LABORATORY STANDARD OPERATING PROCEDURES

1.1 General Laboratory Safety Procedures

DO

- Know the potential hazards of the materials used in the laboratory. Review the Safety Data Sheet (SDS) and container label prior to using a chemical.
- Know the location of safety equipment such as telephones, emergency call numbers, emergency showers, eyewashes, fire extinguishers, fire alarms, first aid kits, and spill kits.
- Review your laboratory’s emergency procedures with your Principal Investigator, Lab Supervisor, or Lab Manager to ensure that necessary supplies and equipment are available for responding to laboratory accidents.
- Practice good housekeeping to minimize unsafe work conditions such as obstructed exits and safety equipment, cluttered benches and hoods, and accumulated chemical waste.
- Wear the appropriate personal protective apparel for the chemicals you are working with. This includes eye protection, lab coat, gloves, and appropriate foot protection (no sandals or open toed shoes). Gloves must be made of a material known to be resistant to permeation by the chemical in use.
- Shoes must cover the entire foot. Open toed shoes and sandals are inappropriate footwear in laboratories. Fabric and athletic shoes offer little or no protection from chemical spills. Leather shoes with slip-resistant soles are recommended.
- Street clothing is to be chosen so as to minimize exposed skin below the neck. Long pants and shirts with sleeves are examples of appropriate clothing. Avoid rolled up sleeves. Shorts (including cargo shorts), capris and, miniskirts are inappropriate clothing in laboratories. Tank tops, sleeveless shirts and midriff-length shirts are not appropriate if not covered by a full-length laboratory coat and must not be worn if wearing an apron alone. Synthetic fabrics must be avoided in high-hazard areas where flammable liquids and reactive chemicals are utilized.
- Contact lenses are not recommended but are permitted. Appropriate safety eyewear is still required for those that use contact lenses. Inform the lab supervisor of the use of contact lenses.
- Wash skin promptly if contacted by any chemical, regardless of corrosivity or toxicity.
- Label all new chemical containers with the “date received” and “date opened.”
- Label and store chemicals properly. All chemical containers must be labeled to identify the container contents (no abbreviations or formulas) and should identify hazard information. Chemicals must be stored by hazard groups and chemical compatibilities.
- Use break-resistant bottle carriers when transporting chemicals in glass containers that are greater than 500 milliliters. Use lab carts for multiple containers. Do not use unstable carts.
- Use fume hoods when processes or experiments may result in the release of toxic or flammable vapors, fumes, or dusts.
- Restrain and confine long hair and loose clothing. Pony tails and scarves used to control hair must not present a loose tail that could catch fire or get caught in moving parts of machinery.

DON’T

- Eat, drink, chew gum, or apply cosmetics in rooms or laboratories where chemicals are used or stored.
- Store food in laboratory refrigerators, ice chests, cold rooms, or ovens.
- Drink water from laboratory water sources.
- Use laboratory glassware to prepare or consume food.
- Smell chemicals, taste chemicals, or pipette by mouth.
- Work alone in the laboratory without prior approval from the Principal Investigator, Lab Manager, or Lab Supervisor. Avoid chemical work or hazardous activities at night or during off-hours. Have a partner for assistance (use the "buddy-system") at night or during off-hours.
- Leave potentially hazardous experiments or operations unattended without prior approval from the Principal Investigator, Lab Manager, or Lab Supervisor. In such instances, the lights in the laboratory should be left on and emergency phone numbers posted at the laboratory entrance.

1.2. Procedures for Proper Labeling, Storage, and Management of Chemicals

Proper chemical labeling and storage is essential for a safe laboratory work environment. Inappropriate storage of incompatible or unknown chemicals can lead to spontaneous fire and explosions with the associated release of toxic gases. To minimize these hazards, chemicals in the laboratory must be segregated properly. The storage procedures listed below are not intended to be all-inclusive but should serve instead to supplement more specific procedures and recommendations obtained from container labels, Safety Data Sheets (SDSs), and other chemical reference material. For more information about chemical storage contact the University Environmental Health and Safety for your respective campus.

1.2.1. Labeling

- Manufacturer chemical labels must never be removed or defaced until the chemical is completely used.
- All chemical and waste containers must be clearly labeled with the full chemical name(s) (no abbreviations or formulas) and must contain appropriate hazard warning information.
- Small containers that are difficult to label such as 1-10 ml vials and test tubes can be numbered, lettered, or coded as long as an associated log is available that identifies the chemical constituents. Groups of small containers can be labeled as a group and stored together.
- Unattended beakers, flasks, and other laboratory equipment containing chemicals used during an experiment must be labeled with the full chemical name(s).
- All chemicals should be labeled with the "date received" and "date opened."
- All laboratory chemical waste containers must be labeled with the name of the chemicals contained.
- All full waste containers must be disposed of promptly. Waste containers must NOT be filled to more than 90% of their capacity).
- All chemical storage areas such as cabinets, shelves and refrigerators should be labeled to identify the hazardous nature of the chemicals stored within the area (e.g., flammables, corrosives, oxidizers, water reactives, toxics, carcinogens, and reproductive toxins). All signs should be legible and conspicuously placed.

1.2.2. Safety Data Sheets

Safety Data Sheets (SDS) for all laboratory chemicals are required to be maintained in the laboratory or on-line. Safety Data Sheets are available from manufacturer's web sites.

- The SDS for the exact chemical or mixture provided by the manufacturer of the product must be available. The chemical identity and manufacturer found on the label must match the chemical identity and manufacturer found on the SDS.
- All personnel must know how to access the SDS whether they are maintained on paper or electronically.
- All personnel must know how to read and understand an SDS. Additional guidance on how to read, understand, maintain and (if necessary) prepare a Safety Data Sheet is available from EHS for your respective campus.

