CHEMICAL HYGIENE PLAN

UNIVERSITY OF HAWAIʻI AT MĀNOA

FEBRUARY 2020

The most current version of this document is maintained online at http://www.hawaii.edu/ehso/.

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PREFACE

The University of Hawaiʻi has a fundamental obligation to safeguard the health, safety, and welfare of its students, personnel, and the visiting public whenever they participate in an official University activity. It is the policy of the University to provide for and maintain, through the implementation of safety and health programs, conditions and practices that provide safe and healthful campus environments. In keeping with this commitment, this Chemical Hygiene Plan was developed as part of the UH Laboratory Safety Program.

The Chemical Hygiene Plan (CHP) provides basic information about hazards that you may encounter in the laboratory and safety precautions to prevent laboratory incidents and minimize exposure to hazardous chemicals. It is for your reference while working with or around chemicals in research laboratories at the University of Hawaiʻi. The University's Environmental Health and Safety Office (EHSO) prepared this plan, followed by review and approval from the University's Chemical and Physical Hazards Committee. Compliance is mandatory for all employees working in campus laboratories due to the requirements of the Hawaiʻi Occupational Safety and Health (HIOSH) division of the Department of Labor and Industrial Relations' standard on "Occupational exposure to hazardous chemicals in laboratories," 29 CFR 1910.1450 (work with hazardous chemicals outside of laboratories is covered by the Hazard Communication Standard, 29 CFR 1910.1200). While these HIOSH regulations pertain specifically to employees, certain provisions of the CHP also apply to students and visitors.

Michael Bruno
Provost
University of Hawaiʻi at Mānoa
(Insert signature date)

FEB 27 2020

INTRODUCTION

The objective of this CHP is to provide uniform requirements for the safe use and disposal of potentially hazardous substances in University laboratories. A variety of hazardous chemicals are used in small quantities in research and teaching laboratories creating a unique environment with a number of risks. These chemicals may cause injury or damage because they are toxic, flammable, corrosive, or reactive with water and other materials. How these substances are handled will determine the degree of risk. General standard operating procedures (SOPs) are outlined, including work with select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity. Specific standard operating procedures should be developed by each laboratory for operations posing a special hazard, for example, heating phosphoric acid, working with pyrophorics, conducting electrophoresis, distillations, extractions, etc.. An additional objective of this plan is for laboratory researchers to evaluate and minimize the risk of physical hazards (high pressure, extreme temperature, high voltage, etc.) encountered in the research environment and develop SOPs for these operations as needed.

Maintaining a safe and healthy environment in the laboratory is ultimately the responsibility of the Supervisor or Principal Investigator. However, each individual is expected to conduct all operations and procedures involving chemical and physical hazards in a safe and prudent manner.

Each laboratory that uses hazardous materials must have a copy of this plan readily accessible. Laboratory personnel must be familiar with the contents that pertain to their workplace and the procedures for obtaining additional safety information needed to perform work duties safely. In order to keep the contents of this manual up-to-date with current regulations and best practices, the EHSO may periodically rewrite, add, or delete sections. Laboratories are not required to keep a printed copy of this plan unless the work location does not have access to an electronic version. If a printed copy is used as a reference, please review the plan material online prior to placing reliance on a dated printed version as the most current version of this document is maintained online at http://www.hawaii.edu/ehso/.

Comments and suggestions for improving the plan are welcomed and encouraged. Please send comments to labsafe@hawaii.edu.

EMERGENCY TELEPHONE NUMBERS

Department of Public Safety (24 Hours)	808-956-6911
POISON CENTER	800-222-1222

ENVIRONMENTAL HEALTH & SAFETY OFFICE (EHSO)

Office of the Director Administrative Assistant	808-956-8660
Laboratory Safety Chemical Hygiene Officer	808-956-5097
Radiation Safety Radiation Safety Officer	808-956-6475
Occupational Health and Safety Occupational Health and Safety Manager	808-956-3204
Hazardous Material Management Hazardous Material Management Officer	808-956-3198
EHSO Training EHSO Training Coordinator	808-956-5180
Diving Safety Diving Safety Officer	808-956-6420
Environmental Compliance Environmental Compliance Officer	808-956-9173

OFFICE OF CAMPUS OPERATIONS AND FACILITIES (OCOF)

Work Coordination Center	808-956-7134
Fire Safety Fire Safety Officer	808-956-4953

OFFICE OF RESEARCH COMPLIANCE, BIOLOGICAL SAFETY PROGRAM

Biological Safety Compliance Program	808-956-9061

PART 1. PROGRAM ADMINISTRATION

A. CHEMICAL AND PHYSICAL HAZARDS COMMITTEE

1. Establish and review procedures to ensure maintenance of prudent laboratory practices and adequate supervision of laboratories/activities identified by the CPHC. This may involve the review of specific standard operating procedures (SOPs) and providing additional recommendations to ensure safe laboratory practices.

2. Review the UHM Chemical Hygiene Plan, as needed, and advise the Vice Chancellor for Research and Director of EHSO on the effectiveness of the plan and propose changes as needed.

3. Encourage investigators to participate in non-punitive reporting system. Create laboratory peer-groups sharing similar hazard types and promote knowledge among investigators. Review incidents involving laboratory-related injuries, illnesses or near misses related to chemical and physical hazards.

4. Review employee complaints regarding chemical and physical hazards in laboratories.

5. Review the policy for monitoring the purchase of chemicals identified by EHSO as highly toxic, explosive, water reactive or difficult and costly to dispose.

6. Review inspection reports by outside regulatory agencies related to chemical and physical hazards and make recommendations to adjust policies and procedures accordingly.

7. Make recommendations to the University Administration regarding responsibility (i.e. facilities management) to provide a safe laboratory environment.

B. DEAN/DIRECTOR/DEPARTMENT CHAIR

1. Have the primary responsibility of establishing and maintaining a safe and healthy environment for their employees, students, and visitors (hereinafter laboratory personnel).

2. Ensure that PI's in charge of laboratories and other chemical storage sites within the department comply with CHP requirements.

3. Take corrective action in cases where an inspection by the EHSO has indicated that a hazard exists in the workplace that has not been corrected in a timely manner, including (but not limited to) electrical hazards, fire safety hazards, physical hazards, and chemical hazards. The Dean/Director/Department Chair will ensure the corrective actions provided by EHSO are implemented. The hazardous condition will be judged to have been corrected only after a subsequent satisfactory inspection by the EHSO.

4. Provide timely notification to the EHSO upon termination/retirement of faculty who used hazardous materials, to expedite clearance of the laboratory for the next investigator.

5. Ensure that Principal Investigators follow the closeout procedures (see Appendix 11) and take measures to enforce them when necessary.

6. Assign responsibility for core laboratories /facilities to one person.

C. ENVIRONMENTAL HEALTH AND SAFETY OFFICE

1. Provide technical assistance to the CPHC, principal investigators, supervisors, and laboratory personnel.

2. Appoint a Chemical Hygiene Officer (CHO).

3. Conduct laboratory surveys, including air monitoring if required.

4. Coordinate CPHC meetings and inform the committee on trends, incidents, near misses, etc..

5. Maintain all relevant records such as training, air monitoring results, and laboratory inspections.

6. Assist principal investigators and supervisors in complying with the CHP.

7. Provide chemical safety training for all Mānoa laboratory personnel as required by the CHP.

8. Review the CHP annually and update, as needed, with input from the CPHC.

D. PRINCIPAL INVESTIGATOR/SUPERVISOR

1. Have direct and overall responsibility for safety and chemical hygiene in the laboratory/workplace. This includes following the policies and procedures of the CHP and correcting deficiencies found during EHSO inspections in a timely manner.

2. Ensure that laboratory personnel are informed of and follow the rules and procedures of the CHP.

3. Inform laboratory personnel about their workplace hazards, including chemical and physical. This includes completing the Laboratory Hazard Assessment (LHA) in UH Safety Solutions (UH Mānoa laboratory safety software system) for each assigned laboratory and ensuring laboratory personnel acknowledge the LHA electronically. This information also includes developing (and updating, as needed) specific Standard Operating Procedures (SOPs) for operations posing a special hazard, for example, heating phosphoric acid, working with pyrophorics, conducting electrophoresis, distillations, extractions, etc. that must be followed.

4. Provide laboratory personal protective equipment (PPE), (gloves, laboratory coats, goggles, etc.) for laboratory personnel and ensure that they are used. PPE can be selected based on the LHA in UH Safety Solutions.

5. Conduct and document the appropriate safety training, including emergency procedures, for all laboratory personnel. Document this training on the Laboratory Personnel Safety Checklist.

6. Periodically survey or “self-inspect” the workplace to ensure safe working conditions. These surveys should include the inspection of all emergency equipment such as eyewashes, safety showers, and spill kits. All defective equipment must be immediately

reported to the appropriate department. Self inspections can be conducted by PI's and their delegate(s) using the Inspect feature of UH Safety Solutions. (https://hawaii.risksafety.solutions/myboard/splash)

7. Review SDS and other sources for information about special first aid requirements for chemicals, e.g., hydrogen fluoride and cyanogen bromide, and prepare accordingly.
8. Provide new hazard information to the EHSO in a timely manner so that it may post appropriate signage at laboratory entrances.
9. Restrict access to areas where an inspection by the EHSO indicates that such restricted access is necessary.
10. Meet with laboratory personnel prior to their departure to ensure that they have properly labeled and prepared hazardous materials for disposal by the EHSO or use by others.
11. Follow required closeout procedures when departing from the University (see Appendix 11).
12. Keep laboratory equipment and chemicals secure against theft or tampering. Keep the laboratory doors closed and locked when no one is present.

E. EMPLOYEES AND OTHER LABORATORY PERSONNEL

1. Know the hazardous properties of the chemicals they use so that proper safety precautions can be determined and followed.
2. Plan and conduct each operation in accordance with the general safety procedures specified in the CHP, as well as whatever additional specific operating procedures that are required by the principal investigator/supervisor, including those addressing physical hazards in laboratories .
3. Develop and maintain good personal chemical hygiene practices.
4. Immediately report improperly functioning safety equipment such as fume hoods directly to the principal investigator/supervisor.
5. Promptly complete required safety training sessions.
6. Immediately report any occupational injury or illnesses to principal investigator/supervisor.
7. Know the location and operation of emergency equipment such as eyewashes, safety showers, etc.
8. Be aware of emergency reporting and evacuation procedures.
9. Immediately inform the principal investigator/supervisor about any unsafe workplace conditions and near misses (see Appendix 15 for incident/near miss form).

PART 2. LABORATORY PERSONNEL INFORMATION AND TRAINING

All personnel working in a laboratory need to take the appropriate training.

- **Initial Training** - All PI's and laboratory personnel shall attend EHSO provided initial (one time) laboratory safety training as soon as possible prior to setting up and working in a lab. In addition the Laboratory Personnel Safety Checklist (Appendix 13) shall be completed by PI's and all laboratory personnel prior to work in a lab.
- **Refresher Training** - Refresher laboratory safety training shall be conducted and documented at least annually by the PI or laboratory manager using the Laboratory Personnel Safety Checklist. All PI's must complete the Laboratory Hazard Assessment (LHA) in UH Safety Solutions (UH Mānoa laboratory safety software system) for their assigned laboratories and all laboratory personnel shall acknowledge the LHA.

A. INFORMATION

All laboratory personnel shall be informed of:

1. Requirements of the OSHA Standard 29 CFR Part 1910.1450, "Occupational exposure to hazardous chemicals in laboratories."

2. The contents and availability of this Chemical Hygiene Plan.

3. Permissible exposure limits (PELs) for HIOSH regulated substances (Appendix 3) or recommended exposure limits where there is no applicable HIOSH standard.

4. Signs and symptoms associated with exposures to hazardous chemicals used in their laboratory.

5. The location of reference materials (including electronic) on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory including, but not limited to, Safety Data Sheets (SDS's).

6. Labeling of original containers based on the Global Harmonization System (GHS) as found in section 5 and appendix B of the UH Hazard Communication Program.

B. TRAINING

Training shall include:

1. The physical and health hazards associated with chemicals stored and used in the work area and physical hazards present in the lab.

2. The contents of this Chemical Hygiene Plan.

3. Methods and observations that may be used to detect the presence or release of a hazardous chemical (e.g., exposure monitoring conducted by the CHO, visual appearance or odor of hazardous chemicals when being released, etc.).

4. The measures employees can take to protect themselves from chemical and physical hazards in the laboratory (e.g., appropriate work practices, emergency procedures).

PART 3. PRIOR APPROVAL CIRCUMSTANCES

Principal Investigator/Supervisor must obtain prior approval to proceed with a laboratory task from the CHO or appropriate EHSO personnel when:

1. Radioactive materials will be used. Contact the EHSO Radiation Safety Program.
2. Recombinant DNA or any biological commodities will be used. Contact the Biological Safety Program.
3. If it is likely that exposure limit concentrations could be exceeded or that other harm could occur. Contact the CHO.
4. Certain hazardous chemicals will be used which require prior approval from the EHSO Hazardous Material Management Program before purchase. Refer to Appendix 4 for a list of these chemicals.
5. Shipping hazardous material(s) air or ground. Contact Hazardous Material Management Program before shipping.

Laboratory personnel must stop working, notify their respective PI, and contact EHSO when:

1. A member of the laboratory staff is injured or becomes ill and it is known or suspected the injury illness is related to the work environment in the laboratory. If emergency assistance is needed, call DPS at 808-956-6911.
2. There is a failure or suspected failure of any equipment used in a process in which an injury or near miss occurs. An Incident/Near-Miss report (see Appendix 15) must be completed and routed to the EHSO.

PART 4. STANDARD OPERATING PROCEDURES

A. GENERAL RULES

1. When working in the laboratory with chemicals, all laboratory personnel should know:

    a. the chemical's hazards, as determined from a SDS and other appropriate references.

    b. appropriate safeguards for using that chemical, including personal protective equipment.

    c. how to properly store the chemical when it is not in use.

    d. proper chemical waste disposal procedures (Appendix 4).

    e. proper personal hygiene practices.

    f. proper methods of transporting chemicals outside the laboratory.

    g. appropriate procedures for emergencies, including first aid, evacuation routes, and spill cleanup procedures.

2. Laboratory personnel should not work alone. Arrangements should be made between individuals working in separate laboratories outside of regular working hours to cross check each other periodically. Alternatively, Department of Public Safety may be asked to check on the employee. Standard Operating Procedures (SOP's) should include laboratory personnel not being alone at any time in the laboratory while performing hazardous experiments/activities.

3. In the event of a power outage, the procedures listed in Appendix 5 should be followed.

4. Individuals who are not properly trained in laboratory safety and the University CHP (e.g. employees' children, minors, guests, etc.) shall not be allowed in University laboratories unless closely supervised and monitored. Consult with the UH Office of Risk Management for direction on allowing minors in laboratories , including any required waivers, etc..

5. No animals, other than those approved for laboratory experimentation by the UH Institutional Animal Care and Use Committee (IACUC), shall be allowed in laboratories. For exceptions to this (i.e., service animals) contact UH Human Resources (employees) and/or the UH Kokua Program (students).

6. The use of open flames in UH Mānoa laboratories is strongly discouraged by the Environmental Health and Safety Office. Every effort must be made to find alternatives to using open flames (electric sterilizers, disposable supplies, etc.).

7. All laboratories shall have a laboratory safety notebook / information binder kept in the laboratory and/or electronic files accessible to all assigned laboratory personnel. The binder/electronic files should include at a minimum:

a. Training records of laboratory personnel.

b. LHA assessment(s) generated from UH Safety Solutions and laboratory personnel acknowledgement(s).

c. Current (annually updated) laboratory personnel safety checklists for all laboratory personnel.

d. Current (annually updated) chemical inventory.

e. SOPs for activities posing special hazards (chemical and physical) in the laboratory. (See Hazard Assessment in Research Laboratories: Toolbox for Researchers for SOP templates and examples.)

