.10 Ensure that all wires are dry before plugging into circuits.
- 8.1.11 Electrical equipment with frayed wires should be repaired before being put into operation.
- 8.1.12 Tag and disconnect defective equipment.
- 8.1.13 Minimize the use of extension cords and avoid placing them across areas of pedestrian traffic.
- 8.1.14 Use only CO₂, halon, or dry chemical fire extinguishers for electrical fires.
- 8.1.15 Use ground fault circuit interrupters for all electrical equipment used for administering electrical current to human subjects or measuring electrical signals



from human subjects.

8.2 High pressure and vacuum work

8.2.1 Pressure differences between equipment and the atmosphere result in many lab accidents. Glass vessels under vacuum or pressure can implode or explode, resulting in cuts from projectiles and splashes to the skin and eyes. Glass can rupture even under small pressure differences. Rapid temperature changes, such as those that occur when removing containers from liquid cryogenics, can lead to pressure differences, as can carrying out chemical reactions inside sealed containers.

8.2.2 The hazards associated with pressure work can be reduced by:

8.2.2.1 Checking for flaws such as cracks, scratches and etching marks before using vacuum apparatus

8.2.2.2 Using vessels specifically designed for vacuum work. Thin-walled or round-bottomed flasks larger than 1-L should never be evacuated

8.2.2.3 Assembling vacuum apparatus so as to avoid strain. Heavy apparatus should be supported from below as well as by the neck

8.2.2.4 Taping glass vacuum apparatus to minimize projectiles due to implosion

8.2.2.5 Using adequate shielding when conducting pressure and vacuum operations

8.2.2.6 Allowing pressure to return to atmospheric before opening vacuum desiccators or after removal of a sample container from cryogenics

8.2.2.7 Wearing eye and face protection when handling vacuum or pressure apparatus

8.3 Repetitive work and ergonomics

8.3.1 Ergonomics is concerned with how the workplace "fits" the worker. Performing certain work tasks without regard for ergonomic principles can result in:

- Fatigue
- Repetitive motion injuries
- Strains, aches and injuries from biomechanical stresses
- Eyestrain from video display terminals (VDTs)
- Decreased morale
- Factors that can increase the risk of musculoskeletal injury are:
 - Awkward positions or movements
 - Repetitive movements
 - Application of force

8.3.2 In a laboratory setting, look for the following when addressing ergonomic concerns:



- 8.3.2.1 Laboratory bench and workbench heights are suitable for all personnel
 - 8.3.2.2 Laboratory chairs are on wheels or castors, are sturdy (5-legged), and are adjustable (seat height, angle, backrest height)
 - 8.3.2.3 VDTs are positioned at or slightly below eye level, and are positioned so as to avoid glare from lights or windows
 - 8.3.2.4 Computer keyboards and pointing devices are positioned so that wrists are kept in a neutral position and forearms are horizontal
 - 8.3.2.5 Color, lettering size and contrast of equipment display monitors are optimized so as not to cause eye strain
 - 8.3.2.6 Work station design does not necessitate excessive bending, reaching, stretching or twisting
 - 8.3.2.7 Vibration-producing equipment, such as vortex mixers and pump-type pipettes are not used for extended periods of time
 - 8.3.2.8 Buttons and knobs on equipment are accessible and of a good size
 - 8.3.2.9 Heavy items are not carried or handled
 - 8.3.2.10 Laboratory workers are using proper techniques when lifting or moving materials
 - 8.3.2.11 Indoor air quality parameters, such as temperature, humidity and air supply are comfortable
 - 8.3.2.12 Floors are slip-resistant
 - 8.3.2.13 Noise levels are not excessive
- 8.4 Glassware safety
- 8.4.1 Use a dustpan and brush, not your hands, to pick up broken glass.
 - 8.4.2 Discard broken glass in a rigid container separate from regular garbage and label it appropriately.
 - 8.4.3 Protect glass that is subject to high pressure or vacuum. Wrapping glass vessels with cloth tape will minimize the possibility of projectiles.
 - 8.4.4 Glass is weakened by everyday stresses such as heating and bumping. Handle used glassware with extra care.
 - 8.4.5 Discard or repair all damaged glassware, as chipped, cracked or star-cracked vessels cannot handle the normal stresses.
 - 8.4.6 When handling glass rods or tubes:
 - o Fire polish the ends,
 - o Lubricate with water or glycerin when inserting through stopper,
 - o Ensure stopper holes are properly sized, and not too small,



- Insert carefully, with a slight twisting motion, keeping hands close together, and
- Use gloves or a cloth towel to protect your hands

9. EQUIPMENT SAFETY

9.1.1 Whenever lab equipment is purchased, preference should be given to equipment that

- Limits contact between the operator and hazardous material, and mechanical and electrical energy
- Is corrosion-resistant, easy to decontaminate and impermeable to liquids
- Has no sharp edges or burrs

9.1.2 Every effort should be made to prevent equipment from becoming contaminated. To reduce the likelihood of equipment malfunction that could result in leakage, spill or unnecessary generation of aerosolized pathogens:

- Review the manufacturer's documentation. Keep for future reference.
- Use and service equipment according to the manufacturer's instructions.
- Ensure that anyone who uses a specific instrument or piece of equipment is properly trained in setup, use and cleaning of the item.
- Ensure that equipment leaving the laboratory for servicing or disposal is appropriately decontaminated.