1.2.3. Storage

HAZARD GROUPS ∗ Flammable/Combustible Liquids ∗ Unstable (shock-sensitive, explosive) ∗ Flammable Solids ∗ Carcinogens & Reproductive Toxins ∗ Inorganic Acids ∗ Toxins, Poisons ∗ Organic Acids ∗ Non-Toxics ∗ Oxidizing Acids (Nitric, etc.) ∗ Gases: ∗ Caustics (Bases) Toxic Gases ∗ Oxidizers Flammable Gases ∗ Water Reactives Oxidizing Gases ∗ Air Reactives Corrosive Gases Inert Gases

- A defined storage place should be provided for each chemical and the chemical should be returned to that location after each use.
- Chemical containers must be in good condition before they are stored. Containers must be managed to prevent leaks.
- Chemicals (including waste) must be separated and stored according to their hazard group and specific chemical incompatibilities. Chemicals within the same hazard group can be incompatible, therefore, it is important to review the chemical label and Safety Data Sheet (SDS) to determine the specific storage requirements and possible incompatibilities.
- Special attention should be given to the storage of chemicals that can be classified into two or more hazard groups. For example, acetic acid and acetic anhydride are both corrosive and flammable. In addition, nitric and perchloric acids are both corrosive and strong oxidizers. Separate organic acids from oxidizing acids using secondary tubs or trays in the corrosives cabinet. Refer to the Safety Data Sheet (SDS) for proper storage procedures.
- Chemicals should be separated by distance. Physical barriers such as storage cabinets and secondary containers should be used to prohibit contact of incompatible chemicals in the event that they are accidentally released or spilled.
- Secondary containers are highly recommended for the storage of liquid chemicals. Secondary containers must be made of a material that is compatible with the chemical(s) it will hold and must be large enough to contain the contents of the largest container.
- Liquids should not be stored above dry chemicals unless they are stored in secondary containers.
- Storage of chemicals within hoods and on bench tops should be avoided.
- Stored chemicals should not be exposed to heat or direct sunlight.
- Storage shelves and cabinets should be secure to prevent tipping. Shelving should contain a front-edge lip or doors to prevent containers from falling.
- Flammable and corrosive storage cabinets should be used when possible.
- Flammable liquids in quantities exceeding a total of 10 gallons in each laboratory must be stored in an approved flammable storage cabinet.

- Only explosion-proof or laboratory-safe refrigerators may be used to store flammable liquids.
- Liquid chemicals should be stored below eye level to avoid accidental spills.
- Chemicals must not be stored in areas where they can be accidentally broken and spilled such as on the floor or on the edge of a bench top.
- Chemicals must not be stored in areas where they obstruct aisles, exits, and emergency equipment.

1.2.4. Chemical Inventory Management

All reportable chemicals must be inventoried. A list of reportable chemicals can be found in the appendices of the Chemical Hygiene Plan. In addition to reportable chemicals, all chemicals should be inventoried. Inventories provide a method for tracking chemicals for ordering and re-ordering, waste disposal, complying with the maximum allowable quantity limits in accordance with the hazard communication, community right-to-know requirements, and tracking dangerous or time-sensitive chemicals for safety and security reasons. Inventories should contain all pertinent information including the following data:

- Chemical name (synonym or trade name found on the Safety Data Sheet), if mixture list composition and percent of components.
- Chemical Abstract Service (CAS) number.
- Manufacturer.
- Product number.
- Physical state.
- Hazard class.
- Container size.
- Units of measure.
- Quantity or number of containers.
- Principal Investigator, Lab Manager, Lab Supervisor, or Chemical Hygiene Officer.
- Owner or researcher.
- Location (e.g., building, room number, cabinet).
- Receiving date.
- Opened container date.
- Expiration date.

Other information such as cost can be recorded as necessary for accounting purposes. Expiration dates are of particular importance for time-sensitive chemicals that can become dangerous with age. Several noteworthy time-sensitive laboratory chemicals include:

- Chemicals that form peroxides.
- Picric acid and other multi-nitro aromatics.
- Chloroform.
- Anhydrous hydrogen fluoride and hydrogen bromide.
- Liquid hydrogen cyanide.
- Formic acid.
- Alkali metals (such as potassium, sodium, and lithium). See Standard Operating Procedure (SOP 3.17), Peroxide-Forming Chemicals and Other Time-Sensitive Materials, Procedures for Safe Handling and Management. Use the following guidelines to manage laboratory chemicals including time-sensitive materials:

1.2.4.1. Acquisition control

- Do not hoard chemicals

- Do not over-purchase quantities
- Use just-in-time purchasing whenever possible
- Dispose of unused portions

1.2.4.2. Research the literature and Safety Data Sheet (SDS) information

- Define storage conditions
- Consider refrigeration requirements or other storage options \
- Consider chemical incompatibilities

1.2.4.3. Define "unsafe" conditions such as:

- Temperature or humidity extremes
- Peroxide concentrations greater than 100 ppm
- Dry picric acid
- Expiration dates

1.2.4.4. Track Laboratory Chemicals

- Maintain a chemical inventory and check expiration dates regularly
- Define inspection interval for each chemical
- Log the date of inspection and re-inspect without fail

1.2.4.5. Manage Expired or "Unsafe" Chemicals

- Never place chemicals where they will become lost or forgotten.
- Do NOT touch lost time-sensitive chemicals. Call EHS for your respective campus immediately (see Laboratory Safety Contacts).

1.3. Chemical Fume Hoods – Procedures for Proper and Safe Use

Chemical fume hoods are one of the most important items of safety equipment present within the laboratory. Chemical fume hoods serve to control the accumulation of toxic, flammable, and offensive vapors by preventing their escape into the laboratory atmosphere. In addition, fume hoods provide physical isolation and containment of chemicals and their reactions and thus serve as a protective barrier (with the sash closed) between laboratory personnel and the chemical or chemical process within the hood.