B. PERSONAL HYGIENE

1. Wash promptly whenever a chemical has contacted the skin.

2. Avoid inhalation of chemicals. Do not sniff to test chemicals.

3. Do not use mouth suction to pipet anything. Pipetting aids must be used at all times.

4. Do not bring food (including gum and candy), beverages, tobacco, or cosmetic products into chemical storage or use areas. Eating, drinking, and applying cosmetics is allowed in designated areas only. Smoking is prohibited in all University facilities.

5. Wash well with soap and water before leaving the laboratory. Avoid the use of solvents for washing skin. Solvents remove the natural protective oils from skin and can cause irritation and inflammation. In some cases, washing with solvent may facilitate absorption of toxic chemicals.

C. PROTECTIVE CLOTHING AND EQUIPMENT

1. Personal Protective Equipment (PPE) shall be provided at no cost to laboratory personnel (the payment requirement applies to anyone determined by HIOSH to be an employee and does not apply to students taking for-credit classes in teaching laboratories under this policy). Carefully inspect all protective equipment prior to use. PIs must ensure PPE is used, maintained, and replaced as needed and laboratory personnel shall use PPE as assigned.

2. PPE must be selected based on the physical and chemical hazards in the lab. This can be accomplished using the Assessment feature in UH Safety Solutions (e.g., Flame resistant laboratory coats used when working with flammables, etc.).

3. When the potential for splash hazard is present (e.g., chemistry laboratories), eye protection in the form of chemical-resistant goggles shall be worn at all times in the laboratory. Ordinary prescription glasses and/or standard safety glasses are not considered effective eye protection since they lack necessary shielding. Chemical-resistant goggles should be worn over glasses for laboratory personnel who wear corrective lenses.

4. Consult with an optometrist prior to wearing contacts in the laboratory. Chemical-resistant goggles must be worn over contacts at all times.

5. When working with corrosive, toxic, allergenic, or sensitizing chemicals, rough or sharp-edged objects, very hot or very cold materials, gloves made of material known to be protective for the hazard shall be worn. No one glove can protect against all hazards. Cloth gloves, while not appropriate for use around liquids, can protect against light abrasive materials and moderate temperature changes. Synthetic or rubber gloves protect against corrosives, solvents, and poisons. Leather gloves, often used for tasks like welding, protect against sparks, heat, & rough abrasives. Consult the manufacturer's performance chart or contact the CHO to determine the proper choice of glove material. Appendix 9 has links to glove selection charts that can be used to determine glove choices.

6. Low-heeled shoes with fully covered uppers shall be worn at all times in the laboratory. Shoes or sandals with open toes shall not be worn.

7. Long pants and garments with long sleeves must be worn when working with or around chemicals.

8. Long hair should be secured behind the head, to prevent it from being pulled into machinery or catching fire.

9. Caution should be taken when wearing loose clothing not to inadvertently allow cuffs, sleeves, or other materials to knock over or absorb chemicals.

10. A full-body-length rubber, plastic, or neoprene apron appropriate for the material being handled should be worn if there is a risk of splash or spill.

11. A proper respirator must be worn whenever exposure by inhalation is likely to exceed the action level (AL) or permissible exposure limits (PEL) and a fume hood is not accessible. Procedures specified in the UHM Respiratory Protection Program shall be followed. Employees must be medically qualified, trained, and fit-tested prior to using a respirator. Contact the CHO before doing any work requiring a respirator.

12. Remove all PPE before leaving the laboratory.

D. HOUSEKEEPING

Housekeeping is directly related to safety and must be given importance of equal value to other procedures. Lack of good housekeeping reduces work efficiency and may result in incidents and near misses. Laboratory personnel must adhere to the following:

1. All work areas, especially laboratory bench tops, should be kept clear of clutter.

2. Access to emergency equipment, showers, eyewashes, fire extinguisher, exits, and circuit breakers shall never be blocked or obstructed.

3. All aisles, corridors, stairs, and stairwells shall be kept clear of chemicals, equipment, supplies, boxes, and debris.

4. Each laboratory must have a puncture resistant container (e.g., cardboard box) lined

with plastic specifically designated for glassware disposal and labeled "Non-Hazardous Broken Glass."

5. Food and drink for human consumption shall not be kept in the same refrigerator used to store chemicals and laboratory samples. Eating and office areas must be clearly separated from laboratory and chemical storage areas.

E. CHEMICAL MANAGEMENT

1. Chemical containers should be regularly monitored for proper labeling and container integrity. Labels which are fading, falling off, or deteriorating must be promptly replaced. Improperly or unlabeled chemicals make hazard identification and disposal difficult, and may create a health hazard. Abbreviations or acronyms may be used to label containers of chemicals generated in the laboratory as long as all personnel working in the laboratory understand the meaning of the label, or know the location of information, such as a laboratory notebook or log sheet that contains the code associated with content information. In addition, small containers, such as vials and test tubes, can be labeled as a group by labeling the outer container (e.g., rack or box). Alternatively, a placard can be used to label the storage location for small containers (e.g., shelf, refrigerator, etc.). (See Appendix 16)

2. Segregate all chemicals in storage according to hazard class. The main hazard classes are flammable/combustible, oxidizer, acid, and base. See Appendix 10 for more detailed chemical storage guidelines.

3. All chemicals should be placed in their proper storage areas at the end of each workday. Chemicals shall not be stored on desks, laboratory bench tops, floors, or in aisles.

4. Secondary containers (flasks, beakers, reaction vessels, etc.) should be labeled unless they are under the immediate control of the user. At the end of each workday, all unlabeled containers are to be labeled as to their contents or the contents must be disposed of as waste.

5. Chemical wastes must be clearly labeled including hazard identification, and stored according to hazard class. Refer to the Hazardous Material Management Plan in Appendix 4 for requirements.

6. A laboratory shall maintain and update annually an inventory of all chemicals, including all containers of chemicals in use or in storage, but excluding working solutions, synthetic intermediates, biological samples, chemical extracts, and waste. Alternatives for chemical inventory management are:
    a. UH Safety Solutions Chemicals Application https://hawaii.risksafety.solutions/signin
    b. A hard copy of the chemical inventory kept in the laboratory safety notebook / information binder and/or via an electronic file accessible by all laboratory personnel and updated annually. The inventory should include, at a minimum, the chemical name, the amount, the storage location, and the hazard class (see Appendix 10 for chemical storage guidelines).

7. Hazardous materials should not be stacked or laid on their side. Stacking bottles can cause pressure and lead to bottles cracking or breaking. Laying a bottle on its side can lead to the bottle leaking.

F. FLAMMABLE MATERIALS

Flammable materials are substances that can ignite easily and burn rapidly. Flammable materials are either in gas, liquid, and solid form. Proper PPE for flammable materials must be used (per section C. above).

Precautions for safe handling of flammable materials include the following:

1. Storage and handling of flammable and combustible liquids shall be conducted in accordance with the requirements in Appendix 6.
2. Flammable substances shall be handled only in areas free of ignition sources (open flame, radiant heat,etc.). Additionally, proper bonding/grounding must be considered when necessary when static electrical discharge is a factor.
3. Flammable substances should never be heated by using an open flame. Preferred heat sources include steam baths, water baths, oil baths, heating mantles, and hot air baths.
4. Class I liquids (see Appendix 6) shall only be transferred from one vessel to another in a laboratory and never in an exit passageway (hallway, vestibule, exit stairwell, etc).
5. Transfer of flammable liquids shall be conducted in a laboratory fume hood or an approved flammable liquid storage room.
6. Empty containers (no pourable liquid remaining) shall be treated in the following manner:
    a. For water soluble solvents: triple rinse, deface the label, and dispose empty container appropriately.
    b. For non-water soluble solvents: allow to evaporate to dryness in a hood, deface the label, and dispose the empty container appropriately.

G. REACTIVE CHEMICALS

A reactive chemical is one that:

1. is unstable (reactive) in its pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure, or temperature, or
2. Is ranked by the National Fire Protection Association (NFPA) as 3 or 4 for reactivity, or
3. Is identified by the Department of Transportation (DOT) as:

a. an oxidizer, or

b. an organic peroxide, or

c. a class A, B, or C explosive

d. violently reacts with exposure to water or air.

Handle reactive chemicals with all proper safety precautions. This includes designating separate storage area, monitoring periodically for degradation, developing SOPs, and using appropriate PPE.

H. CORROSIVE CHEMICALS

1. Materials are classified as corrosive if they:

   a. are capable of rapidly eroding building materials or metals, or

   b. burn, irritate or destructively attack organic tissues such as skin, eyes, lungs and stomach.

Examples of commonly used chemicals that have corrosive properties are:

glacial acetic acid	hydrofluoric acid	hydrochloric acid
fluorine	nitric acid	bromine
sulfuric acid	chlorine	sodium hydroxide

Safe handling procedures will vary with each operation and the type and concentration of the corrosive chemical. Refer to the SDS for specific safe handling procedures.

2. The following general guidelines should be followed for procedures involving acids and bases:

   a. Never pour water into acid. Slowly add the acid to the water and stir.

   b. Open bottles or carboys slowly and carefully, wearing protective equipment to guard hands, face, and body.

   c. Suitable facilities, such as a safety shower and eyewash, shall be located within 50 feet or 10 seconds of the work area for quick drenching or flushing of the eyes and body. PI's shall ensure eyewash stations are flushed once every quarter.

   d. Procedures requiring the use of concentrated acids and bases should be conducted in a fume hood.

   e. Never mix acid wastes with other materials such as solvents, metal-contaminated solutions, etc.. Non-contaminated acid wastes can be easily disposed by neutralization. Never dispose of acids or bases in the sanitary sewer system (i.e., down the drain) until neutralized (pH 5.5-9.5) and then limit the quantity to no more than 2 quarts per day. Neutralization should be conducted in a fume hood, then the solution poured slowly down the drain with copious amounts of water; i.e., leave the water running for approximately 5 minutes.

f. When disposable containers are completely emptied of their contents, flush them thoroughly with water before throwing them away.

g. Contact EHSO Hazardous Material Management Program (see Appendix 4) for assistance with disposal of large quantities (more than 2 gallons or 1 pound) of acids and bases.

I. COMPRESSED GAS CYLINDERS

Use of compressed gases in the laboratory requires anticipating chemical, physical, and health hazards. Only trained individuals shall handle cylinders, install/remove regulators, or connect systems using gases. Cylinders that are knocked over or dropped can be very dangerous. If a valve is knocked off, the cylinder can become a lethal projectile. Accidental releases may result in an oxygen deficient atmosphere or adverse health effects. In short, improper handling and use can cause structural damage, severe injury, and possibly death.

The following guidelines will help ensure safe handling, use, and storage of compressed gas cylinders, including flammable gas, such as Hydrogen.

1. RECEIVING AND STORAGE
   a. Be sure to arrange a return agreement with suppliers prior to purchase since disposal of compressed gas cylinders is difficult and very expensive. Retain all documentation such as purchase orders to facilitate return of cylinders to the manufacturer.

   b. Cylinders should not be accepted unless the cylinder contents are clearly labeled. Color code only should not be accepted, since it does not constitute adequate labeling.

   c. Do not accept cylinders which are damaged or do not have a valve protection cap.

   d. All gas cylinders in use shall be secured in an upright position in racks, holders, or clamping devices. When cylinders are grouped together, they should be individually secured and conspicuously labeled on the neck area.

   e. Oxygen cylinders shall be separated from combustible materials (e.g. oils, greases, fuels, acetylene, flammable gas etc.) by a minimum distance of 20 ft or by a noncombustible barrier at least five feet high having a fire resistant rating of at least 1/2 hour. Systems and components used for other gases and must never be used for oxygen or interconnected with oxygen.

   f. Cylinders should have current hydrostatic test date (normally less than 5 years old for steel and 3 years old for aluminum) stamped on the cylinder. Cylinders should be returned to the supplier for servicing prior to the expiration date.

   g. Do not place cylinders near heat, sparks, or flames or where they might become part of an electrical circuit.

   h. Do not store cylinders in exit corridors or hallways.

2. HANDLING AND USE

a. Only Compressed Gas Association fittings and components are permitted for use with gas cylinders. Only use regulators approved for the type of gas in the cylinder. Do not use adapters to interchange regulators. Never lubricate any fitting or component of a gas cylinder. Tubing, when used, shall be appropriate for the application.

b. Before opening the cylinder valve, be sure that the T-valve is backed out and turns loosely. Open cylinder valves slowly and be sure that the T-valve is not facing anyone, including yourself. Never force a gas cylinder valve. If the valve cannot be opened by the wheel or small wrench provided, the cylinder should be returned.

c. No attempt shall be made to transfer gases from one cylinder to another, to refill cylinders, or to mix gases in a cylinder in the laboratory, unless the cylinder is designed for that purpose, labeled properly, and a written SOP based on a hazard assessment has been created by the PI or a competent person.

d. All cylinders are to be considered full unless properly identified as empty by the user. Empty cylinders must be returned to the supplier and not accumulated.

e. Compressed gases must not be used to clean skin or clothing.

f. Never heat cylinders to raise internal pressure.

g. Do not use copper (>65%) connectors or tubing with acetylene. Acetylene can form explosive compounds with copper, silver, and mercury.

h. Always leave at least 30 psig minimum pressure in all "empty" cylinders. Do not leave an empty cylinder attached to a pressurized system.

PART 5. CONTROL MEASURES

A. VENTILATION

1. Laboratory ventilation is normally designed to provide approximately eight air changes per hour. This flow is not necessarily sufficient to prevent accumulation of chemical vapors. Laboratory work shall be conducted in a fume hood, glove box, or similar device when:

    a. Procedures call for work with toxic substances which are volatile; i.e., evaporate at normal temperature and pressure, or

    b. There is a possibility the action level or PEL (see Appendix 3) will be exceeded.

2. The protection provided by the laboratory fume hoods is dependent upon two important factors:

    a. Proper use of the hood, and

    b. Maintenance of adequate airflow through the hood.

3. The way the hood is used will determine the degree of protection it will provide. Each employee is responsible for implementing the following work practices when using a hood.

    a. Continually monitor air being drawn into the hood by attaching a kim wipe or lightweight strip of paper to the bottom of the sash.

    b. Operate the hood at the lowest working sash height; i.e., recommended maximum 18 inch sash height for hoods with vertical sliding (up and down) sashes and the sashes closed as much as possible for hoods with horizontal sliding (left and right) sashes. This helps to ensure optimum protection when conducting operations in the hood. The lowest working sash height opening maximizes air velocity through the hood face and may provide additional protection from unexpected splashes or chemical reactions.

    c. Avoid using the hood for storage of bottles and equipment, especially along the back wall. Any apparatus that must be housed within the hood should fit completely inside the hood. Elevate the apparatus on blocks (at least 2 inches off the benchtop) to allow air to flow freely around and beneath.

    d. Manipulations within the hood should be performed at least 6 inches inside the face of the hood or as far towards the back of the hood as possible. This minimizes the possibility of contaminants escaping from the hood.

    e. Fully close the hood sash and turn off the fan (if possible) when the hood is not in use. The fan should remain on if volatile materials are being temporarily (i.e., for the duration of a current project) stored in the hood.

    f. Things which cause air turbulence across the face of the hood such as fans, window air conditioning units, or excessive movement should be avoided.

g. Exhaust hoods do not provide adequate protection for all operations involving toxic materials. A higher level of containment should be used for procedures where minor contamination can be serious. If you are in doubt about the level of containment needed for your operation, ask your PI or contact the CHO.