9.1.3 The following sections outline some of the precautions and procedures to be observed with some commonly used laboratory equipment.

9.2 Centrifuges

9.2.1 Improperly used or maintained centrifuges can present significant hazards to users. Failed mechanical parts can result in release of flying objects, hazardous chemicals and biohazardous aerosols. The high speed spins generated by centrifuges can create large amounts of aerosol if a spill, leak or tube breakage occurs.

9.2.2 To avoid contaminating your centrifuge:

- Check glass and plastic centrifuge tubes for stresslines, hairline cracks and chipped rims before use. Use unbreakable tubes whenever possible.
- Avoid filling tubes to the rim.
- Use caps or stoppers on centrifuge tubes. Avoid using lightweight materials such as aluminum foil as caps.
- Use sealed centrifuge buckets (safety cups) or rotors that can be loaded and unloaded in a biological safety cabinet. Decontaminate the outside of the cups or buckets before and after centrifugation. Inspect o-rings regularly and replace if cracked or dry.
- Ensure that the centrifuge is properly balanced.



- Do not open the lid during or immediately after operation, attempt to stop a spinning rotor by hand or with an object, or interfere with the interlock safety device.
- Decant supernatants carefully and avoid vigorous shaking when resuspending.

9.2.3 When using high-speed or ultra-centrifuges, additional practices should include:

- Connect the vacuum pump exhaust to a trap.
- Record each run in a logbook: keep a record of speed and run time for each rotor.
- Install a HEPA filter between the centrifuge and the vacuum pump when working with biohazardous material.
- Never exceed the specified speed limitations of the rotor.

9.3 Heating baths, water baths

9.3.1 Heating baths keep immersed materials immersed at a constant temperature. They may be filled with a variety of materials, depending on the bath temperature required; they may contain water, mineral oil, glycerin, paraffin or silicone oils, with bath temperatures ranging up to 300°C. The following precautions are appropriate for heating baths:

- Set up on a stable surface, away from flammable and combustible materials including wood and paper
- Relocate only after the liquid inside has cooled
- Ensure baths are equipped with redundant heat controls or automatic cutoffs that will turn off the power if the temperature exceeds a preset limit
- Use with the thermostat set well below the flash point of the heating liquid in use
- Equip with a thermometer to allow a visual check of the bath temperature. The most common heating bath used in laboratories is the water bath.

9.4 Shakers, blenders and sonicators

9.4.1 When used with hazardous chemicals, mixing equipment such as shakers, blenders, sonicators, grinders and homogenizers can release significant amounts of aerosols, and should be operated inside a safety cabinet or fume hood whenever possible. Equipment such as blenders and stirrers can also produce large amounts of flammable vapors. The hazards associated with this type of equipment can be minimized by:

- Selecting and purchasing equipment with safety features that minimize leaking
- Selecting and purchasing mixing apparatus with non-sparking motors.
- Checking integrity of gaskets, caps and bottles before using. Discard damaged items.



- Allowing aerosols to settle for at least one minute before opening containers
- When using a sonicator, immersing the tip deeply enough into the solution to avoid creation of aerosols
- Decontaminating exposed surfaces after use

9.5 Ovens and hot plates

9.5.1 Laboratory ovens are useful for baking or curing material, off-gassing, dehydrating samples and drying glassware.

- Select and purchase an oven whose design prevents contact between flammable vapors and heating elements or spark-producing components
- Discontinue use of any oven whose backup thermostat, pilot light or temperature controller has failed
- Avoid heating toxic materials in an oven unless it is vented outdoors (via a canopy hood, for example)
- Never use laboratory ovens for preparation of food for human consumption
- Glassware that has been rinsed with an organic solvent should be rinsed with distilled water before it is placed in a drying oven

9.6 Analytical equipment

9.6.1 The following instructions for safe use of analytical equipment are general guidelines; consult the user's manual for more detailed information on the specific hazards:

- Ensure that installation, modification and repairs of analytical equipment are carried out by authorized service personnel.
- Read and understand the manufacturer's instructions before using this equipment.
- Make sure that preventive maintenance procedures are performed as required.
- Do not attempt to defeat safety interlocks.
- Wear safety glasses and lab coats (and other appropriate personal protective equipment as specified) for all procedures.
- Use sample vials that meet the manufacturer's specifications
- Keep counters clean and free of foreign material

9.6.2 ICP/ICPMS/AA - Sample preparation and analysis for atomic spectroscopy procedures requires the handling of corrosive and toxic materials. Familiarize yourself with the physical, chemical and toxicological properties of these materials. Atomic spectroscopy equipment must be adequately vented as hot exhaust, hazardous wastes, and toxic vapors are emitted during operation. These instruments may also produce RF and UV radiation although they are shielded to minimize exposure. RF transmission can interfere with pacemakers. Recommendations to follow when carrying out atomic emission and absorption analysis are:



- Wear personal safety equipment including safety glasses, lab coats, and gloves.
- Argon dewers and cylinders should be properly secured.
- Inspect the drain system regularly; empty the waste bottle as needed.
- Allow all instrument torch components to cool to room temperature before performing maintenance as inductively coupled plasmas operate at >5000 degrees K.
- Check hood and instrument exhaust systems are operating properly.
- Use caution when preparing samples using heating blocks and acids.
- Use caution as instrument autosamplers components may entangle loose clothing.