- A chemical fume hood must be used for any chemical procedures that have the potential of creating:
    - 1. Airborne chemical concentrations that might approach Permissible Exposure Limits (PELs) for an Occupational Safety and Health Administration (OSHA) regulated substance. These substances include carcinogens, mutagens, teratogens, and other toxics.
    - 2. Flammable/combustible vapors approaching one tenth the lower explosive limit (LEL). The LEL is the minimum concentration (percent by volume) of the fuel (vapor) in air at which a flame is propagated when an ignition source is present.
    - 3. Explosion or fire hazards.
    - 4. Odors that are annoying to personnel within the laboratory or adjacent laboratory/office units.
- Vertical fume hood sashes can be used in three positions: 1) closed, 2) the operating height (or half open), and 3) the set-up position (or fully open).
- Hoods must be closed when unattended.
- The sash opening must be positioned no higher than the operating height (or half open) when the hood is being used with chemicals present or when chemical manipulations are performed. Place the sash in front of the face to protect the persons breathing zone near

the nose and mouth from chemical contaminants released within the fume hood. When working with hazardous chemicals, the hood sash should always be positioned so that it acts as a protective barrier between laboratory personnel and the chemicals.

- The set-up position (fully open) is only used to place equipment in the hood when no chemicals are present. Do not fully open the sash when chemicals are present.
- Sliding horizontal sash panels are used with one panel placed in front of the face and arms reaching around the sides to perform manipulations. Do not slide the panels laterally exposing the face to the interior of the hood with chemicals present.
- Hood baffles or slots should be positioned properly if available. The top baffle/slot should be opened when chemicals with a vapor density of less than 1 (lighter than air) are used. The bottom baffle/slot (if available) should be opened when chemicals with vapor densities greater than 1 (heavier than air) are used.
- Chemicals and equipment (apparatus, instruments, etc.) should be placed at least 6 inches (15 cm) from the front edge of the hood.
- Equipment should be placed in the center of the working surface in the hood. Do not place materials at the front of the working surface because it will block the slot under the air foil sill at the front. Do not place materials at the back of the working surface because it will block airflow to the lower slot under the baffle in the back. Separate and elevate equipment by using blocks or lab jacks to ensure that air can flow easily around and under the equipment.
- Chemical fume hoods must be kept clean and free from unnecessary items and debris at all times. Solid material (paper, tissue, aluminum foil, etc.) must be kept from obstructing the rear baffles and from entering the exhaust ducts of the hood.
- Minimize the amount of bottles, beakers and equipment used and stored inside the hood because these items interfere with the airflow across the work surface of the hood.
- Chemicals should not be stored in a hood because they will likely become involved if there is an accidental spill, fire or explosion in the hood, thus creating a more serious problem. Fume hoods are not flammable cabinets and do not offer fire protection for materials stored inside.
- Sliding horizontal sash windows must not be removed from the hood sash.
- Laboratory personnel must not extend their head inside the hood when operations are in progress.
- The hood must not be used for waste disposal (evaporation).
- Hoods must be monitored by the user to ensure that air is moving into the hood. A small piece of thread, yarn, or small piece of Kimwipe® can be taped to the hood sash as a visual indicator that the hood is pulling air. Any hoods that are not working properly must be taken out of service and reported to Facility Services/Physical Plant (FS/PP) and University Environmental Health and Safety for your respective campus (see Laboratory Safety Contacts).
- Perchloric acid digestions and other procedures using perchloric acid at elevated temperatures must not be performed in standard chemical fume hoods. Specially designed perchloric acid fume hoods must be utilized for this purpose. Call EHS for your respective campus for more information.

1.4. Corrosive Chemicals – Procedures for Safe Handling and Storage

Corrosives (liquids, solids, and gases) are chemicals that cause visible destruction or irreversible alterations to living tissue by chemical action at the site of contact. Corrosive effects can occur not only to the skin and eyes, but also to the respiratory tract through inhalation and to the gastrointestinal tract through ingestion. Corrosive liquids have a high potential to cause external injury to the body, while corrosive gases are readily absorbed into the body through skin contact and inhalation. Corrosive solids and their dusts can damage tissue by dissolving rapidly in moisture on the skin or within the respiratory tract when inhaled. In order to minimize these potential hazards, precautionary procedures must be observed when handling corrosives.

1.4.1. Handling

- Appropriate personal protective equipment (e.g., gloves, fire-resistant or all cotton lab coat, and safety goggles) must be worn when working with corrosive chemicals. A face shield, rubber apron, and rubber booties may also be appropriate depending on the work performed.
- Appropriate protective gloves that are resistant to permeation or penetration from corrosive chemicals must be selected and tested for the absence of pin holes prior to use.
- Eyewashes and safety showers must be readily available in areas where corrosive chemicals are used and stored. In the event of skin or eye contact with a corrosive chemical, the affected area should be immediately flushed with water for 15 minutes. Contaminated clothing should be removed and medical attention sought.
- Corrosive chemicals should be handled in a fume hood to ensure that any possible hazardous or noxious fumes generated are adequately vented.
- When mixing concentrated acids with water, add the acid slowly to the water. Allow the acid to run down the side of a container and mix slowly to avoid violent reactions and splattering. Never add water to acid.
- Appropriate spill clean-up material should be available in areas where corrosive chemicals are used and stored.
- Protective carriers shall be used when transporting corrosive chemicals.

1.4.2. Storage

- Containers and equipment used for storage and processing of corrosive material must be corrosion resistant.
- Corrosive chemicals must be stored below eye level, preferably near the floor to minimize the danger of their falling from cabinets or shelves.
- Acids and caustics (i.e. bases) must be stored separately from each other. Secondary containers or trays must be used to separate acids and bases or other incompatible corrosives within a corrosive cabinet.
- Oxidizing acids must be separated from organic acids and flammable/combustible materials (oxidizing acids are particularly reactive with organics and flammable/combustible materials).
- Acids must be segregated from active metals (e.g., sodium, potassium, and magnesium) and from chemicals that can generate toxic gases (e.g., sodium cyanide and iron sulfide).
- Corrosive gas cylinders must be returned for disposal every two years.

