Laboratory Safety Rules & Standard Operating Procedures

General Laboratory Standards

The following general standards should be followed by employees and students performing laboratory work with chemicals and hazardous materials. These general guidelines can be modified based on a written laboratory-specific evaluation of hazards and risks which lead to a laboratory-specific operation and protective equipment program.

Employees and students should:

- Know the safety rules and procedures that apply to the work that is being done
- Determine the potential hazards and appropriate safety precautions before beginning any new operation
- Know the location of and how to use the emergency equipment in the work area, as well as how to obtain additional help in an emergency, and be familiar with emergency procedures
- Be alert to unsafe conditions and actions and call attention to them so that corrections can be made as soon as possible
- Use equipment only for its designed purpose
- Use only those chemicals for which appropriate safety controls and protective equipment are available
- Eating, drinking, smoking, gum chewing, or application of cosmetics should not occur in areas where laboratory chemicals are present
- Wash their hands prior to leaving the laboratory after using chemicals, even if gloves or other similar PPE was employed
- Do not store or handle food or beverages in storage areas, refrigerators, glassware, or areas that are also used for laboratory operations
- Refrain from using personal electronics such as cell phones in the laboratory
- Refrain from using noise-cancelling headphones or earphones in the laboratory
- Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware
- Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur
- Leave all protective equipment in the lab when exiting including lab coats and protective gloves
- Avoid practical jokes or other behavior that might confuse, startle, or distract other workers
- Do not use mouth suction for pipetting or starting a siphon

- Confine long hair and loose clothing
- Wear closed-toe shoes that encloses the entire feet at all times in the laboratory; NO SANDALS ARE PERMITTED TO BE WORN IN THE LABORATORY
- Safety goggles or alternative eyewear that was designated through the hazard review process must be worn in the lab at all times when chemicals are present and in use
- Long pants or skirt covering legs and ankles must be worn in the laboratory. Bare midriff, legs, or shoulders are not allowed in the laboratory as directed by the laboratory supervisor
- Dispose of chemicals properly at the end of the experiment. Never put hazardous chemicals down the drain unless specific authorization has been granted
- Hazardous experiments should not be unattended
- All new procedures must be evaluated for potential hazards associated with the work by the laboratory supervisor
- Report incidents following the SCU **Injury and Incident Reporting Process** (EHS Website: Incident Reporting)

The following resources are available for those who wish to explore additional or alternative controls:

- Safety Data Sheets (SDS) for the materials in question, available at https://chimeracloud.org/sds/
- "Safety in Academic Chemistry Laboratories" American Chemical Society. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf

Standard Operating Procedures (SOPs)

The special precautions described in the following sections are to be used in conjunction with the information detailed in the above General Laboratory Standards. The special precautions sections and any other relevant instructions in this Chemical Hygiene Plan may be used as part of the written standard operating procedures required by the OSHA Laboratory Standard. **Project-specific and/or area-specific standard operating procedures must be written by departments, work units, Supervisors, Laboratory Supervisors for hazardous chemical and hazardous operations work not covered by the following special precautions sections.**

The use of certain chemicals (for example, toxic gases, pyrophoric substances, and the 13 specific carcinogens that require OSHA notice) must be pre-approved by the Chemical Hygiene Officer (CHO) due to the likelihood of specific permitting or exposure control requirements (see Appendix 8 of the SCU Chemical Hygiene Plan for more details – Restricted Substances).

Physical & Chemical Hazards

"Physical hazard" refers to a chemical for which there is evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive), corrosive, or water-reactive. Materials which present a physical hazard can be safely used if the specific hazard(s) are understood, and measures are taken to address the hazards. If appropriate precautions are not taken, a fire, an explosion, unwanted corrosion, personal injury, or property damage could occur. Certain chemicals cannot be safely mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result.

An eyewash and safety shower must be readily accessible to areas where hazardous materials are used and stored. In the event of skin or eye contact with a hazardous material, immediately flush the area of contact with cool water for 15 minutes. Remove all affected clothing. Get medical help by calling Campus Safety (408-554-4444). Additional information concerning eyewash and safety shower requirements is available in SCU's **Emergency Eyewash and Shower Program**.

Laboratories present special challenges in the prevention of repetitive stress injuries. Laboratory employees are urged to contact EHS to request an ergonomic workstation evaluation if they have any concerns regarding the setup of their workstations.

Working with Flammables:

Flammable/combustible materials are materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source. Flammable materials can generate sufficient vapors at temperatures below 199 °F (93 °C). The vapors of these materials are invisible, and a vapor trail to an ignition source away from the immediate area can result in a flashback. Flammables are more hazardous at elevated temperatures due to more rapid vaporization. In addition, flammable materials react with oxidizers which can result in a fire.