9.6.3 Mass spectrometers (MS) - Mass spectrometry requires the handling of compressed gases and flammable and toxic chemicals. Consult SDSs for products before using them. Specific precautions for working with the mass spectrometer include:

- Avoid contact with heated parts while the mass spectrometer is in operation.
- Verify gas, pump, exhaust and drain system tubing and connections before each use.
- Ensure that pumps are vented outside the laboratory, as pump exhaust may contain traces of the samples being analyzed, solvents and reagent gas.
- Used pump oil may also contain traces of analytes and should be handled as hazardous waste.

9.6.4 Gas chromatographs (GC) - Gas chromatography requires handling compressed gases (nitrogen, hydrogen, argon, helium), and flammable and toxic chemicals. Consult product SDSs before using such hazardous products. Specific precautions for working with gas chromatographs include:

- Perform periodic visual inspections and pressure leak tests of the sampling system plumbing, fittings and valves.
- Follow the manufacturer's instructions when installing columns. Glass or fused capillary columns are fragile: handle them with care and wear safety glasses to protect eyes from flying particles while handling, cutting or installing capillary columns.
- Turn off and allow heated areas such as the oven, inlet and detector, as well as connected hardware, to cool down before touching them.
- To avoid electrical shock, turn off the instrument and disconnect the power cord at its receptacle whenever the access panel is removed.
- Turn off the hydrogen gas supply at its source when changing columns or servicing the instrument.
- When using hydrogen as fuel (flame ionization FID and nitrogen-phosphorus detectors NPD), ensure that a column or cap is connected to the inlet fitting whenever hydrogen is supplied to the instrument to avoid buildup of explosive hydrogen gas in the oven.



- Measure hydrogen gas and air separately when determining gas flow rates.
- Perform a radioactive leak test (wipe test) on electron capture detectors (ECDs) at least every 6 months for sources of 50MBq (1.35 mCi) or greater.
- Ensure that the exhaust from (ECDs) is vented to the outside.
- When performing split sampling, connect the split vent to an exhaust ventilation system or appropriate chemical trap if toxic materials are analyzed or hydrogen is used as the carrier gas.
- Use only helium or nitrogen gas, never hydrogen, to condition a chemical trap.

9.6.5 High-pressure liquid chromatography (HPLC) - HPLC procedures may require handling of compressed gas (helium) and flammable and toxic chemicals. Familiarize yourself with the hazardous properties of these products, as well as recommended precautionary measures, by referring to SDSs.

- Inspect the drain system regularly; empty the waste container frequently when using organic solvents.
- Ensure that waste collection vessels are vented.
- Never use solvents with autoignition temperatures below 110 °C.
- Be sure to use a heavy walled flask if you plan to use vacuum to degas the solvent.
- Never clean a flowcell by forcing solvents through a syringe: syringes under pressure can leak or rupture, resulting in sudden release of syringe contents.
- High voltage and internal moving parts are present in the pump. Switch off the electrical power and disconnect the line cord when performing routine maintenance of the pump.
- Shut down and allow the system to return to atmospheric pressure before carrying out maintenance procedures.

10. PERSONAL PROTECTIVE EQUIPMENT

10.1 Eye and face protection

10.1.1 All staff and visitors must wear appropriate eye and/or facial protection in the following:

- All areas where hazardous materials, or substances of an unknown nature, are stored, used or handled
- All areas where the possibility of splash, flying objects, moving particles and/or rupture exist
- All areas where there are other eye hazards.

10.1.2 Instructions for selection and use of protective eyewear are as follows:

- Light-to-moderate work: approved safety glasses with side shields.
- Work with significant risk of splash of chemicals, or projectiles: goggles.
- Work with significant risk of splash on face, or possible explosion: full face



shield, plus goggles.

- If safety glasses with correction lenses are needed, first consult with your optometrist or ophthalmologist.

10.2 Lab coats

10.2.1 Appropriate protective clothing (e.g., lab coats, aprons) is required in all experimental areas where hazardous materials are handled. Instructions for selection and use of protective laboratory clothing are as follows:

- Select knee-length lab coats with button or snap closures
- Wear protective aprons for special procedures such as transferring large volumes of corrosive material
- Remove protective clothing when leaving the laboratory
- Remove protective clothing in the event of visible or suspected contamination

10.3 Hand protection

10.3.1 In the laboratory, gloves are used for protection from chemical products, biohazardous material and physical hazards such as abrasion, tearing, puncture and exposure to temperature extremes.

10.3.2 Latex gloves and skin reactions

10.3.3 Natural latex is derived from the sap of the rubber tree and contains rubber polymers, carbohydrates, lipids, phospholipids and proteins. During the manufacturing process additional chemical agents are added to impart elasticity, flexibility and durability to the latex. Because of these properties, and because of their high tactile strength and low cost, latex gloves are used for many laboratory procedures. Unfortunately, for some people, wearing latex gloves can cause skin reactions; these can be either irritant or allergic in nature, and can be caused by:

- Chronic irritation from sweating of hands inside gloves or from gloves rubbing against the skin
- Sensitization to the chemical additives used in the manufacturing process
- Reaction to naturally-occurring latex proteins

10.3.4 Frequent hand washing, as well as residues from scrubs, soaps, cleaning agents and disinfectants may further irritate the skin.