4. EHSO conducts annual surveys of fume hoods to ensure adequate airflow is maintained through the hood face. Face velocities should be between 80 and 120 feet per minute (fpm) with the sash lowered to within 18 inches of the bottom of the hood. Call 808-956-7937 if you suspect the hood is not working properly.

5. At no time shall laboratory fume hood alarms be tampered with or disabled. Upon activation of the alarm, work within the hood should cease and facilities and/or the CHO must be notified.

B. SPILL CLEAN-UP PROCEDURES

The range and quantity of hazardous substances used in laboratories require pre-planning to respond safely to chemical spills. Refer to: Emergency Plans for Spills

A specific emergency spill plan and training in the plan is needed for the chemical you will be using.

The cleanup of a chemical spill should only be done by knowledgeable and experienced personnel. Spill kits with instructions, adsorbents, reactants, and protective equipment should be available to clean up minor spills. A minor spill is one that does not spread rapidly, does not endanger people or property except by direct contact, does not endanger the environment, and the laboratory staff is capable of handling safely without the assistance of safety and emergency personnel. All other chemical spills are considered major.

In the event of a major spill the following procedures shall be carried out:

1. Attend to anyone who may be hurt or contaminated if it can be accomplished without endangering yourself.

2. If flammable materials are spilled, de-energize electrical devices if can be done without endangering yourself.

3. Call Department of Public Safety at 808-956-6911.

In the event of a minor spill the following procedures shall be carried out:

1. Attend to anyone who may have been contaminated or hurt.

2. Ensure that the fume hood(s) is on. Open windows where possible to increase exhaust ventilation and if the spilled material is flammable, turn off ignition and heat sources.

3. Secure cleanup supplies and then don proper PPE. Neutralize acids and bases, if possible. Ensure protective apparel is resistant to the spill material.

4. Control the spread of the liquid by containing the spill.

5. Absorb the liquid by adding appropriate absorbent materials from the spill's outer edges toward the center.

6. Collect and contain the cleanup residues by scooping it into a plastic bucket or other appropriate container.

7. Properly dispose of the waste as hazardous waste.

8. Decontaminate the area and affected equipment. Ventilating the spill area may be necessary.

9. Document what happened, why, what was done, and what was learned by completing an incident/near miss report. Such documentation can be used to avoid similar instances in the future. Major incidents are almost always preceded by numerous near misses (See Appendix 15).

10. Contact EHSO to report any minor spills upon completion of cleanup activities and forward a completed incident/near miss report to EHSO. If you have questions regarding spill clean up requirements please contact EHSO at 808-956-3198.

In any event, there should be supplies and equipment on hand to deal with the spill, consistent with the hazards and quantities of the spilled substance. These cleanup supplies should include neutralizing agents (such as sodium carbonate or sodium bisulfate) and absorbents (such as vermiculite and sand). Paper towels and sponges may also be used as absorbent-type cleanup aids, although this should be done cautiously. For example, paper towels used to clean up a spilled oxidizer may later ignite, and appropriate gloves should be worn when wiping up highly toxic material with paper towels. Also, when a spilled flammable solvent is absorbed in vermiculite or sand, the resultant solid is highly flammable and gives off flammable vapors and, thus, must be properly contained or removed to a safe place.

PART 6. EXPOSURE MONITORING

Exposure monitoring shall be performed when there is reason to believe that exposures are in excess of the AL or PEL. Materials which require monitoring under these conditions are listed in Appendix 3. If an employee would like to have an exposure assessment conducted, the CHO should be contacted.

Documentation of exposure monitoring shall be kept and maintained as part of each laboratory personnel's personnel record.

PART 7. MEDICAL CONSULTATIONS AND EXAMINATIONS

Employees shall be provided an opportunity to receive medical attention, including any related follow-up examinations, at the University's expense, under the following circumstances:

1. An individual develops signs or symptoms associated with exposure to hazardous chemicals in the laboratory.
2. Exposure monitoring reveals an exposure level routinely above the AL or PEL for a HIOSH regulated substance for which there are exposure monitoring and medical surveillance requirements.
3. An accident such as a spill, leak, equipment failure, or explosion results in possible over-exposure to hazardous chemicals.

The PI and department Personnel Offices are responsible for establishing and maintaining an accurate record of any medical consultations and examinations provided to an employee.

PART 8. PARTICULARLY HAZARDOUS SUBSTANCES: SELECT CARCINOGENS, REPRODUCTIVE TOXINS, AND HIGHLY ACUTE TOXINS

Particularly hazardous substances (PHS), such as select carcinogens, reproductive toxins, and highly acute toxins require additional planning and considerations. A description of particularly hazardous substances is available from the Occupational Safety and Health Administration (OSHA). Consult the safety data sheet to determine whether a particular chemical may be considered a carcinogen, reproductive hazard, or substance with a high acute toxicity and therefore identified as a PHS.

A. DEFINITIONS

The OSHA Laboratory Standard defines particularly hazardous substances as:

1. Carcinogens – A carcinogen is a substance capable of causing cancer. Carcinogens are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may become evident only after a long latency period. A chemical is considered a carcinogen if it is included in any of the following carcinogen lists:

   a. OSHA-regulated carcinogens as listed in Subpart Z of the OSHA standards.

   b. Under the category "known to be carcinogens" in the *Annual Report of Carcinogens* published by the National Toxicology Program (NTP) latest edition

   c. Group 1 ("carcinogenic to humans") of the International Agency for Research on Cancer (IARC), latest edition. Chemicals listed in Group 2A or 2B ("reasonably anticipated to be carcinogens") that cause significant tumor incidence in experimental animals under specified conditions are also considered carcinogens under the OSHA Laboratory Standard. The specified condition are:

      - After inhalation exposure of 6 - 7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^3.
      - After repeated skin application of less than 300 mg/kg of body weight per week.
      - After oral dosages of less than 50 mg/kg of body weight per day.

2. Reproductive Toxins – Reproductive toxins are substances that have adverse effects on various aspects of reproduction, including fertility, gestation, lactation, and general reproductive performance. When a pregnant woman is exposed to a chemical, the fetus may be exposed as well because the placenta is an extremely poor barrier to chemicals. Reproductive toxins can affect both men and women. Male reproductive toxins can in some cases lead to sterility.

3. Substances with a High Acute Toxicity – High acute toxicity includes any chemical that falls within any of the following OSHA-defined categories:

   - A chemical with a median lethal dose (LD_{50}) of 50 mg or less per kg of body weight when administered orally to certain test populations.

- A chemical with an LD_{50} of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.

- A chemical with a median lethal concentration (LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

4. Designated area: a hood, glove box, portion of a laboratory, or an entire laboratory room, designated as the only area where work shall be conducted with quantities of select carcinogens, reproductive toxins, or highly acute toxins in excess of the limits specified above.

   The procedures described in this section are mandatory when performing laboratory work with greater than 10 mg or 100 mL of any carcinogen, reproductive toxin, or substance that has a high degree of acute toxicity.

B. DESIGNATED AREA

Access to designated areas shall be restricted. Only trained laboratory personnel will be allowed to work with chemicals in the designated area. All such persons will:

1. Use the smallest amount of chemical that is consistent with the requirement of the work to be done.

2. Always use these chemicals in a hood with adequate air flow or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance.

3. Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.

4. Contact the Chemical Hygiene Officer at 808-956-5097 or labsafe@hawaii.edu for more information about reproductive toxins. A partial list of select carcinogens and reproductive toxins is listed in Appendix 7 and Appendix 8.

5. Decontaminate designated areas before normal work is resumed there. This includes contaminated equipment.

6. Remove any protective apparel, place it in an appropriately labeled container, thoroughly wash hands, forearms, face, and neck on leaving a designated area.

7. Prepare wastes for disposal in accordance with the UHM Hazardous Material Management Program (Appendix 4).

8. Do not wear jewelry when working in designated areas since decontamination of jewelry may be difficult or impossible.

APPENDIX 1. EMERGENCY TELEPHONE NUMBERS

Department of Public Safety (24 Hours)	808-956-6911
Poison Control - National Capital Poison Center	800-222-1222

ENVIRONMENTAL HEALTH & SAFETY OFFICE (EHSO)

Office of the Director Administrative Assistant	808-956-8660
Laboratory Safety Chemical Hygiene Officer	808-956-5097
Radiation Safety Radiation Safety Officer	808-956-6475
Occupational Health and Safety Occupational Health and Safety Manager	808-956-3204
Hazardous Material Management Hazardous Material Management Officer	808-956-3198
EHSO Training EHSO Training Coordinator	808-956-5180
Diving Safety Diving Safety Officer	808-956-6420
Environmental Compliance Environmental Compliance Officer	808-956-9173

OFFICE OF CAMPUS OPERATIONS AND FACILITIES (OCOF)

Work Coordination	808-956-7134
Fire Safety Fire Safety Officer	808-956-4953

OFFICE OF RESEARCH COMPLIANCE, BIOLOGICAL SAFETY PROGRAM

Biological Safety Compliance Program	808-956-9061

APPENDIX 2. LABORATORY INSPECTION CHECKLIST

An electronic laboratory self-inspection tool is available to UH laboratory workers with access to the UH Safety Solutions web application. To begin a self inspection follow these instructions:

1. Login to https://hawaii.risksafety.solutions/, found at https://www.hawaii.edu/ehso/lab-safety/uh-safety-solutions/, and complete authentication.
2. Select the Inspect Application.
3. Select Start Inspection.
4. Select “Campus Facilities and Lab Safety-Self Inspection".
5. Enter a party to inspect (if prompted) and select “Let’s go!”

Contact labsafe@hawaii.edu with questions or to request in person training. Questions from UH Safety Solutions - Campus Facilities and Lab Safety-Self Inspection are attached below.

DOCUMENTATION

1. Is the laboratory or facility entrance signage adequate and current? Are emergency notification procedures, contacts with current phone numbers, and hazard warning signs posted at the entrance?
2. Is a current Chemical Hygiene Plan (CHP) and a current Hazardous Materials Management Program Manual (HMMP) available (electronic or hard copy) in the laboratory?
3. Does the facility (non-laboratory) have a Hazard Communication Program Plan and Hazardous Waste Management Program Manual (HMMP) on file?
4. Are Standard Operating Procedures (electronic or hard copy) available for chemicals, experiments, or equipment that pose an increased hazard?
5. Does the laboratory have a written (annually updated) chemical inventory?
6. Are Safety Data Sheets (SDS) available for all chemicals in the laboratory (hard copy or accessible online by all laboratory members)?
7. Have personnel received appropriate initial and annual safety training (where required)? Are the training document records on file?
8. DOCUMENTATION-OTHER?

GENERAL SAFETY

1. Is the laboratory locked when not in use?
2. Are emergency eyewashes and showers available and unobstructed (required if corrosive materials are present)?
3. Are disposable containers for broken glass provided and specifically labeled for glass disposal (“Broken Glass”)?
4. Are laboratory coats, goggles, face shields, gloves, closed-toe shoes and other PPE available and used?

5. Are protective goggles or face shields provided and worn where there is any danger of flying particles or corrosive materials?
6. Have all chemical fume hoods passed inspection within the past 12 months?
7. Are chemical fume hood sashes closed when not in use?
8. Are chemical fume hoods free from excessive storage?
9. Is good housekeeping maintained?
10. Are all floors kept clean and dry and in good repair?
11. Are food and beverages prepared and consumed in areas separate from chemicals?
12. Are glass containers not stored on the floor?
13. Are exits free of any trip hazards or obstruction (minimum 28 inches clearance in any exit access such as hallways and aisles)?
14. Do refrigerators, freezers, microwaves, and ice machines designated for laboratory use have proper “No Food/Drink” signage?
15. Are safety guards in place for equipment with moving parts (belts, blades, fans, etc.)?
16. Is there a first aid kit in the laboratory and is it adequately stocked with items within expiration dates?
17. Employer has a written Respiratory Protection Program?
18. Employees are fit tested to their respirators annually and are current in their medical clearance? Respirators are clean and maintained?
19. Users are annually trained in the proper use of respirators and their limitations?
20. GENERAL SAFETY-OTHER?

CHEMICAL SAFETY

1. Are all highly flammable and toxic procedures performed in a fume hood?
2. Are approved spark-proof refrigerators used for cold storage of flammable liquids?
3. Are flammable chemicals stored in a safe manner (more than 10 gallons stored in an approved flammable storage cabinet)?
4. Are incompatible chemicals segregated in storage (flammables and oxidizers; nitric acid/acids; acids and bases)?
5. Are all chemicals properly labeled, including hazard identification, and percentages of mixtures?
6. Are chemical containers kept closed and in good condition?
7. Are air and water reactive chemicals properly stored?

8. Does the laboratory test peroxide-forming chemicals?
9. Are chemical storage areas identified with signs (e.g., flammables, corrosives, carcinogens, poisons, etc.)?
10. Is a chemical spill kit available (with posted procedures)?
11. Is metallic mercury used in the laboratory? If yes, is a Hg spill kit available?
12. Are only cleaning agents stored under sinks (No hazardous chemicals allowed)?
13. CHEMICAL SAFETY-OTHER?

HAZARDOUS WASTE AUDIT CHECKLIST

1. Is hazardous waste generated and properly managed in the facility or laboratory?
2. Is non-hazardous chemical waste disposed of properly from the facility or laboratory?
3. Does the satellite accumulation area store less than 55 gallons of all hazardous waste and less that one quart of P waste?
4. Is the satellite accumulation area in the same laboratory where the waste is generated?
5. Is the satellite accumulation area kept in good housekeeping condition?
6. Are waste containers separated by hazard class to avoid incompatible storage?
7. Are all the waste containers in good condition (e.g.,not corroded or leaking, and properly sealed or closed)?
8. Are all waste containers properly labeled as to their contents (correct chemicals names, readable labels, and percentages of individual components for mixtures)?
9. Are secondary containers used when required?
10. Can the facility document the proper disposal of all hazardous waste?
11. Is there at least one person in the facility who has attended the EHSO training for Hazardous Waste Generators?
12. Is the "Emergency Plans for Spills" document posted at Satellite Accumulation Area?
13. HAZARDOUS WASTE AUDIT CHECKLIST-OTHER?

COMPRESSED GAS CYLINDERS

1. Are cylinders legibly marked to clearly identify the gas contained?
2. Are incompatible gases properly segregated when not in use (e.g. oxygen and flammable gases must be separated by minimum 20 feet)?
3. Are cylinders secured properly (recommend chains) and protective caps in place when not in use?
4. Are cylinders located or stored in areas where they will not be damaged by passing or

falling objects or subject to tampering by unauthorized persons?

5. Are oxygen cylinders stored 20 feet apart from combustible material or acetylene cylinders, or separated by an approved fire wall (at least 5 feet high) having a fire resistant rating of at least ½ hour?
6. Are multiple gas cylinders securely stored in a cylinder rack and not by strap?
7. Are cylinders of different heights/sizes chained or strapped appropriately?.
8. Cylinders have been hydrotested within the last 5 years to determine their integrity for current and further use?
9. Are cylinders in good condition (no rusting, sidewall indentations, bulging, crack and fissures)?
10. Gas tubing (used for gas cylinders) is in good condition; show no leaks and are not pinched?
11. Is appropriate tubing used (Tygon tubing is not to be used for flammable gases, e.g. hydrogen since it can cause static electricity)?
12. COMPRESSED GAS CYLINDERS-OTHER?