Observe the following special precautions:

1. Eliminate ignition sources such as open flames, smoking materials, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity.
2. Minimize the quantity of flammable materials kept in the work area.
3. Store in approved flammable liquid containers (original containers or safety cans) and storage cabinets, or in a special storage room designed for that purpose. Store away from oxidizers.
4. Flammable liquids stored in glass containers shall not exceed 1 quart. Exception: For conditions where chemical purity must be protected, flammable liquids stored in glass containers shall not exceed 1 gallon unless specific permission for such use has been granted.
5. Refrigerators and freezers used for the storage of flammable materials must have no internal sources of ignition ("lab-safe" or "flammable rated").
6. Ensure that there is proper bonding and grounding when it is required, such as when transferring or dispensing a flammable liquid from a large container or drum. Bonding and grounding must be checked regularly.
7. Ensure that appropriate fire control systems or extinguishers are available and accessible.

Working with Corrosives:

Corrosives are materials that can react with the skin causing burns similar to thermal burns, and/or which can react with metal causing deterioration of the metal surface. Acids and bases are corrosives. Observe the following special precautions:

1. Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant.
2. Eye protection (safety glasses or splash goggles, as appropriate) and rubber gloves should always be used when handling corrosive materials. A face shield, rubber apron, and rubber boots may also be appropriate, depending on the work performed.
3. When mixing concentrated acids (caustics) with water, add the acid (caustic) slowly to water. **Never add water to acid (caustic)**.
4. Acids and bases should be stored separately from each other. Organic acids should be stored with flammable materials, separate from oxidizers and oxidizing acids.

Working with Oxidizers

Oxidizers are materials that readily yield oxygen or another oxidizing gas, or that readily react to promote or initiate combustion of flammable/combustible materials. Oxidation reactions are a frequent cause of chemical accidents. Observe these precautions to reduce risk when storing or handling oxidizers:

1. Know the reactivity of the materials involved in experiment or process. Make sure that there

are no extraneous materials in the area which could become involved in a reaction.

2. If the reaction can be violent or explosive, use shields or other methods for isolating the materials or the process.
3. Use the minimum amounts necessary for the procedure. Do not keep excessive amounts of the material in the vicinity of the process.
4. Store properly, away from organic materials, flammable materials, and other reducing agents.
5. Perchloric acid should be used only in specially-designed perchloric acid fume hoods equipped with wash-down systems to prevent deposition of shock-sensitive perchlorates in the ductwork and machinery. Contact the CHO for review and approval if use of concentrated or hot perchloric acid is needed.

Working with Water-Reactive Materials

Water-reactive materials are substances that generate a flammable, toxic, or hazardous gas upon contact with water or moisture. Fire and explosion are serious concerns when working with these materials. Special precautions for safe handling of water-reactive materials will depend on the specific material, and the conditions of use and storage.

Contact CHO for information on the safe use and storage of a specific material. Examples of water-reactive materials include alkali and alkaline earth metals (e.g. Li, Na, K, Ca, Mg), metal hydrides, some metal and nonmetal chlorides (e.g. $SiCl_4$, PCl_3, $AlCl_3$), calcium carbide, and acid halides.

Working with Pyrophoric Materials

Pyrophoric materials ignite spontaneously upon contact with air. The flame may or may not be visible. Examples include butyllithium, silane, and yellow phosphorous.

Contact CHO for information on the safe use of pyrophorics. All pyrophorics must be stored in an inert atmosphere.

Working with Peroxide-Forming Chemicals (PFCs)

Peroxide-forming or peroxidizable chemicals are substances or mixtures that react with oxygen to form peroxides. Some peroxides can explode with impact, heat, or friction such as that caused by removing a lid. Peroxides form inside the containers of some materials even if they have not been opened. Examples include ethyl ether, tetrahydrofuran, liquid paraffins (alkanes), and olefins (alkenes).

Follow the Guideline for Peroxide-Forming Chemicals (EHS Website: Laboratory Safety) to ensure PFCs are managed appropriately. Contact CHO for further guidance on safe use of PFCs.

Working with Light-Sensitive Materials

Light-sensitive materials are unstable with respect to light energy. They tend to degrade in the presence of light, forming new compounds that can be hazardous, or resulting in conditions such as pressure build-up inside a container which may be hazardous.

Observe the following precautions:

1. Store light-sensitive materials in a cool, dark place in amber colored bottles or other containers that reduce or eliminate penetration of light.
2. Date containers on receipt and upon opening, and dispose of surplus material after one year if unopened or 6 months if opened.