Using one of the following alternatives may reduce the risk of skin problems associated with the use of latex rubber gloves:

- Non-latex gloves
- "Hypo-allergenic", non-powdered or low-protein latex gloves
- Polyethylene, PVC or cloth liners under latex gloves
- Non-latex gloves under latex gloves



10.3.5 Occurrences of skin problems (e.g., rash, itching, peeling, red, blistering skin or dry flaking skin with cracks and sores) that seem to be associated with the wearing of latex gloves should be reported to a physician when symptoms first appear.

10.3.6 Glove selection guidelines

10.3.6.1 Base selection of glove material on:

- o Identification of the work procedures requiring hand protection
- o Flexibility and touch sensitivity required; a need for high tactile sensitivity, for example, would restrict glove thickness, and some protocols may require the use of gloves with non-slip or textured surfaces
- o Type and length of contact (e.g., occasional or splash vs. Prolonged or immersion contact)
- o Whether disposable or reusable gloves are more appropriate

10.3.6.2 Recommended glove materials for a variety of laboratory hazards: Trademark names were included because the reader is likely to encounter them in the literature: consult laboratory or safety equipment suppliers, or the manufacturer, for more information on brand name gloves. Gloves not listed here may also be suitable; refer to the SDS, glove manufacturer or permeation chart.

Hazard	Degree of Hazard	Recommended Material
Abrasion	Severe	Reinforced heavy rubber, staple-reinforced leather
	Less severe	Rubber, plastic, leather, polyester, nylon, cotton
	Severe	Metal mesh, staple-reinforced heavy leather, Kevlar, aramid-steel
	Less severe	Leather, terry cloth (aramid fiber)
Sharp edges		Lightweight leather, polyester, nylon, cotton
	Mild with delicate work	Choice depends on chemical. Examples: natural, nitrile or butyl rubber, neoprene, PTFE (polytetrafluoroethylene), polyvinyl chloride, polyvinyl alcohol, Teflon™, Viton™, Saranex™, 4H™, Chemrel™, Barricade™, Responder™
Chemicals and liquids	Varies depending on the concentration, contact time, etc. Consult SDS, manufacturer or permeation chart	
Cold		Leather, insulated plastic or rubber, wool, cotton
	Over 350 °C	Asbestos Zetex™
Heat		Neoprene-coated asbestos, heat-resistant leather with linings, Nomex, Kevlar™
	Up to 350 °C	
	Up to 200 °C	Heat-resistant leather, terry cloth



	(aramid fiber) Nomex, Kevlar™
Up to 100 °C	Chrome-tanned leather, terry cloth

10.3.6.3 No single glove material is resistant to all chemicals, nor will most gloves remain resistant to a specific chemical for longer than a few hours. Determine which gloves will provide an acceptable degree of resistance by consulting the SDS for the product, contacting glove manufacturers or by referring to a compatibility chart or table for permeation data. These resources may use the following terms:

- o "Permeation rate" refers to how quickly the chemical seeps through the intact material: the higher the permeation rate the faster the chemical will permeate the material;
- o "Breakthrough time" refers to how long it takes the chemical to seep through to the other side of the material, and
- o "Degradation" is a measure of the physical deterioration (for example, glove material may actually dissolve or become harder, softer or weaker) following contact with the chemical

10.3.6.4 Guidelines for glove use include the following:

- o Choose a glove that provides adequate protection from the specific hazard(s)
- o Be aware that some glove materials may cause adverse skin reactions in some individuals and investigate alternatives
- o Inspect gloves for leakage before using; test rubber and synthetic gloves by inflating them
- o Make sure that the gloves fit properly
- o Ensure that the gloves are long enough to cover the skin between the top of the glove and the sleeve of the lab coat
- o Discard worn or torn gloves
- o Discard disposable gloves that are, or may have become, contaminated
- o Avoid contaminating "clean" equipment: remove gloves and wash hands before carrying out tasks such as using the telephone
- o Always wash your hands after removing gloves, even if they appear not to be contaminated
- o Do not reuse disposable gloves
- o Follow the manufacturer's instructions for cleaning and maintenance of reusable gloves
- o Before using gloves, learn how to remove them without touching the contaminated outer surface with your hands

10.4 Respirators

10.4.1 Respirators should be used only in emergency situations (e.g. hazardous spills or leaks) or when other measures, such as ventilation, cannot adequately control exposures.

10.4.2 There are two classes of respirators: air-purifying and supplied-air. The latter



supply clean air from a compressed air tank or through an air line outside the work area, and are used in oxygen-deficient atmospheres or when gases or vapors with poor warning properties are present in dangerous concentrations.

- 10.4.3 Air-purifying respirators are suitable for many laboratory applications and remove particulates (dusts, mists, metal fumes etc.) or gases and vapors from the surrounding air.
- 10.4.4 Selection, use and care of respirators
- 10.4.5 Follow proper procedures for selecting and using respiratory protective equipment. Correct use of a respirator is as vital as choosing the right respirator. An effective program for respiratory protection should include the following:
 - o Written standard operating procedures and training
 - o Selecting a respirator that is suitable for the application. Consult the SDS or the environmental safety office before purchasing and using a respirator
 - o Assigning respirators to individuals for their exclusive use, whenever possible
 - o Fit-testing: evaluation of facial fit for all users of respirators; beards, long sideburns, glasses or the wrong size of respirator may prevent an effective seal between the wearer's face and the respirator
 - o Protocols for using, cleaning and sanitary storage of respirators
 - o Regular inspection of the respirator, and replacement of defective parts
 - o Medical surveillance, before an individual is assigned to work in an area where respirators are required, to verify the person's ability to function under increased breathing resistance.