1.5. Flammable and Combustible Liquids – Procedures for Safe Handling and Storage

Chemicals which exist at ambient temperatures in a liquid form with sufficient vapor pressure to ignite in the presence of an ignition source are called flammable or combustible liquids (note that the flammable/combustible liquid itself does not burn; it is the vapor from the liquid that burns). According to the National Fire Protection Association (NFPA) classification system, “flammables” generate sufficient vapor at temperatures below 100 F (37.8 C), whereas “combustibles” generate sufficient vapor at temperatures at or above 100 F. Invisible vapor trails from these liquids can reach remote ignition sources causing flashback fires. In addition, these liquids become increasingly hazardous at elevated temperatures due to more rapid vaporization. For these reasons, precautionary measures must be observed when handling and storing flammables and combustibles.

1.5.1. Handling

- Appropriate personal protective equipment (e.g., gloves, fire-resistant or all cotton lab coat, and safety goggles) must be worn when working with flammable/combustible liquids.
- Flammable/combustible liquids must never be heated using open flames. Preferred heat sources include steam baths, water baths, oil baths, hot air baths, and heating mantels.
- Ignition sources must be eliminated in areas where flammable vapors may be present.
- Flammable/combustible liquids should only be dispensed under a fume hood. Ventilation is one of the most effective ways to prevent the formation and concentration of flammable vapors.
- When pouring from conductive containers with a capacity of 1 gallon (3.8 liters) or greater, make sure both containers involved are electrically interconnected by bonding to each other and to a ground. The friction of flowing liquid may be sufficient to generate static electricity, which in turn may discharge, causing a spark and ignition
- Flammable/combustible liquids in containers with a volume greater than 1 gallon (3.8 liters) should be transferred to smaller containers that can be easily manipulated by one person.
- Appropriate fire extinguishers must be available in areas where flammables are used.

1.5.2. Storage

- Flammable/combustible liquid in quantities exceeding a total of 10 gallons (38 liters) within a laboratory must be stored in approved flammable storage cabinets or safety cans.
- Flammable/combustible liquid stored outside of flammable storage cabinets in the laboratory should be kept to the minimum necessary for the work being done.
- Containers with a volume greater than 5 gallons (19 liters) shall not be stored in the laboratory without prior approval of IUEHS for the respective campus.
- Flammable/combustible liquid stored in glass containers shall not exceed 1 gallon (3.8 liters).
- Flammable storage cabinets and safety cans must not be altered or modified.
- Safety cans with damaged screens (spark arrestors) or faulty springs (that do not close tightly) do not meet the required specifications of a safety can and must be taken out of service immediately and repaired or replaced.
- Flammable liquids must only be stored in explosion-proof or laboratory-safe refrigeration equipment.
- Flammable/combustible liquid containers, filled or empty, must not be stored in hallways or obstructing exits.
- Bulk waste flammable/combustible liquids should be stored in safety cans.
- Flammables and combustibles must not be stored near oxidizers, corrosives, combustible material, or near heat sources. Make sure all chemicals stored near flammables and combustibles are compatible.

1.6. Oxidizing Agents – Procedures for Safe Handling and Storage

Oxidizing agents are chemicals that bring about an oxidation reaction. The oxidizing agent may 1) provide oxygen to the substance being oxidized (in which case the agent has to be oxygen or contain oxygen) or 2) receive electrons being transferred from the substance undergoing oxidation (chlorine is a good oxidizing agent for electron-transfer purposes, even though it does not contain oxygen). The intensity of the oxidation reaction depends on the oxidizing-reducing potential of the material involved. Fire or explosion is possible when strong oxidizing agents come into contact with easily oxidizable compounds, such as metals, metal hydrides or organics. Because oxidizing agents possess varying degrees of instability, they can be explosively unpredictable.

1.6.1. Examples of Oxidizing Agents

- Gases: Fluorine, Chlorine, Ozone, Nitrous Oxide, Oxygen
- Liquids: Hydrogen Peroxide, Nitric Acid, Perchloric Acid, Bromine, Sulfuric Acid
- Solids: Nitrites, Nitrates, Perchlorates, Peroxides, Chromates, Dichromates, Picrates, Permanganates, Hypochlorites, Bromates, Iodates, Chlorites, Chlorates, Persulfates

1.6.2. Handling

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fire resistant or all cotton lab coat) must be worn when working with oxidizers.
- If a reaction is potentially explosive or if the reaction is unknown, use a fume hood (with the sash down as a protective barrier), safety shield, or other methods for isolating the material or the process.
- Oxidizers can react violently when in contact with incompatible materials. For this reason, know the reactivity of the material involved in an experimental process. Assure that no extraneous material is in the area where it can become involved in a reaction.
- The quantity of oxidizer used should be the minimum necessary for the procedure. Do not leave excessive amounts of an oxidizer in the vicinity of the process.
- Perchloric acid digestions and other procedures using perchloric acid at elevated temperatures must not be performed in a standard chemical fume hood. A specially designed Perchloric Acid Fume Hood must be utilized for this purpose. Contact EHS for your respective campus (see Laboratory Safety Contacts) for more information.

1.6.3. Storage

- Oxidizers should be stored in a cool, dry place.
- Oxidizers must be segregated from organic material, flammables, combustibles and strong reducing agents such as zinc, alkaline metals, and formic acid.
- Oxidizing acids such as perchloric acid and nitric acid must be stored separately in compatible secondary containers away from other acids. For the purpose of storage, the Uniform and International Building Code and the National Fire Protection Association classify oxidizers based on the increase in the burning rate of the combustible material with which it comes into contact. Contact EHS for your respective campus (see Laboratory Safety Contacts) for more information.

1.7. Reactive Chemicals – Procedures for Safe Handling and Storage

Reactives are substances that have the potential to vigorously polymerize, decompose, condense, or become self-reactive due to shock, pressure, temperature, light, or contact with another material. All reactive hazards involve the release of energy in a quantity or at a rate too great to be dissipated by the immediate environment of the reaction system so that destructive effects occur. Reactive chemicals include: 1) explosives, 2) organic peroxides, 3) water-reactives and 4) pyrophorics. Effective control is essential to minimize the occurrence of reactive chemical hazards.