Working with Shock-Sensitive or Explosive Materials

Shock-sensitive/explosive materials are substances or mixtures which can spontaneously release large amounts of energy under normal conditions, or when struck, vibrated, or otherwise agitated. Some materials become increasingly shock-sensitive with age and/or loss of moisture. The inadvertent formation of shock-sensitive/explosive materials such as peroxides, perchlorates, picrates, and azides is of great concern in the laboratory.

1. Contact the CHO when work with shock-sensitive or explosive materials is planned or when it is suspected that the inadvertent formation of shock-sensitive materials in ductwork, piping, or chemicals being stored has occurred.
2. Date all containers of explosive or shock-sensitive materials upon receipt and when opened. Unless an inhibitor has been added, unopened shock-sensitive materials should be discarded within 12 months after receipt. Open containers of shock-sensitive materials should be discarded within 6 months of the date opened.
3. Use the minimum amount of materials necessary for a procedure. Keep a minimum amount of material on hand.

If there is a chance of explosion, use barriers or other methods for isolating the materials or the process.

Working with Gases Under Pressure (Compressed Gases)

Special systems are needed for handling materials under pressure. Toxic and corrosive gases present special problems in design of engineering controls. The physical and health hazards of any material are typically compounded by the pressure hazard. Carefully observe the following special precautions:

1. Signs shall be provided by the CHO and posted by the Laboratory Supervisor identifying type of cylinders to be stored and identifying any potential hazard.
2. Compressed gas cylinders shall be stored and secured in an upright position. Gas cylinders in storage and in use shall be kept tightly secured with chains. City of Santa Clara

Fire Department requirements for gas cylinder restraints are ¼ inch thick steel welded link chain secured around the cylinder at 1/3 the height of the cylinder and 2/3 the height of the cylinder. The restraints shall be secured to the wall or counter in such a manner to prevent demounting due to a moderate earthquake. Lecture bottles shall be supported in a lecture bottle tube support to provide upright support.

3. Always use the smallest size cylinder required to perform the work.
4. Cylinders of compressed gases must be handled as high energy sources.
5. Cylinders on wheeled carts must be capped and secured by an approved (either UL or FM listed) cylinder support strap or chain. The cart must be an approved cylinder cart. Do not attempt to take a loaded cylinder cart up or down a stairway.
6. Close the gas cylinder at the top of the tank when not in use and remove the regulator if the cylinder is not to be used for an extended period of time. Lecture size gas cylinders are too small to have valve protective caps.
7. Cylinders shall be stored and transported with the protective valve cap in place to prevent damage to the cylinder valve in the event the cylinder falls or the valve sustains impact. No cylinder shall be stored or transported with the regulator still installed.
8. All uncapped cylinders must be secured independently (not ganged behind a single chain) to a solid element of the lab structure. Carts are not acceptable for supporting uncapped or in-use cylinders.
9. Never bleed a cylinder completely empty. Leave a slight pressure to keep contaminants out.
10. Do not lubricate an oxygen regulator or use a fuel gas regulator on an oxygen cylinder. Oil or grease on the high-pressure side of an oxygen cylinder can cause an explosion.
11. Always wear goggles or safety glasses with side shields when handling compressed gases.
12. Always use appropriate gauges, fittings, and materials compatible with the particular gas being handled. Regulators must be compatible with gas cylinders (do not use adapters).
13. All compressed gas cylinders and chemical containers should be stored away from heat sources and direct sunlight.
14. Wherever carbon monoxide or hydrogen sulfide is present in quantities greater than one standard lecture bottle size, detection alarms must be present and properly tested and maintained.
15. Wherever hydrogen is present, all tubing must be of braided stainless-steel hose.
16. Alternative tubing materials shall be reviewed by CHO on a case-by-case basis, to ensure that the alternative materials meet fire protection requirements.
17. When work with other toxic, corrosive, or reactive gases is planned, the CHO should be contacted for information concerning specific handling requirements for the gas involved.

(see Appendix 8 of Chemical Hygiene Plan, Restricted Substances). Generally, these gases will need to be used and stored with local exhaust ventilation such as a lab hood or a gas cabinet and a formal permit with the Santa Clara Fire Department may be required as per City Ordinance.