FIRE SAFETY / ELECTRICAL SAFETY

1. Are the cords of all electrical equipment in good condition?
2. Are cords used properly (e.g., no piggy-backing of surge protectors; clear of burners, sinks, aisles; no use of extension cords)?
3. Are electrical panels readily accessible and not blocked (3 foot clearance in front & 30 inch working width clearance)?
4. Gasoline portable containers are approved metal safety cans with a spring-closing lid and spout cover?
5. Are fire extinguishers and fire pull stations readily accessible? Is the building fire alarm system tested annually?
6. Are fire-rated doors not propped open?
7. Are exits visibly marked and illuminated?
8. Is storage at least 18 inches below the ceiling/sprinkler heads (24 inches for rooms without sprinklers)?
9. Are equipment that draw large amounts of power (e.g. refrigerators, microwaves) plugged directly into an outlet?
10. Equipment with exposed heating elements are unplugged when not in use (hot plates, coffee makers, toasters)?
11. Does each electrical outlet, plug box, junction box, and cabinet have a faceplate, cover or

canopy cover and are unused openings in cabinets and boxes effectively closed?

12. When electrical equipment or lines are to be serviced, maintained or adjusted, are necessary switches opened, locked-out and tagged whenever possible?
13. Combustible material is not stored in boiler, mechanical or electrical rooms.
14. Does the facility have a written fire emergency plan? Have fire drills been conducted?
15. FIRE SAFETY / ELECTRICAL SAFETY-OTHER

RADIATION SAFETY

1. RADIATION SAFETY - OTHER?

APPENDIX 3. "LIMITS FOR AIR CONTAMINANTS" STATE OF HAWAIʻI OCCUPATIONAL SAFETY & HEALTH STANDARDS

The "limits for air contaminants" can be found at HAR 12-60-50, exhibit A and B, at the following link:

https://labor.hawaii.gov/hiosh/standards/standards-admin-rules-part-2/

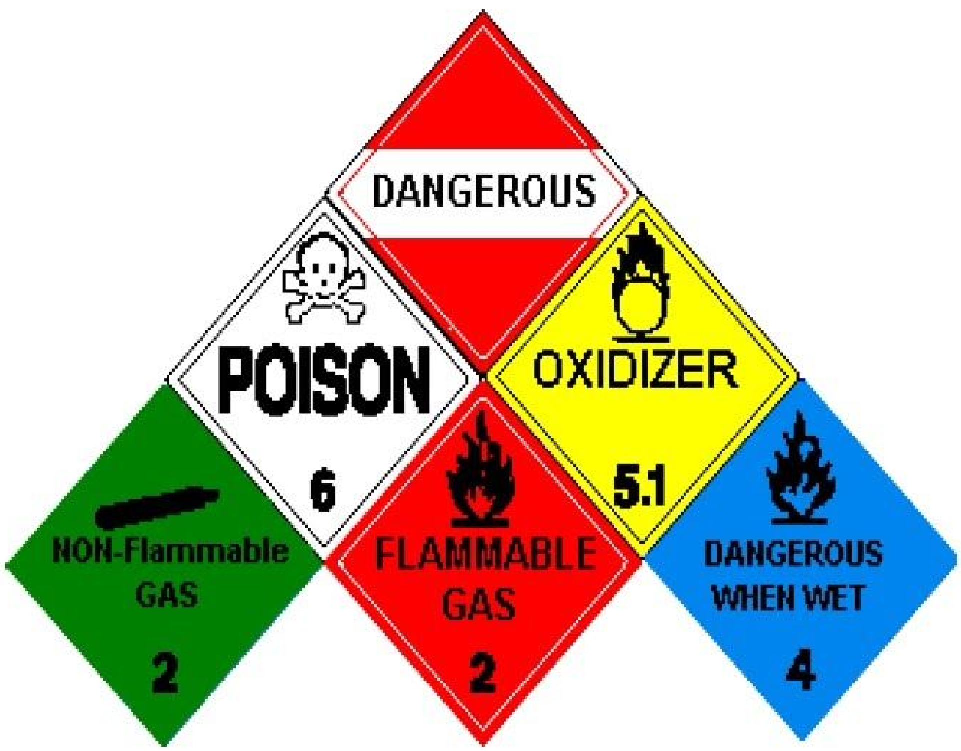
12-60 Exhibit A (Effective 10/27/18; Enforcement Date 2/1/19)
https://labor.hawaii.gov/hiosh/files/2018/12/Appendix-A.xlsx

12-60 Exhibit B (Effective 10/27/18; Enforcement Date 2/1/19)
https://labor.hawaii.gov/hiosh/files/2018/12/Exhibit-B-12142018.pdf

APPENDIX 4. HAZARDOUS MATERIAL MANAGEMENT PROGRAM

http://www.hawaii.edu/ehso/wp-content/uploads/2016/07/UHHMMP01-1.pdf

UNIVERSITY OF HAWAII AT MANOA



Hazardous Material Management Program

January 2020

APPENDIX 5. UHM EMERGENCY PROCEDURES DURING POWER OUTAGES

EMERGENCY PROCEDURES FOR LABORATORIES DURING POWER OUTAGES

It is important to remember that some equipment cannot be turned off and certain other pieces of equipment do not shut themselves off when there is a power outage. Pre-plan specific procedures for your laboratory while adhering to the following:

1. Close chemical fume hood sashes. No work is allowed in fume hoods during a power outage.

2. Ensure that all chemical containers are secured with caps, parafilm, etc..

3. All non-essential electrical devices should be turned off. Keep the doors of refrigerators and freezers closed. Check to ensure large lasers, radio frequency generators, etc. have been turned off.

4. Turn off all gas cylinders at the tank valves. If a low flow of an inert gas is being used to "blanket" a reactive compound or mixture, it may be appropriate to leave the flow of gas on. The decision to do this should be part of the written SOP specific for each laboratory and included in this CHP.

5. Check all cryogenic vacuum traps (N_2, CO_2 + solvent). The evaporation of trapped materials may cause dangerous conditions.

6. Check all pressure, temperature, air, or moisture sensitive materials and equipment. This includes vacuum work, distillations, glove boxes used for airless/moistureless reactions, etc.

APPENDIX 6.

UHM REQUIREMENTS FOR STORAGE AND HANDLING OF FLAMMABLE AND LIQUIDS

University of Hawai'i at Mānoa
REQUIREMENTS FOR STORAGE AND HANDLING OF FLAMMABLE LIQUIDS

STORAGE REQUIREMENTS

1. Flammable liquids stored in the open in a laboratory work area or inside any building shall be kept to the minimum necessary for the work being done.
2. Maximum quantity permitted in laboratories and other areas of use is limited to a total of 10 gallons, all classifications combined, outside of a flammable storage cabinet or approved flammable storage room. Please refer to Table 1.
3. Quantities stored in flammable storage cabinets shall be limited to 60 gallons of category 1 and 2 or 3 and 4 liquids and the total of all liquids shall not exceed 120 gallons. Please refer to Table 1 for maximum allowable container size for each class. Not more than three cabinets shall be located in the same fire area.
4. Quantities exceeding the above must be stored in an approved flammable storage room meeting the requirements of the Uniform Building and Fire Codes.
5. Flammables shall not be stored near exit doorways, stairways, in exit corridors, or in a location that would impede egress from the building.
6. Materials which will react with water or other liquids to produce a hazard shall be segregated from flammable liquids.
7. Refrigerators, freezers, and other cooling equipment used for storing flammable liquids must be rated for storing such items and prominently labeled as such. Equipment that is IM or UL listed as "flammable storage" or "explosion proof" must be used for flammable or volatile liquid storage. "Flammable storage" indicates that flammable materials are isolated from sparks. "Explosion proof" indicates that the entire unit is sealed and can be used in explosive atmospheres.

HANDLING AND DISPENSING

1. Category 1 and 2 liquids shall not be transferred from one vessel to another in any exit passageway.
2. Transfer of flammable liquids from 5 gallon containers (or less) to smaller containers shall be done in a laboratory fume hood or in an approved flammable liquid storage room.
3. Empty containers shall be treated in the following manner:
    a. For water soluble solvents ---- rinse, deface label, and dispose with normal trash.
    b. For non-water soluble solvents ---- allow to evaporate to dryness in a hood, rinse, deface label, and dispose with normal trash.

TABLE 1

Category	**1**	**2**	**3**	**4**
Flash point	less than 73.4 F	less than 73.4 F	between 73.4 F and 140 F	between 140 F and 199.4 F
Boiling point	less than or equal to 95 F	greater than 95 F		
Flammability Potential	Extremely High	Very High	High	Moderate
Examples of commonly used materials	acetaldehyde benzoyl peroxide ethyl ether pentane methyl formate	acetone ethanol butylamine gasoline methanol isopropanol	amyl acetate butanol chlorobenzene turpentine xylene	formaldehyde hydrazine kerosene
Maximum Container Size:				
Glass	1 pint (500 ml)	1 quart (1 liter)	1 gallon (4 liter)	1 gallon (4 liter)
Metal or approved plastic	1 gallon	5 gallon	5 gallon	5 gallon
Safety cans	2 gallon	5 gallon	5 gallon	5 gallon
Metal drums (DOT)	N/A	5 gallon	5 gallon	5 gallon

APPENDIX 7. SELECT CARCINOGENS

The OSHA Laboratory Standard 29 CFR 1910.1450 defines select carcinogens as any substance which meets one of the following criteria:

1. It is regulated by OSHA as a carcinogen; or
2. It is listed under the category "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or
3. It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or
4. It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
   a. After inhalation exposure of 6 - 7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3;
   b. After repeated skin application of less than 300 (mg/kg of body weight) per week; or
   c. After oral dosages of less than 50 mg/kg of body weight per day.

The following websites maintain comprehensive lists of select carcinogens:

https://www.osha.gov/SLTC/carcinogens/standards.html

https://ntp.niehs.nih.gov/pubhealth/roc/index.html

http://monographs.iarc.fr/ENG/Classification/index.php

The following is a combined list of chemicals carcinogens from OSHA, NTP, and IARC. The combined list is provided as a guide and is not comprehensive. Please refer to SDSs for specific chemical information.

- Acetaldehyde
- Acetamide
- Acetylaminofluorene, 2-
- Acrylamide
- Acrylonitrile
- Adriamycin (doxorubicin hydrochloride) Aflatoxins
- Aflatoxin M1
- Alcoholic beverages (consumption)
- Alpha-Chlorinated toluenes
- Aluminium production
- Amino-2,4-dibromoanthraquinone, 1-
- Amino-2-methylanthraquinone, 1-
- Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole, 2-
- Amino-9H-pyrido[2,3-beta]indole), A-alpha-C(2-
- Aminoanthraquinone, 2-
- Aminoazobenzene, para-
- Aminoazotoluene, ortho-

- Aminobiphenyl, 4- Amitrole
- Amsacrine
- Analgesic mixtures containing phenacetin
- Androgenic (anabolic) steroids
- Anisidine, ortho-
- Antimony trioxide
- Aramite
- Areca nut
- *Aristolochia* genus herbal remedies
- Arsenic and arsenic compounds
- Asbestos
- Attapulgite (palygorskite), long fibers >5mm
- Auramine, technical-grade
- Azacitidine
- Azaserine
- Azathioprine
- Aziridine
- Benz(a)anthracene
- Benzene
- Benzidine
- Benzidine-based dyes (technical grade) (Direct Black 38, Direct Blue 6, Direct Brown 95)
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(j)fluoranthene
- Benzo(k)fluoranthene
- Benzofuran
- Benzotrichloride
- Benzyl violet 4B
- Beryllium and beryllium compounds
- Betel quid with tobacco
- Betel quid without tobacco
- Bis(2-chloroethyl)-2-naphthylamine(Chlornaphazine), N,N- Bis(chloromethyl)ether
- Bis(bromomethyl)propane-1,3-diol, 2,2-
- Bischloroethyl nitrosourea (BCNU)
- Bis(chloromethyl) ether
- Bitumens, extracts of steam-refined and air-refined
- Bleomycins
- Bracken fern
- Bromodichloromethane
- Butadiene, 1,3-
- Butanediol dimethanesulphonate (myleran), 1,4-
- Butanediol dimethylsulfonate (myleran), 1,4-
- Butylated hydroxyanisole (BHA)
- Butyrolactone, beta-
- C.I. Basic Red 9 monohydrochloride
- Cadmium and certain cadmium compounds
- Caffeic acid
- Captafol
- Carbon black extract

- Carbon tetrachloride
- Carrageenan, degraded
- Catechol
- Ceramic fibers (respirable size)
- Chlorambucil
- Chloramphenicol
- Chlordane
- Chlordecone (kepone)
- Chlorendic acid
- Chloro-4-(dichloromethyl)5-hydroxy-2(*5H*)-furanone, 3-
- Chloroaniline, para-
- Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU), 1-(2-
- Chloroethyl)-3-4-methylcyclohexyl-1 nitrosourea, 1-(2-
- Chlorinated paraffins (C12, 60% Chlorine)
- Chlorinated toluenes, alpha- (not necessarily all in group)
- Chlornaphazine
- Chloro-2-methylpropene, 1-
- Chloro-2-methylpropene, 3-
- Chloro-o-phenylenediamine, 4-
- Chloro-ortho-toluidine, para-
- Chloroform
- Chloromethyl ether
- Chloromethyl methyl ether (technical grade)
- Chlorophenols and their sodium salts
- Chlorophenoxy herbicides
- Chloroprene
- Chlorothalonil
- Chlorozotocin
- Chromium compounds, hexavalent
- CI Acid Red 114
- CI Basic Red 9
- CI Direct Blue 15
- Cisplatin
- Citrus Red No. 2
- *Clonorchis sinensis* (Oriental liver fluke)
- Coal tar pitches
- Coal tars
- Cobalt and cobalt compounds
- Cobalt metal with tungsten carbide
- Cobalt metal without tungsten carbide
- Cobalt(II) sulfate and other soluble cobalt(II) salts
- Coffee (bladder)
- Conjugated estrogens
- Creosotes
- Cresidine, para-
- Cupferron
- Cycasin
- Cyclophosphamide
- Cyclosporin A

- Dacarbazine
- Danthron (1,8-dihydroxyanthraquinone)
- Daunomycin
- DDT
- Diacetylbenzidine, N,N'-
- Diaminoanisole, 2,4-
- Diaminoanisole sulfate, 2,4-
- Diaminodiphenyl ether, 4,4'
- Diaminotoluene, 2,4-
- Diazoaminobenzene
- Dibenz(a,h)acridine
- Dibenz(a,h)anthracene
- Dibenz(a,j)acridine
- Dibenzo(a,e)pyrene
- Dibenzo(a,h)pyrene
- Dibenzo(a,i)pyrene
- Dibenzo(a,l)pyrene
- Dibenzo(c,g)carbazole, 7H-
- Dibromo-3-chloropropane, 1,2-
- Dibromoethane (EDB), 1,2-
- Dibromopropan-1-ol, 2,3-
- Dichloroacetic acid
- Dichlorobenzene, para-
- Dichlorobenzene, 1,4-
- Dichlorobenzidine, 3,3'-
- Dichloro-4,4'-diaminodiphenyl ether, 3,3'-
- Dichloroethane, 1,2-
- Dichloromethane (methylene chloride)
- Dichloropropene (technical grade), 1,3-
- Dichlorvos
- Diepoxybutane
- Diesel engine exhaust
- Diesel fuel (marine)
- Di (2-ethylhexyl) phthalate
- Diethyl sulphate
- Diethylhydrazine, 1,2-
- Diethylstilbestrol
- Diglycidyl resorcinol ether
- Dihydrosafrole
- Diisopropyl sulfate
- Dimethoxybenzidine, 3,3'-
- Dimethoxybenzidine (ortho-dianisidine), 3,3'
- Dimethyl sulphate
- Dimethylaminoazobenzene, para
- [(Dimethylamino) methylamino]-5-[2-(5-nitro-2-, trans-2-
- Dimethylaniline, 2,6- (2,6-xylidene)
- Dimethylbenzidine, 3,3'-
- Dimethylbenzidine (ortho-toluidine), 3,3'-
- Dimethylcarbamoyl chloride