11. EMERGENCY PROCEDURES

11.1 First aid

11.1.1 Know how to handle emergency situations before they occur:

- o Become familiar with the properties of the hazardous products used in your area.
- o Familiarize yourself with the contents of the first aid kit and learn how to use them. Keep instructions readily available and easy to understand.
- o Locate and know how to test and operate emergency equipment, such as showers and eyewashes, in your area.

11.1.2 The emergency first aid procedures described below should be followed by a consultation with a physician for medical treatment.

11.2 Burns

11.2.1 In the laboratory, thermal burns may be caused by intense heat, flames, molten metal, steam, etc. Corrosive liquids or solids such as bases and acids can cause chemical burns; first aid treatment for chemical burns is described below. In electrical burns, electrical current passing through the body generates heat.

11.2.2 Burns to the skin



- 11.2.2.1 If the burn is electrical in origin, ascertain that the victim is not in contact with the power supply before touching him/her. If the victim remains in contact with a power source, unplug the device or shut off the main power switch at the electrical distribution panel.
- 11.2.2.2 Dial 911 if the burn is serious. Seek immediate medical treatment for all electrical burns, even if they don't appear to be serious.
- 11.2.2.3 Remove jewelry, including watches, from the burned area.
- 11.2.2.4 Expose the burnt area, but avoid removing clothes that are stuck to the skin.
- 11.2.2.5 If possible, immerse burnt surfaces in cold water for at least 10 minutes, or apply cold wet packs.
- 11.2.2.6 Avoid applying lotions, ointments or disinfectants to a burn. First and second degree burns can be washed with soap and water after the cool down period.
- 11.2.2.7 Cover first and second degree burns with a moist bandage; apply dry compresses to third degree burns and to entry and exit wounds of electrical burns.
- 11.2.2.8 Do not burst blisters, as they form a natural barrier against infection.
- 11.2.3 Burns to the eyes
- 11.2.3.1 Burns to the eyes may be caused by chemical substances, heat (hot liquids, steam, open flames, molten metal, etc.), or radiation from welding procedures, laboratory lamps and lasers. Burns caused by ultraviolet, visible or near-infrared radiation may not produce symptoms until 6-8 hours after exposure. General first aid procedures for thermal and radiation burns to the eyes are as follows:
- Prevent the victim from rubbing or touching the eyes.
 - For heat burns, flush the eyes with cool water until the pain subsides.
 - Cover the eyes with dry sterile gauze pads; apply a wet compress to the eyes if it is too painful to close them.
 - Send the victim for medical care.
- 11.2.4 Cuts
- 11.2.4.1 First aid treatment for minor scrapes, scratches, cuts, lacerations or puncture wounds include the following:
- Wash the wound and surrounding area with mild soap and running water
 - Remove any dirt around the wound
 - Cover with an adhesive dressing or gauze square taped on all sides



with adhesive tape

- Wounds caused by dirty, soiled or grimy objects should be examined by a physician, who will determine whether a tetanus immunization is needed
- If the wound was caused by an object that has contacted human blood or body fluids, the victim must be seen by a physician immediately, as immunization or post-exposure prophylaxis may be required.
- If a wound is bleeding profusely, the first aider should attempt to stop the bleeding as quickly as possible:
 - Elevate the injured area above the level of the heart, if possible, in order to reduce the blood pressure to the area of the wound.
 - Apply direct pressure to the wound unless an object is protruding from it (in this situation, apply pressure around the injury). Direct pressure can be applied with the fingers of the hand, the palm of the hand or with a pressure dressing.
 - If bleeding cannot be controlled with direct pressure, apply pressure to the arteries supplying the injured area. This involves compressing the artery between the wound and the heart, against a bone.
 - Do not remove a dressing that has become soaked with blood, as this may interrupt the clotting process; apply an additional dressing on top of the first.
 - Avoid over-tightening of the dressing; i.e., do not cut off the blood circulation to limbs.
 - As a tourniquet completely stops the flow of blood to beyond the point of application, it should be applied only as a last resort, as in the case of a severed limb.

11.2.5 Chemical splashes to the skin

- If the splash affects a large area of skin, go to the nearest shower and rinse thoroughly for at least 20 minutes; remove contaminated clothing while in the shower
- For splashes involving a small skin area, proceed to the nearest drench hose, remove contaminated clothing and jewelry and rinse for 15 minutes.

11.2.6 Chemical splashes to the eyes:

- Go to the nearest eyewash and rinse for at least 20 minutes.
- If you are wearing contact lenses, remove them as quickly as possible, while continuing to flush.
- Hold your eyelids open with your fingers.
- Roll your eyeballs, so that water can flow over the entire surface of the eye.



- Lift your eyelids frequently to ensure complete flushing.
- Cover the injured eye with dry sterile gauze pads while waiting for medical attention.

11.3 Fire

11.3.1 The immediate response depends on the size of the fire. Laboratory personnel should attempt to extinguish a fire only if it is clearly safe to do so.