Working with Cryogens and Dry Ice

Some of the hazards associated with cryogens (fluids used to maintain extremely low temperatures such as liquid nitrogen) and dry ice are fire, pressure, embrittlement of materials, and skin or eye burns upon contact with the liquid. Cryogens can condense nearly pure liquid oxygen from the air, creating a severe fire risk. A pressure hazard exists because of the large expansion ratio from liquid to gas, causing pressure build up in containers. The large expansion ratio may displace oxygen gas in the lab, potentially introducing an asphyxiation hazard. Many materials become brittle at extreme low temperatures. Brief contact with materials at extreme low temperatures can cause burns similar to thermal burns. Carefully observe the following special precautions:

1. Equipment should be kept clean, especially when working with liquid or gaseous oxygen.
2. Mixtures of gases or fluids should be strictly controlled to prevent formation of flammable or explosive mixtures.
3. For flammable cryogens the precautions for working with flammables section of this appendix should also be followed
4. Always wear goggles when handling cryogens. If there is a splash or spray hazard, a face shield over the goggles, an impervious apron or coat, cuff less trousers, and fully-covering, non-lacing shoes should be worn. Watches, rings, and other jewelry should not be worn. Gloves should be impervious and sufficiently large to be readily thrown off should a cryogen be spilled. Cryo-gloves or pot holders should also be used. Respirators or gas detection monitors may be required if the cryogen is toxic and sufficient local exhaust ventilation is not available. Contact CHO or EHS to determine if exposure monitoring is necessary.
5. Oxygen gas monitors equipped with alarms are required in spaces where there is a potential asphyxiation hazard. If oxygen concentration falls below the safe level and alarms activate, all lab occupants must evacuate the room and initiate appropriate emergency actions.
6. Containers and systems containing cryogens should have pressure relief mechanisms.
7. Containers and systems should be capable of withstanding extreme cold without becoming brittle. Glass containers should be taped solidly around the outside or encased in plastic mesh.
8. Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air because oxygen can condense from the air, which could lead to an explosion hazard.

9. Funnels should not be used for pouring liquid nitrogen or any other cryogen.
10. Large mobile dewars or liquid nitrogen refrigerators (or the trolleys carrying these) used for transporting cryogens within a building or between buildings should be equipped with a braking mechanism.
11. Large containers with cryogen should be transported on a freight elevator, if one is available. No passengers may ride on the elevator during cryogen transport.
12. Large mobile dewars at risk for tipping should be transported on appropriate carts.
13. Wheeled trolleys may not be used if the vessel must pass over elevator thresholds or other slots/crevasses wider than 25% of the wheel width.
14. Dispensing stations designed to allow employees and students to fill smaller vessels from a larger self-pressurizing dewar must be located in non-public areas, and should be posted with standard operating procedures.
15. Smaller vessels of liquid nitrogen or other cryogens transported by hand within or between buildings must have a handle or bail, and must be covered.

Health Hazards

"Health hazard" refers to chemicals for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. This term includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system and agents which damage the lungs, skin, eyes, or mucous membranes.

For many toxic materials, hygienic standards have been established and action must be taken to prevent personnel from receiving exposures in excess of these standards. These standards may be referred to as threshold limit values (TLVs) or permissible exposure limits (PELs).

The SDS will list the hygienic standard for the hazardous chemical or each component of a mixture. In addition, the CHO can be contacted for information regarding published TLVs, PELs, other toxicology concerns. For more thorough review of a particular compound, or an evaluation of the exposure to a specific material used in the work area, contact the CHO.

Protection from health hazards is provided by ensuring that exposure to such hazards is minimized or eliminated. To minimize the exposure, it is necessary to determine the route by which the exposure may occur, i.e. inhalation, skin contact, puncture, ingestion, or a combination of exposure routes.

Working with Allergens

The term allergens describe a wide variety of substances that can produce skin and lung

hypersensitivity. Examples include diazomethane, chromium, nickel dichromates, formaldehyde, isocyanates, and certain phenols. Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity. Conduct aerosol producing procedures in a fume hood.

Working with Reproductive Toxins

The term "reproductive toxins" is used to describe substances that cause harmful effects on the male or female reproductive system or the developing embryo and fetus. These effects include but are not limited to menstrual irregularity, lowered fertility, testicular atrophy, and birth defects. Embryotoxins or teratogens can cause malformations or death of an embryo or fetus. Because the period of greatest susceptibility to embryotoxins is the first 8-12 weeks of pregnancy, which includes a period when one may not know that one is pregnant, women of child-bearing potential should take care to avoid contact with these toxins. Special precautions when working with these substances include:

1. A review should take place for use of embryotoxins between the Laboratory Supervisor and CHO. Review continuing uses annually or whenever a procedural change is made.
2. Label embryotoxins as follows: EMBRYOTOXIN: READ SPECIFIC PROCEDURES FOR USE.
3. Store embryotoxins and reproductive toxins in unbreakable containers or unbreakable secondary containers in a well-ventilated area.
4. Guard against spills and splashes. Appropriate safety apparel, especially gloves, should be worn. All hoods, glove boxes, or other essential engineering controls should be known to be operating properly before work is started.
5. Report of all incidents of exposure or spills.