- Dimethylhydrazine, 1,1-
- Dimethylhydrazine, 1,2-
- Dimethylvinyl chloride
- Dinitrofluoroanthrene, 3,7-
- Dinitrofluoroanthrene, 3,9-
- Dinitropyrene, 1,6-
- Dinitropyrene, 1,8-
- Dinitrotoluene, 2,4-
- Dinitrotoluene, 2,6-
- Dioctyl phthalate [Di(2-ethylhexyl)phthalate]
- Dioxane, 1,4-
- Direct Black 38
- Direct Blue 6
- Direct Brown 95
- Disperse Blue 1
- Epichlorohydrin
- Epoxybutane, 1,2-
- Epstein-Barr virus
- ErioniteEstrogens (not conjugated): estradiol-17
- Estrogens (not conjugated): estrone
- Estrogens (not conjugated): mestranol
- Estrogens (not conjugated): ethinylestradiol
- Ethylbenzene
- Ethyl acrylate
- Ethyl methanesulphonate
- Ethyl-N-nitrosourea, N-
- Ethylene oxide
- Ethylene thiourea
- Ethylene dibromide
- Ethyleneimine
- Etoposide
- Etoposide in combination with cisplatin and bleomycin
- Formaldehyde
- Formylhydrazino)-4-(5-nitro-2-furyl)thiazole, 2-(2-
- Fuel oils (residual, heavy)
- Furan
- Furyl)-3-(5-nitro-2-furyl)acrylamide], AF-2[2-
- Fusarium moniliform (toxins derived from) (Fumonisin B1, Fumonisin B2, Fusarin C)
- Gallium arsenide
- Gamma radiation (ionizing radiation)
- Gasoline
- Gasoline engine exhausts
- Glasswool (respirable size)
- Glu-P-1 (2-amino-6-methyldipyrido[1,2-a:3',2'-d]imidazole)
- Glu-P-2(2-aminodipyrido[1,2-a:3',2'-d]imidazole)
- Glycidaldehyde
- Glycidol
- Griseofulvin
- HC Blue No 1

- *Helicobacter pylori* (infection with)
- Hepatitis B virus (chronic infection with)
- Hepatitis C virus (chronic infection with)
- Heptachlor
- Hexachlorobenzene
- Hexachlorocyclohexanes
- Hexachloroethane
- Hexamethylphosphoramide
- Human immunodeficiency virus type 1 (infection with)
- Human immunodeficiency virus type 2 (infection with)
- Human papilloma virus type 16
- Human papilloma virus type 18
- Human papilloma virus type 31
- Human papilloma virus type 33
- Human papilloma virus: some types other than 16, 18, 31, and 33
- Human T-cell lymphotropic virus type I
- Hydrazine and hydrazine sulfate
- Hydrazobenzene
- Hydroxyanthroquinone, 1-
- Indeno(1,2,3-cd)pyrene
- Indium phosphide
- Involuntary smoking
- IQ (2-amino-3-methylimidazo[4,5-f]quinoline)
- Iron-dextran complex
- Isoprene
- Kaposi's sarcoma herpesvirus/human herpesvirus 8
- Kepone (chlordecone)
- Lasiocarpine
- Lead
- Lead acetate and lead phosphate
- Lead compounds, inorganic
- Lindane and other hexachlorocyclohexane isomers
- Magenta (containing CI Basic Red 9)
- Magnetic fields (extremely low frequency)
- Man-made mineral fibers (glasswool, rockwool, slagwool, and ceramic fibers), respirable size
- Mate drinking (hot)
- MeA-alpha-C(2-amino-3-methyl-9H-pyrido[2,3-b]indole)
- MeIQ (2-amino-3,4-dimethylimidazo[4,5-f]-quinolone)
- MeIQx (2-amino-3,8-dimethylamidazo[4,5-f] quinoxaline)
- Medroxyprogesterone acetate
- Melphalan Merphalan
- Methoxsalen with ultraviolet A therapy (PUVA)
- Methoxypsoralen, 8- plus ultraviolet radiation
- Methoxypsoralen, 5-
- Methyl mercury compounds (methylmercuric chloride)
- Methyl methanesulphonate
- Methyl chloromethyl ether
- Methyl-1-nitroanthraquinone (uncertain purity), 2-

- Methyl-N'-nitro-N-nitrosoguanidine, N- (MNNG)
- Methyl-N-nitrosourethane, N-
- Methyl-N-nitrosourea, N-
- Methylaziridine (propyleneimine), 2-
- Methylazoxymethanol and its acetate
- Methylchrysene, 5-
- Methylene bis(2-methylaniline), 4,4'-
- Methylenebis (N,N-dimethyl)benzenamine, 4,4'-
- Methylenebis(2-chloroaniline) (MBOCA), 4,4'-
- Methylene chloride (dichloromethane)
- Methylenedianiline, 4,4'- and its dihydrochloride
- Methyleugenol
- Methylthiouracil
- Metronidazole
- Michler's Ketone
- Mineral oils - untreated and mildly treated oils
- Mirex
- Mitoxantrone
- Mitomycin C
- Monocrotaline
- MOPP and other combined chemotherapy for cancer
- Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]-2- oxazolidinone, 5-(
- Mustard gas (sulphur mustard)
- Nafenopin
- Naphthalene
- Naphthalamine, alpha-
- Naphthylamine, beta-
- Neutrons (ionizing radiation)
- Nickel and certain nickel compounds
- Niridazole
- Nitrilotriacetic acid and its salts
- Nitro-2-furyl)-2-thiazolyl]acetamide, N-[4-(5-
- Nitroacenaphthene, 5-
- Nitroanisole, 2-
- Nitrobenzene
- Nitrobiphenyl, 4-
- Nitrochrysene, 6-
- Nitrofen
- Nitrofluorene, 2-
- Nitrofurfurylidene)amino]-2-imidazolidinone, 1-[(5-
- Nitro-2-furyl)-2-thiazolyl] acetamide, N-[4-(5-
- Nitrogen mustard N-oxide
- Nitrogen mustard hydrochloride
- Nitrogen mustard
- Nitrolotriacetic acid and its salts
- Nitromethane
- Nitropropane, 2-
- Nitropyrene, 1-
- Nitropyrene, 4-

- Nitroso-N-ethylurea, N-
- Nitroso-N-methylurea, N-
- Nitrosodi-n-butylamine, N-
- Nitrosodi-n-propylamine, N-
- Nitrosodiethanolamine, N-
- Nitrosodiethylamine, N-
- Nitrosodimethylamine, N-
- Nitrosomethylamino)propionitrile, 3-(N-
- Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK), 4-(N-
- Nitrosomethylethylamine, N-
- Nitrosomethylvinylamine, N-
- Nitrosomorpholine, N-
- Nitrosonornicotine, N- (NNN)
- Nitrosopiperidine, N-
- Nitrosopyrrolidine, N-
- Nitrososarcosine, N-
- Norethisterone
- Ocratoxin A
- Oestrogen-progestogen therapy, postmenopausal
- Oestrogens, nonsteroidal*
- Oestrogens, steroidal*
- Oil Orange SS
- *Opisthorchis viverrini* (infection with)
- Oral contraceptives, sequential or combined
- Oxazepam
- Oxydianiline, 4,4'-
- Oxymetholone
- Panfuran S (containing dihydroxymethylfuratrizine)
- Phenacetin
- Phenazopyridine hydrochloride
- Phenobarbital
- Phenolphthalein
- Phenoxybenzamine hydrochloride
- Phenyl glycidyl ether
- Phenytoin
- PhIP (2-amino-1-methyl-6-phenylimidazo [4,5-b] pyridine)
- Phosphorus-32 (32P), as phosphate
- Pickled vegetables, traditional Asian
- Plutonium-239 (239Pu) and its decay products, as aerosols
- Polybrominated biphenyls (PBBs)
- Polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Ponceau MX
- Ponceau 3R
- Potassium bromate
- Procarbazine hydrochloride
- Progesterone
- Progestins
- Propane sultone -propiolactone, 1,3-

- Propane sultone, 1,3-
- Propiolactone, beta-
- Propylene oxide
- Propylthiouracil
- Radionuclides,and particle emitting, internally deposited
- Radium-224 (224Ra) and its decay products
- Radium-226 (226Ra) and its decay products
- Radium-228 (228Ra) and its decay products
- Radon-222 (222Rn) and its decay products
- Refractory ceramic fibers
- Reserpine Riddelliine Safrole
- Salted fish, Chinese style
- *Schistosoma haematobium* (infection with)
- *Schistosoma japonicum* (infection with)
- Selenium sulfide
- Shale oils
- Silica (crystalline)
- Sodium ortho-phenylphenate
- Solar radiation
- Soots
- Sterigmatocystin
- Streptozotocin
- Styrene
- Styrene oxide (styrene-7,8-oxide)
- Sulfallate
- Sulphuric acid (occupational exposures to strong inorganic acid mists)
- Sunlamps and sunbeds (use of)
- Talc containing asbestiform fibers
- Tamoxifen
- Tenopiside
- Tetrachlorodibenzo-p-dioxin (TCDD), 2,3,7,8-
- Tetrachloroethylene (perchloroethylene)
- Tetrafluoroethylene
- Tetranitromethane
- Thioacetamide
- Thiodianiline, 4,4'-
- Thiotepa [tris(1-aziridinyl)phosphine sulfide]
- Thiouracil
- Thiourea
- Thorium dioxide
- Thorium-232 (232Th) and its decay products
- Tobacco products (smokeless)
- Tobacco smoke
- Toluene diisocyanates
- Toluidine, ortho- (3,3-Dimethylbenzidine)
- Toluidine hydrochloride, ortho-
- Toxaphene (polychlorinated camphenes)
- trans-2[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)vinyl]- Treosulphan
- Treosulphan

- Trichloroethylene
- Trichlormethine (trimustine hydrochloride)
- Trichlorophenol, 2,4,6-
- Trichloropropane, 1,2,3-
- Tris(2,3-dibromopropyl)phosphate
- Trp-P-1 (3-Amino-1,4-dimethyl-5H-pyrido[4,3-b]indole)
- Trp-P-2(3-Amino-1-methyl-5H-pyrido[4,3-b]indole)
- Trypan blue
- Ultraviolet radiation: A, B, and C including sunlamps and sunbeds
- Uracil mustard
- Urethane
- Vanadium pentoxide
- Vinyl acetate
- Vinyl bromide
- Vinyl chloride
- Vinyl fluoride
- Vinylcyclohexene, 4-
- Vinylcyclohexene diepoxide, 4-
- Welding fumes
- Wood dust
- X-radiation (ionizing radiation)
- Zalcitabine
- Zidovudine (AZT, retrovir)

Occupational exposures associated with a technological process known to be carcinogenic:

- Boot and shoe manufacture and repair
- Carpentry and joinery
- Coal gasification
- Coke oven emissions
- Coke production
- Dry cleaning
- Furniture and cabinet making
- Glass manufacturing industry (occupational exposure)
- Art glass, glass containers and pressed ware
- Hairdresser or barber (occupational exposure to dyes)
- Insecticide use (occupational)
- Iron and steel founding
- Isopropyl alcohol manufacture (strong-acid process)
- Magenta manufacture
- Painter (occupational exposures)
- Printing processes (occupational exposures)
- Petroleum refining (occupational refining exposures)
- Rubber industry
- Soots, tars, and mineral oils
- Textile manufacturing (occupational exposures)
- Wood industries

APPENDIX 8.
REPRODUCTIVE TOXINS AND SUBSTANCES WITH HIGH ACUTE TOXICITY

Reproductive Toxins – Reproductive toxins are substances that have adverse effects on various aspects of reproduction, including fertility, gestation, lactation, and general reproductive performance. When a pregnant woman is exposed to a chemical, the fetus may be exposed as well because the placenta is an extremely poor barrier to chemicals. Reproductive toxins can affect both men and women. Male reproductive toxins can in some cases lead to sterility.

Substances with a High Acute Toxicity – High acute toxicity includes any chemical that falls within any of the following OSHA-defined categories:

- A chemical with a median lethal dose (LD_{50}) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD_{50} of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

The State of California Office of Environmental Health Hazard Assessment (OEHHA) maintains a list of known carcinogens and reproductive toxins. Proposition 65 requires the state to maintain and update a list of chemicals known to the state to cause cancer or reproductive toxicity. The Prop 65 list can be found in the following links:

https://oehha.ca.gov/media/downloads/proposition-65//p65list030819.pdf

https://oehha.ca.gov/proposition-65/proposition-65-list

APPENDIX 9. GLOVE SELECTION GUIDE

The Internet resources provided will help you select the best glove and provide the most protection. For chemical mixtures or multiple hazards, pick the glove with the highest resistance to the most toxic substance or consider a double-glove protocol. If you are in doubt, do not hesitate to call the manufacturer's representative for technical assistance or EHSO.

Choosing the right protective glove for the job is critical to safe handling of animals as well as hazardous and toxic chemicals and other laboratory tasks. Match the individual glove by manufacturer and style to the required task and exposure particulars. No single glove will protect against all harmful substances. Nor will one glove suit all applications. No matter which glove is used, they all can potentially leak or become punctured or torn. No glove can offer 100% protection either, as permeation and degradation take their toll during use. To ensure the highest level of protection train employees to know the hazards of the substances they handle and the estimated breakthrough times for the gloves selected. Always handle toxic and hazardous chemicals with utmost care.

Resources:

- Ansell - https://www.ansellguardianpartner.com/chemical/home#hp
- Showa-Best - https://www.showagroup.com/us/en
- HexAmour - https://www.hexarmor.com/learning-center
- Microflex - https://www.ansell.com/us/en/industrial/brands/microflex/

Adapted from "All Hands on Deck: a primer on protective gloves" by Vince McLeod, CIH; ALN; 2010-06-24

APPENDIX 10. CHEMICAL STORAGE GUIDELINES

http://www.hawaii.edu/ehso/wp-content/uploads/2016/07/Chemstorage.pdf

Effective segregation in chemical storage reduces the risk of dangerous chemical reactions.
This guide must be used in conjunction with information from the manufacturer's safety data sheets and chemical-specific expert knowledge.
This storage group system is intended to be used in research settings to store laboratory-scale quantities of chemicals.

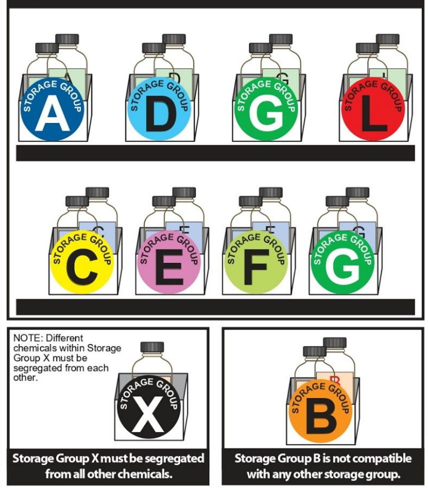
STORAGE GROUPS

Store chemicals in separate secondary containment and cabinets

- **A** Compatible Organic Bases
- **B** Combatible Pyrophoric & Water Reactive Materials *
- **C** Compatible Inorganic Bases
- **D** Compatible Organic Acids
- **E** Compatible Oxidizers & Peroxides (not including Strong, Oxidizing Acids)*
- **F** Compatible Inorganic Acids (not including Oxidizers or Combustibes)
- **G** Not Intrinsically Reactive, Flammable, or Combustible
- **I** Compatible Strong, Oxidizing Acids
- **J** Poison Compressed Gases*
- **K** Compatible Stable Explosives* (not including Oxidizing Explosives)
- **L** Flammables, Combustibles, & Organic Solvents
- **X** Incompatible with ALL Other Chemicals* (including other Chemicals within X)

* Contact UH EHSO @ 808-956-5097 or email at labsafe@hawaii.edu
* Special handling and storage requirements - Consult manufacturer's SDS

If space does not allow Storage Groups to be kept in separate cabinets the following scheme can be used with extra care taken to provide stable, uncrowded, and carefully monitored conditions.