11.3.2 All staff members should familiarize themselves with the locations of the fire alarms and evacuation routes in the areas that they occupy. Anyone discovering smoke, strong smell of burning or smell of an unusual nature, should immediately:

- Shout "FIRE!" repeatedly to give the alert.
- Pull the fire alarm.
- Evacuate the premises in a swift, orderly fashion.
- Once outside the building, move away from the doors to enable others to exit.
- Meet at the MWQI trailers.

11.3.3 Clothing fires

11.3.3.1 If your clothing should catch fire, it is important not to run, as this would provide additional air to support the flames. Remember the "Stop, Drop and Roll" rule:

- Stop where you are
- Drop to the floor, and
- Roll to smother the flames

11.3.3.2 As soon as the flames are extinguished, go to the nearest emergency shower to cool burned areas with copious amounts of water. If someone else is on fire:

- Immediately immobilize the victim and force him/her to roll on the ground to extinguish the flames.
- Assist in smothering the flames, using whatever is immediately available, such as a fireproof blanket or clothing.
- Give appropriate first aid.

11.4 Hazardous chemical spills

11.4.1 In the event of a spill of a hazardous (volatile, toxic, corrosive, reactive or flammable) chemical, the following procedures should be followed:

11.4.1.1 If there is fire, pull the nearest alarm. If you are unable to control or extinguish a fire, follow the fire evacuation procedures.



- 11.4.1.2 If the spill is in a laboratory or chemical storeroom:
 - 11.4.1.3 Evacuate all personnel from the room
 - 11.4.1.4 Be sure the hood/local exhaust is turned on
 - 11.4.1.5 If flammable liquids are spilled, disconnect the electricity to sources of ignition if possible.
- 11.4.2 If the spill is in a corridor or other public passageway:
 - 11.4.2.1 Evacuate all people from the area and close off the area to keep others out.
 - 11.4.2.2 Notify the Emergency Response Team. If safe, follow the appropriate procedures for spill containment, neutralization and disposal.



ATTACHMENT 1 FUME HOODS

Step 1. Inspection of Fume Hood

A complete internal and external fume hood inspection shall be performed by the inspector, evaluating the following:

- 1.) Use of proper materials designed for that fume hood;
- 2.) Excessive storage of any materials inside the fume hood;
- 3.) Physical damage to the fume hood;
- 4.) Items that should not be inside the fume hood;
- 5.) The ability of the sash to open, close, and stay in a stationary position;
- 6.) Proper function of the fume hood flow indicator; and
- 7.) Any unusual sounds from the hood motor.

Step 2. Qualitative Airflow Measurement

- 1.) Evaluate capture and flow characteristics of each hood using a titanium tetrachloride (TiCl_4). TiCl_4 reacts with water vapor in the air generating a 'smoke' fume. The TiCl_4 is held by the tester while standing directly in front and middle of the hood, (emulating the area most likely to be occupied by the user of the hood). Carefully generate a stream of smoke in a manner which traverses the face of the hood from the top right, across the top to the left, then from the left to right... et cetera, until the face of the hood has been completely checked from left to horizontally and vertically. See example diagram in Figure 1.
- 2.) Static cells and cells of reverse vector flow can quickly be observed. In an optimally operating fume hood, the fume is captured and quickly cleared from the hood, moving in a laminar fashion toward the back of the hood. Hoods can exhibit several manifestations of poor performance, including reverse vector flow and static cells. In reverse vector flow, the air from the hood does not flow toward the back of the hood, but rather spills out into the surrounding ambient air, or migrates into the users face. Where this occurs, note the boundary of the reverse flow on the grid on the form with a line and mark the area with the letter "R." Static cells are identified on the grid with an "S."