Working with Chemicals of Moderate Chronic or High Acute Toxicity:

Examples of chemicals of moderate chronic toxicity or high acute toxicity include diisopropylfluorophosphate, hydrofluoric acid, and hydrogen cyanide. Observe the following precautions:

1. Consult one of the standard compilations that list toxic properties of known substances and/or other reputable sources and learn what is known about the substance that will be used. Follow the specific precautions and procedures for the chemical.
2. Use and store these substances only in designated (restricted access) areas placarded with appropriate warning signs.
3. Use a hood or other containment device for procedures that may result in the generation of aerosols or vapors; trap released vapors to prevent their discharge with fume hood exhaust.
4. Avoid skin and eye contact by use of safety eyewear, gloves, lab coat, and other protective apparel as appropriate.

5. Purchase and use the minimum amount necessary for the procedure.
6. Be prepared for accidents and spills. At least two people should be present at all times if compounds in use are highly toxic or of unknown toxicity.
7. Store breakable containers in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper.
8. If a major spill occurs outside the hood, evacuate the area and call for assistance.
9. Thoroughly decontaminate or dispose of contaminated clothing or shoes. If possible, chemically decontaminate by chemical conversion to a less toxic product.
10. Store contaminated waste in closed, suitably labeled, impervious containers.

Working with Chemicals of High Chronic Toxicity

Examples of chemicals exhibiting high chronic toxicity include dimethylmercury, nickel carbonyl, benzo-a-pyrene, N-nitrosodiethylamine, and other human carcinogens or substances with high carcinogenic potency in animals.

1. Conduct all transfers and work in designated (restricted access) areas: a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all persons with access are aware of the substances being used and necessary precautions.
2. Protect vacuum pumps against contamination with scrubbers or HEPA filters and vent effluent into the hood.
3. Decontaminate vacuum pumps or other contaminated equipment, including glassware, before removing them from the designated area. Decontaminate the designated area before normal work is resumed there.
4. On leaving the area, remove protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck.
5. Use a wet wiping method or a vacuum cleaner equipped with a HEPA filter to decontaminate surfaces. DO NOT DRY SWEEP SPILLED POWDERS.
6. If using toxicologically significant quantities of a substance on a regular basis (in quantities above a few milligrams to a few grams, depending on the substance, 3 or more times per week), contact the CHO.
7. Keep accurate records of the amounts of these substances stored and used, the dates of use, and names of users.
8. The designated area must be conspicuously marked with warning and restricted access signs and all containers should be appropriately labeled with identity and warning labels (e.g., CANCER-SUSPECT AGENT).
9. Ensure that contingency plans, equipment, and materials to minimize exposures of people

and property in case of accident are available.

10. For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and at a pressure of at least 0.5 inches of water gauge. For a positive pressure glove box, thoroughly test for leaks before each use. In either case, trap the exit gases or filter them through a HEPA filter and/or appropriate chemical filter/ scrubber before releasing into a fume hood.
11. Use chemical decontamination whenever possible; ensure that containers of contaminated wasted are transferred from the designated area under the supervision of the CHO.

Working with Nanomaterials

Nanomaterials are materials or particles having at least one external dimension in the size range of approximately 1 – 100 nanometers. Work with nanomaterials in most laboratory setting specifically involves engineered nanomaterials, which are nanomaterials that have been intentionally designed and synthesized with very specific size, shape (e.g. sphere, rod, tubes), and other properties. These very small particles exhibit properties different from larger particles of the same composition, which potentially introduce additional health hazards. Contact the CHO if a risk assessment or further guidance is needed. Observe the following precautions:

1. Whenever possible, minimize handling of nanomaterials in a dry, powder form to avoid release of airborne particles. Nanomaterials dispersed in liquid or bound to a solid substrate/matrix generally present less risk of becoming airborne.
2. Perform any activities that may generate aerosols or airborne particles (e.g. handling powder, sonication, pouring, mixing) in a ventilated enclosure, such as fume hood or glove box/bag.
3. Clean up spills of nanomaterial solutions immediately to avoid drying of solvent and potential creation of airborne particles.
4. Clean work areas potentially contaminated with nanomaterials with wet wiping or vacuum cleaner equipped with a HEPA filter. Do not dry sweep or use compressed air.
5. Dispose waste nanomaterials as hazardous waste, unless they are known to be non-hazardous.