1.7.1. Explosives

A chemical that causes sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden adverse conditions. Heat, light, mechanical shock, detonation, and certain catalysts can initiate explosive reactions. Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, or ozonide are sensitive to shock and heat and can explode violently.

- Appropriate personal protective equipment (e.g., face shield, safety goggles, leather outer gloves, chemical resistant gloves, fire-resistant or all cotton lab coat) must be worn when working with explosives.
- Before working with explosives, understand their chemical properties, know the products of side reactions, know the incompatibility of certain chemicals, and monitor environmental catalysts such as temperature changes.
- Containers should be dated upon receipt and when opened. Expired explosives should be disposed of through EHS for your respective campus promptly.
- Explosives should be kept to the minimum necessary for the procedure.
- If there is a chance of explosion, use protective barriers (e.g., fume hood sash and safety shield) or other methods for isolating the material or process.
- Explosives should be stored in a cool, dry, and protected area. Segregate from other material that could create a serious risk to life or property should an accident occur.

1.7.2. Organic Peroxides

These chemicals contain an -O-O- structure bonded to organic groups. These compounds can be considered as structural derivatives of hydrogen peroxide, H-O-O-H, in which one or both of the hydrogen atoms have been replaced by an organic group. Generally, organic peroxides are low-powered explosives that are sensitive to shock, sparks, and heat due to the weak -O-O- bond which can be cleaved easily. Some organic compounds such as ethers, tetrahydrofuran, and p-dioxane can react with oxygen from the air forming unstable peroxides. Peroxide formation can occur under normal storage conditions, when compounds become concentrated by evaporation, or when mixed with other compounds. These accumulated peroxides can violently explode when exposed to shock, friction, or heat.

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fireresistant or all cotton lab coat) must be worn when working with organic peroxides or peroxide-forming compounds.
- Containers must be labeled with the receiving and opening dates. Discard unopened material within the timeframes outlined in the Waste Management Guide for your respective campus.
- Containers should be airtight, and stored in a cool, dry place away from direct sunlight and segregated from incompatible chemicals.
- Do not refrigerate Peroxide-formers, liquid peroxides, or solutions below the temperature at which the peroxide freezes or precipitates. Peroxides in these forms are extra sensitive to shock (never store diethyl ether in a refrigerator or freezer).
- Unused peroxides should never be returned to the stock container.

- Do not use metal spatulas with peroxide-formers. Use only ceramic or plastic spatulas. Contamination by metal can cause explosive decomposition.
- Avoid friction, grinding, and all forms of impact, especially with solid organic peroxides. Never use glass containers with screw cap lids or glass stoppers. Instead, use plastic bottles and sealers.
- Containers with obvious crystal formation around the lid or viscous liquid at the bottom of the container must NOT be opened or moved. Call EHS for your respective campus (see Laboratory Safety Contacts) for guidance and disposal.
- Organic peroxides produce vapors during decomposition. This can result in pressure build-up. The rapid increase in pressure may cause explosive rupture of containers, vessels or other equipment.
- Ignition sources must be avoided.
- Organic Peroxides have a Self-Accelerating Decomposition Temperature (SADT). Never store organic peroxides where they may be exposed to temperatures above the SADT. At or above this temperature an irreversible runaway reaction will take place. The recommended storage temperature is printed on the product label and Safety Data Sheet.

1.7.3. Water-Reactives

A chemical that reacts with water or moisture in the air (humidity) releasing heat or flammable, toxic gas. Examples include alkali metals, alkaline earth metals, carbides, hydrides, inorganic chlorides, nitrides, peroxides, and phosphides.

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fireresistant or all cotton lab coat) must be worn when working with water-reactives.
- Water-reactives should be stored under mineral oil in a cool, dry place and isolated from other chemicals.
- Water-reactives must not be stored near water, alcohols, and other compounds containing acidic OH. In case of fire, keep water away. Appropriate fire extinguishers should be available in areas where water-reactives are used (use a Type "D" fire extinguisher to extinguish active metal fires).

1.7.4. Pyrophorics

A chemical that ignites spontaneously in air below 130 F (54 C). Often the flame is invisible. Examples of pyrophoric materials include silane, silicon tetrachloride, white and yellow phosphorus, sodium, tetraethyl lead, potassium, nickel carbonyl, and cesium.

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fireresistant or all cotton lab coat) must be worn when working with pyrophorics.
- Pyrophorics must be used and stored in inert environments.
- Appropriate fire extinguishers must be available in areas where pyrophorics are used.

1.7.5. Synthesis

Synthesis of any reactive or energetic (explosive) compound is subject to the following requirements:

- The principal investigators written prior approval of the procedure is required.
- The procedure must be documented in writing with specific step by step instructions.
- The principal investigator is required to provide documented procedure-specific training and documented daily supervision of the research.
- A written hazard analysis of the procedure is required prior to start up and whenever a change to the procedure is made.

- Appropriate hazard controls, as determined by the hazard analysis, must be in place prior to the experiment.
- The synthesized quantity is limited to 100 milligrams. Synthesis of more than 100 mg of reactive or energetic compounds is prohibited.

1.8. Electrical Safety Procedures

Serious injury or death by electrocution is possible when appropriate attention is not given to the engineering and maintenance of electrical equipment and personal work practices around such equipment. In addition, equipment malfunctions can lead to electrical fires. By taking reasonable precautions, electrical hazards in the laboratory can be dramatically minimized.