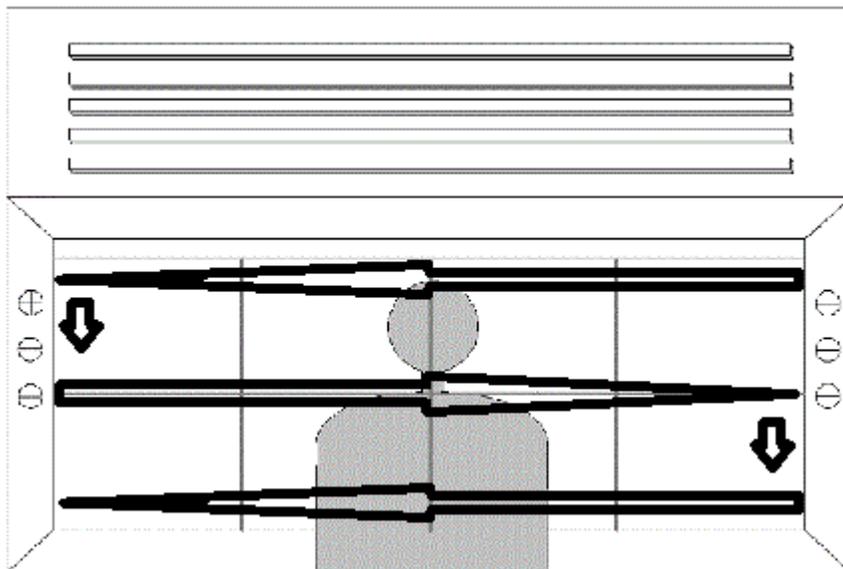


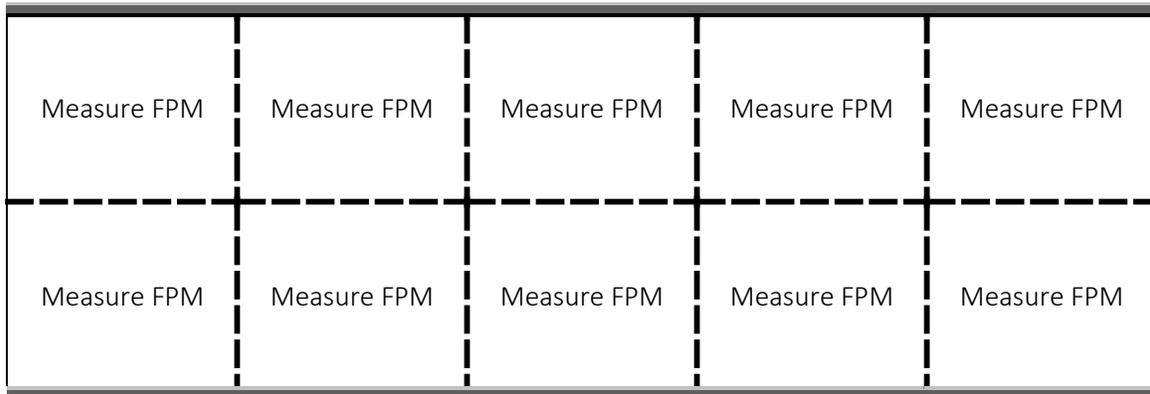
Figure 1 Hood Smoke Test

Step 3. Quantitative Verification - Face Velocity Measurements

- 1.) The face velocity of the hood shall be determined by using an air velocity meter such as the Dwyer Vaneometer.
- 2.) Position the sash at the 18" height.
- 3.) Set a simple grid pattern with grid intervals of 1 foot or less on the face of the hood.
- 4.) Measure and record face velocity at the center of every segment. See Figure 2.



Base of Sash



Hood Airfoil Surface

Figure 2 - Hood Opening grid pattern ~1 foot squares

- 1.) Perform this procedure a total of 5 times.
- 2.) Calculate average face velocity and identify minimum value.
- 3.) If average face velocity is greater than or equal to 100 FPM to a maximum of 150 FPM, and with a minimum of 70 FPM at any point, the unit has PASSED the quantitative evaluation.
- 4.) Record all collected data on Laboratory Fume Hood Certification Form.
- 5.) Once the inspection is completed, a certification sticker will be placed on the hood indicating the date of inspection and face velocity in feet per minute at a specified sash height, usually 18 inches.
- 6.) If the fume hood fails to meet the required face velocity with the sash open to a maximum of 18 inches, the sash shall be lowered and the hood re-tested. This process shall be performed until the fume hood meets the required feet per minute rating. Note: The sash cannot be lowered to a point less than 12 inches from the base of the sash opening.
- 7.) If a fume hood fails certification, a warning sign shall be placed at a prominent location on the sash of the fume hood indicating that the fume hood should not be used until it has been serviced and is working properly. This sign shall ONLY be removed by the Laboratory Safety Officer once the fume hood has passed certification requirements.

Step 4. Maintenance of Laboratory Exhaust Systems

- Building & Facilities is responsible for:
 - 1.) Performing preventive maintenance on fans, ductwork, filters, and fume hoods;
 - 2.) Performing repairs and maintenance identified by routine laboratory reviews or by laboratory staff; and
 - 3.) Notifying Laboratory Management and coordinating with users when fume hoods must be turned off for repair, maintenance, or other operations; and
 - 4.) Notifying Laboratory Management following repairs of fume hoods failing initial fume hood certification requirements for follow-up face velocity measurements and other verifications as needed.

Routine Use of Fume Hoods



- 1.) Fume hoods properly used and maintained, will render substantial protection, provided the user is aware of its capabilities and limitations.
- 2.) When using a fume hood, the following considerations shall apply:
 - a. Fume hoods shall not be used to store chemicals or other materials;
 - b. Stored materials cause disruption to airflow patterns within the hood and pose a risk to the user. See diagram of airflow patterns through empty and cluttered fume hoods. See Figure 3.
 - c. Avoid potential exposures by not putting any part of your body, with the exception of hands and forearms, into the fume hood;
 - d. When it is necessary to keep a large apparatus inside a hood, it should be placed upon blocks or legs to allow air to flow underneath.
 - e. During manipulation and operation within the fume hood, sashes shall be kept at the certification sticker height to ensure proper air flow and protection of the user;
 - f. When fume hoods are not being used, fully lower the sash to offer protection from experiments inside the hood;
 - g. If applicable, Filters shall be maintained as recommended by the manufacturer;
 - h. If any fume hood is suspected of not operating properly, discontinue its use and inform the Laboratory Safety Officer or Laboratory Management to arrange for evaluation and repair;
 - i. Do not use fume hoods which have not been certified. To have a fume hood certified, notify the Laboratory Safety Officer;
 - j. If the fume hood is covered with materials to protect light sensitive substances, then an opening not less than that which can be considered safe for operation shall be maintained.