Last updated 03/19/19

Storage Group Classification System created by Stanford University

March 19, 2019

Recommended Storage Groups for Common Chemicals

CHEMICAL	Group
1-Butanol or 2-butanol	L
1-Propanol	L
2-Mercaptoethanol	L
Acetic acid, glacial (flammable)	D
Acetic anhydride (in THF or acetone: L)	X
Acetone	L
Acetonitrile	L
Acetaldehyde	L
Acrolein	X
Acrylamide	G
Agarose	G
Ammonium acetate	G
Ammonium chloride	G
Ammonium formate	G
Ammonium hydroxide	C
Ammonium nitrate	E
Ammonium persulfate	E
Ammonium sulfate	G
Ammonium sulfide	L
Benzene	L
Benzyl chloride	B
Benzoic acid	D
BIS/Bis-acrylamide	G
BIS-TRIS	A
BIS-TRIS-HCl	G
Borax	G
Boric acid	G
Calcium chloride	G
Chloroform	G
Chromic acid	I
Citric acid	D
Coomassie Blue	G
Dextrose	G
Dichloromethane	L
Diethylamine (flammable)	A
Diethyl pyrocarbonate (DEPC)	L
Dimethyl sulfoxide (DMSO)	L
Drierite	G
Econo-Safe, UniverSOL, BetaMax, CytoScint, Scintisafe, EcoLume, Ecoscint, Opti-fluor	L
EDTA (in solution: G)	D
Ethanol	L
Ethanolamine	A
Ethers	L
Ethidium bromide	G
Ethyl acetate	L
Ethylene glycol	L
Ficoll	G
Formaldehyde	L
Formamide	L
Formic Acid (≥85%)	D
Glutaraldehyde	G
Glycerol	L
Glycine	G
Guanidine hydrochloride	G
Guanidinium thiocyanate	C
Halothane, isoflurane	G
HEPES	G
Hexanes	L
Hydrochloric acid	F
Hydrogen peroxide, > 5%	E
Hydrogen peroxide, < 5%	G
Imidazole	A
Isobutyl alcohol	L
Isopentane	L
Isopropanol	L
Lithium hydroxide	C
Magnesium chloride	G
Magnesium sulfate	G
Maleic acid	D
Methanol	L
N-Methyl-2-pyrrolidone	L
N,N-Dimethylformamide	L
Nitric acid	I
p-Dioxane	L
Paraformaldehyde	L
Perchloric acid	I
Periodic acid	I
Permount	L
Phenol (solid)	G
Phenol (liquid, ≤ 89% phenol)	L
Phosphoric acid	F
Picric acid (any concentration)	X
Piperidine	A
PIPES, free acid	G
Potassium acetate	G
Potassium chloride	G
Potassium cyanide	C
Potassium hydroxide (KOH)	C
Potassium phosphate (K_3PO_4)	G
Propionic acid	D
Propylene oxide	L
Pump oil	L
Pyridine	A
SDS (Sodium dodecyl sulfate) (in solution: G)	L
Sigmacote	L
Sodium acetate	G
Sodium azide	X
Sodium bicarbonate	G
Sodium bisulfate	G
Sodium bisulfite	G
Sodium borate	G
Sodium borohydride	B
Sodium carbonate	G
Sodium chlorate	E
Sodium chloride (NaCl)	G
Sodium citrate dihydrate	G
Sodium dichromate dihydrate	E
Sodium hydroxide (NaOH)	C
Sodium hypochlorite	E
Sodium hypochlorite solution (i.e. bleach)	E
Sodium phosphate	G
Sodium sulfide, anhydrous	B
Succinic acid	D
Sucrose	G
Sulfuric acid	I
Tannic acid	G
TEMED	A
TES free acid	G
Tetracycline	G
Tetrahydrofuran	L
Trichloroacetic acid	D
Trifluoroacetic acid	D
Toluene	L
Triethanolamine	A
TRIS	A
Triton X-100	G
Trizol	L
TWEEN 20	G
Urea	G
WD-40	L
Xylenes	L
Zinc chloride	G

This Storage Group System was created by Stanford University.
See other side for information about the (Stanford) Storage Group System. Storage Groups are continuously reviewed and updated as needed. If you have any questions or suggested changes, please contact the University of Hawaii EHSO at 808-956-5097.

APPENDIX 11. CLOSEOUT PROCEDURES AND CHECKLIST

CLOSE-OUT PROCEDURES FOR DEPARTING/RETIRING FACULTY AND STAFF

Proper disposal of all hazardous materials used in the workplace is the responsibility of the chemical user or supervisor/Principal Investigator (PI) to whom a chemical use room/laboratory is assigned. Enforcement of this policy is the responsibility of the supervisor/PI. Proper disposition of hazardous materials is required whenever a chemical user leaves the University or transfers to a different laboratory/chemical use room. This process should be started at least a month before departure from the chemical use room/laboratory to allow ample time to properly dispose of all materials. Hazardous waste pickup should be completed before the chemical use room/laboratory is vacated. The disposal must be in compliance with the University's Hazardous Materials Management Plan. The following checklist should be completed prior to the chemical user's departure. Once completed, the checklist should be signed and submitted to the user's Dean or Director and to the Environmental Health and Safety Office (EHSO).

If periodic inspections by the EHSO reveal that proper close-out procedures have not been followed, the EHSO will oversee correction/remediation of any problems created by failure to follow those procedures, and the cost of correcting those problems will be charged to the budget of the level V unit within which the problems were identified by the EHSO.

The University of Hawaiʻi at Mānoa laboratory decommissioning policy and checklist can be referenced for proper laboratory closeout procedures.

APPENDIX 12. INSPECTION AND ENFORCEMENT PROCEDURES

In order to ensure that University laboratories and research support areas (including shops) are operating in as safe a manner as possible, the University's Environmental Health and Safety Office (EHSO) will conduct periodic inspections. The procedures that will be followed are described below:

Initially, the PI/supervisor in charge of the work area will be given prior notice that an inspection will be conducted. On the appointed day, a member of the EHSO will conduct an inspection of the facility. The supervisor is strongly encouraged to accompany the EHSO representative. A report will be issued to the PI and/or the supervisor via email or via UH Safety Solutions. If deficiencies were observed during the inspection, the report will list a response date by which the supervisor must reply to the EHSO indicating when and how all the deficiencies will be corrected.

Once the response from the supervisor has been received and reviewed by the EHSO, a compliance date will be established. If the supervisor does not respond to the report, the EHSO will establish the compliance date. In either case, the supervisor will be informed about the compliance date. Once the compliance date has been reached, the EHSO will follow-up to ensure the deficiencies have been corrected. If all the deficiencies have been corrected, then no further action will be taken and the PI and/or supervisor will be informed. If only minor deficiencies (as defined by the EHSO) remain after the follow-up, then the EHSO and the supervisor will establish a new compliance date.

If major deficiencies (as defined by the EHSO) remain, a second report will be generated and sent to the original report's recipients and the department Chair and Dean. If necessary (as deemed by the EHSO), a meeting will be scheduled between the supervisor, department Chair, Dean/Director, and the EHSO. The participants at this meeting will discuss how the deficiencies can be corrected. A new compliance date will be scheduled at this meeting.

The EHSO will follow-up based on the new compliance date. If all deficiencies are corrected, then no further action will occur and the supervisor, Department Chair,Dean/Director will be informed. However, if any deficiencies still remain, then the EHSO will formally send the matter to the Office of Vice Chancellor for Research (OVCR) for further action. The OVCR may take appropriate action (i.e., disciplinary action in accordance with applicable collective bargaining agreements). The OVCR will inform the EHSO Director of all activities taken to correct the situation in a timely manner.

APPENDIX 13. LABORATORY PERSONNEL SAFETY CHECKLIST

http://www.hawaii.edu/ehso/wp-content/uploads/2018/04/Lab-Personnel-Safety-Checklist-April-2018.pdf

UNIVERSITY of HAWAI'I MĀNOA

CLEAR

LAB PERSONNEL SAFETY CHECKLIST

1

EMPLOYEE/STUDENT NAME/POSITION (PRINT FIRST NAME, LAST NAME, and POSITION):

PRINCIPAL INVESTIGATOR/SUPERVISOR (PRINT FIRST AND LAST NAME):

DEPARTMENT/BLDG/ ROOM #:

DATE OF INITIAL REVIEW WITH EMPLOYEE: ________________

All employees/students working in a research laboratory at UH Manoa shall be trained in the topic areas on this list, where applicable, to ensure compliance with UH Safety and Health policies and procedures and to reduce the occurrence of workplace illness and injury. This checklist shall be reviewed with the employee/student in person by the lab supervisor or his/her/their designee annually.

ADMINISTRATIVE POLICIES & PROCEDURES	Date Reviewed	N/A
Has the PI/Lab Supervisor reviewed with the employee/student the laboratory signage system as indicated on the door?		
Has the PI/Lab Supervisor discussed the nature of the research being conducted in the laboratory?		
Has the *UH Safety Solutions Laboratory Hazard Assessment* been assigned for review and acknowledgment?		
Has the employee/student been trained on the safe methods for performing specific job duties (have Standard Operating Procedures (SOP's) been reviewed)?		
Have basic laboratory safety requirements (prudent laboratory practices) been explained and reinforced with the employee/student?		
Has the PI/Lab Supervisor reviewed the laboratory Chemical Hygiene Plan (CHP) with the employee/student?		

EMERGENCY POLICIES & PROCEDURES	Date Reviewed	N/A
Have all applicable emergency equipment locations and procedures been identified and reviewed with the employee/student (see the following for specific areas to be covered)?		☐
• Emergency Shower		☐
• Emergency Eyewash		☐
• Workplace first aid kit		☐
• Chemical spill kit(s) location(s) and spill procedures		☐

Contact UH EHSO with any questions at 808-956-5097 or labsafe@hawaii.edu — *Last Updated April 15, 2019*

UNIVERSITY of HAWAI'I MĀNOA

LAB PERSONNEL SAFETY CHECKLIST

2

Has the Emergency Response Guidebook (see Department of Public Safety website: http://manoa.hawaii.edu/dps/emergencyguidebook.html) been reviewed (with emphasis of the following information)?		
• Department of Public Safety telephone Extension: 808-956-6911		
• Meeting location upon evacuation: (fill in the blank) ____________________		
Have the workplace procedures for properly reporting, documenting, and receiving treatment for a workplace injury been reviewed?		
• Other (not listed) ____________________		
Has the PI/Lab Supervisor discussed the need for the employee/student to inform their health care providers of the hazardous substances (chemical, biological, radioactive) used in the laboratory during each medical visit (for example, in the case of pregnancy, informing the physician about hazardous materials used in the laboratory)?		☐

POTENTIAL HAZARDS/RISKS	Date Reviewed	N/A
Has the PI/Lab Supervisor discussed the hazardous components of the research?		
Has the PI/Lab Supervisor discussed the safe use of, storage location, inventory location, and quantities of the following items (if present)?		
• Chemical		☐
• Biological		☐
• Radioactive		☐
Has the PI/Lab Supervisor discussed other potential hazards, including physical hazards (high/low pressure and/or temperature, fire, compressed gases, lasers, machinery, hand/power tools, electricity, noise, vibration, heights, etc.)?		
Has the employee/student received instruction on known symptoms associated with exposure to highly toxic chemicals and/or biological commodities used in the laboratory?		☐

Personal Protective Equipment	Date Reviewed	N/A

Contact UH EHSO with any questions at 808-956-5097 or labsafe@hawaii.edu — *Last Updated April 15, 2019*

UNIVERSITY of HAWAI'I MĀNOA

LAB PERSONNEL SAFETY CHECKLIST

3

Has the *UH Safety Solutions Laboratory Hazard Assessment* information concerning Personal Protective Equipment (PPE) required in the laboratory been reviewed and acknowledged?		
Has appropriate PPE been provided to the employee/student?		
Has the student/employee been shown how to properly don, wear, doff, and maintain PPE?		
Has the student/employee been informed of the limitations of PPE?		

HAZARDOUS WASTES	Date Reviewed	N/A
Have the locations been identified and the procedures for handling various wastes been reviewed with the student/employee?		
• Hazardous Chemical Waste (location of the Satellite Accumulation Area(s), location of emergency procedures, etc.)		
• Sharps/broken glass		
• Radioactive materials		
• Biological materials		

TRAINING(S) Note: Training required to work in a lab will depend on commodities present and be determined by the PI.	Date Completed	N/A
Do you work in a laboratory setting? If yes, complete EHSO provided Laboratory Safety training. **Initial in-person** training: https://www.hawaii.edu/ehso/lab-safety-training/		
Conduct **annual** laboratory safety refresher training with PI/lab supervisor using this document.		
Completed Hazardous Waste Generator training (if generating chemical waste and submitting for proper disposal to UH EHSO). **Initial in-person** training: https://www.hawaii.edu/ehso/hazardous-waste-generator-training/		
Completed Hazardous Waste Generator **annual refresher online** training through Laulima.		
Completed Biosafety and Bloodborne Pathogen training. **Initial in-person** training: https://www.hawaii.edu/researchcompliance/biosafety-education		
Completed Biosafety and Bloodborne Pathogen **annual refresher online** training through Laulima.		
Completed Radiation Safety training.		

Contact UH EHSO with any questions at 808-956-5097 or labsafe@hawaii.edu — *Last Updated April 15, 2019*

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LAB PERSONNEL SAFETY CHECKLIST

4

Initial in-person training: https://www.hawaii.edu/ehso/radiation-training/		☐
Completed Radiation Safety **annual refresher online** training through Laulima.		☐ ☐
If you are planning to use a *respirator* on the job, a medical clearance, training, and fit testing may be required. Please contact the EHSO prior to initial use.		☐
For other training(s) that are not listed above but may be required by your PI (e.g. compressed gas safety, pressure vessel safety, fire safety, electrical safety, etc.), contact the EHSO for guidance.		

All laboratory personnel must: **KNOW** the hazards, **UNDERSTAND** the hazards and risks, and have the **SKILLS** to execute safe practices.

ACKNOWLEDGMENT OF RESPONSIBILITIES:
I have acknowledged that I fully understand the policies and procedures for working at this facility. I agree to comply with all safety procedures at all times. Furthermore, I understand that if I endanger my own or a colleague's safety, I may have restricted access to certain work areas and duties as deemed necessary by my supervisor until further review and training.

Employee/Student:

Signature Date

Principal Investigator/Lab Supervisor:

Signature Date

Keep this completed form with employee training records.

Contact UH EHSO with any questions at 808-956-5097 or labsafe@hawaii.edu — *Last Updated April 15, 2019*

APPENDIX 14. SAFE HANDLING PRACTICES FOR MOVING CHEMICALS

http://www.hawaii.edu/ehso/wp-content/uploads/2019/05/Safe-Handling-Practices-For-Moving-Chemicals.pdf

UNIVERSITY of HAWAI'I MĀNOA

University of Hawaii EHSO 2040 East-West Rd. 808-956-8660 www.hawaii.edu/ehso

University of Hawaii EHSO
Safe Handling Practices For Moving Chemicals

This fact sheet provides guidance and explains basic considerations for chemical handling and storage precautions when moving chemicals between labs and buildings at UH Manoa. As a key reminder, ensure that everyone involved is trained in the safe handling of chemicals. Never move chemicals alone. Utilizing at least two people will make this process much safer and easier!

1. **First, perform a pre-move visual inspection and inventory of the chemicals that will be moved.**
   a. Make a list of the chemicals and note the type (e.g. Acid, Base, Reactive, Toxic), and their respective amounts to be moved.
   b. Make sure that each container is correctly labeled as to its contents.
   c. Observe the general condition of each chemical container.
   d. Observe each container's cap or closure seal for the formation of crystals. CAUTION: DO NOT TIGHTEN, OPEN OR MOVE CONTAINERS THAT HAVE CRYSTALS FORMING ON THE CAPS AND SEALS. Observe whether crystals, which could be the sign of decomposition, have formed INSIDE the container. Ethers and other classes of organic peroxides can decompose and produce potentially dangerous and explosive crystals.
   e. Identify the specific areas in the new location where chemicals will be stored and ensure necessary storage containment equipment are on site.
2. **Locate the Safety Data Sheet (SDS) for each chemical to be moved.** Each SDS has chemical specific handling and safety information that must be properly followed in order to move the chemical safely. The SDS should be readily available to those moving chemicals or responding to spills.
3. **Plan the move - Choose the best route to take from point A to point B.** Do not take containers up and down stairs if possible and do not allow personnel not actively involved with moving chemicals to ride in elevators. Use of a freight elevator is recommended if available.
4. **Prepare the chemicals for the move.**
   a. Remember to use the proper goggles, gloves, and other personal protective equipment before handling any chemicals.
   b. Group the containers for the move by Hazard Class. Do not move acids with toxics, or oxidizers with organic solvents. Make a separate move for each Hazard Class.
   c. Transfer salvageable chemicals from deteriorating or contaminated containers to new containers with new labels. Properly dispose of unsalvageable and excess chemicals as Hazardous Waste.
   d. Box chemical containers if possible, using the correct packing materials (e.g. Vermiculite, original packaging boxes). Ensure the bottoms of boxes used are secured PRIOR to loading with chemical bottles.

Last updated August 27, 2019

   e. If you use a cart to move containers make sure it has rails so the containers don't slip off. Place heavy containers on the bottom rack of the cart. Do not overload the cart and make several trips if necessary.
   f. Take a chemical spill kit with you in the event you have a spill along the move. This can be a coffee can filled with Vermiculite or the Acid/Base neutralizer kit found in many labs.
   g. Ensure the receiving location is accessible before leaving the point of origin.
   h. Keep a cell phone with you to provide a means of communicating emergencies during the entire process.
5. **Compressed cylinder handling.**
   a. Always remove regulators from the cylinders before moving.
   b. Always replace the metal valve cover on the cylinder before moving.
   c. Move the cylinder with a cylinder dolly made especially for moving cylinders. Make sure the cylinder is securely chained or strapped to the dolly.
   d. DO NOT lay cylinders on their sides. Laying a cylinder on its side can cause condensed liquids in the cylinder to enter the valve. When the valve is opened the liquid can rapidly volatilize and expand. This can produce potentially explosive conditions.
6. **Cold storage transport.**
   a. Determine your requirements for transportation of temperature sensitive materials.
   b. Plan to have dry ice and liquid nitrogen on hand for your transportation needs. Consult with UH Biosafety for transportation of biological samples. Have a refrigerator/freezer at your destination to quickly transfer items into cold storage.
7. **Before the move think about your storage system and where you are moving.** The best way to store and segregate reactive chemicals is by family groups, making sure that you do not put certain groups right next to each other. For example, store phenols and amines well away from acid chlorides. Inorganics should be separated from organics. The inert or low-reactive materials can be stored in alphabetical order. This "mixed" system can work well and will help you comply with chemical storage requirements. Guidelines for chemical storage with emphasis on secondary containment can be found here: http://www.hawaii.edu/ehso/wp-content/uploads/2016/07/Chemstorage.pdf
8. **During the move be prepared for unexpected events!**
   a. Stay with the containers. Do not let them out of you sight while you are moving them between points "A" and "B."
   b. Be aware of the surroundings. Watch for doors opening in your way. Warn people of the hazard before they get close to you.
   c. If it begins to rain while you are outside of a building you will need to find safe cover for the containers.
   d. Have your spill kit available as well as the phone numbers to call in the event you have a spill along the move. Familiarize yourself with UH chemical hygiene plan "Spill Clean-Up Procedures."

Emergency contacts:

- **UH Environmental Health and Safety Office - 808-956-8660,** labsafe@hawaii.edu
- **Department of Public Safety (DPS) - 808-956-6911**

Last updated August 27, 2019

APPENDIX 15. NEAR MISS REPORT FORM

http://www.hawaii.edu/ehso/wp-content/uploads/2016/07/Nearmiss.pdf

NEAR-MISS REPORT

Forward Original to
ENVIRONMENTAL HEALTH AND SAFETY OFFICE
2040 East-West Road
Honolulu, Hawaii 96822-2320

1. Name of Person Involved (Last, First, Middle Initial)

2. Title of Person Involved

3. Name of Person Completing Form (Last, First, Middle Initial)

4. Title of Person Completing Form

5. Department

6. Contact Phone Number(s)

7. Witness (Name and Phone no.)

8. Date and Time of Incident

Date: ____________ Time: ____________ AM

____________ PM

9. Near-Miss Location Site of incident (Bldg. name, Room no., stairs, hallway, etc.). If outside of building, give location in reference to nearest building, eg. on mall mauka of Bilger Hall.

10. Near-Miss Description (Descibe fully, the protocol/procedures being followed including all substances, equipment, and machinery being used which was related to the near-miss. Use additional sheets if necessary.)

11. Personal Protective Equipment (PPE) Used (if applicable)

12. Severity — Circle the level of severity which you feel could occur if such an incident evolved (Example: High = fatality, permanent disability, high dollar loss; Medium = temporary disability, some lost dollar; Low = minor or no injury, no lost dollar. Consider such factors as physical injuries, damage to equipment/property, and environmental impacts)

HIGH **MEDIUM** **LOW**

13. Probability — Circle the level of probability which you feel that a person or property may be exposed to in a similar situation and that required hazards or system failures may be present or likely. (Example: High = tasks occur fequently and by numerous individuals; Medium = tasks occur on a regular basis by certain individuals; Low = tasks occur infrequently by few individuals. Also consider such criteria as complexity of the system, latent and human factors, etc.)

HIGH **MEDIUM** **LOW**

14. Corrective Actions (What should be done or has been done to prevent recurrence of his incident? e.g. employee training, change of procedures, purchasing of equipment, etc.)

15. Miscellaneous Information (Provide any other information or recommendations which you feel are pertinent to this incident)

APPENDIX 16. CHEMICAL ABBREVIATION KEY

http://www.hawaii.edu/ehso/wp-content/uploads/2019/10/UH-Chemical-Abbreviation-Key-Final-October-11-2019.pdf

University of Hawai'i Mānoa | **Chemical Abbreviation Key** *Laboratory Safety* | Chemical Names and Warnings

Abbreviation	Chemical Name & CAS #	GHS Hazards & Signal Word
NaOH	**Sodium Hydroxide** 1310-73-2	Danger
PBS	**Phosphate Buffered Saline**	N/A
PEG	**Polyethylene** 9002-88-4	N/A
PIPES	**Piperazine-N, N'bis(2-ethanesulfonic acid)** 5625-37-6	N/A
SDS	**Sodium Dodecyl Sulfate** 151-21-3, 7732-18-5	Danger
TAE	**Tris/Acetate/EDTA** 6850-28-8	N/A
TBE	**Tris/Borate/EDTA Acetate** 77-86-1, 10043-35-3, 7732-18-5	Warning
TBS	**Tris Buffered Saline**	N/A
TCA	**Trichloroacetic Acid** 375-85-9	Danger
TEMED	**N,N,N',N'- tetramethylethylenediamine** 110-18-9	Danger
THF	**Tetrahydrofuran** 109-99-9	Danger
TMAH	**Tetramethylammonium Hydroxide** 75-59-2	Danger
Tris	**Tris-(hydroxymethyl) amino-methane** 77-86-1	Warning

University of Hawai'i Mānoa | **Chemical Abbreviation Key** *Laboratory Safety* | Chemical Names and Warnings

Abbreviation	Chemical Name & CAS #	GHS Hazards & Signal Word
BPB	**Bromophenol Blue** 115-39-9	Warning
CAPS	**3-(Cyclohexylamino)-1-propanesulfonic Acid** 1135-40-6	Warning
Destain	**Methanol, Acetic Acid, H_2O**	Danger
DI H_2O	**Deionized Water** 7732-18-5	N/A
DCM	**Diochloromethane (Methylene Chloride)** 75-09-2	Warning
DMF	**N, N-dimethylformamide** 68-12-2	Danger
DMSO	**Dimethyl Sulfoxide** 67-68-5	Warning
EDTA	**Ehylenediaminetetraacetic Acid** 60-00-4	Warning
EtBr	**Ethidium Bromide** 1239-45-8	Danger
EtOH	**Ethanol** 64-17-5	Danger
HCl	**Hydrochloric Acid** 7647-01-0	Danger
HEPES	**N-(2-Hydroxyethyl) piperazine N' 2-(2-ethanesulfonic acid)** 7365-45-9	Warning

Only use abbreviations on reagent working containers.
Do not use abbreviations on hazardous waste containers!

University of Hawai'i Mānoa | **Chemical Abbreviation Key** *Laboratory Safety* | Chemical Names and Warnings

Abbreviation	Chemical Name & CAS #	GHS Hazards & Signal Word

University of Hawai'i Mānoa | **Chemical Abbreviation Key** *Laboratory Safety* | Chemical Names and Warnings

If you are adding additional chemical abbreviations to your chart, the pictograms below can be copied and pasted in the GHS Hazards column. The signal word and hazard symbols of the chemical can be found in the safety data sheet of the substance. UH Manoa affiliated individuals can use their UH ID to access the UH Safety Solutions Chemicals Application to find signal words and hazard symbols.

APPENDIX 17. UH MĀNOA NANOTECHNOLOGY SAFETY GUIDELINES

UNIVERSITY of HAWAIʻI
MĀNOA

University of Hawaiʻi EHSO 2040 East-West Rd. 808-956-8660 www.hawaii.edu/ehso

UH Mānoa Nanotechnology Safety Guidelines[1]

Researchers at UH Mānoa are increasing resources devoted to nanotechnology. Subsequently, the Environmental Health & Safety Office (EHSO) is collaborating with researchers to work with these new materials safely. Currently, there is limited occupational safety information on nanoparticles and nanomaterials in the university research environment. EHSO wants to ensure that employees using nanotechnology are aware of the potential hazards and risks involved and the control measures that should be utilized to limit exposures. This guidance document proactively addresses the safety issues in the emerging field of nanotechnology and ensures that University employees performing nanotechnology research are aware of the potential hazards and risks involved and the control measures that should be utilized to limit exposures.

The Centers for Disease Control and Prevention (CDC) and the National Institute for Occupational Safety and Health (NIOSH) have published a pamphlet on *Safe Nanotechnology in the Workplace*. If you perform nanotechnology research please review and discuss with your principal investigator and colleagues. The pamphlet will inevitably generate additional questions regarding proper engineering controls and personal protective equipment (PPE) specific to the nanotechnology research your laboratory performs. EHSO has generated a *Summary of Recommended Nanomaterial Risk Levels* (See Table 1) that will help when addressing these issues and performing a risk assessment on your specific research.

Several additional nanotechnology safety resources are also listed below. If you have further questions or would like a workplace nanotechnology safety evaluation please contact Laboratory Safety at labsafe@hawaii.edu.

- OSHA Fact Sheet: Working Safely With Nanomaterials
- 2012 NIOSH Report: General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories

[1] Reference: (The University of North Carolina at Chapel Hill), used with permission

Table 1 - Summary of Recommended Nanomaterial Risk Levels

NRL	TYPE OF NANOMATERIAL	PRACTICES	ENGINEERING CONTROLS	PERSONAL PROTECTIVE EQUIPMENT (PPE)
1	Polymer matrix	Standard Laboratory Practices including: ● SOP should be updated with NRL defined ● Labeling of storage containers of nanomaterials with both the chemical contents and the nanostructure form	Fume hood **or** biological safety cabinet (Class II Type A1, A2 vented via a thimble connection, B1 or B2)	Standard PPE (laboratory coat, gloves, safety glasses with side shields)
2	Liquid dispersion	NRL-1 practice plus: ● Use secondary containment for containers that store nanomaterials ● Wipe contaminated areas with wet disposable wipes ● Dispose of contaminated cleaning materials as segregated nanomaterial waste	Fume hood or biological safety cabinet (Class II Type A1, A2 vented via a thimble connection, B1 or B2) or approved vented enclosure (e.g., Flow Sciences vented balance safety enclosure [VBSE])	NRL-1 practice plus: Nitrile gloves Safety goggles
3	Dry powders or a erosols	NRL-2 practice plus: ● Vacuum with HEPA-equipped hand vacuum cleaner ● Label work areas with "Caution Hazardous Nanoscale Materials in Use"	Fume hood or biological safety cabinet (Class II Type A1, A2 vented via a thimble connection, B1 or B2) or approved vented enclosure (e.g., Flow Sciences vented balance safety enclosure [VBSE]). HEPA filtered exhaust preferred for fume hoods containing particularly "dusty" operations.	NRL-2 practice plus: N95 respirators are required if work operation must be done outside of containment
4	Dry Powders or aerosols of parent materials with known toxicity or hazards	NRL-3 practice plus: ● Baseline medical evaluation or employees including physical exam, pulmonary function test (PFT) and routine blood work. ● Access to the facility should be permitted only to persons who are knowledgeable about the hazards of the material and the specific control measures implemented to avoid exposures and/or environmental releases. These control measures should include work practices (SOPs), engineering controls, spill and emergency procedures, personal protective equipment, disposal procedures, and decontamination/clean up procedures. Department procedures should address the designation and posting of the laboratory, how access will be controlled, and any required entry and exit protocols.	Fume hood or biological safety cabinet (Class II Type B1 or B2) or glove box or approved vented enclosure (e.g., Flow Sciences vented balance safety enclosure [VBSE]). HEPA filtered exhaust with Bag-In/Bag-Out capability preferred for hoods, BSCs, and gloveboxes.	NRL-3 practice plus: Need determined and respirator selected with reference to the engineering controls in use and potential for aerosol generation

Safe Use of Nanomaterials

This section discusses the unique properties of nanomaterials, solid superatomic materials with at least one dimension in the range of one to 100 nanometers. Subsequent sections discuss the potential safety and health concerns from nanomaterials (based on cell culture and animal studies), the routes of exposure, and guidance on how to prevent exposures to nanomaterials.

Introduction

Nanomaterials are any solid superatomic materials with at least one dimension (length, width, or depth) between one and 100 nanometers (nm). This size range (1-100 nm) is referred to as "nanoscale". Nanomaterials can exhibit unique physical and chemical properties not seen in larger molecules of the same composition, properties described later in this section. Substantial private and public investments are flowing into the exploration and development of products that can take advantage of the unique properties of nanomaterials. Researchers and EHSO staff must consider the potential health, safety, and environmental risks that might result during this research and development boom caused by the promise of nanotechnology.

The National Institute for Occupational Safety and Health (NIOSH) has a strategic plan and research agenda to address the health and safety of nanomaterials. Consult their Nanotechnology Page for more information. https://www.cdc.gov/niosh/programs/nano/default.html

Size and Types of Nanomaterials

One meter consists of 1000 millimeters (mm). One millimeter equals 1000 micrometers (µm), and one micrometer equals 1000 nm. Thus, 1 nm = 1×10^{-9} m.

How do nanomaterials compare in size to other objects regarded as "small"? Dust mites have a diameter of approximately 200 µm. Human hairs have a diameter of 60-120 µm. Thus, both are 1000 or more times larger than nanoscale. The smallest known bacterial species, such as the genus Mycoplasma, have a diameter of approximately 300 nm (.3 µm), which is still greater than nanoscale. Some smaller viruses (e.g. Parvoviruses, diameter ~25 nm) exist at nanoscale, but most viruses are larger. Typical double-stranded DNA has a diameter of ~2.5 nm.

Nanomaterials are among the smallest materials that can exist, because the smallest unit of elemental matter that retains the properties of the element (the atom) is not much smaller than nanoscale. Due to the uncertain position of the electron cloud around the central nucleus, scientists can only estimate the diameter of atoms. However, most estimates of atomic diameter range from .05 to .25 nm (0.5 to 2.5 Angstroms).

Nanomaterials divide roughly into two main categories: ambient (or "natural") nanoparticles, and engineered/manufactured nanomaterials. The rest of this section will use the term "nanoparticles" when referring specifically to nanoscale natural (non-engineered) substances. The term "nanomaterials" will be used as a blanket term for all nanoscale substances. In most scientific uses, the terms are interchangeable.

Ambient nanoparticles are also known as "ultrafine" particles in standard industrial hygiene terminology. Sources include diesel engine exhaust, welding fumes, and other combustion processes. Most grinding and crushing processes are incapable of producing nanoparticles, unless fine bead mills are used. Ultrafine/nanoparticles have a larger surface area per unit volume than an equal volume of same composition larger particles. This can lead to different physical, chemical, and biological response properties.

Other natural nanoparticles include smaller viruses and rickettsia, and intracellular proteins, nucleic acids, and organelles.

Figure 1.

Figure 1. (Left) Diesel engines produce particulate soot, which includes ultrafine amorphous carbon. (Right) Welding produces metal fumes, many of which are ultrafine/nanoscale.

Engineered or manufactured nanomaterials are deliberately created and used for a structural/functional purpose. Engineered nanomaterials can include both homogeneous materials and heterogeneous structures with specific applications in computing, medicine, and other disciplines. The next section will examine several examples of engineered nanomaterials.

Uses of Nanoparticles / Nanomaterials

This section is not remotely inclusive, but gives you a few examples of nano-based products that are currently available, and others that are in development.

Consumer Products

Several commercially available products already use nanoparticles for their desirable properties. 3M makes a dental composite called FiltekTM that consists of nanosilica particles. Other companies use nanofibers to impart stain and wrinkle resistance to fabrics. Tennis balls manufactured with nanoclay particle cores hold air pressure longer than conventional balls. Zinc oxide nanoparticles are now common in many sunscreens and cosmetics, the advantage being that the nanoparticles are transparent (unlike the larger particles) so the products are clear rather than white. Of course, nanotechnology also has a rich present and future in computing and technological applications, to create smaller and more powerful chips. In the coming years, the number of these nano-based consumer products is expected to grow exponentially.

Laboratory Products

Many nanotech-based products are already used in research laboratories, and you might already have some of these in your lab. New scintillation fluids contain proprietary fluor-containing nanoparticles that do not require organic solvents as the carrier. The advantage is that used scintillation cocktail is only radioactive waste, rather than mixed radioactive and ignitable waste, saving disposal costs. Sturdy fluorescent probes are now available, using quantum dot semiconductor particles. Recently, scientists were able to combine polyguanine with silica nanoparticles to create a new electrochemical immunosensor for TNF-α[1].

Uses in Medicine

The ability to employ nanoparticles and create nanomaterials holds great potential in the field of medicine, as many diseases result from damage at the molecular or cellular level. Therefore, the ability to deliver pharmaceuticals and therapeutic gene "payloads" at the cellular level, with nanomaterials acting as the delivery system, holds great promise. For example, calcium phosphate nanoparticles can deliver DNA to particular cells targeted for gene therapy[2] . A recent breakthrough in imprint lithography allows the production of monodisperse nanoscale particles that can effectively contain delicate payloads[3]. In the near future, it might be possible for engineered nanomaterials to take over the function of damaged/defective subcellular organelles such as mitochondria[4].

Carbon Nanotubes

Carbon nanotubes (CNTs) also deserve attention, since they are a basic building block for many current and future products. These allotropes of carbon assemble themselves into cylindrical sheets. Single-walled CNTs have a diameter of approximately 1.3 nm, while multi-walled CNTs have larger diameters that are still within nanoscale.

Figure 2.

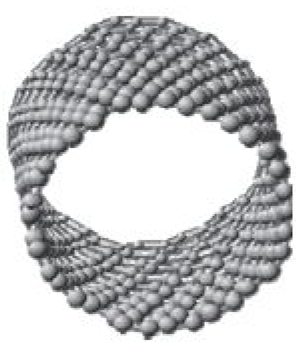

Figure 2. Representation of a single- walled carbon nanotube.

CNTs can be up to several millimeters long, and possess tensile strength more than twenty times greater than carbon steel. CNTs also are efficient conductors of heat, excellent electron emitters, and can assemble into strong ropes of increasing diameter through VanDerWaal's forces. All of these are highly desirable material properties. Currently, CNTs are used in diverse applications such as lightweight carbon fiber bicycle pieces, water desalination filters, concrete strengthening, and solar cells. Their field emission properties have been harnessed to produce scanning X-ray imaging systems[5]. As the production and use of carbon nanotubes in laboratory research environments increases, the potential for exposure to CNTs also increases. The next section will cover known and suspected health effects from CNTs and other nanomaterials.

Potential Health Hazards of Nanomaterials

As stated earlier, nanomaterials have a larger surface area to volume ratio compared to larger materials of the same composition. Nanomaterials, like many other solids, can have biological impacts based on their structure. Below is a summary of known and suspected health hazards from nanomaterials, based on recent research in animal models and in vitro assays.

Respirable Exposures

Inhalation is the most likely exposure route in laboratory settings, and the most extensive health effects studies have involved the inhalation route. From the time when carbon nanotubes were first seen through transmission electron microscopy, investigators noticed a startling physical similarity to asbestos (Figure 3). Both exist as fibers; with a length/width aspect ratio of at least 3:1, and both can exist at nanoscale (asbestos fibers as small as 2.5 nm diameter can occur naturally). Several decades of experimental data and retrospective epidemiological evidence have shown that asbestos exposure can lead to pulmonary fibrosis, mesothelioma, and increased risk of lung cancer, which is strongly synergistic when combined with smoking. Can CNTs cause similar health effects?

Figure 3

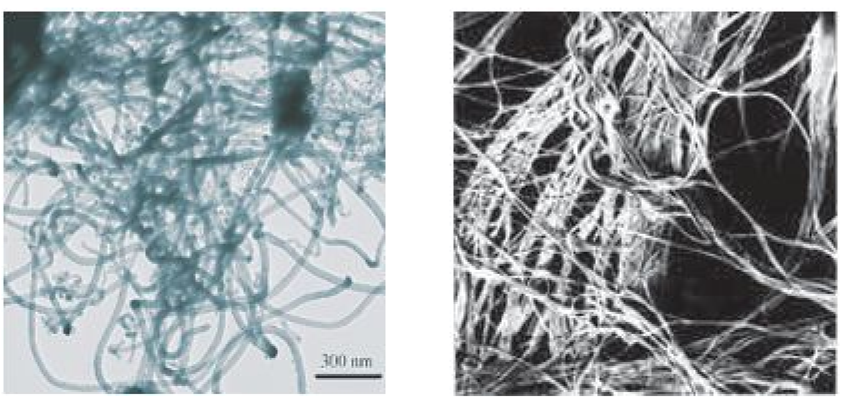

Figure 3. Transmission electron micrographs of carbon nanotubes (left) and asbestos (right).

CNTs can, like asbestos, reach the gas exchange (alveolar) regions of the deep lung, and trigger inflammation and oxidative stress. Studies in mice have shown that single-walled CNTs can produce pulmonary granulomas, whereas equivalent mass doses of ultrafine carbon black did not[6,7]. This implies that the shape and surface chemistry properties of CNTs impart an increase in pulmonary toxicity.

Respiratory studies for other nanomaterials are also informative. Extensive research on diesel exhaust particulates has led to their characterization by the International Agency for Research on Cancer as a reasonably anticipated human lung carcinogen. For titanium dioxide (a substance used at nanoparticle size in cosmetics, sunscreens, and self-cleaning windows), 25 nm diameter particles produced more potent lung damage than 250 nm diameter particles[8]. Since both sizes of particles are capable of reaching the deep lung, there must be another factor such as surface area to volume ratio, solubility, or agglomeration creating the toxicity difference. Nanoparticles that agglomerate tend to deposit in the nasopharyngeal region or the upper airways.

Discrete nanoparticles that reach the deep lung might be small enough to penetrate through alveolar epithelial cells, enter the capillaries, and translocate to other organs[9]. For discrete nanoparticles that remain in the nasopharyngeal region, translocation to the brain via axonal transport through the olfactory nerve has been shown in rats[10].

In summary, animal studies indicate the following potential concerns from exposures to nanomaterials through the inhalation route:

- CNTs might possess asbestos-like properties;
- For all nanomaterials, equivalent mass doses of the same materials might exhibit higher toxicity at nanoscale size;
- Previously unobserved translocation routes (via alveoli to bloodstream, via olfactory nerve to brain) might exist.

Skin Exposures

Skin penetration might be a viable exposure route for nanomaterials, though it is too soon to know whether it represents an important exposure route. Studies of titanium dioxide nanoparticles (found in some cosmetics and sunscreens) found that these particles did not penetrate beyond the epidermis[11]. Another study has shown that quantum dot nanomaterials with varying physicochemical properties were able to penetrate the intact skin of pigs[12]. Localized effects are also possible, as shown in vitro when CNTs were absorbed into skin cells leading to cytokine production and oxidative stress[13].

Ingestion Exposures

Very little is known about potential adverse effects from exposure to nanomaterials by ingestion. Ingestion might be the least likely exposure route in a laboratory or workplace setting. Ingestion could occur directly by mouth, or indirectly through mucociliary clearance of upper airways. It is presumed that nanomaterials could reach just about any organ or tissue after ingestion, if they are capable of penetrating skin cells, alveolar epithelium, and blood vessel walls.

Potential Safety Hazards of Nanomaterials

Safety hazards with nanomaterials vary based on the composition of the materials. However, a few general observations are possible. For flammable or combustible solids (e.g. some metals), nanoscale materials could present a higher fire-explosion risk compared to coarser particles of the same material [14]. Decreased particle size can increase the combustion potential and combustion rate, and reactive/catalytic properties can exist at nanoscale that do not exist at larger scales. Gold is relatively inert as a macromolecule, but gold nanoparticles can catalyze the conversion of carbon monoxide to carbon dioxide.

The greater activity of nanoscale materials forms the basis for research into nanoenergetics. For example, nanoscale thermite powders composed of aluminum and molybdenum trioxide ignite more than 300 times faster than corresponding micrometer-scale material[15].

Protective Measures

This section details the ways that you can protect yourself when working with nanomaterials. Though there are still gaps in the safety and health knowledge literature, this section describes prudent use and handling practices that can protect you not just from nanomaterials, but other potentially harmful substances in the lab.

The most significant exposure route in laboratory settings would be inhalation, and this is the route with the most toxicity data. Respirable exposures would be most likely during the creation or handling of nanomaterials in aerosol, powder, or colloidal suspension. Nanomaterials in composites are not as likely to result in respirable exposures unless they are cut, ground, or degraded. As with all potential exposures, the best place to start is the OSHA "hierarchy of controls", which goes from engineering controls to work practice controls to personal protective equipment. Engineering controls always come first, since they have the potential to remove the exposure from the work area. Do not consider using personal protective equipment until you have considered all engineering and work practice controls.

Engineering Controls

It is a sound assumption that local exhaust ventilation systems (such as laboratory hoods) would effectively remove nanomaterials from the air, based on research about the capture of ultrafine particles by these systems.

To avoid re-entrainment of nanomaterials, EHSO recommends High-Efficiency Particulate Air (HEPA) systems in conjunction with local exhaust ventilation. Filtration systems must be able to capture at least 99.97% of monodispersed 300 nm aerosols in order to qualify for HEPA rating. The 300 nm diameter is the most penetrating particle size. Particles smaller than 300 nm (including the nanoscale of 1-100 nm) are actually captured more effectively due to diffusion or electrostatic attraction, and particles larger than 300 nm are captured by impaction and interception. Thus, HEPA filters should effectively capture nanomaterials, however, the filter must sit properly in the housing, or nanomaterials will bypass it and take the path of least resistance. Local exhaust systems should be posted for nanomaterial use so that personnel that change HEPA filters are aware of potential hazards.

Work Practice Controls

The most effective work practice control is product substitution, with a safer product used in place of a more hazardous one. For nanomaterial research, this is generally not feasible, since the experiment requires the unique nanoscale properties. However, other work practice controls are feasible. Try to use "wet" materials whenever possible, since dry materials are much more likely to cause respirable exposures. Make sure to clean up work areas effectively; use wet methods (not dry sweeping!) and consider the purchase of a HEPA vacuum. As with all laboratory substances, designate food and drink areas far from where you handle materials. If necessary, provide for adequate hand washing, showering, and clean clothes storage areas. Good work practice controls can minimize your exposure potentials from all major routes (respirable, skin contact, and ingestion).

Personal Protective Equipment

Earlier, under the Engineering Controls section, it was noted that HEPA filtration systems on ventilation systems could remove more than 99.97% of airborne nanomaterials. Similarly, properly fitted elastomeric respirators with HEPA cartridges
(Figure 4a) should be able to prevent respirable exposure to airborne nanomaterials. Proper fit is critical, since a poor face seal means the particles and their airstream take the path of least resistance through the seal gaps into the breathing zone. Protective Clothing and Equipment for more information about the medical evaluation and fit testing requirements for tight-fitting respirators. Remember that you cannot consider respiratory protection or any other personal protective equipment until feasible engineering and work practice controls are exhausted.

Filtering facepiece respirators such as the N-95 (Figure 4b) are capable of filtering nanomaterials, but are prone to gaps and inward leakage. These respirators are not personal protective equipment from exposure to nanoaerosols.

Figure 4. 

Figure 4a. (left): Elastomeric respirator with HEPA cartridges.
Figure 4b. (right): N-95 filtering facepiece respirator.

There is currently very little data to indicate whether skin protective equipment such as gloves, Tyvek® sleeves and suits, etc., can protect from nanomaterials. Most available data is from bloodborne pathogen protective equipment, which is challenge-tested with a 27 nm bacteriophage per ANSI (the American National Standards Institute).

Currently, it is unknown whether the skin is a significant route of exposure to nanomaterials. Until more data becomes available, you should use gloves (double gloving for extensive skin contact) and sleeves to prevent skin contact, and change gloves frequently. When handling nanomaterials in solution you should wear gloves that are chemically resistant to the solution or solvent nanomaterials are suspended in.

Waste Handling

All nanomaterial waste should be handled as chemical waste. Contaminated solid waste (paper, gloves, wipes, tips) should be collected and submitted using the online chemical waste pick-up form available on the EHSO website. Pure unused nanomaterials in solid or powder form should be containerized and submitted as waste. Nanomaterials dissolved or suspended in solvents or formulations should also be collected following the waste handling rules outlined in the UH HMMP and submitted as a chemical waste mixture.

Conclusion

Nanomaterials exhibit unique properties that could challenge traditional perceptions about particle behavior and industrial hygiene, and more research is ongoing. At this time, it appears that traditional prudent approaches to avoid exposures (engineering controls, work practice controls, personal protective equipment) would also work for nanomaterials.

Please contact EHSO if you have any questions, or if you want to request an evaluation of your work conditions.

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