- Laboratory personnel should know the location of electrical shut-off switches and/or circuit breakers in or near the laboratory so that power can be quickly terminated in the event of a fire or accident.
- Electrical panels and switches must never be obstructed and should be clearly labeled to indicate what equipment or power source they control.
- All electrical equipment should be periodically inspected to ensure that cords and plugs are in good condition. Frayed wires and wires with eroded or cracked insulation must be repaired immediately, especially on electrical equipment located in wet areas such as cold rooms or near cooling baths. Insulation on wires can easily be eroded by corrosive chemicals and organic solvents.
- All electrical outlets should have a grounding connection requiring a three-pronged plug.
- All electrical equipment should have three-pronged, grounded connectors. The only exception to this rule are instruments entirely encased in plastic (such as electric pipetters and some types of microscopes) and Glas-Col heating mantels. If equipment does not have a three-pronged plug, replace the plug and cord to ground the equipment.
- Face plates must not be removed from electrical outlets.
- Electrical wires must not be used as supports.
- Extension cords should be avoided. If used, they should have three-pronged, grounded connectors, positioned or secured as not to create a tripping hazard, and ONLY for temporary use.
- All shocks must be reported to the principal investigator or supervisor. All faulty electrical equipment must be immediately removed from service until repaired.
- Electrical outlets, wiring, and equipment within a laboratory or building must only be repaired by Facility Services/Physical Plant (FS/PP) for your respective campus or other professional electricians.
- Electrical appliances must only be repaired by authorized electricians or the manufacturer. Unauthorized modifications of electrical appliances is prohibited.
- Proper grounding and bonding of flammable liquid containers should be practiced to avoid the build-up of excess static electricity. Sparks generated from static electricity are good ignition sources.
- Experimental electrical equipment in laboratories must be shielded, insulated, or have appropriate fail-safe devices when energized or in use. Personnel must be proficient in use of the equipment and safety precautions. Personnel should be trained in first aid and CPR in case of electrical shock.

1.9. Glassware and Sharps – Procedures for Safe Handling and Disposal

1.9.1. Definitions

Sharps - The term "sharps" refers to “any item having corners, edges, or projections capable of cutting or piercing the skin.”

Puncture Proof – Commercial sharps containers intended for the disposal of broken glass, syringe needles, scalpels, etc.

Puncture Resistant – Re-used containers that, when carefully used, will resist puncture by the disposed item. Examples of “sharps” include:

- Needles
- Broken glass
- Syringes
- Razor blades
- Lancets
- Glass Pasteur pipettes
- Scalpel blades
- Microtome blades
- Exacto knives
- Any other sharp lab waste

1.9.2. Handling

- Glassware and sharps should be handled and stored carefully to avoid damage.
- Reusable syringes that are not biologically contaminated must be capped and put away after use. Cap syringes using the one-handed method of picking up the cap with the needle then carefully securing the cap onto the syringe. Retractable syringes are preferred. A disposable syringe should be used for biological materials and should be placed in a sharps container without recapping.
- Chipped, broken, or star-cracked glassware should be discarded or repaired. Damaged glassware should never be used unless it has been repaired.
- Because of the potential for catastrophic breakage resulting in sharp projectiles, only thick-walled, pressure-resistant glassware may be utilized under positive pressure or a vacuum.
- Use appropriate hand protection when inserting glass tubing into a rubber stopper or when placing rubber tubing on glass hose connections. Use of plastic or metal connectors should be considered.
- Use appropriate hand protection when picking up broken glass or other sharp objects. Small pieces should be swept up using a brush and dustpan.

1.9.3. Disposal

Sharps waste is categorized by the type of contamination present. Specific disposal methods are dictated by category, but all categories require packaging in puncture resistant cardboard or plastic containers in order to minimize the risk of injuries.

1.9.4. Uncontaminated Sharps

Uncontaminated metal or glass sharps should be collected in puncture-proof containers, labeled, sealed, and disposed according to your campus procedures found in the IU Waste Management Program. Note: Disposable items such as pipette tips and wood swabs that are not sharps but may perforate the liners of the waste receptacles present a hazard to custodians. These may be placed in any puncture resistant container such as a non-breakable plastic jar, bottle, thick plastic bag or other type of container and placed in the waste receptacle. Custodial services will remove this waste.

1.9.5. Chemically Contaminated Sharps

Chemically contaminated metal or glass sharps that are grossly contaminated with hazardous chemicals, should be collected in puncture-proof containers, labeled, sealed, and disposed according to your campus procedures found in the EHS Waste Management Program. Note: Spill residue with broken glass, spill absorbents, etc., must be collected as "Hazardous Chemical Waste" and not placed into the broken glass receptacles. Caution: To avoid dumpster fires, boxes may only be used if the chemical contamination is compatible with the organic cellulose of the box material. Materials contaminated with oxidants should be placed in glass, metallic, or chemically resistant plastic containers.

1.9.6. Radioactive Sharps

Refer to the EHS Radiation Safety Manual for disposal of materials with radioactive contamination.

1.9.7. Biohazardous items

Refer to the EHS Biosafety Manual for disposal of materials with biohazardous contamination.

1.10. Personal Protective Equipment – Procedures for Selection and Use

Personal protective equipment (PPE) is selected based on the potential hazard presented by the work. Scrutinize each laboratory procedure individually for potential hazards based on the chemicals to be used and the procedure to be performed. The hazard assessment is then used to determine the appropriate personal protective equipment. Each laboratory group is responsible for assessing the potential hazards presented by their work. The potential hazards presented by typical laboratory procedures and the corresponding personal protective equipment are found on the form. The list does not include all laboratory procedures. Additional tasks and personal protective equipment should be added as necessary on the form. Many chemicals not on the list also require the use of gloves and other personal protective equipment. Never underestimate the risk of exposure. Always practice good chemical hygiene and use personal protective equipment.

1.10.1. Hand protection

No glove is resistant to all chemicals. Consult the glove manufacturer's selection guides for chemical compatibility prior to use. Glove selection guides can also be found at the manufacturer's web sites.

1.10.1.1. Selection

When selecting and using gloves always:

- Consider chemical resistance, thickness, length, and dexterity requirements.
- Inspect all gloves before use for signs of swelling, cracking, discoloration, pinholes, etc.
- Consider double gloving (wearing one glove over another) as a precaution.
- Change gloves frequently or as often as needed if they become contaminated.
- Do not wear gloves into the hallways or other common areas.
- Do not touch doorknobs, phones, etc., when wearing gloves. (Remove them before touching anything to prevent leaving chemical residue on the item.)
- Remove gloves by pinching the material in the palm and turning them inside out as the glove is removed over the finger tips (thus keeping contamination on the inside of the removed glove.)
- Rinse thicker reusable gloves after every use.

1.10.1.2. Chemical Resistance

Chemical resistance is based on several characteristics of the glove material. When selecting the appropriate glove, the following properties must be considered:

- Degradation,
- Breakthrough time, and
- Permeation rate.

- Degradation is the change in one or more of the physical properties of a glove caused by contact with a chemical. Degradation typically appears as hardening, stiffening, swelling, shrinking or cracking of the glove. Degradation ratings indicate how well a glove will hold up when exposed to a chemical. When looking at a chemical compatibility chart, degradation is usually reported as E (excellent), G (good), F (fair), P (poor), NR (not recommended) or NT (not tested).
- Breakthrough time is the elapsed time between the initial contact of the test chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove.
- Permeation rate is the rate at which the test chemical passes through the glove material once breakthrough has occurred and equilibrium is reached. Permeation involves absorption of the chemical on the surface of the glove, diffusion through the glove, and desorption of the chemical on the inside of the glove. Resistance to permeation rate is usually reported as E (excellent), G (good), F (fair), P (poor), NR (not recommended), or NT (not tested). If chemical breakthrough does not occur, then permeation rate is not measured and is reported ND (none detected).
- Manufacturers stress that permeation and degradation tests are done under laboratory test conditions, which can vary significantly from actual conditions in the work environment. Users may decide to conduct their own tests, particularly when working with highly toxic materials or chemicals for which no data can be found. This must always be done carefully in a fume hood with PPE and without touching the chemicals or contaminated materials with the hands (e.g., use forceps). For mixtures, it is recommended that the glove material be selected based on the shortest breakthrough time.
    - Butyl - Offers the highest resistance to permeation by most gases and water vapor. Especially suitable for use with esters and ketones.
    - Neoprene - Provides moderate abrasion resistance but good tensile strength and heat resistance. Compatible with many acids, caustics and oils.
    - Nitrile - Excellent general duty glove. Provides protection from a wide variety of solvents, oils, petroleum products and some corrosives. Excellent resistance to cuts, snags, punctures and abrasions.
    - PVC - Provides excellent abrasion resistance and protection from most fats, acids, and petroleum hydrocarbons. PVA Highly impermeable to gases. Excellent protection from aromatic and chlorinated solvents. Cannot be used in water or water-based solutions.
    - Viton - Exceptional resistance to chlorinated and aromatic solvents. Good resistance to cuts and abrasions.
    - Silver Shield - Resists a wide variety of toxic and hazardous chemicals. Provides the highest level of overall chemical resistance.

- Natural rubber - Provides flexibility and resistance to a wide variety of acids, caustics, salts, detergents and alcohols. (See Latex Gloves and Related Allergies below).

1.10.1.3. Latex Gloves and Related Allergies

Allergic reactions to natural rubber latex can sometimes occur. The term "latex" refers to natural rubber latex and includes products made from dry natural rubber. Natural rubber latex is found in many products including disposable gloves and other personal protective equipment. Several chemicals are added to this fluid during the processing and manufacture of commercial latex. Some proteins in latex can cause a range of mild to severe allergic reactions. The chemicals added during processing may also cause skin rashes. Latex exposure symptoms include skin rash and inflammation, respiratory irritation, asthma and shock. The amount of exposure needed to sensitize an individual to natural rubber latex is not known, but when exposures are reduced, sensitization decreases. In addition to skin contact with the latex allergens, inhalation is another potential route of exposure. The proteins responsible for latex allergies have been shown to fasten to powder that is used on some latex gloves. Latex proteins may be released into the air along with the powders used to lubricate the interior of the glove. The following actions are recommended to reduce exposure to latex:

- Whenever possible, substitute another glove material.
- If latex gloves must be used, choose reduced-protein, powder-free latex gloves.
- Wash hands with mild soap and water after removing latex gloves. Once a worker becomes allergic to latex, special precautions are needed to prevent exposures during work. Certain medications may reduce the allergy symptoms, but complete latex avoidance is the most effective approach.

1.10.2. Protective Eyewear

Protective eyewear is required whenever there is a reasonable probability that the eyes could be exposed to chemicals. The type of eyewear required depends on the hazard classification of the area and procedure to be performed.

1.10.2.1. Types of Protective Eyewear

1.10.2.1.1. Safety Glasses

Safety glasses have shatter resistant lenses made of materials like polycarbonate plastic with side shields attached to the temples that meet the specifications of the American National Standards Institute Standard Z87.1-1989. Safety glasses are designed to stop physical objects or harmful radiation such a laser light from entering the eyes and provide little or no protection from vapors or liquids.

1.10.2.1.2. Goggles

Properly vented safety goggles are the preferred eye protection to be worn when chemicals are handled in the laboratory. These should be worn over prescription glasses. Goggles come in two types: vented and non-vented. Non-vented goggles are used to protect your eyes from vapors, mists, fumes, or other eye hazards that require complete eye coverage with no leaks or perforations. Vented goggles are used where there are moderate quantities of liquids being used but no vapors or mists are involved. There are several types of vented goggles. The type of vented goggles made for laboratory use has a series of buttons embedded into the plastic. These buttons house a baffle plate that allows air to pass but presents a physical barrier to liquids. Do not use the common vented goggle with simple holes drilled in the sides. This type of vented goggle will not stop liquids from coming in through the holes and is not suitable for laboratory work.

1.10.2.1.3. Face Shields

Face shields are designed to augment other types of eye protection and are not meant to be a stand-alone form of eye protection. Face shields are used to protect your entire face to catch any liquids that might splash onto the face.

1.10.2.2. Hazard Classifications

Areas and operations within research buildings can be classified into three types of hazardous areas based on the following definitions. It is important to recognize that the procedure is classified as well as the area. If a procedure creates a greater hazard than the laboratory classification would indicate, eye and face protection appropriate for the hazard shall be worn. It would be possible to have a Class 3 operation in a Class 2 area. Appropriate additional protection would be required.

1.10.2.2.1. Class 1 – Eye Protection Not Required

This classification includes laboratories that do not use chemicals, biological materials, or physically hazardous materials. Hazards requiring eye protection are seldom encountered in this area. These areas are exempt from the requirement that occupants and visitors must wear industrial safety glasses. Examples include computer or imaging laboratories and other areas such as:

- Offices including enclosed offices within laboratories or protected desk areas. To comply with this requirement there must be a line of sight barrier (for example an office partition) between personnel and any chemicals or any chemical process in the laboratory;
- Conference rooms;
- Libraries and reading rooms;
- Corridors, lobbies, elevators, and stairwells;
- Locker and rest rooms;
- Mail and copier rooms;
- Computer and computer user rooms; and
- Lounges and break rooms.

1.10.2.2.2. Class 2 – Eye Protection Required When Hazards Exist

This classification includes laboratories that use chemicals, biological materials, or physically hazardous materials on an occasional basis. Eye protection must be worn when the hazards exist. Safety eyewear such as industrial safety glasses with side shields are required for workers and visitors in these areas. Examples include laser laboratories and some research laboratories.

1.10.2.2.3. Class 3 – Eye Protection Required At All Times

Specific and predictable eye hazards exist in these areas such as laboratories that routinely use chemicals, biological materials, or machinery. Examples of eye protection required in these areas are acid splash goggles, face shields, welding helmets, and laser goggles. Industrial safety glasses alone may not provide adequate eye protection in these areas. Examples include chemistry teaching laboratories and organic chemistry laboratories. Note: Contact lenses may complicate treatment in the event of an accident. They may be allowed or prohibited based on the specific laboratory procedures and policy. The use of contact lenses is only allowed in conjunction with appropriate safety eyewear and the laboratory supervisor’s approval. Instructors or supervisors must be aware of those wearing contact lenses.

1.10.2.3. Exemption Procedure

Eye protection may need to be removed while viewing materials through a microscope or similar equipment. Eye protection must be replaced after operation is complete. Microscope and similar equipment must be located in an area where removal of eye protection does not place personnel at risk from other hazards in the area.

1.10.2.3.1. Local Safety Procedure Required

State if eye protection can be removed behind a line of sight barrier. Define the line of sight barrier. Any approved exemptions must be identified on the Personal Protective Equipment Hazard Assessment Form.

1.10.3. Protective Clothing

Protective clothing in the form of lab coats, aprons, and closed-toed shoes are required whenever the possibility of chemical contamination to the body exists. Protective clothing that resists physical and chemical hazards should be worn over street clothes. Lab coats and aprons should be left in the laboratory and not taken home. This prevents the worker from carrying incidental contamination out of the laboratory and presenting a chemical hazard to co-workers, friends, or family. Disposable outer garments such as Tyvek suits, aprons, and lab coats may be useful when cleaning and decontamination of reusable clothing is difficult. Shorts, loose clothing (including ties), or torn clothing are inappropriate for work with hazardous chemicals.

1.10.3.1. Lab Coats

Lab coats are appropriate for minor chemical splashes and spills. They must be worn buttoned with the sleeves covering the arms. Do not roll up the sleeves.

1.10.3.2. Aprons

Rubber or plastic aprons are appropriate for handling corrosives or irritating liquids.

1.10.4. Footwear

Safety shoes or other specialized foot protection are generally not required for most laboratory operations. However, shoes must cover the entire foot. Open toed shoes and sandals are inappropriate footwear in laboratories. Fabric and athletic shoes offer little or no protection from chemical spills. Leather shoes or equivalent (chemically resistant shoes) with slip-resistant soles are required. Shoes may have to be discarded if contaminated with a hazardous material. Chemical resistant overshoes, boots, or disposable shoe coverings (“booties”), may be used to avoid possible exposure to corrosive chemicals or large quantities of solvents or water that might penetrate normal footwear (e.g., during spill cleanup). Although generally not required in most laboratories, composite-toed safety shoes may be necessary when there is a risk of heavy objects falling or rolling onto the feet, such as in bottle-washing operations, animal care facilities, or if large quantities of liquids are stored and moved in drums. Please refer to the EHS Foot Protection Program for additional guidance.

1.10.5. Respiratory Protection

Respiratory protection is typically provided by using adequate engineering controls such as chemical fume hoods, canopy hoods, snorkel hoods, glove boxes, and appropriately equipped biological safety cabinets. It should be noted that not all biological safety cabinets provide protection from toxic chemical vapors and fumes. These devices should be carefully selected and used only for their intended purpose. A respirator may only be used when engineering controls, such as general ventilation or a fume hood, are not feasible or do not reduce the exposure of a chemical to acceptable levels. Contact EHS for your respective campus for more information or to obtain a respirator and arrange the required respirator fit test and medical examination.

1.10.6. Head Protection

Head protection may be necessary in industrial type laboratories where overhead hazards exist or fluids may splash onto the head. Appropriate head protection in the form of hard hats or fluid barrier hats should be used in these cases. Hooded disposable coveralls may also be used if necessary.

1.11 Other References

USU EHS Hazardous Waste Pick up
http://rgs.usu.edu/ehs/ehs-tools/

USU EHS Laboratory trainings
http://rgs.usu.edu/ehs/laboratory/

Contacts:

- Cameron Pehrson, Safety/Industrial Hygienist;
    - 435-797-3290, Cameron.pehrson@usu.edu
- Rachel Curry, Chemical Hygienist, Safety/Industrial Hygienist;
    - 435-797-7423, rachel.curry@usu.edu

Last modified on January 12th, 2018

*Safety protocols modified from the Indiana University Environmental Health & Safety Laboratory Standard Operating Procedures
https://protect.iu.edu/doc/environmental-health/lab-chp/lab_chp_sop_entire-2.pdf