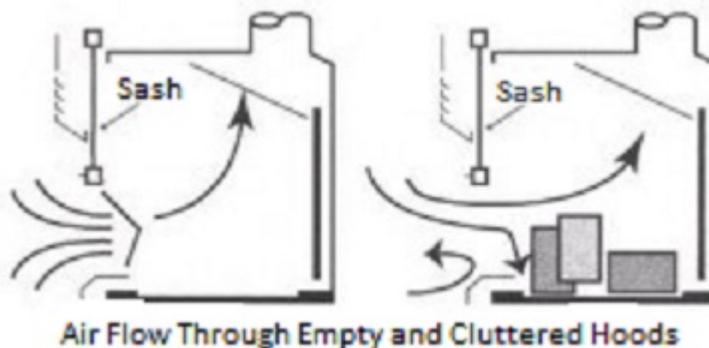
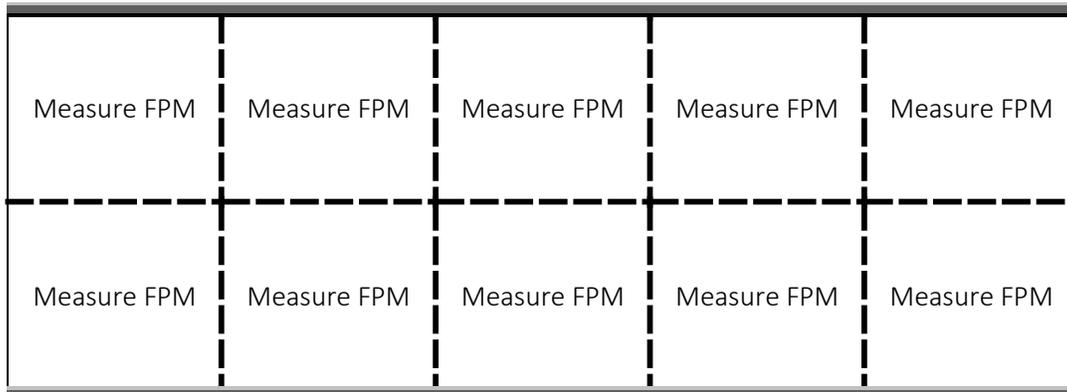


Figure 3

- 3.) Hood flow Velocities shall be verified prior to daily use.
- 4.) Determination of the Fume Hood's Face Velocity
- 5.) The face velocity of the hood shall be determined by using a Dwyer Vaneometer air velocity meter.
- 6.) Position the sash at the 18" height.
- 7.) Set a simple grid pattern with grid intervals of 1 foot or less on the face of the hood.
- 8.) Measure and record face velocity at the center of every segment. See Figure 2.



Base of Sash



Hood Airfoil Surface

Figure 4 - Hood Opening grid pattern ~1 foot squares

- 9.) Calculate average face velocity and identify minimum value.
- 10.) If average face velocity is greater than or equal to 100 FPM to a maximum of 150 FPM, and with a minimum of 70 FPM at any point, the unit has PASSED.
- 11.) Record average and minimum face velocities in Laboratory Fume Hood Logbook.
- 12.) Note any other conditions which may adversely affect the operation of the fume hood before beginning usage.

References:

California Code of Regulations, Title 8, Section 5154.1; Ventilation Requirements for Laboratory-Type Hood Operations.

Forensic Applications Consulting Technologies, Inc.; A Brief Discussion on the Current Status of Laboratory Fume Hood Evaluation Protocols, Caoimhín P. Connell, 04/20/2004.

Stanford University, Laboratory Fume Hoods - Performance Criteria and Certification Protocol, 07/24/2008.



Laboratory Fume Hood Certification

Date: _____

Inspector: _____

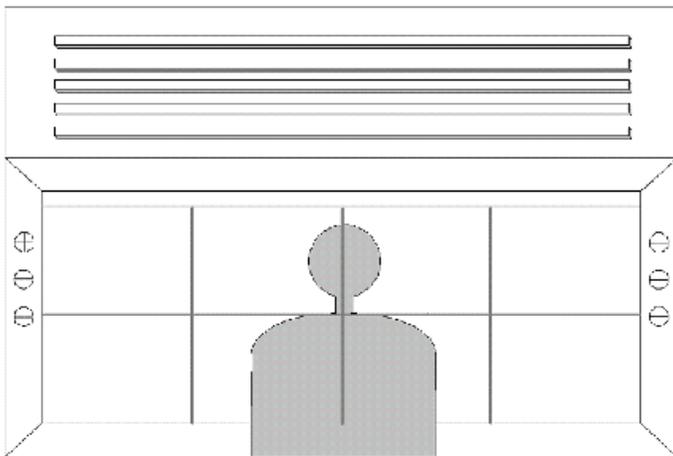
Hood Number: _____

General Inspection

Yes / No	1. Use of proper materials designed for that fume hood;
Yes / No	2. Excessive storage of any materials inside the fume hood;
Yes / No	3. Physical damage to the fume hood;
Yes / No	4. Items that should not be inside the fume hood;
Yes / No	5. The ability of the sash to open, close, and stay in a stationary position;
Yes / No	6. Proper function of the fume hood flow indicator; and
Yes / No	7. Any unusual sounds from the hood motor.

Notes:

Qualitative Verification – Smoke Testing



Pass / Fail

Notes:



Cont'd

Quantitative Verification - Face Velocity Measurements (FPM)

	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6	Grid 7	Grid 8
Measurement								
1								
2								
3								
4								
5								
average (FPM)								
Pass / Fail								

Notes:
